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Conference Paper

Modelling Migration and Regional Labour Markets: An Application of New Economic Geography Model Rhomolo

52nd Congress of the European Regional Science Association: "Regions in Motion - Breaking the Path", 21-25 August 2012, Bratislava, Slovakia

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Kancs, D'artis; Lopez-Bazo, Enrique; Manca, Fabio; Persyn, Damiaan (2012) : Modelling Migration and Regional Labour Markets: An Application of New Economic Geography Model Rhomolo, 52nd Congress of the European Regional Science Association: "Regions in Motion - Breaking the Path", 21-25 August 2012, Bratislava, Slovakia, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

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Modelling Migration and Regional Labour Markets:

An Application of New Economic Geography Model RHOMOLO¹

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August 2012 – Preliminary draft, not to be quoted without permission.

Abstract: This paper presents the theoretical structure of modelling migration and regional labour markets in the RHOMOLO model, which is built to support the EU policy design by undertaking holistic, micro-founded and disaggregated policy impact assessment. The RHOMOLO model is based on the theories of general equilibrium, endogenous growth and new economic geography. Employing the RHOMOLO model one can analyse how policy changes affect variables such as regional unemployment rates, participation rates, and regional non-market wage levels. Our focus is on modelling the dynamic regional response over time to shocks in labour demand, and less on fully explaining the origins or long-run levels of regional unemployment and participation.

Keywords: Economic modelling, spatial dynamics, policy impact assessment, regional development, economic geography, spatial equilibrium, DSGE, labour market, labour supply, labour demand.

JEL classification: C63, C68, D58, F1, F12, H41, J20, J64, O1, O31, O40, R13, R3, R4.

¹The authors acknowledge helpful comments from Andries Brandsma, Henri de Groot, Alessandro Ferrara, Ben Gardiner, Olga Ivanova, Gert-Jan Linders, Philippe Monfort, Giuseppe Piroli, Evgueni Poliakov, Dirk Stelder, Mark Thissen, the ECOMOD, ERSA, IER, GTAP and IIOA conference participants in Istanbul, Lodz, Jonkoping, Barcelona, Smolenice, Geneva, Washington and Sevilla, as well as the participants in seminars and workshops at the European Commission. The authors acknowledge financial support from the EU Project 'System of regional model for impact assessment of EU Cohesion Policy'. 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.

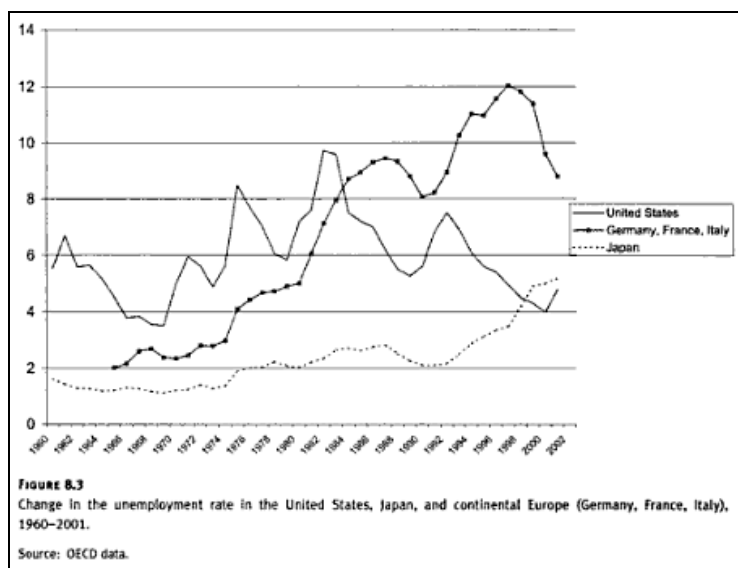
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1. Introduction

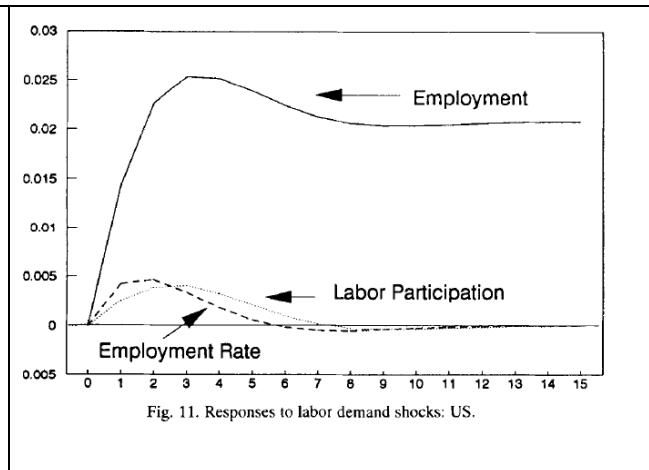
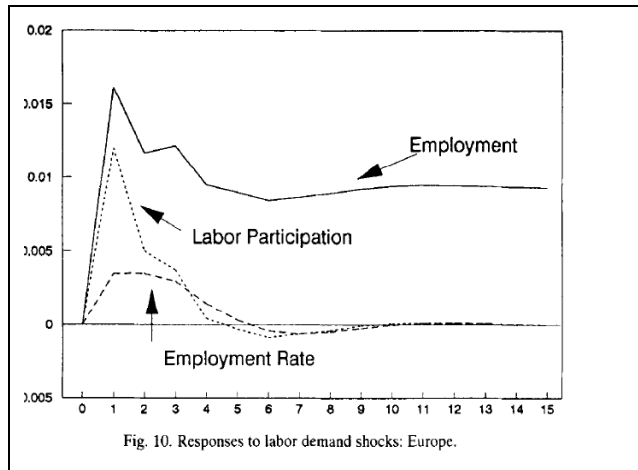
Labour markets serve an important channel of adjustment to exogenous shocks, such as global economic crisis. European labour markets are characterised by patterns and trends, which are fundamentally different from labour markets, e.g. US (Bean 1994; Elhorst 2003; Cahuc and Zylberberg 2004; Blanchard 2005). It is important to identify the specifics of European labour markets, as they will influence our modelling choices of labour market in RHOMOLO.

Stylised facts:

1. There is little proof that unemployment is driven by "excess labour supply". To the contrary, countries with high employment rates have low unemployment rates. The empirics rather point at limited job creation in regions and countries with high unemployment rates rather than large differences in labour supply.
2. Similar shocks have had very different effects on unemployment in the EU, compared to Japan and the US. Take the oil shocks in the '70 as an example, and consider the evolution of unemployment given in the figure below, taken from Cahuc and Zylberberg (2004). Although all countries were facing the same shocks, the Japanese unemployment rate did not change much. The effect on the US unemployment rate has been transient. Broadly speaking, unemployment in the EU is a story of hysteresis, and this is a rather unique feature in an international comparison.



3. There are large international differences in unemployment and participation rates, even when comparing across EU countries. A large degree of hysteresis is an important possible explanation for these differences, but not the only possible one. There might be "deeper" underlying causes in the labour market institutions (for example the setup of unemployment benefits, employment protection).
4. It is less well known that relative regional unemployment differences (relative to the country average, for example), in contrast to differences between countries, are not persistent in most EU countries, with some notable exceptions: Spain, Italy and Belgium (see Jimeno and Bentolila, 1998, for example).
5. In contrast to the US, migration does not respond quickly or strongly to regional shocks. The response of unemployment and especially participation, in contrast, is much faster and stronger compared to the US. See for example Blanchard and Katz (1992), or the impulse-responses from Decressin and Fatás, 1995, shown below (left EU, right US). The difference between the sum of participation and employment rate changes on the one side, and the employment change on the other side, shows the effect on migration. In the EU, only in the third year after the shock migration accounts for more than 25% in the adjustment of the labour force. In the US this is already more than 1/3 in the first year.



Although, RHOMOLO is not a forecasting tool, and does not and should not aim to reproduce any of the above correlations for the sake of it. Nevertheless, some of these observations are highly relevant even for a model with the limited aim of policy evaluation using a benchmark.

2. Previous literature

2.1. A simple model of regional labour market dynamics

In this section we review alternative modelling assumptions and their consequences for labour market dynamics. Blanchard and Katz (1992) use simple timing assumptions to endogenise wages, employment and unemployment in a tractable model. The basic model uses just 4 equations to describe the labour market in a region i in year t :

$$\begin{aligned}w_{it} &= -d \left(n_{it}^* - u_{it} \right) z_{it} \\c w_{it} &= -u_{it} \\n_{i,t+1}^* - n_{it}^* &= b w_{it} - g u_{it} + x_{st} + \varepsilon_{i,t+1}^s \\z_{i,t+1} - z_{it} &= -a w_{it} = x_{di} + \varepsilon_{i,t+1}^d\end{aligned}$$

Where n^* is the size of the local labour force, u the unemployment rate, and n^*-u is employment. The first equation describes labour demand; the second is a "wage equation", relating (non-market-clearing) wages to unemployment. The third equation describes how the size of the labour force (via migration and participation decisions) depends on regional wages, unemployment, and a region specific labour supply trend x_{st} . The last equation describes the position of the labour demand curve as a function of past wages. The size of the labour force is predetermined with respect to all other variables, which keeps the model tractable. Note that participation is not explicitly modelled: the model describes the size of the labour force and assumes it growth with increasing wages, but the model does not describe how the size of the labour force relates to the size of the working population.

Lower wages attract more firms (due to lower production costs) and hence increase the next-period labour demand (with an elasticity of a). The immediate demand-curve has a slope of a , and the long run labour demand curve is flat. Similarly, high wages attract workers from other regions in $t+1$ (with an elasticity of b). The immediate supply-curve is vertical and the long run labour supply curve is flat. The position of long run demand and supply is determined outside of the region, and depends on the general equilibrium of the entire economy. The long-run effect of regional shocks on regional employment is determined by which short-run adjustment factor dominates. In RHOMOLO capital accumulates in regions with a higher return, and with labour migration, long run labour demand and supply curves are flat. The relative speed of migration versus the responsiveness of investment to regional differences in capital returns determines how much firms and workers will have moved after regional shocks.

Labour demand shocks have only temporary effects on unemployment and wages in this simple framework. The only permanent shift is in the number of workers and jobs.

$$\hat{w}_{it} = -\frac{a - db}{1 - db} \rightarrow 0$$

$$\hat{n}_{it} = -b \frac{a - db}{1 - db} \frac{1}{1 - db} \rightarrow -b / (1 - db)$$

The graphs below show the effect of a labour demand shock on unemployment and wages in the model, after making some small changes and choosing some almost arbitrary parameter values. The persistence of unemployment decreases as firms or workers are more mobile, or (not in the model) if the wages decrease faster in response to increases in unemployment.

2.2. Regional unemployment differences: Regional versus national unemployment persistence

On average, and perhaps surprisingly, EU regional unemployment persistence (relative to the country or even EU-wide average) is lower than in the US, with the notable exception of some specific countries (Spain, Italy, Belgium) (see Eichengreen, 1992). Apart from these countries, in other EU countries, participation plays an important role in the adjustment process. One could ask, however, how much more a decrease in participation is to be desired over an increase in unemployment?

A straightforward explanation for these “special cases” would be that the worse-off regions in these countries are constantly being hit by region-specific shocks. This is unlikely, and does not seem to be the case. One alternative explanation is that the wage setting structure in these countries prevents wages to adjust in the worse-off regions, an idea that has been forwarded by Jimeno and Bentolila, and others, for Spain, Brunello, Lupi and Ordine for Italy, and Bogaert for Belgium.

In order to capture rigidities in the wage setting structure, Jimeno and Bentolila replace the wage equation with:

$$w_{it} = fw_t - c_A u_t - c_R u_{it}, \dots \dots \dots 0 \leq f < 1$$

such that regional wages depend on the national wage and the national unemployment rate; apart from the regional unemployment rate. Secondly, they assume that labour supply in a region depends not only the level of regional wages and unemployment (for participation decisions), but also on deviations of this variable as compared to the national average (regarding migration decisions).

$$n_{it}^* = \alpha n_{it-1}^* + b_p w_{it-1} - g_P u_{it-1} + v_{it} + b_M (w_{it-1} - w_{t-1}) - g_M (u_{it-1} - u_{t-1}) + \phi_{it}$$

Despite these extensions, the model of Jimeno and Bentolila remains relatively tractable. In this model, the persistence of unemployment depends on how current unemployment reacts to the current size of the labour force (positively), and how in turn the size of the current labour force depends on past unemployment (negatively). There are differences in persistence between the national and regional level, however. A key result is that regional unemployment persistence depends on how much regional wages are connected to the national level (the tighter the connection, the higher the persistence), especially in a context where the responsiveness of participation and migration decisions to local conditions is limited.

2.3. Differences between groups of workers

Mauro and Spilimbergo (1999) take a very simple approach to introducing worker heterogeneity and estimate a Blanchard-Katz type of model for regional labour market adjustment but separately for low and high skilled labour. High skilled labour is found to be much more mobile. Regional unemployment differences and unemployment hysteresis (both on the regional and national level) are found to be higher for low skilled labour. Similarly, Ammermueller, Lucifora and Origo estimate a wage curve not only per occupation, but also per region.

2.4. Discouragement/exclusion

Although, the effect of shocks to labour demand may last long, the above framework excludes permanent effects of shocks on unemployment or wages. It is not un-thinkable, however, increases in unemployment may alter the long-run equilibrium unemployment. One mechanism could be that the unemployed quickly lose human capital while unemployed, and effectively become excluded from the labour market. Alternatively, in a matching framework, the unemployed might become discouraged and give up searching altogether.

Such an exclusion effect can be approximated in the framework, by including not only the level, but also the differences of the unemployment rate in the wage curve, as a proxy for the number of short run unemployed.

2.5. Nominal & real rigidities

Note that we explicitly refrain from writing the wage equation (2) as full-fledged Philips curve. Quite elaborate wage setting schemes have been considered by Cahuc and Zylberberg (2004), in order to include temporary effects of unanticipated surprises in prices and productivity.

2.6. The role of capital accumulation

Elements which seem to be missing in the above framework are productivity, and a role for other production factors (capital,...). Sluggish wage adjustment in presence of a negative shock to productivity, leads to periods where the return to capital is below the equilibrium, and capital accumulation therefore would be lagging. These elements are somewhat implicit in the model, however, in the sense that a limited response of wages to an increase in unemployment gives little incentive for capital/firms to flow into the region. Substituting capital mobility for capital accumulation gives the same result.

2.7. Causes of unemployment (differences) beyond shocks and persistent effects

The studies on regional labour market dynamics mentioned above focus on the dynamics rather than the level of unemployment and other labour market variables. As the focus of RHOMOLO is on comparison of the evolution of variables following some induced shock, as compared to a base run, one might argue that similarly, the focus in RHOMOLO should be on modelling these dynamics (as discussed in the previous section) and less on modelling the regional levels of unemployment rates, and –for example- the causes of the permanent (rather than persistent) regional differences in European regional labour market outcomes. Obviously the difference between permanent and persistent might be thin.

Many causes of persistent regional differences in labour market outcomes have been suggested in the literature, which go well beyond explaining them as the result of hysteresis in labour market adjustment and an accumulation of adverse shocks in less well-off regions. Good overviews on the topic are given by Blanchard and Katz (1997), Blanchard (2005) and Elhorst (2003). Blanchard and Wolfers (2000) attempt empirically to determine which institutional setups are at the root of permanently high unemployment rates.

What is difficult about the origins of unemployment, and long-term (structural) differences between regions, is that the possible causes are many. Mismatch (skill, spatial,...), wage-push factors (union activity, efficiency wages, tax wedges (labour taxes and social security contributions), the structure of the unemployment benefit system (eligibility, time-structure), labour legislation (employment protection legislation, maternity leave,...), active labour market policies. There is some consensus on which mechanisms are likely to be important:

In addition, dualism in the labour market has been blamed for the strikingly different labour market performance of Spain and Portugal (Bover, García-Perea and Portugal, 2000).

3. The general structure and labour markets in RHOMOLO

3.1. The setup of the model

RHOMOLO is a holistic regional model developed especially for ex-ante impact assessment of European Cohesion Policy (ECP). In order to assess spatially, sectorally and temporally specific impacts of policies, among others, the model incorporates the following features:

- Endogenous location and links between regions within a New Economic geography framework;
- Inter-temporal investment decision a la endogenous growth theory;
- Vertically linked imperfectly competitive industries with endogenous prices and quantities solved in the framework of computable general equilibrium.

RHOMOLO is constructed in a framework of a spatial computable general equilibrium, which takes as a basis the notion of the Walrasian equilibrium. The global economy consists of R regions in the EU and one aggregate region capturing the rest of the world, and is disaggregated into I sectors. RHOMOLO v.2 is based on data at NUTS2 level, covering 267 regions of the EU,³ and follows the NACE classification of 6 sectors of economic activities. Both dimensions can be expanded to any level of geographical and sectoral level of disaggregation, for which sufficient socio-economic data are available.⁴

Each region is endowed with F types of production factors. RHOMOLO v.2 distinguishes between labour, capital and land, $f \in \{LS_{er}, KS_r, LDS_r\}$. Labour supply, LS_{er} , is further disaggregated according to education level of workers, e : low, medium and high-skill. The regional supply of labour, LS_{er} , with education e in region r is determined by labour endowment in the previous period plus population growth and net migration flow (workers are mobile both between regions and between sectors). Sector-specific capital stock, K_{ir} , evolve according to the last period's capital stock minus depreciation plus new investments into capital. The regional endowment of land, LDS_r , is exogenous.

There are three types of economic agents in the model: households, h , governments, g , and firms (industries), i . Households, which are further disaggregated according to their income level, receive

³ Generally, the model can be implemented at any level of spatial and sectoral disaggregation, subject to data availability.

⁴ Throughout the paper we use subscript o to denote the origin region and subscript d to denote the destination region for trade

income from the employed factor ownership and government transfers, including unemployment benefits. Most of the income is spent on consumption of goods and services, the rest is saved. The 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 transfers through subsidies, and save part of their income.

Each region hosts two types of firms (which are representative for the respective sectors): 'traditional' type and 'modern' type. The traditional sectors are perfectly competitive and produce a homogenous good under constant returns to scale. Monopolistically competitive sectors exhibit increasing returns to scale and have mobile firms across regions, which produce horizontally differentiated goods. In each modern sector we assume the Chamberlinean monopolistic competition with free entry and exit of firms. Hence, output prices are equal to marginal costs plus mark-up, which depends on the elasticity of substitution between varieties of differentiated goods. Both types of goods - traditional and modern - are traded between all regions subject to positive trade costs.

All production activities in the model are associated with emissions and environmental damage. The model incorporates the representation of all major greenhouse gas and non-greenhouse gas emissions. Changes in the levels of emissions have a direct impact on the welfare of households.

RHOMOLO is solved in a recursively dynamic framework. Because of the detailed regional and sectoral dimensions of RHOMOLO, computationally, it would be impossible to implement full dynamics, as it would exponentially 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 models that are linked between periods by an exogenous and endogenous variable updating procedure, 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. It is possible to add updating mechanisms for other variables, such as public expenditure, transfers, technological change or debt accumulation. 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 past states of the economy, but not the result of inter-temporal optimisation of economic agents.

flows, migration, capital and income flows.

3.2. Households' behaviour

In each period household h solves a static one-period optimisation problem by maximising the Stone-Geary utility function (1) subject to budget constraint (2):

$$\Omega_{hr} = A_{hr} \prod_i C_{hir} - \mu H_{hir}^{\alpha H_{hir}} \quad (1)$$

$$B_{hr} = Y_{hr} - 1 - ty_r + T_{ghr} + c_{hr} \sum_e \xi_{er} wu_{er} U_{er} - C_{hr} - SH_{hr} \quad (2)$$

where $C_i > \mu H_i > 0$ is the demand for good i , μH_{hir} is the subsistence consumption level, and c_{hr} is the initial consumption share. Parameters sc_{ir} and tc_{ir} capture subsidies and taxes for product i , ξ_{er} is the replacement rate of unemployment for workers with education e in region r , and A_{hr} is a scaling parameter. According to budget constraint (2), the total budget, B_{hr} , of household h in region r consists of income, Y_{hr} , social transfers, T_{ghr} , from government g , and unemployment benefits, $wu_{er} U_{er}$, which is allocated between the consumption of goods of services, C_{hr} , income tax, ty_r , and savings, SH_{hr} .

Solving the consumer optimisation problem yields a Linear Expenditure demand System (LES):

$$P_{ir} - 1 - sc_{ir} + tc_{ir} C_{hir} = \alpha H_{hir} \left(B_{hr} - \sum_i \mu H_{hir} P_{ir} - 1 - sc_{ir} + tc_{ir} \right) + P_{ir} - 1 - sc_{ir} + tc_{ir} \mu H_{hir} \quad (3)$$

where P_{ir} is the consumer price for good i in region r .

The income of household h in region r stems from supplying labour, L_{ehir} , with education e to industry i at wage w_{eir} , and from renting capital, K_{hir} , and land, LD_{hr} , to firms:

$$Y_{hr} = \sum_{ei} w_{eir} L_{ehir} + \sum_i RK_{ir} K_{hir} + PLD_r LD_{hr} \quad (4)$$

where RK_{ir} and PLD_r are rental rates of capital and land in sector i region r , respectively.

Household h in region r saves a fixed share, SH_{hr} , of her budget:

$$SH_{hr} = mps_{hr} \left(Y_{hr} - 1 - ty_r + T_{ghr} + c_{hr} \sum_e \xi_{er} wu_{er} U_{er} \right) \quad (5)$$

where mps_{hr} is the marginal propensity to save.

3.3. Firms' behaviour

The input demand and output supply of firms is modelled via nested CES-Leontief production functions. At the top level, depending on output, XD_{ir} , firms determine the use of intermediate inputs, IO_{jir} , and the composite capital-labour-land-energy input, $LDKLE_{ir}$, according to the Leontief production technology:

$$IO_{jir} = io_{jir} XD_{ir} \quad (6)$$

$$LDKLE_{ir} = io_{yir} XD_{ir} \quad (7)$$

where io_{jir} and io_{yir} are input-output coefficients for intermediate inputs and value added, respectively. The associated price index for the composite capital-labour-land-energy input, $PLDKLE_{ir}$, is calculated according to the CES price index:

$$PLDKLE_{ir} = \frac{1}{\alpha LDKLE_{ir}} \gamma LD_{ir}^{\sigma LDKLE_{ir}} PLD_r^{1-\sigma LDKLE_{ir}} + \gamma KLE_{ir}^{\sigma LDKLE_{ir}} PKLE_{ir}^{1-\sigma LDKLE_{ir}} \frac{1}{1-\sigma LDKLE_{ir}} \quad (8)$$

where PLD_r is the price of land, $PKLE_{ir}$ is the price of capital-labour-energy bundle, σ is the elasticity of substitution, a are scale parameters in each nest, and γ are factor share parameters.⁵

In the subsequent stages, the demand for capital, labour, land and energy inputs is determined through profit maximisation according to a nested CES production function subject to firm output, XD_{ir} , (see Figure 1):

$$XD_{ir} = TFP_{ir} \left(\sum_f a_{fir}^{\frac{1}{\sigma}} F_{fir}^{\frac{\sigma-1}{\sigma}} \right)^{\frac{\sigma}{\sigma-1}} \quad (9)$$

where TFP_{ir} is the total factor productivity.

Second, firms decide on dividing the composite primary factor demand, $LDKLE_{ir}$, between the composite

⁵Note that in the model parameters are sector, region, and factor specific, respectively. Here, however, the subscripts of parameters are suppressed for the sake of transparency.

capital-labour-energy input, KLE_{ir} and land, LD_{ir} . The demand for primary factors KLE_{ir} and LD_{ir} is obtained by taking partial derivatives according to Shephard's lemma:

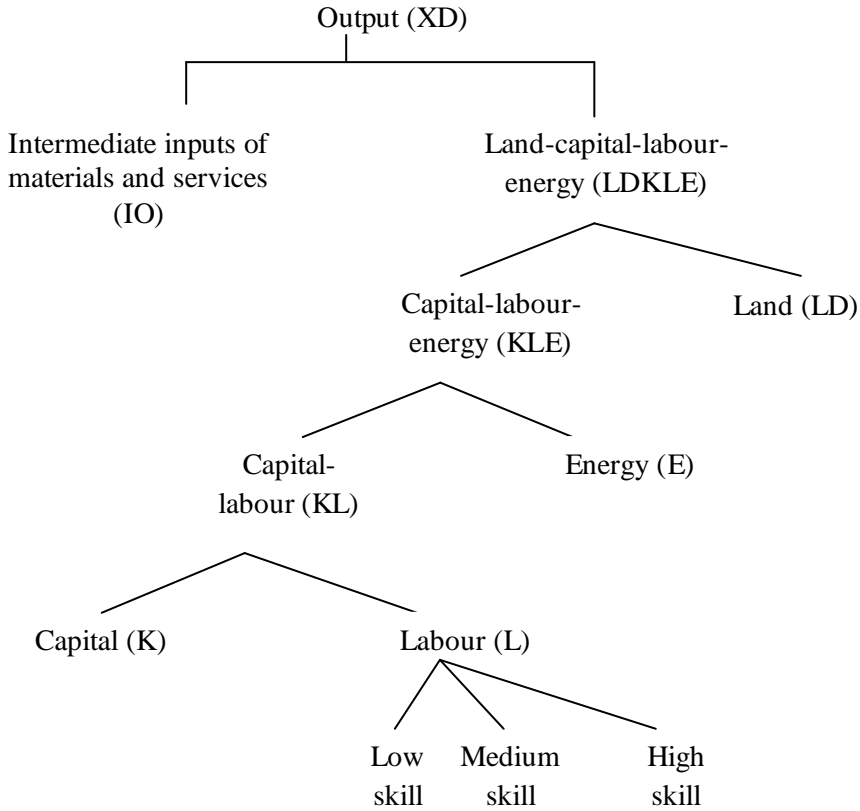
$$KLE_{ir} = LDKLE_{ir} \left(\frac{\gamma KLE_{ir}}{PKLE_{ir}} \right)^{\sigma LDKLE_{ir}} PLDKLE_{ir}^{\sigma LDKLE_{ir}} a LDKLE_{ir}^{\sigma LDKLE_{ir} - 1} \quad (10)$$

$$LD_{ir} = LDKLE_{ir} \left(\frac{\gamma LD_{ir}}{PLD_r} \right)^{\sigma LDKLE_{ir}} PLDKLE_{ir}^{\sigma LDKLE_{ir}} a LDKLE_{ir}^{\sigma LDKLE_{ir} - 1} \quad (11)$$

The associated price index for the composite capital-labour-energy input, $PKLE_{ir}$, is determined by prices for the composite capital-labour input, PKL_{ir} , and energy, PE_{ir} :

$$PKLE_{ir} = \frac{1}{\alpha KLE_{ir}} \gamma KE_{ir}^{\sigma KLE_{ir}} PKL_{ir}^{1 - \sigma KLE_{ir}} + \gamma E_{ir}^{\sigma KLE_{ir}} PE_{ir}^{1 - \sigma KLE_{ir}} \frac{1}{1 - \sigma KLE_{ir}} \quad (12)$$

Figure 1. Production technology of firms in RHOMOLO



At the third level, firms decide on the division of the composite capital-labour-energy input demand, KLE_{ir} , between capital-labour demand, KL_{ir} , and energy demand, E_{ir} . As above, it is derived by applying Shephard's lemma:

$$KL_{ir} = KLE_{ir} \left(\frac{\gamma KL_{ir}}{PKL_{ir}} \right)^{\sigma KLE_{ir}} PKLE_{ir}^{\sigma} a KLE_{ir}^{\sigma KLE_{ir} - 1} \quad (13)$$

$$E_{ir} = KLE_{ir} \left(\frac{\gamma E_{ir}}{PE_{ir}} \right)^{\sigma KLE_{ir}} PKLE_{ir}^{\sigma KLE_{ir}} a KLE_{ir}^{\sigma KLE_{ir} - 1} \quad (14)$$

The associated price index for the composite capital-labour input, PKL_{ir} , is:

$$PKL_{ir} = \frac{1}{\alpha KLE_{ir}} \gamma K_{ir}^{\sigma KLE_{ir}} (1 + tk_{ir} RK_{ir} + \delta_{ir} PI_r)^{1 - \sigma KLE_{ir}} + \gamma LT_{ir}^{\sigma KLE_{ir}} PLT_{ir}^{1 - \sigma KLE_{ir}} \frac{1}{1 - \sigma KLE_{ir}} \quad (15)$$

where RK_{ir} is the return to capital, PI_r is the average price of physical investment good, tk_{ir} is the capital tax, and δ_{ir} is the sector and regional specific depreciation rate. Price index (15) represents the marginal costs of producing an additional unit of output. In addition to variable inputs, monopolistically competitive firms face also fixed costs of production (labour and capital), which correspond to firm entry costs. The output of monopolistically competitive firms is priced according to the average costs pricing rule, covering both marginal and fixed costs of production.

At the fourth level, the composite capital-labour input demand is split between the demand for capital, K_{ir} and the demand for the composite labour input, LT_{ir} . As above, in accordance with Shephard's lemma, the demand for primary factors K_{ir} and LT_{ir} is obtained by taking partial derivatives:

$$K_{ir} = \left(KL_{ir} \left(\frac{\gamma K_{ir}}{1 + tk_{ir} RK_{ir} + \delta_{ir} PI_r} \right)^{\sigma KLE_{ir}} PKL_{ir}^{\sigma KLE_{ir}} a KLE_{ir}^{\sigma KLE_{ir} - 1} \right) + N_{ir} KF_{ir} \quad (16)$$

The total input of physical capital consists of two types: variable capital input and fixed capital input. Whereas variable capital input is calculated according to Shephard's lemma, fixed capital input is the product of the number of operating firms, N_{ir} , and the fixed input requirement of capital per operating firm, KF_{ir} .

$$LT_{ir} = \left(KL_{ir} \left(\frac{\gamma L_{ir}}{PLT_{ir}} \right)^{\sigma KL_{ir}} PKL_{ir}^{\sigma KL_{ir}} aKL_{ir}^{\sigma KL_{ir}-1} \right) \quad (17)$$

The associated CES price index for the composite labour input, PLT_{ir} , is:

$$PLT_{ir} = \frac{1}{\alpha LT_{ir}} \left(\sum_e \gamma LT_{eir}^{\sigma LT_{ir}} PL_{eir}^{1+1+tle_{ir}} tli_{ir}^{1-\sigma LT_{ir}} \right)^{\frac{1}{1-\sigma LT_{ir}}} \quad (18)$$

where N_{ir} is the number of firms operating in sector i , tli_{ir} is the employers' social security contribution, and tle_{ir} is the employees' social security contribution.

At the fifth level, Shephard's lemma yields the demand for different types of labour, L_{eir} , by education level e :

$$L_{eir} = LT_{ir} \left(\frac{\gamma LT_{eir}}{PL_{eir}^{1+1+tle_{ir}} tli_{ir}} \right)^{\sigma LT_{ir}} PLT_{ir}^{\sigma LT_{ir}} aLT_{ir}^{\sigma LT_{ir}-1} + N_{ir} LF_{eir} \quad (19)$$

where LF_{eir} is fixed labour input.

In the same way as for physical capital, the total input of labour, L_{eir} , consists of two types: variable labour input and fixed labour input. Whereas variable labour input is calculated according to Shephard's lemma, the fixed labour input is equal to the product of the number of operating firms (varieties), N_{ir} , and fixed labour demand per operating firm, LF_{eir} .

3.4. Trade

The 'love of variety' preferences of consumers (Dixit and Stiglitz, 1977) imply that there is demand for each variety of each differentiated good in every region. Good i produced in origin region o is bought in destination region d according to the Constant Elasticity of Transformation (CET) production possibility frontier:⁶

⁶Note that variables in small letters denote the share of the respective variable in capital letters. For example, $xdde_{irs}$ denotes the share of $XDDE_{irs}$.

$$XDDE_{iod} = X_{id} \left(\frac{\gamma_{3id} P_{id}}{PDDT_{id}} \right)^{\sigma_{Aid}} aA_{id}^{\sigma_{Aid}-1} \left(\frac{\gamma_{4iod} PDDT_{id}}{PDC_{io} + PTM_c trmV_{iod}} \right)^{\sigma_{Aid}} aA_{id}^{\sigma_{Aid}-1} \quad (20)$$

According to equation (20), inter-regional trade, $XDDE_{iod}$, as a share of total sales in the destination region, X_{id} , is determined by domestic sales prices, P_{id} , of commodity i in destination region d , producer price, PDC_{io} , in exporting region o , composite consumer price, $PDDT_{id}$, for good i sold in importing region d , price for trade and transport services, PTM_c , in country c , transport costs, $trmV_{iod}$, and the parameters of the model.

The associated CES price index, $PDDT_{io}$, for domestic good i produced in region o is:

$$PDDT_{io} = \frac{1}{aA_{io}} \sum \gamma_{4ido}^{\sigma_{Aid}} PDC_{id} + PTM_c trmV_{ido}^{1-\sigma_{Aid}} \frac{1}{1-\sigma_{Aid}} \quad (21)$$

Part of goods consumed in region r stem from EU regions o , the rest is imported from the rest of the world. The domestic demand of good i from the rest of the world, $MROW_{ir}$, is derived from the CES production function:

$$MROW_{ir} = X_{ir} \left(\frac{\gamma_{A2ir}}{PWMROW_i^* ER_c} \right)^{\sigma_{Air}} P_{ir}^{\sigma_{Air}} aA_{Air}^{\sigma_{Air}-1} \quad (22)$$

where $PWMROW_i$ is import price for goods from the rest of the world, and γ_{Air}^{σ} are CES share parameters in the Armington function for imports. The associated price, P_{ir} , is a composite index of weighted prices for locally produced goods, $PDDT_{io}$, and imports from the rest of the world, $PWMROW_i^*$:

$$aA_{ir} P_{ir}^{1-\sigma_{A_r}} = \gamma_{A3ir}^{\sigma_{A_r}} PDDT_{ir}^{1-\sigma_{A_r}} + \gamma_{A2ir}^{\sigma_{A_r}} PWMROW_i^* ER_c^{1-\sigma_{A_r}} \quad (23)$$

Analogously, the supply of exports to the rest of the world, $EROW_{ir}$, is derived from the CET production possibility frontier:

$$EROW_{ir} = XD_{ir} \left(\frac{\gamma_{T2ir}}{PDC_{ir}} \right)^{\sigma_{Tir}} PD_{ir}^{\sigma_{Tir}} aT_{ir}^{\sigma_{Tir}-1} \quad (24)$$

where γ_{Tir} are CET share parameters for exports, and aT_{ir} is scaling parameter.

3.5. Factor markets

Labour supply, LS_{er} , with education e in region r is determined by the stock of human capital, LSH_{er} , and net labour migration $LMIG_{er}$:

$$LS_{er} = LSH_{er} + LMIG_{er} \quad (25)$$

The equilibrium supply of workers, LS_{er} , equals to the total labour demand from all industries, L_{eir} , and unemployment, U_{er} . This equilibrium condition determines the level of wage, PL_{er} , for workers with education e in region r :

$$LS_{er} = \sum_i L_{eir} + U_{er} \quad (26)$$

The total unemployment, U_{er} , for workers with education e in region r is a fixed proportion, u_{er} , of the total labour supply, LS_{er} :

$$U_{er} = LS_{er} u_{er} \quad (27)$$

The level of regional unemployment is determined by the wage curve, which relates the unemployment rate, u_{er} , to the level of real wages, PL_{er}^{real} , for workers with education e in region r :

$$\log PL_{er}^{real} = \chi_1 \log u_{er} + \chi_2 \quad (28)$$

where χ_1 and χ_2 are econometrically estimated parameters.

The net migration rate, $LMIG_{er}^{rate}$, in region r for education level e is a function of its relative wages, RW_{er} , and its relative wage squared, where the relative wage is calculated by dividing wage rate in region r by the average wage the country c , $r \in c$:

$$LMIG_{er}^{rate} = \chi_3 + \chi_4 RW_{er} + \chi_5 RW_{er}^2 \quad (29)$$

where $\chi_3 - \chi_5$ are econometrically estimated parameters.

The total demand for land, LD_{ir} , is equal to land supply, LDS_r^* , which is fixed in region r :

$$\sum_i LD_{ir} = LDS_r^* \quad (30)$$

3.6. Government⁷

There are two types government in the model: national and regional. Both governments receive income from taxes, consume goods and services, make transfers through subsidies, and save part of their income.

Government utility is modelled via Cobb-Douglas preferences, implying that the expenditure share for good i is fixed. Country c 's government demand, CG_{ir} , for good i in region $r \in c$ is equal to:

$$CG_{ir} \frac{P_{ir}}{aG_{ir}} = TAXR_c + \sum_{\substack{r \in reg \\ i \in pub}} trf_r K_{ir} RK_{ir} + KYN_{ir}^* DEF_c + \sum_{r \in reg} TRFRG_r DEF_c - \sum_{r \in reg} TRFNG_r DEF_c - SUBS_c - \sum_{hr \in reg} \left(TRF_{hr} DEF_c + c_{hr} \sum_e \xi_{er} wu_{er} U_{er} \right) - SG_c DEF_c + TRREU_c ER_c \quad (31)$$

Region r 's government demand, CGR_{ir} , for good i is equal to:

$$CGR_{ir} \frac{P_{ir}}{aGR_{ir}} = TAXRR_r + 1 - trf_r \sum_{i \in pub} K_{ir} RK_{ir} + KYN_{ir}^* DEF_c - TRFRG_r DEF_c + TRFNG_r DEF_c - SUBS_r - \sum_h TRFR_{hr} DEF_c - SGR_r DEF_c + TRREU_r ER_c \quad (32)$$

Tax revenue, $TAXR_c$, of country c 's government is sum of all taxes at national level:

$$TAXR_c = \sum_i tc_{gir} + vatac_{gir} + exst_{gir} P_{ir} \left(\sum_h C_{hir} + I_{ir} + CG_{ir} + CGR_{ir} \right) + txd_{gir} XD_{ir} TFP_{ir} PD_{ir} + ty_{gr} \sum_h Y_{hr} + \sum_i \left(\sum_e PL_{eir} L_{eir} \right) tle_{gir} + tli_{gir} 1 + tle_{ir} + tk_{gir} K_{ir} RK_{ir} \quad (33)$$

with $r \in c$. Tax revenue, $TAXRR_r$, of region r 's government is sum of all taxes at regional level:

$$TAXRR_r = \sum_i tc_{gir} + vatac_{gir} + exst_{gir} P_{ir} \left(\sum_h C_{hir} + I_{ir} + CG_{ir} + CGR_{ir} \right) + txd_{gir} XD_{ir} TFP_{ir} PD_{ir} + ty_{gr} \sum_h Y_{hr} + \sum_i \left(\sum_e PL_{eir} L_{eir} \right) tle_{gir} + tli_{gir} 1 + tle_{ir} + tk_{gir} K_{ir} RK_{ir} \quad (34)$$

Subsidies, $SUBS_c$, from country c 's government are equal to:

⁷ This feature is currently under development and will be fully implemented in RHOMOLO v.3.

$$SUBS_c = \sum_i sc_{gir} P_{ir} \left(\sum_h C_{hir} + I_{ir} + CG_{ir} + CGR_{ir} \right) + \sum_i sp_{gir} XD_{ir} TFP_{ir} PD_{ir} \quad (35)$$

with $r \in c$. Subsidies, $SUBSR_r$, from region r 's government are equal to:

$$SUBSR_r = \sum_i sc_{gir} P_{ir} \left(\sum_h C_{hir} + I_{ir} + CG_{ir} + CGR_{ir} \right) + \sum_i sp_{gir} XD_{ir} TFP_{ir} PD_{ir} \quad (36)$$

3.7. Equilibrium conditions

The supply of good i in region r equals the sum of household demand, C_{hir} , national and regional government demand, CG_{ir} and CGR_{ir} , investment demand, I_{ir} , changes in the stocks, SV_{ir} , production of transport and trade margin, TMX_{ir} , and intermediate demand $io_{jir} XD_{ir}$ for good i in region r :

$$X_{ir} = \sum_h C_{hir} + CG_{ir} + CGR_{ir} + I_{ir} + SV_{ir} + TMX_{ir} + \sum_j io_{jir} XD_{ir} \quad (37)$$

Changes in stocks, SV_{ir} , is fixed part, svs_{ir} , of output, X_{ir} :

$$SV_{ir} = svs_{ir} X_{ir} \quad (38)$$

The profit of firms operating in monopolistically competitive sectors is equal to fixed costs:

$$\Pi_{ir} = N_{ir} \left(\sum_e LF_{eir} + KF_{ir} \right) CPI_r \quad (39)$$

The long-run equilibrium requires that the number of firms in the modern sectors is no longer changing in response to short-run profits, which implies zero profits in the long-run:

$$N_{ir} \sigma_{ir} \sum_e LF_{eir} + fcK_{ir} CPI_r = PD_{ir} XD_{ir} TFP_{ir} \quad (40)$$

Zero profit condition (39) determines the number of firms, which operate in monopolistically competitive sector i in region r . In perfectly competitive (traditional) industries the fixed cost is zero and the number of firms is equal to one.

The domestic producer prices of commodities, PD_{ir} :

$$\begin{aligned}
PD_{ir} - 1 - txd_{ir} + sp_{ir} \quad XD_{ir} TFP_{ir} = K_{ir} \quad 1 + tk_{ir} \quad RK_{ir} + \delta_{ir} PI_r + \sum_j io_{jir} XD_{ir} P_{jr} + E_{ir} PE_r + PLD_r LD_{ir} \\
+ KYN_{ir}^* DEF_c + \sum_e PL_{eir} L_{eir} \quad 1 + 1 + tle_{ir} \quad tli_{ir}
\end{aligned} \tag{41}$$

where KYN_{ir} is negative operative surplus, txd_{ir} is the tax rate on production, and sp_{ir} is the subsidy rate on production.

The consumer price for good i in region r depends on domestic producer prices of commodities, PD_{ir} , the number of available varieties, N_{ir} , and the elasticity of substitution between varieties, σR_{ir} :

$$PDC_{ir} = PD_{ir} N_{ir}^{\frac{1}{1-\sigma R_{ir}}} \tag{42}$$

The gross output of sector i in region o equals the inter-regional sales in the EU and exports to the rest of the world:

$$XD_{io} PD_{io} TFP_{io} = \sum_d XDDE_{iod} PDC_{io} + EROW_{io} PDC_{io} \tag{43}$$

The supply of good i for production of transport and trade margin, TMX_{io} , in region o equals the transport sector's demand for good i in region o :

$$TMX_{io} = atm_{io} \sum_{i,o} trm_{iod} XDDE_{iod} \tag{44}$$

where atm_{io} is the share of commodity i used for production of transport and trade margin in region o .

The associated price for the composite transport and trade margin, PTM_c , in country c is a weighted average of trade margins in region r sector i :

$$PTM_c = \sum_{io} atm_{io} P_{io} \tag{45}$$

The price for capital, PK_{ir} , is the ratio of region-level return, RK_{ir} , relative to the nominal interest rate, RGD_c , in country c :

$$PK_{ir} = RK_{ir} / RGD_c \tag{46}$$

The real gross regional product, GDP_r , in region r is equal to the gross output minus intermediate inputs plus commodity taxes:

$$GDPR_r = \sum_i XD_{ir} TFP_{ir} PD_{ir}^* - \sum_{ij} iO_{jir} XD_{ir} P_{jr}^* - \sum_i E_{ir} P_{jr}^* + \sum_i t_{ir} - 1 P_{ir}^* \left(\sum_h C_{hir} + I_{ir} + CG_{ir} + CGR_{ir} \right) \quad (47)$$

3.8. Dynamics⁸

RHOMOLO is a recursively dynamic model, driven by the accumulation of physical capital, knowledge capital and human capital. The first equilibrium in the sequence is represented by the base year of the SAM. In every following period, which corresponds to a certain year in the future, the stocks of physical capital, human capital and knowledge capital are updated according to the respective accumulation laws (laws of motion). In each period RHOMOLO is solved for a general equilibrium (all markets clear), given the exogenous macroeconomic conditions, the constant ‘steady state’ growth rate and depreciation in every period.

The stock of capital, K_{irt+1} , available in period $t+1$ is equal to capital in period t plus investment minus depreciation:

$$K_{irt+1} = 1 - \delta_{ir} K_{irt} + I_{irt} \quad (48)$$

where K_{irt} denotes the capital demand in sector i , region r , and period t (see equation 16), and I_{irt} is investment by destination sector. Parameter δ denotes the depreciation rate. The law of motion for the accumulation of sectoral capital stock (52) implicitly assumes that the stocks are measured at the beginning of every period, whereas the flows are measured at the end of the period.

The total investment in new physical capital is fixed each year. However, the allocation of investment between sectors is endogenous. The inter-sectoral allocation of investment is modelled through an investment demand function, according to which investment demand, I_{ir} , for good i in region r in period t is given by:

$$I_{ir} = Igrav_{ir} IT_c K_{ir} TFP_{ir} e^{ROR_{irt-1}} / \sum_{j,s \in regc_r} K_{js} TFP_{js} e^{ROR_{jst-1}} \quad (49)$$

where $Igrav_{ir}$ is scaling parameter in the investment gravity equation, IT_c denotes the total private investment, K_{ir} denotes the capital stock, TFP_{ir} denotes the total factor productivity, and ROR_{irt} is the rate

⁸ This feature is currently under development and will be fully implemented in RHOMOLO v.3.

of return to capital. Scaling parameter, $I_{grav_{ir}}$, ensures that investment demand, I_{ir} , for good i in region r sums up to the total investment, IT_c , in country c .

The composition of capital goods in the composite investment demand is determined by utility maximisation of an 'investment bank', which is a virtual economic agent in charge of buying physical capital investment goods for all sectors and regions.⁹ The demand for investment good i in region r is share αI_{ir} in the total private investment, IT_c , in country c :

$$t_{ir} I_{ir} P_{ir} = \alpha I_{ir} IT_c \quad (50)$$

where $t_{ir} = 1 - sc_{ir} + tc_{ir} + vatc_{ir} + exst_{ir}$ is the composite tax variable.

The total investment, IT_c , equals savings net of changes in the stocks:

$$IT_c = S_c + SROW_c ER_c - \sum_{ir} SV_{ir} P_{ir} \quad (51)$$

where S_c are domestic savings, $SROW_c$ are savings from/to the rest of the world, and $\sum_{ir} SV_{ir} P_{ir}$ are changes in the stocks.

The total savings, S_c , in country c is sum of savings made by households, SH_{hr} , firms (capital depreciation), $\sum_{ir} \delta_{ir} K_{ir} PI_r$, the national and regional governments, SG_c and $\sum_r SG_r$, respectively:

$$S_c = \sum_{hr} SH_{hr} + \sum_{ir} \delta_{ir} K_{ir} PI_r + SG_c + \sum_r SG_r \quad (52)$$

The total savings accumulated in each period are invested into sector-specific physical capital accumulation.

The price for the composite investment good i in region r is derived from the Cobb-Douglas investment production function:

$$PI_r = \prod_{i,r \in reg} \left(t_{ir} \frac{P_{ir}}{\alpha I_{ir}} \right)^{\alpha I_{ir}} \quad (53)$$

⁹Hence, the interregional capital flows do not flow directly between sectors, but through a national investment pool. Instead, the savings are distributed between the regions and sectors according to industry/region-specific demand equation for investment.

The rate of return, ROR_{irt-1} , for investment good i in region r in period $t-1$ is equal to:

$$ROR_{irt-1} = PK_{irt} - 1 + gr^* PK_{irt} + \delta_{irt} \quad (54)$$

Human capital is defined as the amount of efficient labour units available in a region at the end of the previous period. In line with homogeneity of the model, human capital stock is modelled in real (not monetary) units, and is a function of the amount of education investment of by households and government in physical units. Its empirical proxy is the average years of schooling of workforce for each ISCED educational attainment level.

For each educational level, e , of workers (low skill, medium skill, and high skill) the accumulation law represents technology for producing human capital. According to this technology, part of human capital depreciates in each period of time. This represents the retirement rate and depends on demographic situation in the region. The new stock of human capital, LSH_{ert+1} , of workers with education e in region r at time $t+1$ is produced using the previous human capital, LSH_{ert} , private and public investments into education, C_{hirt} , CG_{irt} and CGR_{irt} , respectively, and the share of labour endowment (time) spent on education, δH_{er} :

$$LSH_{ert+1} = AH_{ert} LSH_{ert}^{1-\delta H_{er}} \left(\sum_{hi \in edu} eh_{ceht} C_{hirt} + LSH_{ert} / \sum_e LSH_{ert} \sum_{i \in edu} CG_{irt} + CGR_{irt} \right)^{\delta H_{er}} \quad (55)$$

Consumer demand for education is given in equation (3), whereas regional and national government demand for education was derived in equations (31) and (32).

The accumulation of knowledge capital is modelled via a TFP growth equation, where TFP growth, ΔTFP_{ir} , in sector i , region r is a function of an exogenous component, α_0 , and regions r 's R&D intensity, RD_r :

$$\Delta TFP_{ir} = \alpha_0 + \alpha_1 RD_r \quad (56)$$

where RD_r is captured by R&D expenditures normalised by the gross value added, and α_0 and α_1 are econometrically estimated parameters.

4. Extending the modelling of regional labour markets in RHOMOLO

4.1. Labour demand

In most settings described in section 2, firms are free to choose the amount of labour at a given wage. Consistent with the concept of "labour demand curve", the demand for labour at given wages in RHOMOLO is described in section 3.3.¹⁰

First, consider the assumptions on capital rents, investment, and capital mobility, and their implications for the long run labour demand function. Even with "immobile firms", if investment is targeted at regions with higher capital rents, de-facto capital is mobile in RHOMOLO. If capital mobility acts to equalise rents and wages in the long run, we would have a flat long-run labour demand curve at the regional level in the above models. A complication in RHOMOLO is the fact that – in a context with increasing returns to scale and transport costs – migrants increase the local market size and the demand for local products. The combination of mobile labour and capital then might imply that there is no stable long-run labour demand schedule. The model as such already contains a tendency toward a core-periphery structure which might also show in the behaviour of the labour markets (runaway wages and employment). In order to add an additional dispersion force and hence increase the stability of spatial equilibrium in RHOMOLO, one could consider part of labour force, e.g. low skill, as immobile (see Kancs 2011).

RHOMOLO distinguishes between three types of workers: high skill, medium skill, and low skill. In contrast, Boeters and Savard (2012) argue to limit the modelling of demand for different types of labour (e.g. low versus high skilled) by assuming perfect substitutability, after re-expressing (multiplicatively) labour of different types in common efficiency-equivalent units.

4.2. Labour supply

Labour supply is introduced into RHOMOLO taking a step-by-step approach. We start with assuming labour supply as fixed (determined by exogenous demographic factors), then changes in labour supply due to migration are introduced. In order to exclude circular causality type of regional agglomeration, and first verify that the behaviour of the labour market is reasonable without such effects, all income effects are excluded at this stage.

¹⁰ There are several alternative approaches how to model labour demand. Important examples are bargaining between unions and firms over both wages and employment. But the added value seems to be limited.

If a migration equation of the following through which the effective labour supply the proposed specification for labour migration which has a smooth (slowly decaying) response of migration as a function of regional wage differentials is good. In the limit, however, this specification would imply migration flattens out any regional wage difference in the long run, which seems to contradict the evidence and may make it impossible to make predictions on long run regional unemployment differentials. In order to avoid this, migration costs can be introduced.

Adding participation decisions is a further important improvement. It is indeed the focus of most CGE models which a focus on labour markets. It seems especially relevant given that (i) the empirical observation that participation is an important adjustment mechanism to regional shocks in the EU, more important than migration; (ii) the importance which is (rightfully) attached in the 2020 agenda to improving the employment rate. The unemployment rate hides the fact that many people chose not to participate in the labour market, whereas higher participation could greatly benefit the local economy, and general well-being. It would be very interesting to model participation decisions in RHOMOLO, consider whether policy changes can induce more people to enter the labour market, and how this affects welfare.

Modelling participation is quite a challenge, however. A fully fledged modelling would require estimating both the intensive margin (number of hours) and extensive margin (participate/not to participate). It requires a calibration using three types of labour supply elasticities: the elasticity of participation and working hours to wage, and the elasticity of working hours with respect to non-market income. These appear to be available from the existing literature, but it is highly unlikely to find these on the regional level.

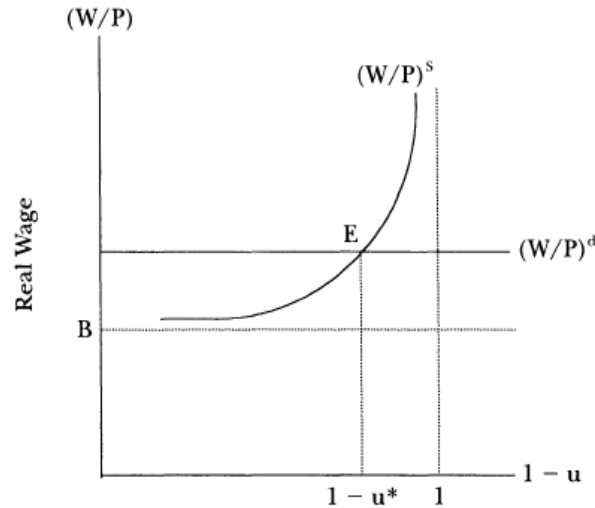
Participation decisions are likely to be very different for low versus high skilled labour, as the average wage and non-market income is likely to be very different. Unemployment further complicates these matters, requiring individuals to compare the utility of labour market participation, with the utility of employment and the utility of unemployment. A distribution of disutility of supplying labour must be assumed.

4.3. Wages

We start with building a model for wage formation. Several examples of possible specifications were given in the previous section. Complex expressions are often used in large macro models, where the wage equation could include, for example, measures of union bargaining power, risk aversion, the degree of competition on the goods market, influences from the tax-system. In standard macro models monetary variables also play an important role.

We start with a simple specification with an intercept. Taking n as the employment rate, wages can be expressed as:

$$w = w^* + t \frac{n}{1-n} x \quad (56)$$



Where w^* is the competitive wage level (which acts as the minimum level of wages), $n/(1-n)$ expresses the fact that labour market tightness leads to increasing wage pressure, t and x are parameters, which can have to be calibrated, in order to express regional and national labour market conditions.

Testing the behaviour of the model with this simple specification for a wage equation is a first but important step to introduce labour market imperfections into RHOMOLO. Only if we see that sensible results are produced given this simple ad-hoc specification, we should consider richer specifications. The choice of the final form of the wage equation to be used depends on the questions we want to ask the model. Combining the wage equation with the horizontal regional labour demand curve gives the long-run regional unemployment rate.

The specification of the wage equation can be further extended e.g. by including vacancies to obtain an estimate of labour market tightness, or productivity or unemployment benefits (bargaining or efficiency wage models, see for example Blanchard and Katz (1992)). This would bring the RHOMOLO model more in line with the matching-approach taken in QUEST. The lack of good data on vacancies on the regional level makes this very difficult to implement, however. More possible extensions are the inclusion of labour productivity.

5. Conclusions

This paper presents the modelling of migration and regional labour markets in the RHOMOLO model, which is built to support the EU policy design by undertaking holistic, micro-founded and disaggregated policy impact assessment. The RHOMOLO model is based on the theories of general equilibrium, endogenous growth and new economic geography and incorporates a multi-level government system. Employing the RHOMOLO model one can analyse how policy changes affect variables such as regional unemployment rates, participation rates, and regional non-market wage levels. Our focus is on modelling the dynamic regional response over time to shocks in labour demand, and less on fully explaining the origins or long-run levels of regional unemployment and participation.

Capturing and empirically verifying the dynamic responses to policy changes is one of the main challenges of general equilibrium modelling in comparison to macroeconometric modelling. This is a problem for models at national level, for which international trade data and national accounts data are usually available and are reasonably consistent. It is even more troublesome for regional general equilibrium models. The finer the granularity, the more account needs to be taken of the movement of goods, factors such as labour, and factor income across regional borders, on which regional data are often missing or incomplete. This makes empirical verification piecemeal and less powerful. Regional data generated in line with the theory underlying the model do not necessarily coincide with the true structure of regional economies.

This paper presents the newly developed dynamic spatial general equilibrium model – RHOMOLO, the structure of which attempts to address data limitations in a consistent framework. Despite the achieved advances in dealing with issues of data paucity, this paper takes the view that, whereas new economic geography models are the most appropriate tool for dealing with the interactions between markets that are geographically and sectorally segmented, they should be built to complement rather than replace existing dynamic macroeconometric models.

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