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Simulating the Interplay Between Regional Demographic and Economic Change in Two Scenarios

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Abstract

This paper describes the structure and a number of results of a regional demo-economic model that was developed for NUTS 2 regions in Belgium, Germany and The Netherlands. In this paper, results of two demo-economic scenarios are presented for the three countries. The model, DECORES (Demographic ECOnomic REgional Simulation) consists of five modules: population, labour market (labour supply and labour demand), economy, commuting and land use. The population and labour supply modules are based on existing models. A number of scenarios are developed. We present here a series of results of two scenarios: low and high economic growth. The main result at the national level is the finding that tensions on the labour market will rise in the short term under high economic growth because labour supply is only moderate or even zero, whereas demand will increase substantially. At the regional level large growth differentials may be observed between core, ring and peripheral regions. These developments are to a large extent the result of the effects of congestion, concentration and dispersion.

Keywords: simulation model, internal migration, regional aspect, demographic change, economic change, scenarios

1. Introduction

Whereas the world population is still growing fast, in Europe a different phase has started in which population growth is very small or even negative (Van der Gaag et al., 1999). At present the world population grows at an annual rate of 1.5 per cent whereas the growth rate of the European population is almost zero. According to latest population scenarios of the European Commission, the population of Italy and Germany will start to decrease before 2010. Following De Beer and Van Wissen (1999) population decline is very likely in many European countries and almost inevitable in central and eastern European countries in the first half of the 21st century.

When looking at the regional level, the demographic picture becomes more diversified. Even in most countries where an ongoing population growth is foreseen there are regions who will experience population decrease in the next decades. Before 2025 about 40 per cent of all NUTS 2 regions[1] will have started to decline in population size. In most growing regions migration is the most important growth component (Van Wissen et al., 1997; Van der Gaag et al., 1999). In general external migration is an important growth component for the large urban centres, whereas internal migration is important for the regions in the vicinity of these central regions.

Although at present unemployment is still a major issue in many countries in the European Union, this may change in the future due to demographic developments. In a number of countries unemployment is no longer an issue and labour shortages have already appeared, both as a result of economic growth and smaller growth of labour supply. These developments raise many questions, for instance: what are the economic consequences of a stagnating population? Will there be structural shortages on the labour market or will labour supply adjust through higher participation (of women, elderly) and/or immigration of labour. Will the economy adjust by changing to more capital intensive and less labour intensive modes of production, thereby substantially increasing the level of productivity? Or, will work be exported to other regions in the world with an abundance of labour supply, such as Asia or Africa?

The interaction between demography an economy is also important at the regional level, but the picture is even more complicated. Regional imbalances in the labour market can be solved much more easily through internal migration and interregional commuting than international imbalances. But at the same time these structural changes at the regional level may have far-reaching effects on the demographic and economic system of a country. The regional economic structure may change if some regions maintain a positive population growth rate, whereas others experience persistent population loss; or jobs may follow changing regional population and labour supply trends and relocate from declining to growth regions to find labour and a local market for its products. Increasing regional labour market imbalances will have profound effects on commuting patterns as well, and in turn on the demand for transport infrastructure, which in many countries is already having severe capacity problems. These developments add to the trends that are the result of the more or less autonomous residential preferences of the population, who tend to relocate in the less densely populated regions at a larger distance from the main working regions.

This phase of population stagnation and decline at the national and regional level is new, at least in times of peace and prosperity, and it is not sure what exactly the consequences are of these developments. This lack of knowledge about the consequences of regional demographic-economic interactions under a regime of population stagnation and decline motivated the present study. This study deals with two demographic-economic scenarios at the regional level using a regional demo-economic simulation model. The model system was developed for three countries in northwestern Europe: Belgium, Germany and The Netherlands at NUTS 2 level. By using two scenarios, which are based on economic growth scenarios, a number of feasible future demographic and regional economic developments are explored, in order to obtain more insight into a number of potential bottlenecks that may arise. These scenarios can be characterised as high and low economic growth and are discussed in section three.

The problem of modelling regional demo-economic interactions was tackled before (e.g. Gordon and Ledent, 1981; Murdock et al., 1984; Sanderson, 1980). Economic-demographic modelling is often pursued by economists. These models differ in a number of respects from the present model. First, the demographic submodel is usually not of great concern for economists and as a result the demographic outcomes of these models are often criticised by demographers (Murdock et al., 1984). In contrast, the starting point for this model is a set of existing population and labour supply scenarios. The present model is built around two existing detailed demographic modules. The first demographic module is based on the regional population scenarios that were commissioned by the European Commission and compiled in 1998 (Van der Gaag et al., 1999; for an evaluation see Rees et al., 1999). In the remainder of this paper these are referred to as EUROPOP scenarios. The second demographic element is the labour supply module that is based on a series of labour force scenarios for European countries. These were compiled for the Directorate General V of the European Commission and completed in 1999. A regional dimension was added to these national scenarios. These are referred to as the DGVLAB scenarios.[2]

The second difference with traditional economically based demo-economic models is that we recognize that the determinants of demographic behaviour do not always conform to standard economic theory. This is especially relevant for the linkages between economic growth and natural increase, and between regional economic growth and internal migration. These issues will be elaborated in the next section in some detail, when discussing the structure of the demo-economic model DECORES. Next, in section three the two scenarios are presented. Section four deals with a number of results at the national level for these countries, whereas section five presents more details at the regional level. In the final section the results are discussed and evaluated, and some conclusions will be drawn as well.

2. The Structure of DECORES

DECORES (Demo-ECOnomic REgional Simulation) was developed on behalf of the Spatial Planning Office of The Netherlands. It is a tool for exploring a number of problems and solutions at the regional level for northwest Europe, associated with stagnating population growth (Van Wissen and Huisman, 2001). DECORES is a dynamic model system with the following modules:

- demography (birth, death, internal and external migration);
- labour market (supply and demand, unemployment);
- economy (gross regional product, productivity);
- commuting; and
- land use (urban versus other land use).

The model is defined at the NUTS-2 level: 9 provinces in Belgium, 38 *Regierungsbezirke* in Germany and 12 provinces in The Netherlands. These regions usually comprise one ore more major urban agglomerations as well as the rural areas between these agglomerations. The main exceptions are the NUTS 2 regions Bruxelles and Berlin, which coincide with the respective city definitions.

The relationships between the modules and the components within the modules determine the dynamic structure of DECORES. The following modules are defined (figure 1):

1. Demography, including birth, death, internal and external migration, classified by age, sex and region;
2. Economy, which consists of a regional production function;
3. Labour market, with submodules labour supply (by age, sex and region), derived from demography, labour demand (by region), derived from the regional production function, and unemployment (by region);

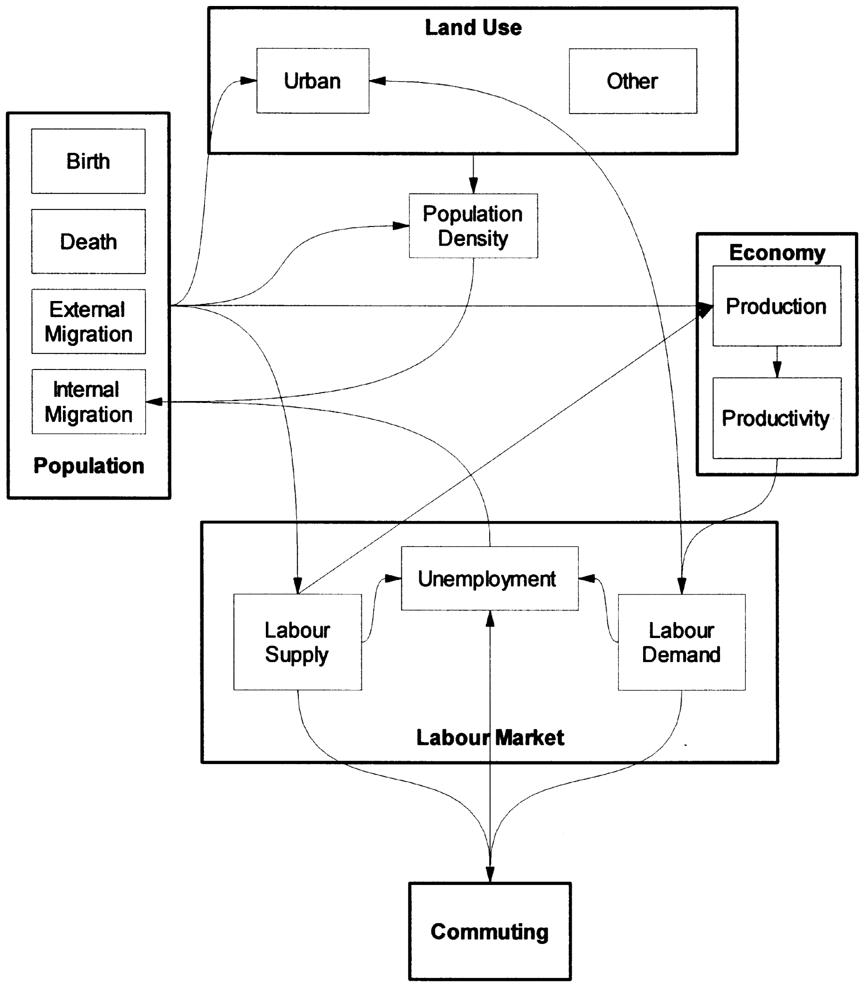

Figure 1. Structure of DECORES.

4. Commuting: the spatial matching of labour supply and demand: by region of residence and region of work (travelling occupations are treated separately);
5. Land use, with a distinction in urban and other land use.

The model works as follows. In the first step, the regional population at time t, POP(t) is determined. Here, as already specified above, two options can be used:

1. Full consistency with the EUROPOP assumptions for all components, which implies an exogenous determined population for each region,
2. Endogenous internal migration and exogenous determined birth, death, and international migration. Internal migration is determined by non-demographic economic and spatial variables, which makes population endogenous in the model.

In the second model step, labour supply, LS(t) is calculated from the regional population structure, based on the baseline DGVLAB scenario. In the third step, in the economic module, the change in gross regional product between time t and $t+1$, ΔGRP(t), is determined. Regional economic growth is dependent on regional population change, exports, and employment change. Therefore, if we use the option of endogenous population change in the population module, population and economy are mutually dependent on each other. From the change in regional production, the (related) change in labour demand, ΔLD(t) is derived. In the fourth step labour supply and demand are matched spatially in the commuting module. Next, in the fifth step, the change in population and change in the number of jobs is translated into change in urban land, ΔURB(t). All variables are updated and the model moves to the next time period $t+1$, where again population is projected one year ahead. A complete overview of model equations is given in appendix A.

2.1. The population module

The population module is a cohort component multiregional model. The components birth, death and external migration follow the assumptions as specified in the low and high regional population scenarios of EUROPOP (Van der Gaag et al., 1999). The main parameters of these scenarios are given in Table 2 of section three below. The assumptions behind these scenarios are based on the assumed (qualitatively determined) links between economic determinants and demographic consequences. These relationships are based on observations on economic time series and demographic indicators in Europe in the last decades, which may or may not be consistent with economic theories of demographic behaviour. With respect to fertility, a positive relationship between economic growth (income) and fertility can be observed in northwestern European countries since the end of the sixties. This is in accordance with Becker's home production theory, in which children are treated as durable goods, and more of the good is demanded with rising income (Becker, 1960). Moreover, there is general agreement about the positive relationship between economic welfare or income and life expectancy (McKeown, 1976; Van Poppel, 1990). There is also a positive relationship between economic welfare or growth and migration. For international migration this implies larger net inflows with economic growth (King, 1993; Massey et al., 1993). To summarize, in the high scenario it is assumed that fertility, life expectancy as well as international net migration is high, whereas in the low scenario the reverse is true. The demographic assumptions of the high and the low economic scenarios are given in section three below.

The population scenarios do not only specify the level of each of the components, but also the geographical distribution in the level of these parameters. Here it is assumed that in the low scenario divergence or at least no convergence of demographic differences between regions takes place, whereas in the high scenario convergence towards the assumed national level occurs. Whereas this is likely for fertility, mortality and international net migration, for internal migration a more complicated relationship may apply (Amstrong and Taylor, 2000). In DECORES two options may be chosen. In the standard option, in accordance with traditional economic theory, higher regional incomes and job opportunities will attract migrants to the region. Lower incomes and unemployment will push workers out of the region, towards regions that are more prosperous and with better job opportunities. In the more complicated second option, internal migration conforms to empirically observed relations between key regional economic indicators and in- and outmigration. Here, as explained in more detail below, unemployment is important, but regional wage differentials do not exist, due to nationwide labour contracts. Moreover, non-economic factors such as regional amenities are important as well. This means, for instance, that people migrate out of the regions with high congestion and high levels of economic activity.

The scenarios presented in this paper use this economic driven internal migration assumption. The population module determines the change in population structure between time t and $t+1$.

The model formula for outmigration is equal to:

$$\text{Prob}(\text{Outmig}(i, t, t+1)) = \exp\{Z_i(t)\}/(1 + \exp\{Z_i(t)\}) \tag{1}$$

which is a binary logit formulation for grouped data. The linear sum Z is equal to:

$$Z(i, t) = a_1 + a_2 * \text{UNEMP}(i, t) + a_3 * \text{DENS}(i, t) + a_4 * \text{Dens}^2(i, t) + a_5 * \text{LD}(i, t) \tag{2}$$

where UNEMP is equal to the regional unemployment figure relative to the national level per 100 of the labour force, DENS is equal to population density (persons/km^2). DENS^2 the density squared, and LD the regional share in the number of jobs. All variables relate to the situation *primo* year t. The parameters of this equation were estimated using data for The Netherlands in the period 1990–1996. We used pooled data as well as data for separate years. We estimated models based on cross-sectional as well as on first differences. The results of the first difference method using the period 1992–1994 were the most satisfactory (*t*-values between brackets):

$$Z(i,t) = \underset{(0.04)}{5.49 * 10^{-4}} + \underset{(2.04)}{0.019 * \text{UNEMP}(i,t)} - \underset{(-2.44)}{5.84 * 10^{-3}} * \text{DENS}(i,t) + \underset{(1.85)}{2.27 * 10^{-6}} * \text{DENS}^2(i,t) + \underset{(2.52)}{19.51} * \text{LD} \quad n = 12,\ R^2(\text{adj.}) = 0.52 \quad (3)$$

The results indicate that if unemployment increases, so does outmigration. The relationship with population density is non-linear and U-shaped (see figure 2). Population density in The Netherlands has a maximum value of 1200 inhabitants per km^2. In other countries occasionally higher densities can be found. The estimated coefficients show that negative consequences of congestion will lead to high increases of outmigration at very high density levels. The turning point is at 1300 inhabitants per km^2. Another indicator of congestion, which is different from population density, and measured in employment terms, is the size of the production system: larger production system implies a larger outmigration as well. Although this result looks perverse at first sight, it does conform to a number of findings in studies of internal migration in Europe. These findings do not conform to the standard economic model, but reflect household preferences for housing quality in low density areas at the expense of increased commuting distances (Green et al., 1999; Amstrong and Taylor, 2000).

The model for inmigration shares has the following form:

$$P(i,\ t, t+1) = \exp\{Z(i,t)\} / \sum_k \exp\ \{Z(k,t)\} \quad (4)$$

which is a multinomial logit model, that guarantees that $\Sigma_i P_i = 1$. The form of Z is equal to that of outmigration:

$$Z(i,t) = b_1 + b_2 * \text{UNEMP}(i,t) + b_3 * \text{DENS}(i,t) + b_4 * \text{DENS}^2(i,t) + b_5 * \text{LD}(i,t) \quad (5)$$

All variables relate to the situation *primo* year *t.* This model was also estimated using cross-sectional as well as first differences for the period 1990–1996 in The Netherlands. The most satisfying estimation results were produced using cross-sectional data for 1994:

$$Z(i,t) = \underset{(0.28)}{0.098} - \underset{(0.66)}{0.089} * \text{UNEMP}(i,t) + \underset{(0.22)}{4.81 * 10^{-4}} * \text{DENS}(i,t) - \underset{(-0.41)}{6.25 * 10^{-7}} * \text{DENS}^2(i,t) + \underset{(2.09)}{7.52 * \text{LD}(i,t)} \quad n = 12;\ R^2(\text{adj.}) = 0.56 \quad (6)$$

Most of the coefficients are not significant, but all are of the right sign. These results indicate that the higher the unemployment rate, the lower the inmigration. In addition, the relationship between density and inmigration shares is a skewed dome shaped curve. For

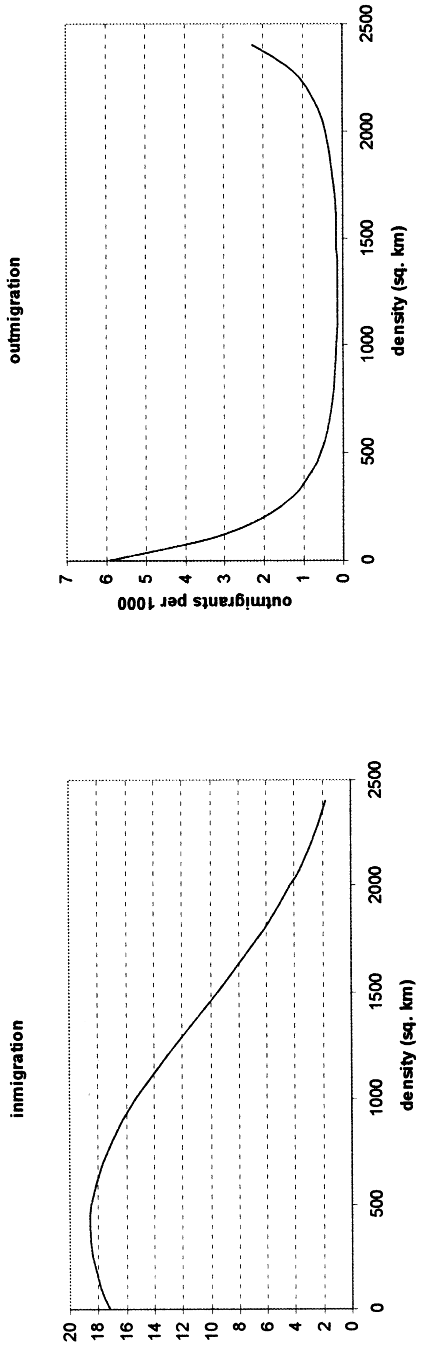

Figure 2. Density dependence of internal outmigration rate (right) and immigration share (left).

relatively low density values the attractiveness increases with increasing density. After a certain threshold value, which is different for each region, the pull effect diminishes.

2.2. Labour supply module

The outcome of the population module is an age- and sex-specific population structure for each region. Application of age- and sex-specific participation rates, which vary over the regions and years, results in regional labour supply (by age and sex). These participation rates are equal to the existing DGVLAB labour supply scenarios (Van Dalen et al., 1999). Underlying these rates is a set of assumptions formalised in a parametric model that includes various determining variables. Key factors that may influence labour force participation, such as age, sex, marital status, presence of young children in a household and educational level of respondents, were investigated. Insight was gained to what extent labour supply varies systematically with these factors. A number of assumptions about future developments in these key factors were formulated for the period 1996–2015. In DECORES the base line scenario was used, and these rates may be adjusted by specifying an annual percentage shift over time.

2.3. Economic module

In DECORES a simple production function was specified, relating relative growth in gross regional product (GRP) to relative growth in regional exports, regional population and regional employment. Ledent (1980) proposed this simple formula in a demo-economic framework. The specification includes intermediate demand, as indicated by the regional labour supply variable, and the two final demand categories: consumption (indicated by population size) and export. The function is a simple linear equation, and, since all variables are specified in relative change terms:

$$\Delta\text{GRP}(t) = \beta_1 * \Delta\text{Export}(t) + \beta_2 * \Delta\text{Pop}(t) + \beta_3 * \Delta\text{LS}(t) \tag{7}$$

The coefficients β are elasticities, since all variables are specified as growth rates. ΔPop and ΔLS are endogenous and produced by the model itself. ΔExport is exogenous. The elasticities β have to be estimated using empirical data. OLS estimates of these elasticities for the three included countries at the national level are given in Table 1 below. Time series of regional export data were not available, and therefore estimation at the regional level of this production function was not possible.

Figure 3 gives the observed and predicted annual change in GDP in the period 1961–1997 for The Netherlands. The estimated coefficients for Belgium are relatively similar. The elasticity of population is larger than 1. Economic growth may be more related to the growth in the number of consumption units, or households, which is also larger than the growth of the population. The elasticity of the production system (indicated by the labour supply) is around 0.50. The export elasticity is slightly lower. The German results are

Table 1. OLS-estimates of production function (7) for three countries

	Germany		The Netherlands		Belgium	
	Period 1984–1996 $n = 12^*$		Period 1961–1996 $n = 36$		Period 1962–1996 $n = 35$	
Parameter	Coeff.	*t*-value	Coeff.	*t*-value	Coeff.	*t*-value
Δ Export	0.24	3.90	0.30	5.89	0.39	6.52
Δ Population	0.39	0.52	1.17	1.90	1.29	1.38
Δ Labour supply	0.13	3.16	0.45	2.60	0.56	0.82
R^2	0.72		0.73		0.64	

* 1991 excluded. Note that the German time series pertain to western Germany in the time period until 1990, and to Germany as a whole from 1992 onwards.

different, but these were estimated from a much shorter time series, that includes the unification of Germany. These results were used in the economic module for each country.

2.4. Labour demand

Based on the GRP the change in labour demand can be derived using a simple transformation function:

$$\Delta \mathrm{LD}^{\mathrm{F}}(i,\ t+1) = \alpha * \Delta \mathrm{GRP}(i, t) \tag{8}$$

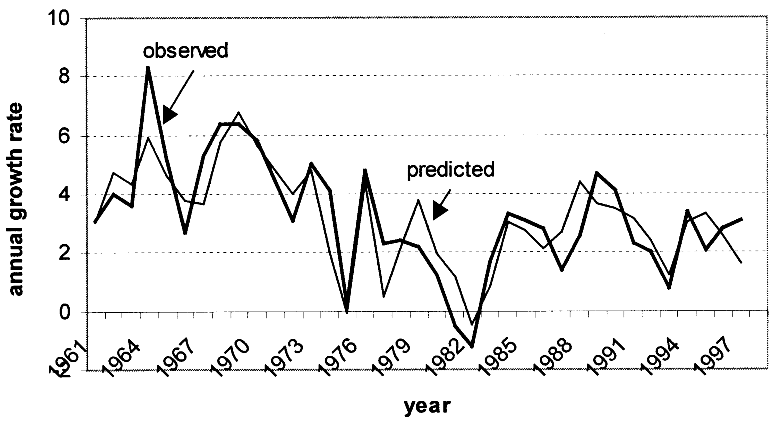

Figure 3. Observed and predicted annual change in GDP in the Netherlands 1961–1997.

Historically, the change in production has almost always been larger than the growth in employment, so α is smaller than 1. From observed time series we can obtain an estimate of this parameter. Using data that pertain to the average change in the nineties of the total number of jobs in the three countries, we obtain very different estimates for all three countries: 0.75 for The Netherlands, but only 0.3 for Belgium and almost 0 in Germany. So the countries differ to a large degree in the way in which economic growth results in more jobs. In The Netherlands the ratio is highest. In Germany economic growth was very low, mainly due to the unification, which makes a reliable estimate difficult. For Germany, a base line value equal to the Belgian case was specified.

2.5. Commuting module

Labour demand and labour supply are matched in the commuting module, which is specified as a doubly constrained spatial interaction model. We take into account occupations without a fixed working place (travelling occupations), unemployment, as well as foreign in- and out-commuting. First, labour supply in fixed working places LS^F is calculated by subtracting from the total labour supply the number of unemployed: UNEMP, non-fixed occupations LS^{NF} and commuters from this region to other countries INTCOMOUT:

$$LS^F(i, t) = LS(i, t) - UNEMP(i, t) - LS^{NF}(i, t) - INTCOMOUT(i, t) \tag{9}$$

LS^{NF} and INTCOMOUT are calculated from survey data on commuting. The share of the labour force in these categories is held constant throughout the simulations.

On the demand side total labour demand for fixed work places is derived from the total labour demand minus foreign commuters into the region:

$$LD^F(j, t) = LD(j, t) - INTCOMIN(j, t) \tag{10}$$

Here we assume that foreign commuters all have fixed workplaces. Using observed historical flows of commuters between residential regions i and work regions j, we are able to obtain a commuting matrix. From these historical flows conditional probabilities $P_{j\,|\,i}$ can be calculated, giving the probability of working in j when living in i. From these probabilities a flow matrix FLOW(i,j) can be calculated:

$$FLOW(i, j, t) = LS^F(i, t) * P_{j|i} \tag{11}$$

However, this matrix is not necessarily consistent with labour demand $LD^F(j,t)$. Therefore iterative proportional fitting (IPF) is applied in order to estimate a commuting matrix that is as close as possible to FLOW(i,j,t) and consistent with labour supply and labour demand (i.e. consistent with $LS^F(i,t)$ and $LD^F(j,t)$). This is equivalent to estimating a spatial interaction model based on the principle of miminum information or maximum entropy (Wilson, 1974; Willekens, 1983):

$$\text{FLOW}(i, j, t) = \text{A}(i)\text{LS}^{\text{F}}(i)B(j)\text{LD}^{F}(j)\text{P}_{j|i} \tag{12}$$

Where the A(i) and B(j) are the well-known balancing factors in spatial interaction modelling, that guarantee that the sum of FLOW(i,j) over all origins i or destinations j equals the given marginal totals $\text{LS}^{\text{F}}(j)$ and $\text{LD}^{\text{F}}(i)$ respectively. In this process unemployment (UNEMP) is the labour reservoir. If $\Sigma_i \text{LS}^{\text{F}}(i) < \Sigma_j \text{LD}^{\text{F}}(j)$ the pool of unemployed decreases until equality is reached. However, unemployment in any region cannot decrease below 2 per cent of the labour force -the minimal frictional level of unemployment. Therefore, if labour demand becomes too large, a solution cannot be found: there is simply not enough supply to fill the jobs.

2.6. Land use

In this module the change in the urban area in each region is calculated, based on the change in population and jobs, using the linear function:

$$\begin{aligned} \text{Urb}(i, t+1) = {} & \text{Urb}(i, t) + \delta_1 * [\text{Pop}(i, t+1) - \text{Pop}(i, t)] \\ & + \delta_2 * [\text{LD}^{\text{F}}(i, t+1) - \text{LD}^{\text{F}}(i, t)] \end{aligned} \tag{13}$$

The coefficients δ denote the change in urban land use per one inhabitant of the region and one employed person. They are estimated using time series of Dutch data. The estimated coefficients of this model are: est $\delta_1 = 1.63 * 10^{-4}$ (t-value $= 3.82$) and $\delta_2 = 2.16 * 10^{-4}$ (t-value $= 2.23$); $R^2 = 0.78$). Each additional person in a region adds 163 m^2 urban land to the region, and each new job adds 216 m^2 of the urban land to the region respectively. These values were used in the model. The change in urban land is assumed to reduce the area of agricultural land. Negative change in the amount of urban land is not possible.

The model, using the above parameter estimates, was partly validated at the national level for the period 1995–2000, using as validation variables GDP change, labour supply and demand, and unemployment rate. The model reproduces the observed economic variables reasonably well, for each of the three countries.

3. Two Demo-Economic Scenarios

In order to test the potential of DECORES two demo-economic scenarios were prepared. Here we present results for three countries. Each of these scenarios will be described below.

3.1. Low economic growth scenario

In this scenario economic growth in European countries is low. This is reflected in the economic sector in negative growth of exports, and a low value of relative employment growth (α parameter in DECORES). Labour participation is stagnating: there is no change in participation until 2025. In the demographic module, this results in a low population growth scenario: low fertility, low external migration, low life expectancy, and low internal migration mobility (for a discussion of these demographic parameters, see van der Gaag et al., 1999). We also hypothesise that low economic growth results in a focus on concentration of all activities in the core areas of the countries. Therefore, economic growth in the core regions is somewhat higher than in the peripheral regions. Due to these concentration tendencies, congestion is not a factor that drives people out of the most densely populated regions. On the contrary, the high density areas are the most popular regions, because people think that they can find the best opportunities for work here. Therefore, the increase in internal outmigration rates and the decrease in inmigration probabilities at higher densities (figure 2) is absent in this scenario, which is expressed in a value of 0 for the quadratic term of density. In terms of urban land use, we hypothesise that the average amount of urban area needed per person and per job is 10 per cent lower than observed in the recent past.

3.2. High economic growth scenario

In a situation of high economic growth exports are high, employment opportunities increase significantly, and labour force participation rates increase as well. This high economic growth leads to high population growth: high fertility, high life expectancy, high international migration, and high internal mobility. These economic developments are consistent with observed economic growth at the national level in the period 1995–2000. For instance, in this period, the Dutch GNP increased annually with around 3 percent, and exports increased annually with values between 4.5 and 7 per cent. Somewhat lower values were observed in Belgium, and German values were only about half of these values. Thus, in The Netherlands, the observed values in the period 1995–2000 should in principle be taken as economic indicator values for the high economic growth scenario. However, as explained below, labour market shortages arise in the (near) future in this scenario, and consequently more moderate values have to be used in order to generate consistent results. For the other countries these problems are less severe, but here also labour market tensions arise at a future point in time, due to decreasing labour supply.

We also hypothesise that high overall economic growth results in dispersion at the regional level: the peripheral regions benefit most from these developments. Economic growth in these regions is somewhat higher, while in the core regions there are strong congestion effects, which lead to increased internal outmigration and reduced inmigration at higher densities. Due to higher incomes, the amount of urban land used per person and per job is 10 per cent higher than observed in the recent past.

We use similar values for the economic variables for each region in each country. The model in principle allows specifying different values for each region, but there is insufficient information about export growth at the regional level, as well as elasticities of regional production functions.

Table 2 gives a summary of all assumptions in the two scenarios. In the next sections the results of these scenarios will be presented. For the period 1995–2000 we use observed economic input variables for export growth.

4. National Results

These scenarios are driven by economic mechanisms. In figure 4 the annual change in GDP is depicted for each of the three countries in the two scenarios. In the low scenario soon after the year 2000 each country shows a sharp decline in GDP growth, until values between 0 and 1 percent. In the high scenario GDP grows between 2 (Germany) and 4 (The Netherlands) percent (figure 4) after the year 2000.

In table 3 a number of summary statistics are listed for both scenarios. Population growth differences between the two scenarios and between the countries are significant, with generally low increase or even decrease (Belgium) in the low scenario, and high increases in the high scenario, even as high as 23 per cent in The Netherlands.

As a result of these large differences in GDP change between both scenarios and between the countries, there are large differences in labour demand development over time,

Table 2. Summary of assumptions for two demo-economic scenarios

Parameter	Low economic growth			High economic growth		
Country	B	G	NL	B	G	NL
Economy & labour market						
– export growth%	0.5	0.5	0.5	4.25	6.1	5.95
– Labour/GRP change ratio	0.2	0.05	0.4	0.4	0.3	0.75
– annual % change in female labour participation	0.0	0.0	0.0	0.6	0.02	1.35
Population						
– fertility (TFR)	1.4	1.4	1.4	2.0	1.8	2.0
– life expectancy	M:74 F:80	M:73 F:80	M:75 F:80	M:83 F:86	M:83 F:86	M:83 F:86
– external migration/1000	1.00	1.00	1.00	2.00	4.00	3.00
– internal migration mobility rate relative to 1995 value	−10%	−10%	−10%	+10%	+10%	+10%
Land use						
– m^2 per additional person	145	145	145	180	180	180
– m^2 per additional job	180	180	180	240	240	240

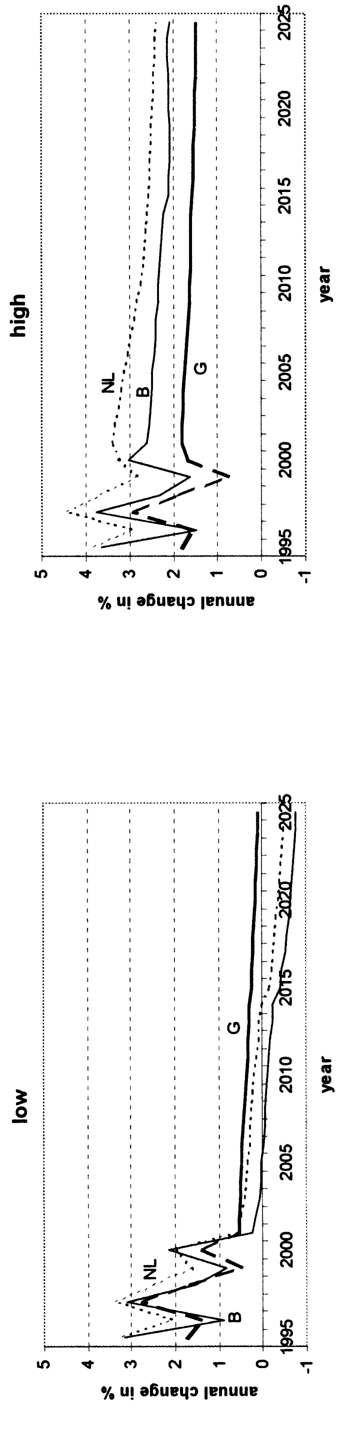

Figure 4. GDP change in two scenarios for three countries.

Table 3. Key output indicators of scenarios

Indicator	Low economic growth			High economic growth		
Country	B	G	NL	B	G	NL
% change population 95–25	−3.8	5.3	1.8	13.8	14	23
% change labour demand 95–25	18	1.9	6.5	34	17	101
unemployment 2025	0.12	0	0	0	0	0
% change urban land 95–25	5.2	5.6	17	63	29	137
% change commuting 95–25	3.7	14	15	42	18	132
% point change in male participation 95–25	−5	−6	−5	−4	−7	−2
% point change in female participation 95–25	0	+3	+2	+6	+2	+17

with the largest increase in The Netherlands in the high scenario. In the other extreme, in the low scenario in Germany labour demand will hardly increase at all.

Unemployment will drop to zero in all countries in all scenarios. However, there are large differences between the countries and scenarios in timing (figure 5). In both the low and the high growth scenario unemployment decreases steadily, with the exception of the low scenario for Germany, where a slight increase is observed between 2005 and 2010. In the high scenario unemployment drops to zero, first in The Netherlands in 2005, then in Belgium in 2015 and in Germany in 2022. Clearly, labour supply cannot keep up with economic growth rates as high as observed in the last 5 years in The Netherlands.

The change in urban land reflects the combined effect of population and job change. In the low scenario there is only a small percentage increase in Belgium and Germany, but still 17 per cent in The Netherlands. In the high scenario the urban area will more than double. In Belgium the increase is half the Dutch growth figure.

Inter-NUTS-2 commuting will rise slightly in the low, but sharply in the high scenario. Again, the largest increase is to be seen in The Netherlands. Most of this increase is due to the large increase in the number of jobs, but the growth rate is even higher than that of jobs.

In the low scenario, male labour market participation will drop with a few percentage points, for instance in The Netherlands from 76 to 71 per cent. This is the result of aging of the working population, since age-specific participation rates are held constant in this scenario. Female participation will remain stable or increase slightly: here the higher participation rates and aging effects almost balance each other. In the high scenario the main differences are to be found in female participation, with an especially high increase in percentage points in The Netherlands.

5. Regional Results

In addition to these national results for the three countries, in this section a number of results at the regional level will be shown.

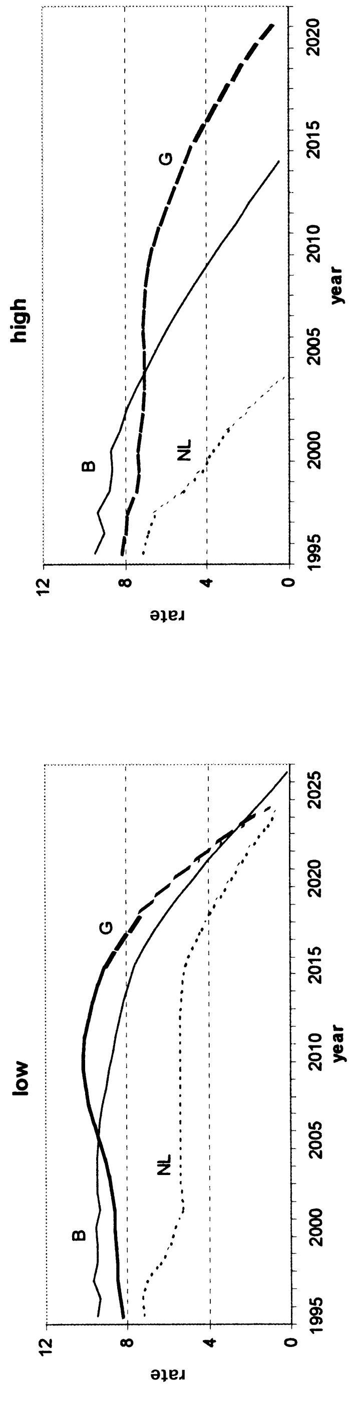

Figure 5. Unemployment rate in two scenarios in three countries 1995–2025.

Figure 6 depicts the change in GDP in 2025 in the regions in the three countries. There is substantial regional variation in growth rates, with negative values in the low scenario prevailing in The Netherlands and Belgium. In Germany relatively more regions show positive growth rates.

As a result of the regional labour market differentials (caused by differences in population growth, population structure, commuting, and economic growth) unemployment is different among the regions as well. In figure 7 the regional distribution of unemployment in 2005 is shown. The value for 2005 was chosen because after 2005, as can be seen in figure 4 at the national level already, in the high scenario the labour supply is insufficient to meet demand in The Netherlands, and in later years the same can be observed in the other countries.

The figures clearly show the special position of East Germany and Wallon, each having high unemployment rates, compared to The Netherlands and Southern Germany with low values. The same distributions emerge in both scenarios, but at different levels.

As a result of both population change and employment change, the size of the urban area changes as well. Clearly, there are large differences between the low and the high scenario, with is most profound in the core and peripheral areas of the countries. In the high scenario urban growth is much more dispersed, in all countries.

Finally, the divergent trends in labour supply and demand also have their effect on interprovincial commuting patterns. In the low scenario commuting increases only slightly. Figure 9 shows the change in commuting for each region in the high scenario. In the peripheral regions outgoing worktrips increase in both scenarios. In the high scenario commuting increases substantially in almost all provinces. Incommuting increases mostly

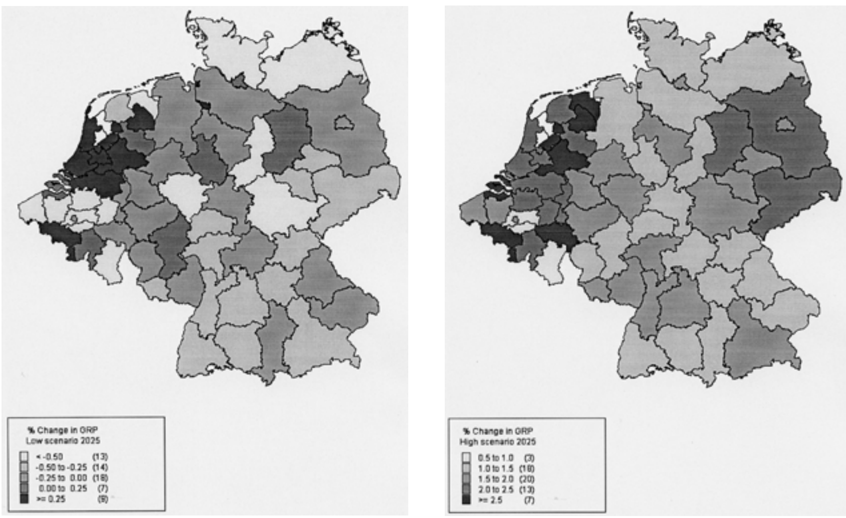

Figure 6. Growth in GDP in 2025 in NUTS 2 regions in low (left) and high (right) scenario.

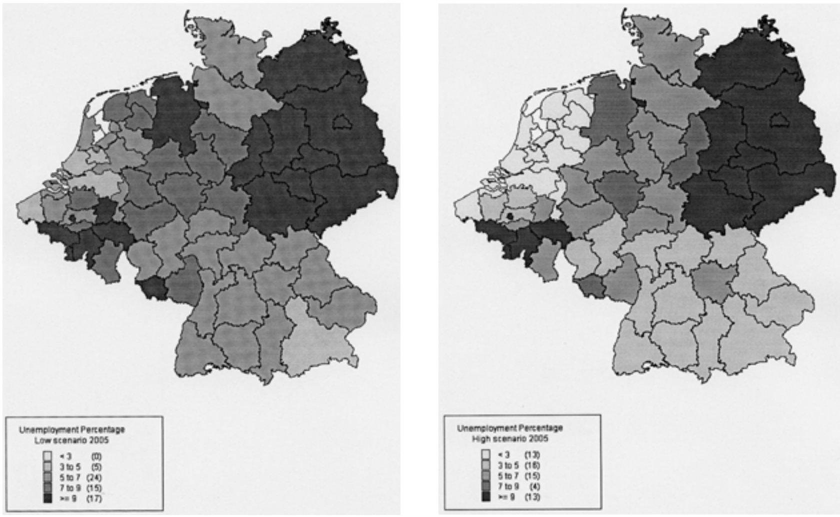

Figure 7. Regional unemployment in the low (left) and high (right) scenario in 2005.

in the regions around the major cities, whereas outcommuting increases most strongly in the core regions. The divergent developments in labour demand and supply not only have a strong effect on the regional labour markets, but also on the regional redistribution of commuting patterns.

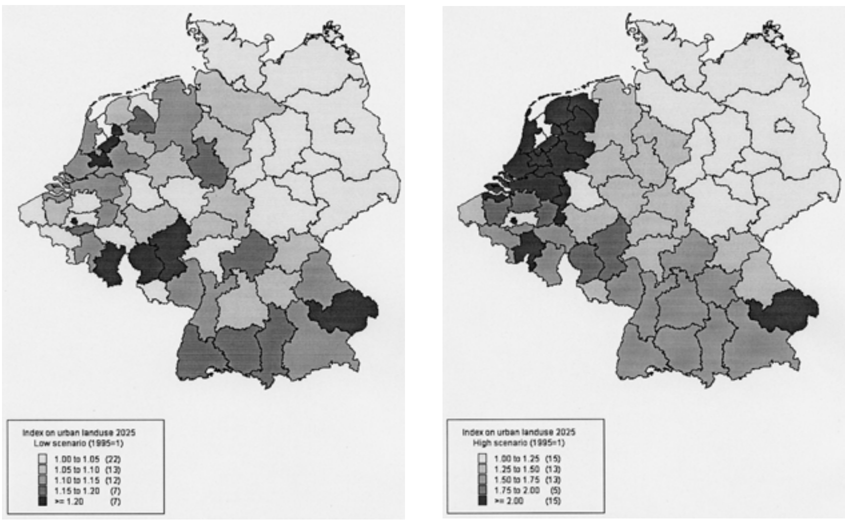

Figure 8. Growth in urban area in low (left) and high (right) scenarios.

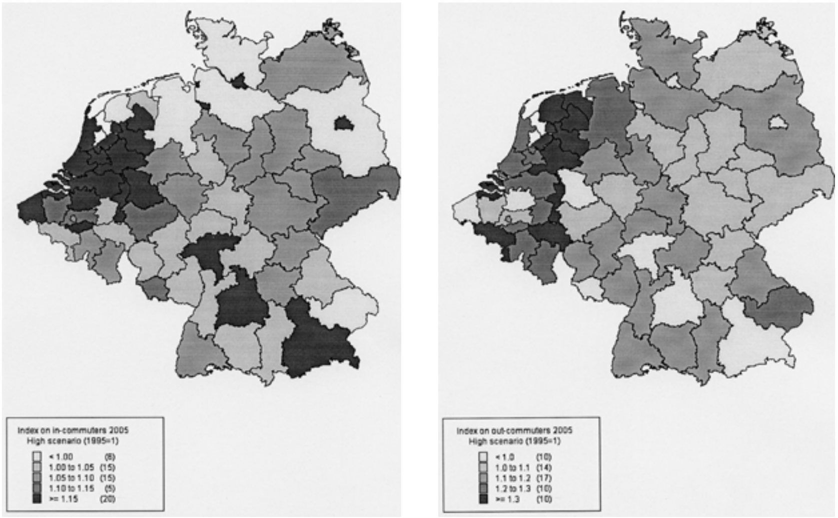

Figure 9. Change in incommuting (left) and outcommuting (right) in high scenario.

6. Conclusions

In this paper a regional demo-economic model was presented, which integrates a number of existing demographic and labour supply scenarios in a coherent framework. This framework allows feedback relations between population and economy, or population/ec-economy and spatial characteristics. Moreover, the same model was applied into three countries. The results of DECORES show that such an integrated view has a number of advantages. Confronting labour market supply and demand showed that labour supply issues have become critical, and this will have consequences for future economic growth. The advantages of this approach are clear. First, the models are more comprehensive, and their structure reflects complex feedback mechanisms that are highly relevant in reality. Second, these additional modules provide a form of consistency check for the demographic and labour supply outcomes. Assumptions are usually made with reference to economic determinants, but in these demo-economic models at least some of these assumed links are made explicit. The model results will tell if these assumptions are consistent and valid.

A classical point of critique on demo-economic models is that they are economic models, supplemented with a simple demographic module. This critique does not apply to DECORES. The model is built around demographic models of population and labour force supply, supplemented with (relatively simple) economic, commuting and land use modules. The simplicity of the economic model is not a problem for its purpose: to establish a robust link between economic growth, labour market and population growth.

Nevertheless some other points of critique are worth mentioning. First, including feedback effects has also disadvantages. The specification of the model is more difficult, and the uncertainties in the outcomes increase, due to increased specification error, measurement error, and possibly bias in the estimation of the coefficients of these more complex models. This applies to the national level, but much more at the regional level, where we also have to deal with spatial interactions. For instance, the model results are sensitive to the specification of the density functions in the internal migration function (figure 2). Another example is the model structure of the spatial match between labour demand and supply. Here, unemployment and commuting are determined simultaneously: if the distance to the nearest job is too large, the worker chooses to be unemployed. Unfortunately, we do not have additional empirical information to validate this choice function.

Secondly, the population and labour participation submodels are to a large extent exogenous, with the only exception of the internal migration module that is (optionally) driven by labour demand and population density. The demographic components fertility and mortality can be made endogenous on economic variables as well, although their impact on total population size in the projection period will probably be limited. External migration is much more important as a determinant of population change. The distribution of these international immigration flows is dependent on economic indicators (Van der Gaag and Van Wissen, 1999), although the regional distribution of foreign migration is still largely directed towards the central urban regions (Van der Gaag and Van Wissen, 2001). Nevertheless, making external migration endogenous would improve the theoretical structure of the model.

This point raises the question when the model structure is complete. In principle many more mechanisms could be included. For instance, part time work, an important category in The Netherlands, especially for women, is not included in DECORES. Changing from part time to full time would probably reduce the labour market problems predicted in The Netherlands and the situation might not be as bad as predicted. Nevertheless, the main results of the present model will not be changed by including more detailed mechanisms. This would probably obscure the main message from these demo-economic scenarios: demographic constraints should be taken into account in economic scenarios for the future, at the national and regional level.

Appendix A: Model Equations

Population module

Births:
$\text{Births}(r,t) = E_a \text{Pop}(a,s=2, r, t) * \text{Birthrate}(a,t)$
where s = 2 means female population

Deaths:
$\text{Deaths}(r,t) = E_a E_s \text{Pop}(a,s,r,t) * \text{Deathrate}(a,s,r,t)$

Internal migration arrival-shares:
$\text{Arr}(r,t) = f(b_1 + b_2 * U(r,t) + b_3 * \text{Dens}(r,t) + b_4 * \text{Dens}^2(r,t) + b_5 * \text{LD}(r,t))$

for all ages and sexes. Age- and sex-specific arrivals using observed 1995 age-sex profiles

Internal migration departure-rates:

$\text{Dep}(r,t) = f(a_1 + a_2 * U(r,t) + a_3 * \text{Dens}(r,t) + a_4 * \text{Dens}^2(r,t) + a_5 * \text{LD}(r,t))$

for all ages and sexes. Age- and sex-specific departure rates using observed 1995 age-sex profiles.

Net international migration:
$\text{Intmig}(r,t) = E_a E_s \text{Pop}(a,r,s,t) * \text{Intmigrate}(a,r,s,t)$

Calculation of population at time $t+1$:
$\text{Pop}(r, t+1) = \text{Pop}(r,t) - \text{Deaths}(r,t) + \text{Arr}(r,t) - \text{Dep}(r,t) + \text{Intmig}(r,t)$
where the summation over ages and sexes is omitted.

Labour Supply at time $t+1$:
$\text{LS}(r, t+1) = E_a E_s \text{Activityrate}(a,s) * \text{Pop}(a,r,s,t+1)$

Changes in Gross Regional Product:
$\Delta\text{GRP}(r,t) = \beta_1 * \Delta\text{export}(r,t) + \beta_2 * \Delta\text{Pop}(r,t) + \beta_3 * \Delta\text{LS}(r,t)$

Changes in labour demand:
$\Delta\text{LD}(r,t) = \alpha * \Delta\text{GRP}(r,t)$

Commuting:
$\text{LS}^{\text{F}}(i,t) = \text{LS}(i,t) - \text{UNEMP}(i,t) - \text{LS}^{\text{NF}}(i,t) - \text{INTCOMOUT}(i,t)$
$\text{LD}^{\text{F}}(j,t) = \text{LD}(j,t) - \text{INTCOMIN}(j,t)$

$\text{FLOW}(i,j,t) = \text{A}(i)\ \text{LS}^{\text{F}}(i)\ \text{B}(j)\ \text{LD}^{\text{F}}(j)\text{P}_{j|i}$
$A(i,t) = 1/\{E_j B(j,t)\ \text{LD}^{\text{F}}(j,t)\ \text{P}_{j|i}\}$ (balancing factor for residential regions i)
$B(j,t) = 1/\{E_i A(i,t)\ \text{LS}^{\text{F}}(i,t)\ \text{P}_{j|i}\}$ (balancing factor for working regions j)

Land use:
$\text{Urb}(r,t+1) = \text{Urb}(r,t) + \delta_1 * [\text{Pop}(r,t+1) - \text{Pop}(r,t)] + \delta_2 * [\text{LD}^{\text{F}}(r,t+1) - \text{LD}^{\text{F}}(r,t)]$
$\text{Arab}(r,t+1) = \text{Arab}(r,t) - \delta_1 * [\text{Pop}(r,t+1) - \text{Pop}(r,t)] - \delta_2 * [\text{LD}^{\text{F}}(r,t+1) - \text{LD}^{\text{F}}(r,t)]$

List of Abbreviations and Symbols

a	age
s	sex
r, *i*, *j*	region
t	time *t*
Pop	population
LS	labour suply
LD	labour demand
Arr	arrival-shares
Intmig	net international migration per person
Dep	departure rates

GRP	gross regional product
UNEMP	unemployment rate
$P_{j\mid i}$	historical commuting flow distribution of for residential region *i* over working regions *j*
Urb	urban area
Arab	arable area
OppTotal	total area
DENS	population density
Nonfixed	Workers in non-fixed working occupations

Notes

[1] A regional division defined by Eurostat, the statistical agency of the European Union. There are 203 NUTS 2 regions in the current European Union, with an average of 1.7 million inhabitants each, although the variation in size is very large.

[2] Not to be confused with regional labour supply scenarios that have been compiled for Eurostat in 1996 (EUROLAB).

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References

Amstrong, H. and J. Taylor. (2000). *Regional Economics and Policy, Third Edition*. Oxford: Blackwell Publishers.

Becker, G.S. (1960). "An Economic Analysis of Fertility." In NBER (ed.), *Demographic and Economic Change in Developed Countries.* Princeton, NBER, 209–231.

De Beer, J. and L. van Wissen (eds.). (1999). *Europe: One Continent, Different Worlds. Population Scenarios for the 21st Century.* Dordrecht: Kluwer.

Gordon, P. and J. Ledent. (1981). "Towards an Interregional Demoeconomic Model." *Journal of Regional Science* 21(1), 79–87.

Green, A., T. Hogarth, and R.E. Shackleton. (1999). "Longer Distance Commuting as a Substitute for Migration in Britain: A Review of Trends and Implications." *International Journal of Population Geography* 5, 453–464.

King, R. (1993). "European International Migration 1945–1990: A Statistical and Geographical Overview." In: R. King (ed.), *Mass Migration in Europe, the Legacy and the Future*. Belhaven Press: London, 7–18.

Ledent, J. (1980). "A Demoeconomic Model of Interregional Growth Rate Differences." *Geographical Analysis* 12(1), 55–67. Also available as IIASA research report no. rr-80-26.

Massey, D.S., J. Arango, G. Hugo, G. Kouaouci, A. Pellegrino, and J.E. Taylor. (1993). "Theories of International Migration: A Review and Appraisal." *Population and Development Review* 19, 431–466.

McKeown, T. (1976). *The Modern Rise of Population*. London: Edward Arnold.

Murdock, S.H., F.L. Leistritz, R.R. Hamm, S.S. Hwang, and B. Parpia. (1984). "An Assessment of the Accuracy of a Regional Economic-Demographic Projection Model." *Demography* 21(3), 383–404.

Rees, P., M. Kupiszewski, H. Eyre, T. Wilson, and H. Durham. (1999). "The Evaluation of Regional Population Projections for the European Union." Report prepared for the European Commission, Directorate General XVI.

Sanderson, W.C. (1980). "Economic-Demographic Simulation Models: A Review of Their Usefulness for Policy Analysis." IIASSA Research Report 80-14, Laxenburg, Austria.

Van der Gaag, N., L. van Wissen, E. van Imhoff, and C. Huisman. (1999). "National and Regional Population Trends in the European Union". Eurostat Working Paper 3/1999/E/n8.

Van der Gaag, N. and L. van Wissen. (1999). "Analysis and Forecasting of International Migration by Major Groups" (Part II). Eurostat Working Paper 3/1999/E/no. 9. Luxembourg: Eurostat.

Van der Gaag, N. and L. van Wissen. (2001). "Determinants of the Subnational Distribution of Immigration." *Tijdschrift voor Economische en Sociale Geografie/Journal of Economic and Social Geography* 92, 26–40.

Van Dalen, H., C. Huisman, and E. van Imhoff. (1999). *Arbeidsaanbod in de Europese Unie, Convergentie of Divergentie?* (Labour supply in the European Union, Convergence or Divergence?) *Demos*, 4, 25–29.

Van Poppel, F. (1990). "Determinants and Consequences of Mortality." In C.A. Hazeu and G.A.B. Frinking (eds.), *Emerging Issues in Demographic Research*. Amsterdam: Elsevier, 233–276.

Van Wissen, L., N. van der Gaag and E. van Imhoff. (1997). "Demografische ontwikkelingen in Europa." In: Van Nimwegen, N. and G. Beets (eds.), *Bevolkingsvraagstukken in Nederland anno 1997*. NIDI report nr. 50, The Netherlands.

Van Wissen, L. and C. Huisman. (2001). "Demography, Economy and Urbanization: A Demo-Economic Regional Simulation Model." In J.C.H. Stillwell and H.J. Scholten (eds.), *Land Use Simulation for Europe*, 143–157. Kluwer Academic Publishers, The Netherlands.

Willekens, F.J. (1983). "Specification and Calibration of Spatial Interaction Models. A Contingency Table Perspective and an Application to Intra-Urban Migration in Rotterdam." *Tijdschrift voor Economische en Sociale Geografie TESG* 74, 239–252.

Wilson, A.G. (1974). *Urban and Regional Models in Geography and Planning*. London, New York: John Wiley.