A spatial equilibrium simulation approach to explain unemployment rate differentials between areas

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Abstract

This paper primarily focuses on how area-specific asymmetries and exogenous shocks influence spatial unemployment disparities. We approach through a model specification with two areas and two categories of workers with different underlying residential site preferences. Workers apply for vacant jobs according to a strategy that maximizes their expected payoffs. Their choices, and the spatial equilibrium solution, depend on wage offers, interarea distances, the time horizon, the spatial distribution of jobs, the unemployment insurance, and costs related to migration and commuting. Through numerical simulation experiments we discuss how such factors influence area-specific unemployment rates and spatial labour market interaction.

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1 Introduction

It is well known in the literature that unemployment rates tend to vary systematically between regions. As an example, Partridge and Rickman (1996) find significant levels of dispersion in US state unemployment rates in the 1970s and early 1990s. Evans and McCormick (1994) study changes in the regional pattern of unemployment in the UK since the 1970s. Based on results from OECD-studies, they start out from the fact that regional unemployment differentials have been strikingly persistent for a very long period, both in the UK and in other OECD countries.

In this paper we primarily focus on intraregional aspects of the labour market, in scenarios accounting for the possibility of interarea daily commuting. This is motivated by the fact that unemployment rates often vary systematically between specific areas within an administrative region. As an example, this applies for the Rogaland county, in southern parts of Western Norway. This county can be subdivided into a southern area, a northern area, and an inner area. More or less independently of the business cycle unemployment rates have been systematically higher in the central southern area than in the somewhat less prosperous northern area. At the same time, however, the unemployment rates persistently have been lowest in the lagging, peripheral, inner area. One ambition of this paper is to formulate a modeling framework that contributes with explanations of persistent area-specific unemployment differentials. Most other studies apply to more macroscopic definitions of the geography, where migration flows between extensive, administratively defined, regions, are the only form of spatial interaction. We take the spatial dimension explicitly into account through the specification of distances between the areas. Hence, we allow for commuting as a possible adjustment to exogenous shocks.

Though our model formulation is relatively general in some respects, some simplifying assumptions have to be introduced to make the analysis tractable. For example, we consider a geography with two regions, or areas, with two distinct groups of workers. The workers are homogeneous with respect to job qualifications, but their underlying residential site preferences might differ. Such preferences can be related to area-specific amenities, and/or to some kind of attachment to the native area. The underlying residential site preferences are assumed to be homogeneous within each group of workers.

We further assume that wages and the spatial distribution of jobs are exogenously given. It is certainly possible to modify the model to account for wage adjustments and firm relocations as equilibrating forces in response to exogenous shocks. We will not make such attempts in this paper, however. Rather, we offer conditional results that are relevant when observed events are to be explained, and a regional policy is outlined. We focus on spatial competitive mechanisms that are effective also in a scenario where wages and the spatial job distribution are endogenously determined.

Our analysis focus on how unemployment and spatial labour market interaction reflect individual location decisions. The choice of a specific location combination of job and residence can be explained as a result of a utility maximisation problem: the individual worker chooses the combination corresponding to the highest level of expected utility, given the monetary values of area attachment, the wage in the two areas, the unemployment insurance, the probability of being offered a job in the areas, and the costs related to moving and commuting. In this paper we take into consideration, however, that workers cannot make unrestricted choices in the universal choice set of labour market options and residential locations. To be more precise, account has to be taken to the possibility of a spatial mismatch between the supply and the demand for jobs, there will be competition between workers in an area with excess demand for jobs. We take this competition into account through a spatial equilibrium formulation of the problem.

One important feature of the model formulation is that the relation between unemployment and the two forms of spatial interaction is explicitly taken into account. Migration and commuting are endogenously and simultaneously determined variables in the model.

Despite our set of simplifying assumptions the model is very complex. Analytically derived solutions and comparative static results cannot be accomplished even in the simplest possible case where workers are distributed into 12 distinct groups (see section 3.1). Through numerical methods, however, we think that our analysis offers important and nontrivial insight into problems related to frictional and structural unemployment, migration, commuting and interarea equilibrium.

In section 2 we review some of the literature on spatial unemployment differentials. Our modeling framework is presented in section 3, which starts out by defining the basic set-up (subsection 3.1), continues by explaining the search procedure of the workers (subsection 3.2), before the utility functions and the spatial equilibrium part of the construction is accounted for (subsection 3.3). Subsection 4.1 introduces a case that represents a benchmark situation in our simulation experiments, while subsection 4.2

explains what forms of unemployment that is incorporated in our approach. Section 5 deals with simulation experiments in balanced systems, followed by a discussion in section 6 of how the equilibrium solution depends on the time perspective in such systems. The basic problems of our paper is addressed in section 7. Subsection 7.1 deals with simulation experiments based on a case where the two groups have unequal underlying residential site preferences for their respective native areas. In subsection 7.2 we illustrate that qualitatively different equlibria might develop if residential site preferences rather is related to some kind of amenities located in the regional center. Another central issue in the paper is how spatial wage differentials influence area-specific unemployment rates and labour market mobility. This issue is addressed in subsection 7.3. Subsection 7.4 considers the impact of spatial redistributions of labour demand. Finally, our results are summarized in section 8, that also offers some concluding remarks and possible model modifications.

2 Alternative approaches to explain spatial unemployment differentials

In the literature regional unemployment differentials are explained as a result of a dichotomy between equilibrium and disequilibrium variables, see for instance Partridge and Rickman (1996, 1997). The level of regional unemployment is in addition of course influenced by national business cycle effects, but we will not consider such effects. A disequilibrium typically results from a shock that redistributes labour demand between the regions, resulting in different rates of employment growth.

In their empirical analyses Partridge and Rickman (1996, 1997) explain equilibrium unemployment differentials as a function of producer and household amenities, the fixed costs of migration, demographic characteristics, and labour market variables, including wage rates. Such factors explain why regional unemployment differentials persist after growth rates in employment have equalized. Partridge and Rickman (1997) point out that equilibrium differentials are more structural and that they may be more difficult to address by economic policy than disequilibrium differences. In Partridge and Rickman (1996) they find that the equilibrium unemployment rate in a region is related to the education of the labour force, the industry mix, and the mobility of workers. Consequently, a successful regional labour market policy should focus on those variables.

Asymmetric exogenous shocks might cause a disequilibrium situation. In general a spatial equilibrium will be reestablished through a set of equilibrating forces. Two forms of equilibrating forces are counteracting adjustments in in wages and housing prices. Another is capital mobility. As Partiridge and Rickman (1997) point out production costs can be negatively related to the unemployment rate. The line of arguing is that quit rates are negatively related the unemployment rate, while hiring and training costs are positively related to quit rates. Hence, firms can be attracted to areas with a large unemployed labour force.

In our paper we only account for equilibration through labour mobility; workers migrate or commute out of areas with increased unemployment. In an empirical study based on data from the US Partridge and Rickman (1997) find that high unemployment in a state depends significantly on the lagged unemployment in neighbouring states within a region. Hence, unemployment and labour supply tend to increase through immigration if neighbouring areas have high unemployment. According to other studies labour mobility is higher in USA than in European countries, see for instance Bentivogli and Pagano (1999). At the same time studies confirm a lower responsiveness of migration to wages in European nations than in US states.

The well-known Harris-Todaro model represents an early attempt to account for an equilibrium explanation of regional unemployment differentials. Harris and Todaro (1970) developed the modeling framework to explain accelerating rural-urban labor migration in developing countries. One important point is that migration to the urban area is positively related to the rural-urban expected wage differential. The wage in the urban area is institutionally determined according to a minimum level that is substantially higher than the rural area income potential. Still, the presence of urban unemployment means that the rural area will not be totally depopulated. The expected wage in the urban area is the institutionally determined minimum wage times the probability of receiving a job offer. Hence, rural-urban migration reduces the expected wage in the urban area, and an equilibrium solution will eventually be reached where the expected wage differential is zero and migration has ceased. Harris and Todaro (1970) also show how a policy prescription of generating urban job opportunities might exacerbate the problem of urban unemployment.

In the Harris-Todaro model the households location decisions are determined by a trade-off between wage rates and the prospects of being offered suitable jobs. Marston (1985) focuses on the effect of location-specific amenities. According to Marston (1985) persistent interregional unemployment differentials reflect workers' underlying preferences for certain areas. Those underlying preferences are related to the presence of attractive amenities (climate, parks, clean air etc.). In an equilibrium situation utility levels related to different areas are equal at the margin. This means that the presence of attractive amenities are compensated with high unemployment.

Based on a set of observations Marston (1985) also points out, however, that wages tend to be higher in high unemployment areas. Such empirical findings cannot be explained within the disequilibrium context, and they contradict the idea that excess labour supply in an area results in lower wages. Hence, Marston (1985) claims that the main component of area unemployment rate differentials are local equilibrium components, like for example specific local amenities. The main reason is that disequilibrium unemployment will be eliminated even if only a small fraction of workers migrates as a response to an unfavourable labour market situation. This means that migration adjustments forces are strong relative to disequilibrating shocks. Marston (1985) carries through empirically based analysis indicating that migration flows in general are able to restore spatial equilibrium within a year. This has the important policy implication that government funding programs are useless as means of reducing unemployment in an area.

In their search for explanations of regional unemployment differentials Evans and McCormick (1994) put far less weight to supply side mechanisms than Marston (1985) did. Evans and McCormick (1994) based their approach on the observation that regions in the United Kingdom with employment growth did not typically experience decreasing wages or rising relative unemployment. According to Evans and McCormick (1994) this means that the persistent employment growth in some regions is not a result of a corresponding change in workers' preferred location. Rather, Evans and McCormick (1994) conclude that unemployment differentials are maintained by variations in the labour force participation amongst manual workers, and by the migration of non-manual workers to growing regions. In general Decressin and Fatás (1995) found that a shock primarily is absorbed by changes in the labour participation rate in Europe, while it is more reflected in in migration flows in the US.

McCormick (1997) also points out that migration adjustments differ between countries and categories of workers. For example, the migration rate is considerably higher for non-manual workers than for manual workers in the UK, while the opposite applies for the US. McCormick (1997) also discusses a recent trend of convergence of regional unemployment rates. One possible explanation, he claims, is that the erosion of unemployment benefits and union power has reduced the incentive to queue for jobs in less prosperous areas. Some studies conclude that explanations of unemployment differentials differ considerably across states. Based on US state unemployment data Partridge and Rickman (1997) find that the unemployment rate differentials primarily are attributable to equilibrium factors, but disequilibrium effects are found to play a strong role in some states.

3 The modeling framework

Our model incorporates elements both from the Harris-Todaro model and from the approach in Marston (1985). The workers consider both expected wage differentials and location-specific amenities in their choice of an optimal combination of job and residential location. An equilibrium solution appears when there are no further incentives for workers to move. To formulate an operational model and a stringent analysis it is necessary to introduce a set of simplifying assumptions on the geography, the population, the labour market, and the individual behaviour. In subsection 3.1 we account for the economic and geographical circumstances of our analysis, while aspects of the individual behaviour and the process towards equilibrium are left for subsections 3.2-3.3.

3.1 The basic set-up

We consider a geography with two areas A and B which are separated by a distance d. The geography has two groups of workers. A-workers are basically attached to area A, but they still might choose to reside in area B if job opportunities are better there. Similarly, B-workers are basically attached to area B, but that does not necessarily mean that they all live in area B. We further assume that workers are homogenous with respect to job qualifications, and that there is only one category of jobs. Demographic characteristics of the population are ignored. The jobs are assumed to be exogenously distributed between the two areas. Given this set of simplifying assumptions the population can be distributed into 12 distinct groups, according to their job situation, residential location and area attachment. This is illustrated in figure 1.

Work Residence	Area A	Area B	Unemployed
Area A	$L_{111}+L_{112}$	$L_{121}+L_{122}$	$L_{101}+L_{102}$
Area B	$L_{211}+L_{212}$	$L_{221}+L_{222}$	$L_{201}+L_{202}$

Figure 1: Distribution of workers among alternative locations and job situations.

We let L^0_{ijk} denote the initial number of workers in each category, where the indices are interpreted as follows:

- i is residential location: $i = 1$ in A and $i = 2$ in B.
- j is working category: $j = 0$ unemployed, $j = 1$ works in A, and $j = 2$ works in B.
- k is residential preference: $k = 1$ prefers A and $k = 2$ prefers B.

The system is equipped with a dynamic structure through the assumption that a fraction α of the workers is retired in each period. To keep the system stable, we then assume that a corresponding number of unemployed workers are recruited to the labour force. We keep track of these quantities by defining temporary categories l_{ijk} as follows:

$$l_{ijk} = \begin{cases} (1-\alpha)L^0_{ijk} + \sum_{j=0}^{2} \alpha L^0_{ijk} & \text{if } j = 0 \\ (1-\alpha)L^0_{ijk} & \text{otherwise} \end{cases}$$

Hence l_{ijk} denotes the resulting categories after retirement and recruitment.

To proceed further, we assume that wages and unemployment benefits are exogenously given, and we let W_j denote the wages in working category $j = 0, 1, 2$. The unemployment insurance is assumed to be equal in the two areas, and we impose the additional restriction that $W_0 < \min\{W_1, W_2\}$. We also assume that there is a fixed isotropic traveling cost κ (pr km) between the two areas.

As mentioned in the introduction the analysis to follow offers conditional results, ignoring possible equilibrating forces through wages or capital mobility. Still, it can be argued that our assumptions on wages and job distribution might be reasonable in some scenarios, at least if a relatively short term time horizon is considered. It is well known from standard macroeconomic theory that wage adjustments might be sluggish. This can be due to coordination problems and contracts in economies where wage-setting results from periodical negotiations between employers and labour unions. For such reasons Marston (1985) argues that exogenous shocks tend to show up in unemployment more than in wages. The spatial distribution of jobs can also be sticky in a short run time perspective. This can for example result from an active policy to maintain the number of jobs in different areas.

In addition we also ignore the fact that location choices often result from a decision process of a household with more than one job-seeker. Both the labour market situation and the residential site preferences might differ between members of a household.

Our approach is also implicitly based on the simplifying assumption that housing prices are completely inelastic with respect to the exogenous changes we consider, while the housing stock is perfectly elastic with respect to changes in the spatial population distribution. Housing market effects might reduce migration flows between geographic areas. As pointed out by Evans and McCormick (1994) especially low income groups might find it difficult to migrate from declining to growing areas. According to Evans and McCormick (1994) housing market conditions might also influence regional unemployment differentials through the impact on local consumption on other goods. They find from their data that changes in local household wealth influence local unemployment two years later. An alternative interpretation of our model is that it applies only for a group of workers, corresponding to a specific profession. In such a setting it is more reasonable to assume exogenously given housing prices and to ignore problems related to adjustments in the housing stock.

3.2 The search procedure

In each period the workers apply for jobs according to the following principles:

- Unemployed workers always apply for job in their area of residence. They apply for the other job as well if the wages net of commuting cost exceed the unemployment fee. If they get both jobs, they prefer the job with the highest wages net of commuting cost. On equality they prefer the job in their town of residence.
- Employed workers apply for job in the other area if the wages net of commuting cost exceed their present wages. They never apply for their own job.

Given the size of all the categories l_{ijk}, the wages W_j, the traveling cost K, and the distance d between the towns, it is then possible to determine the number of applicants to each of the two jobs. To determine the outcome of the application process, we next need to consider the number of vacant jobs.

Let $E_j, j = 1, 2$ denote the number of jobs in town A and B, respectively. The number of vacant jobs $EV_j, j = 1, 2$ can then be computed as follows:

$$EV_j = \sum_{i,k=1}^{2} \alpha L^0_{ijk} + E_j - \sum_{i,k=1}^{2} L^0_{ijk}$$

Here the first term represent vacancies due to retirement while the last two terms represent the jobs that are initially vacant.

According to our assumptions there is only one category of jobs, and the job seekers are homogeneous to the firms. As in the Harris-Todaro model it is then reasonable to assume that a periodic random job selection process exists whenever the number of available jobs is exceeded by the number of job seekers. For simplicity we have also assumed that a vacant position is only offered to one worker during a period. Hence if a worker get two job offers (this can only happen if the worker is unemployed), he turns down one of the offers which is then vacant in the next period.

3.3 Utility functions and the spatial equilibrium part of the construction

We now turn to the spatial equilibrium part of the construction. As in the Harris-Todaro model unemployment might represent an economically rational choice on the part of the individual migrant. In our model the benefits of residing in this area has to be weighed against expected costs related to the probability of not being offered a job here. To put themselves into a more favorable position *before* the application round, the workers can decide to move to the opposite town. The outcome of this process, however, depends on the actions of the other workers. If all workers move to the position with the highest wage, it is likely that unemployment flourish in that area, and the probability of being offered a job will be relatively low. Hence it might be favorable to reside in the other position. We now let p_{ijk} denote the probability that a worker residing in town i, working in category j, and with preference to k moves to the opposite town. We assume that all A-workers have identical utility functions

$$V_1 = \sum_{i=1,j=0}^{2,2} L_{ij1} W_j + \sum_{j=0}^{2} L_{1j1} \cdot A^+ - \sum_{j=0}^{2} L_{2j1} \cdot A^- - \sum_{j=0}^{2} L_{1j1} \cdot C_{12} \cdot p_{1j1} - \sum_{j=0}^{2} L_{2j1} \cdot C_{21} \cdot p_{2j1} \tag{1}$$

Here $\sum_{i=1,j=0}^{2,2} L_{ij1}W_j$ is the total wages for all A-workers. A^+ represents a monetary value for A-workers to reside in A. A^- denotes the disutility for A-workers to reside in B. Those variables represent the value of area attachment, or, in other words, the underlying residential site preferences. Such preferences can be argued to originate from two kind of sources. First, residential site preferences can be related to area-specific amenities and/or to the presence of cultural activities, shopping opportunities etc. Such amenities and activities might be positively related to the population density, and/or to the order in the central place system. Some variables, like crime, congestion, and other environmental disamenities, may be negatively related to the degree of urbanization. Our approach is less macroscopic than Marston (1985) concerning the explanation of residential site preferences. Climate is for instance not relevant in our study, since we have in mind regions with only insignificant variation in such amenities. The other source of underlying residential site preferences is individual-specific. Such preferences can be imprinted from childhood experiences at the place where one grew up, and/or explained through physical and social familiarity with a community. In their empirical studies of migration flows both Partridge and Rickman (1996) and Bentivogli and Pagano (1999) account for this kind of emotional attachment to an area. C_{12} is the cost of moving from A to B and C_{21} is the cost of moving from B to A. Correspondingly we assume that all B-workers have identical utility functions, given by:

$$V_2 = \sum_{i=1,j=0}^{2,2} L_{ij2}W_j + \sum_{j=0}^{2} L_{2j2} \cdot B^+ - \sum_{j=0}^{2} L_{1j2} \cdot B^- - \sum_{j=0}^{2} L_{1j2} \cdot C_{12} \cdot p_{1j2} - \sum_{j=0}^{2} L_{2j2} \cdot C_{21} \cdot p_{2j2} \tag{2}$$

In general we let workers move first, and then apply for jobs in each period. We assume that the objective for the A-workers is to optimize V_1, while the B-workers wish to optimize V_2. For both groups of workers this means a determination of the optimal residential location site, represented by the moving probabilities in the model. Optimal moving probabilities depend on their present residential location as well as on the general state of the system, represented by the number of workers in the 12 distinct groups that are illustrated in figure 1. Hence, there is an interactive and competitive element that calls for the specification of an equilibrium condition. This is taken into account in the technical description of our numerical algorithm. We start out with a more or less arbitrary initial residential location pattern. On the onset we put all $p_{ijk} = 0.5$. Keeping all p_{ij2} fixed, we let the A-workers choose all p_{ij1} to optimize V_1. Then fixing all p_{ij1} the B-workers update all p_{ij2} to optimize V_2. This process is then repeated for a number of times until the system comes to rest at an equilibrium solution. The final migration probabilities and the final states $L_{ijk} = L_{ijk}^N$ resulting from these probabilities are then defined to be the predicted equilibrium of the system.

The equilibrium moving probabilities are pertaining to an average response of the workers within each of the 12 categories of figure 1. Those optimal moving probabilities cannot categorically be interpreted at an individual level. The optimal moving probabilities might be mixed, in the sense that not all workers within a category will either move ($p_{ijk} = 1$) or stay in the relevant zone (($p_{ijk} = 0$). A mixed probability of for instance $p_{221} = 0.6$ means that A-workers with job and residence in area B initially prefer to move to area A. Still, not all A-workers move, the mixed probability has to be interpreted at an aggregate level. An intuitive explanation of the process can be as follows: Moving is a time-consuming rather than instant reaction to a suboptimal situation, and the time required to move within a period (one year) is individual-specific.

When A-workers start moving from area B to area A, however, the labour market conditions change in favour of area B. The mixed probability of 0.6 means that the A-workers with job and residence in area B evaluate the two areas as equally attractive when 60% of the workers in this category have moved to area B within a period. This specific case represents a partial line of arguing, but the general equilibrium solution reflect such competitive mechanisms. Hence, mixed moving probabilities represent a balance between competitive forces in the labour market, and they might appear as a part of an equilibrium solution if the time horizon, N, is relatively short. We will focus on the impact of the time horizon in subsequent sections.

As stated above an equilibrium solution should be interpreted at an aggregate rather than an individual level. An alternative interpretation of our model is to consider it as a game between the two groups of workers, in a setting where both A- and B-workers act collectively in the labour market. The model solution then corresponds to a Nash equilibrium. This interpretation, however, rests on the existence of a superior and coordinating unit that distributes the individuals between the 6 alternative categories, or, in other words, selects one of the microstates that corresponds to the aggregate Nash equilibrium solution. This interpretation in game theoretical terms might seem far-fetched, it would be more satisfying if the model construction was explicitly stated in terms of individual behaviour. Still, for the relevant kind of problems there is no reason to believe that a model specification based on individual decisions behaves qualitatively different from an aggregate model specification. If our model comes up with the conclusion that it is collectively rational that a group of workers move from an area, there is no reason to believe that the same would not follow from a process of individually rational decisions. Our approach is more according to a sort of an efficiency principle, where the workers are redistributed between alternative residential location areas as a response to changes in the relative labour market attractivity of the various areas. We consider the simplest possible scenario to account for spatial labour market competition, with only two areas and two groups of workers. Despite this simplicity, however, we think that our approach captures some fundamental mechanisms, and contributes with interesting input to important labour market issues.

4 Specification and interpretation of our scenario

In this section we specify the geographical characteristics and the economic conditions underlying our numerical experiments.

4.1 The benchmark situation

We assume a geography with two areas. Area A is the center of the geography, in the sense that the exogenously given number of jobs is higher in area A than in area B, and that the number of A-workers exceeds the number of B-workers. Yearly commuting costs increase proportionally with distance, $K = \kappa \cdot d$, where d represents the distance between the areas; $d = d_{AB} = d_{BA}$. Intra-area distances are ignored; $d_{ii} = 0, i = A, B$. We start out by considering a benchmark situation with the following set of values of parameters and exogenous variables: $W_A = W_B = 250000$ NOK, $W_0 = 200000$ NOK, $\kappa = 500$, $\alpha = 0.0125$, $A^+ = B^+ = 15000$, $A^- = B^- = 0$, $d = 70, C_{12} = C_{21} = 20000$. In addition we let $E_A = 70000$, $E_B = 30000$, which corresponds to the number of A- and B-workers, respectively.

Our benchmark situation represents a *balanced system*: the number of A- and B-workers corresponds to the number of jobs in area A and B, respectively, wages are equal in the two regions, moving and commuting costs are isotropic, and the value of the underlying residential site preferences are equal for the two groups of workers. An equilibrium solution was initiated from a more or less arbitrarily chosen distribution of the population into the alternative residential sites and job situations in Figure 1; $L_{ijk}, i = 1, 2, j = 0, 1, 2$, and $k = 1, 2$. A time horizon of $N = 5$ was specified. This results in a set of equilibrium values of the spatial population distribution which was next used as initiating values for a new sequence towards an equilibrium solution. This procedure was repeated until it produced a set of equilibrium values that reproduced themselves as the new equilibrium solution when they were used as initiating values for an iterated sequence of movement probabilities with time horizon of $N = 5$. Hence, our benchmark situation represents a steady state equilibrium solution, that results from a procedure of repeated and converging competitive equilibrium solutions.

One way to present simulation results is through the vectors:

$$(L_{10k}, L_{11k}, L_{12k}, L_{20k}, L_{21k}, L_{22k}), \qquad k = 1, 2$$

Our benchmark situation corresponds to the following equilibrium solution:

A-workers (281, 56923, 160, 0, 0, 12647)

B-workers (0, 12682, 0, 120, 252, 16935)

Based on such vectors it is straightforward to find equilibrium unemployment figures, commuting flows, as well as the distribution of employment and population between the two areas. For example unemployment in area A, $U^A = L_{101} + L_{102} = 281$, the number of commuters from area A to area B, $T_{AB} = L_{121} + L_{122} = 160$, while the population in area A, $N_A = L_{111} + L_{112} + L_{121} + L_{122} + L_{101} + L_{102} = 70046$.

The movement probabilities represent an interesting aspect of the equilibrium solution:

$$(p_{10k}, p_{11k}, p_{12k}, p_{20k}, p_{21k}, p_{22k}), \qquad k = 1, 2$$

In our benchmark situation the strategies of the workers are reflected through the following movement probabilities:

A-workers (0, 0, 1, 1, 0.8, 0)

B-workers (1, 0, 0.863, 0, 0.637, 0)

This equilibrium solution involves some mixed strategies. Notice particularly that B-workers with residence in area B and job in area A move by a probability of 0.637. The mixed strategy reflects a situation where the underlying residential site preferences and moving costs are traded off against commuting costs. The effect of area-specific amenities and moving costs work in favour of staying, while moving means that no commuting costs are involved in subsequent periods.

The equilibrium solution incorporates two other mixed strategies; ($p_{211} = 0.8, p_{122} = 0.863$). Intuitively the corresponding two groups of workers are expected to move by a probability of 1. Our results serve as an example that some probability estimates should be interpreted with care. The explanation of the somewhat contraintuitive estimates is related to numerical aspects rather than substantial features of the relevant problem: Notice from the equilibrium solution that no A-workers reside in region B unless they have a job there. Similarly, no B-workers are unemployed in region A, and no B-workers choose a residential location in region A if their job is in region B. With only very few workers appearing in a specific category, our numerical optimization procedure has an insufficient basis for estimating the corresponding movement probability. In such cases our procedure often degenerates in some coordinates. To obtain movement probabilities reflecting real behavioural effects rather than numerical aspects a simple device is to replace the zeros in the initial situation by some small positive numbers. An equilibrium solution then results where $p_{211} = p_{122} = 1$. It is important to notice, however, that the values of p_{211} and p_{122} have approximately no impact on utility levels and the equilibrium distribution of the workers into specific categories.

Except that $p_{212} = 0.637$, the equilibrium solution results from pure strategies. B-workers stay in area A only if their job is located there. Similarly, A-workers move from area A if their job is in area B, and they will not reside in area B unless this is where they have a job.

4.2 A categorization of the unemployment in the model

Notice from the equilibrium benchmark situation that 281 workers are unemployed in area A. At the same time there are (70000-(56890+12715+252)) 143 vacant jobs in this area. The situation is similar in area B. The fact that there are both unemployment and vacant jobs in the equilibrium solution might seem contradictory. The explanation is related to the dynamic structure of the model. First, all jobs that are vacant at the start of a period will in fact be occupied within the end of this period. At the same time, however, new jobs become vacant since some workers quit, to accept a job offer from a firm in the other area. In most cases there will not be applicants for all such jobs within the same period. Only in balanced and strongly polarized cases all vacant jobs are expected to be occupied within the same period. This applies to cases where the interarea distance is long, and the inhabitants in an area only consider jobs in the same area. In general, however, some of the vacant jobs will not be occupied until the subsequent period. Hence, some of the unemployment that results from model predictions is *frictional*, caused by the time involved when workers move into and out of jobs.

In addition to this frictional unemployment the model also incorporates one form of *structural unemployment*. In the literature structural unemployment is explained from mismatches of either skill or location in the labour market. In our model labour is assumed to be homogenous, but here is a spatial dimension that causes a problem of mismatching. To avoid costs related to commuting and moving workers want to reside in the area with the best prospects of being offered a job, ceteris paribus. This explains the interactive or competitive element of the problem. If there are few vacant jobs and many applicants in one area while the situation is the reverse in the other area, high structural unemployment might result. This kind of structural unemployment depends for example on distances between regions and on the level of the unemployment insurance.

In our balanced benchmark situation unemployment rates are calculated to be equal in the two areas; $u^A = u^B = 0.4\%$. In section 7 we will consider some cases that are not balanced, and we will see how persistent spatial unemployment differentials might result from scenarios where the relative attractiveness of areas is systematically changed.

To summarize this section, it is clear that our model incorporates specific forms of frictional and structural unemployment. Here is of course no elements of cyclical unemployment, which occurs when output is below its full-employment level.

5 Effects of some balanced changes in specific cost and benefit elements

A balanced change in exogenous variables means that the relative attractivity of the two areas is not disturbed. In this section we will consider the impact of such balanced changes on optimal movement probabilities and the location pattern. To be more precise we will now focus on effects of variations in moving costs, commuting costs, and the underlying residential site preferences. The values of those variables affect the strategic actions of the workers. In our benchmark situation we have for instance seen that $p_{212} = 0.637$. For other values of the exogenous variables the corresponding group of workers might interact by a pure strategy. Assume for example a situation where the underlying residential site preferences are higher, the moving costs are higher, and commuting costs are lower than in the benchmark situation. For B-workers with residence in area B and job in area A this makes the option to stay in area B relatively more attractive than it was in the benchmark situation. With a 20% change in the variables p_{212} changes from 0.637 to 1.0. Given the relatively short time perspective of $N = 5$ this leads to higher population in area B, and more commuting from area B to area A. To be more precise the system reaches the following state:

A-workers (302, 57103, 98, 0, 0, 12508)

B-workers (0, 11909, 0, 129, 746, 17205)

Notice the tendency of increased polarization, with more A-workers residing in area A while B-workers tend to be more concentrated to area B, compared to the benchmark situation. Notice also that more B-workers choose to reside in area B even if their job is in area A.

By changing the values of exogenous variables a wide range of equilibrium movement probabilities can be obtained. Assume for example a case where the only change from the benchmark situation is stronger underlying residential site preferences, $A^+ = B^+ = 30000$. This results in the following equilibrium movement probabilities:

A-workers (0, 0, 0, 1, 1, 1)

B-workers (1, 1, 1, 0, 0, 0)

Hence, all workers move from the area that they are not attached to, even if their present job is located in this area. The effect of area attachment and the prospects of being offered a job in the native area outweigh the effect of moving costs and expected commuting costs. This is reflected in the corresponding spatial residential pattern:

A-workers (1972, 61225, 6813, 0, 0, 0)

B-workers (0, 0, 0, 846, 7485, 21658)

Assume next a scenario that differs from the benchmark situation only with respect to commuting costs between the two areas. In our model commuting costs can be represented either by the distance between the regions or by κ, the travelling costs per unit of distance. A situation where commuting costs are twice as high as in the benchmark situation corresponds to either $d_{AB} = 140$ or to $\kappa = 1000$. In both cases the resulting spatial residential pattern is given by:

A-workers (0, 57916, 0, 0, 0, 12095)

B-workers (0, 12084, 0, 0, 0, 17905)

The nature of this state is very different from the benchmark situation, and from the case with strong area attachment. The individual strategies are now dominated by the wish to avoid commuting. In our balanced system this results in an equilibrium solution with no vacant jobs, no unemployment, and no commuting.

The fact that no unemployment and no commuting costs are involved does not necessarily mean that an equilibrium solution corresponds to a higher level of welfare than for example our benchmark situation. Aggregate utility also depends on how many workers that reside in the area that they are attached to. This is the reason why utility levels are found to be higher for both groups of workers in the case where $A^+ = B^+ = 30000$ than in the case where $d = 140$ (or $\kappa = 1000$). At the same time both those cases result in higher utility levels than our benchmark situation. Similar experiments illustrate how innovations in the transportation network might lead to increased unemployment and reduced welfare in cases where the time horizon is relatively short. It is important to remember, however, that such experiments are based on a model with a given number of homogeneous jobs and workers. We ignore the possibility that a better integrated region leads to a more efficient allocation of heterogenous labour. New labour market opportunities might also attract firms and workers to the region. In general, transport innovations might induce a process of growth in regional income, employment and population.

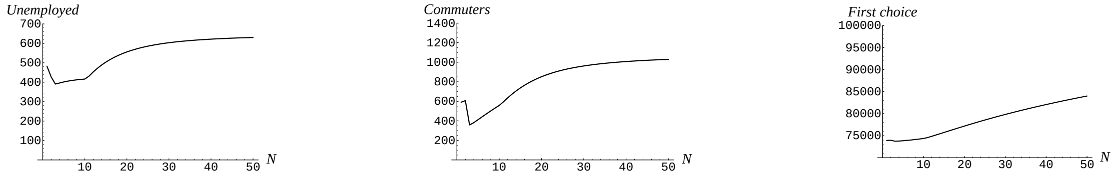
Though our model is simple the results certainly reflect real effects, proving that the impact of transportation innovations is more ambiguous than it is often claimed in the debate on such matters. Increased unemployment and reduced welfare might result when workers settle in positions involving commuting as a starting point in the competition for first-best altenatives, with job and residence in the preferred area. This results in an equilibrium solution with higher realization of the underlying residential site preferences than in a situation with long distance between the areas. With a time horizon of $N = 5$, however, this benefit is more than outweighed by higher commuting costs. In the next section we will see that this conclusion might be reversed if a longer term time horizon is considered.

6 Effects of varying the time perspective in balanced systems

We will now enter into a discussion of how the specification of N influences the equilibrium solution. As was clear from section 4, our benchmark situation also represents a steady state equilibrium, defined from a procedure with a sequence of repeated competitive equilibria. In each equilibrium state in this sequence the workers make their decisions according to a time horizon of $N = 5$ periods. In this section, on the contrary, we only consider cases where N represents both the planning horizon of the workers and the number of repetitions of optimal strategies in the sequence of events towards a competitive equilibrium solution. To avoid an excessive presentation of numbers, we restrict the description of the equilibrium solution to the following central quantities:

- Total unemployment $(L_{101} + L_{102} + L_{201} + L_{202})$
- The total number of commuters in the system $(L_{121} + L_{122} + L_{211} + L_{212})$
- The total number of workers realizing their first choice $(L_{111} + L_{222})$

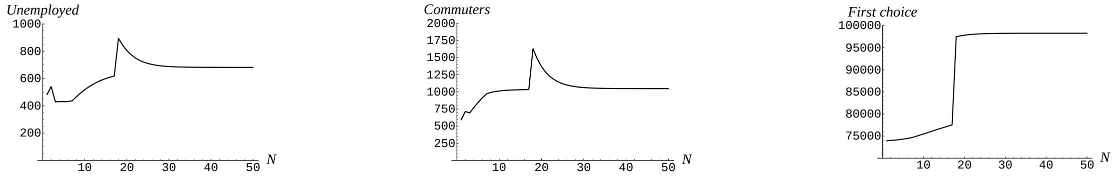
The responsiveness of these quantities with respect to N is illustrated in figure 2. Except from the variations in N this figure is based on our benchmark situation.



a) b) c)

Figure 2: The responsiveness of some central quantities with respect to N; the values of exogenous variables are according to the benchmark situation.

Figure 2 indicates that the number of unemployed and the number of commuters stabilize in increasing time horizon. Based on this figure we can not be sure, however, that the equilibrium solution converges towards a long term, steady state, solution as N is increased. Rather than extending N far beyond reasonable values we will discuss such matters by considering cases where the values of some exogenous variables are not the same that they were in the benchmark situation. We will first consider cases with shorter distance between the two areas. In figure 3 the distance is 50 between the two areas.

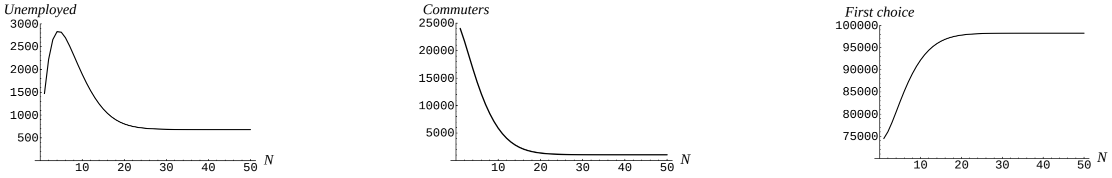


a) b) c)

Figure 3: The responsiveness of some central quantities with respect to N; $d_{AB} = 50$.

For very low values of N the nature of the equilibrium solution to some degree depends on the initial values of the variables L_{ijk}. This explains the irregularities for $N \leq 4$ in figure 3. For higher values of N the equilibrium solution is more or less independent of the initial state of the system, and the irregularities reflect the fact that the optimal strategies of the workers depend on the time horizon that is considered. The nature of the optimal strategies for instance changes substantially as N approaches 18 in this case with $d_{AB} = 50$.

If a long enough time perspective is considered, all workers will move from the area that they are not basically attached to. This applies for any values of the exogenous variables in the model. In the case with $d = 50$ optimal strategies are the same for all $N \geq 18$. This does of course not mean that unemployment, commuting and the population distribution is left unchanged if higher values of N is considered. With additional repetitions of the optimal strategies the equilibrium solution converges towards a steady state of long term equilibrium. We have seen from the figures 2 and 3 that the time horizon required to reach this long term equilibrium solution depends on the distance between the two areas. To make this point clearer figure 4 gives an illustration for the case where the distance is very short, $d_{AB} = 10$.



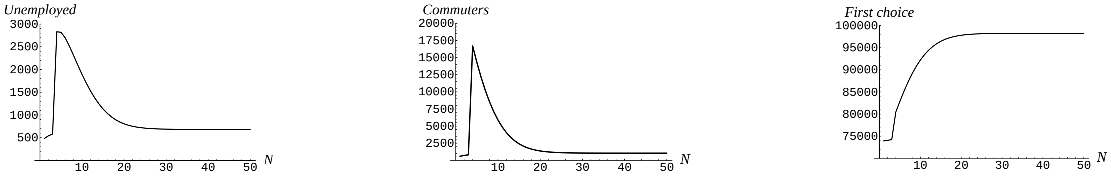
a) b) c)

Figure 4: The responsiveness of some central quantities with respect to N; $d_{AB} = 10$.

If distance (traveling time) is reduced a process of migration flows is generated working in favour of a location pattern where more workers are located according to their underlying residential site preferences. This process leads to a large increase in unemployment and commuting flows in the system if a short term time horizon is considered. At the same time, however, the curves converge a lot faster towards the long term equilibrium solution than in cases with longer distance. With $d_{AB} = 50$ we have seen that a time horizon of $N = 18$ periods was required to reach a situation where all workers apply the pure strategies that consist in staying in the area that they are basically attached to, and move from the other area. With $d_{AB} = 10$ such strategies are chosen even with a time horizon of $N = 1$, while 130 periods are required in the case with $d_{AB} = 70$. The graphs for any value of distance approaches the path corresponding to the case with $d_{AB} = 10$. The time horizon required to reach the steady state equilibrium solution is positively related to distance, but the nature of the long term equilibrium solution is independent of distance.

In figure 5 the values of the underlying residential site preferences are twice as high as in our benchmark situation. The time horizon required to reach a steady state equilibrium solution is then considerably reduced. The mechanisms are similar to the case with a short distance between the areas, and for $N \geq 5$ the curves in figure 5 overlap the corresponding curves in figure 4. In general, the speed of adjustment towards the long term equilibrium solution is determined by the balance between commuting costs, moving costs, and the benefits of realizing underlying residential site preferences. In a case where workers are not basically attached to a specific area, a long term equilibrium solution will develop where the two groups of workers are evenly distributed between the two areas. At the same time both unemployment and the level of commuting flows will be lower in this long term equilibrium solution than in the cases illustrated by figures 2, 3, 4 and 5. With no underlying residential site preferences involved the matching procedure is simplified and the structural dimension of unemployment is removed from the long term equilibrium solution.

The impact of transportation innovations depends on what time perspective that is considered. Figure 2 shows that unemployment is not very sensitive to the time horizon if the initial situation is according to our benchmark situation, where $d_{AB} = 70$. We have seen, however, that reductions in distance affect both individual strategies and the nature of the competitive equilibrium. To be more precise, more workers will move to the area of attachment even if they have no job in that area. If the time horizon is relatively short, we have seen in section 5 that this change in strategies results in



a) b) c)

Figure 5: The responsiveness of some central quantities with respect to N; $A^+ = B^+ = 30000$.

increased unemployment and reduced aggregate utility levels for both groups of workers.

For a longer term time perspective, however, those conclusions might be reversed. More repetitions of the optimal strategies will, however, work in the direction of a more favourable equilibrium solution where more workers have job and residence in the area of attachment, unemployment is low, and aggregate utility levels are high for both groups, relative to the initial situation.

In an evaluation of a road transportation investment project the short term losses represented by increased unemployment and reduced welfare has to be weighed against the longer term benefits. According to our model, however, the steady state equilibrium is independent of distance. The explicit time perspective required to reach this steady state level is positively related to the distance between the areas. If the interarea distance is relatively long also after the improvements in the transportation network, it will take a long time for the costs and benefits of the investments to materialize, and the steady state equilibrium has limited interest for the present generation of workers. Still, investments in road infrastructure are of course often motivated to serve other purposes than spatial labour market interaction. In addition one should keep in mind that the nature of the long term equilibrium solution might change if we for instance modified the simplifying assumption that both jobs and workers are homogeneous. We have, however, accounted for some relevant adjustment mechanisms, and we will not enter into a discussion of how our conclusions depend on the set of simplifying assumptions.

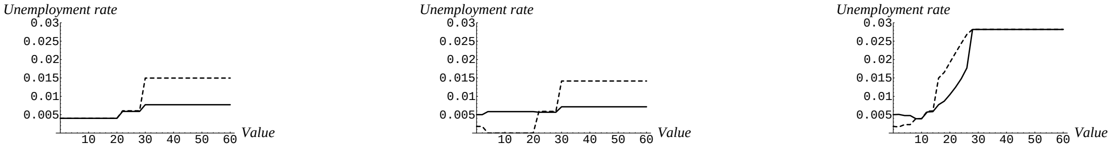
7 Simulation experiments focusing on unemployment differentials and labour market mobility

In this section we systematically change the values of exogenous variables that affect the relative attractivity of the two areas. Corresponding to each such unbalanced scenario we account for how the resulting labour market equilibrium solution depends on general factors like commuting costs (distance), the time perspective, and the unemployment insurance. In the simulation experiments to follow the results are compared to our benchmark situation. Some of the exogenous variables might seem to be more or less fixed, or at least very sluggish, in nature. It can be argued to be unreasonable to compare equilibria with very different values of variables like the underlying residential site preferences or the time horizon of workers. Remember, however, that the individual composition of the population changes due to the dynamics of our model. Hence, both preferences and behavioural aspects might change considerably over time.

7.1 A case with asymmetric underlying residential site preferences for the native area

In this subsection we will systematically vary the monetary values of the underlying residential site preferences of A- and B-workers. Assume first a case where $B^+ = 15000$. In part a) of figure 6 we systematically and partially vary the underlying residential site preferences of A-workers, without specifying whether the variations are due to native area attachment or amenities related for instance to the degree of urbanisation. In all the figures to follow the dashed curves represent the peripheral area.

According to figure 6 a) the unemployment rate will be the equal in the two areas unless A-workers have underlying residential site preferences exceeding a monetary value of about 28000. For higher values of A^+ the unemployment rate will be constantly higher in the peripheral area B. Before we enter into an explanation, consider parts b) and c) of figure 6. Part b) of the figure corresponds to a situation where B-workers have no underlying residential site preferences for any area, $B^+ = B^- = 0$. Part c) represents an experiment where both groups of workers are attached to their respective native areas, but $A^+ = 2B^+$. This can for example be due to different individual-specific evaluation of urbiculture versus rural life.



a) $B^+ = 15000$ b) $B^+ = 0$ c) $A^+ = 2B^+$

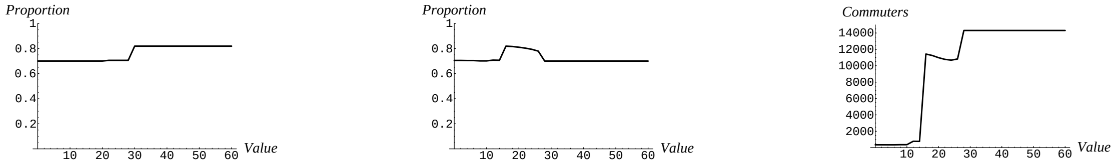
Figure 6: Cases where the underlying residential site preferences of A-workers are systematically varied. Value in 1000 NOK.

Based on the following observations we will now explain some characteristic features of the simulation experiments illustrated in figure 6:

Observation 1: For low values of both A^+ and B^+ it follows that $u_A > u_B$. Why will not net migration flows from area A to area B operate as an equilibrating force in such cases? First, notice that unemployment is in general low, and that moving only marginally changes the probability of being offered a job. Hence, residential location decisions are dominated by the moving costs. If at least one of the groups has a rather strong area attachment, however, those moving costs will not explain area-specific unemployment disparities. Part a) of figure 6 illustrates that $B^+ = 15000$ is sufficient to ensure that unemployment rates are fully equalized for low values of A^+.

Observation 2: For intermediate values of A^+ it follows from all three parts of figure 6 that $u_B > u_A$. According to part a) of figure 7 the proportion of the workers residing in area A will increase from about 0.7 to 0.82 if $A^+ > 30000$. In fact, the net increase in migration from area B to area A accounts for the complete difference in unemployment rates between the two areas. For example, the segment where $u_A > u_B$ in part c) of figure 6 is explained by the variations in the spatial residential pattern of workers in part b) of figure 7. The spatial labour market equilibrium is achieved through commuting flows. This is illustrated in part c) of figure 7, which corresponds to the situation where $A^+ = 2 * B^+$, as in figure 6 c) and figure 7 b). To understand how underlying residential site preferences influence the spatial labour market equilibrium, it is important to consider a modelling framework where the two relevant forms of spatial interaction is simultaneously taken into account.

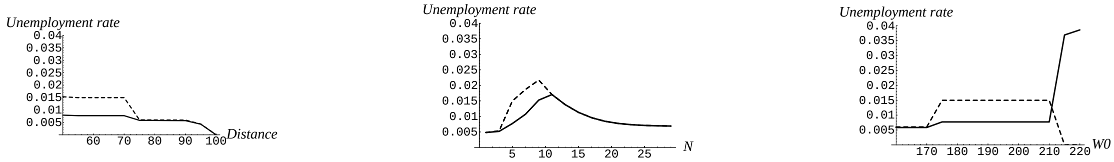
Observation 3: If both groups have strong, but not necessarily equal, underlying residential site preferences, the unemployment rates will be equal in the two areas. This is illustrated in part c) of figure 6 for the scenario where $A^{+} = 2B^{+}$. In cases with high values of both A^{+} and B^{+} a more polarized equilibrium solution will be reached where A- and B-workers to a larger degree tend to reside in their native areas. At the same time there will be a more even distribution of residents between the two areas than in the case where B^{+} is low. Notice also from parts c) of the figures 6 and 7 that unemployment will be high in cases where both groups have strong basic residential site preferences, and that the labour market will be equilibrated through substantial commuting flows.



a) $B^{+} = 15000$ b) $A^{+} = 2B^{+}$ c) $A^{+} = 2B^{+}$

Figure 7: The impact on the proportion of the workers residing in area A, and on commuting flows, of systematic variations in underlying residential site preferences. Value in 1000 NOK.

Except from cases where both groups have insignificant underlying residential site preferences, we have seen that the observed unemployment rates will either be equal in the two areas, or the unemployment rate will be lowest in the area for which the native inhabitants have the strongest basic residential site preferences. Such results might be specific to the numerical simulation experiments that we have considered. We will now discuss the impact of some exogenously given variables that appear to be neutral with respect to the balance between the areas. In figure 8 we focus on the effects of the distance between the areas, the time perspective, and the unemployment insurance in a case where $A^{+} = 30000$ and $B^{+} = 15000$.



a) b) c) W_0 in 1000 NOK.

Figure 8: Effects on area-specific unemployment rates of varying d_{AB}, W_0 and N in the case where $A^{+} = 30000$ and $B^{+} = 15000$.

According to figure 8 a) the unemployment rate differential will be the same for any $d_{AB} < 70$. If $d_{AB} \geq 75$, $u_A = u_B$. A long distance means that options involving commuting flows become less attractive, and an equilibrium solution will be reached where the residential location pattern corresponds to the spatial distribution of jobs. Similarly, a long term time perspective ($N > 11$) means that an equilibrium solution will be reached with equal unemployment rates in the two areas, see part b) of figure 8. In such cases a more polarized location pattern will be developed, where A- and B-workers to a larger degree tend to reside in their native areas.

The reservation wage of the workers is in general positively related to the unemployment insurance. This explains why the unemployment will be high in cases with high values of the unemployment insurance. In such cases workers get relatively more concerned with their residential location than by their labour market status. In figure 8 A-workers are more attached to their native area than B-workers. According to part c) of the figure high values of W_0 result in an equilibrium solution with considerable unemployment in area A, and no unemployment in area B. Contrary to the other cases with significant area attachments this unemployment rate differential is not explained by migratory changes in the labour stock. Hence, this represents an exception from the rule that cases with asymmetric and significant residential site preferences do not generate equilibrium solutions where the unemployment rate is highest in the area subject to the strongest area attachment. Partridge and Rickman (1996) find that states characterised by many inhabitants living in the same residents for at least five years have greater unemployment rates. To the degree that this variable represents an attachment to the native area our analysis does not support such results. Residential location decisions might also, however, be explained by the presence of area-specific amenities. Such cases are addressed in the forthcoming subsection.

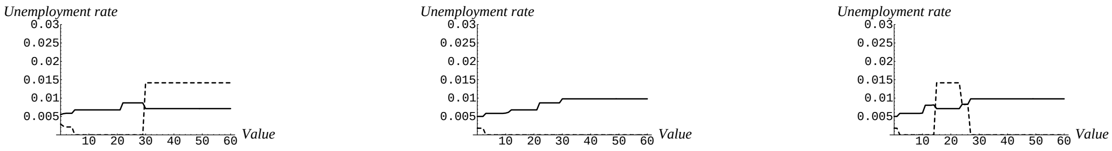
7.2 A case with amenities located in the regional center

We will now consider cases where the presence of different kinds of amenities dominates the effect of native area attachment. Still, the evaluation of the amenities might differ between the groups, and the attachment to their native areas might also differ. The net effect, though, is that both groups of workers are basically attracted to the same area. To be more precise, we assume that the presence of amenities are positively related to the degree of urbanization, and that both groups have underlying residential site preferences in favour of area A.

Marston (1985) argued in favour of a situation where unemployment rates tend to be highest in areas with attractive amenities. One ambition of this paper is to offer explanations for such observations. In subsection 7.1 we have seen that unemployment rates will in general not be according to Marston's hypothesis if at least one of the two groups are more attracted to their native area than to the location of attractive area-specific amenities.

In figure 9 a) the B-workers are assumed to have residential site preferences for area A corresponding to a monetary evaluation of 15000. According to the figure the unemployment rate will be highest in the regional center, area A, if A-workers have a low or intermediate monetary value of the amenities in area A. Notice for instance that $u_A > u_B$ if A-workers for some reason are less attached to the amenities than B-workers. In cases where A-workers are strongly attached to area A, however, it follows from figure 9 a) that the unemployment rate will be highest in area B. Without goint into details and illustrations the explanation is a relocation of the labour stock from area B to area A, combined with an increase in the number of unemployed in area B. An equilibrium solution will be induced where area A has a higher proportion of inhabitants than of the jobs in the region. Corresponding to this pattern there are substantial commuting flows from area A to area B.

Figure 9 b) represents cases where all the workers in the geography have the same monetary evaluation of the amenities in the regional center. In those cases the main conclusion is unambiguous: unemployment is highest in the regional center, where the amenities are located. According to our simulation experiment the unemployment rate



a) $B^- = 15000$, varying A^+

b) $A^+ = B^-$

c) $A^+ = 2B^-$

Figure 9: Cases with amenities located in the regional center. Value in 1000 NOK.

differential is positively related to how strong the underlying residential site preferences are. We also find that a net migration from area A to area B results if the monetary value of the underlying residential site preferences exceeds a specific limit. This is illustrated in figure 10 a), while the accompanying effect on commuting flows is illustrated in part b) of the figure.

a)

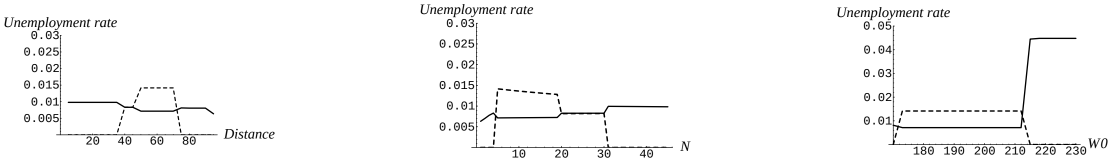
b)

Figure 10: The impact on the proportion of workers residing in area A and on commuting flows of varying the monetary evaluation in the case where $A^+ = B^-$. Value in 1000 NOK.

Figure 9 c) illustrates the results of a numerical experiment where the underlying residential site preferences in favour of area A are twice as strong for A-workers as for B-workers. This can be argued to represent an adjustment related to the attachment to the native area. The figure illustrates that no unambiguous conclusion applies for the unemployment differentials in this scenario. For some intermediate values of $A^+(= 2B^-)$ the net effect of commuting costs, the probability of being offered a job, and the underlying residential site preferences results in strategies that induce an equilibrium solution where $u_B > u_A$. Outside this interval of intermediate values, however, the relevant kind of asymmetric preferences results in an equilibrium solution with no unemployment in area B, see figure 9 c).

Like in subsection 7.1 we have also now carried through some simulation experiments of how a specific equilibrium solution is influenced by the distance between the areas, the time perspective, and the unemployment insurance. In figure 11 we consider a case where $A^+ = 30000$ and $B^- = 15000$, while $A^- = B^+ = 0$.

Assume first that only the underlying residential site preferences differ from the benchmark situation. This means that $d_{AB} = 70$, $N = 5$, and $W_0 = 200000$. This results in an equilibrium solution where $u_A \approx 0.7\%$ while $u_B \approx 1.4\%$, see figure 9 for an illustration. According to figure 11 a) this situation changes if the distance between the two areas is somewhat longer. Longer distance makes the option with residence in area A and job in area B less attractive. This results in changed strategies and an equilibrium solution where $u_A > u_B$. If the distance between the two areas gets even longer the costs of commuting get prohibitive, and an equilibrium solution will be reached with no commuting flows and no unemployment. In such a case the spatial distribution of



a) b) c) W_0 in 1000 NOK.

Figure 11: Effects on area-specific unemployment rates of varying d_{AB}, W_0 and N in the case where $A^+ = 30000$ and $B^- = 15000$.

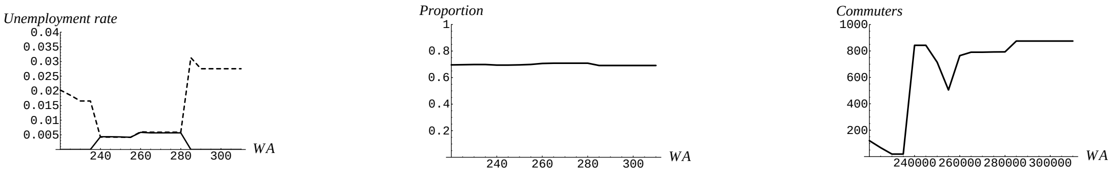
inhabitants will correspond to the distribution of jobs between the areas.

If the interarea distance is short, solutions involving commuting costs are relatively more attractive, and relatively more weight is put on the residential location. According to figure 11 a) no unemployed workers will reside in area B if $d_{AB} \leq 35$ in the case where $A^+ = 30000$ and $B^- = 15000$. Correspondingly, we find that 84% of the inhabitants in the region reside in area A, while about 13200 workers commute from area A to area B.

If workers have a short time horizon of $N \leq 4$ the combination of commuting costs and job prospects dominates the effect of the underlying residential site preferences. For example, A-workers will definitely stay in area B if their job is located there. With a longer time horizon, however, the optimal strategy of A-workers will be to move from area B, independent of their job status. This contributes to a relocated labour stock in favour of area A, reducing the prospects of getting job offers in this area. Hence, labour market considerations make area B relatively more attractive. This explains the unemployment in this area. The fact that $u_B > u_A$ for $5 \geq N < 20$ reflects a relocated labour stock rather than better job prospects in area A than in area B. If the time horizon extends beyond 20 periods an equilibrium solution results where the job prospects are best in area B, to balance the effect of the location-specific amenity. For very high values of N, equilibrium solutions will be reached where area B has no unemployment. The impact of variation in the unemployment insurance is similar to the case that is illustrated in figure 8 c).

7.3 The impact of spatial wage differentials

In section 2 we have seen that the Harris-Todaro model focuses on the effects of the rural-urban wage differential. This differential explains high urban unemployment as well as rural-urban migration that reduces job prospects and the expected wage in the urban area. Similar mechanisms are taken into account in our modeling framework, but we will see that this does not necessarily result in higher unemployment rates in the area with high wages.



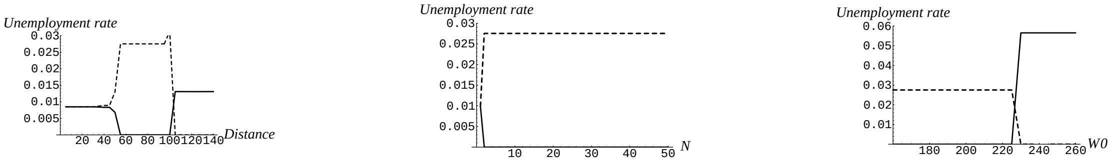
a) b) c)

Figure 12: The impact on area-specific unemployment rates, the residential location pattern, and commuting flows of varying the wage in the regional center. W_A in 1000 NOK.

Figure 12 is based on a numerical simulation experiment where the wage in area A, W_A is systematically varied, while the values of all other parameters and exogenous variables are kept as in our benchmark situation. Consider first the cases where $W_A < 285000$. It follows from part a) of figure 12 that equilibrium solutions will then develop where the unemployment rates are either equal or highest in the area with highest wage. At first sight, it might seem more surprising that our model predicts $u_A = 0$ and considerable unemployment in area B in cases where $W_A > 285000$. This is not according to results based on the Harris-Todaro model, and it also contradicts the empirical findings in Partridge and Rickman (1996), where wage differentials are found to be positively related to the unemployment rate. This calls for an explanation.

It is reasonable that discontinuous changes is predicted in optimal strategies and in the equilibrium solution when W_A passes 285000. The spatial wage differential ($W_A - W_B$) exceeds the costs of commuting between area A and area B when $W_A > 285000$. All unemployed workers and all workers with a job in area B will then apply when jobs become vacant in area A. Workers who receive a job offer enter into a new category, and move to area A in the subsequent period. In this respect there are no differences between A- and B-workers, and to some degree A-workers will be expelled from area A, reducing the proportion of workers residing in the area that they are attached to. The important point is, however, that the probability of receiving job offers from area A is considerably reduced. Hence, the expected wage in area A will be reduced, and this balances the system in an equilibrium solution with no unemployment in area A, while the spatial population pattern will be according to the spatial distribution of jobs, see part b) of figure 12. Our model further predicts that there will be 875 commuters from area B to area A in cases with $W_A > 285000$. At first sight, this might also seem to be an odd result. The explanation is related to the dynamic structure of our model; 1.25% of the workers retire in each period. This means that 875 jobs get vacant in area A during a period. Those jobs will be occupied by job-seekers residing in area B, who are registered as commuters until they move to area A in the subsequent period.

Figure 13 a) illustrates results from a numerical experiment where the distance between the areas is systematically varied in a case where $W_A = 300000$. If $d_{AB} > 100$ the commuting costs between the areas will exceed the wage differential, and this changes the optimal strategies and the equilibrium solution. To be more precise, no unemployed workers will reside in area B, and the unemployment will be highest in the high-wage area, as in the Harris-Todaro model. Figure 13 a) also shows that $u_A = u_B$ if the interarea distance is short; the labour market will then be equilibrated through considerable commuting flows. Due to our rigid assumptions on job distribution, wage setting, area attachment, and housing prices the spatial residential pattern is more or less autonomous to variations in the interarea distance.



a) b) c) W_0 in 1000 NOK.

Figure 13: Effects on area-specific unemployment rates of varying d_{AB}, W_0 and N in the case where $W_A = 300000$.

For low values of N equilibrium solutions to some degree depend on the initial state of the system. Ignoring this effect, however, figure 13 b) illustrates that the influence of wage differentials on the spatial variation in unemployment is independent of the time perspective. Once again, we find that high unemployment insurance work in favour of an equilibrium solution with higher unemployment in the regional center than in the peripheral area B, see figure 13 c). Contrary to previous cases, with no spatial variation in wages, such an equilibrium solution now appears for values of W_0 that are considerably lower than W_A, though they do not differ much from W_B.

7.4 An exogenous redistribution of labour demand between the areas

In section 2 we have seen that the literature distinguishes between equilibrium and disequilibrium variables when regional unemployment differentials are explained. So far our discussion has ignored the possibility of disequilibrium shocks that redistribute labour demand between the areas. In this section we discuss possible effects on unemployment and spatial interaction of employment growth in the regional center. This growth is assumed to be distributive, in the sense that it is based on a relocation of firms from area B to area A. Such a relocation might for instance be explained by the underlying residential site preferences of owners, or by the potential of realizing economies of scale and scope. In this paper we will not, however, enter into an analysis of how the location pattern of firms is determined.

Assume that 5000 jobs are redistributed from area B to area A. This means that $E_A = 75000$ and $E_B = 25000$. Consider first the case where the values of all other exogenous variables are according to our benchmark situation. The resulting equilibrium solution is then:

A-workers (805, 62775, 6431, 0, 0, 0)

B-workers (0, 11909, 0, 345, 180, 17556)

The most appearant change from our benchmark equilibrium solution (see section 4.1) is that no A-workers reside in area B. The interarea redistribution of jobs has induced a considerable migration flow from area A to area B, accompanied by a commuting flow in the other direction (6431 workers commute from area A to area B). The corresponding optimal strategies are:

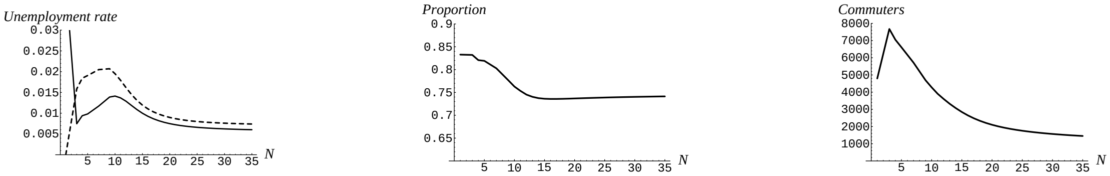
A-workers (0, 0, 0, 1, 0.689, 1)

B-workers (1, 0, 1, 0, 0, 0)

Hence, neither A- nor B- workers will move from the area they are attached to, irrespective of their job status.

This equilibrium solution means that 81920 workers reside in area A while 18080 workers reside in area B. The unemployment rate is highest in area B: $u_A = 0.98\%$, $u_B = 1.91\%$. This is according to Partridge and Rickman (1996), who find that unemployment is negatively related to disequilibrium employment growth. Similarly, Evans and McCormick (1994) based their approach on the observation that UK regions with employment growth do not typically experience rising relative unemployment. Marston (1985), on the other hand, put more weight on supply side mechanisms, and starts out from the observation that unemployment tends to be high in expansive areas. Marston (1985) explains this as a result of location-specific attractive amenities and workers' preferred location. No such asymmetric residential site preferences are taken into account in the case above.

Hence, the reason why the unemployment *rate* increases considerably more in area B than in area A is the spatial redistribution of the labour stock.



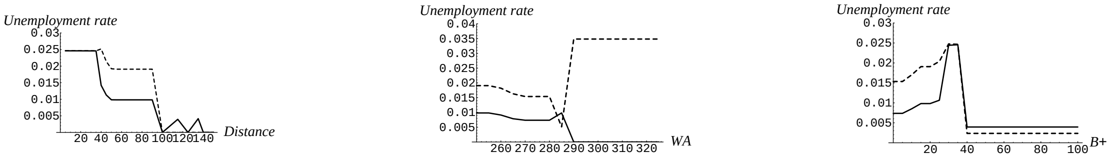
a) b) c)

Figure 14: The responsiveness of some central quantities with respect to the time horizon, N, when $E_A = 75000$ and $E_B = 25000$.

Consider next cases with an extended time horizon; $N > 5$. A migratory adjustment process will then find place, where the distribution of the labour stock approaches the spatial distribution of job opportunities. This is illustrated in figure 14 b). Part a) of this figure illustrates that structural unemployment is reduced when the system develops towards a long term equilibrium solution with improved spatial matching of job supply and demand. At the same time the adjustments in the spatial distribution of the labour stock lead to reduced spatial unemployment differentials. Still, $u_B > u_A$ also in the long run, steady state equilibrium solution for the asymmetric system where the number of jobs in area A exceeds the number of A-workers. Notice in addition that a more balanced system involves reduced equilibrating commuting flows, see figure 14 c).

Figure 14 illustrates that the structural unemployment is high if the time horizon is short. The redistribution of jobs affects the optimal residential location decisions even if the time horizon is very short. This explains the high unemployment in area A for $N \leq 2$. Hence, the immediate response is that unemployment increases most in the area that experiences employment growth.

If $d_{AB} \geq 100$ we find that an equilibrium solution develops where all workers live in the area where they work, even for the relatively short time horizon of $N = 5$. In such cases a redistribution of jobs is followed by migration flows, and neither results in structural nor frictional unemployment in the system (see figure 15). This corresponds to observations from the US economy, where employment shocks are found to be reflected in migration flows (see Decressin and Fatás 1995). Figure 15 further illustrates that the redistribution of jobs will not induce unemployment differentials between the areas if the distance is short. The labour market will then be balanced through commuting flows.



a) b) c)

Figure 15: The impact of the redistribution of jobs on area-specific unemployment rates for alternative values of d_{AB}, W_A, and B^+. W_A and B^+ in 1000 NOK.

According for instance to the Harris-Todaro model expansive areas are expected to offer high wages. Part b) of figure 15 illustrates that an equilibrium solution will be reached where all unemployment is concentrated to the lagging area B. Similar to the discussion in section 7.3 the explanation is related to the fact that there will be a very high number of applicants for vacant jobs in area A. Hence, the expected wage in area A will be low, and no workers want to reside here unless they have a job in the area. This represents a mechanism that is not taken into account in other approaches to explain spatial unemployment differentials, and it is not consistent with the hypothesis that high wage is compensated by high unemployment in an equilibrium solution. Figure 15 c) illustrates that the unemployment differential resulting from the redistribution of jobs will be insignificant if B-workers are strongly attached to their native area. Notice also that $u_A > u_B$ in such a case.

8 Summary of results and concluding remarks

Based on a spatial equilibrium simulation approach our main motivation has been to study how spatial unemployment disparities are influenced by area-specific asymmetries and exogenous shocks. For this purpose we introduced a set of rather restrictive assumptions. We have for example ignored the possibility that asymmetries and shocks might influence relative wages, housing prices and/or capital mobility. The equilibrating forces in our approach are represented by labour mobility, and we have focused on how spatial unemployment disparities are related to migration and commuting flows. In general our numerical simulation approach captures mechanisms relevant also in a more comprehensive spatial equilibrium analysis, and we think that our analysis contributes with important and nontrivial insight to labour market issues. First, we considered balanced systems, with equilibrium solutions where the unemployments rates are equal in the two areas.

According to our simulation experiments the system develops towards a steady state equilibrium solution with some unemployment and commuting if the time perspective is long. In this long term equilibrium solution most workers reside in the area that they are attached to. The time perspective required to reach a steady state equilibrium solution is positively related to the degree of area attachment and negatively related to the distance between the areas. If workers are strongly attached to their native area a polarized equilibrium solution develops, where the two groups are not residentially integrated. In a short term time perspective such an equilibrium solution might involve considerable unemployment and commuting flows.

If the workers act according to a very long time horizon a steady state equilibrium solution will develop that is independent of the distance between the areas. Ignoring the possibility that the system initially is in such a state, we find that transportation innovations in a short term time perspective lead to an equilibrium solution with increased commuting, increased unemployment, and reduced aggregate welfare of the workers. The innovations initiate a process, however, resulting in increased aggregate welfare. Long term benefits have to be weighed against short term losses and investment costs.

A lot of interesting labour market problems appear in systems that are not balanced. Through simulation experiments we have reached the results listed below on the unemployment rate differential between the regional center A and the more peripheral area B. The values of exogenous variables not mentioned at each point are assumed to be as in our benchmark situation.

a) Unemployment disparities might exist if both A- and B-workers have low, but asymmetric, underlying residential site preferences for their native area. In such cases moving decisions are dominated by cost factors, and unemployment disparities will at least not be eliminated by migration flows within a relatively short time horizon.

b) If only A-workers are strongly attached to their native area, the unemployment *rate* will be highest in area B. This reflects a changed residential location pattern of the labour stock. The labour market is equilibrated though commuting flows.

c) If both groups are strongly, but asymmetrically, attached to their native area, a polarized equilibrium solution results where the unemployment rate is equal in the two areas.

d) If the distance is long between the two areas, options involving commuting are less attractive. In such cases the unemployment rate will be equal in the two areas, even if one of the groups are strongly attached to their native area. Similarly, unemployment rates in the two areas tend to be equalized if workers make their choices according to a long time horizon, or if the unemployment insurance is low. If the unemployment insurance is very high, unemployment will be concentrated to the area that is subject to the strongest attachment from native inhabitants.

e) If both groups of workers are equally strongly attracted to an amenity in area A the unemployment rate will unambiguously be highest in area A.

f) If the attraction towards area A is different for the two groups of workers, the direction of the unemployment differential is ambiguous. Equilibrium solutions might develop where the labour force is concentrated to area A, and $u_B > u_A$. If both groups are either strongly or weakly, but not necessarily equally, attracted to area A, however, $u_A > u_B$.

g) Equilibrium solutions where $u_B > u_A$ can only develop if the time horizon, the distance between the areas, and/or the unemployment insurance do not deviate substantially from our benchmark situation. Once again, the unemployment will be concentrated to area A if the unemployment insurance is very high.

h) Assume that the distance between the areas does not deviate considerably from our benchmark situation. If the wage differential exceeds the costs of commuting between the two areas, an equilibrium solution then develops where all unemployment is concentrated to the low-wage area.

i) If the interarea distance is short, the unemployment rates will be equal in the two areas, and the labour market will be equilibrated through commuting flows. In cases with long distance the wage differential will in general not exceed the commuting costs. Unemployed workers will then prefer to reside in the high-wage area, while the low-wage area has no unemployment. If the unemployment insurance is high relative to the wage in the low-wage area, unemployment will be concentrated to the high-wage area.

j) Consider a distributive growth process where jobs are relocated from area A to area B. This results in an equilibrium solution where a higher proportion of the labour force resides in area A, and $u_A > u_B$.

k) The immediate response is that structural unemployment increases most in the area that experiences employment growth. In situations with a long time horizon the system approaches a steady state equilibrium solution with improved matching of job supply and demand. Structural unemployment and unemployment rate differentials will be reduced, but $u_B > u_A$.

l) If the distance between the areas is long (for example 100 km rather than 70 km as in our benchmark situation), workers choose to live in the area where they work, and a redistribution of jobs neither results in structural nor frictional unemployment. If the distance is short the redistribution results in relative high, but equal, unemployment rates in the two areas.

m) Assume that firms in the expansive area A offer considerably higher wages than firms in area B. An equilibrium solution will then be reached where all unemployment is concentrated to the lagging area B.

n) If B-workers are strongly attached to their native area, a redistribution of jobs from area B to area A will only result in an insignificant unemployment differential.

The attractiveness of an area for residential purposes is for instance positively related to the presence of amenities, the wage level, and to what proportion of the jobs in the region that is located in the area. According to our numerical simulation experiments an attractive area will not unambiguously experience higher unemployment rate than a less attractive area. The direction of the unemployment rate differential depends on the source of attractivity. For example we find that the unemployment rate will be highest in the attractive area if both groups of workers are equally strongly attracted to the presence of a location-specific amenity. This corresponds to the discussion in Marston (1985). If the attractive area in addition experience employment growth and increasing wages, however, no general conclusions can be drawn on the spatial unemployment differential. We will not enter into a more detailed discussion of how different combinations of exogenous variables affect the spatial unemployment differential, our main ambition has been to focus on effects of partial changes. In a comprehensive study of regional economic problems it is important to account for the fact that unemployment rates often area poor directing devices of the economic situation of an area. Our analysis has for example illustrated that a low-wage, lagging area *might* experience lower unemployment rates than an expansive area. In a comparison to other approaches it is in general important to notice that we take the possibility of equilibrating commuting flows explicitly into account. Hence, the discussion in other approaches relates to the cases where we consider distances long enough to rule out options involving commuting as a realistic alternative.

It is certainly possible to modify and extend our modeling framework in a lot of directions. One possible modification is to account for equilibrating price mechanisms in a scenario where area-specific wages and housing prices depend endogenously on the labour market situation and the migration flows. Some studies also modify the assumption of a uniform wage level within a region. Migration decisions might depend on spatial differentials in both the level and the variability of wages, see for instance Bentivogli and Pagano (1999), where wages are assumed to be normally distributed, with different region-specific mean and variance. Heterogeneity of wages and career opportunities represent an important factor when spatial labour market interaction is to be explained. Similarly, it is of course possible to account for heterogeneity of workers, for example with respect to their attacment to a specific amenity or to their native area.

Bentivogli and Pagano (1999) find null response of migration flows to unemployment differentials in European nations. One possible explanation is countercyclical changes in the labour force participation rates. Variations in the participation rate might of course be relevant also when a geography of regions, or areas, within a nation is considered. Still, we have ignored such variations, and focused on the role of commuting flows as a form of equilibrating spatial interaction. Our study has made clear that migration, commuting and unemployment differentials are closely related, and empirical studies should be carried through where the two forms of spatial interaction are simultaneously taken into account.

References

[1] Bentivogli, Chiara and Patrizio Pagano, 1999, "Regional disparities and labour mobility: the Euro-11 versus the USA", LABOUR 13 (3) 737-760.

[2] Decressin, J and Fatás A, 1995, "Regional labor market dynamics in Europe", *European Economic Review* 39:1627-1655.

[3] Evans, Philip, and Barry McCormick, 1994, "The new pattern of regional unemployment: Causes and policy significance", *Economic Journal* 104, pp. 633-647.

[4] Harris, John R. and Michael P. Todaro, 1970, "Migration, unemployment and development: A two-sector analysis", *American Economic Review* 60, 126-142.

[5] Marston, Stephen T. 1985, "Two views of the geographic distribution of unemployment", *Quarterly Journal of Economics*, vol. 100, pp. 57-79.

[6] McCormick, Barry, 1997, "Regional unemployment and labour mobility in the UK", *European Economic Review* 41, pp. 581-589.

[7] Partridge, Mark D. and Dan S. Rickman, 1996, "The dispersion of US state unemployment rates: the role of market and non-market equilibrium factors", *Regional Studies*, Vol.31.6,pp. 593-606.

[8] Partridge, Mark D. and Dan S. Rickman, 1997, "State unemployment differentials: equilibrium factors vs. differential employment growth", *Growth and Change*, Vol. 28, pp. 360-379.

[9] Partridge, Mark D. and Dan S. Rickman, 1999. "Which comes first, jobs or people? An analysis of the recent stylized facts", *Economic Letters* 64, 117-123.