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Discussion paper

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An agent-based computational approach to explaining persistent spatial unemployment disparities *

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Abstract

This paper explores possible reasons for persistent spatial unemployment disparities using agent-based computational methods. The method relies on observing the actions of thousands of individuals within an artificial society. The paper models the effect of unemployment insurance, wage disparities, region specific amenities and innate residential preferences on regional labour market interactions, accounting for both migration and commuting. An empirical example of Rogaland county in south-west Norway is given, where unemployment disparities have proved remarkably persistent for decades. The model provides non-trivial insight into the nature of spatial unemployment disparities as well as making a valuable contribution to the policy debate.

1 Introduction

It is well known in the literature that unemployment rates tend to vary systematically between regions. For example, Partridge and Rickman (1996) found significant levels of dispersion in US state unemployment rates in the 1970s and early 1990s. Evans and McCormick (1994) studied changes in the regional pattern of unemployment in the UK since the 1970s. Utilising results from OECD-studies, they begin their analysis with the observation that regional unemployment differentials have been strikingly persistent for a very long period, both in the UK and in other OECD countries.

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In their seminal work, Blanchard and Katz (1992) discuss mechanisms which should operate to close such disparities: migration, firm relocation and wage adjustments. In some cases, as in the empirical example presented in their paper, such mechanisms work and disparities are low. However, the existence of persistent disparities in many countries requires an alternative explanation. The main explanations centre either around frictions in the process of adjustment or some kind of equilibrium explanation for disparities.

The problem with the current literature (reviewed by Elhorst, 2003)is that approaches tend to focus on only one explanation at a time and tend to ignore either migration or commuting in order to provide a model simple enough for analysis. This is potentially a major weakness in such approaches as the limitations imposed on their conclusions are not clear. It is the ambition of this paper to simultaneously model migration, commuting, frictions in the equilibrating forces and equilibrium explanations of regional unemployment rates. Due to the fact that even a large number of simplifying assumptions would leave an analytical model completely intractable, a micro-simulation model is used (for reviews discussions of computational methods see, for example, Testfatsion (2001, 2003) or Epstein (1999)).

A two region economy populated by an artificial society of heterogeneous, utility maximising agents is simulated as a base to conduct various experiments. The aim of these experiments is to ascertain the relative strength of various factors in the adjustment process as well as to gain an understanding of when and why persistent unemployment disparities arise. The agents in the model are realistic in that they will be born, age, marry, divorce, give birth, retire and die. Conditional probabilities of such events occurring will be based on Norwegian statistical data in order to incorporate as many real world features as possible. Agents will be able to apply for work in either region in the economy and will be free to choose whether to migrate or commute. They will also be able to choose not to work at all. The outcome of this decision will depend on the utility function of the individual and, if appropriate, their family.

An empirical example will be provided to compare with the output of the model. The example of spatial unemployment patterns in south west Norway are used. Disparities in this area have been highly persistent. Possible explanations for this will be discussed using the output of the simulation model.

2 Regional unemployment disparities

A brief review of the literature on spatial unemployment disparities will be presented in this section to provide a foundation for the model presented later. Spatial unemployment disparities can be divided into two main types: equilibrium and disequilibrium disparities. Equilibrium disparities can be divided into two types based on different traditions in the literature: expected wage explanations (Harris and Todaro, 1970) and amenity based explanations (Marston, 1985). This paper will construct a framework which is capable of modelling all of these explanations in a context where both commuting and migration are possible.

2.1 Disequilibrium unemployment disparities

The best model to describe disequilibrium differentials is provided by Blanchard and Katz (1992) in their seminal work on spatial unemployment disparities in the US. In this model disparities are quickly eliminated by migration flows, firm relocations and wage adjustments. However, there is significant evidence from many countries that disparities are not eliminated quickly and persist in the long run. The main reason for persistent differentials in this framework would be frictions in the system preventing the equilibrating mechanisms from working.

2.1.1 Migration

The main evidence on migration comes largely from the US and Europe with results which differ significantly. For example, Puhani (2001) studied labour mobility within the European Union and found that migration did not play a significant role in the adjustment of the economy following a regional shock. Fidrmuc (2004) found that while wage differentials are statistically significant in determining the flow of migrants in the EU transition countries, the overall effect of the migration is negligible. Decressin and Fátas (1995) compared Europe to the US and found that changes in relative labour demand tend to be met by migration in the US but that in Europe they are met with changes in the participation rate. Bentivogli and Pagano (1999) also compared the US and EU. They found that migration is much more influenced by wage differentials in the US than in Europe. In the EU, migration is more sensitive to a wage risk factor measured by the variability of income than in the US. They also found that migration is unresponsive to rising unemployment in Europe but not in the US.

2.1.2 Firm relocations

Considerably less research has been undertaken with the aim of understanding firm relocation decisions. Maoh and Kanaroglou (2007) provided a recent review of the literature on the subject. Some of the main points are that firms prefer to stay in their present location if possible (Bade, 1983), fairly significant regional deficiencies are required to induce a firm to move (Van Wissen 2000) and that the main determinates of moving decisions are internal factors (Brouwer et al, 2004). Maoh and Kanaroglou (2007) also found that when most firms moved, they tended to move only a short distance, usually within the same region. They also found that it tended to be small firms which moved. This suggests that the percentage of jobs which moved as a result of firm relocation decisions would be small. Alternative theoretical explanations of firm behaviour are presented by van Dijk and Pellenbarg (2000) in which firms are less responsive to local labour market conditions. Diamond and Simon (1990) even find evidence that many firms prefer to locate in high wage cities in order to benefit from agglomeration effects. This makes the exact relationship between firm relocation decisions far more complicated than the one posited in the Blanchard and Katz (1992) framework.

2.1.3 Wage flexibility

A significant amount of research has taken place to establish how flexible wages are in response to shocks. Jimeno and Bentolila (1998) examined the problem of persistent regional unemployment in Spain between 1976 and 1994. They found that wages were very unresponsive to any regional economic conditions, including unemployment. They believed this was caused by union power and centralised wage setting. In a study of differences between EU regions, Abraham (1996) found that wages showed little sign of adjusting after a shock and that inter regional migration was very low compared to the US. In a more recent study, Buettner (2007) found that it took the old EU-15 countries around twice as long to adjust to a shock as the new EU accession countries. Siebert (1997) also concluded that wages in the EU failed to adjust and that this is the caused by sclerotic labour market institutions.

2.2 Equilibrium unemployment disparities

Rather than assuming that disparities will be closed in the long run, this class of models considers situations where an economy will reach an equilibrium state with potentially large spatial disparities present.

2.2.1 Expected wages

Harris and Todaro (1970) describe disparities as arising from differences in the expected wage rather than absolute values of unemployment and wages. Their work takes place in the context of developing economies although is also relevant in other cases. They model a two sector economy where workers can choose to migrate from a low unemployment rural area to a high unemployment urban area. In the model, the wages in the urban sector are higher than in the rural sector. People may choose to migrate from the rural to urban despite the higher level of unemployment in the urban sector because the expected wage is higher in the urban sector. The key point here is that even though the risk of unemployment is higher, migration is optimal because this is compensated for by higher wages. Only when the expected wage is equal in both sectors does migration cease. This equilibrium does not require an even distribution of unemployment or equal wages in both regions.

2.2.2 Amenity theories

In the model developed by Marston (1985), rather than considering the wage rate alone, workers consider the total utility of living in a particular area. Their utility is a function of wages, as in the traditional approaches, but also of the area amenities or characteristics. In this model, a worker may choose to live in an area with high unemployment because they are compensated by the amenities offered by the region. For this reason, it would be expected that a region with high amenity value would have a higher unemployment rate and therefore lower expected wages.

3 The Model

This section develops the micro-simulation model on which the paper is based. In this style of model there is no top-down structure imposed. Instead, rules governing individual behaviour are defined and then agents are free to interact within these rules. These rules are set out in this section.

The first stage in the process is to define an initial population. In this case, the starting level of 5,000 was chosen. Each individual has the following attributes: sex, age, marital and parental status, place of birth, current address, work location, salary and utility parameters. In order to ensure that the population evolves beyond its initial starting point, the system is run over a period of 500 years before stabilising at a "normal population", i.e. a population with a reasonable number of people in every age group. This first initiation phase is run without letting any agents take up employment. These steps are run on a monthly basis for every agent in the model with the conditional probabilities of the events occurring based on Norwegian data.

3.1 Birth, marriage, divorce, ageing, work and death

Any adult woman in the model can give birth with the probability of doing so being conditional on age. The birth rate was based on Norwegian data with a slight adjustment made to achieve a stable population level suitable for experimentation. The sex of a child is determined randomly. If the woman is not married, the father is drawn randomly from the population of single men.

Children are converted to adults when they reach the age of 15. At the age of 70, people are retired. Adults can marry, divorce, have children and apply for work. Mortality rates are based on standard life insurance tables, using Gompertz-Makeham's law (Gompertz, 1825; Makeham, 1867) i.e. that the death intensity of a man of age x is given by the function:

$$\mu = \alpha + \beta c \text{ where } \alpha = 0.9, \beta = 4.4 \cdot 10^{-5} \text{ and } c = 1.10154 \tag{1}$$

These are the values that are commonly used by Norwegian insurance companies. Death rates of women are adjusted by a 3 year age correction. The death rates we have used in the simulation are hence conditional on both age and sex.

Every month, any unmarried agent can get married with the probability being conditional on age, sex and previous marital status. Spouses are drawn from the population of single people, with those living in the same region more likely to be selected. Candidates living in the opposite zone have their chances degraded by the function:

$$\max\left[-e^{\text{marriagedeterrence}\cdot d}, 0.01\right] \tag{2}$$

where d is the distance between the zones. The system does not allow large age differences; a woman cannot be more than 5 years older or 15 younger than a man. The spouse moves to the same address as their partner and brings any children with them. Married adults can be divorced with probabilities being conditional on age and sex.

Any adult can apply for work. In this paper we consider a simplified situation with homogeneous jobs and workers and where the salary is allowed to vary between the two zones. An agent only applies for work if they will experience a net gain in utility. Successful applicants are randomly selected with unfilled vacancies carried over to the next period. No workers are fired in the mode with vacancies only becoming available when workers move, retire or die.

3.2 Utility considerations

Each individual is equipped with a utility function $U_{\alpha\beta}$ of the form:

$$U_{\alpha\beta}(V, W) = (V + \Omega)^{\alpha} W^{\beta} \tag{3}$$

Here V is a monetary component while W represents a location preference. The parameter Ω represents the willingness to pay for a location-specific amenity attached to a region. The amenity can for instance be related to an attractive coastline, clean air, the presence of cultural activities, more diversified labour market opportunities, or the accessibility to administrative services. Theoretically, Ω could also be negative, representing crime rates, congestion, or other environmental disamenities. As a simplifying assumption the monetary evaluation of this amenity is equal for all citizens in the economy, though this assumption can easily be relaxed. For most of the experiments to be reported in this paper $\Omega = 0$. Residential site preferences may, however, also be related to the place of birth, that is to childhood experiences as well social familiarity with a community (Partridge and Rickman 1997). This kind of location preference is defined by the expression:

$$W = e^{-\gamma d} \tag{4}$$

where d is the distance to the individual's place of birth. The parameters (α, β, γ) quantify the strength of the preferences. The distance deterrence parameter γ is constant for all individuals with the same place of birth, but can differ between zones. The parameters α, β quantify how much weight an individual puts on money versus location. These parameters are drawn randomly at birth. In this paper we assume that α and β are independent and uniformly distributed over the interval (0.5, 1). Other types of utility functions and other choices for the distribution of parameters are of course possible.

3.3 Movement

Every individual in the model considers moving, on average, once per year. If an agent considers moving, the system compares the utility offered by the available alternatives. This utility consideration is based on the probability of obtaining work in the two zones, determined by averaging unemployment rates over the previous 12 months. This determines two probabilities, p_1 and p_2. The workers are myopic and assume that these probabilities are constant in the future. Based on these probabilities, agents calculate their expected total salary given their expected total lifetime. Each possible salary is discounted at a rate of 7% and multiplied by the probability that he or she obtains that particular salary (net of commuting costs).

3.3.1 Example of moving decision utility comparison

Assume that a person with age t is unemployed, let w_0 denote unemployment insurance and let w_1 and w_2 denote the salaries (net of commuting costs) in the two zones. If $w_0 < \min[w_1, w_2]$ and $w_1 < w_2$, can the transition matrix, M, be computed as follows:

$$M = \begin{bmatrix} 1 - p_1 - p_2 + p_1 p_2 & p_1 - p_1 p_2 & p_2 \\ 0 & 1 - p_2 & p_2 \\ 0 & 0 & 1 \end{bmatrix} \tag{5}$$

The expected salary S_i after i years is then given by the expression:

$$S_i = \left(M^i \begin{bmatrix} w_0 \\ w_1 \\ w_2 \end{bmatrix} \right)^{(1)} \tag{6}$$

where the superscript 1 means that the first component of the vector inside the brackets is computed. Retirement takes place after the individual has reached 70 years of age. The total expected salary is then given by the expression:

$$V_0 = \sum\nolimits_{i=0}^{70-t} S_i \cdot e^{-\rho i} + \sum\nolimits_{i=70-t+1}^{T_t} S_{70-t} \cdot e^{-\rho i} \cdot 0.66 \tag{7}$$

Here S_{70-t} is the expected salary at the time of retirement. In Norway the pension is typically 66% of that value. T_t is the expected remaining lifetime of a person of age t. The value of T_t is computed using Gompertz-Makeham's law. The individual then computes:

$$V_0 = \sum\nolimits_{i=0}^{70-t} S_i \cdot e^{-\rho i} + \sum\nolimits_{i=70-t+1}^{T_t} S_{70-t} \cdot e^{-\rho i} \cdot 0.66 - m_r \tag{8}$$

where m is the cost of moving to the applicable region. This redefines the salaries net of commuting cost, so all the components in Equation (6) must be updated. An individual considering moving computes the monetary values V_0 and V_1 above. Then he or she computes location values W_0 (using present address) and W_1 (using alternative address). The next stage is to compute the two utility values $U_{\alpha,\beta}(V_0, W_0)$ and $U_{\alpha,\beta}(V_1, W_1)$. If the person is unmarried, he or she decides to move if $U_{\alpha,\beta}(V_1, W_1) > U_{\alpha,\beta}(V_0, W_0)$. If the person is married, however, the same calculation is carried out for the spouse. The results are added and the couple moves if the alternative location provides a larger total utility. The utility of both spouses is given equal weight.

3.4 Wages and job creation/destruction

The initial population was generated from a situation with exogenously given values for the spatial distribution of wages and basic sector activities. It is not, however, always reasonable to consider wages to be insensitive to employment shocks. Some of the literature discussed shows that wages can vary in response to shocks. Economic theory certainly suggests that they should, so it is important that this is modelled here. Wages are assumed to behave according to the following expression:

$$w_i^{(t)} = w_i^{(t-1)} \left(1 + \frac{U_i^{(t)} - U_i^{(t-1)}}{U_i^{(t-1)}}\right)^{-\mu}, \mu > 0, i = 1, 2 \tag{9}$$

where w is the wage and U is the number of unemployed people. The subscript i denotes the region while μ models the sensitivity of wages to changes in the level of unemployment. The expression corresponds to a standard specification of the Phillips curve. In our numerical experiments it is set to a value of 0.1. This is based on the work of Blanchflower and Oswald (1994,1995) and their wage curve which gives an empirical relationship between changes in unemployment and wages.

It is also possible to model wages as exogenous where they do not respond to local economic conditions. There are several reasons justifying such an approach. One is that such a situation corresponds to a New Keynesian style framework where wages are inflexible due to rigidities in the system such as union power and centralised wage setting. In such an economy, adjustments would have to take place through employment and output changes rather than through wage changes. Another reason is that the assumption of exogenous wages gives us the opportunity to study partial effects of other exogenous changes, and to identify the direction and strength of other competitive mechanisms, that may initiate price adjustments in, for instance, the labour market. Finally, it is straightforward to verify that persistent spatial wage disparities are observed in many economies. The literature provides several explanations of such observations, based on relationships that are not endogenously accounted for in our approach. Combes et al. (2008) distinguish between three broad sets of explanations for such observations. One strand of explanation focuses on differences in non-human endowments (for instance due to a favourable location, climate, or natural resources). A second alternative focuses on interactions-based explanations and the division of labour. Wages may be higher in thicker labour markets with a greater division of labour, and easier matching of skill and labour demand (see Combes et al. 2008). Another type of interactions-based explanation is found in the "new economic geography" literature, where the clustering of production activities typically results in a net effect of increasing returns, transport costs and agglomeration economies in specific production sectors. This literature contributes spatial equilibrium models where wage disparities typically depend on transportation costs between the regions, see for instance Fujita et al. (1999). Alonso-Villar and Chamorro-Rivas (2001), for instance, argue that knowledge-based industries tend to clustered in one region, while more traditional industries are located in other regions, where wages are lower in scenarios with relatively low transport costs between the regions. As a third explanation of spatial wage disparities Combes et al. (2008) focus on spatial differences in the skill composition of the workforce.

The opportunities for employment are split into two parts: the local sector and the basic sector. The number of jobs in the local sector is endogenous to the model. The size of the local sector in a region is proportional to its population, as is always assumed in economic base theory. No workers are fired and there are no vacancies until workers retire or find alternative work. The number of basic sector jobs can be treated as endogenous or exogenous to the model (as with wages). When they are modelled as endogenous, they respond to changes in wages in the model as follows:

$$B_i^{(t)} = B_1^{(t-1)} \left(1 + \frac{w_i^{(t)} - w_i^{(t-1)}}{w_i^{(t-1)}}\right)^{-\eta}, \eta > 0, i = 1, 2 \tag{10}$$

Where w is the endogenous wage (see Section 3.4) and η models the sensitivity of jobs to changes in the wage. This elasticity is set to unity in the model. When wages are exogenous, the number of basic sector jobs is effectively exogenous since wages do not change over time. We also ignore the impact of other factors that may influence location decisions of basic sector firms systematically. It would be possible to introduce a stochastic component to this mechanism to introduce friction into the system although this is not included here.

3.5 Preparing the model for experimentation

Before experimenting with the model it was necessary to ensure that the system was stable so that comparisons could be made. If, for instance, the population was falling and a negative shock hit, the effects, with respect to unemployment rates, would tend to cancel each other out. This would complicate the analysis.

One of the key variables of interest is the distance between the two regions in the model. These distances have two effects. Firstly, they increase the cost of commuting between the regions. Secondly, they increase the psychological costs of moving. In total, 5 different distances were modelled: $20, 50, 80, 110$ and 140 kilometres. A separate initial population was needed for each of these systems since the development of the population will depend, in part, on the distance between the two regions. When trying to select a birth rate which would give a system with a stable population, it was observed that a rate which was stable for a system with 140 km between the zones would not give stable population for a system with 20 km between the zones. After some investigation, it was discovered that this was caused by the stochastic processes in the model. Different outcomes were observed depending on what random numbers were generated. This would not be problematic were it not for the fact that the aim of the study is to compare how different systems respond to a shock. If the systems are different to start with, then it is difficult to make such comparisons. Different sets of random numbers were used for each system so that the population was stable. This meant that the population used in each experiment was not identical, even though the rules governing their behaviour were the same.

At first this may seem strange, as it would be expected that in order to draw valid comparisons everything should be identical in all models except for the distance between the zones. Rather than this being a weakness it is a strength of the approach as stochastic processes are present in the real word. If each population is thought of as a separate economy, then the process equates to studies which compare economies which have certain things in common. Examples of doing this in order to draw comparisons can be found many times in the literature. For example, Weiler (2005) compared how West Virginia and west German labour markets responded to shocks because "aggregate joblessness is similar in the two areas" (pp. 441-442). Bornhorst and Commander (2006) examined the causes of regional unemployment persistence in transition countries because all of these countries have certain things in common.

At the end of this process, each economy had a population of around 18,000 divided approximately equally between both regions. The number of jobs in each region was defined in such a way as to give unemployment rates of around 5% to represent the natural rate of unemployment. Different sizes of populations were experimented with. With small populations, stochastic processes can tend to dominate and the results can be slightly unstable. As the population increases, the system becomes more stable. After a certain point, the only effect on increasing the number of agents is an increase in the computational resources required to run the model. A population of 18,000 seems more than sufficient to obtain a stable system.

4 Simulation experiments

The aim of this paper is to understand how unemployment differentials between regions arise and why they persist over time. In order to achieve this, the model economy developed was subjected to a number of shocks, and the response of the unemployment rates in both regions monitored for a 20 year period. The response of the economy to the shocks was monitored with different levels of friction in the system. One of the main ways in which this was modelled was by changing the distance between the zones. Firstly, this increases the cost of commuting to a job in the opposite zone. Secondly, it increases the utility cost of moving since an individual has a preference to live in the zone in which they were born.

The shock modelled in this paper is the removal of 1000 jobs (25% of basic sector employment) from Region 1. As no workers in this model are fired, these jobs are removed through natural wastage i.e. workers retiring, moving or dying. This means that it takes some years for the shock to take full effect. This effect would correspond to a country where employment law prevents workers from being fired. It would be possible to model a situation where workers lost their jobs immediately. This would raise the question of which workers should lose their jobs. It could be random, or based on tenure or age (operating as proxies for human capital). This is unimportant in the current context since it is the equilibria before and after the shock which are of primary interest.

The parameters to be changed along with their default values are: unemployment insurance (300,000 NOK pa); wages in Region 2 (400,000 NOK pa); the cost per km of commuting (2.5 NOK); the willingness to pay for the amenity in Region 1 ($\Omega = 0$) and the strength of the residential site preference ($\beta \sim U[0.5, 1]$). In order to allow the effect of the shock to be monitored, the model will be run for the initial 100 year period with all of the parameters at the default level, the model will then be run for a further 10 years with a parameter change and then the system will be shocked and monitored for 20 years. This should allow the effect of the parameter change and the shock to be separated.

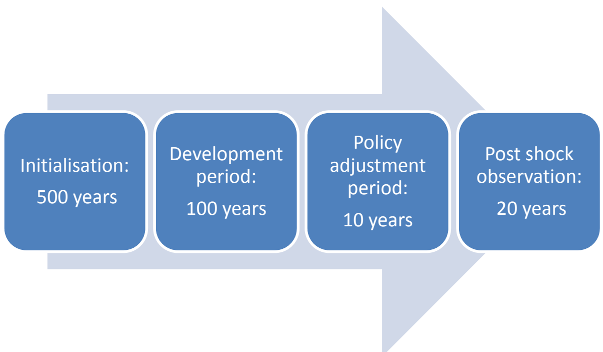
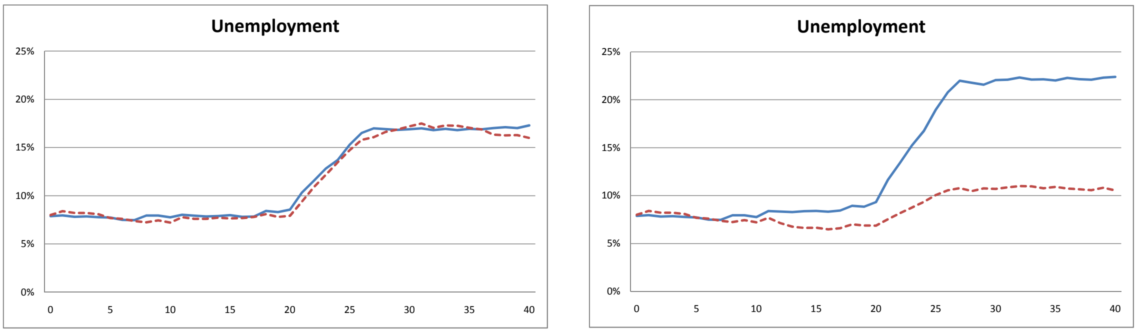


Figure 1: The time line of the model.

4.1 The effect of varying unemployment insurance

The effect on the adjustment process to the shock was monitored for unemployment insurance rates of 200,000, 250,000, 300,000 and 350,000 NOK. Changes to the level of unemployment insurance had no significant effects in the system with 20 km between regions. This is since the cost of moving or commuting is so low that it is beneficial to take action to gain employment even if the excess of wages over unemployment insurance is small. The system with a distance of 50 km did not respond significantly to a decrease in the level of unemployment insurance but increasing it to 350,000 NOK caused a substantial unemployment disparity to appear when the employment shock was introduced, see Figure 2 (the 80 km system behaves in a similar way).



(a) 300,000 NOK (b) 350,000 NOK

Figure 2: The effect of a change in Unemployment Insurance: 50 km between Regions with 1000 jobs removed from Region 1 (unbroken line) in year 20.

While these results appear simple and highly intuitive, they are underpinned by extremely complex behaviour at the micro level. In Figure 2(a), the minor unemployment disparities which emerge are purely disequilibrium and are quickly eliminated in the style of the Blanchard and Katz (1992) model. In Figure 2(b), an equilibrium disparity emerges which is not eliminated even in the long run. The nature of this disparity is complicated and can only be understood by utilising the work of Harris and Todaro (1970) and Marston (1985).

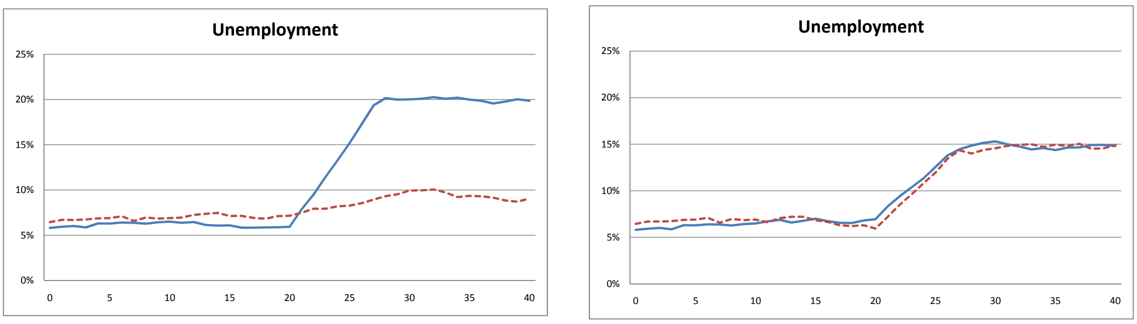
It is helpful to consider part of the logic which individuals in the model use. An unemployed agent, living in Region 1, who has applied for work and who cannot migrate has an annual expected wage of:

$$E[Y] = \Phi + (1-u_1)(w_1-\Phi) + (1-u_2)(w_2-\Phi-C_{12}) - (1-u_1)(1-u_2)(w_2-\Phi-C_{12}) \quad (11)$$

where Y is income, Φ is unemployment insurance, u_i is the unemployment rate in Region i, w_i is the wage rate in Region i and C_{12} is the cost of commuting from Region 1 to Region 2. This exact equation is not part of the model but is useful as an explanatory device. Firstly, the agent can always claim unemployment insurance so this appears in their expected earnings. The probability of obtaining work in their region of residence decreases as the unemployment rate in that region rises. The marginal benefit will be equal to the excess of wages over the unemployment insurance payment. In this case, it will always be positive because wages are assumed to be exogenous meaning that the worker will always take an available job in the region in which they live when wages exceed unemployment insurance. The marginal benefit of taking a job in the alternative region is always lower since commuting costs must be incurred to access this labour market. The agent will only take a job in this region if the wage is greater than unemployment insurance payment plus the cost of commuting. At a certain point as the unemployment insurance rises, employment in the opposite region becomes unattractive and drops out of the equation. This reduces the expected income from being in employment. The agent will now only accept a job in the home region. This explains why the commuting mechanism fails to close the disparity once the unemployment insurance rate rises.

Of course, people are free to migrate in this model. This means that once commuting becomes unattractive, people can leave the region and access the labour market in the opposite region. This would be attractive when the disparity in Figure 2(b) emerges and increases the expected wage in Region 2. There is indeed some adjustment and the unemployment rate in Region 2 rises slightly in response to the shock in Region 1. The adjustment is very small however and not enough to close the gap. There are two explanations for this lack of migration. The first is frictional e.g. there are moving costs of 100,000 NOK in the model which provides some discouragement to moving. This disequilibrium explanation is not capable of explaining the persistent disparity observed. To understand what is happening, Marston's amenity theory must be employed. Most of the residents in Region 1 were also born in Region 1. In the simulation model, agents prefer to live in the region in which they were born. The strength of this preference varies from person to person. This amounts to saying that these people have a willingness to pay to live in their birth region. It is this amenity (which benefits the agent over their whole life) which inhibits migration and stops the adjustment of the economy rather than the one-off moving cost. In this situation, even though there is a large disparity, everyone is maximising their utility. Region 1 residents trades off the increase in the expected wage which they could achieve by migrating against the amenity value of living where they were born. This is an equilibrium solution and can persist in the long term.

Figure 3 shows the same mechanism working in the opposite direction in the case of the 110 km system. There is an unemployment disparity with an unemployment insurance rate of 300,000 NOK, as shown in Figure 3(a). When the insurance rate is reduced to 250,000 NOK, only disequilibrium disparities are present. The 140 km system behaves in a similar way to the 110 km system, though a larger reduction in the unemployment insurance is required to give a sufficiently large incentive for people to migrate or commute to obtain work. In effect, this incentive creates a net benefit from commuting and hence reintroduces it into the workers' expected wage considerations.



(a) 300,000 NOK (b) 250,000 NOK

Figure 3: The effect of a change in Unemployment Insurance: 110 km between Regions with 1000 jobs removed from Region 1 (unbroken line) in year 20.

There is evidence of these kinds of effects in the literature. Meyer (1990) and Bover et al. (2002) found that as the level of unemployment insurance rose, the duration of a unemployment spells increased. This was since workers became more selective about which job offers they would accept, as with the workers in the simulation model. Meyer (1990) showed that when agents knew their period of eligibility was coming to an end, they were more likely to find work. This, along with results from the simulation model, suggests that economies with lower levels of unemployment insurance should experience lower regional disparities as there are incentives present to induce people to move or commute to obtain employment.

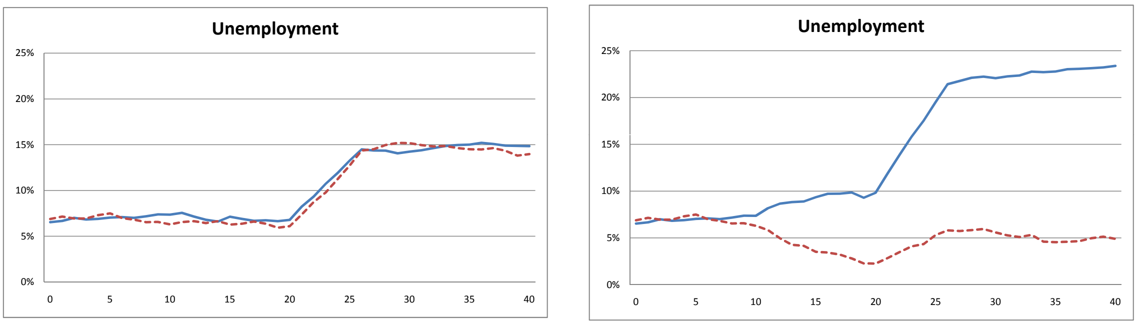
In the model presented in this paper, this unemployment spell can continue *ad infinitum* since there is no limit to how long people can claim the benefit. It was decided to model in this way for two reasons. Firstly, in many countries when the period of unemployment insurance comes to an end people are transferred to some kind of social insurance. The continuation of unemployment insurance in the model presented here accounts for this. Secondly because modelling this way significantly reduces the complexity of the model while still offering useful insights.

4.2 The effect of a wage disparity

The effect of a wage disparity on unemployment differentials was monitored. The wage rate in Region 2 was changed from 400,000 NOK to 375,000, 425,000 and 450,000 NOK. In the systems with 20 and 50 km, none of the wage disparities that was introduced created an unemployment disparity. This is due to the low cost of moving or commuting between the regions.

When wages are equal in both regions in the 80 km system, there is no unemployment disparity, and this also applies to cases where the wage rate in Region 2 is increased. When the wage rate in Region 2 is lowered to 375,000 NOK, a large disparity opens up between the regions, as shown in Figure 4. This disparity begins as soon as the wage is lowered but is greatly exacerbated when the employment shock hits Region 1. The unemployment rate in Region 2, however, remains very low and is even slightly lower than it was before both the shock and the wage change. The reason for this is that there is now an asymmetry in the expected wage calculations of individuals living in both regions. It is beneficial to commute from Region 2 to Region 1 but not from Region 1 to Region 2. This insulates the labour market in Region 2 from people commuting in and competing for jobs. This lower unemployment rate helps to increase the expected wage, even though the nominal wage is lower. The expected wage in Region 1 falls as the unemployment rate rises. The gap in expected wages is never completely closed due to the inhibition of migration by the amenity value of living in the birth region.

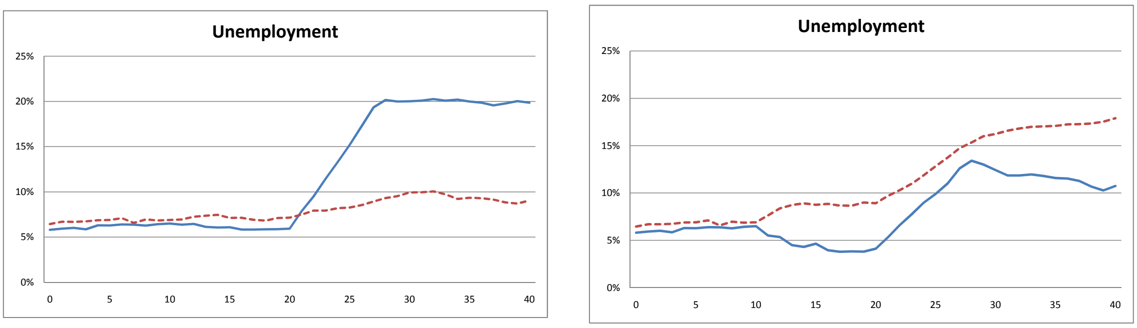
In the 110 km system, lowering the wage in Region 2 has no effect. This is since the wage disparity does not give a strong enough incentive for people to move or commute due to the greater distance involved in this system. Increasing the wage in Region 2 does generate effects. Figure 5 shows that prior to the shock, there is little difference in unemployment rates when there is no wage disparity. When the shock hits, a large disparity opens up. When the wage



(a) No wage disparity

(b) -25,000 NOK

Figure 4: The effect of a wage disparity, $w_2 - w_1$: 80 km between regions, with 1000 jobs removed from Region 1 (unbroken line) in year 20.



(a) No wage disparity

(b) +25,000 NOK

Figure 5: The effect of a wage disparity, $w_2 - w_1$: 110 km between Regions with 1000 jobs removed from Region 1 (unbroken line) in year 20.

is increased in Region 2, unemployment begins to rise in this region. When the employment shock hits, unemployment in both regions rises but is always highest in Region 2. As the system adjusts to the shock, the unemployment rate in Region 1 begins to fall while the rate continues to rise in Region 2. In this system, the friction in the system actually narrows the disparity for a period. The gap shows signs of widening towards the end of the monitoring period. The effect of the wage increase in this case is to shift much of the unemployment from Region 1 to Region 2. In the 140 km system, a disparity of 25,000 NOK, either positive or negative, has no discernible effect on the unemployment disparity. When the wage in Region 2 is increased to 450,000 NOK, a similar effect is witnessed to that in the 110 km system.

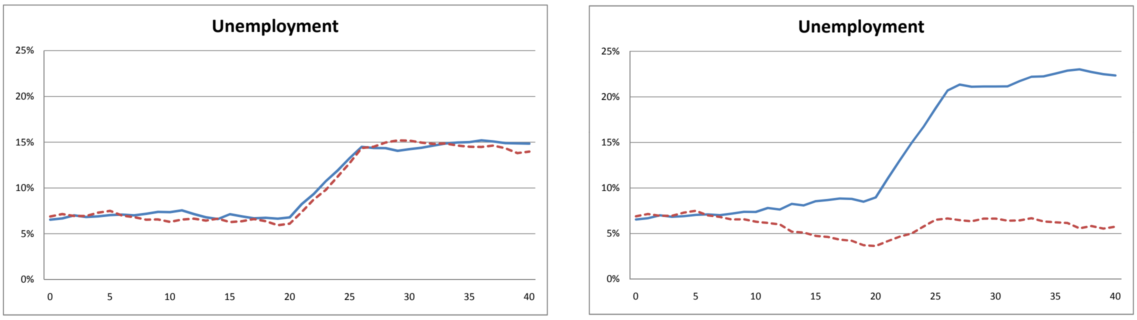
Summarised, our experiments illustrate that the effect of wage disparities depends on the distance between the regions. Within the range of reasonable wage disparities that we consider, unemployment disparities are not induced in the short distance systems, and there is apparently a marked difference in response between the intermediate 80 km system and the two long distance systems. In the 80 km system an unemployment disparity results from a reduced wage in a region, while unemployment disparities can then only be induced through wage increases in one of the regions in the long distance systems. Notice, however, that in all cases the region with the highest wage will be the region with the most unfortunate development in unemployment. The corresponding unemployment disparities correspond to the Harris-Todaro explanation, where wage differences are traded off against the probability of receiving a job offer in an equilibrium solution where the expected wage differential is zero and migration has ceased. It is also according to empirical findings in Partridge and Rickman (1996), where wage differentials are found to be positively related to the unemployment rate. Notice that changes in unemployment primarily reflect supply side responses to exogenous parameter changes. Job offers are only affected to the degree that moving decisions of households influence the level of local sector activities in a region.

There is less evidence in the literature of how local employment shocks affect unemployment. In general one would expect wages to respond at least slightly to such large changes in employment (1000 out of 4000 basic sector jobs are removed in this experiment). It is, however, useful to consider the case of exogenous wages given that there is significant evidence of unresponsive wages in the literature (see Section 2.1.3).

4.3 The effect of varying the cost of commuting

The cost per km of commuting was changed from 2.5 NOK/km to 2, 3 and 5 NOK/km. None of those changes to the cost of commuting caused an unemployment disparity in the 20 and 50 km systems. This is since the low distances mean that it is always inexpensive to commute relative to the excess of the wage over the unemployment insurance rate.

There are no changes to the unemployment rates for a decrease or a small increase in the 80 km system. Figure 6 shows that when the cost is increased to 5 NOK/km, a disparity opens up as people no longer find it beneficial to commute between the two regions. An increase in the cost of commuting has no effect in the 110 km system since it was already very expensive. Reducing the cost to 2 NOK/km however, closes the unemployment gap as people now find it beneficial to commute to find employment. This is shown in Figure 7. When the distance between the regions is increased to 140 km, none of the considered changes to the cost of commuting affect

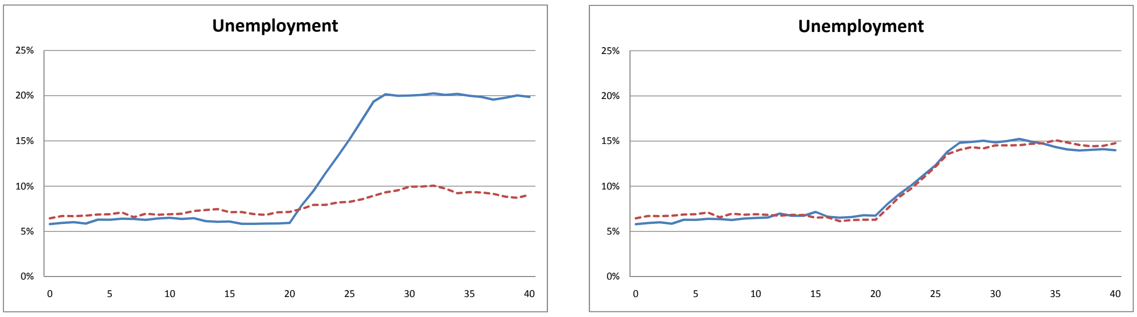


(a) 2.5 NOK/km

(b) 5 NOK/km

Figure 6: The effect of a change in commuting costs: 80 km between Regions with 1000 jobs removed from Region 1 (unbroken line) in year 20.

the unemployment outcomes.



(a) 2.5 NOK/km

(b) 2 NOK/km

Figure 7: The effect of a change in commuting costs: 110 km between Regions with 1000 jobs removed from Region 1 (unbroken line) in year 20.

In general, an increase in the cost of commuting can open up an unemployment disparity in any system. The potential for opening up, or increasing, a disparity is positively related to the distance between the two regions. In a case with a long distance between the regions even a modest increase in commuting costs can lead to a substantial spatial unemployment disparity. Similarly, a reduction in the cost of commuting may act to reduce any unemployment disparity in all the systems. Our experiments provide useful information on how for instance transport innovations or changes in petrol prices may affect a regional labour market with specific characteristics (parameter values). As an example of one important contribution, our approach can be used to identify critical distances where specific changes in transportation policy can induce a more favourable kind of labour market equilibrium.

4.4 The effect of introducing a location-specific amenity and varying the strength of the residential preference

The utility function introduced in Section 3.2 included a parameter Ω representing the willingness to pay for an amenity in Region 1. In the example illustrated in Figure 8 we assume that $\Omega = 50,000$. The important point to be made from the figure is that the amenity causes a persistent unemployment disparity disfavouring Region 1. This reflects an increased population (labour stock) in Region 1, while the number of jobs in the region is largely fixed (there is some increase in local sector jobs to reflect the increase in population), and it is not feasible to commute from Region 1 to Region 2 due to the large distances involved (110 km). Even when the unemployment rate in Region 1 exceeds that in Region 2, migration continues. This suggests that the extra utility provided by the amenity compensates for the higher risk of unemployment associated with living in that region and the disutility people born in Region 2 experinace from living away from their home region. Hence, our results offer an explanation for observations where unemployment rates tend to be highest in areas with amenities which are attractive to everyone. This supports Marston's (1985) approach, where attractive amenities are traded off by high unemployment in an equilibrium explanation of persistent spatial unemployment disparities. It also represents a possible explanation for the empirical finding (Partridge and Rickman 1997) that regions (US states) characterised by many inhabitants living in the same residences for at least five years have greater unemployment rates.

The disparity takes some time to open up. This is most likely due to discounting. When agents in Region 2 consider moving to Region 1, they consider the discounted value of the amenity. Some older people will not expect to live long enough to benefit from the amenity. As younger people are born into the system, they discount the benefit over their entire lifetime. This gives a higher present value of the amenity to a young person than to an older person. To capture this effect Figure 8 refers to a longer time perspective than the other experiments in this paper, and we have dropped the shock represented by the removal of 1000 jobs from Region 1 to keep clear of disturbing additional effects in this experiment.

The distribution of the willingness to pay to live in the region of birth was varied. As explained in Section 3.2 each person in the model has a value for this preference drawn from a uniform probability distribution. The range of this preference was altered in several ways

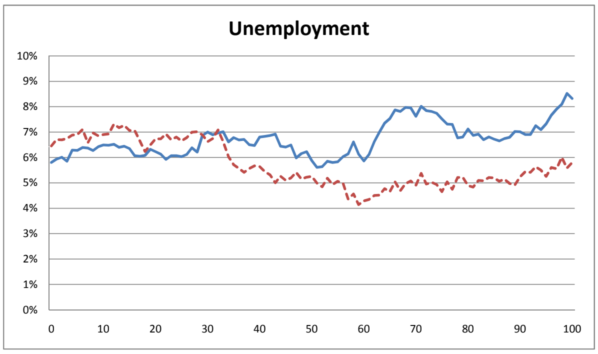


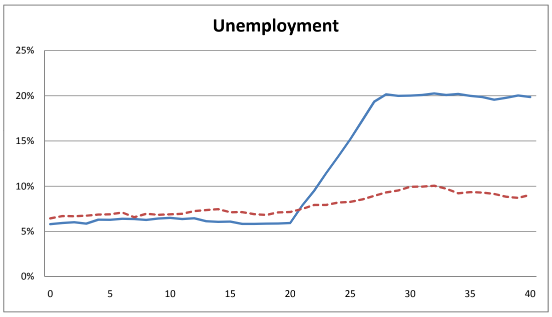
Figure 8: The effect of an amenity worth 50,000 NOK per year to each person living in Region 1 (unbroken line). The distance between the regions is 110 km.

however, only lowering the limits by 0.5 produced any noticeable effects and even then only in the long distance systems. When the strength of preferences is lowered in the 110 km system, the disparity is reduced slightly although not closed. When the shock hits Region 1, it is the unemployment rate in Region 2 which responds initially, as can be seen in Figure 9. This is since people are now more willing to migrate to gain work. The 140 km system responds in a similar way.

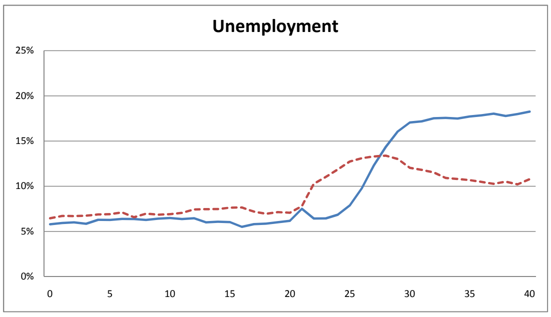
The argument following from Figure 9 can of course be reversed: the presence of innate residential site preferences may increase a spatial unemployment disparity. Such preferences contribute to reduce spatial mobility. Although not presented here, removing the residential site preference component from the model results in large fluctuations in each regions population depending on where jobs are available. In this system there is no persistent disparity in unemployment. This suggests that even a mild residential site preference is a sufficient condition for an unemployment disparity to persist. In cases where workers are not basically attached to a specific area, the two groups of workers naturally also tend to be more evenly distributed between the two regions in a long term equilibrium solution.

4.5 Experiments involving a relocation of jobs

Some experiments were conducted where the jobs were moved to Region 2 rather than being removed from the system. The results of experiments involving a relocation of jobs gave similar results to those already outlined. Disparities were opened and closed with the same parameter configurations as above. As an example, Figure 10 refers to the experiment where commuting



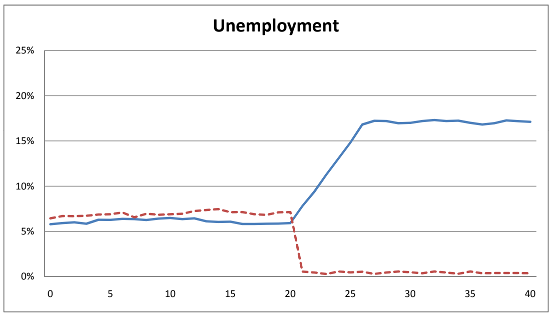
(a) No change



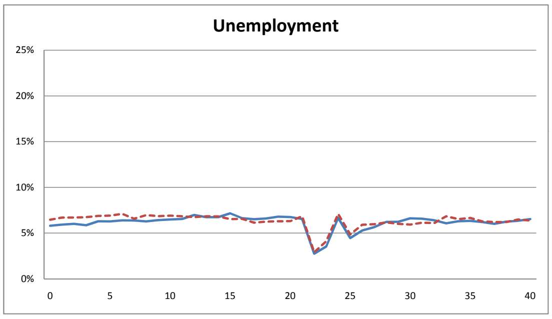
(b) -0.5

Figure 9: The effect of a change in the strength of residential site preferences: 110 km between Regions with 1000 jobs removed from Region 1 (unbroken line) in year 20.

costs are reduced from 2.5 to 2.0 NOK per km. Similar to the case in Figure 7(b) this closes the spatial unemployment disparity. It is natural, however, that the aggregate unemployment remains at the same level after the intraregional relocation of production activities, while this was not the case when jobs were removed from the system.



(a) 2.5 NOK/km



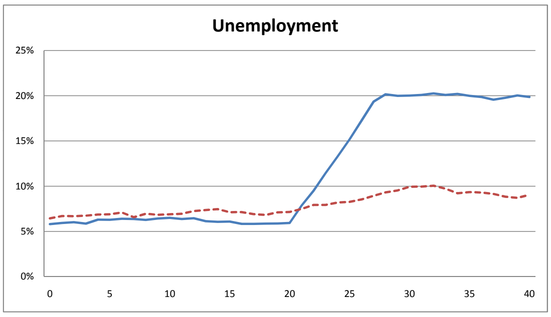
(b) 2 NOK/km

Figure 10: The effect of a change in the cost of commuting in the 110 km system with 1000 jobs moved from Region 1 (unbroken line) to Region 2 in year 20.

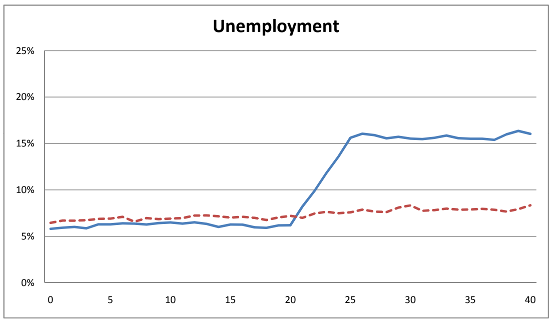
One interesting feature of systems with an unemployment disparity is related to the vacancy rate. This does not appear in Figure 10(b), but even 20 years after the shock there are a high number of vacant positions in Region 2 (around 30% of the new jobs remain unfilled) even though there is a high unemployment rate in Region 1. This would presumably constrain the growth of Region 2. The reduction of the cost of commuting closes this disparity allowing firms in Region 2 to find the workers they require while reducing the unemployment rate in Region 1.

4.6 The experiments under endogenous wages and basic sector jobs

The introduction of endogenous wages and basic sector jobs provided results consistent with prior expectations i.e. rises in unemployment trigger falls in wages which generates new jobs. Figure 11 shows what happens when 1000 jobs are removed from Region 1 in situations with exogenous and endogenous wages and basic sector jobs.



(a) Exogenous wages



(b) Endogenous wages

Figure 11: The effect of endogenous wages and basic sector jobs in the 110 km system with 1000 jobs removed from Region 1 (unbroken line) in year 20.

While there is still an unemployment disparity in the case with endogenous wages, the disparity is around 5 percentage points lower. This is since the rise in unemployment in Region 1 causes a fall in wages. This induces firms to hire additional workers which helps to reduce the impact of the initial job losses. The precise magnitude of the effect will depend on the elasticity of wages with respect to unemployment and the elasticity of basic sector jobs to wages. Wages are assumed to have an elasticity of 0.1 based on evidence presented in Section 3.4 while the elasticity of basic sector jobs is assumed to be equal to unity. This experiment demonstrates that an economy with at least some flexibility in wages and job creation will experience lower unemployment disparities.

We will not present more results based on the experiments under endogenous wages and basic sector jobs. As stated above the experiments provided results representing reasonable modifications of the cases where wages and the number of basic sector jobs are exogenous. We have primarily focused on the cases with no price adjustments in this paper, to concentrate on the partial effects of changes in other exogenous variables in a numerically based approach analogous to comparative static analysis.

5 An empirical example

The aim of the paper was to gain an insight into spatial unemployment patterns. The example of Rogaland county in the south west part of Norway is presented here. The main employment centre of the region is the city of Stavanger. The city is also the centre of Norway's oil and gas industry and is therefore a very prosperous city. The paradox is that the unemployment rate in the city has tended to be higher than in lagging peripheral areas further inland. One of many such areas is the municipality of Suldal. Figure 12 shows the unemployment rate in the municipalities of Stavanger and Suldal for the years 1992 to 2007.

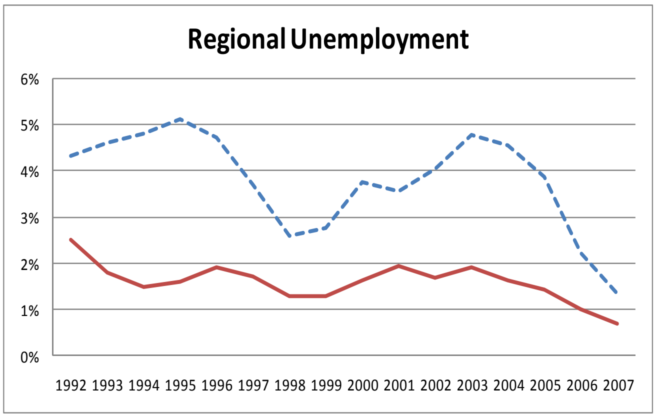


Figure 12: The unemployment rate in Stavanger (broken line) and Suldal: 1992-2007

The unemployment rate in Stavanger has been higher than Suldal for the entire period, even when taking into account cyclical fluctuation in the rate. The pattern resembles some of the output generated from the model, in particular the figures relating to wage disparities (Figures 4 and 5 and the presence of an amenity (Figure 8). Both of these explanations could be appropriate.

According to Marston (1985) excessive migration costs represent a disequilibrium explanation to unemployment rate differentials between areas; excessive migration costs might put the equilibrating forces out of action. Similarly, Partridge and Rickman (1997) point to the fact that utility improvements cannot be obtained through migration in cases with high monetary and psychological costs of household relocation. In such situations it makes good sense to implement active policy interventions to stimulate aggregate demand in areas with high unemployment. Based on a set of observations Marston 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 claims that the main component of area unemployment rate differentials are local equilibrium components, like for example specific local amenities (such as those present in a regional centre such as Stavanger). The main reason is that disequilibrium unemployment will be eliminated even if only a small fraction of workers migrate in response to an unfavourable labour market situation i.e. migration adjustments forces are strong relative to disequilibrating shocks. Marston's empirical work indicates that, in general, migration flows are able to restore spatial equilibrium within a year, far less than the 16 years shown in Figure 12. This has the important policy implication that government funding programmes are useless as means of reducing unemployment in an area such as Stavanger.

Wage disparities could also explain this pattern. High wages in Stavanger encourage people from the more peripheral areas to commute to Stavanger to benefit from higher wages and a more differentiated labour market. The incentives to commute in the opposite direction are lower. This means that jobs in Stavanger are occupied both by residents and people living in outlying areas while jobs in the outlying areas are occupied almost exclusively by people resident there. It is important to state that this pattern is replicated for many pairs of industrial centres and lagging areas in the region.

6 Conclusion

The experiments showed that the existence of persistent unemployment disparities is dependent not only upon the physical geography in which the labour markets are located but also on a variety of other factors. Wage disparities, unemployment insurance, the presence of amenities and a desire to reside in the region of birth were all important in determining the spatial distribution of unemployment. All of these factors contribute to explaining why the Blanchard and Katz model is not able to explain the persistent unemployment disparities observed in countries around the world.

The simulation approach employed here is relatively new to the area of spatial disparities. It has proved uniquely successful in simultaneously modelling equilibrium and disequilibrium explanations of unemployment disparities in situations where commuting and migration are possible. The main result was that higher levels of friction in the system increase the probability of a disparity emerging and persisting. This was illustrated through the introduction of a large shock to one of the regions in the model. This extreme example clearly illustrates the points raised although many of the results would apply even in the absence of such shocks. When regions are well integrated, generally when the distance between them is low, the impact of shocks is evenly spread. When they are isolated, only partial adjustment takes place with the majority of the effects concentrating in the affected area. In the case of Stavanger there are two obvious policy options which can be considered. On the demand side, jobs could be created in Stavanger to mop up unemployment. On the supply side, commuting connections between Stavanger and peripheral areas such as Suldal could be improved to allow unemployed people in Stavanger to access their labour markets. Incentives to migrate could be increased through a lowering of unemployment insurance and disincentives to migration such as moving costs, or taxes could be removed.

The results produced by the model suggest that creating jobs in Stavanger could have unintended consequences. If the new jobs lower unemployment, the expected wage of living in Stavanger would rise. This could encourage new migration to the area and increase the unemployment rate back to its previous level. This is the crucial distinction between equilibrium and disequilibrium unemployment. Deviations from the equilibrium expected wage will trigger adjustments back to equilibrium through changes in the nominal wage or the unemployment rate. With respect to unemployment, such a policy intervention would be entirely ineffectual in the medium to long term.

Supply side measures could be more effective. Any factors which impede migration should be minimised. The success of such a policy would depend on the precise reasons for the disparity. Even if migration were costless, it would not be certain that people would wish to move from Stavanger to more rural areas. Reductions in the cost of commuting could prove effective although the scope for making such improvements is often limited. A reduction in unemployment insurance would increase the cost of living in a high amenity area where the unemployment rate was high. This should encourage at least some migration to the low unemployment area. Lowering rates of unemployment insurance may not be feasible given that it would have to be implemented nationally and that such moves can prove controversial in political terms.

There is a third option which appears counter-intuitive at first. Instead of introducing jobs into Stavanger, it could be the case that introducing them into the low unemployment areas would prove more effective in reducing aggregate unemployment. Such a move would increase the expected wage in rural locations. This could encourage some of the unemployed people in Stavanger to forgo the amenity value of the city to take up work in other municipalities. It could also reduce the flow of migrants from rural areas to Stavanger. This is particularly true if those born in such areas have an innate preference to reside there. Increasing the amenity value of the rural areas may also be effective although there is no clear way to achieve this. However, preferences for urban areas over rural areas could naturally change over time.

The approach used here provides many possible avenues for exploration. In particular, the dynamics through which the system adjusts to shocks could be monitored an insights gained into how such mechanisms are affected by various parameter configuration. The results yielded by this approach go beyond what is possible with a purely analytical approach while avoiding the difficulties inherent with empirical research. The model also provides a useful contribution to the policy debate around how best to deal with unemployment disparities and shows that solutions which may seem obvious will not necessarily produce the desired results.

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