Regional versus Local Multipliers of Economic Change?
A Microsimulation Approach

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Abstract

The changing dynamics of regional and local labour markets during the last decades have led to an increasing labour market segmentation and socio-economic polarisation and to a rise of income inequalities at the regional, urban and intra-urban level. These problems call for effective social and local labour market policies. However, there is also a growing need for methods and techniques capable of efficiently estimating the likely impact of social and economic change at the local level. For example, the common methodologies for estimating the impacts of large firm openings or closures operate at the regional level. The best of these models disaggregate the region to the city (Armstrong 1993, Batey and Madden 1986). This paper demonstrates how microsimulation modelling techniques can be used for local labour market analysis and policy evaluation to assess these impacts (and their multiplier effects) at the local level – to measure the effects on individuals and their neighbourhood services. First, we review these traditional macro-scale and meso-scale regional modelling approaches to urban and regional policy analysis and we illustrate their merits and limitations. Then, we examine the potential of microsimulation modelling to create a new framework for the formulation, analysis and evaluation of social and local labour market policies at the individual or household level. Outputs from a local labour market microsimulation model for Leeds are presented. We show how first it is possible to investigate the interdependencies between individual's or household's labour market attributes at the micro-scale and to model their accessibilities to job opportunities in different localities. From this base we show how detailed what-if analysis can be performed to estimate the impact of major changes in the local labour market through job losses or gains, including local multiplier effects.

1. Introduction

'To move to better dynamic representations of urban processes suggests that individuals rather than groups or aggregates must form the elemental basis of these simulations'

(Batty, 1996:261)

There is growing interest in simulating the characteristics and behaviour of individuals or households in urban and regional analysis. Research agendas for building large-scale micro models of cities have been articulated elsewhere (see Birkin *et al*, 1996 and Wegener and Spiekerman, 1996 for example). A major component of these research agendas is the urban economic system. It is important to begin with understanding the local labour markets of cities and regions. The aim of this paper is to examine the

potential of microsimulation models for building local labour markets linked to other forms of economic activity. In section 2 of the paper we review traditional methodologies for examining local labour markets, most importantly input-output models. These have been commonly used for examining the impact of major job gains or job losses in terms of the multiplier effects on other parts of the economy. Although there has been great progress with the development of these models most treat the spatial resolution as at best the region (the work of Batey and Madden is an important exception to this and their work is reviewed in more detail). Thus, we articulate a methodology for examining the impact of major changes in the economy through a much more detailed consideration of household journey to work models and analysis of the types of residents and residential areas which are most directly affected. An important component of the household database is household income (whether from earned or unearned sources). Thus, changes in job status can be directly linked to changes in household income, which, in turn, can be directly linked to changes in household consumption and expenditure. From the State perspective, impacts of major job losses or gains can be evaluated in terms of the changes in income provided through state subsidies (this part of the research agenda is explored in more detail in Ballas and Clarke 1999). The methodology of creating the household data sets is discussed in section 3. Section 4 looks at the labour market and income components of this database in more detail. An example of a major change in the labour market is discussed in section 5. Here, we simulate the closure of a major manufacturing plant in East Leeds. Although the model is still in its infancy, the initial results show how it is possible to estimate local multiplier effects of major changes in the local economy.

2.Spatial modelling approaches to socio-economic impact assessments

The impacts of significant employment or population change should be an area of major concern in economics and geography. Governments (whether national or local) should be aware of the consequences of major employment gains or losses in our cities and regions. Openshaw (1995) concludes:

> Governments need to predict the outcomes of their actions and produce forecasts at the local level.
>
> (Openshaw, 1995: 60)

Further, Armstrong and Taylor (1993) stress the importance of the ability to predict the effects of a government policy change on regional income and employment. In addition, they refer to the recent cuts of defence spending and employment in the UK and they address the following questions with respect to these budget cuts:

Which regions will suffer most? Which towns will be most affected?

(Armstrong and Taylor, 1993:5)

Clearly, the regional or city impact analysis of regional or budget policy changes is an extremely useful task with very important political implications and it is vital for the formation of appropriate regional or urban policies aimed at tackling or ameliorating regional employment and growth problems. Nevertheless, it should be noted that cities and regions comprise of smaller areas, which differ considerably in population size and demographic structure, labour force skills, income and spending power, consumption patterns, accessibility to workplaces and many other important characteristics. Respectively, there is considerable variation in the household mix of smaller city areas, such as wards, as these comprise of even smaller areas such as enumeration districts. It would therefore be particularly useful if we could predict the intra-urban and intra-ward impact of regional and urban policy changes. In other words, it would be vital for policy-making purposes if we could answer questions such as:

Which neighbourhoods will suffer/benefit most? Which households will be most affected? What will be the intra-region, intra-urban and intra-ward impact of a possible plant closure/development?

Reassuringly, there has long been an interest in the impacts of major job gains or losses on the fortunes of the local economy. Qualitatively, interviews are often carried out to investigate how workers made redundant following plant closures fare in adapting to the changing labour market and how long term unemployment is increased for those unable to retrain (a useful summary appears in Tomaney *et al* 1999). Similar impact and multiplier assessments have been extensively studied using a modelling perspective in the fields of regional science and economic geography. The most common methodological approaches have been the use of economic base models and/or input-output models. Armstrong (1993) provides a good example of the former. He looked at the impact of job gains made at Lancaster University using Keynesian local open

economic multipliers for the Lancaster and Morecambe urban regions. His results showed that additional jobs outside the University would be created in retailing, transport and leisure. However, the problem here is the spatial scale. In reality, the impacts of this investment would be much greater close to the investment site and would be almost negligible in labour markets far removed from south Lancaster (such as Morecambe). Other useful reviews of economic base multiplier models appear in Glasson *et al* (1988) and Vias and Mulligan (1997).

There are many examples of input-output models. These models can show three types of impact assessments (here we deal with the impacts of investment rather than disinvestment). The first are direct impacts that are the jobs generated by the new investment itself. Second, are the indirect impacts that include the jobs created through the increased business for other business/industrial organisations generated by the new investment (inter-industry links). Third, are the induced impacts. These are jobs generated as a result of additional household income and expenditure. These might be associated with the extra expenditure spent in retailing, transport, leisure, child care etc. The vast majority of input-output models have dealt with regional rather than local multiplier effects. However, there have been a number of studies which have tried to examine more local impacts by adding a spatial interaction model of intra-urban commodity flows and/or adding new demographic sections which link population sub-models formally to the economic input-output models (Batey and Madden 1983, 1999, Phibbs 1989, Jin and Wilson 1993, Stombol et al 1998). An excellent recent example is the study of the impact of extending both Liverpool and London Heathrow Airports (Batey and Madden 2000). In these case studies, the basic components of change in population and employment are undertaken using a labour market accounting framework which links all the activity level variables in a labour market (demand, supply, migration, unemployment etc). These equations are then embedded within the extended input-output model in order to measure the economic effects of demographic change.

Batey and Madden recognised the need to define a study region which would be most affected by the developments. Hence, they designed a study area based on the surrounding local districts only. Within this more restricted study area they could estimate the number of persons or households unemployed and therefore how many jobs would be taken up locally and how many would be subject to in-migration. Thus they

were able to predict 'changes in industrial gross outputs, jobs taken up by previously unemployed local residents, jobs taken up by in-migrants and changes in the numbers of long-term and short-term unemployed' (Batey and Madden 2000, p15)

Their results for the London case study estimated that for 51760 direct jobs, 29676 indirect and 10585 induced jobs would also be created. When broken down by industry type, this was very useful policy information both for the developers trying to obtain planning permission and the government who were trying to evaluate this information. Batey and Madden also explain how a further important issue was the desirability of demonstrating to the Exchequer in Central Government the beneficial fiscal impacts, including increase in income tax revenue, increase in employers' NIC contributions, reduction in unemployment benefits and reduction in community charge rebates.

The Batey and Madden paper is the best illustration of a spatially disaggregated input-output model (or a type 4 model in their language). However, there are still some interesting spatial issues to explore further. First, the results pertain to the combined area they label Greater Merseyside. Local planners may well be as interested in the variations within this area. There is no way of doing this in their methodology without introducing a labour market journey to work model. We would argue that it would also be interesting to look in more detail at the distribution and income effects of the job market changes at the small area level. Then, it may be possible to in turn disaggregate the local multiplier effects spatially as well as sectorally.

Jun (1999) offers a useful methodology to extend the input-output framework geographically. He argues for the inclusion of a journey to work model to allocate job gains/losses from the input-output model spatially. He also includes a shopping model to allocate the additional expenditures that come from the induced consumption fuelled by job growth. He also calls for the incorporation of a land-use transport model. The entire methodology gets close to providing a new research agenda for the kinds of comprehensive urban models so popular in the 1960s and 1970s.

This paper articulates a similar research agenda to that of Batey and Madden and that of Jun using microsimulation techniques, which we argue will allow greater consideration

of local impacts. This methodology should run alongside the economic analysis of the input-output model. The microsimulation approach would have the following steps:

1) build a database of individual households in a city or region

2) estimate the labour market characteristics of each household (age, sex, socio-economic status, economic sector, employed/unemployed)

3) estimate household income (from earned income for those employed and income from state benefits for those unemployed)

4) estimate location of work for those employed (i.e. build a journey to work model based on household characteristics defined above)

Then, for say an investment which creates new jobs:

5) model the locations of the households employed directly through the investment

6) adjust their household income and consumption directly

7) estimate the individual firms in the area that will also benefit from the new investment (through direct inter-firm linkages) (ultimately we could have an intra-urban commodity flow model).

8) model the impacts of the new consumption patterns in terms of (additional) spending on goods and services

9) allocate that spending to particular institutions (through direct links between households and organisations).

Longer term, we would also wish to model other characteristics of the increased levels of income and expenditure (or again decreased levels for job losses). The full microsimulation model would ultimately also consider household behaviour in relation to the housing market, the education market and the health market. There is now plenty of evidence to suggest that access to all these markets is now strongly influenced by income and wealth.

This framework would thus provide a powerful applied database of local information in relation to household characteristics and behaviour to support greater planning within cities or regions.

3. A microsimulation approach to local labour market policy analysis

3.1 What is microsimulation

Microsimulation is a methodology aimed at building large-scale data sets on the attributes of individuals or households and on the attributes of individual firms or organisations and at analysing policy impacts on these micro-units (Orcutt *et al*, 1986; Birkin and Clarke, 1995; Clarke, 1996). Because microsimulation models are concerned with the behaviour of micro-units (such as households or firms) they are especially well suited to estimate and analyse the distributional impacts of policy changes (Mertz, 1991). Further, microsimulation modelling frameworks provide the possibility of defining the goals of economic and social policy, the instruments employed and also the structural changes of those affected by socio-economic policy measures (Krupp, 1986).

As Clarke (1996) points out, in essence there are two major procedures to be carried out in microsimulation modelling. The first is the construction of a micro-data set. This can be a population of individuals or households or firms in a city or region along with their associated characteristics. This procedure usually involves the use of contingency tables or conditional probability analysis to estimate chain conditional probabilities. In particular, conditional probabilities are calculated from available known data and then they are used to reconstruct detailed micro-level populations. This process can be clarified with the use of an illustrative example related to the labour market. Lets assume that we wish to investigate the relationships between sex (*S*), age (*A*), educational qualifications (*Q*), economic position (*EP*) and socio-economic group (*SEG*) for a given population group X in location *i*. From the 1991 Census of the UK population we can obtain for the population in a specified area (e.g. at the ward level) separate tabulations of:

- sex by age by economic position (Small Area Statistics table 08)
- level of qualifications by sex (Small Area Statistics table 84)
- socio-economic group by economic position (Small Area Statistics table 92)

From these tabulations we could calculate the respective conditional probabilities, and then our problem would be to estimate the probability:

- $p(x_i, S, A, Q, EP, SEG)$

given a set of constraints or known probabilities:

- $p(x_i, S, A, EP)$

- $p(x_i, Q, S)$

- $p(x_i, SEG, EP)$

There are a number of ways to solve this problem such as linear programming models, discrete choice models, balancing factor methods in spatial interaction models (Wilson, 1970) and Iterative Proportional Fitting techniques (Birkin, 1987; Clarke, 1996; Fienberg, 1970; Norman, 1999; Williamson *et al*, 1996;Wong, 1992;).

There are also other approaches to microdata generating such as reweighting of a parent sample of microdata, which are available at a different (from the desired) spatial scale (Ballas *et al*, 1999; Williamson *et al*, 1998).

The second stage of the microsimulation procedure is to create a sample of individuals based on the estimated or computed set of probabilities. The creation of such a data set can be achieved by Monte Carlo simulation. Clarke (1996) illustrates how this procedure can be employed for the creation of a micro-level population with the following characteristics: age, sex, marital status and household tenure (see figure 2). Supposing that the age, sex, and marital status of the head of household, is available from the Census, it is possible, using one of the methods mentioned above, to estimate probabilities of household tenure given head of household's age, sex, and marital status (box 2 in figure 2). The first synthetic household in this example has the following characteristics: male head of household, aged 27, married. As it can be seen in box 2 the estimated probability that a household of this type would be owner-occupied is 70%. The next step in the procedure is to generate a random number to see if the synthetic household gets allocated to the owner occupied category. The random number in this example is 0.542 and falls within the 0.001 - 0.700 range needed to qualify as owner-occupied. The same procedure is then carried out sequentially for the tenure allocation to all the synthetic households (Clarke, 1996). It should be noted that the difficult task in microsimulation is to specify which variables are dependent upon others and to determine the ordering of probabilities (*Ibid.*).

The above procedures can be carried out for all the variables we wish to include in a microsimulation model. The advantages and drawbacks of the microsimulation method are presented in figure 3 (for more details see Birkin and Clarke, 1995). As can be seen,

one of the main advantages of microsimulation is the ability to link data sets from different sources. Figure 4 depicts the data sets that could be linked in the context of a labour market microsimulation model. All these data sources could be used for the generation of a new microdata set which would include attributes from all the original data sets. This microdata set could be then reaggregated to any spatial zoning system. It should be noted that in a microsimulation framework variables are specified as lists rather than matrices, which leads to very efficient data storage. In addition, data storage, manipulation and analysis can become even more efficient when an object-oriented approach to microsimulation modelling is adopted (Ballas *et al*, 1999). One of the biggest drawbacks of microsimulation frameworks is the difficulty in validating the model outputs, since microsimulation models estimate distributions of variables which were previously unknown. However, one way of validating microsimulation model outputs is to reaggregate estimated data sets to levels at which observed data sets exist and compare the estimated distributions with the observed.
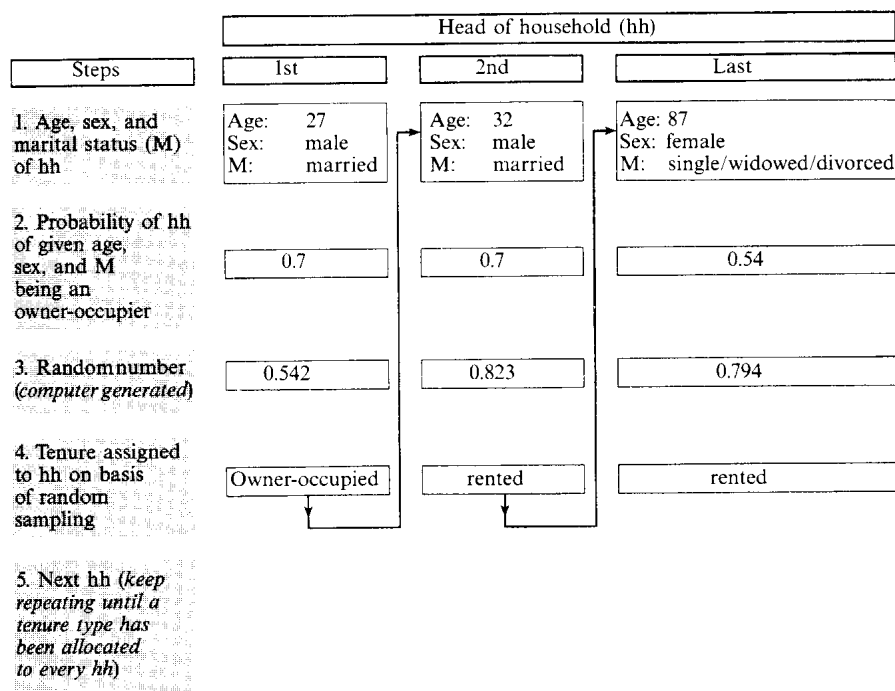

Figure 1 - An example of the microsimulation process: tenure allocation procedure (after Clarke, 1996:3)

Advantages	Drawbacks
Data linkage	*Difficulties in calibrating the model and validating the model outputs*
Spatial flexibility	*Large requirements of computational power*
Efficiency of storage	
Ability to update and forecast	

Table1: Advantages and drawbacks of microsimulation
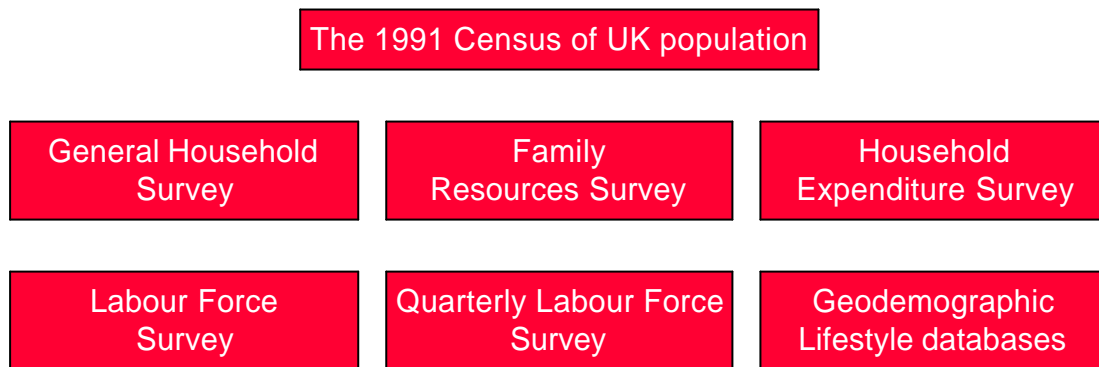
Figure 2 - Data sets that can be linked in a labour market microsimulation framework

3.3 SimLeeds: A spatial microsimulation model for Leeds

As aforementioned, the aim of this paper is to argue the case for a microsimulation approach to regional policy impact analysis. In this section we present *SimLeeds*, which represents a micro-analytical spatial modelling approach to regional policy analysis and to the prediction of the impact of major new expenditure injections into regional economies, as well as of the impact of plant closures.

As seen in the previous section, microsimulation techniques can be used to combine data from different sources and to reconstruct detailed micro-level populations. Therefore, they can be used to combine detailed microdata sets such as the Samples of Anonymized Records (SARs) with less detailed but more spatially disaggregated data sets, such as the 1991 Census Small Area Statistics (SAS), in order to build a micro-level population. The SARs are samples of individual census records, which are anonymized in various ways to ensure that there is no breach of the confidentiality of the census and that no individual can be identified from the data (Middleton, 1995) and they are released at the national and regional scale.

Microsimulation frameworks have the advantages of a list-based approach to microdata representation. In such frameworks variables are treated as lists rather than matrices. For instance, in the context of a microsimulation approach a household or an individual has a list of attributes which are all stored as lists rather than as occupancy matrices (Clarke, 1996). From a computer programming perspective, the household can also be seen as an object with its associated object variables (attributes). Therefore, it can be argued that an *object-oriented* language such as *JAVA* or *C++* is most suitable for microsimulation modelling. In the context of this paper we used *SimLeeds*, which is a spatial microsimulation model, built in JAVA for the local labour market of Leeds. *SimLeeds* is a product of on-going research and uses different approaches to conditional probability analysis for microsimulation modelling. In particular, it provides different options of microsimulation modelling ranging from Iterative Proportional Fitting (IPF) based microsimulation to *Simulated Annealing* reweighting approaches (for more details on the different methodologies employed by *SimLeeds* see Ballas *et al*, 1999). The nature and number of the variables of the household or individuals modelled by *SimLeeds* depend on the selected modelling method and on the needs of the user. They also depend on time constraints, given that microsimulation modelling is highly computationally intensive.

In the context of this paper we used *SimLeeds,* to analyse and combine conditional probabilities derived from the SARs and the SAS and to build a micro-population on the basis of random sampling from these probabilities. In particular, the outputs of *SimLeeds* were based on maximum likelihood estimates of conditional probabilities for the individual attributes of interest. These estimates were obtained with the application of the Iterative Proportional Fitting (IPF) technique on data from the Samples of Anonymised Records and from the Small Area Statistics (for more details on this methodology see Ballas *et al*, 1999). Moreover, the analysis micro-unit was the individual and the variables of each micro-unit that were selected in the context of this paper are listed in table 2.

| Micro-unit attributes |
|---|
| Location (place of residence) at the ED level. |
| Location (workplace) at the ward level |
| Age |
| Sex |
| Marital Status |
| Tenure |
| Employment Status |
| Industry (SIC) |
| Socio-economic group |

Table 2 – *SimLeeds* variables
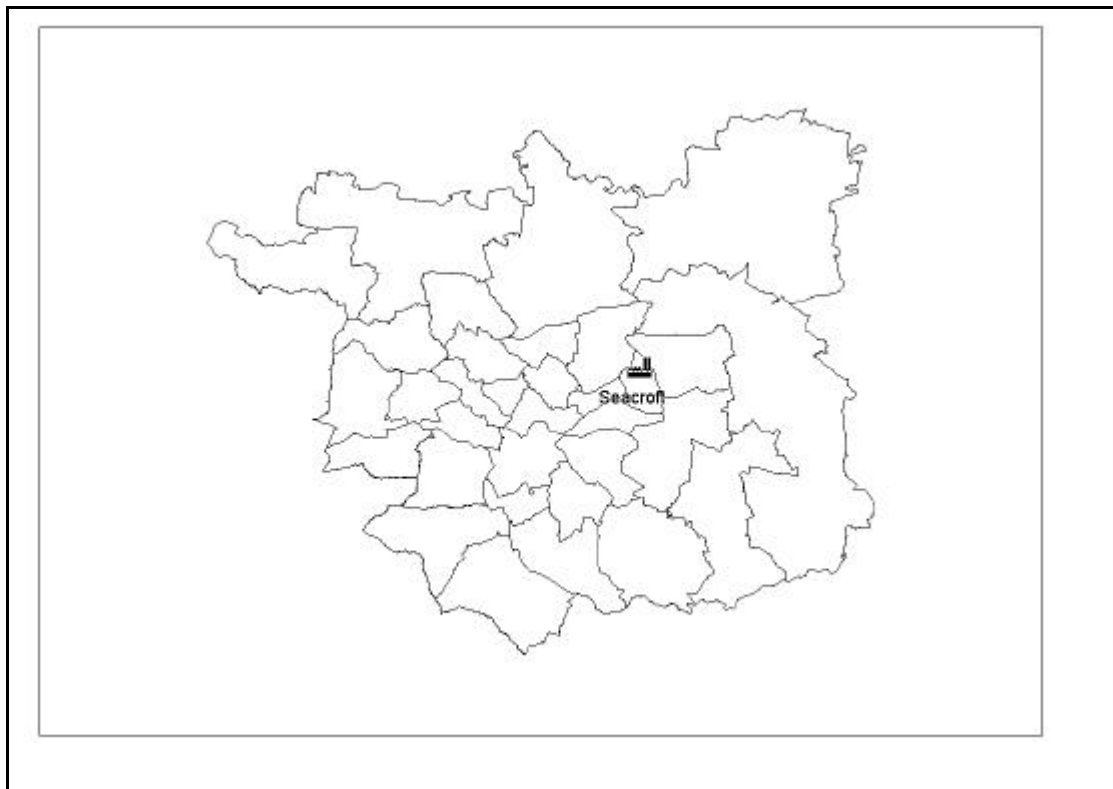
Figure 4 - Location of the hypothetical plant

We believe that models such as *SimLeeds* belong to a new era of policy-relevant modelling environment, in the sense that they can provide new spatially detailed information to enhance urban and regional policy impact analysis and evaluation at the micro-scale.

An example of how this kind of spatial analysis can be performed is useful at this stage. In the context of this paper we used *SimLeeds* to perform spatial impact analysis of a hypothetical closure of an engineering plant located at the Leeds ward of Seacroft (see figure 4.

Figure 5 depicts the observed travel-to-work flows to *Seacroft*. As can be noticed, *Seacroft*, *Whinmoor* and *Halton* are the wards with the largest numbers of individuals who work in *Seacroft*. In particular, 20% of the people who work in *Seacroft* live in *Seacroft*. In addition, 17.8% of the people who commute to Seacroft come from Whinmoor and 8.7% come from Halton. Therefore, it can be reasonably expected that these wards will be probably the most affected in the event of a plant closure in Seacroft.
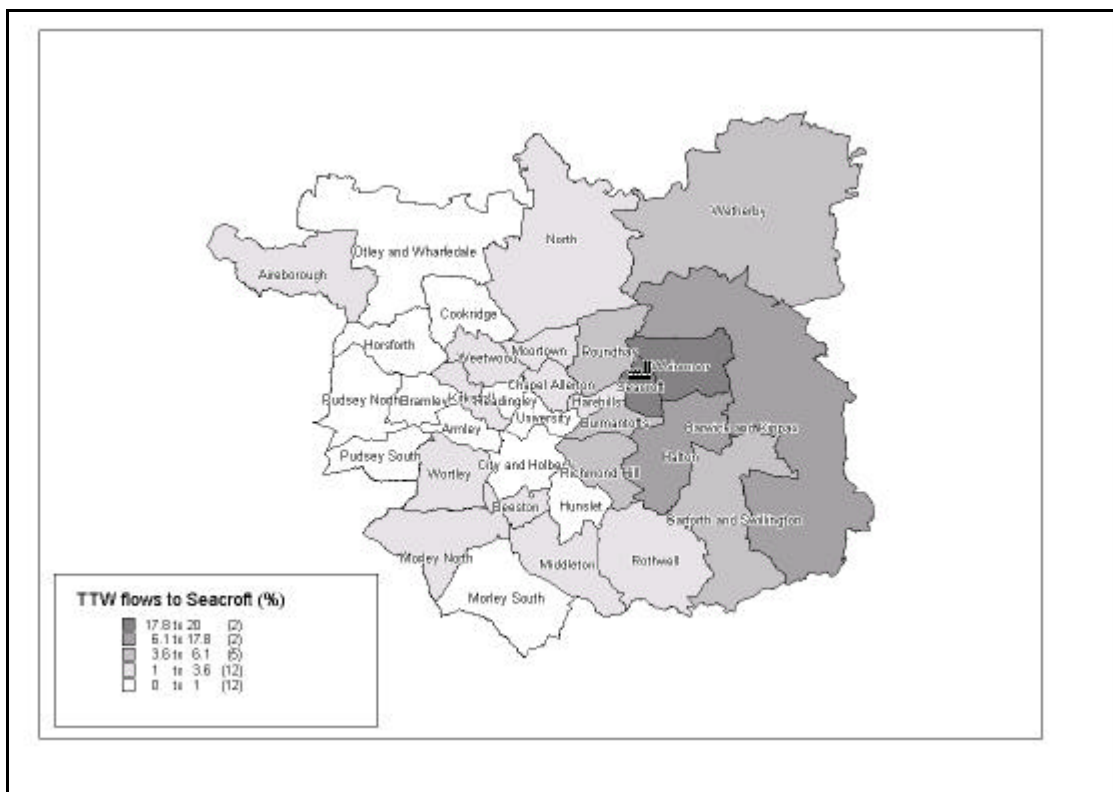

Figure 5 - Travel to Work flows to Seacroft

Nevertheless, it should be noted that the volume of the impact on these wards depends on their socio-economic and demographic structure. Further, there is considerable variation in the socio-economic mixture of the population within wards. In particular, wards comprise of enumeration districts (EDs) which are small areas with an average of 200 inhabitant households.

In the context of our hypothetical example, *SimLeeds* model outputs can provide useful insights into the analysis of the intra-ward impacts of the supposed plant closure. For instance, figure 6 depicts the estimated spatial distribution for the whole Leeds Metropolitan District of *male employees*, aged between *16-29*, who work in the *Metal Goods, Engineering, Vehicles* industry (SIC3) and are *skilled manual workers*, live in *owner-occupied* housing and their marital status is *single, widowed or divorced*. Respectively, figure 7 depicts the same spatial distribution, focusing on the wards of Seacroft, Whinmoor and Halton, which as seen above have the highest numbers of economically active population that works in Seacroft.
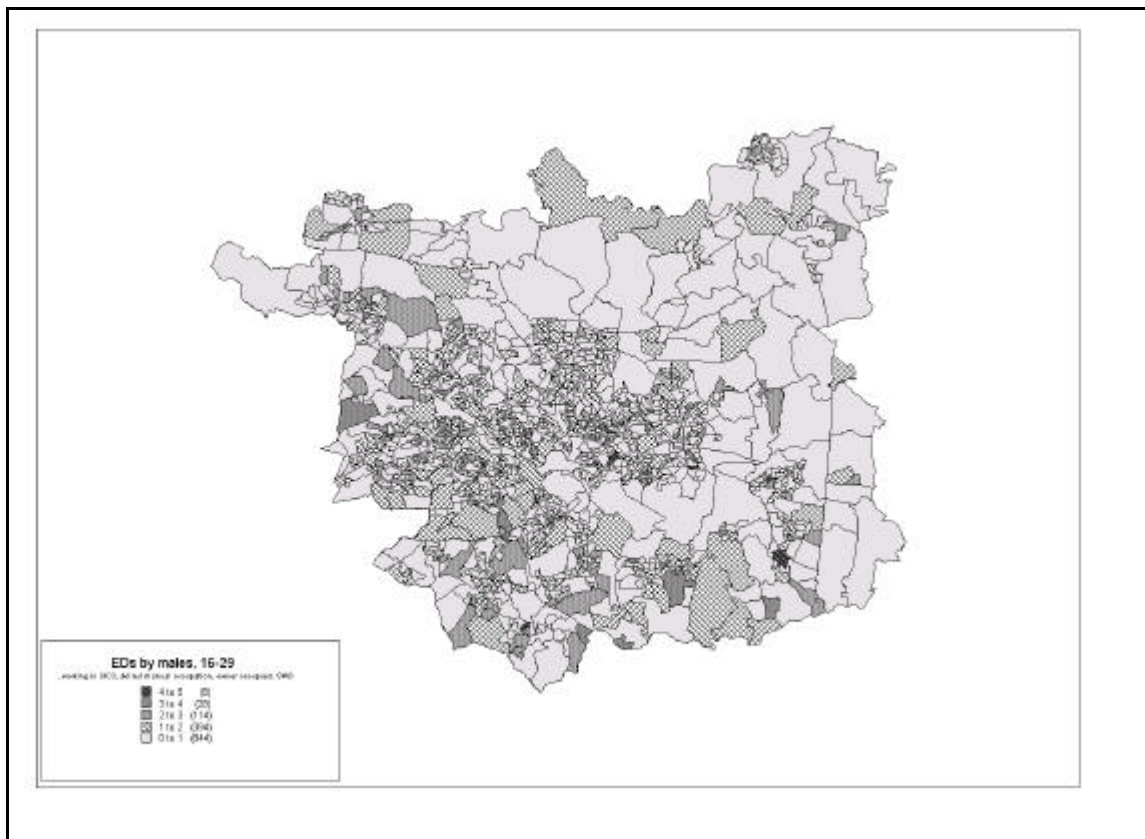
Figure 6 – Spatial distribution of a spatially disaggregated micro-group.
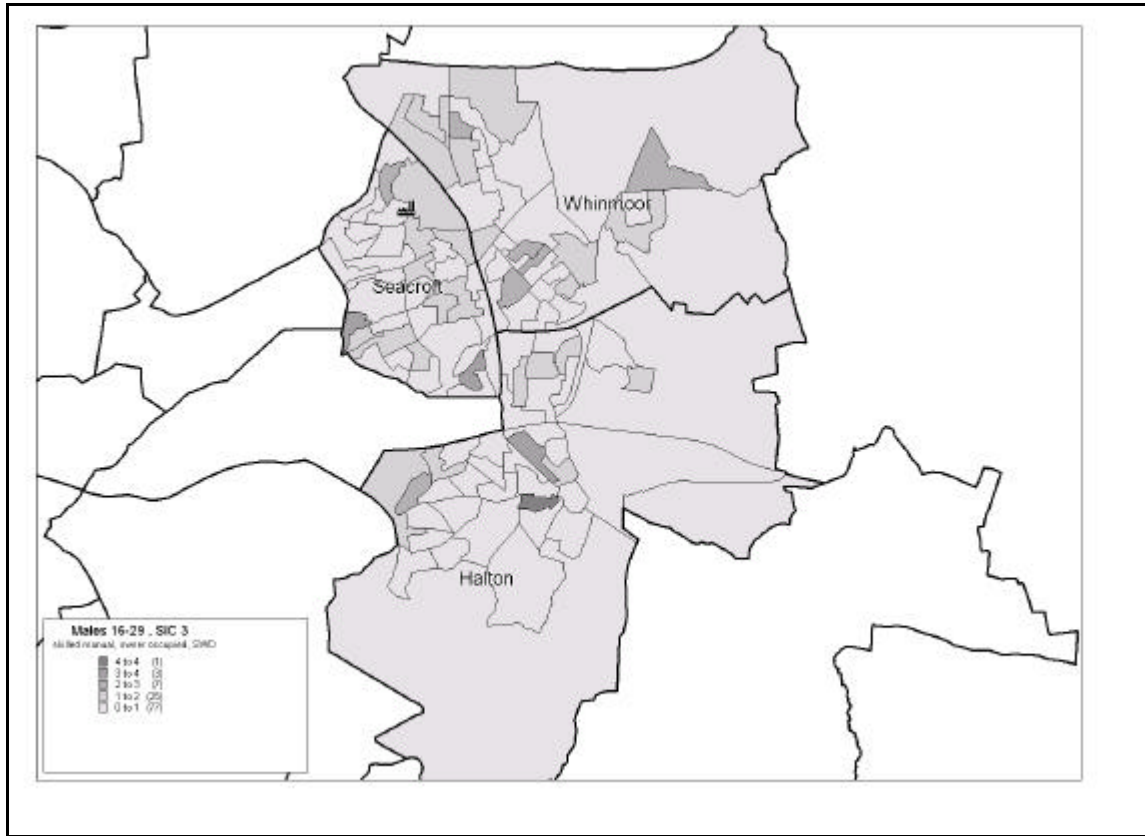
Figure 7 - Focusing on Seacroft, Halton and Whinmoor

Further, figure 8 depicts the estimated geographical distribution of all the economically active employees as well as the estimated spatial distribution and size of different micro-groups at the ED level in the wards of Seacroft, Whinmoor and Halton. These micro-population groups are described in more detail in table 2.

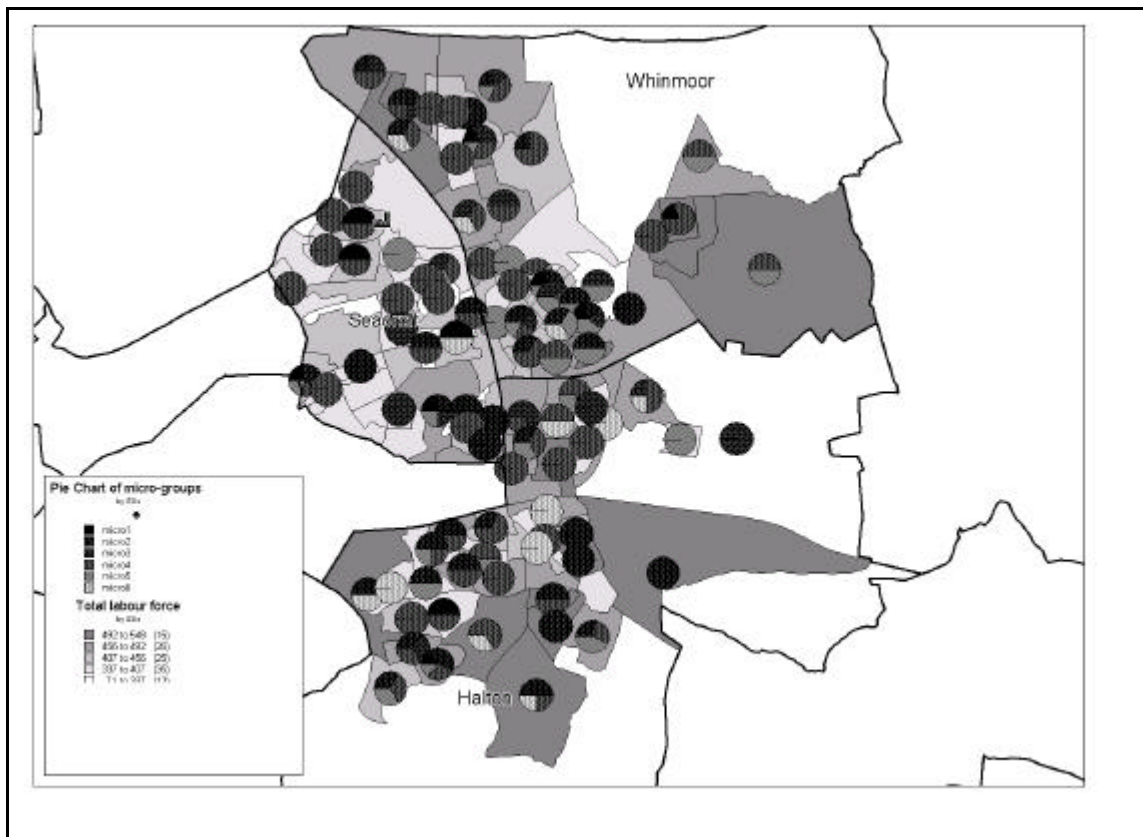| Attribute	Micro-group 1	Micro-group 2	Micro-group 3	Micro-group 4	Micro-group 5	Micro-group 6
MARSTAT	SWD	SWD	SWD	SWD	SWD	SWD
TENURE	Owner occupied	Owner occupied	Owner occupied	Owner occupied	Owner occupied	Owner occupied
SCLASSFH	Profesional etc	Managerial and Technical	Skilled non manual	Skilled manual	Partly skilled	Unskilled
DINDUSDIV	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles
ECONPRIM	Employee	Employee	Employee	Employee	Employee	Employee

Table 2 – Micro-groups 1-6

In addition, figure 9 depicts the estimated spatial distribution and size of another 6 micro-groups, which are described in table 3. Micro-groups 1-12 belong to the wider economically active population group, which is employed in the *Metal Goods, Engineering, Vehicles* industry. A more aggregate picture of this population group is

presented in figure 10. In particular, the latter depicts the estimated size and spatial distribution of the population sub-groups described in table 4.

Attribute	Micro-group 7	Micro-group 8	Micro-group 9	Micro-group 10	Micro-group 11	Micro-group 12
MARSTAT	SWD	SWD	SWD	SWD	SWD	SWD
TENURE	Rented	Rented	Rented	Rented	Rented	Rented
SCLASSFH	Profesional etc	Managerial and Technical	Skilled non manual	Skilled manual	Partly skilled	Unskilled
DINDUSDIV	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles
ECONPRIM	Employee	Employee	Employee	Employee	Employee	Employee

Table 3 - Micro-groups 7-12

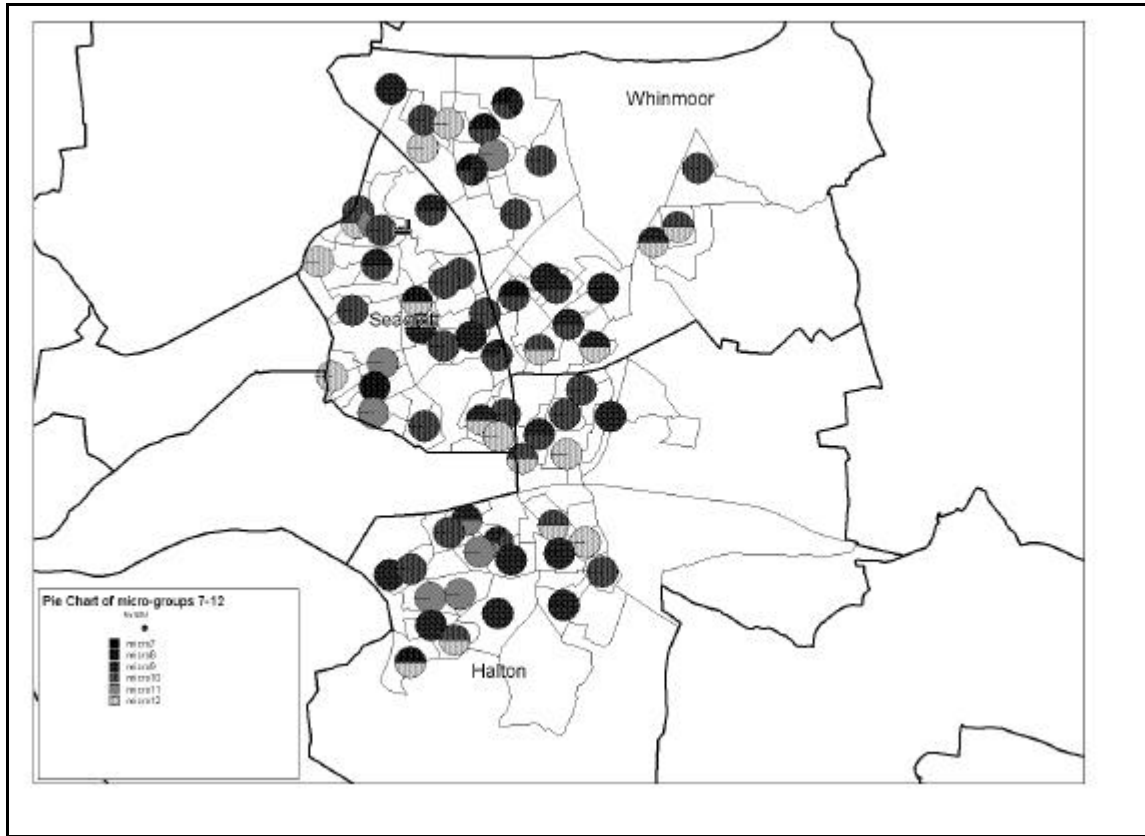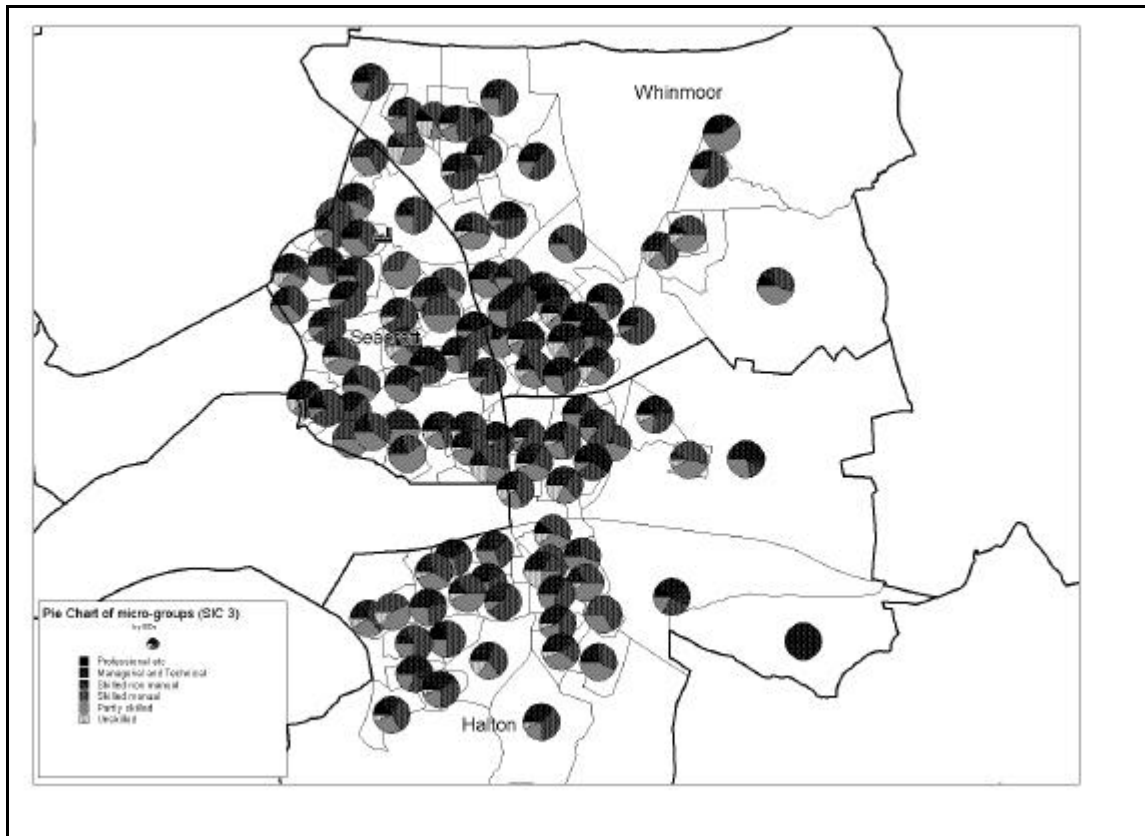**Figure 8** - Spatial distribution of Leeds labour force and of SIC3 micro-groups 1-6

Figure 9 - Spatial distribution of SIC3 micro-groups 7-12

| Attribute	Micro-group 13	Micro-group 14	Micro-group 15	Micro-group 16	Micro-group 17	Micro-group 18
MARSTAT	ALL	ALL	ALL	ALL	ALL	ALL
TENURE	ALL	ALL	ALL	ALL	ALL	ALL
SCLASSFH	Profesional etc	Managerial and Technical	Skilled non manual	Skilled manual	Partly skilled	Unskilled
DINDUSDIV	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles	Metal goods, engineering, vehicles
ECONPRIM	Employee	Employee	Employee	Employee	Employee	Employee

Table 4 – Micro-groups 13-18

These *SimLeeds* model outputs provide useful insights into the impact analysis of the hypothetical plant closure. Nevertheless, more specific *what-if* geographical analysis needs to be performed in order to estimate the possible plant closure impact at the small area level.

Figure 10 – Spatial distribution of SIC3 broad socio-economic groups

3.3 *What-if* **micro-spatial impact analysis**

In this section we enhance the above analysis and we use *SimLeeds* to model the possible employment and income effect of the hypothetical engineering plant closure on different localities. At this stage we would need some information on the size and employment structure of the plant's workforce. In the context of our example, we assumed that the plant has 3,000 employees and that the plant's workforce structure is as depicted in figure 11.
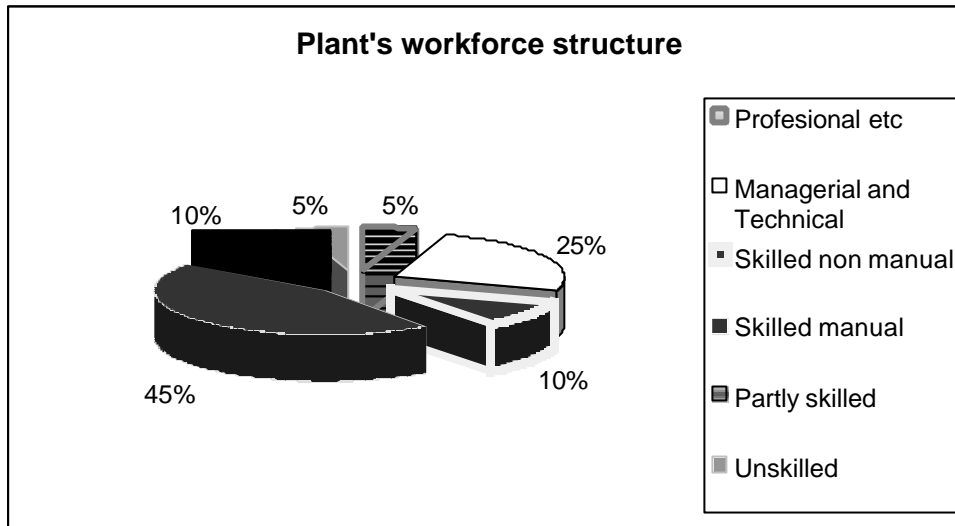
Figure 11 – The hypothetical plant's workforce

As can be seen, most of the hypothetical plant's workforce belongs to the *skilled manual* category (45% of the total workforce) and to the *Managerial and Technical* category (25% of the total workforce).

Given the hypothetical structure of our plant's labour force and looking at the travel-to-work patterns, it is reasonable to expect that the EDs of Seacroft, Whinmoor and Halton that have the highest numbers of skilled manual workers will be affected the most from the plant closure. The spatial distribution of this economically active population sub-group can be seen in figure 10. However, figure 12 gives a clearer description of the size and spatial distribution of this group. In particular, figure 12 presents a graduated thematic map based on the size of this group in each ED. In addition, another economically active population sub-group that will be affected from the plant closure comprises the managerial and technical employees who work in the *Metal Goods, Engineering, Vehicles* industry. Figure 13 depicts clearly the estimated spatial distribution of this sub-group. As can be seen there are several EDs with relatively high concentrations of this population group and it can be reasonably expected that these EDs will be significantly affected by the closure of the plant.
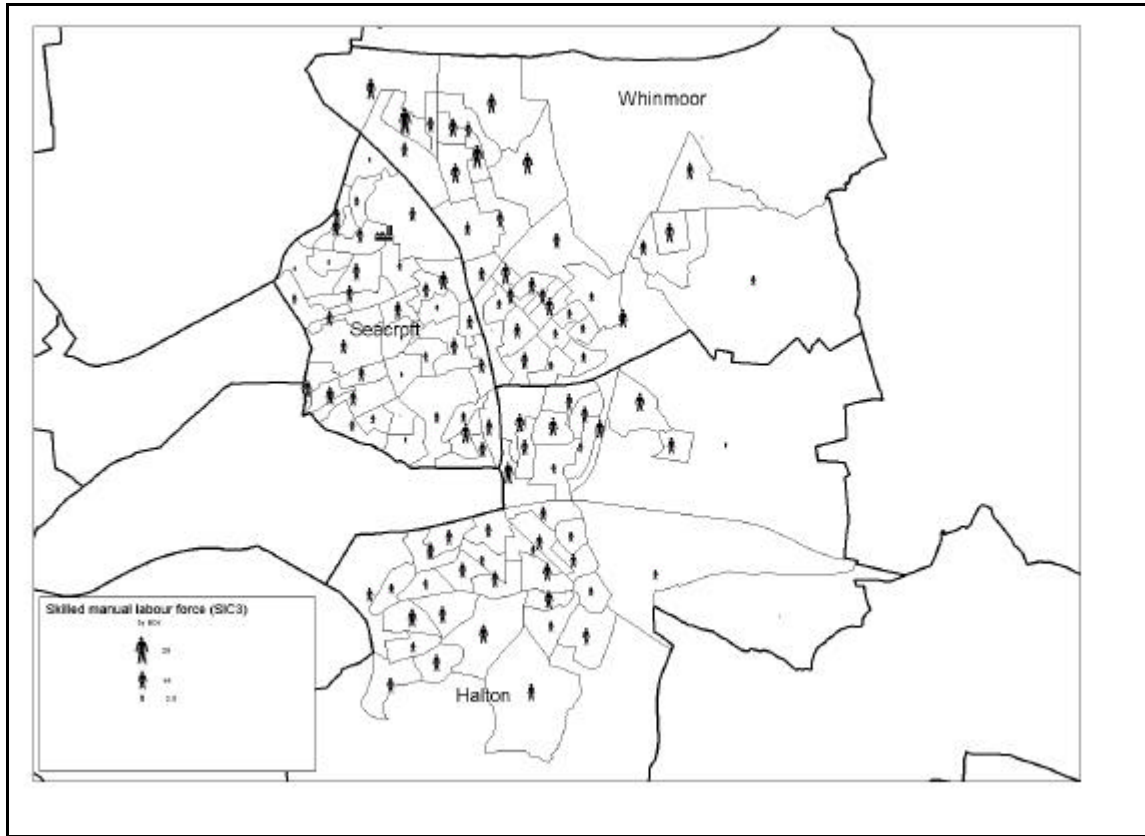
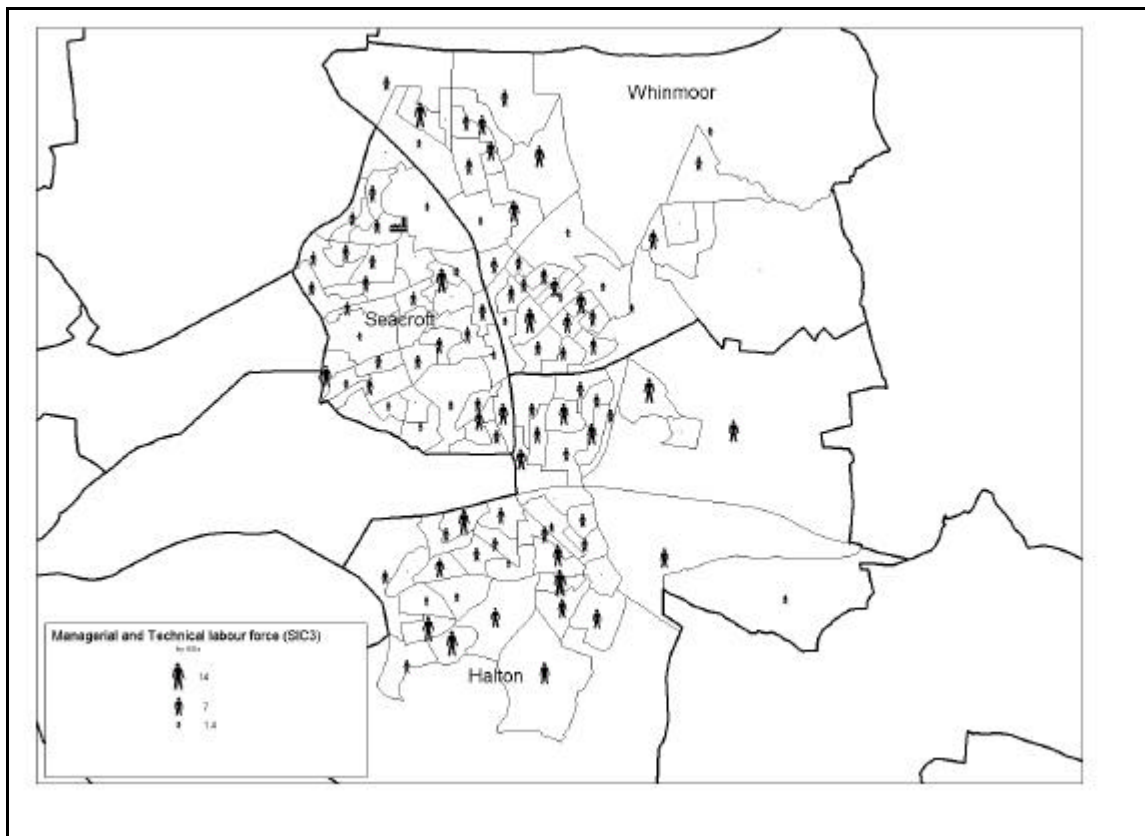**Figure 12 -** Spatial distribution of SIC3 *skilled manual* workers

Figure 13 - Spatial distribution of SIC3 Managerial and Technical labour force

On the other hand, the EDs with large concentrations of the *Professionals etc*, population sub-group may be affected less in terms of jobs loss. Nevertheless, it can be argued that these localities will experience relatively higher *income loss*, given that the earned income of this population group can be reasonably expected to be significantly higher than the income of the *manual workers'* group. In the context of this paper we assumed that the earned income of each individual is conditional upon its estimated attributes.   For now we have associated income with some socio-economic attributes (industry, tenure, marital status). The estimated income structure of our population sub-groups is depicted in figure 14. Our future work will include the modelling of income more precisely using all economic and social variables at our disposal.
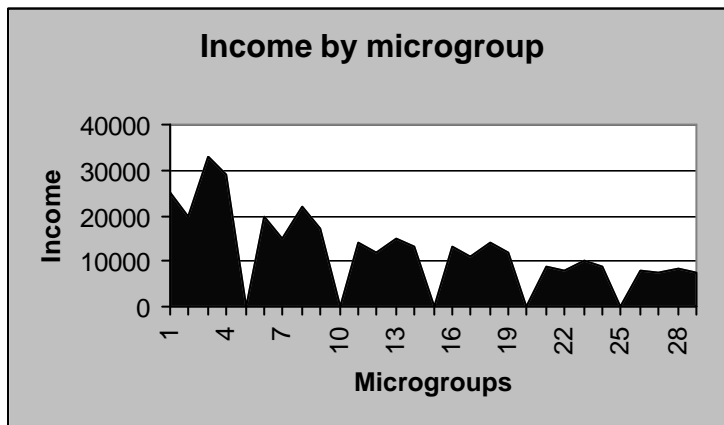
Figure 14 – Estimated income structure

As can be seen in figure 14, there is considerable variation in the income of each population sub-group. This income structure was used to assign to each ED the total earned income by each population sub-group as well as the total earned income by employees in the *Metal Goods, Engineering, Vehicles* industry. Figure 15 depicts the geographical distribution at the ED level of the total estimated earned income by all the labour force that is employed in the above industry (SIC3).
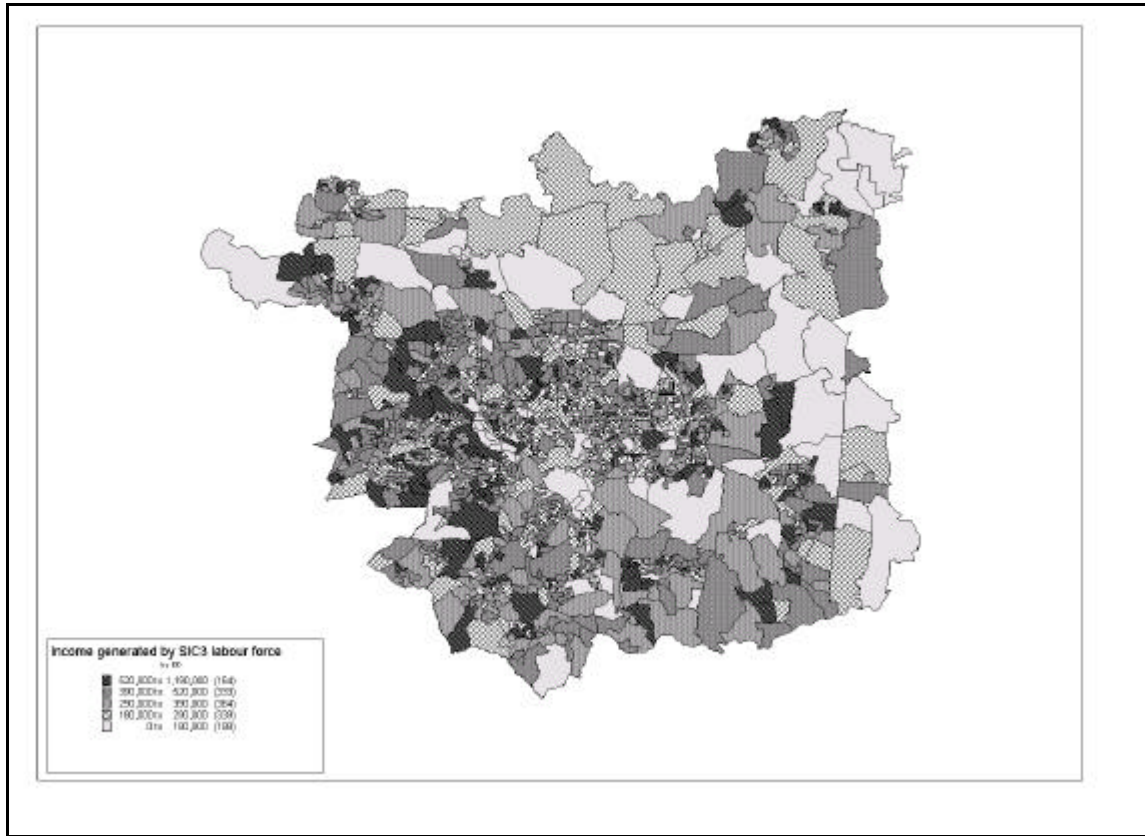
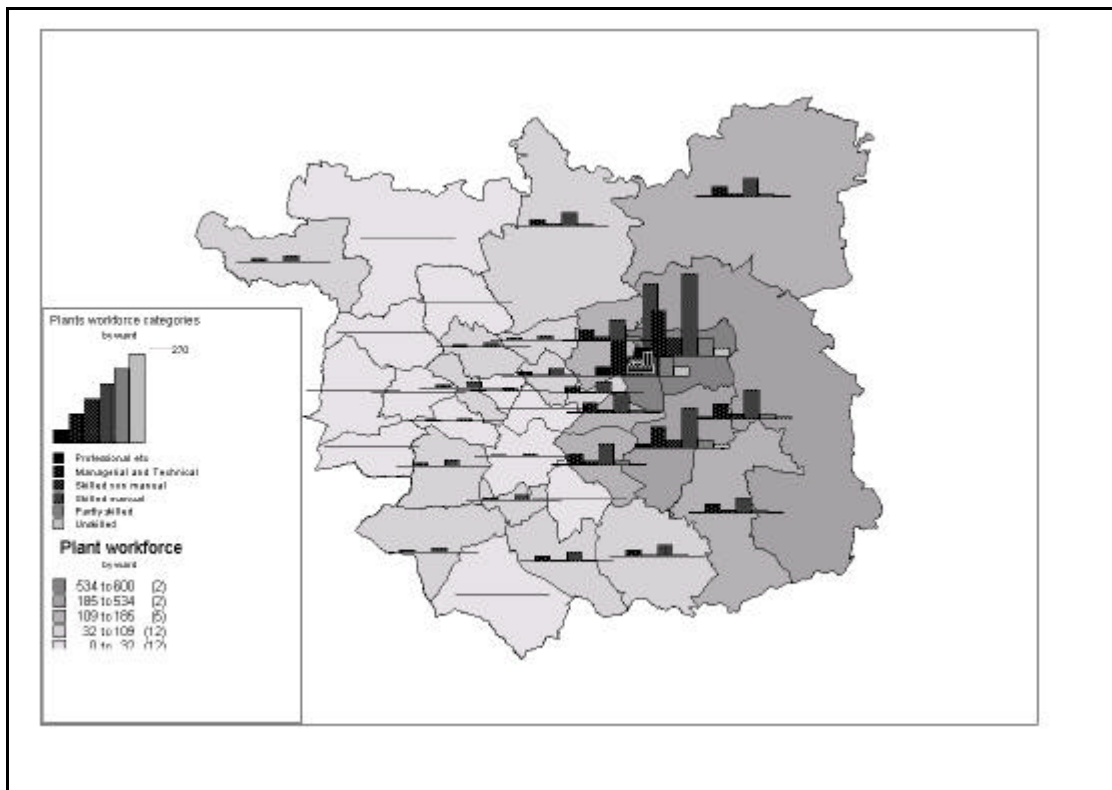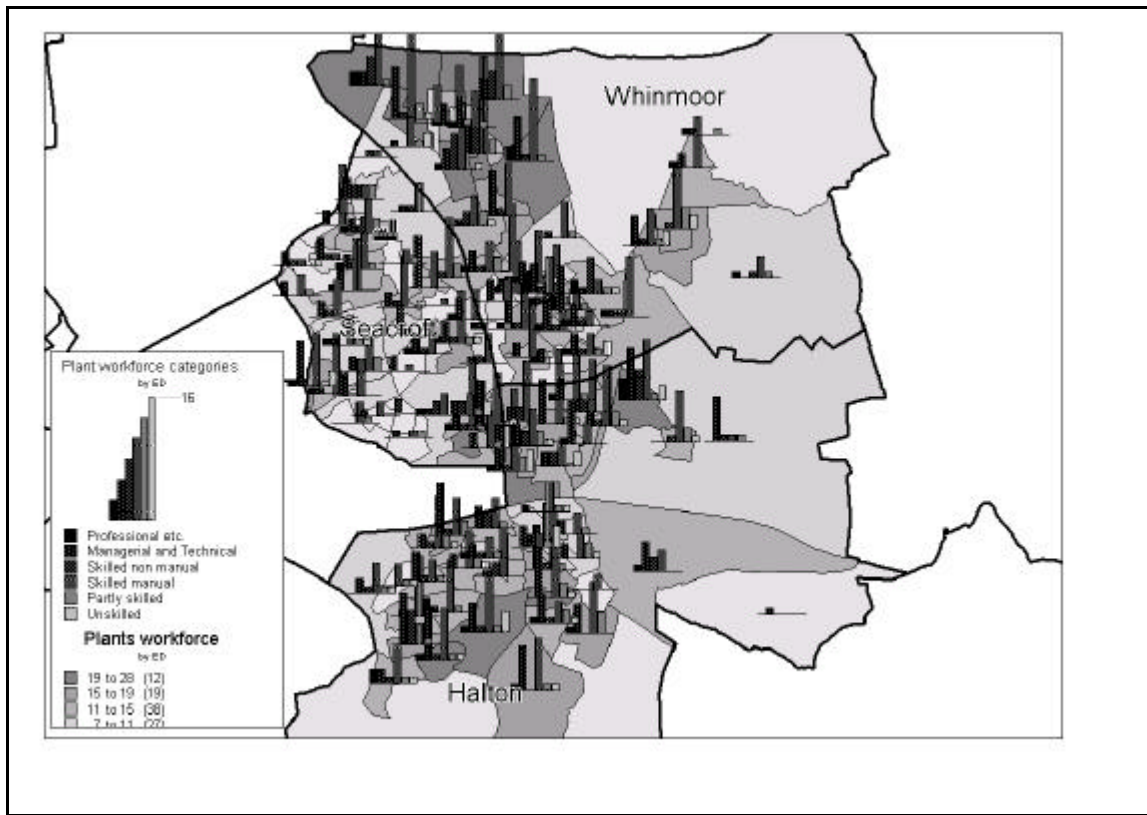**Figure 15** - Spatial distribution of estimated earned income

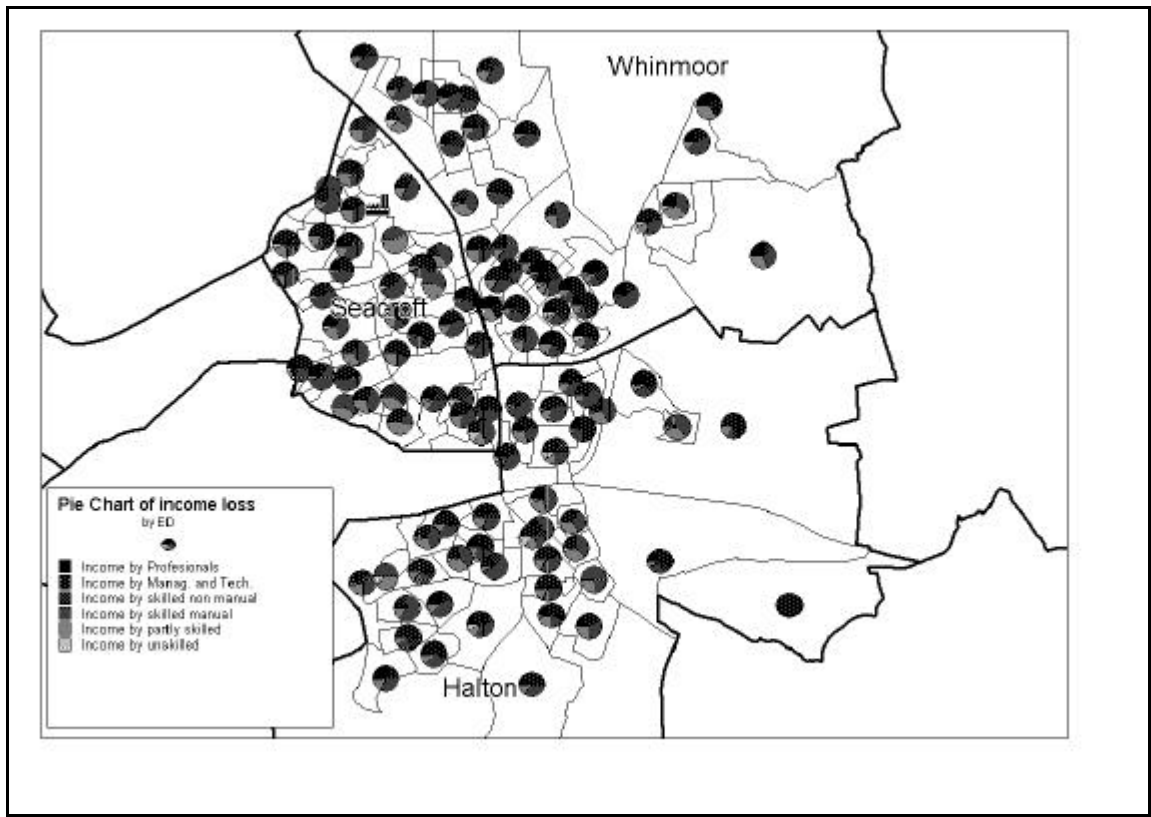**Figure 16 -** Estimated spatial distribution of the plant's workforce

Further, figure 16 shows the estimated spatial distribution of the plant's workforce at the ward level, whereas figure 17 depicts the distribution of the plant's workforce at the ED level in our study area.

Figure 17 - Estimated spatial distribution of plant's workforce in Seacroft, Halton and Whinmoor

In addition, figure 18 depicts the estimated spatial distribution and size of income loss resulting from the plant closure. In particular, figure 18 presents the geographical distribution of total income loss and of the income loss by population sub-group. The above estimates were based on the assumption that the plant closure would affect mostly the areas with the highest travel-to-work flows to Seacroft. More specifically, we used the observed travel-to-work flow rates, the hypothetical plant's workforce size and structure, as well as the estimated spatial distribution of different population sub-groups in order to determine which localities would experience the highest income losses. For instance, the 5% of the 3,000 employees of the plants, i.e. 150 employees belong to the Professionals etc. group. These 150 employees were distributed first to different wards and then to different EDs on the basis of the actual travel-to-work flows at the ward level and of the estimated spatial distribution of Professionals at the ED level. In a similar way we assigned the entire workforce of our hypothetical plant to different

wards and EDs and we then estimated the possible income effect from the plant closure
and its spatial distribution.

Figure 18 - Estimated spatial distribution income loss by SEG in Seacroft, Halton and Whinmoor

Figure 19 – Estimated spatial distribution of income loss in Seacroft, Halton and Whinmoor

Nevertheless, as stated above, these estimates of earned income are still relatively crude. More reliable estimates can be obtained if more disaggregated population groups are assigned to different incomes and if the income structure assumptions are based on some kind of survey such as the annual New Earnings Survey in the UK or a commercial lifestyle database. Further, the above impact analysis can become more sophisticated if *SimLeeds* is extended to take into account the household income generated from other sources (see for example Caldwell *et al*, 1998) as well as the demand side of the Leeds local labour market and the input-output linkages of other plants and firms with the closing plant.

3.4 Towards a local multiplier impact analysis

So far we have performed a spatial microsimulation-based impact analysis of a hypothetical plant closure and we have estimated the initial employment and income effect of this plant closure. However, it should be noted that these initial employment and income impacts have further multiplier effects to different localities. In particular, the initial job and income losses may trigger different event changes. The disposable income loss for each individual or household eventually leads to the decrease of consumption of goods and to possible changes of the preferred retail location etc. (i.e.

moving to less expensive stores). Further, there are also net monetary losses for the government from the decrease of income tax revenue and from the increase of the benefit claims from the households that lose their jobs. It should also be noted that the initial income and employment impact of the plant closure would have third and fourth round multiplier effects, which could include the closures of local convenience grocery stores as a result of the fall of local demand for their goods. These closures in turn would generate further job losses, which would have further multiplier effects at different localities within the city. The volume of all the multiplier effects will depend on various factors such as:

- The total household income loss

- The existing income derived from stocks, shares, savings etc.

- The *marginal propensity for consumption* of each individual household

- The existing consumption patterns and preferences of the local labour force

- The size of the small area

It should be noted that the above analysis could be reversed to evaluate positive multiplier effects from major expenditure injections into a local economy.

Further, all these multiplier effects can be addressed and analysed in a spatial microsimulation framework. In particular, it is possible to estimate local multipliers based on small area (such as EDs) distributions of labour force members (micro-units) in order to predict the direct, indirect and induced income and employment effects at the micro-scale.

In order to facilitate a spatial microsimulation based local multiplier analysis we need to extend *SimLeeds*, so that it will include the demand side of the local labour market as well as other urban sub-systems that make up the local economy such as the housing market, schools, hospitals, retail and financial institutions etc. In addition, we need to obtain information on the conditional probabilities of each micro-unit changing state. In particular, we could estimate, using various data sources, the probability of an individual to change states conditional upon his/her attributes and circumstances. For instance, we could estimate the probability of each individual migrating, changing retail location, sending their children to another school etc. if he/she becomes

employed/promoted/unemployed etc., given his/her existing household attributes. We could then perform Monte Carlo sampling from these probabilities to update the population of micro-units under different *what-if* policy scenarios. Likewise, on the demand side of the local labour market we can simulate the behaviour of the local firms, financial institutions and major employers under different scenarios. It should be noted that the obtained and estimated information on all the sub-systems of the urban economy could be used for the estimation of different multipliers at the small area level or in other words of spatially disaggregated multipliers.

4. Concluding comments

In this paper we have presented a micro-analytic spatial modelling approach to regional policy analysis and to the prediction of the impact of plant closures as well as of the impact of major new expenditure injections into regional economies. First, we reviewed the existing spatial modelling approaches to socio-economic impact assessment and we argued that, although there has been considerable progress in the development and application of spatial modelling techniques, there is a need for the evaluation of the possible impact of regional and urban policies at the local scale. We then argued the case for a microsimulation approach to urban and regional policy analysis.

Further, we outlined the merits and limitation of microsimulation modelling techniques and we demonstrated how these techniques can be employed for local labour market policy analysis and policy. In particular, we have presented *SimLeeds*, which is a spatial microsimulation model developed for the local labour market of Leeds. We have argued that the *SimLeeds* model outputs provide insights into the design and analysis of local labour market policies and initiatives. We then gave an example of how spatial microsimulation models such as *SimLeeds* can be used to assess the employment and income geographical effect of economic changes such as plant closures.

It has also been argued that *local* rather than *regional* multipliers of economic change can be estimated in the context of spatial microsimulation modelling frameworks. In particular, urban dynamics and event modelling can be introduced to models such as *SimLeeds* in order to explore household or firm changes and their likely impacts on different localities.

Our aim is to further develop *SimLeeds*, so that it will include the demand side of the local labour market as well as other urban sub-systems that make up the local economy. We will also include more micro-unit attributes and dynamic modelling procedures in order to render *SimLeeds* capable of performing sophisticated *what-if* local multiplier analysis. In addition, we will add mapping capabilities to *SimLeeds* and therefore display its outputs without the need of transferring the data to Geographical Information Systems (GIS) software packages.

Finally, given that *SimLeeds* is being developed in JAVA, which is a platform independent programming language, it can be put on the World Wide Web and linked to Virtual Decision-Making Environments (VDMEs). The latter are Internet World Wide Web based systems that allow the general public to explore 'real world' problems and become more involved in the public participation processes of the planning system (Carver *et al*, 1999; Evans *et al*, 1999). We believe that models such as *SimLeeds* can be used not only to inform us what are the consequences and the local multiplier effects of major policy changes but also to inform the general public about these and to enhance, in this way, the public participation in policy making procedures.

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