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ABSTRACT

In this paper, a spatial socio-demographic modelling framework is developed. By operating this framework, desired information by urban and regional planners, geographers and economists such as the journal-to-work flow, employment, unemployment, vacancy and dependent at a spatial level can be derived. In Section I, the motivations for developing such a framework are described. The description of the socio-demographic modelling framework, together with the operation procedures, is provided in Section II; In Section III, the Leeds Metropolitan District (Leeds MD) is taken as a study case, and some preliminary results are briefly discussed. The discussion of future application is addressed in the last section.

Key Words:

Spatial, socio-demographic, modelling framework, LMD study

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1. INTRODUCTION

Economic institutions, firms, and in particular, the urban and regional planners, have realized that, due to the complexity and interdependence of the world we live in, the demographic study alone would not be sufficient to provide the desired information without considering at least the following two more features: (i) population and human behavior with spatial characteristics and their social and economic impacts on a spatial level, e.g. the intention and actual movement of a particular group of people from one region to another, and its impacts on regional social and economic structures; and (ii) the demographic study linked with regional economic system, the internal mechanism of which usually influences the level of both employment and hence the unemployment. This can be found, in evidence, in a huge range of literature, for example, the models developed by Rogers (1966, 1967), and Rees and Wilson (1977) identify the spatial features, and the models developed by Rogers etc.(1978), Stone (1961), Stone and Weale (1986), Batey and Madden (1983), Madden and Batey (1986), Madden (1985), and some empirical tests by Pyatt and Round (1984), Round (1986) have linked demographic and economic systems, and explore their interdependency at the regional level. However, some of these models are so comprehensive that the data required are hardly available; and some of them are perfectly constructed, and the operation of which is too difficult to be easily mastered, and the results are too complicated to be expounded.

The aim of this paper is to provide a spatial socio-demographic modelling framework that can be easily understood and manipulated by those who have little knowledge of mathematics, and the derived information can be easily interpreted.

The Leeds Metropolitan District (termed Leeds MD) is taken as a study case. The reasons are: (a) considerable work has been done previously, e.g. Clarke and Birkin (1987), Birkin and Clarke (1989), Rees etc. (1990). Some of the results can be used for comparison purpose; (b) to the authors' knowledge, this kind of socio-demographic study that has linked the demographic and economic systems has never been done for the Leeds MD before, whilst a range of vital information such as the commuters between Inner and Outer Leeds and the rest of the World, the levels of employment, unemployment, vacancy, work force, dependent and their interdependence need to be derived to unlock the 'black box'. To meet such a demand, this study attempts to construct a so-called spatial socio-demographic table for the Leeds MD, from which some desired but preliminary information can obtained.

The structure of this paper is arranged as follows: in Section 2, the socio-demographic modelling framework is described in detail. The procedures of how the Leeds MD socio-demographic table is constructed, and the interpretation of the derived results are dealt with in Section 3. In the closing Section, some issues relating to further development of the model and uses of the Leeds MD socio-demographic table are discussed.

2. THE MODELLING FRAMEWORK

The overall spatial socio-demographic modelling framework is provided in Table 1. A two-layer calculation procedure which is illustrated in Figure 1 is required: (1) calculate the journey-to-work flow, labour demand and supply from exogenous variables, and (2) taking the derived results from Layer 1 as exogenous inputs, the vacancy, unemployment and, eventually, the balanced population situation can be computed.

POSITION OF TABLE 1

The exogenous variables for the first layer include: (i) the initial population (P_i^m) by social class (m=1,...M) by residential region (i=1,...,I) in a previous time period, say, year t-1, which is required to calculate the labour force by social class m by region i (P_i^m); (ii) the number of trip makers by social class by region (R^m_i), and the wage level (W^n_j) in industry n (n=1,...,N) in industrial region j (j=1,...,J), which are used to estimate the journey-to-work flow; (iii) the investment in industry n in region j (I^n_j) and (iv) the interregional input-output coefficient ($\underline{a}^{nn'}_{jj'}$) together with gross output of industry n in region j (X^n_j) which affect the labour demand coefficient level.

POSITION OF FIGURE 1

The calculation of the desired variables in Layer 2 and the derived exogenous variables are linked by those linkages such as economically activity rate ($\hat{a}^m_i$), dependent rate ($\hat{o}^n_j$) and labour demand coefficient ($\hat{e}^n_j$). In this study, it is assumed that the activity rate and the dependent rate are obtainable, and the labour demand coefficient is a function of (a) input-output coefficient, (b) the gross output and (c) investment, which are given in equation 6 in Table 1. It can be written as:

$$\hat{\mathbf{e}} = \mathbf{B}^* \cdot \underline{\hat{\mathbf{e}}} + \hat{\mathbf{1}} \cdot \boldsymbol{i} = \Sigma_n \Sigma_j b^{nn'*}_{jj'} \hat{e}^n_j + \hat{1}^n_j \cdot i^n_j \tag{14}$$

where:

$$\mathbf{B}^* = [b^{nn'*}_{jj'}] = (\mathbf{I} - \underline{\mathbf{A}}^*)^{-1} \tag{15}$$

in which $\underline{\mathbf{A}}^*$ is the conventional input-output coefficient matrix but closed with respect to households, i.e. the household rows are included in the processing industries; $\mathbf{B}^*$ [$=(\mathbf{I}-\underline{\mathbf{A}}^*)^{-1}$] is the Leontief type inverse matrix, each element $b^{nn'*}_{jj'}$ provides, in the non-household rows of the inverse, the total effect (direct, indirect and induced) on the output of each sector of an increase in sales to final demand by industry n in region j. The direct effect on employment in each sector of a change in output of industry n in region j, i.e. the direct labour demand coefficient is defined as $\hat{e}^{n}_{j}$. The product of the total output effect $[b^{nn',*}_{jj'}]$ and the direct labour coefficient, over non-household industries, shows the total number of labour demand resulting from a change in output [c.f. Jensen etc (1979) and Jin etc. (1991)].

$\hat{1}$, is a diagonal labour-investment coefficient matrix $(njxn'j')$, each element $1^{nn'}_{jj'}$ of which shows the number of labour required in industry n in region j due to an increase in investment into industry n in industry j. It is worth noting that this coefficient matrix channels the investment into different industries in the different regions, and shows the impacts on the labour demand. A sum of investment into a capital intensive industry will have less labour demand, whilst into a labour intensive industry will yield high labour demand. i is a investment-output coefficient vector $(njx1)$, each element i^{n}_{j} of which provide the investment ratio to its gross output. Consequently, $\hat{1}\cdot i$ shows the number of labour demand, via the new increased investment, when one unit of gross output is produced. The total labour demand coefficient is equal to the labour demand resulting from a change in output and from the new investment into different industries in different regions.

Through those linkages, the journey-to-work flow (L_{ij}^{mn}), the labour force (R_i^m) and the total number of labour demand can be computed. Model 6 illustrates that the journey-to-work flow is a function of trip makers, wage level or the number of job opportunities and distance between resident place *i* and work place *j*. A spatial interaction modelling structure can be employed here to estimate the flow, with the number of trip makers as supply factor and the wage level or the number of job opportunities as attractiveness force. The distance is negatively related to the flow. We then have:

$$L_{ij}^{mn} = K\hat{R}_i^{m\alpha} W_j^{n\beta} t_{ij}^{mn-\gamma} \tag{16}$$

where *K*, α, β and γ are parameters. However, there are two problems associated with the model: (1) using the wage level to be the attractiveness force may be insufficient. The trip making is usually motivated by the number of job opportunities rather than the wage level alone; and (2) the distance attenuation and application of the inverse power, according to the above model, as the distance become shorter and shorter, the number of trip makers will be unlimited larger and larger. It is obviously untrue, in particular, when trip flows among a system of small areas are to be estimated. Then, a negative exponential form may needs to be introduced. Equation 16 [c.f. Wilson (1974), Field and Macgregor (1987)] can then be written as:

$$L_{ij}^{mn} = K\hat{R}_i^{m\alpha} W_j^{n\beta} e^{t_{ij}^{mn-\gamma}} \tag{17}$$

The number of labour demand and supply are calculated from the model (2) and (12) respectively. Both the activity rate ($\hat{a}_i^m$) and labour coefficient ($\hat{e}_j^n$) are policy factors which can be adjusted by planners. When a country or a region is facing a serious unemployment problem, the economically activity rate can be regulated, for instance, any person under 18 years old are not allowed to work, and those over 55 should be retired; alternatively, adjust the labour coefficient by, for example, channeling the investment into the labour intensive rather than capital intensive industries, i.e. adjusting the labour-investment coefficient in equation 14.

In the second layer calculation, the derived results from the layer 1 calculation will be used as exogenous input data, such as the actual employment by social class by residential region which is defined in model 5, the actual employment by job type by industrial region which is defined in model 8, and the number of labour demand and supply calculated from model (2) and (12). The number of unemployment and vacancy are calculated as the differences between (i) the labour force and the actual employment by social class by residential region and (ii) the number of labour demand and the number of actual employment by job type by industrial region, which are provided in model (10) and (11) respectively.

To check the consistency of the whole calculation system, a balance equation needs to be introduced, that is, the total population by social class by residential region should be equal to the total employment by industry by industrial region [NB. the distinctions between residential and industrial regions are only for theoretical purpose. In the real world, they are mixed, and the number of residential regions (I) are identical to the number of industrial regions (J)]. The total population by social class by residential region and by industry by industrial region are derived from model (1) and (4) respectively. We then have:

$$\Sigma_m \Sigma_i P_i^m = \Sigma_n \Sigma_j P_j^n \qquad (18)$$

The imbalance situation may imply: (1) the difference between the commuters from and to the rest of the world; (2) something wrong with estimation.

3. THE SOCIO-DEMOGRAPHIC STUDY FOR THE LEEDS MD

The application of the spatial socio-demographic modelling framework into the Leeds Metropolitan District (Leeds MD) results from two reasons: (1) the Leeds MD, a urban district with 33 wards in the region of Yorkshire and Humberside in England, needs to have a full account for its socio-demographic situation such as employment, unemployment, labour force, vacancy and their interactions to response the current economic depression; (2) much work has been done by a group of experts in the School of Geography in the University of Leeds as well as the Gmap Ltd, and some of the results can be 'borrowed' either to be incorporated in the model directly or to be used for comparison and references. However, this practical work is very preliminary and crude, although it reflects the overall regional socio-demographic structure. Furthermore, this empirical work demonstrates how the modelling framework is applied.

The socio-demographic study for the the Leeds MD focuses on describing the structures of employment, workforce, vacancy, labour requirement and population by social class by industry by spatial levels. The following questions need to be addressed: (i) in general, what is the current socio-demographic situation in the Leeds MD; (ii) what is the journey-to-work pattern within the Leeds MD; (iii) why there are unemployment happening in these social classes whilst not in others; why there are many employment opportunities in these industries whilst not in others. The identified social classes and spatial levels (i,j=1,...,3; Inner, Outer Leeds and the rest of the World) are as same as those defined in a previous work by Jin and Birkin (1991a). Seven aggregated industries (n=1,...,7) are included: agriculture, energy, manufacturing, construction, distribution, transportation and service, and seven social classes (m=1,...,7) that indicate skill levels are considered. They are: (1)

employer or manager; (2) professional workers; (3) skilled workers (non-manual); (4) skilled workers (manual); (5) semi-skilled workers; (6) unskilled manual workers; (7) others (such as the Armed Forces and inadequately described).

For convenience, all the variables that to be calculated are nested into a table named: the spatial socio-demographic table for the Leeds MD, and shown here as Table 2, in which the first row shows the calculation of journey-to-work flow, actual employment, labour force, unemployment, inactive persons and total population by social class by spatial level respectively. The first column shows the calculation of journey-to-work, actual employment, labour requirement, vacancy, dependent and population by industry by spatial level respectively. Row 2 and column 2, with the exceptions of cell (1,2) and (2,1), indicate the aggregate variables. The diagonal cells, with the exception of cell (1,1), show the comparisons between (a) the total employment by social class and the total employment by industry, (b) the total labour force by social class and the the total number of labour requirement by industry, (c) the total number of unemployment and vacancy, (d) the total number of inactive persons and dependent, and (e) total number of population by social class and by industry.

POSITION OF TABLE 2

Such a table for the Leeds MD is derived through the following steps: collecting data, dealing with the components and constructing the table, each of which will now be discussed in turn.

Step 1: Collecting data

Since such a table requires quite a large amount of data, the data have to be obtained in a variety of ways. The ways we used are: postal questionnaires, accessing the detailed census data from the SASPAC (the Small Area Statistics), estimation and others.

The data collection process was first started by accessing the Census data at the Manchester University computing centre. The SASPAC contains two types of data: census 100% and 10% sampled data. Both types of data can be obtained at the ward levels, for example, household size, or employment by industry for the 33 wards in the the Leeds MD can be easily accessed. The only requirements are to apply for permission to use the package, and after such permission is gained, a small instruction file has to be specified to retrieve the required data file. The problem is that census data are only updated in every ten years. In our study, the most recent census data that can be used are those obtained from the census in 1981. To remedy such a shortcoming, a direct survey was then undertaken to update the census data.

POSITION OF TABLE 3

Table 3 describes the main contents of a questionnaire and the coded results in which four types of households are identified. In the first row of the second column, the data '4' indicates the number of residents in this household; in the third column, the number '2' shows that two persons are working (and two are dependents). The tick mark (√) in the columns of 'social class' and 'industry' shows to which social groups and industries the two employed persons belong. Clearly, one of them belongs to the professional worker classification and another to non-manual skilled worker class, and both of them are employed in the service industry. In the questionnaire, different numbers are used to distinguish the employees who work in the different industries. The household income is put into the last column of the table. About 250 questionnaires were sent out to households chosen at random, that is, about 8 questionnaires are sent to a set of 8 pre-chosen households in each of the 33 wards in the Leeds MD, and 121 came back before the dead-line. Although the sample is very small, the results do reflect the social-demographic situation of the city of Leeds. Table 4 shows the sorted results relating to the owner occupied category for Outer Leeds.

POSITION OF TABLE 4

Another way to collect data is to consult experts, and ask them to provide the desired data that are not usually available in any published sources. For instance, the journey-to-work data for the 33 wards have been estimated by a group of experts in the School of Geography in the University of Leeds, which are then borrowed and incorporated into this study. These data are normally derived from the spatial interaction model, the structure of which is similar to what is demonstrated in model (6), or from the RUIN model (Birkin and Clarke, 1987). Since these models have been perfectly developed in theory, the estimated results are sometimes differed from reality, for example, as far as the journey-to-work flows in the Leeds MD are concerned, the figures for employment in transportation sector are even bigger than those in service industry. This is clearly not true. Such flows have to be modified by applying the surveyed data.

STEP 2: Deals with the components in the Leeds MD table

The first task is to describe the journey-to-work flow. In order to be consistent with the economic system, two zones (Inner and Outer Leeds) are then identified. The journey-to-work flow then shows the number of employees living in either Inner Leeds or Outer Leeds or the rest of the World who go to work in the industries in either Inner or Outer Leeds or the rest of the World. By summarizing the journey-to-work flows across industries in both Inner and

Outer Leeds areas and the rest of the World, the total origins of employment by social class can be derived. The total destinations of employment can also be derived if the journey-to-work flows are summarized across the social classes in both Inner and Outer Leeds and the rest of the World.

The derivation of labour force and employment is obtained using census data. The activity rate is defined as the economically active population to the total number of residents in Inner and Outer Leeds (See Table 5). The workforce by social class is calculated by multiplying the economic activity rate by the total population, and unemployment is calculated as the difference between the total employment and the workforce.

POSITION OF TABLE 5

The labour coefficient and vacancy are derived from both census data and the data from some previous work, e.g. Jin and Birkin (1991a) and Jin etc. (1991b). The labour coefficient in this study is simply derived from the first part of model (14). The number of new labour demand resulting from new investment is not considered because this empirical study is only for the current situation. However, future study for next time period should consider the labour requirement occasioned from new investment. The calculated labour coefficients for different industries in both Inner and Outer Leeds are listed in Table 6, which are used to work out the total number of labour requirement. By comparing the calculated number of labour requirement to the actual employment, the vacancy for each industry for each zone is then derived.

POSITION OF TABLE 6

Step 3. The socio-demographic table for the Leeds MD

The remained problems focus on how to assemble those previously derived components into a table and how to properly interpret the elements of such a table. The constructed socio-demographic table is shown in Table 7.

POSITION OF TABLE 7

This table contains 36 (6 x 6) 'cells', in each of which a subset of elements are included. The cell (1,1) is in fact a 15 x 15 matrix (7 industries, 7 social classes, two zones and the rest of the World). The data across the columns show the destinations of those employed persons originating from different social classes in Inner and Outer Leeds and the rest of the World, for example, about 2239 skilled non-manual skilled workers in Inner Leeds are working in the manufacturing industry in the same zone, but 2,711 go to Outer Leeds, and 3,450 go to the rest of the World. Cell (1,2), a 15 x 1 vector, is the total employment by social class by zone, for instance, the total skilled non-manual employment in Leeds is 42,325. Cell (1,3), a 15 x 1 vector, is the total labour force for each social class in each zone, which is calculated from the economic activity rate and total residents, for example, the total workforce generated by the skilled non-manual employment in Inner Leeds is about 50,298. Cell (1,4), also a 15 x 1 vector, expresses the total unemployment by social class by zone, which is calculated as the difference between cell (1,3) and (1,2). Obviously, the total skilled non-manual unemployment in Leeds is 7,973 (50,298-42,325). Cell (1,5) provides the number of inactive persons which are calculated from model (3). Cell (1,6) is the total population by social class by residential zone.

Looking at the journey-to-work down the columns, cell (1,1), a 15 x 15 matrix, shows the origins of employment, for instance, about 2,239 persons employed in the manufacturing industry in Inner Leeds come from the skilled manual class in Outer Leeds, and 2,811 from the rest of the World. Cell (2,1), a 1 x 15 vector, is the total actual employment by industry, for example, there are 32,614 persons employed in manufacturing industry in Inner Leeds. Cell (3,1), a 1 x 15 vector, is the number of labour demand under a certain set of labour coefficients, for instance, the labour coefficient for the manufacturing industry is presumed to be 210, the total requirements should be 40,253. Cell (4,1), also a

1 x 15 vector, is the vacancy for each industry, which is calculated as the difference between the total employment in cell (3,1) and the total number of labour requirement in cell (2,1). Again, taking manufacturing industry as an example, the vacancy will be 7,640 in Inner Leeds. Cell (5,1) shows the number of dependent supported by those workers in each industry in each zone. In Inner Leeds, 56,628 persons have to be supported by the manufacturing industry. The last cell, (6,1), is the total population calculated by adding the total employment in cell (2,1) and the total number of dependent in cell (5,1).

Cell (2,2) shows that the total number of employment by social class are equal to the total number of employment by industry, which is 288,744. The number, '34,152' in cell (3,3) is calculated as the difference between the total number of labour force and labour requirement which shows the theoretical unemployment if all the number of vacancy are fulfilled with the unemployed persons. The number '34152' in cell (4,4) results from the difference between the total unemployment and vacancy which has the same meanings to cell (3,3). The number '-83879' in cell (5,5) describes the difference between the total number of inactive persons and dependent. Clearly, the number of dependent are larger than the number of inactive persons because all the unemployed persons are assumed to be supported by the employed workers. Cell (6,6) shows that this table is a balance one, and the total population by social class are equal to the those by industry.

Step 4: The output information from the Leeds MD table

The following information can be obtained from the Leeds socio-demographic table which describes the steady state conditions for the socio-demographic system for the Leeds

(1) The journey-to-work flow by social class by residential zone by sector by industrial zone by the rest of the World

(2) Employment structure by social class and industry for Inner, Outer Leeds and the rest of the World

(3) The workforce and unemployment structure for Inner, Outer Leeds and the rest of the World

(4) The labour requirement and job vacancy structures by industry for Inner and Outer Leeds

(5) The number of inactive persons by social class and dependent by industry for Inner and Outer Leeds

(6) The population structures by social class and by industry for Inner and Outer Leeds

The Leeds socio-demographic table can also be further operated, Some additional but interesting results could be derived. For instance, the coefficients, named 'interregional social supply coefficient' and 'interregional industrial demand coefficient' can be derived. The former one may indicate the labour supply structure across the industrial zones. If L_{ij}^{mn} is notated as the journey-to-work flow, and R_i^m with a hat (ˆ) is the total employment by social class, the social supply coefficient may be worked out from:

$$C_{ij}^{mn} = L_{ij}^{mn} \;/\; \hat{R}_i^m \qquad (8.1)$$

where

$$\hat{R}_i^m = \Sigma_n \Sigma_j \, L_{ij}^{mn} \qquad (n=1,\ldots,N;\; j=1,\ldots,J)$$

C_{ij}^{mn} can be further aggregated as C_{ij}^{m*}, which shows the supply structure for each social group in each zone to industrial zones and the rest of the World.

The latter one, the interregional industrial demand coefficient ($\underline{C}^{mn}{}_{ij}$), may show the industrial demand structure across the residential zones, which can be expressed as:

$$\underline{C}_{ij}^{mn} = L_{ij}^{mn} \;/\; \underline{R}_i^m$$

where

$$\underline{R}_i = \Sigma_n \Sigma_j L_{ij}^{mn} \quad (n=1,\ldots,N;\; j=1,\ldots,J)$$

$\underline{C}_{ij}^{mn}$ can be further aggregated to $\underline{C}_{ij}^{*n}$ which describes the demand structure for each industry in each zone from residential zone and the rest of the World. These two types of coefficients calculated for the the Leeds MD are shown in Table 8 and 9.

POSITION OF TABLE 8

As far as the interzonal social supply coefficients (Table 8) are concerned, the persons who are residents in Inner Leeds normally work in the same zone, for example, 66% of the professional workers living in Inner Leeds also work in Inner Leeds, and 19.91% go to Outer Leeds and 13.98% to the rest of the World. Those who live in Outer Leeds, however, follow a different pattern in that most of them go to Inner Leeds or the rest of the World to work, for instance, 49.33% of the professional workers who live in Outer Leeds go to work in Inner Leeds, and about 28.09% of them work in Outer Leeds, and 22.58% go to the rest of the World. This two different patterns may be interpreted as evidence that there are more job opportunities in Inner Leeds than Outer Leeds, and as Outer Leeds is near other urban districts, e.g. Bradford, the workers in Outer Leeds then go to the rest of the World because the gravity force is scattered.

POSITION OF TABLE 9

For the interzonal industrial demand coefficients, the industries in Inner Leeds are very attractive to those in Outer Leeds, for example, 57.75% of the employment in Energy sector, and 53.10% of the employment in construction are from the Outer Leeds; However, the attraction to the rest of the World are relevantly small, for instance, only 8.62% of the employment in manufacturing industry is from the rest of the World. This may due to the 'hinder' effect caused by Outer Leeds, and part of the inflows from the rest of the World are stopped by the industries in Outer Leeds. The industries in Outer Leeds attract employment from both Inner Leeds and the rest of the World, for example, 21.12% and 20.23% of the employment in manufacturing industry are from Inner Leeds and the rest of the World respectively.

4. CONCLUDING COMMENTS

In this paper, we have presented a spatial socio-demographic modelling framework which aims to provide a feasible method for urban and regional analysis. The application of such a framework into the Leeds MD and a set of preliminary results have been described and briefly interpreted. Some limitations and possible extensions can now be discussed in turn.

The major limitation relating to this modelling framework is the updating problem. Since this framework basically provides a descriptive method, the results generated may only be sufficient to do static spatial socio-demographic analysis. For a comprehensive study or simulation purpose, the updating problem needs to be considered. From this modelling framework *per se*, dynamic results can perhaps be derived from injections of exogenous variables and those obtained from the last time period, say t. Another possible updating method is to employ some methodology developed by, for example, Duley, Rees and Clarke (1988).

Readers may have realized that the calculation of the labour coefficient requiring a set of input-output coefficients, the feasibility of access such a set of data depends on the level of spatial resolution. When a study area of interest is a nation, the input-output coefficients are easy to obtain because, in most cases, the national input-output tables, are usually available. However, if the study of area is either an individual region, or a group of regions, or much more aggregated regions such as a group of urban zones, the collection of the input-output coefficient will be very difficult. A method, termed HEM, developed by Jin and Rees (1992) may be employed to estimate those desired coefficients. However, the HEM approach needs some surveyed data too.

With respect to the empirical application for the Leeds MD, we have to admit that this is only a rudimentary experiment for the Leeds MD socio-demographic analysis which entails a considerable amount of work. Potential work may include: (i) extend the aggregated seven industries into the more disaggregate sectors to provide detail information; (b) inject new collected data required by the model and generate updating results for more recent years and, if possible, make simulations for future years; (c) distribute the derived results to some experts and ask them to check the accuracy of the results. These pieces of work sound simple but it in fact will cost considerable amount of time and finance to accomplish them.

To conclude, this modelling framework can generate quite detail information for spatial socio-demographic analysis and, we feel that this framework, due to its simplicity, can be widely used by urban and regional planners and those in the relevant fields.

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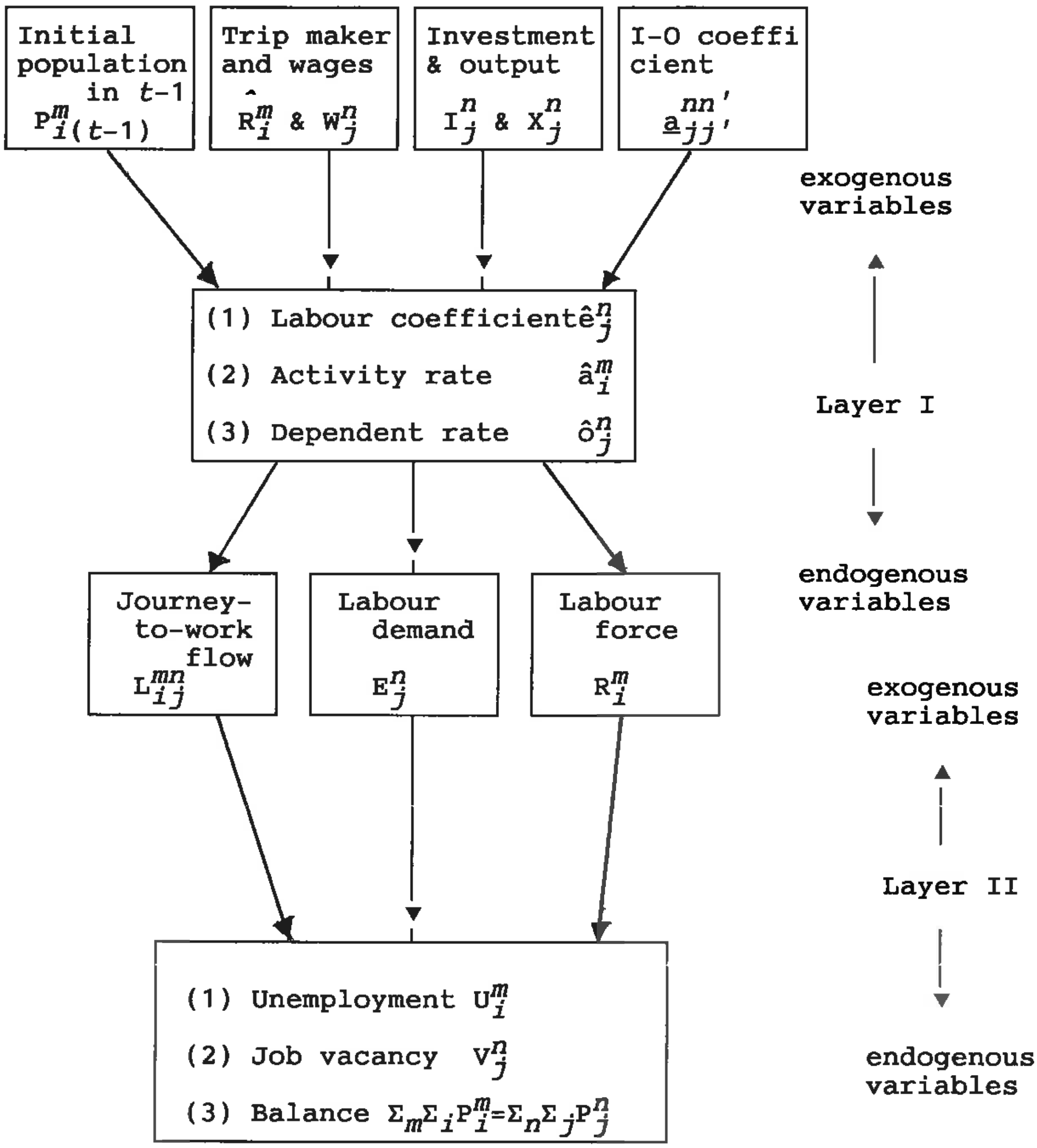

Figure 1: The calculation procedure for the socio-demographic modelling framework

TABLE 1: The overall spatial socio-demographic modelling framework

(1) Population in a region

a) by social class

$$P_i^m = R_i^m + Z_i^m \quad (1)$$

$$R_i^m = \hat{a}_i^m P_{i(t-1)}^m \quad (2)$$

$$Z_i^m = (1-\hat{a}_i^m) P_{i(t-1)}^m \quad (3)$$

b) by industry

$$P_j^n = \underline{R}_j^n + S_j^n \quad (4)$$

$$\underline{R}_j^n = \Sigma_m \Sigma_i L_{ij}^{mn} \quad (5)$$

$$L_{ij}^{mn} = f(E_j^n,\ R_i^m,\ W_j^n,\ t_{ij}, \ldots) \quad (6)$$

$$S_j^n = \hat{o}_j^n \underline{R}_j^n \quad (7)$$

(2) Actual employment

a) by social class

$$\hat{R}_i^m = \Sigma_n \Sigma_j L_{ij}^{mn} \quad (8)$$

b) by industry (job type)

$$\underline{R}_j^n = \Sigma_m \Sigma_i L_{ij}^{mn} \quad (9)$$

(3) Unemployment and job vacancy

a) Unemployment by social class

$$U_i^m = R_i^m - \hat{R}_i^m \quad (10)$$

b) job vacancy by industry

$$V_j^n = E_j^n - \underline{R}_j^n \quad (11)$$

$$E_j^n = \hat{e}_j^n X_j^n \quad (12)$$

$$\hat{e}_j^n = f(\underline{a}_{jj}^{nn\prime},\ X_j^n, \ldots) = \mathbf{B}^* \cdot \underline{\hat{\mathbf{e}}} + \hat{\mathbf{1}} \cdot \boldsymbol{i} \quad (13)$$

VARIABLES:

P_i^m: type *m* population in residential region *i*;

P_j^n: population by industry *n* in industrial region *j*;

$\hat{R}_i^m$: actual employment by social class *m* by region *i*;

$\underline{R}_j^n$: actual employment by industry *n* in region *j*;

R_i^m: labour force by social class *m* by region *i*;

E_j^n: labour demand by industry *n* in region *j*;

I_j^n: investment in industry *n* in region *j*;

L_{ij}^{mn}: the journey-to-work flow, i.e. the number of persons who belong to social class *m* in residential region *i* go to work in industry *n* in industrial region *j*);

U_i^m: unemployment by social class *m* in region *i*;

V_j^n: vacancy in industry *n* in region *j*;

Z_i^m: inactive population by social class *m* in region *i*;

S_j^n: dependent supported by those working in industry *n* in region *j*;

X_j^n: gross output product in industry *n* in region *j*;

W_j^n: wage level of industry *n* in region *j*;

$\underline{a}_{jj'}^{nn'}$: the input-output coefficient with the inclusion of household sectors;

$\hat{a}_i^m$: activity rate (Here it is defined as the ratio between the people who can work and the total population);

$\hat{e}_j^n$: the labour coefficient, i.e. the number of labour required by industry *n* in region *j*;

i_j^n: investment-gross output coefficient;

$\hat{l}_j^n$: labour-investment coefficient;

$\hat{o}_i^m$: dependent rate (Here it is define as the number of persons supported by one worker in industry n in j);

t_{ij}: transportation cost between residential and industrial regions.

Table 2: The spatial socio-demographic table for the Leeds Metropolitan District

	(1)	(2)	(3)	(4)= (3)-(2)	(5)	(6)= (3)+(5)
(1)	L_{ij}^{mn}	$\hat{R}_i^m$	R_i^m	U_i^m	Z_i^m	P_i^m
(2)	$\underline{R}_j^n$	$\Sigma_m\Sigma_i R_i^m = \Sigma_n\Sigma_j \underline{R}_j^n$	$\Sigma_m\Sigma_i R_i^m$	$\Sigma_m\Sigma_i U_i^m$	$\Sigma_m\Sigma_i Z_i^m$	$\Sigma_m\Sigma_i P_i^m$
(3)	E_j^n	$\Sigma_m\Sigma_i E_j^n$	$\Sigma_m\Sigma_i R_i^m - \Sigma_n\Sigma_j E_j^n$	/	/	/
(4)= (3)-(2)	V_j^n	$\Sigma_m\Sigma_i V_j^n$	/	$\Sigma_m\Sigma_i U_i^m - \Sigma_n\Sigma_j V_j^n$	/	/
(5)	S_j^n	$\Sigma_m\Sigma_i S_j^n$	/	/	$\Sigma_m\Sigma_i Z_i^m - \Sigma_n\Sigma_j S_j^n$	/
(6)= (2)+(5)	P_j^n	$\Sigma_m\Sigma_i P_j^n$	/	/	/	$\Sigma_m\Sigma_i P_i^m = \Sigma_n\Sigma_j P_j^n$

Table 3: The contents of a questionnaire*

(1)	Per-sons (2)	Emplo-ment (3)	Social class (4) 1	2	3	4	5	6	7	Industry (5) 1	2	3	4	5	6	7	Hosld Income (6) £
Owner occu.	4	2		√	√									√		√	42,000
City Coun.	3	1				√						√					8,000
Housing Asso.	2	0															5,000
Rental& Other	2	2			√	√						√				√	30,000

* The original questionnaire is designed as a letter. All the data in this table are examples.

Table 4: The social survey results about the owner occupied households in the Leeds MD

(1)	Per-son (2)	Employ ment (3)	Social class (4) 1	2	3	4	5	6	7	Industry (5) 1	2	3	4	5	6	7	Hosld Income (6) £
1	3	1		√								√					8k
2	4	2		√		√									√	√	11k
3	2	1	√													√	20k
4	2	0															8k
5	4	2	√			√								√		√	14k
6	5	2		√			√							√		√	9k
7	4	1		√										√			9k
8	2	2			√	√										2*	11k
9	3	3		2	√							2	√				15k
10	4	2		2										√		√	14k
11	2	2			√	√							√	√			[]
12	2	2					√	√		√	√						[]
13	2	2		√	√									√		√	12k
14	3	2		√		√										2	10k
15	4	3		√			√		√			2				√	15k
16	4	2			√			√				√		√			11k
17	1	0															9k
18	11	7				7								√	5	√	19k
19	1	0															6k
20	2	0															10k
21	4	2		√	√									√		√	[]
22	5	2			√	√								√		√	7k
23	3	2	√	√								√				√	16k
24	1	0															8k
T	78	42	3	13	7	13	3	2	1	1	1	6	2	10	6	16	—

* It indicates the number of employees.
[] No data.

Table 5: The economic activity rate for the LMD

	1*	2	3	4	5	6	7
Inner	0.536	0.553	0.592	0.515	0.523	0.497	0.527
Outer	0.523	0.489	0.587	0.517	0.544	0.574	0.538

* For seven social classes:employer, professional worker, skilled (non-manual) worker, skilled (manual) worker, semi-skilled worker, manual worker and others.

TABLE 6: The estimated labour coefficients (persons/£m)

	I*	II	III	IV	V	VI	VII
Inner	257.1	149.1	21.8	73.6	69.2	39.3	39.2
Outer	61.4	35.1	48.1	79.4	99.3	173.0	129.9

* For seven industries: agriculture, energy, manufacturing, construction, distribution, transportation and service.

Table 7: The Socio-demographic table for Leeds Metropolitan

To / From	Inner Leeds I	II	III	IV	V	VI	VII (1)
Inner							
1	0.0	129.3	1282.2	1320.8	1524.9	479.4	2096.0
2	0.0	91.8	402.8	14.3	136.3	43.9	2147.1
3	0.0	436.5	2239.0	2080.0	4478.8	1761.0	14595.9
4	18.0	1145.2	8533.7	3121.3	4717.5	563.4	2079.9
5	0.0	1135.8	4998.5	1411.8	2842.7	897.7	3946.4
6	0.0	104.3	1074.6	683.8	1118.3	637.9	2523.6
7	0.0	0.0	0.0	0.0	27.3	0.0	221.4
Outer(1)							
1	7.0	422.9	1597.0	2540.2	2115.7	739.2	2817.7
2	0.0	197.1	378.1	70.2	311.7	128.0	2629.4
3	0.0	810.9	1950.5	2824.9	4903.9	2626.2	16846.1
4	14.0	1985.9	4896.5	3901.3	4045.0	450.8	1878.2
5	0.0	1437.3	2054.3	1458.6	1909.7	523.3	2892.1
6	0.0	99.6	395.7	611.0	700.9	280.8	1299.9
7	0.0	0.0	0.0	0.0	18.5	0.0	268.1
ROW	20	580	2811	1440	1970	680	3010
Actual Employer (2)	59	8576	32614	21478	30823	9811	59251
Labour Demand (3)	61	8812	40253	22078	31741	11240	72144
Vacancy (4)	2	236	7639	600	918	1429	12893
Dependent (5)	70	12794	56628	34065	46065	13696	95629
Total population (6)	109	20790	86432	54103	75018	22827	151850

(a) ROW - the rest of the World.
(b) This is a very crude table. Readers who intend to use it need to seek advice from the authors.

District (To be continued)

Outer Leeds						
I	II	III	IV	V	VI	VII
46.0	38.0	1003.2	885.5	1482.0	292.0	752.9
4.0	52.0	325.6	33.6	19.0	140.0	280.1
52.0	449.0	2711.8	2041.7	2442.1	2104.0	3502.6
104.0	717.0	6179.8	1677.1	2268.7	665.0	1102.3
384.0	388.0	4360.0	865.9	1752.5	648.0	1475.7
18.0	85.0	959.9	594.7	504.8	391.0	1093.2
0.0	0.0	24.5	18.1	0.0	0.0	0.0
303.0	298.0	1806.6	1210.2	1583.0	483.0	2675.9
14.0	161.0	408.0	107.5	34.3	156.0	1233.8
150.0	739.0	2972.6	2239.3	2211.6	2079.0	13291.4
333.0	1155.0	4955.9	1461.3	1562.0	563.0	2059.0
670.0	336.0	2596.1	510.5	830.5	510.0	2371.5
5.0	57.0	530.5	301.8	291.4	252.0	1153.7
0.0	9.0	23.3	9.6	0.0	0.0	0.0
90	1670	7490	1860	4270	1340	7860
2173	6154	36350	13817	19253	9623	38852
2595	8610	45893	15818	21409	10213	47603
420	2456	9543	2001	2156	590	8751
3749	7623	51948	20327	23973	12424	55786
5832	12148	80808	32284	38956	20707	86778

(To be continued)

Rest of the World (ROW)	Employ-ment by S. class (2)	Labour force (3)	Unemp-loyment (4)	Inactive persons (5)	Total popula-tion (6)
1470	12801	17049	4248	14311	31360
600	4291	4938	647	4032	8970
3450	42345	50298	7953	34681	84979
2360	35253	58635	23382	55405	114040
1350	26459	35889	9430	32671	68560
470	10260	14859	4599	15031	29890
570	861	3901	3040	3500	7401
5420	24020	31013	6993	28229	59242
1700	7528	10486	2958	40924	21410
9420	63266	66059	2993	46457	112516
4670	33930	44049	10319	41551	85600
2240	29340	24544	4204	20566	45110
580	6561	6770	209	5023	11793
700	1029	4133	3104	3556	7689
90					
	C(2)= R(2)= 288744	C(3)= 372623	C(4)= 83879	C(5)= 315936	C(6) 688559
	R(3)= 338471	C(3)- R(3)= 34152			
	R(4)= 49727		C(4)- R(4)= 34152		
	R(5)= 399815			C(5)- R(5)= -83879	
	R(6)= 688559				C(6)= R(6)= 688559

Table 8: The interzonal *social supply coefficient*

	Inner	Outer	ROW
Inner			
1	0.533705	0.351471	0.114824
2	0.661042	0.199114	0.139844
3	0.604359	0.314167	0.081475
4	0.572407	0.360648	0.066945
5	0.575761	0.373213	0.051026
6	0.598737	0.355450	0.045813
7	0.288750	0.049460	0.661790
Outer			
1	0.426310	0.348039	0.225651
2	0.493353	0.280857	0.225791
3	0.475102	0.375529	0.149369
4	0.506078	0.356289	0.137633
5	0.505179	0.384692	0.110128
6	0.516503	0.395073	0.088424
7	0.278658	0.040739	0.680603

Table 9: The interzonal *industrial demand coefficient*

	Inner	Outer	ROW
Inner			
I	0.305085	0.355932	0.338983
II	0.354791	0.577583	0.067626
III	0.568205	0.345633	0.086162
IV	0.401896	0.531059	0.067045
V	0.481675	0.454408	0.063917
VI	0.446747	0.483947	0.069306
VII	0.465982	0.483217	0.050800
Outer			
I	0.279797	0.678785	0.041417
II	0.280955	0.447676	0.271368
III	0.428218	0.365717	0.206065
IV	0.442693	0.422688	0.134619
V	0.439910	0.338294	0.221796
VI	0.440611	0.420139	0.139250
VII	0.211232	0.586463	0.202306