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CONSTRUCTION OF AN INPUT-OUTPUT TABLE FOR YORKSHIRE AND HUMBERSIDE

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CONTENTS

Abstract

This paper focuses on the construction of an input-output table for Yorkshire and Humberside, which aims to provide providing much more information for regional planners than currently available. Procedures for estimating the components in an input-output table are described first, and then the calculations of regional economic multipliers including output, income and employment multipliers are outlined. A general analysis of the economy of Yorkshire and Humberside based on these estimated multipliers is also undertaken. The output information which includes intermediate transactions, import and export for Yorkshire and Humberside, together with two Fortran programmes which provide procedures for constructing a regional input-output table and deriving associated multipliers are detailed in Appendices.

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Construction of an Input-output Table for Yorkshire and Humberside

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1. Introduction:

Input-Output technique offers a very powerful approach to the analysis of a regional economy. It describes the relationships among industries in such a way that intervention could achieve a reasonable or the best economic structure without influencing the balance of the economy. It also demonstrates the multiple impacts of a change in economic level, income or employment. Using such information, regional planners may monitor the economy, for example, encouraging the development of those industries that can provide more output, income and the chances of employment, and discouraging those industries that have smaller or negative impacts on the regional economy. In this paper, we attempt to use this technique to construct an input-output table for the region of Yorkshire and Humberside. The methodology we adopt is a combination of both conventional and newly developed estimation approaches. We suggest that regional imports and exports can be derived from a comparison of regional intermediate requirements and regional production level, and that the elements of both regional final demand and primary input can be estimated from regional GDP(Gross Domestic Product).

The paper is structured as follows: firstly, in the introductory section, we expound the purpose of and procedures for generating the input-output table. We then outline the methodology used to treat the components in the regional table. We also describe the calculation of regional multipliers such as output, employment and income in Yorkshire and Humberside. Finally, the output results are elaborated.

1.1 Motivation

The motivation for constructing the table is firstly to provide a comprehensive analysis of the regional economy of Yorkshire and Humberside. During the past ten years the Yorkshire and Humberside economy has experienced fluctuating fortunes, for example the decrease of employment and the level of GDP from 1981. However the trends turned towards growth from 1985. As far as the regional economy is concerned, Yorkshire and Humberside has lower than national average values in term of, for instance, employment, per capita income and GDP. It is important however to analyse the economy systematically and in a more disaggregate way which the technique permits. A considerable amount of work is currently being undertaken on refining input-output methodologies. This paper attempts to bridge the gap between those methods that were developed and the regional I-O tables for the region of Yorkshire and Humberside that were constructed in the past and those that might be developed in the future.

The second reason is to generalise a methodology for the development of an input-output table that can be applied to any other regions. A regional input-output table can be estimated using this generalised procedure only if relevant data are available.

The third purpose is to provide an essential step for developing a comprehensive framework which focuses on the an integrated multispatial input-output model (Wilson and Jin, 1991a and b). The completion of the general framework is achieved by firstly generating the regional, and then the urban and interzonal input-output tables so that tables are consistent with each other. Clearly, this step is very important for this framework.

1.2 Procedures

Like a national input-output table, the regional table for Yorkshire and Humberside consists of five basic component (Figure 1): intermediate industrial transactions (I), final demand (II), primary input (III), total input and output product (IV and V). Our construction is to deal with these five element one by one.

	Intermediate Transaction	Final Demand	Total Output
Interme-diate	I	E : X : P : II	V
Primary Input	Personal income III		
Total input	IV		

Figure 1: Basic components in an input-output table (OPEN Model)

We start with the estimation of the intermediate transaction (I) which is the most difficult component to construct. The popular RAS balance approach is implemented here because it provides one of the most accurate estimating techniques current available (see Morrison and Smith, 1974). We then turn to the estimation of regional imports and exports, which are derived from the comparison of regional requirements and supply. This part of the work is more or less similar to the Pool technique developed by Schafer and Chu(1969), by which the regional requirement is estimated by applying location quotients. The requirements in this study are obtained from balancing the national table by using both regional row and column constraints in stead of employing location quotients. We also attempt the possibility of using available data to derive the components

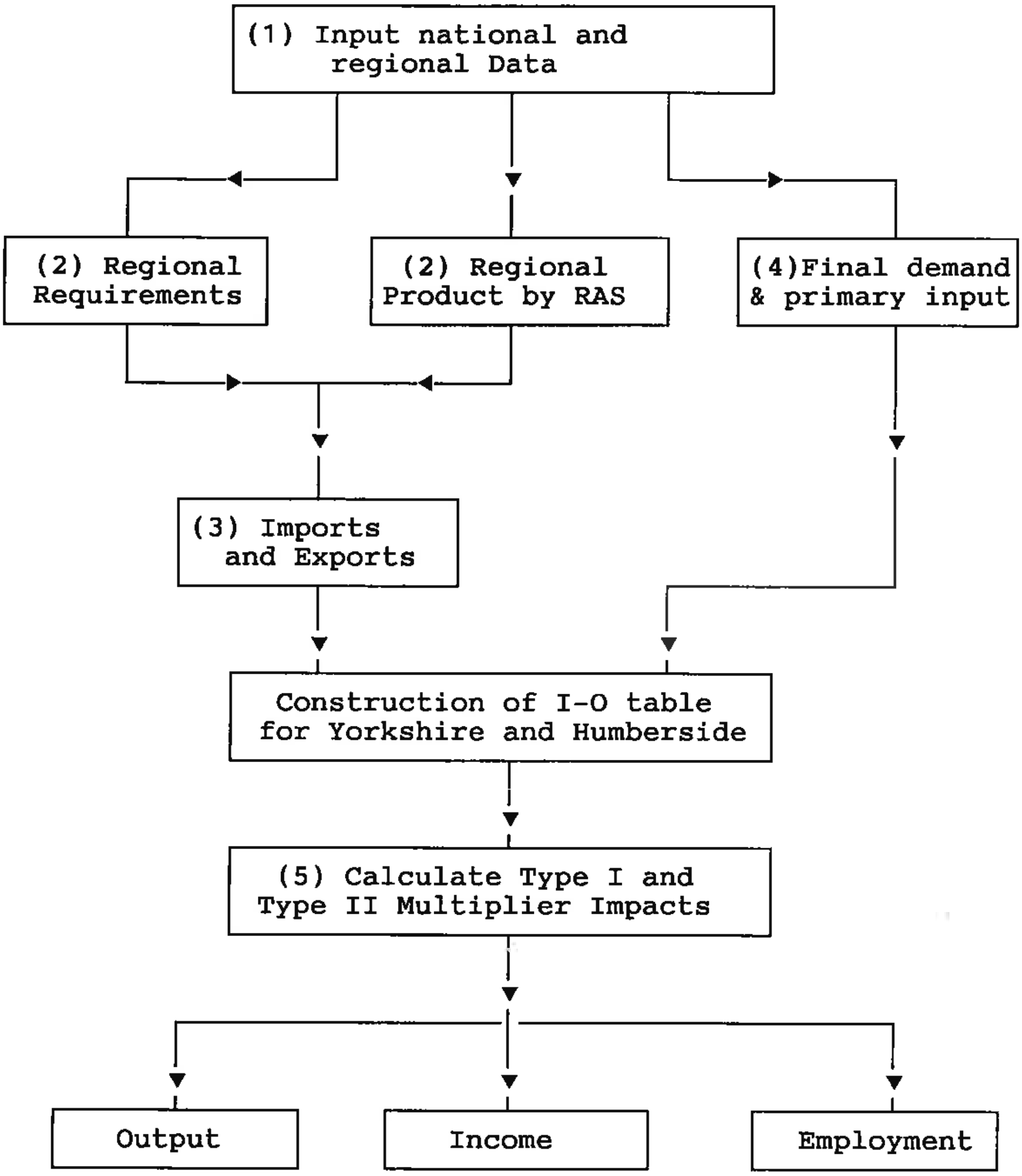

Figure 2: The overall structure for the constructing the I-O table for Yorkshire and Humberside

in both the final demand and primary input, and illustrate three circumstances of availability of the regional GDP and their relationships with those data demanded in the regional I-O table. These elements contained in final demand and in primary input are then calculated by spelling out the relationships between estimated imports and exports and the regional GDP. After the construction of the input-output table, we then move to the regional economic impacts. Both Type I and Type II output, income and employment multipliers are derived so that the interrelationships and economic impacts are illustrated. The procedure is outline in Fig.2.

2. Accounting Procedures

This section deals with the treatment of different estimated components of input-output table. It is necessary here to define the accounting constrains, the accounting procedures and the conventions adopted for the construction of the regional I-O table for Yorkshire and Humberside.

There is only a limited literature about accounting data. National data are relatively easy to access from, for example, "The United Kingdom National Account", "Key Data", "Annual Abstract of Statistics" and, most usefully, "Input-output table for UK" issued about every five years. However, there is an almost insurmountable problem in getting the relevant data for constructing a regional input-output table. The most deadly available published data are regional GDP, and income and expenditure figures from "Regional Trends" issued every year. However those data cannot be put directly into a regional input-output table. Aggregated GDP, income and expenditure figures are very difficult to disaggregate across the industries within the region. Furthermore, data on regional imports and exports are not available either. The problem facing us therefore is how to estimate regional data from the national data; and how to derive regional data on the interrelationships. Our first concern is the description of the national input-output table.

2.1. The National Input-output Table for the United Kingdom

The national input-output tables for the UK, starting from 1954, are issued at regular intervals, about every five years, tables are available for the years of 1963, 1968, 1974, 1979. The most recent table available for this study is that for 1984 which was published in 1988. In this table, 102 sectors based on the 1980 SIC (Standard Industry Classification) are included. The 102 sectors can further be aggregated into 7 industries, i.e, agriculture, energy, manufacture, construction, distribution, transportation and service which includes both the private and public services (see Appendix 1), on which sectors of the input-output table for Yorkshire and Humberside are based. This aggregation is necessary for reasons of simplification of the table and compatibility with the national table.

2.2. Treatment of regional intermediate transactions

The intermediate transaction component of a regional input-output table is the most important part for regional economic analysis. However, it is the most difficult to construct. For more than three decades, regional analysts have been concerned with deriving this component, and many methods including both survey and non-survey have been developed, the surveying method however was soon replaced by the non-survey approach due to its high cost in terms of both finance and time. Non-survey techniques, such as the location quotient, supply-demand pool, short-cut and hybrid methods, compared to the survey method are both economical and fast but they run high risk of being inaccurate. The RAS approach is regarded as the best estimation method because of its partial use of survey data. In the construction of the regional input-output table for Yorkshire and Humberside, we adopt the RAS technique to estimate intermediate transactions. The RAS method is described as an estimation that derives the regional transactions from their national counterparts (See for example Morrison and Smith in 1974). The process firstly treats the national input-output matrix as an estimate of the regional table which is then combined with a vector of regional gross output to yield an estimated vector of intermediate outputs. Secondly, the matrix is adjusted to conform with the row constraint, thirdly, a vector of intermediate inputs is estimated by using the results of step 2, and fourthly the matrix is adjusted to conform with the column constraint. The same steps are then repeated until the matrix converges to a state in which both row and column constraints are satisfied. This converged matrix is the estimated regional intermediate transaction. This technique requires three sets of data: (1) the national coefficient matrix; (2) regional gross product by sector; (3) regional row and column constraints. The first set of data is calculated by dividing the national intermediate transactions by the national gross product, gained from the national input-output table. The calculated coefficient matrix together with the coefficient for primary input and final demand are listed in Appendix 2.

The last two sets of data are derived from both the level of regional and national GDP and employment. The total regional gross product is firstly calculated by multiplying the ratio between the regional and national GDP, and spreading this across industries by employing the ratio of regional employment to the total regional employment. The regional column and row constraints are assumed to be smaller than the differences between the regional gross products and regional GDP but larger than the constraints estimated directly from the national table because it is supposed that the imports and exports in a regional have a bigger share than those in a nation.

The regional intermediate transactions are estimated from the above approach and by giving the tolerance value, 0.05, i.e. the precise value is 95%, the national table is converged with the regional row and column constraints after 11 iterations. Smaller tolerance value has been tested, say, 0.001, the national table could not converged even after 1000 iterations. The regional coefficient matrix for Yorkshire and Humberside derived from the RAS iteration approach is listed in Appendix 3.

2.3 Treatment of regional import and export

Regional imports and exports are important components of both regional input-output tables and regional economic analysis. They are important because they reflect the trade relationships between this region and the rest of the world. Neither imports nor exports, however, can be economically obtained from survey method nor by estimation from national data directly. Since regional imports and exports depend upon the supply and demand relationships between this region and the rest of the world, we can follow the method developed by Shaffer and Chu (1969) which firstly calculates the regional requirements (demand) and then actual regional production levels (supply), and finally compares the regional requirements to regional supply. A positive balance may indicate that regional demand is larger than regional production, in which case, it is assumed that the gap is offset by imports from the rest of the world; a negative difference indicates that there is surplus product in this region which it is supposed to be exported to the rest of the world. The regional requirements for each industry in Yorkshire and Humberside are computed as the products of the national coefficient matrix and the regional gross products following Shaffer and Chu. In the case of regional supply, we adopt the RAS approach rather than either the location quotient or the pool technique because RAS has partially employed survey data, and therefore the supply matrix is possibly more accurate. In addition the calculated exports and imports can be considered to be consistent with the regional intermediate transactions. The regional import and export values for Yorkshire and Humberside computed from this method are shown in Table 1. (See Appendix 3 for import and export matrix)

Table 6.1. Import and Export in Yorkshire and Humberside:
£m

	I	II	III	IV	V	VI	VII
Imp	4.872	16.873	64.398	27.866	657.683	3.244	1854.606
Exp	84.96	117.374	874.472	120.661	190.585	32.085	441.732

2.4 Treatment of regional final demand and primary input

Regional primary input and final demand are conventionally taken as factors. In practice, in the construction of a regional input-output table, such factors are seldom available. In order to construct a regional input-output table and derive a balanced regional economy, the components of both the final demand and primary input have to be estimated too. Broadly the approach we employ is to decompose the regional GDP, find the interrelationships between the regional GDP and regional final demand and primary input, and hence derive the components through these relationships. A brief review of these elements in a regional input-output table is necessary before further exploring their relationships.

Regional final demand($F^r{}_{if}$), usually consists of consumers' expenditure ($C^r{}_{i1}$), investment ($S^r{}_{i2}$), government expenditure ($G^r{}_{i3}$), and exports ($E^r{}_{i4}$). Residuals can be considered to indicate estimating and statistic errors ($\varepsilon^r{}_{i5}$). The first three cells of the final demand vector may be taken as "the other final demand". An accounting balance in which the estimated regional intermediary transaction plus final demand equals to the total regional output must exist:

$$\Sigma_j R^r A^n S^r + C^r_{i1} + S^r_{i2} + G^r_{i3} + E^r_{i4} + \varepsilon^r_{i5} = X^r_i \qquad (1)$$

in which R and S indicate the regional row and column constraints, and A is the national coefficient matrix. These three together indicate the regional intermediate transactions derived from the RAS method.

Regional primary input contains regional imports(M^r_j); and sales by final demand(D^r_j) which may represent "the purchase of goods which do not come from an identifiable supply source in the period of the account" (CSO, 1988). It is possible to take this component out of primary input because it could be assumed to be an invisible sector selling goods into intermediary consumption or into other categories of final demand. Primary inputs also contain regional net taxes (T^r_j), incomes from employment ($I1^r_j$), from self-employment ($I2^r_j$), profits (P^r_j) and rent (R^r_j). The total regional output will be equal to

$$\Sigma_i R^r A^n S_r + M^r_j + D^r_j + T^r_j + I1^r_j + I2^r_j + P^r_j + R^r_j = X^r_j \qquad (2)$$

We then move to the components of the regional GDP. There are usually three ways of viewing GDP, all of which are, in theory, equivalent: income, expenditure and the sum of the value added, of these the first two are frequently used. Adopting the income approach, regional gross product $GDP(I)^r_j$ seems likely to amount to the incomes after tax from employment ($I1^{r}_{j}$) plus the incomes after tax from self employment ($I2^{r}_{j}$) plus the gross trading profits and surplus (P^{r}_{j}) plus rent (R^{r}_{j}) less stock appreciation (L^{r}_{j}).

$$GDP(I)^{r}_{j} = I1^{r}_{j} + I2^{r}_{j} + P^{r}_{j} + R^{r}_{j} - L^{r}_{j} \qquad (3)$$

Putting equation (3) into (2), the total regional input products become equivalent to equation (4), and hence the components of primary input are derived since import (M^{r}_{j}) has been estimated from comparison of regional demand and supply. Tax (T^{r}_{j}) and sale by final demand may be ignored.

$$\Sigma_{i} R^{r}A^{n}S^{r} + M^{r}_{j} + GDP(I)^{r}_{j} + L^{r}_{j} = X^{r}_{j} \qquad (4)$$

The regional gross domestic product ($GDP(E)^{r}_{j}$) can be calculated using the expenditure route too. The components of the accounting identity are: consumers' expenditure (C^{r}_{j}); capital investment (S^{r}_{j}); general government final demand (G^{r}_{i}); exports of goods and services (E^{r}_{j}); imports of goods and services (M^{r}_{i}). The regional GDP using this method is therefore the sum of the components above,

$$GDP(E)^{r}_{i} = C^{r}_{i} + S^{r}_{i} + G^{r}_{i} + E^{r}_{i} - M^{r}_{i} \qquad (5)$$

Replacing the relevant components in equation (1), it can now be rewritten as equation (6), so final demand is derived because the import has already been estimated.

$$\Sigma_{j} R^{r}A^{n} S^{r} + GDP(E)^{r}_{i} + M^{r}_{i} = X^{r}_{i} \qquad (6)$$

There are three circumstances under which regional GDP can be made available: (i) GDPs derives from both 'income' and 'expenditure', or (ii) GDP derives only from 'income' and, (iii) GDP derives only from 'expenditure'. The first condition is an ideal one because the elements of regional demand and primary input, as shown in the equations (4) and (6), can be replaced by GDP(E) and GDP(I) respectively. The second case will cause slight trouble. As only GDP(E) is on hand, there is no problem when the components in the regional final demand are estimated since GDP(E) can be put into the final demand directly. However, the price factor should be considered when the GDP(E) is calculated at market price. To work out the GDP(E) at factor cost, the net taxes ($T^r{}_j$) which are the balances between taxes and subsidies on expenditures should be removed so that the impact that taxes have upon prices paid in the market will be lessened (CSO,1987). With regard to the estimation of primary input, GDP(E) cannot be used directly because there are differences (residuals) which are due to estimation or statistical errors that exist between the GDPs from the two routes even though they should theoretically be equivalent. The residuals therefore should be subtracted from or added to equation (6).

In most cases, the income approach is much more commonly used than the expenditure approach because of the availability of data so that only estimation procedures for regional GDP using the income approach can be adopted. Thus primary input can be substituted by GDP(I) and the "other final demand" (O^r_i) may be derived from equation (6).

$$O^r_i = GDP(I)^r_i + M^r_i - E^r_i \quad (7)$$

Again the residual should be taken into account in which case the total final demand will be

$$F^r_i = O^r_i + E^r_i +/- \varepsilon^r_i \quad (8)$$

where ε^r_i is the residual due to the estimation or statistical errors.

The above procedures describe the ways in which GDP from the <u>income</u> route can be put directly into the primary input because it has exactly the same counterpart, and the GDP from the <u>expenditure</u> route can be put into the final demand too. In practice, however, the GDP at a regional level is almost always derived from the income approach. In this case, GDP from the income approached is used but needs to be adjusted by adding or subtracting the residual from final demand, so that the other final demand including household consumption, fixed capital formation, and government expenditure, can be obtained. A further question is about how to decompose the other final demand, especially personal consumption, and primary input, and particularly personal income. Personal consumption and income are very important because the calculation of both Type I and Type II multipliers require their estimates. Income multipliers are discussed in section 4.

Both the personal income, which includes income from employment and selfemployment, and personal consumption estimates are fairly straightforward. Survey data on income and expenditure, and national data are employed simultaneously. The survey data is collected from such data sources as the regional income and consumption survey section in "Regional Trends", and the relevant section in "Key Data". The "Family Income and Expenditure Survey" is also referred. Income is calculated from the following equation:

$$I^r_j = (I^n_j \;/\; GDP(I)^n_j \;)\;(\text{ or } +/- \;\Gamma^r_j\;)\; GDP(I)^r_j \qquad (9)$$

where Γ^r_j is the regional income structure by surveying. If the survey structure is larger than the national ratio, then the latter is adopted; when it is smaller than the national ratio, then the former ratio will be used. The reason is that we distinguish the difference between the national income level and that in Yorkshire and Humberside. The income level in Yorkshire and Humberside is lower than the average income level in the UK.

The regional consumption in each sector is estimated from the national data too but weighted by using the regional employment structure, which is expressed in equation 10:

$$E^r_j = (E^n_j \ / \ E^n_* \ ) \ E^r_* \qquad (10)$$

where E^n_* indicates the total consumption in the UK, and E^r_* is the total consumption in Yorkshire and Humberside.

The adjusted weights and the estimated income and consumption are listed in Table 2:

Table 2: The estimated income and expenditure in Yorkshire and Humberside.

		I	II	III	VI	V	VI	VII
A*	weight	0.274	0.202	0.757	0.530	0.690	0.458	0.764
	£m	159.7	652.6	2269.6	722.9	2072.8	712.2	6094.4
B*	weight	0.009	0.018	0.269	0.029	0.153	0.026	0.494
	£m	81.0	158.3	2326.2	255.4	1319.8	225.1	4264.4

* A and B indicate Income and Expenditure respectively

2.5. The input-output table for Yorkshire and Humberside

We have so far completed the construction of most elements of the regional input-output table for Yorkshire and Humberside. The remaining problems focus on deriving the total regional input and output products and achieving a balance condition between input and output. The total input product for each industry is derived from summation along the vertical direction, i.e. by summing the intermediate input products estimated from the RAS technique, the regional imports for each industry and the other primary input products obtained from the regional GDP. The regional total output is gained from summation in the horizontal direction, i.e. by summing those intermediate output products estimated by the RAS approach, and regional export from the comparison of the regional requirements and production, and the other final demand through the interrelationships between the components of final demand and the regional GDP. A balanced regional input-output table for Yorkshire and Humberside is then derived which is illustrated in Table 3.

It is important to note that, due to the availability of the most recent national input-output table, this regional table has to be constructed based on data for 1984, which should be borne in mind when the Yorkshire economy is analysed using this table. However, it does reflect the general structure of the regional economy, and may be updated as more recent data becomes available.

Table 3: The input-output table for Yorkshire and Humberside (1984)

	AGRIC	ENERGY	MANUF	CONSTR	DISTRBN	TRANSP	SERVICE
I.	153.398	0.000	359.488	0.000	8.336	0.000	0.000
II.	58.133	922.091	457.013	29.096	96.550	177.214	122.354
III.	42.835	165.325	3458.911	474.031	341.674	275.470	528.554
IV.	15.560	4.312	49.694	604.516	34.645	9.128	150.261
V.	40.790	45.221	521.093	51.039	63.300	98.372	82.065
VI.	18.657	53.185	317.782	22.010	84.159	175.109	77.214
VII.	116.317	58.236	895.762	270.423	431.389	114.456	1449.379
Sub IDIN	445.690	1248.370	6058.743	1451.115	1060.453	849.749	2409.827
IMPO	4.872	16.873	64.398	27.866	657.683	3.244	1854.606
INCM	159.742	652.575	2269.639	722.920	2074.830	712.190	6094.428
PRFT	423.258	1123.425	3412.361	641.080	932.170	842.810	1882.572
RESD	28.653	299.328	-1466.464	363.146	-353.909	-274.733	2774.175
PRIM INPT	616.525	2092.201	4279.934	1028.718	3310.774	1283.511	12605.781
TOTO INPT	1062.215	3340.571	10338.677	2479.833	4370.827	2133.260	15015.608

Note: I -- AGRICULTURE; II -- ENERGY; III -- MANUFACTURE;

IV -- CONSTRUCTION; V -- DISTRIBUTION; VI -- TRANSPORTATION;

VII - SERVICE;

SUB-IDIN -- SUB-TOTAL OF INTERMEDIATE PRODUCT;

IMPO -- IMPORT; INCM -- INCOME; PRFT -- PROFIT;

RESD -- RESIDUAL; PRIM IMPT -- PRIMARY INPUT;

TOTO INPT -- TOTAL INPUT PRODUCT.

* Consumption is included in the vector of 'other final demand'

£million

Total intermediate	Consumption *	Other final demand	Export	Residual	Total final demand	Total output product
521.222	81.102	587.872	84.960	-131.839	540.993	1062.215
1862.451	158.298	1792.873	117.374	-314.753	1478.120	3340.571
5286.800	2326.191	5746.398	874.472	-694.521	5051.877	10338.677
868.116	255.423	1391.866	120.661	219.851	1611.717	2479.833
901.880	1319.984	3664.683	190.585	-195.736	3468.947	4370.827
748.116	225.066	1558.244	32.085	-173.080	1385.144	2133.260
3334.962	4264.433	9831.606	441.732	1849.040	11680.646	15015.608
12523.547	8630.497	24573.542	1861.869	558.962	26217.444	38740.991
2629.542						
12686.324						
9257.676						
1643.902						
26217.444						
38740.991						

3. Calculation of regional multiplier impacts

3.1. Calculation procedure

The main purpose for constructing a regional input-output table is to comprehensively analyse the regional economy. While "input-output multipliers are probably the most important tool used in local and regional economic impact analysis" (Richardson, 1972). Input-output multipliers may include three kinds of multipliers: output, income and employment, of which the income multiplier is more commonly used, in order to estimate the repercussions of changes in the level of expenditures on total income. Input-output multipliers can also be grouped into Type I and Type II multipliers. In the former case, personal income and consumption are treated exogenously included (conventionally named the Open model, see Figure 1). Both the direct and indirect impacts on the level of total output, income and employment resulting from a change in final demand can be demonstrated. With Type II multipliers, personal income and consumption are endogenously included in the intermediate section (named the Closed input-output model, see Figure 3). Both the direct and indirect impacts together with the induced impacts which are due to a change in income that results from a change in the level of expenditures in final demand are considered. The calculation of Type I and Type II income and employment multipliers are briefly discussed in turn (See the detailed specification in Richardson, 1972; Jensen et al, 1979; Hewings,1985).

	Intermediate Transaction	Final Demand	Total Output
Intermediate	: E I : X ....:.P. Income :	II	V
Primary Input	III		
Total input	IV		

Figure 3: Key components in an input-output table (Closed)

Income multipliers reflect repercussions on income due to a specified change in the economy, for example, a change in the level of regional expenditure. The direct income multiplier (A^{Hm}) measures the impacts on income directly occasioned by a change in final demand, which can be calculated from the input-output table, i.e. dividing the income row by the total regional gross product. The multipliers which express the total income effect in an open model are obtained by multiplying the total output coefficient matrix($\underline{A}$) by the direct income multipliers, i.e. $\underline{A}A^{Hm}$, by which the indirect income impact can be ascertained from the difference between the total and direct multipliers. The equivalent total multiplier of a closed model is derived from the household row of the expanded inversed matrix ($\underline{A}^*$). The induced effect can therefore be calculated as $\underline{A}^* - \underline{A}A^{Hm}$.

Employment multipliers measure the employment-creating effects due to industrial expansion. The calculation for both the Open and Closed model are almost as same as those derived for income multipliers with the exception that the direct employment multiplier (A^{Em}) is gained from outside of the regional input-output table. The total employment multiplier can be derived by multiplying $\underline{A}$ by the corresponding direct employment multipliers, i.e. $\underline{A}A^{Em}$, and the total employment multiplier of a Closed model is equal to the employment row of $\underline{A}^{*'}$. The calculation of both the Type I and Type II income and employment multipliers, together with the output multipliers are shown in Table 4.

3.2 Multiplier analysis

The calculation of the input-output multipliers for Yorkshire and Humberside are processed on the Amdhal mainframe by running the relevant Fortran programme. This programme is structured in Appendix 8. Quite an amount of output information is available for analysis. First of all, the output multipliers are produced. They reflect the change in all the industries in a region due to a change in final demand. Both the direct and indirect output multiplier, the Open and Closed, are calculated and attached in Appendix 6, and income and employment multipliers are listed in Table 5.

Table 4: The Calculation of Input-output multipliers.

	Direct (1)	Total(Open) (2)	Indirect (3)	Total(Closed) (4)	Induced (5)
Output					
Open	A	$\underline{A} = (I-A)^{-1}$	$\underline{A} - A$		
Closed				$\underline{A}^{*}$	$\underline{A}^{*} - A$
Income					
Open	A^{Hm}	$\underline{A}\ A^{Hm}$	$\underline{A}A^{Hm} - A^{Hm}$		
Closed				$\underline{A}^{*}$	$\underline{A}^{*}-\underline{A}A^{Hm}$
Employment					
Open	A^{Em}	$\underline{A}\ A^{Em}$	$\underline{A}A^{Em} - A^{Em}$		
Closed				$\underline{A}^{*'}$	$\underline{A}^{*'}-\underline{A}A^{Em}$

Type I multiplier = [(1) + (3)] / (1) = (2) / (1)

Type II multiplier = [(1) + (3) + (5)] / (1) = (4) / (1)

In this section, we focus on the analysis of income and employment multipliers which are very important factors in regional planning. The direct income multipliers that indicate the first round effect on income of an increase in output of each industry are derived from the income row of the input-output table for Yorkshire and Humberside. They more or less reflect the degree of labour intensiveness of an industry. In Yorkshire and Humberside, it is clear that the distribution and service industries have the highest figures, namely, 0.475 and 0.408 respectively which show that they are the most labour intensive industries. This argument can also be proved from the direct employment multipliers too. In Yorkshire and Humberside, the ranks for the distribution and service industries are the second and fifth. The reason that the direct employment multiplier for manufacturing industry is higher than that for the service industry is that manufacturing in Yorkshire and Humberside is very heterogeneous and the labour orientated sectors such as the food, textile and clothing take a very big share, for instance, the food sector alone takes about 15 percent of the total employment in manufacturing industry (Leigh et al. 1990).

The direct and indirect income, and the employment multipliers indicate the increase in income and employment in all industries resulting from an increase in sales of one pound to final demand by each industry. In Yorkshire and Humberside, the direct and indirect income effect of the service industry due to £1.00 increase in final demand would be £0.485; and the direct and indirect employment effect would be 0.101 employments.

The total (direct plus indirect plus induced) income and employment effect includes the increase in income occasioned by increased personal consumption, i.e. the induced effect which is calculated as the difference between the total effect and the direct and indirect effect. Take the service industry as an example, the total income effect is £0.874 due to an increase in support requirements, and the induced effect that results from an increase in personal consumption is £0.0388. The total employment effect for the service industry is 0.101 employees and the induced effect is 0.049 employees.

The analysis of these multipliers may benefit the regional planners in at least ways: (i) to help to identify potential effects in each industry so relevant policies may be made. From Figure 5 and 6, we can see the different effects on all industries of economic expansion. For example, both the manufacturing (III) and distribution (V) industries have the same effects, the potential effects (indirect and induced), however, are much higher in manufacturing than in distribution industry; (ii) if various regions are considered, and an interregional table is derived, multipliers for a same industry but located in different regions can be obtained. Policy on industrial location may be properly made by comparing regional multipliers. This is what we will focus on in future, through the development of interregional tables for the region of Yorkshire and the city of Leeds.

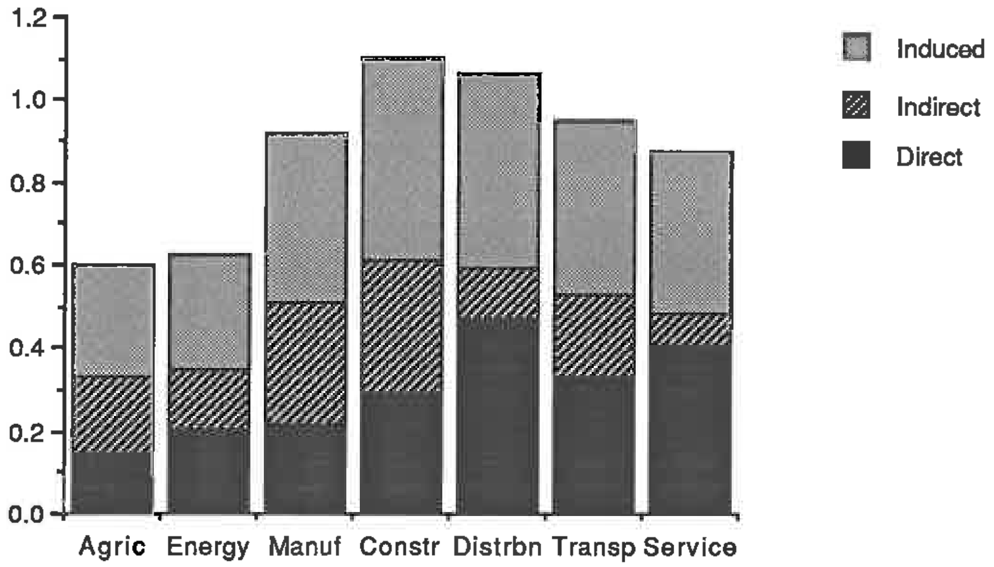

Figure 4: The direct, indirect and induced income multipliers for the region of Yorkshire and Humberside

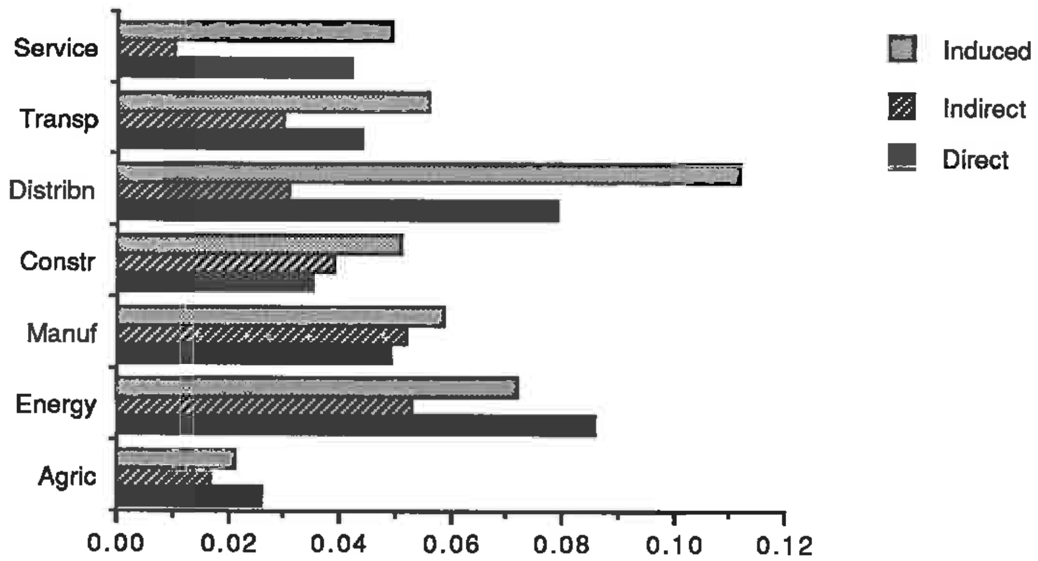

Figure 5: The direct, indirect and induced employment multipliers for the region of Yorkshire and Humberside

Table 5: Income and employment multipliers for Yorkshire and Humberside

	I	II	III	IV	V	VI	VII
1. Income:							
Direct	0.150	0.202	0.220	0.292	0.475	0.335	0.482
Indirect	0.182	0.147	0.289	0.321	0.119	0.195	0.079
Induced	0.266	0.279	0.407	0.490	0.475	0.423	0.388
Type I	2.214	1.727	2.313	2.100	1.251	1.581	1.196
Type II	3.984	3.108	4.163	3.779	2.252	2.845	2.152
2. Employment:							
Direct	0.026	0.086	0.049	0.035	0.079	0.044	0.042
Indirect	0.017	0.053	0.052	0.039	0.031	0.030	0.010
Induced	0.021	0.072	0.059	0.051	0.112	0.056	0.049
Type I	1.662	1.617	2.059	2.106	1.391	1.679	1.242
Type II	2.454	2.449	3.274	3.569	2.809	2.943	2.400

4. Summary and concluding comments

In this paper, we have described the procedures for deriving different components basically required by a regional input-output table. We suggest that the RAS balance technique can be used to derive the intermediate transactions for Yorkshire and Humberside, and a comparison between regional supply and requirement may result in regional export and import. The components in both final demand and primary input are obtained from spelling out the relationships between regional GDP and final demand and primary input. Regional GDP is available under three circumstances, methods for estimation from each of which are outlined. The output, income and employment impacts are also calculated. Regional planners can employ these multipliers to analyse the regional economy, and identify strategic scenarios for regional development.

It is necessary to recognise the limitations of this work. First of all, this input-output table is constructed based on very limited survey work. Much information is collected or estimated from national or general regional data. Needless to say, such a table may be highly inaccurate. Secondly, the broad aggregation of industries in this table ignores the heterogeneity within each industry; Thirdly, most non-survey techniques such as the RAS technique rely on the availability of a national input-output table which is usually delayed for five or six years. In spite of its limitations, such a table does provide a wealth of information for regional planners.

REFERENCE

CSO, (1988) Input-output tables for the United Kingdom, 1984, London.

CSO, (1989) United Kingdom National Accounts, London.

CSO, (1987) United Kingdom National Accounts, London.

CSO, (1985) Regional Trends, London.

CSO, (1990) Regional Trends, London.

CSO, (1988) Key data, London.

Hewings, G.J.D. and Jensen, R.C. (1985) "Regional, inter-regional and multiregional input-output analysis." In Nijkamp(ed.), Handbook of Regional and Urban Economics, pp. 295-355

Jensen, R.C., Mandeville,T.D., and Karunaratne, N.D. (1979) Regional economic planning: Generation of regional input-output analysis. London: Croom Helm.

leigh, C.M. Stillwell, J, Wilson, A.G. and Monck, C. (1990) Yorkshire and Humberside: Economic Development and Future Prospective, Yorkshire and Humberside Association.

Morrison, W.I. and Smith, P. (1974) "Nonsurvey input-output techniques at the small area level: An evaluation," Journal of Regional Science, 14, 1-14.

Richardson, H.W. (1972) Input-output and regional economics. New York: Halsted Press.

Schaffer, W.A. and Chu, K. (1969) "Nonsurvey techniques for constructing interindustry models," Papers, Regional Science Association, 23, 83-89.

Wilson, A.G. and Jin, Y-X, (Forthcoming), "Generation of an Integrated Multispatial Input-output Models of Cities," Paper will be presented at 31st European Regional Science Conference in Lisbon, Portugal.

Appendix 1: Classification of industry I-O groups

Group	Industry/Commodity	SIC Activity Heading
I.Agriculture		0100 - 0300
	Agriculture & horticulture	
	Forestry and fishing	
II.Energy		1113 - 1700
	Extraction of coal, mineral oil and natural gas	
	Electricity and nuclear fuel	
	Gas and Water supply	
III.Manufacture	Extraction of ores & minerals	2100 - 2600
	Iron and steel production	
	Aluminium and alloys	
	Extraction of stone, clay	
	Cement, lime and plaster	
	Concrete and glass products	
	Chemicals and fertilizers	
	Metal products	3111 - 3740
	Industrial plant & tractors	
	Textile machinery	
	Process machinery & contractors	
	Construction and mechanical handling equipment	
	Mechanical power transmission equipment	
	Machinery equipment	
	Electrical equipment for industry, batteries, etc.	
	Motor vehicles and parts	
	Shipbuilding and repairing	
	Aerospace equipment	
	Other vehicles	
	Oil and fats; Meat processing	4115 - 4959
	Milk and milk products	
	Fruit, vegetables processing	
	Grain milling, starch, sugar	
	Miscellaneous foods	
	Soft drinks; Tobacco	
	Cotton and knitted goods	
	Textile finishing	
	Leather and leather goods	
	Footwear; Clothing & furs	
	Household and made-up goods	
	Timber processing and wood products (not furniture)	

Appendix 1: To be continued

Group	Industry/Commodity	SIC Activity Heading
	Pulp, paper and board Printing and publishing Processing of plastics Other manufacturing	
IV.Construction		5000 - 5040
	Construction and demolition Construction and repairing of buildings Civil engineering Installation of fixtures Building completion works	
V.Distribution		6100 - 6670
	Wholesale distribution Retail distribution Hotel, catering etc.	
VI.Transportation		7100 - 7700
	Railways Road and other inland transport Sea & air transport Transport services	
VII.Services		7901 - 9900
	Postal services Telecommunication Banking and finance Insurance; Other services Public services	

Source: <<Indexes to the SIC>>(Revised 1980)

Appendix 2: National coefficient matrix for UK (1984)

	AGRIC	ENERGY	MANUF	CONSTR	DISTRN	TRANSP	SERVICE
I.	0.149	0.000	0.041	0.000	0.005	0.000	0.000
II.	0.039	0.279	0.036	0.013	0.040	0.076	0.017
III.	0.027	0.047	0.256	0.199	0.133	0.111	0.069
IV.	0.008	0.001	0.003	0.207	0.011	0.003	0.016
V.	0.024	0.012	0.036	0.020	0.023	0.037	0.010
VI.	0.014	0.018	0.028	0.011	0.039	0.084	0.012
VII.	0.062	0.014	0.056	0.096	0.142	0.039	0.160

Note: I - AGRICULTURE; II - ENERGY; III - MANUFACTURE; IV - CONSTRUCTION; V - DISTRIBUTION; VI - TRANSPORTATION; VII - SERVICE; VIII - PERSONAL INCOME AND CONSUMPTION.

Appendix 3: Regional coefficient matrix

	AGRIC	ENERGY	MANUF	CONSTR	DISTRBN	TRANSP	SERVICE
I.	0.144	0.000	0.035	0.000	0.002	0.000	0.000
II.	0.055	0.276	0.044	0.012	0.022	0.083	0.008
III.	0.040	0.049	0.335	0.191	0.078	0.130	0.035
IV.	0.015	0.001	0.005	0.244	0.008	0.004	0.010
V.	0.038	0.014	0.050	0.021	0.014	0.046	0.005
VI.	0.018	0.016	0.031	0.009	0.019	0.082	0.005
VII.	0.110	0.017	0.087	0.109	0.099	0.054	0.097

Appendix 4a: The regional requirement flow for Yorkshire and Humberside

£M

	AGRIC	ENERGY	MANUF	CONSTR	DISTRBN	TRANSP	SERVICE
I.	158.270	0.000	423.884	0.000	21.854	0.000	0.000
II.	41.426	901.329	372.190	32.238	174.832	161.368	255.265
III.	28.680	151.837	2646.689	493.487	581.317	235.682	1036.077
IV.	8.498	3.231	31.016	513.325	48.079	6.370	240.250
V.	25.493	38.767	372.190	49.597	100.529	78.561	150.156
VI.	14.871	58.150	289.481	27.278	170.462	178.354	180.187
VII.	65.857	45.228	578.963	238.064	620.655	82.807	2402.498

Appendix 4b: The regional product for Yorkshire and Humberside

£m

	AGRIC	ENERGY	MANUF	CONSTR	DISTRBN	TRANSP	SERVICE
I.	153.398	0.000	359.488	0.000	8.336	0.000	0.000
II.	58.133	922.091	457.013	29.096	96.550	177.214	122.354
III.	42.835	165.325	3458.911	474.031	341.674	275.470	528.554
IV.	15.560	4.312	49.694	604.516	34.645	9.128	150.261
V.	40.790	45.221	521.093	51.039	63.300	98.372	82.065
VI.	18.657	53.185	317.782	22.010	84.159	175.109	77.214
VII.	116.317	58.236	894.762	270.423	431.389	114.456	1449.379

Appendix 5a: The import flow for Yorkshire and Humberside

£m

	AGRIC	ENERGY	MAUNF	CONSTR	DISTRBN	TRANSP	SERVICE
I.	4.872	0.000	64.398	0.000	13.519	0.000	0.000
II.	0.000	9.928	0.000	3.142	78.283	0.000	132.911
III.	0.000	0.000	0.000	19.455	239.646	0.000	507.523
IV.	0.000	0.000	0.000	0.000	13.434	0.000	89.989
V.	0.000	0.000	0.000	0.000	37.229	0.000	68.091
VI.	0.000	6.945	0.000	5.268	86.303	3.244	102.973
VII.	0.000	0.000	0.000	0.000	189.269	0.000	953.119
Total	4.872	16.873	64.398	27.866	657.683	3.244	1854.606

Appendix 5b: The export flow for Yorkshire and Humberside

£m

	AGRIC	ENERGY	MANUF	CONSTR	DISTRBN	TRANSP	SERVICE
I.	0.000	0.000	0.000	0.000	0.000	0.000	0.000
II.	16.707	0.000	84.821	0.000	0.000	15.846	0.000
III.	14.155	8.318	812.210	0.000	0.000	39.789	0.000
IV.	7.062	0.972	18.678	91.191	0.000	2.758	0.000
V.	15.297	5.134	148.901	1.442	0.000	19.811	0.000
VI.	3.786	0.000	28.299	0.000	0.000	0.000	0.000
VII.	50.460	11.468	315.796	32.359	0.000	31.649	0.000
TOTAL	0.000	117.374	874.472	120.661	190.585	32.085	441.732

Appendix 6a: The direct output multiplier for the OPEN model
£m

	AGRIC	ENERGY	MANUF	CONSTR	DISTRBN	TRANSP	SERVICE
I.	0.144	0.000	0.035	0.000	0.002	0.000	0.000
II.	0.055	0.276	0.044	0.012	0.022	0.083	0.008
III.	0.040	0.049	0.335	0.191	0.078	0.130	0.035
IV.	0.015	0.001	0.005	0.244	0.008	0.004	0.010
V.	0.038	0.014	0.050	0.021	0.014	0.046	0.005
VI.	0.018	0.016	0.031	0.009	0.019	0.082	0.005
VII.	0.110	0.017	0.087	0.109	0.099	0.054	0.097

Appendix 6b: The direct output multipliers for the CLOSED model

	I	II	III	IV	V	VI	VII	VIII
I.	0.144	0.000	0.035	0.000	0.002	0.000	0.000	0.008
II.	0.055	0.276	0.044	0.012	0.022	0.083	0.008	0.015
III.	0.040	0.049	0.335	0.191	0.078	0.130	0.035	0.225
IV.	0.015	0.001	0.005	0.244	0.008	0.004	0.010	0.025
V.	0.038	0.014	0.050	0.021	0.014	0.046	0.005	0.127
VI.	0.018	0.016	0.031	0.009	0.019	0.082	0.005	0.022
VII.	0.110	0.017	0.087	0.109	0.099	0.054	0.097	0.450
VIII.	0.150	0.202	0.220	0.292	0.475	0.335	0.406	0.001

Appendix 6c: The total output multipliers for the OPEN model

	AGRIC	ENERGY	MANUF	CONSTR	DISTRBN	TRANSP	SERVICE
I.	1.173	0.005	0.064	0.017	0.008	0.010	0.003
II.	0.103	1.393	0.111	0.056	0.045	0.145	0.018
III.	0.107	0.115	1.551	0.410	0.140	0.243	0.068
IV.	0.027	0.004	0.015	1.329	0.014	0.010	0.015
V.	0.055	0.027	0.087	0.053	1.025	0.067	0.010
VI.	0.031	0.029	0.058	0.030	0.028	1.102	0.009
VII.	0.166	0.043	0.174	0.211	0.131	0.102	1.118

Appendix 6d: The total output multipliers for the CLOSED model

	I	II	III	IV	V	VI	VII	VIII
I.	1.189	0.022	0.088	0.046	0.037	0.036	0.026	0.048
II.	0.142	1.434	0.170	0.128	0.115	0.207	0.075	0.117
III.	0.355	0.376	1.931	0.869	0.585	0.639	0.431	0.748
IV.	0.054	0.033	0.057	1.380	0.063	0.054	0.056	0.083
V.	0.149	0.127	0.231	0.227	1.193	0.217	0.148	0.284
VI.	0.058	0.058	0.101	0.082	0.077	1.147	0.050	0.084
VII.	0.506	0.400	0.695	0.838	0.739	0.644	1.615	1.023
VIII.	0.598	0.628	0.916	1.103	1.070	0.953	0.874	1.800

APPENDIX 7: PROGRAMME FOR DERIVING REGIONAL AND URBAN INTERMEDIATE TRANSACTIONS

```
C* * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C*    PROGRAMME FOR CONSTRUCTING THE INPUT-OUTPUT TABLE  *
C*               FOR YORKSHIRE AND HUMBERSIDE             *
C*                   BY YU-XIAN JIN                       *
C*                    JANUARY 1991                        *
C*SCHOOL OF GEOGRAPHY, UNIVERSITY OF LEEDS, LEEDS LS2 9JT*
C* * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
C
C
C THIS PROGRAMME PROVIDES THE PROCEDURES OF ESTIMATING THE
C REGIONAL INPUT-OUTPUT TABLE.
C
C
C (1) ESTIMATING REGIONAL INTERMEDIATE TRANSACTIONS FROM
C     THE NATIONAL TABLE USING THE 'RAS' BALANCE ITERATION.
C
C (2) ESTIMATING REGIONAL IMPORT AND EXPORT FLOWS USING THE
C     THE FOLLOWING STEPS:
C
C     (I) GENERATE THE REGIONAL INTERMEDIATE REQUIREMENTS
C         BASED ON THE NATIONAL COEFFICIENTS
C     (II)COMPARE THE REGIONAL REQUIREMENTS AND REGIONAL
C         INTERMEDIATE PRODUCTS. THOSE ELEMENTS THAT ARE
C         LARGER THAN ZERO ARE REGARDED AS IMPORTS, AND
C         THOSE NEGATIVE ELEMENTS ARE EXPORTS.
C
C
C
C11111111111111111111111111111111111111111111111111111111111
C11                                                       11
C11       STEP 1: DEFINITIONS OF VARIABLES                11
C11                                                       11
C11111111111111111111111111111111111111111111111111111111111
C
C
      PARAMETER(NI=7,NJ=7)
      DIMENSION AAA(NI,NJ),NR(NI),NC(NJ),RR(NI),RC(NJ)
      DIMENSION RBN(NI,NJ), MOEX(NI,NJ)
      DIMENSION RCF(NI,NJ),MOIE(NI,NJ),MOIM(NI,NJ)
      DIMENSION RGROSS(NI),RRT(NI,NJ),TEX(NI),TIM(NJ)
C     AAA --- NATIONAL COEFFICIENTS
C     RBN --- REGIONAL REQUIREMENTS BASED ON
C             THE NATIONAL COEFFICIENTS
C     NR,NC,RR,RC --- COLUMN AND ROW CONSTRAINTS
C     RRT,RCF --- REGIONAL INTERMEDIATE FLOWS AND
C                 COEFFICIENTS
C     TEX,TIM --- TOTAL EXPORT AND IMPORT
C     MOEX,MOIM --- MATRICES OF EXPORT AND IMPORT
C     RGROSS --- REGIONAL GRASS PRODUCT
```

```
      REAL NR,NC,MOIE,MOIM,MOEX
C
C
C
C2222222222222222222222222222222222222222222222222222222222
C22                                                     22
C22   STEP 2: READ IN DATA FROM DATA FILE               22
C22                                                     22
C2222222222222222222222222222222222222222222222222222222222
C
C
      READ(2,*)((AAA(I,J),I=1,NI),J=1,NJ)
      READ(2,*)(RR(I),I=1,NI)
      READ(2,*)(NR(J),J=1,NJ)
      READ(2,*)(RC(I),I=1,NI)
      READ(2,*)(NC(J),J=1,NJ)
      READ(2,*)(RGROSS(I),I=1,NI)
C
C
C3333333333333333333333333333333333333333333333333333333333
C33                                                     33
C33        STEP 3: BEGINNING OF CALCULATION             33
C33                                                     33
C3333333333333333333333333333333333333333333333333333333333
C
C
C     (i) CALCULATE REGIONAL REQUIREMENTS
C
      DO 400 I=1,NI
         DO 400 J=1,NJ
         RBN(I,J)=AAA(I,J)*RGROSS(I)
400   CONTINUE
C
C     (ii) CALCULATE REGIONAL INTREMEDIATE TRANSACTIONS
C
C      NOD=100
C
      CALL RAS(AAA,NI,NJ,RR,RC,NR,NC,NI,NJ,0.05,NOD)
      IF(NOD.GT.100)STOP
      WRITE(3,122) NOD
      DO 150 I=1,NI
         DO 150 J=1,NJ
            RRT(I,J)=AAA(I,J)
            RCF(I,J)=RRT(I,J)/RGROSS(J)
150   CONTINUE
C
C     (iii) CALCULATE THE REGIONAL IMPORT AND EXPORT
C
      DO 180 I=1,NI
         DO 180 J=1,NJ
         MOIE(I,J)=RBN(I,J)-RRT(I,J)
C
      DO 222 I=1,NI
```

```
          DO 222 J=1,NJ
          IF(MOIE(I,J).LT.0)THEN
            MOEX(I,J)=MOIE(I,J)
            MOEX(I,J)=-MOEX(I,J)
            ELSE
            MOIM(I,J)=MOIE(I,J)
           ENDIF
222    CONTINUE
C
C      DO 233 J=1,NJ
          TEX(J)=0.0
          DO 233 I=1,NI
          TEX(J)=TEX(J)+MOEX(I,J)
233    CONTINUE
C
       DO 244 I=1,NJ
          TIM(I)=0.0
          DO 244 J=1,NJ
          TIM(I)=TIM(I)+MOIM(I,J)
244    CONTINUE
C
C
C4444444444444444444444444444444444444444444444444444444
C44                                                   44
C44    STEP 4: TABULATION OF OUTPUT RESULTS           44
C44                                                   44
C4444444444444444444444444444444444444444444444444444444
C
C
C      HAVE BEEN DELETED
C
122    FORMAT(5X,'ITERATION TIMES = ',I4)
133    FORMAT(2X,7F10.3)
       STOP
       END
C
C
C5555555555555555555555555555555555555555555555555555555
C55                                                   55
C55    STEP 5: SUBROUTINES PROGRAMMES                 55
C55                                                   55
C5555555555555555555555555555555555555555555555555555555
C
C
C
       SUBROUTINE RAS(TON,M,N,RROW,RCOL,NROW,NCOL,IR,
     *               IC,EPS,NO)
C
C
       REAL TON(M,N),RROW(IR),RCOL(IC),NROW(IR),NCOL(IC)
       LOGICAL CONVRG
       ITERNO=NO
       DO 2500 NO=1,ITERNO
```

```
      CONVRG=.TRUE.
      DO 2100 J=1,IC
2100  NCOL(J)=0
      DO 2300 I=1,IR
         RN=RROW(I)/NROW(I)
         DO 2400 J=1,IC
         TON(I,J)=TON(I,J)*RN
2400     NCOL(J)=NCOL(J)+TON(I,J)
         IF(ABS(NROW(I)-RROW(I)).GT.EPS) CONVRG=.FALSE.
2300  CONTINUE
      DO 2150 I=1,IR
2150  NROW(I)=0
      DO 2350 J=1,IC
      RN=RCOL(J)/NCOL(J)
         DO 2450 I=1,IR
         TON(I,J)=TON(I,J)*RN
2450     NROW(I)=NROW(I)+TON(I,J)
         IF(ABS(RCOL(J)-NCOL(J)).GT.EPS) CONVRG=.FALSE.
2350  CONTINUE
      IF(CONVRG) RETURN
2500  CONTINUE
      NO=ITERNO+1
      RETURN
      END
```

```
C   * * * * * * * * * * * * * * * * * * * * * * * * * * *
C   *                                                   *
C   *   PROGRAMME FOR CALCULATING MULTIPLIERS IMPACTS   *
C   *                                                   *
C   *                  DECEMBER, 1990                   *
C   *                                                   *
C   * * * * * * * * * * * * * * * * * * * * * * * * * * *
C
C  THIS PROGRAMME IS TO CALCULATE THE REGIONAL ECONOMIC
C  MULTIPLIER IMPACTS WHICH INCLUDE OUTPUT, INCOME AND
C  EMPLOYMENT MULTIPLIERS. DATA NEEDED FOR THIS PROGRAMME
C  ARE:
C  (A) THE REGIONAL DIRECT OUTPUT MULTIPLIER MATRIX;
C  (B) THE DIRECT INCOME AND CONSUMPTION MULTIPLIERS;
C  (C) THE DIRECT EMPLOYMENT MULTIPLIER.
C      THE CALCULATED OUTPUT INFORMATION MAY INCLUDE:
C      (1) OUTPUT MULTIPLIER
C      (2) TYPE I INCOME MULTIPLIERS
C          (DIRECT AND INDIRECT)
C      (3) TYPE II INCOME MULTIPLIERS
C          (TYPE I AND INDUCED)
C      (4) TYPE I EMPLOYMENT MULTIPLIERS
C          (DIRECT AND INDIRECT)
C      (5) TYPE II EMPLOYMENT MULTIPLIER
C          (TYPE I AND INDUCED)
C
C      *THE AUTHORS WOULD LIKE TO THANK DR. T PAN FOR HIS
C      HELP ON WRITTING PART OF THE PROGRAMME ON INVERSE
C
C       *********   DEFINITIONS   **********
C
      PARAMETER (NI=7,NJ=7,NNI=8,NNJ=8)
      DIMENSION NAO(NI,NJ),NIO(NI,NJ),NAC(NNI,NNJ)
      DIMENSION NAOM(NI,NJ),NAOMC(NNI,NNJ),TI(NJ)
      DIMENSION NIC(NNI,NNJ),HHTI(NI,NJ)
      REAL NAO,NIO,NAC,NIC,NAOM,NAOMC
C     NAO,NAC -- OPEN AND CLOSE NATIONAL MATRICES
C     NIO,NIC -- INVERSE OPEN AND CLOSE NATIONAL MATRICES
C
      DIMENSION HATI(NI,NJ),HI(NJ),HTI(NJ),HIDR(NJ)
      DIMENSION HATII(NNI,NNJ),HC(NI),TII(NJ),HIDU(NJ)
C     TI,TII --- TYPE I AND TYPE II MULTIPLIERS.
C     HI,HC  --- HOUSEHOLD INCOME AND CONSUMPTION
C     HTI,HIDU --- TYPE I AND TYPE II INCOME MULTIPLIERS
C
      DIMENSION EDI(NJ),ETI(NJ),ETII(NJ),TIE(NJ),TIIE(NJ)
      DIMENSION EETI(NI,NJ),EETII(NI,NJ),EIDR(NJ),EIDU(NJ)
      DIMENSION RGROSSP(NI),RFD(NJ),GROSS(NJ),TOI(NI,NJ)
C     EDI --- DIRECT EMPLOYMENT MULTIPLIER.
C     ETI --- TYPE I EMPLOYMENT MULTIPLIER.
C     TIE --- TYPE I MULTIPLIER OF EMPLOYMENT.
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C       TIIE --- TYPE II MULTIPLIER OF EMPLOYMENT.
C       EIDR --- INDIRECT EMPLOYMENT MULTIPLIER.
C       EIDU --- INDUCED EMPLOYMENT MULTIPLIER.
C       RGROSSP,RFD --- REGIONAL GROSS PRODUCT AND
C                       THE GIVEN FINAL DEMAND
C
C
C       ********* READ DATA FROM DATA FILE **********
C
C
        READ(4,*) ((NAO(I,J),J=1,NJ),I=1,NI)
        READ(4,*) (HI(J),J=1,NJ)
        READ(4,*) ((NAC(I,J),J=1,NNJ),I=1,NNI)
        READ(4,*) (EDI(J),J=1,NJ)
        READ(4,*) (RFD(J),J=1,NJ)
9991    FORMAT(1X,7F10.3)
10000   FORMAT('  **********  DATA DEMANDED  *********** '/
         '  -------------------------------------- '  )
9992    FORMAT(1X,8F9.3)
C
C
C       *********   CALCULATION   **********
C
C       :*:*:*:*:  CALCULATE THE INVERSE MATRIX     :*:*:*:*:
C
        CALL MINUS(NAO,NI,NJ,NAOM)
        CALL INVMATRIX(NAOM,NI,NJ,NIO)
C
C       :*:*:*:*: CALCULATE THE TYPE I MULTIPLIER   :*:*:*:*:
C
C       (1) TYPE I INCOME MULTIPLIER
C
        DO 2000 I=1,NI
           DO 2000 J=1,NJ
           HHTI(I,J)=NIO(I,J)*HI(I)
C          HTI(J)=HTI(J)+NIO(I,J)*HI(I)
2000    CONTINUE
C
        DO 2010 J=1,NJ
           HTI(J)=0.0
           DO 2010 I=1,NI
           HTI(J)=HTI(J)+HHTI(I,J)
2010    CONTINUE
C
        DO 2003 I=1,NI
           TI(I)=HTI(I)/HI(I)
2003    CONTINUE
C
        DO 2005 J=1,NJ
           HIDR(J)=HTI(J)-HI(J)
2005    CONTINUE
C
C       (2) TYPE I EMPLOYMENT MULTIPLIER
```

```
C
      DO 2100 I=1,NI
         DO 2100 J=1,NJ
         EETI(I,J)=NIO(I,J)*EDI(J)
2100  CONTINUE
C
      DO 2200 J=1,NJ
         ETI(J)=0.0
         DO 2200 I=1,NI
         ETI(J)=ETI(J)+EETI(I,J)
2200  CONTINUE
C
      DO 2210 J=1,NJ
         TIE(J)=ETI(J)/EDI(J)
2210  CONTINUE
C
      DO 2220 J=1,NJ
         EIDR(J)=ETI(J)-EDI(J)
2220  CONTINUE
C
C     :*:*:*:  CALCULATE THE TYPE II MULTIPLIERS  :*:*:*:
C
      CALL MINUS(NAC,NNI,NNJ,NAOMC)
      CALL INVMATRIX(NAOMC,NNI,NNJ,NIC)
C
C     (1) TYPE II INCOME MULTIPLIER
C
      DO 2020 J=1,NNJ-1
      HC(J)=NIC(8,J)
2020  CONTINUE
C
      DO 2040 J=1,NJ
      HIDU(J)=HC(J)-HTI(J)
2040  CONTINUE
      DO 2060 J=1,NNJ-1
         TII(J)=HC(J)/HI(J)
2060  CONTINUE
C
C
C     (2) TYPE II EMPLOYMENT MULTIPLIER
C
      DO 2400 I=1,NNI-1
         DO 2400 J=1,NNJ-1
         EETII(I,J)=NIC(I,J)*EDI(J)
2400  CONTINUE
C
      DO 2500 J=1,NJ
         ETII(J)=0.0
         DO 2500 I=1,NI
         ETII(J)=ETII(J)+EETII(I,J)
2500  CONTINUE
C
      DO 2550 J=1,NJ
```

```
            TIIE(J)=ETII(J)/EDI(J)
 2550    CONTINUE
 C
         DO 2560 J=1,NJ
            EIDU(J)=ETII(J)-ETI(J)
 2560    CONTINUE
 C       PREDICT REGIONAL PRODUCT BY THE GIVEN FINAL DEMAND
         CALL PREDICT(NIO,NI,NJ,RFD,NJ,RGROSSP,NI)
         DO 2900 I=1,NI
            DO 2900 J=1,NJ
            TOI(I,J)=NAO(I,J)*RGROSSP(I)
 2900    CONTINUE
 C
 C     *******   TABULATION OF RESULTS   ********
 C
          THIS PART IS DELETED.
 C
 C
          STOP
          END
 C
 C        THIS SUBROUTINE IS TO FIND OUT (I-A) WHICH IS THE
 C        PRE-STEP TO CALCULATE INVERSE MATRIX.
 C
          SUBROUTINE MINUS(AA,NK,NL,AM)
          DIMENSION AA(NK,NL),AM(NK,NL)
          DO 200 I=1,NK
             DO 200 J=1,NL
             AM(I,J)=AA(I,J)
             AM(I,J)=-AM(I,J)
 200      CONTINUE
          DO 210 I=1,NK
             AM(I,I)=1.0+AM(I,I)
 210      CONTINUE
          RETURN
          END
 C
 C
 C        THIS SUBROUTINE(II) IS FOR FINDING OUT THE
 C        INVERSE OF MTRIX A
 C
 C
          SUBROUTINE INVMATRIX(A,N,NP,AINV)
          DIMENSION A(NP,NP),AINV(NP,NP),INDX(100)
          DO 10 I=1,N
             DO 15 J=1,N
                   AINV(I,J)=0.0
 15       CONTINUE
             AINV(I,I)=1.0
 10       CONTINUE
          CALL LUDCMP(A,N,NP,INDX,D)
          DO 20 J=1,N
             CALL LUBKSB(A,N,NP,INDX,AINV(1,J))
```

```
20      CONTINUE
        RETURN
        END
C
C
        SUBROUTINE LUDCMP(A,N,NP,INDX,D)
        PARAMETER (NMAX=100,TINY=1.0E-20)
        DIMENSION A(NP,NP),INDX(NP),VV(NMAX)
        D=1.0
        DO 50 I=1,N
           AAMAX=0.0
           DO 55 J=1,N
              IF(ABS(A(I,J)).GT.AAMAX) AAMAX=ABS(A(I,J))
  55       CONTINUE
           IF(AAMAX.EQ.0.0) PAUSE 'Singular matrix.'
           VV(I)=1./AAMAX
  50    CONTINUE
        DO 60 J=1,N
           DO 65 I=1,J-1
              SUM=A(I,J)
              DO 70 K=1,I-1
                 SUM=SUM-A(I,K)*A(K,J)
  70          CONTINUE
           A(I,J)=SUM
  65       CONTINUE
           AAMAX=0.0
           DO 75 I=J,N
              SUM=A(I,J)
              DO 80 K=1,J-1
                 SUM=SUM-A(I,K)*A(K,J)
  80          CONTINUE
              A(I,J)=SUM
              DUM=VV(I)*ABS(SUM)
              IF (DUM.GE.AAMAX) THEN
                 IMAX=I
                 AAMAX=DUM
              ENDIF
  75       CONTINUE
           IF (J.NE.IMAX) THEN
              DO 85 K=1,N
                 DUM=A(IMAX,K)
                 A(IMAX,K)=A(J,K)
                 A(J,K)=DUM
  85          CONTINUE
              D=-D
              VV(IMAX)=VV(J)
            ENDIF
            INDX(J)=IMAX
            IF (A(J,J).EQ.0.0) A(J,J)=TINY
            IF (J.NE.N) THEN
               DUM=1.0/A(J,J)
               DO 90 I=J+1,N
                  A(I,J)=A(I,J)*DUM
```

```
   90           CONTINUE
              ENDIF
   60     CONTINUE
          RETURN
          END
C
          SUBROUTINE LUBKSB(A,N,NP,INDX,B)
          DIMENSION A(NP,NP),INDX(NP),B(N)
          II=0
          DO 100 I=1,N
             LL=INDX(I)
             SUM=B(LL)
             B(LL)=B(I)
             IF (II.NE.0) THEN
                DO 105 J=II,I-1
                   SUM=SUM-A(I,J)*B(J)
  105           CONTINUE
             ELSE IF (SUM.NE.0.0) THEN
                     II=I
             ENDIF
             B(I)=SUM
  100     CONTINUE
         DO 110 I=N,1,-1
C            SUM=B(I)
            IF (I.LT.N) THEN
               DO 115 J=I+1,N
                  SUM=SUM-A(I,J)*B(J)
  115          CONTINUE
            ENDIF
            B(I)=SUM/A(I,I)
  110    CONTINUE
         RETURN
         END
C
C     THIS SUBROUTINE IS TO PREDICT THE GROSS PRODUCT
C     BY EMPLOYING THE TOTAL REQUIREMENT COEFFICIENT
C     AND THE FINAN DEMAND.
C
       SUBROUTINE PREDICT(TRC,NM,NN,FD,NG,GRO,NF)
       DIMENSION TRC(NM,NN),FD(NG),GRO(NF)
       DO 3000 I=1,NM
          GRO(I)=0.0
          DO 3000 J=1,NN
          GRO(I)=GRO(I)+TRC(I,J)*FD(J)
3000   CONTINUE
       RETURN
       END
C
C
C
```