THE SPATIAL AND DISTRIBUTIONAL IMPACTS OF GOVERNMENT SPENDING: A SOCIAL ACCOUNTS APPROACH

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Andrew Trigg ABSTRACT

THE SPATIAL AND DISTRIBUTIONAL IMPACTS OF GOVERNMENT SPENDING: A SOCIAL ACCOUNTS APPROACH

This thesis reports the findings of a research programme which is directed towards the development of an integrated approach to regional impact analysis. The analysis concentrates on the construction of an integrated impact assessment framework, which is designed for the measurement of the spatial and distributional impacts of government spending.

The review of literature focuses on a menu of different models which are integrated in order to conceptualise linkages between intra and interregional activities. Starting with the household exogenous Leontief input-output model, intra-regional linkages are developed with the endogenisation of household activity; the explicit consideration of demographic flows; the incorporation of previously unemployed residents; and the endogenisation of investment. Interregional linkages are conceptualised by fusing the demographic-economic model with a two-region social accounts matrix (SAM). The integration of different modelling traditions is developed further with the use of labour time as the numeraire.

Strathclyde and the rest of Scotland are chosen as a two-region system for use as a case study, with the core data requirements of the impact model provided by the Scottish and Strathclyde input-output tables (1973). Using these tables an ad hoc residual procedure is developed for the derivation of interregional trade data.

An important methodological outcome is the development of a new multiplicative decomposition for the conceptualisation of the integral components of extended input-output multipliers. Compared with other methods of decomposition, this procedure provides a direct and succinct approach to the conceptualisation of multiplier relationships. The other main methodological conclusion relates to the labour value extension to the input-output model. It is proven that the theory of unequal exchange is irrelevant to the study of intranational regions in the U.K.

The empirical analysis consists of an examination of the structure of production multipliers, and an assessment of the impacts of education, health and defence expenditure. The main conclusion of the multiplier analysis is that the specification of interregional linkages is a vital component of the impact assessment framework, and is particularly relevant to the measurement of the impacts of simultaneous injections of final demand in both regions. The impact analysis concludes that the social spending categories of public expenditure (health and education) provide a greater stimulus to economic activity than defence expenditure. It is also concluded that a reduction in defence expenditure would be more easily compensated for in the rest of Scotland relative to Strathclyde. The analysis demonstrates the capacity of the impact assessment framework for assessing various policy initiatives.

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CHAPTER ONE

INTRODUCTION

1.1. INTRODUCTION AND BACKGROUND TO THE STUDY

Over the past fifty or so years ther has been an acceleration in the growth of public expenditure as a proportion of total economic activity. In the U.K. public expenditure made up 29.0% of GNP in 1939, but rose to 54.7% in 1984 (Brown and Jackson 1986). Cockle (1985) has identified three levels of decision-making for the allocation of public expenditure. Firstly, decisions are made with respect to the magnitude of the total claim made by the public sector on economic resources and incomes. Secondly, this outlay must be allocated between different categories of public expenditure such as defence, education, health expenditure, and so on. Finally, with each category of expenditure a series of localised objectives need to be satisfied. In view of the increasing size of the public sector, the decision-making process by which government expenditure is allocated each year is referred to as an "awesome planning feat" (Cockle 1985, p.xii).

For this planning process to be efficiently implemented a vast amount of information is required by central government. In the 1960's a particular area of concern was the availability of statistics relating to the distribution of public expenditure between intra-national regions. The newly formed Department of Economic

Affairs (DEA) published a pamphlet, *Economic Planning in The Regions* (1968), which highlighted the need for central government to take into account the likely distribution of public expenditure between regions. According to Short (1981), however, information on the distribution of public expenditure between regions was not subsequently collected in sufficient detail or with sufficient coverage of regions to "aid the formation of the strategies to any significant degree" (p.1). In an attempt to solve this problem, Short integrated public expenditure into a regional accounting framework; estimates of public expenditure in the U.K. regions were provided for the period of 1974/75 to 1977/78 inclusive.

An estimation of the actual distribution of public expenditure, as provided by Short, helps to assess the past efforts of public authorities to meet the needs of each region; and this provides a background to future proposals for the allocation of public expenditure. However, the degree to which public expenditure affects a region's output and employment, also depends on the structural response of that region's economy to injections of public expenditure. It is conceivable that equal injections of public expenditure in two regions could result in different responses of output, employment etc., due to the differing structures of each regional economy. In order to provide a more detailed assessment of the benefits accrued to regions by public expenditure, some form of *impact analysis* is therefore required.

One of the most notable examples of regional impact analysis has been the extensive research carried out in the United States into the regional impacts of defence and space-related expenditures (see Leontief 1965; Isard and Langford 1969; refer to Richardson 1972, pp. 146-53, for a review of this tradition). The impetus for this research has partly derived from the wealth of information which has been collected on defence-orientated spending, and more importantly from the high regional concentration of such spending - a reduction in defence spending would have serious ramifications for the economic well being of regions in which it is highly concentrated. Studies into the impacts of an arms cut usually consider the impacts of an accompanying increase in non-military demand (see Bezdek 1974; Rosenbluth 1978). Such an approach provides an insight into two of Cockles' levels of resource allocation in the public sector: between different categories of public expenditure, and between different points in space.

Various models can be used for the analysis of regional impacts (see Pleeter 1980), but in recent years a common theme has emerged for the consideration of such models - namely the need for integration in regional analysis. Batey and Madden (1986), in an introduction to the volume, *Integrated Analysis of Regional Systems*, have argued that this interest in integrated regional analysis can be largely attributed to the "severe limitations of analysis in which a single region or activity is studied in isolation from others" (Batey and Madden 1986, p.1). This argument applies particularly to the field of regional impact analysis, for the specification of linkages between regional activities and between separate regions enables the extension of an impact assessment framework from a partial to a more general level of analysis.

Batey and Madden (1986) identify the emergence of a coherent field of analysis concerned with the problem of integration in the regional context. Three levels of integration are considered to be important:

1. Regional activity: The most significant linkage is between demographic and economic activity, but energy and transport, and their relationship with population and employment, are also considered to be important.
2. Interregional linkages: This concerns the measurement of flows of goods and services, people, or money flows between regions.
3. Conjoining different types of regional models: This can include, for example, the integration of a forecasting model with an optimising model.

The specification of linkages as part of an integrative approach can involve more than the introduction of a series of extensions to one model. Sometimes a different type of model is needed to expand the scope of the analysis. This situation arises for the estimation of linkages between demographic and economic systems in an interregional context.

In recent years there has been an increasing interest in the demographic-economic interface. According to Schinnar,

> "there is abundant evidence pointing to the fact that demographic variations have been induced by manipulations or movements in economic variables and, conversely, that demographic changes have important 'feedback' effects on economic matters."
>
> (Schinnar 1976a, p.455)

An important development in this area of analysis has been the work of Batey and Madden (1981; 1983) on the extension of the Leontief input-output model to include household activities. In order to render the model more consistent, households are divided along activity lines - in particular the impacts of previously unemployed residents on household income generation is considered. This type of impact model is particularly relevant to the depressed regions of advanced capitalist countries in which high unemployment is a common malaise.

Stone and Weale (1986) have adopted a two-region version of the Batey-Madden model (see Trigg 1987). The reformulation of the demographic-economic model has involved the introduction of the parallel tradition of social accounting. As such the Stone-Weale model involves the integration of regional activity, both within and between regions, via the conjoining of the demographic-economic input-output model with a two-region social accounts matrix (SAM). Two comments can be made in relation to this development. Firstly, the Stone-Weale model has been presented only as a conceptual framework; so that there is "much research to be done if it is to progress from a toy model to a useful tool for studying the world we live in" (Stone and Weale 1986, p.79). Secondly, although the field of social accounting has been revitalized in recent years by an increasing concern with the growth and development of Third World countries (see Thorbecke 1985), the application of social accounting techniques to more advanced capitalist economies has been limited; especially in the area of regional social accounting. Richardson argues, with respect to regional income and production accounts, that "no one makes strong pleas for the construction of such accounts nowadays" (Richardson 1978, p.3). This is partly explained by the high costs of data collection and estimation, which cannot justify the short-term results generated by such models. However, despite the almost exclusive application of social accounting models to Third World countries, the social accounting techniques developed over the past dozen or so years can readily be applied to a model such as that developed by Stone and Weale, in the context of a developed economy; particularly in view of the advances made by Batey and Madden in a one-region context.

Another example of integrated modelling has been the fusion of the Leontief input-output model with Marx's labour value system. Morishima (1973) provides a system of value equations which can easily be adapted to the standard input-output table. Recent applications of the Morishima value system have concentrated on the measurement of unequal exchange between spatial locations (see Marelli 1983; Webber and Foot 1984). Spatial flows of labour values are seen as crucial factors relating to the uneven development of regions. Of central importance to this approach is the role of public expenditure as a stimulant to economic activity (see Emmanuel 1969).

These different modelling traditions provide an introduction to the origins of this study. The theme of the study is to develop an integrated impact assessment framework, which includes linkages between regional activities and interregional linkages, using an integration of several separate traditions of economic modelling.

The aim of the study is to adapt this model to the measurement of the spatial and distributional impacts of government spending. This approach provides an additional level of integration - between demand and supply side activities. Government spending constitutes the demand side injection of economic activity in a region, whilst the linkages between intra-regional and interregional activities constitute the supply side response of the regional economy to the injection.

The development of such a model provides an insight into the complex process by which the benefits from government spending are allocated to different parts of an interregional economy. This study is an exercise in the development of a conceptual framework which can be used to assess public policy objectives.

1.2. THE OBJECTIVES OF THE STUDY

The specific objectives of the study are:

1. To conceptualise a collection of intra and interregional linkages in an integrated impact assessment framework.
2. To construct this model through the integration of different types of models and different modelling traditions.
3. To select a case study area for which the necessary data can be derived for the operationalisation of this model.
4. To assess, by means of theoretical and empirical investigation, the importance of each integral component of the model.
5. To conceptualise government spending as an exogenous impulse to the model.
6. To demonstrate the utility of the model by way of a comparative analysis of the impacts of different categories of government spending.

At the outset, it must be stressed that the emphasis of this study is on the development of a conceptual model in order to improve the *analysis* of government spending as an exogenous impulse. The detailed assessment of government spending as a useful input to the process of policymaking, is an area of secondary concern. Thus the task here is to develop an impact assessment framework which can be used to improve our understanding of the relationship between government spending and the structure of an interregional economy.

1.3. STRUCTURE OF THE THESIS

In this chapter to date we have considered the background to the problem of measuring the impacts of government spending, and the objectives of the research. This section outlines the structure which has been adopted for the thesis and summarises the main points covered in each chapter.

Chapter Two is concerned with the development of a conceptual approach to the formulation of an integrated regional impact model. The chapter begins with a comparison of the Leontief input-output model with the two other main impact models: the economic base and econometric models. This discussion serves to assess the applicability of the Leontief model to the objectives of the study and to consider its limitations. We then consider the assumptions of the basic input-output model in detail, and as the first step to an integrative approach the chapter turns to the consideration of linkages between demographic and economic activities. This discussion involves the examination of a lineage of one-region multipliers, each of which contributes to the integration of regional activity. The chapter then turns to examine the separate but parallel tradition of social accounting. Special emphasis is placed upon the distribution-orientated approach to social accounting which is closely related to the demographic-economic input-output tradition.

In Chapter Three a series of new extensions to the demographic-economic model are introduced. The chapter begins with the formulation of the linkage between industrial output and investment activity. This is accomplished through the development of a dynamic extension to the demographic-economic model. The chapter then turns to the consideration of interregional linkages, in order to expand the impact model from a partial to a more general approach. An interregional extension is conceptualised by fusing the demographic-economic model with a two-region social accounts matrix (SAM). An extended system of two-region multiplier equations is derived. Finally, a labour value extension is introduced: in contrast to the usual social accounting models, which use money units as the numeraire, all commodity flows are measured in units of labour time. This extension is interpreted as a natural corollary to the demographic-economic tradition.

In Chapter Four a data set is derived for the operationalisation of the two-region impact assessment model. A case study area is chosen for the regions of Strathclyde and the rest of Scotland. A number of established techniques are applied to the specific data problems associated with this study area. The chapter begins with the derivation of interregional flows of intermediate commodities, which provides the core of the two-region model. Subsequent analysis concentrates on the derivation of data for the household and investment components of the model. In addition, a number of supplementary data requirements, such as the estimation of labour time by sector, are considered.

Chapter Five provides an assessment of the relative importance and applicability of each component of the model. The chapter begins with a comparative empirical evaluation of some of the extensions to the input-output model. These extensions are compared in terms of their impacts on the size of production multipliers. The main theme of this analysis is the comparison of the inter-regional extensions with the demographic-economic and inv-estment extensions to the input-output model. The chapter then turns to the decomposition of the two-region mult-iplier in order to examine the relative responses of each regional economy to a uniform change in final demand. This analysis provides an insight into the supply side of the economy as a background to the complete demand-driven impact analysis. Finally, a purely theoretical assessment of the applicability of the labour value extension is considered. The theory of unequal exchange, which is one of the most popular empirical applications of labour value analysis, is assessed in relation to an intranational context.

In Chapter Six the two-region social accounts matrix (SAM) is further developed in order to take into account government spending explicitly. Following on from the theoretical discussion in Chapter Five, the chapter begins with the formulation of a theoretical approach to the role of government spending in the impact assessment framework. This development involves the modification of the structure of the two-region SAM and the disaggregation of final demand into government activities. The chapter then turns to a specific application of this modified SAM to measure the impacts of public expenditure programmes. The empirical analysis focuses on the impacts of health, education and defence expenditure. An aggregate analysis compares the overall impacts of each category of expenditure, whilst a sectoral disaggregation is conducted in order to explain the results obtained. In addition, a two-region analysis concentrates on the relative structural responses of each region to the injections of public expenditure; and an analysis of the response of surplus labour time is conducted.

The final chapter of the thesis, Chapter Seven, summarises the main points of the research programme and draws out a number of conclusions concerning the findings of the research. Several recommendations are suggested for future research.

CHAPTER TWO

A REVIEW OF VARIOUS TRADITIONS IN IMPACT ANALYSIS

2.1. INTRODUCTION

The main purpose of this chapter is to consider a number of closely related traditions in the field of regional analysis. This review of literature sets the context for the conceptual model which shall be developed in Chapter Three. Each individual tradition is appraised in relation to the objectives of the study concerning the development of an integrated impact assessment framework (see Chapter One).

Various models have been developed in order to measure economic impacts in a regional context. Section 2.2 reviews the three main techniques of regional impact analysis and provides an introduction to the application of the Leontief input-output model. In Section 2.3 the field of demographic-economic input-output analysis is introduced and interpreted as a series of extensions to the simple Leontief model; each extension providing a linkage between different regional activities. A lineage of demographic-economic multipliers is derived using a one-equation format for each model considered. In Section 2.4 the field of social accounting is reviewed as a separate but parallel tradition to demographic-economic analysis; thereby providing the groundwork for the inter-regional extensions to the demographic model which shall be formulated in Chapter Three. The final section contains a summary of the conclusions to this chapter.

2.2. THE INPUT-OUTPUT MODEL AS AN IMPACT ASSESSMENT FRAMEWORK

2.2.1. Introduction

Impact analysis involves the specification of an exogenous stimulus which constitutes the direct impact, and the construction of a model which derives estimates of the indirect effects (see Pleeter 1980). Therefore, impact analysis depends crucially on the choice of an economic model with which to measure indirect impacts. A variety of techniques are available to the regional impact analyst, the three main categories being the economic base, input-output and econometric models. These categories cannot always be clearly separated; often impact assessment frameworks are hybrid versions which involve elements of each model. Nevertheless, the consideration of each category in isolation provides a useful background to the field of impact analysis.

An assessment of the viability of each model depends on the nature of the specific applications for which the model is required. At the present juncture we can assume that the model is required for a short-term impact analysis of government spending. In later chapters a long-term time profile is introduced, but for the moment we make the above assumption in order to distinguish impact analysis from a forecasting framework. With forecasting, final demand is projected over the long-term, say for five years, and the forecasting model is used to measure the consequent effects on output and employment. For impact analysis final demand is not projected, but changed exogenously, with the impacts estimated over a short period, such as one year.[1]

2.2.2. The Economic Base Model

The economic base model constitutes one of the earliest techniques employed in regional analysis. Glickman (1977) has traced it back to the work of Hoyt (1933), but the series of seminal papers by Andrews, which appeared in *Land Economics* during the 1950's, are usually quoted as the basis for the application of economic base concepts at the regional level. Economic base analysis is used to define the proportion of activity in a region that is dependent on markets outside that region: this is the basic sector. The remaining sector is defined as nonbasic, with no dependence on interregional trade. Hewings (1977) has defined the basic sector as the "driving mechanism" which is essential for a region's prosperity (p.14). A region's growth or decline depends on the ability of that region to export goods and services.

There are a number of difficulties associated with the economic base model, including for instance the choice of a unit of measurement and the problem of identification of basic and nonbasic sectors. The most significant limitation is the restrictions of the economic base model for the purposes of impact analysis. The multiplier which

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1. This definition of impact analysis and forecasting can be found in Miller and Blair (1985), p.100.

is derived from the economic base model applies specifically to the measurement of the impacts of exports. For a more general impact analysis, such as the case of government spending, the economic base model is not applicable. The economic base model, therefore, is not suited to the objectives of the present study.

2.2.3. The Input-Output Model

The model which can be used as a more general impact assessment framework, and which forms the core of this thesis, is the Leontief input-output model. According to Richardson (1979) this is the most popular model applied in the area of economic impact analysis. The modern input-output table was originally devised by Wassily Leontief (1936), although Quesnay's (1758) famous *Tableau Economique* provides the historical antecedant. In short "the input-output method is based upon the simple, but fundamental, notion that the production of outputs requires inputs" (Armstrong and Taylor 1985, p.26). These inputs can take the form of industrial goods, household services, or government services required for production. Industrial outputs are either directed to other industries as inputs, or to a separate 'final demand' sector which consists of items of expenditure which are exogenous to the production process.

The economic base model can be considered as a special case of the input-output model (see Romanoff 1974). In its general form the input-output table shows the relationship between all categories of final demand - items of expenditure such as exports, government spending and investment - and the industrial structure of the economy.

Conversely, the economic base model concentrates on the impact of exports under the special case of a two-sector model (basic and nonbasic). The input-output model can be interpreted as an extension of the economic base model into a more general impact assessment framework.

The first applications of the input-output model at the regional level were in the 1950's. Isard and Kuenne (1953) used an input-output model in order to measure the impacts of steel in the Greater-New York Philadelphia region, whilst Moore and Peterson (1955) developed a model for Utah. These original models relied on the adjustment of national coefficients to the regional level. It was not until the 1960's that the full survey-based models started to be constructed. Classic examples are the survey-based models for Philadelphia (Isard and Langford 1969) and West Virginia (Miernyk et al 1970). It is generally accepted nowadays that the best alternative for the implementation of an input-output approach, is to undertake a compromise between expensive survey techniques and short cut non-survey techniques (see Richardson 1985). A discussion of thesetechniques is outlined in Chapter Four of this thesis.

The input-output model provides a sound basis for the construction of an impact assessment framework. One of the conceptual attractions of the input-output method is the enormous detail into which economic activity is divided. The interindustry accounts matrix explicitly models "whirlpools of industrial relationships" by which all industrial activities are linked together (Dorfman, Samuelson and Solow 1958, p.205); dependent on each other for the supply and demand of goods and services required in the production process. For the purposes of measuring indirect impacts, the demand for goods produced by one industry can be traced through to every other industry in the economy and back to the industry in question. Without such a detailed industrial disaggregation the measurement of economic impacts would not model the *interdependence* of industrial units which is crucial to the growth and development of a regional economy.

Furthermore, the estimation of interindustry linkages enables the formulation of an additional linkage between industrial activities and the distribution of income and expenditure in a region. The version of the input-output model which enables the specification of this linkage, is closed with respect to household activities. Households are treated as an ordinary industry in the input-output table, performing the dual functions of providing labour services to industry and consuming industrial commodities. This version of the input-output model can be used to assess the distributional impacts of a change in final demand (see Section 2.3).

2.2.4. The Regional Econometric Model

A more recently developed impact technique is the regional econometric model. The starting point for regional econometric model building is the work of Klein (1969). Klein argued that the national econometric model, which has been developed extensively under post-war Keynesian demand management, should be applied at the regional level. Regional econometric models use time series data, instead of data which relates to one point in time, as in the case of the input-output model. The objective is to establish, through the use of regression techniques, the relationships between economic variables which are important to the structure of a regional economy. For impact analysis a multi-equation model is usually employed in order to measure the effects of changing exogenous variables such as government spending on other variables such as output, employment and income. Usually, the regional econometric model is the satellite of a national model. Adams, Brooking and Glickman (1973), for example, set up an econometric model for Mississippi which was linked with the Wharton Annual and Industry Model.

The regional econometric model provides an interesting contrast to the input-output model. Four main criteria can be considered in comparing these two models:

1. Assumptions: The input-output model requires the imposition of several strict assumptions in order to link together each industry in an operational framework (see Section 2.3). Assumptions such as linearity, constant returns to scale, and no substitution, enable the modelling of economic change using a detailed collection of information. These assumptions, however, dictate the parameters which are to be estimated in the impact framework, and this restricts the range of investigation. In contrast, econometric models "are constrained only by the broad bounds of economic theory itself". (Glickman 1977, p.38). In an econometric model the relationships between variables which hold for a particular region, can

be incorporated without any a priori restrictions. The main problem for econometric models, however, is the availability of data at the regional level.

2. The availability of data: When Klein conceptualised his regional econometric model in 1969, he took little account of the availablilty of data at the regional level (see Glickman 1974). The strict national accounts framework, suggested by Klein, cannot be implemented at the regional level. Data is not always available for the expenditure side of the accounts; according to Glickman (1974) it is rare to find regional time series data for consumption, exports, imports or nonmanufacturing investment. This lack of data limits the conceptual structure of the econometric model, with much of the analysis having to concentrate on output and income instead of the expenditure side of the accounts. To compound the problem, Richardson (1979) has pointed out that time series data for output is not available for all industrial sectors. In both the United States and the U.K., time series data is not available for non-manufacturing sectors at the regional level. Due to these data problems, Pleeter (1980) has commented that regional data often has to be derived from national variables. Such data problems mirror the limitations of non-survey techniques in input-output analysis, in which national figures are often grossed down to the regional level (see Round 1983).

For the econometric model, however, time series data is required for at least fifteen points in time, whereas for the input-output model the observations relate to only one point in time. The problem of data availability, therefore, which applies to any regional impact model, is compounded for the econometric model by time series data requirements.

3. Technical problems: The problems of data availability for the econometric model engender a number of technical difficulties. For a national econometric model, time series data is usually available on a quarterly basis. In contrast, most regional econometric models have to rely on annual data.[2] This means that there are usually relatively few observations available for the equation system. Glickman (1977), for a survey of ten econometric models, found that most have between fifteen to seventeen observations.[3] In an econometric model the number of observations available is crucial to its explanatory power. A major problem is the reduction in the degrees of freedom if the number of observations is low. The degrees of freedom are basically the number of observations minus the number of constraints placed on the data by the calculation procedure (Pindyck and Rubinfeld 1981). Therefore, if the number of observations is low then there are few degrees of freedom to play with. This reduces the statistical confidence which can be inferred as to the accuracy of the results estimated by the model. In order to maintain sufficient degrees of freedom, often a number of

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2. Glickman (1974) could identify only a handful of regional econometric models which have employed quarterly data.

3. Although this survey is somewhat dated, it provides an insight into the data available for econometric models.

explanatory variables have to be left out of the specification (Pleeter 1977). To quote Bacharach, "The choice is typical of the econometric method: the more complex our descriptions, the less confidence we can place in the accuracy of our estimates" (Bacharach 1970, p.2). Therefore, it would appear that the regional econometric model is not constrained only by "the bounds of economic theory", as Glickman (1977) stated, but is severely constrained by the technical problems associated with data availability at the regional level.

The practical problems associated with the construction of an econometric model illustrate its limitations, but are different from the problems associated with the construction of an input-output model. Input-output analysts undertake surveys of interindustry flows in order to build data sets which are not otherwise available. In constrast, the econometric modeller relies on data which is already available. Obviously, data which goes back over twenty years or so cannot be collected using a survey. The point to make here is that a survey or non-survey input-output model is a much more ambitious contribution to regional information than the econometric model. There are, of course, a number of technical difficulties associated with survey methods, such as sampling, aggregation and balancing problems (see Bulmer-Thomas 1982). But, without ignoring such limitations, it should be emphasised that the input-output model provides point estimates of interindustry flows on the basis of actual observations instead of calculating implied flows based on the stochastic inference of econometric relationships.[4]

4. Interregional trade: The lack of regional time series data for exports and imports, as identified by Glickman (1974), is crucial to the estimation of interregional trade linkages in econometric models. Even at the state level, time series data for exports and imports in the United States is only readily available in Alaska, Hawaii and Puerto Rico. Therefore, "flows in and out of cities, countries, states and other subnational regions simply are not known with any precision" (Klein and Glickman 1977, p.6). As a consequence, there is no substantive tradition in econometric model building for the integration of regional models via linkages of interregional trade.[5]

Conversely, in input-output modelling there is an established tradition of interregional analysis (see Section 4.2). The estimation of interregional trade flows in input-output models has proved difficult due to problems of data availability; but the development of various survey and non-survey techniques has rendered such an estimation feasible for one point in time. In econometric modelling the need for time series data increases the severity of the problem:

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4. There are, however, some examples of stochastic input-output models: Gerking (1976) employed a stochastic estimation procedure to reconcile row and column totals in a survey-based input-output table. This method, however, has not been widely accepted. Miernyk (1976) argued that it is wrong to apply stochastic methods to a deterministic model.

5. A recent exception is the ECESIS economic-demographic model of the United States which estimated the trade linkages between 51 state econometric models (see Beaumont et al 1986).

> "Conceptually, there is a powerful argument for an interdependent interregional systems approach but this would be more difficult to develop with the standard social accounts of econometric models than with interregional input-output ... models."
>
> (see Richardson 1979, p.213)

Due to the problems of data availability, therefore, if an interregional component is required for the proposed impact assessment framework, then an input-output model can be considered as the best alternative.

In recent years there has been a trend towards the linking together of input-output and econometric models. For the construction of multi-sector Computable General Equilibrium (CGE) models, econometric techniques have been used to introduce non-linear behavioural and technical relations to the input-output model (see Thorbecke 1985). At the regional level L'Esperance et al (1977) have used econometric techniques to generate the final demand vector for an input-output model. Stevens et al (1981) have argued that econometric methods are feasible for the estimation of interindustry flows, but not with the sectoral detail or accuracy which is captured by an input-output model. It is for this reason that the input-output model has been used as the core for a number of econometric policy simulation models (see also, Conway 1979; and Kushnirsky 1982).

2.2.5. Conclusions

The input-output table provides the backbone for the development of a regional impact assessment framework. Economic base models are not comprehensive enough to model the impacts of government spending, whilst econometric models are difficult to apply to the estimation of interregional trade flows. The input-output model is adjudged to be more applicable to an analysis of the interregional impacts of government spending. Furthermore, despite the restrictive assumptions of the input-output model, it displays a number of attributes relative to the econometric model with respect to problems of data availability and technical problems. The application of a deterministic input-output model, however, should not detract from the potential which econometric techniques offer for the modelling capability of input-output as an impact assessment framework.

In the next section we examine the input-output model more closely, and consider its applications as a demographic-economic framework.

2.3. THE DEMOGRAPHIC-ECONOMIC INPUT-OUTPUT MODEL

2.3.1. The Type I Input-Output Model

The simplest version of the Leontief input-output model is open with respect to household income and expenditure. Household expenditure is assumed to be exogenous and is therefore included as part of final demand. Table 2.1 shows the distribution of industrial outputs between industries (y_{ij}) and to final demand (f_j):

TABLE 2.1 The Open, Static Input-Output Table

		Purchasing Industries				Final Demand	Gross Outputs
		1	2	. . .	n		
Producing Industries	1	y_{11}	y_{12}	. . .	y_{1n}	f_1	y_1
	2	y_{21}	y_{22}	. . .	y_{2n}	f_2	y_2
	.	.	.		.	.	.
	.	.	.		.	.	.
	.	.	.		.	.	.
	n	y_{n1}	y_{n2}	. . .	y_{nn}	f_n	y_n

where

y_{ij} = intermediate demand for the i^{th} industry's output by the j^{th} industry,

y_i = gross output of industry i , and

f_i = final demand for industry i's outputs.

The input-output table is converted into an analytical tool through the derivation of technical coefficients. Each industry's demand for intermediate goods is interpreted as a fixed proportion of that industry's gross output:

$$a_{ij} = \frac{y_{ij}}{y_j}, \tag{2.1}$$

If industry j's gross output changes then intermediate flows from industry i to industry j adjust according to this fixed proportion. These fixed proportions are called input coefficients and are assembled in a technical coefficients matrix :

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & & \vdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}, \tag{2.2}$$

Using this matrix of input coefficients the accounting identity for the Leontief system can be expressed as follows :

$$y = Ay + f, \tag{2.3}$$

where

y = a vector of gross outputs,

A = a square matrix of input coefficients, and

f = a vector of industrial final demand.

By manipulation

$$(I - A)y = f, \tag{2.4}$$

so that

$$y = (I - A)^{-1}f, \tag{2.5}$$

where

$m_{T1} = (I - A)^{-1}$.

The inverse m_{T1} is a matrix of open, static input-output multipliers, showing the impact of sectoral changes in final demand on sectoral gross outputs. In regional applications of the input-output model this has been called the Type I model (see Hirsch 1959). Before developing this model as an impact assessment framework, we can examine the assumptions which need to be made in in order to make it operational.

2.3.2. <u>Assumptions of the Type I Input-Output Model</u>

The assumptions associated with the open, static (Type I) input-output model can be summarised as follows:[6]

(1) Production functions in each industry are linear.

(2) Inputs are used in fixed proportions, i.e. input coefficients are constant over time.

(3) No joint production.

(4) No substitution between factors of production.

(5) Prices and wages are constant.

(6) No production-capacity constraints.

(7) No consumption effects.

(8) No investment-accelerator effects.

Leontief originally designed the input-output model in order to provide an empirically workable example of Walras's general equilibrium system. The adoption of linear production functions (assumption 1) was, according to Leontief (1951), originally used by Walras in his first formulation of a general equilibrium system. The inputs purchased by each sector are only a function of the level of output of that sector. Therefore, the specification

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6. The classification of these assumptions derives from the original work of Leontief (1951) and from Harrison and Lund (1967) and Polenske (1980).

of this relationship using linear production functions, though not strictly necessary (Chenery and Clark 1959), is a convenient method for linking together a network of industrial sectors.

The assumption of constant coefficients (assumption 2) means that the technical relationships specified between industries are fixed over time. Harrison and Lund (1967) have listed six factors which work against this assumption, two of which are caused by assumptions (4) and (5) above. The other four factors are economies of scale, localisation economies, urbanisation economies and technological change. Although the existence of economies of scale is an important factor relating to industrial agglomeration, in the Leontief model constant returns to scale are assumed. Raising all inputs to an industry by the proportion k will always increase output by k also. Together with assumption (1) we can state that the Leontief production function displays *linear homogeneity* (see Chiang 1974).

Localisation and urbanisation economies are both external economies, the first occurring to an industry as a result of like-producing units aggregating to one point, the second as a result of unlike-producing units aggregating at one point. These factors are assumed not to exist due to the constant returns to scale implicit in the Leontief production function. The fixity of the input coefficients also precludes the possibility of technical change.

The assumption of no joint production (assumption 3) is a simplifying device through which each industry is assumed to have only a single primary output. If each industry were allowed to produce more than one product then this would present major difficulties for the computation of a solution to the system of input-output equations. We therefore assume that each industry's products, apart from the primary product, has a zero coefficent. This assumption can be relaxed by the activity /commodity formulation often used in the SAM framework (see Section 2.4).

The fourth assumption, namely, the non-substitution of factors of production, derives from assumption (2). In the Leontief model factors cannot be substituted for each other according to marginal increases or decreases in productivity. If one factor is increased its marginal productivity is zero - all factors have to be increased in order to generate an increase in production; and each factor is used up according to fixed proportions. Intermediate inputs in the Leontief system are therefore *complementary*, this being the basis for the interdependence of industrial sectors. In defence of assumption (4), Leontief (1951) argued that substitutability does in fact take place if one industrial sector increases its output at the expense of another sector. Each industry has different fixed proportions of factors of production, so that as output changes these factors are substituted for each other in the production process. Therefore, factor substitution takes place at the interindustry level, but does not take place within each industry.

Assumptions (5) and (8) are easier to relax than the preceding assumptions. Although the price mechanism is not usually explicitly modelled in an input-output model, Polenske (1979) has shown how prices can be introduced. Obviously, if prices and wages are assumed constant this precludes the possibility of market clearing, both in the labour market and in the economic system as a whole.

The recognition of production-capacity constraints in the input-output literature has been limited. The usual assumption has been that firms are operating at below full capacity and can therefore easily adjust to changes in final demand during the short-run. However, Batey and Weeks (1987) recently demonstrated how the input-output multipliers can easily be adjusted according to production-capacity constraints.

The refinement of the last two assumptions (7 and 8) forms a major component of the analysis presented in the ensuing chapters of this thesis. The incorporation of household activities and investment as endogenous variables provides the opportunity to expand the scope and accuracy of the input-output framework. As a starting point, we consider the Type II household endogenous input-output model as a basis for the development of a regional impact framework.

2.3.3. The Type II Input-Output Model

In the Type I input-output model all household expenditure is subsumed within final demand. If final demand changes only interindustry activity is allowed to respond - household expenditure is exogenous to the model. Although this is the simplest version of the input-output model, in his original work Leontief (1951) constructed a model which was closed with respect to households; households were treated as an ordinary industry in the input-output table. As such, the household sector consumes industrial commodities (inputs) and provides labour services (outputs). If output in the industrial sectors increases, in response to an injection of final demand, the household sector is deemed to produce more labour services and consume more industrial commodities. This interaction of household and industrial activity is incorporated as part of the multiplier framework. In the regional literature this household endogenous model has been referred to as the Type II input-output model (again, refer to Hirsch 1959).

The Type II input-output model is particularly relevant to the regional context. Artle (1965) has argued that at the regional level the conventional boundary between intermediate and final demand needs to be removed. A small regional economy is more open than a national economy, so that changes in final demand generate relatively less intermediate demand for locally produced goods. Components of final demand such as household expenditure, therefore, become more important relative to intermediate demand. Artle thus incorporates household expenditure as an endogenously determined variable in his input-output model for the Stockholm economy.

A justification of Artle's argument has been provided more recently by Hewings and Romanos (1981), following on from the findings by Beyers (1974) that the linkage between the household sector and industrial sectors is more important than the interindustry linkage. From a study of the region of Evros in Greece, Hewings and Romanos found that 50 per cent of the important parameters in the Leontief inverse were located in the row and column relating to the household sector. Factor payments to labour, therefore, may induce a greater impact on the regional economy than an increase in output for an industry which is strongly related to other industries in the regional economy.

To render household consumption endogenous requires the addition of an extra row and column to the (I - A) matrix in the Type I model (see Equation 2.4). The extra row contains a vector of income from employment coefficients (h_w), with the extra column providing a vector of consumption propensities (h_c). The Type II model has the following structure :[7]

$$\begin{bmatrix} (I - A) & -h_c \\ -h_w & 1 \end{bmatrix} \begin{bmatrix} y \\ y_H \end{bmatrix} = \begin{bmatrix} f \\ o \end{bmatrix}, \qquad (2.6)$$

where

h_c = a column vector of household consumption propensities,

h_w = a row vector of income from employment coeffients, and

y_H = a scalar representing endogenous household income.

Given an exogenous increase in final demand, extra output results in increased employed income, via h_w, and increased household expenditure via h_c. The Type II model can be interpreted as a system of two simultaneous equations :

7. The 1 in the bottom right-hand quadrant means that intra-household transactions are ignored.

$$(I - A)y - h_c y_H = f, \tag{2.7}$$

$$y_H = h_w y. \tag{2.8}$$

Substituting Equation (2.8) into Equation (2.7) we obtain

$$(I - A)y - h_c h_w y = f, \tag{2.9}$$

which re-arranged gives the one-equation format of the Type II model :

$$y = Ay + h_c h_w y + f. \tag{2.10}$$

By manipulation

$$y = (I-A)^{-1} h_c h_w y + (I-A)^{-1} f, \tag{2.11}$$

so that

$$y = (I - (I-A)^{-1} h_c h_w)^{-1} (I-A)^{-1} f, \tag{2.12}$$

where

$$c_{T2} = (I - (I-A)^{-1} h_c h_w)^{-1}, \text{ and}$$

$$m_{T2} = (I - (I-A)^{-1} h_c h_w)^{-1} (I-A)^{-1}.$$

It follows that that m_{T2} is the Type II multiplier which consists of the original Type I multiplier $(I-A)^{-1}$ pre-multiplied by the new Type II component c_{T2}:

$$m_{T2} = c_{T2} m_{T1} \tag{2.13}$$

The component c_{T2} can be interpreted as a coefficient matrix showing the constant relationship between the Type I and Type II output multipliers. This multiplicative decomposition has been used by Round (1985) for the isolation of feedback effects in a multiregional input-output model; and is more straightforward than the more commonly used multiplier relationships specified by Bradley and Gander (1969) and Katz (1980). Both examine multiplier relationships for each industrial sector through the summation of columns in the Leontief inverse. Katz, in particular, uses this approach in order to derive the difference between the Type I and Type II output multipliers. The matrix decomposition shown in Equation (2.12) is more comprehensive because it covers all industrial sectors; and more simple because it does not rely on a complicated summation procedure.

An alternative procedure for decomposing multipliers is the 'four quadrant' method, which has been extensively employed by Batey (1985). By splitting up the extended block matrix associated with each input-output model (such as that contained in Equation 2.6) into four quadrants, relationships can be derived between the multipliers associated with each model. Batey investigated relationships between different types of employment and income multipliers but the decomposition could also be applied to output multipliers. The point to make here is that the 'four quadrant' method does not derive multiplier ratios directly; it is a method by which multipliers can be derived from the block matrix format of an extended input-output model. The derivation of multiplier ratios involves a second stage of analysis in which two multipliers, derived from separate block matrices, are compared. This method contrasts with the multiplicative decomposition in which each extension incorporated in a model falls out in the decomposition as a matrix of multiplier ratios. In comparison to the 'four quadrant' method, the multiplicative decomposition provides a much more simple and succinct procedure for deriving relationships between extended multipliers.

2.3.4. The Demographic-Economic Tradition

The Type II model can be interpreted as the "rudimentary form" of the so-called demographic-economic input-output model (see Batey 1985, p.75). Labour services sold by households to the industrial sector are interpreted as *demographic* commodities, whilst the industrial sectors which employ this labour for the production of goods and services are interpreted as *economic* activities. This demographic-economic interpretation of the Type II model has led to a series of extensions which are particularly relevant to the regional context. In the analysis that follows the demographic-economic tradition is reviewed with a view to extending the scope and consistency of the Type II model as an impact assessment framework.

The oldest "substantial study" to concentrate on the linkage between economic and demographic factors was conducted by Coale and Hoover (1958) (see Suits et al 1975, p. 92). This study concentrated on the relationship between economic development and the determinants of population growth - specifically, birth and death rates. A largely descriptive analysis examined trends in population and economic indicators, mainly for the Indian economy, but also for several other low-income countries. Subsequent to this study a wealth of literature has focused on the relationship between population growth and economic development. Notable examples include the work of Enke (1966), and Denton and Spencer (1973). A comprehensive review of this literature has been undertaken by Birdsall (1977).

Madden, Batey and Worrall (1981) have asserted that the work of Fullerton and Prescott (1975) provides a useful starting point for the development of the demographic-economic tradition in input-output analysis. Fullerton and Prescott recognized the potential offered by the input-output model for the specification of the linkage between demographic and industrial sectors. A cohort survival model was linked to an input-output model for the state of Iowa in the United States, with particular attention to the simulation of the water sector.

We can go back to 1960, however, for a classic example of demographic-economic modelling by Berman, Chintz and Hoover (1960). This was a technical report relating to a series of projects carried out for the New York Metropolitan Region. In the opening part of this report, Berman relates the demographic and economic traditions to the two great economists: Wassily Leontief and Thomas Malthus. From Leontief she takes the inter-industry analysis of the input-output model, and from Malthus a demographic approach. Malthus's argument, "that mouths appear as soon as the food to go into them appears", is applied by Berman, in a modern guise, to regional analysis. The linkage between a regional economy and its population works through the demand for labour; which may be met from natural growth of the existing population, from its increased participation in the labour force, or from in-migration. Whatever the outcome, changes in the demand for labour will affect the population mix of a regional economy.

The demand for labour, therefore, becomes the crucial link between economic and demographic systems. Schinnar (1976b) has used this linkage to fuse together the input-output model with the demographic accounts developed by Richard Stone. With respect to this linkage Schinnar writes,

> "The demographic-economic accounting linkage proposed here is specifically designed to deal with conditions under which the demand for labour generated via an input-output model is related to labour markets which can be described by cohort and activity characteristics."
>
> (see Schinnar 1976, p.46)

Ten years earlier, Stone (1966) had recognized that the input-output model could be applied to the modelling of demographic flows. A system of demographic accounts was constructed in which the inflows and outflows of a particular year were measured in terms of actual human flows. The inflows constituted people already living in a region, births, and immigrants. The outflows consisted of deaths, emigrants, and survivors into the next year. These inflows (inputs) and outflows (outputs) were represented in an input-output matrix.

The application of the input-output model to demographic accounting led to the development of the linkage between demographic and economic accounts. Stone (1973) developed a set of demographic-economic accounts which focused on the requirements of the education system. The accounts relating to demographic and economic flows were modelled using separate input-output formulations, but a vector of labour demand coefficients provided the linkage between the labour demand required in the demographic system and the gross outputs generated by the economic system.

The work of Schinnar (1976b) can be seen as both a theoretical and empirical elaboration of the groundwork provided by Richard Stone. In the analysis that follows, the 'Schinnar model' forms the basis for a series of extensions to the demographic-economic model. In the original formulation, Schinnar related employment to population using a matrix of labour participation rates. For the present analysis, however, there is no need to show algebraically how Schinnar related employment to the population mix. What is important is the relationship which Schinnar stipulated between final demand, output and employment. We therefore concentrate on the relationships between Schinnar's Equations (1), (6) and (7) (see Schinnar 1976b, pp.64-65).

Schinnar specified a direct proportional relationship between gross outputs and labour demand:

$$L = \hat{\ell}\, y , \qquad (2.14)$$

where

L = a vector of labour inputs (workers) required to sustain the level of activity stipulated by the economy,

$\hat{\ell}$ = a diagonal matrix of labour coefficients, and

y = a column vector of gross output.

The Leontief relationship, as derived in Equation (2.5), is substituted into Equation (2.14) so that

$$L = \hat{\ell}\, (I - A)^{-1} f. \qquad (2.15)$$

Final demand is then split up into government expenditure (f_g) and household consumption (f_h):

$$f = f_h + f_g. \tag{2.16}$$

Household consumption is derived from the following relationship:[8]

$$f_h = QL, \tag{2.17}$$

where

f_h = a column vector of household consumption associated with the economically stipulated level of employment, and

Q = a matrix of consumption coefficients in which q_{ij} denotes the rate of per capita consumption of the ith commodity by the jth demographic group.

By substituting equations (2.16) and (2.17) into Equation (2.15) we have

$$L = \hat{\ell}\,(I - A)^{-1}\,(f_g + QL), \tag{2.18}$$

so that

$$L = \hat{\ell}\,(I - A)^{-1}f_g + \hat{\ell}\,(I - A)^{-1}QL. \tag{2.19}$$

By manipulation

$$L = (I - \hat{\ell}\,(I - A)^{-1}Q)^{-1}\hat{\ell}(I - A)^{-1}f_g. \tag{2.20}$$

This expression shows the relationship between government expenditure and employment, and therefore contains the Schinnar employment multiplier. By simple manipulation we can derive the Schinnar output multiplier. From Equation (2.14) we know that

$$y = \hat{\ell}^{-1}L. \tag{2.21}$$

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8. In this formulation household consumption is related directly to employment, whereas in Schinnar's Equation (6) household consumption is related to population.

Therefore, pre-multiplying Equation (2.20) by $\hat{\ell}^{-1}$:

$$y = \hat{\ell}^{-1}(I - \hat{\ell}(I - A)^{-1}Q)^{-1}\hat{\ell}(I - A)^{-1}f_g, \tag{2.22}$$

By manipulation

$$y = (\hat{\ell} - \hat{\ell}(I - A)^{-1}Q\hat{\ell})^{-1}\hat{\ell}(I - A)^{-1}f_g, \tag{2.23}$$

so that

$$y = (\hat{\ell}^{-1}\hat{\ell} - \hat{\ell}^{-1}\ \hat{\ell}(I - A)^{-1}Q\hat{\ell})^{-1}(I - A)^{-1}f_g, \tag{2.24}$$

and

$$y = (I - (I - A)^{-1}Q\hat{\ell})^{-1}(I - A)^{-1}f_g. \tag{2.25}$$

The Schinnar output multiplier has the structure:

$$m_{TS} = (I - (I - A)^{-1}Q\hat{\ell})^{-1}(I - A)^{-1} \tag{2.26}$$

It can easily be proved that this multiplier is the same as the Type II output multiplier specified in Equation (2.12). Close inspection of the two multipliers reveals that the proof of this proposition rests on the identity between the components $Q\hat{\ell}$ and $h_c h_w$. This identity can be proven by comparing the rudimentary forms of these two components.

Firstly, the row vector of income from employment coefficients (h_w) consists of a row vector of wage rates (w) post-multiplied by a diagonal matrix of labour coefficients:

$$h_w = w\hat{\ell}, \tag{2.27}$$

so that

$$h_c h_w = h_c w\hat{\ell}. \tag{2.28}$$

Secondly, the matrix of consumption coefficients consists of the column vector of consumption propensities (h_c) post-multiplied by the vector of wage rates:

$$Q = h_c w. \tag{2.29}$$

Substituting Equation (2.29) into Equation (2.28) we obtain

$$h_c h_w \quad = \quad Q\hat{\ell}. \qquad (2.30)$$

This identity proves that Schinnar merely adopted a Type II input-output model in order to link together a set of demographic and economic accounts. This result apparently conflicts with the findings of Batey (1985) that the Type II and Schinnar models generate different multipliers. Batey derives a variable ratio between the Type II and Schinnar employment multipliers (see Batey 1985, p.86). However, the version of the Schinnar model which Batey examines is not the same as the model shown in Equation (2.25). This can be demonstrated by setting up the block matrix format of the Schinnar model. From Equation (2.25) we can derive the expression

$$(I - A)y - Q\hat{\ell}y \quad = \quad f, \qquad (2.31)$$

in which, for purposes of exposition, final demand (f) is included instead of government spending. This equation can be split up into two simultaneous equations:

$$(I - A)y - QE \quad = \quad f, \text{ and} \qquad (2.32)$$

$$E \quad = \quad \hat{\ell}y. \qquad (2.33)$$

In block matrix form the Schinnar model can therefore be represented as

$$\begin{bmatrix} (I - A) & -Q \\ -\hat{\ell} & I \end{bmatrix} \begin{bmatrix} y \\ E \end{bmatrix} = \begin{bmatrix} f \\ 0 \end{bmatrix} , \qquad (2.34)$$

where

E = a vector of labour demand by industrial sectors.

This model differs from the version of the Schinnar model derived by Batey (1985), in that employment is determined as a vector instead of as a scalar.[9] As a consequence, the consumption and labour coefficients are expressed as matrices instead of vectors. If employment is determined as a scalar then implicit in the formulation is an average wage rate which is needed to transform total employment into total employed income. In contrast, the income from employment coefficients (h_w) in the Type II model implicitly include a different wage rate for each sector. Therefore, Batey (1985) derived different employment multipliers for the Type II and Batey versions of the Schinnar model, because in the latter model an average wage rate was specifed and in the former different wage rates were specified for each sector. The detail in which wage rates are specified in a model is therefore crucial to the structure of the derived multipliers.

Although the original Schinnar model generates multipliers which are the same as the Type II multipliers, it enables the explicit consideration of both economic and

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9. The version of the Schinnar model derived by Batey (1985) has the following structure:

$$\begin{bmatrix} (I - A & -\beta_c \\ -\ell & 1 \end{bmatrix} \begin{bmatrix} y \\ e \end{bmatrix} = \begin{bmatrix} f \\ o \end{bmatrix} ,$$

where

β_c = a column vector of household consumption coefficients per employed worker,

ℓ = a row vector of labour coefficients per unit of output, and

e = a scalar representing employment.

demographic flows in an input-output formulation. In contrast to the Type II format, employment flows are shown explicitly in the Schinnar format - in the Type II format income is determined explicitly.

This explicit consideration of employment flows has led to the interpretation that the Schinnar version of the Type II model, and the suite of models to which it provides the antecedant, are part of a demographic-economic lineage. Stocks of employed workers are measured in demographic units, namely human beings, in contrast to the Type II formulation in which flows of income are measured in economic units (money). Of course industrial outputs are still measured in money units; hence the label 'demographic-economic'. A strict definition would categorize the Schinnar model as 'economic', in view of the identity between the Schinnar and Type II multipliers; the Type II model being an economic model in which the impacts of changes in final demand on industrial ouptuts are modelled via an income-expenditure loop. In the input-output literature, however, the Schinnar model, and more importantly the lineage of models which derive from it, have been defined as 'demographic-economic' due to the use of demographic units as a numeraire. Once stocks of employed workers are shown explicitly this enables the consideration of non economic population factors which feed into labour supply, such as births, deaths, fertility and migration.

The demographic format of the Type II model offers the potential for various extensions to the demographic-economic linkage. Gordon and Ledent (1979), for example, have undertaken three main extensions to the Type II model. They expand the Schinnar model to a multiregional system, endogenise household consumption propensities according to the income per head in each demographic group, and consider the concept of labour force participation explicitly. Some mention should also be made of the series of BACHUE models, which model economic and demographic linkages in developing countries (see Rodgers, et al 1978; and Moreland 1984). These are typically large scale models in which a demographic subsystem has been added to the main macroeconomic model. They can be characterised as essentially disequilibrium models in which there is a high degree of segmentation and disaggregation. In addition to the disaggregation of population by age and sex, people are categorized according to education, employment status, geographical location, marital status, and sometimes according to household status. Central to these models has been the modelling of feedback linkages between economic and demographic components.

Of equal importance has been the work of Batey and Madden (1981, 1983), which placed emphasis on the diaggregation of households into employed and unemployed residents.[10] With the high unemployment which has permeated the problem regions of advanced capitalist economies, the

10. The explicit consideration of unemployment in the disaggregation of the household sector derives partly from the work of Blackwell (1978)

consideration of the employment-unemployment mix is particularly relevant to regional policy; and as such forms the basis for the refinement and extension of the Type II input-output model.

The Type II model assumes, given an exogenous increase in final demand, that newly employed workers change from a position of zero income (during unemployment) to a position of full employed income once they enter employment. Another interpretation would be to consider all newly employed workers as in-migrants who received no previous income within the study region. Morrison (1973), for example, argues that the assumption that all new jobs are taken by in-migrants is reasonable for a new town such as Peterborough in the 1970's. Such an assumption does not apply, however, to the case of a depressed region in which there is a large pool of unemployed labour. For a depressed region, an increase in income can be seen as an increment of employed income over unemployment benefit. Such a depressed region, namely Merseyside in the North West of England, provides the focus for the work of Batey and Madden.

In their early work Madden and Batey (1980) consider the adoption of an iterative solution to the unemployment inconsistency in the Type II model. This iterative approach is based on the Type III input-output model which was developed by Miernyk et al (1967) for the rapidly growing economy of Boulder, Colorado. For the Type III model marginal increases in income for existing households generate lower consumer expenditure than absolute increases in income for in-migrant households. Miernyk et al set up an iterative framework by which income is distributed between in-migrant and already existing households in respect to a change in final demand. This method was employed by Madden and Batey (1980), with separate consumption functions adopted for employed and unemployed households.

A preferred version of the Batey-Madden model employs a simultaneous equation method (again, refer to Madden and Batey 1980; and Batey and Madden 1981). This model involves the disaggregation of households according to the employment status of the head of the household.

The most refined version of the model, however, disaggregates the workforce into employed and unemployed workers regardless of household characteristics (Batey and Madden 1983). In Appendix A the inconsistencies of the *household* disaggregation are demonstrated, in order to show the relative merits of a consumption framework which models *individual* expenditure.

The version of the Batey-Madden model which incorporates a personal (individual) consumption framework can be called the Type IV model, and has the following structure:[11]

11. The version of the Batey-Madden model shown here is only the same as the original Type IV model (see Batey and Madden 1983, p.317) if we assume an average wage rate across all sectors. Not until the next chapter, when the model is further extended, will this assumption be dropped.

$$\begin{bmatrix} (I - A) & -Q & -c \\ -\hat{\ell} & I & 0 \\ 0 & i^T & 1 \end{bmatrix} \begin{bmatrix} y \\ E \\ u \end{bmatrix} = \begin{bmatrix} f \\ 0 \\ x \end{bmatrix}, \qquad (2.35)$$

where

c = a column vector of consumption coefficients per unemployed worker,

u = a scalar representing the stock of unemployed workers,

x = a scalar representing total labour supply, and

i^T = a row vector of 1's.

This model can be interpreted as an extension involving the addition of an extra row and column to the Schinnar (Type II) model shown in Equation (2.34). The structure of the Type IV model in Equation (2.35) can be explained by showing the three simultaneous equations:

$$(I - A)y - QE - cu = f, \qquad (2.36)$$

$$E = \hat{\ell}y, \text{ and} \qquad (2.37)$$

$$u = x - i^T E. \qquad (2.38)$$

Equation (2.37) relates employment to output, which feeds into household consumption via the component QE in Equation (2.36). In Equation (2.38) unemployment is derived as a residual after subtracting the endogenously determined employment level from the exogenous stock of labour supply. This latter expression feeds into unemployed consumption in Equation (2.36) via the component cu. The Type IV model translates extra employment into induced employed consumption in the same way as the Type II model, but this coincides with a reduction in unemployed consumption.

A one-equation format of the Type IV model can be derived by substituting Equations (2.37) and (2.38) into Equation (2.36):

$$(I - A)y - Q\hat{\ell}y - c(x - i^T\hat{\ell}y) = f. \qquad (2.39)$$

The element $i^T\hat{\ell}$ is the same as a vector of labour coefficients ℓ, so that

$$y = Ay + Q\hat{\ell}y + c(x - \ell y) + f. \qquad (2.40)$$

Using this one-equation format, the Type IV output multiplier can be derived. For such a derivation the term cx, which represents the subsistence consumption of all workers, regardless of employment status, can be subsumed into final demand because it does not depend on output. By manipulation

$$y = (I - A)^{-1}Q\hat{\ell}y - (I - A)^{-1}c\ell y + (I - A)^{-1} f, \qquad (2.41)$$

so that

$$y = (I-(I-A)^{-1}Q\hat{\ell})^{-1}(I-A)^{-1}[-c\ell y+f] , \qquad (2.42)$$

and

$$y = (I+(I-(I-A)^{-1}Q\hat{\ell})^{-1}(I-A)^{-1}c\ell)^{-1} (I - (I-A)^{-1}Q\hat{\ell})^{-1}(I-A)^{-1}f. \qquad (2.43)$$

Therefore, the Type IV multiplier has the structure

$$m_{T4} = c_{T4}m_{T2}, \qquad (2.44)$$

where

$$c_{T4} = (I + (I - (I-A)^{-1}Q\hat{\ell})^{-1}(I-A)^{-1}c\ell)^{-1}.$$

The Type IV multiplier (m_{T4}) consists of the Type II multiplier (m_{T2}) pre-multiplied by the new Type IV component. This component (c_{T4}) measures the relationship between the Type II and Type IV output mutlipliers. This multiplicative decomposition conceptualises the impact of the Type IV component on the structure of the overall demographic-economic output multiplier.

In Chapter Three the one-equation format of the Type IV model is related to the structure of a social accounts matrix (SAM). Before developing this extension, however, we undertake a brief review of the tradition of social accounting.

2.4 THE SOCIAL ACCOUNTS MATRIX

In this section a review is presented of the well established tradition of social accounting. Hewings (1985) has argued that developments in social accounting are consistent with the demographic-economic analysis associated with Schinnar (1976) and Batey and Madden (1983). In particular, the incorporation of a household account in a social accounts matrix (SAM) is analogous to the addition of extra rows and columns to the input-output model. For the moment, before considering the relationship between the SAM and the demographic-economic model in the next chapter, the field of social accounting is reviewed as a separate tradition.

Hicks (1942) coined the phrase 'social accounting' in his preface to *The Social Framework*, in order to distinguish between the social accounting of the community and the private accounting of the individual. He claimed that social accounting would provide the groundwork for future work in both economic theory and descriptive economics. As a starting point, economic theory was considered too abstract, whilst descriptive economics could be just a dull collection of facts. Hicks had the insight to realise that a system of accounts offered the potential to fuse together both theory and practice in order to understand complicated economic relationships.

Paralleling the work of Hicks in the 1940's, was the construction of the first system of national accounts (SNA). In 1946 Richard Stone prepared a monograph to The League of Nations which, according to Carson, "stands as a landmark in the development of the economic accounting approach" (Carson 1975, p.178). Stone's work influenced the format of The United Nations SNA which was set up in 1952.[12] The SNA largely reflected work carried out in both the U.S. and Europe during the Second World War, although the work of Kusnets, in assembling data for the U.S. Department of Commerce during the 1930's, is central to this development.

The 1952 SNA contains six accounts: Domestic Product, National Income, Domestic Capital Formation, Households and Private Nonprofit Institutions, General Government, and a Rest of the World Account. All accounts are calculated according to the double-entry book-keeping principle, so that for any transaction there are two transactors, one who pays and the other who receives. A credit for one transactor is a debt for another - any transaction must appear in the account of both transactors.

Whilst the 1940's saw an acceleration of work on national income estimation, the 1950's saw the birth of regional science. An important component of this new area of regional analysis was the estimation of regional accounts. In 1958 the Committee of Regional Accounts was formed, and sponsored its first conference at Washington University in 1960. The collection of papers edited by Hochwald (1961), and the work of Hirsch (1962) were important to the evaluation of concepts and objectives. Isard (1960) published his *Methods in Regional Analysis* in which a whole chapter was devoted to 'Regional Income Estimation and Social Accounting'.

It was widely recognized that many of the tech-

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12. See United Nations Statistical Office (1953).

niques used for national accounts could be applied to the regional context. Isard (1960) had reservations about such an approach, but he regarded the double-entry book-keeping principle as a basic technique for the regional accounts format. Indeed, he even regarded the triple-entry system, which was used by Deane (1953) to compare the regions of North Rhodesia and Nyasaland, as "one answer" (Isard 1960, p.100).

It was Richard Stone, with his interest in the Leontief input-output tables, who recognized the advantages of a single-entry matrix. In his *Input-Output and National Accounts* Stone (1961a) showed how the income and product accounts could be co-ordinated with the input-output accounts; and in the same year he also published a paper entitled, 'Social Accounts at the Regional Level: A Survey', in which a schematic three-region social accounts matrix (SAM) was developed. This model can be examined in order to demonstrate the relationship between double-entry and single-entry accounts.

Take the example of a typical intra-regional building block (Table 2.2).

<u>TABLE 2.2</u> <u>The Single-Entry Intra-Regional Building Block</u>

	P	C	K
P	0	C_{jj}	V_{jj}
C	Y_{jj}	0	0
K	D_{jj}	S_{jj}	0

where

C_{jj} = production in region j allocated to consumption in region j,

V_{jj} = production in region j allocated to investment in region j,

Y_{jj} = income allocated to factors of production in region j,

D_{jj} = depreciation in region j,

S_{jj} = savings in region j ,

P = production,

C = consumption, and

K = capital.

Each row and column represents a separate account, with expenditure placed in the columns and receipts in the rows. This schematic SAM can be split up into a set of three double-entry accounts (Table 2.3).

TABLE 2.3 A Double-Entry Format for the Intra-Regional Building Block

Production Account		Consumption Account		Capital Account	
Expenditure	Receipts	Expenditure	Receipts	Expenditure	Receipts
Y_{jj}	C_{jj}	C_{jj}	Y_{jj}	V_{jj}	D_{jj}
D_{jj}	V_{jj}	S_{jj}			S_{jj}

Each item which appears in one account also appears on the opposite side of another account; hence the term double-entry accounting. For example, consumption payments (C_{jj}) are a receipt for the production account and an expenditure for the consumption account. The single-entry SAM is advantageous because each entry appears only once. The main advantage, however, is that all accounts are brought together into one clear and consistent framework instead of several tables. Stone (1961b) used the intra-regional building block, together with a collection of inter-regional building blocks to formulate a set of three-region accounts. This construction of intra and inter-regional building blocks in an SAM will be developed further in the next chapter.

Despite the considerable interest shown in the concepts of social accounting at the region level during the 1960's, the actual estimation of regional SAM's never really took off. Polenske (1980) points to the gap in the United States between the last conference set up by the Committee of Regional Accounts in 1964, and 1969 when Hirsch received funding for two more conferences. It was not until 1971 that Woodward tried to estimate a set of regional accounts for the United Kingdom. He attributed much of the lack of research during the 1960's to the non-availability of data, with his own work relying heavily on the breakdown of national figures.

The non-availability of data has formed the crux of the commentary by Richardson (1978) that the benefits derived from the construction of regional accounts are often outweighed by the time and effort required for implementation. He argued that except for Czamanski (1973), "no-one makes strong pleas for the construction of such accounts nowadays" (Richardson 1978, p.3). Richardson also considered that the estimation of information on regional stocks would be of more value to the regional scientist than flow estimates.

As a partial defence against Richardson's arguments, Polenske (1980) has maintained that requests for data have in fact continued to be made, but have not appeared in published form. In addition, Round(1986b) has argued that the estimation of regional stocks, as favoured by Richardson, is even more difficult to implement than the estimation of interregional flows.

In spite of the criticisms of social accounting at the regional level, the 1970's saw a mushrooming of applications of the SAM to the development of *Third World* economies. The work of Pyatt and Thorbecke (1976) exemplifies the sense of urgency which was generated for the need to construct economy-wide planning frameworks into which the SAM would form the core. In the forward to Pyatt and Thorbecke's book, Emmering argued that if status quo development policies were maintained then developing countries would not be able to feed their peoples within one generation. These so called development policies had resulted in exceptional rates of growth which had only benefited the few involved in the modern sector, and had not filtered down to the majority of the people. The solution to this problem, in his view, involved a radical redistribution of income and wealth so as to meet the basic needs of the poor.

The reference point for the application of social accounting techniques to developing economies has been the 1968 SNA.[13] Pyatt and Thorbecke (1976) welcomed this new version of the SNA, particularly for its use of a matrix format, but also for its contributions in terms of definitions and sources. The overall problem with this modern SNA, however, is the conceptual framework, which is pre-

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13. See United Nations Statistical Office (1968)

occupied with the objective of growth on an aggregate national scale. Questions of distribution between different income groups are not considered because they do not form the focus of interest for the conceptual framework.

Central to the application of a distribution based orientation to social accounting has been the input-output model. In national accounting frameworks, from which the SAM is derived, interindustry transactions are not included because only net flows are considered. In Stone's original SAM (Table 2.2) all diagonal entries appear as zeros. Such entries can be excluded without affecting the balancing of each account. If the interindustry flows of the input-output table were to be included in Stone's SAM, these entries would appear on the diagonal.

Pyatt and Roe (1977) provide a powerful argument for the inclusion of the input-output table in the SAM. The input-output model enables the monitoring of distributional objectives at a disaggregated level. Instead of estimating the size of aggregates, as with a national accounts framework, the relative size and interdependence of different sorts of production can be analysed. Pyatt and Roe have neatly demonstrated the relationship between the input-output table and the SAM.

The input-output table is first presented in its usual inverted 'L' format (Table 2.4).

TABLE 2.4 An Aggregated Input-Output System

	Production	Final Demand	TOTAL
Production	Interindustry Transactions	Consumption Investment	Gross Outputs
Factors of Production	Value Added		
TOTAL	Gross Outputs		

Reading column-wise, industrial sectors consume factors of production (value added), and intermediate products from other sectors. Along the rows, gross output consists of interindustry flows and final demand. These flows can be incorporated into a square SAM (Table 2.5).

In the SAM the interindustry flows are included on the diagonal; if they were omitted this would not upset the balance of the rows and columns. The classification of these accounts is a variation of the production, consumption and accumulation accounts used by Stone (1961b; see Table 2.2), except that there is a division between production and institutions accounts. The institutions accounts are disaggregated into a current account, reflecting the balance between factor payments against consumer expenditure and savings; and into a capital account which measures the funding of investment. A special account for factors of production is introduced in order to distribute value added to the institutions accounts. The inclusion of this account reflects the primacy given by Pyatt and Roe (1977) to distributional questions. Indeed, in another version of the schematic

TABLE 2.5 An Aggregated SAM Embracing Input-Output Transactions

			Production Accounts		Institutions Accounts	
			Production Activities 1	Factors of Production 2	Current 3	Capital 4
1	Production Accounts	Production Activities	Interindustry Transactions	0	Consumption Expenditure	Investment Expenditure
2		Factors of production	Value added	0	0	0
3	Institutions Accounts	Current	0	Factor Payments	Current Transfers	0
4		Capital	0	0	Savings	Capital Transfers

SAM the factors of production account is ordered at the top of the SAM in order to emphasise the importance of distribution in the SAM format (see Pyatt and Roe 1977, p.45).

Further disaggregations of the accounts in the SAM have been carried out by Chandler, Gnasegarah, Pyatt and Round (1980) for the Malaysian economy. In this SAM the factor accounts take a prominent position, but a new "wants" account is introduced in order to monitor the impacts of policy changes on the welfare of individuals. This "wants" account can be used, hypothetically, to measure imputed transfers of benefits from the public sector to households (see Chapter Six). For the Malaysian SAM, however, wants are only converted into commodities.

Another development in the Malaysian SAM is the disaggregation between commodities and activities, enabling the consideration of the structure of production in more detail. This follows standard SNA practice, with the rationale provided by Stone (1970), who argued that sales structures usually relate to commodities whilst cost structures relate to industries. The fact that some industries produce more than one commodity means that the two concepts need to be separated if sales and costs structures are to be explicitly considered.

The accounts which make up the SAM can be disaggregated and re-arranged depending on the purposes for which the data base is required. The SAM's developed for Third World economies have been used to monitor distributional objectives, and this has determined the disaggregation of the accounts. As Tyler and Roe (1977) have noted, however, the organisation of data in a SAM is not of itself a model; in the same way as national income estimates do not constitute Keynesian macroeconomics. The structure of a model depends on the mathematical relationships imposed on the data. The models derived for the Sri Lanka and Malaysian SAM's are characterised by *linear* relationships between endogenous and exogenous variables.

The specification of linear relationships is common to what Thorbecke (1985) has referred to as a first-generation of social accounts frameworks. Other such models include the early work of Pyatt et al (1972) for Iran; Thorbecke and Sengupta (1972) for Columbia; and Ng (1974) for the Philippines. The so called second-generation of computable general equilibrium models (see Section 2.2) involve the introduction of *non-linear* behavioural and technical relations.

Pyatt and Roe (1977) have asserted that there are obvious deficiencies with a fixed coefficient linear modelling approach, but that "we are still at the stage of trying to elicit information about directions of effect and broad orders of magnitude rather than aspire to any greater precision." (Pyatt and Roe (1977), p.68). The pursuit of greater precision would require a non-linear approach, which would in some cases involve the organisation of additional data to that which is contained in the SAM. Therefore, the use of an SAM in which linear assumptions are maintained provides a "first cut" to the estimation of orders of magnitude relating to various problems.

2.5. SUMMARY AND CONCLUSIONS

In this chapter we have selected the Leontief input-output model as the core component of an impact assessment framework. A comparison with the modelling approaches of economic base and econometrics has enabled the consideration of the limitations of the input-output method relative to other techniques. A focus on the main objectives of the study, however, has concluded that the economic base method is not applicable to the measurement of the impacts of government spending, whilst an econometric approach is more difficult to apply to the estimation of interregional trade flows.

The scope of the input-output model has been expanded by introducing household activity as an endogenous component of the multiplier framework. The review of literature relating to this component has focused on a lineage of multipliers from the Type I Leontief model, the Type II household endogenous model, the Schinnar demographic-economic model, through to the Batey-Madden Type IV model. Each matrix of output multipliers has been conceptualised using a one-equation format, and relationships between these multipliers have been derived using a new multiplicative decomposition. Compared with other methods of decomposition, this procedure provides a direct and succinct approach to the conceptualisation of multiplier relationships. The utility of this procedure has been demonstrated by the derivation of identical multipliers for the Type II and Schinnar formulations of the household endogenous model. This discovery has to some extent diminished the importance of the demographic-economic tradition, but this tradition has been reviewed in its own right, for the explicit consideration of demographic flows has been the impetus for a number of developments in extended input-output analysis. One such development is the incorporation of unemployed activity in the Batey-Madden Type IV input-output model. The personal consumption framework has been established as the best format for the specification of consumer expenditure in the Type IV model.

The field of social accounting has been reviewed as a separate but parallel tradition to demographic-economic input-output analysis. The single-entry social accounts matrix (SAM) has been presented as a refined version of the more cumbersome double-entry accounts. Particular emphasis has been placed on the development of social accounting techniques which derive from the focus in Third World economies towards distributional questions.

In the next chapter a precise linkage is formulated between the demographic-economic input-output model and the SAM. In addition, in order to further the development of linkages between intra-regional activities, an inter-regional extension shall be introduced.

CHAPTER THREE

THE CONSTRUCTION OF AN INTEGRATED IMPACT ASSESSMENT FRAMEWORK

3.1. INTRODUCTION

In this chapter we further extend the input-output model into an integrated impact assessment framework. The extensions employed involve the integration of economic activity, both within and between regions, and the integration of different traditions of economic analysis. These extensions build upon the structure of the Batey-Madden Type IV input-output model discussed in Section 2.3.

In Section 3.2 the further integration of economic activity is accomplished by considering investment as an endogenous variable. A dynamic extension is introduced in order to model the additional capacity requirements of firms in response to changes in final demand. In Section 3.3 this dynamic version of the Type IV model is expanded to include linkages between two regions. This two-region extension is conceptualised using a social accounts matrix. In contrast to the usual social accounting models, which use money units as the numeraire, in Section 3.4 labour time is introduced as the unit of measurement. All commodity flows are transformed into Marxian labour values, but this development is interpreted as a natural extension to the demographic-economic model. The final section outlines a number of conclusions.

3.2. A DYNAMIC EXTENSION TO THE TYPE IV MODEL

The models considered to date have been essentially static frameworks used to project short-term impacts of changes in final demand (see Chapter Two). According to assumption six (Section 2.3.2) firms are assumed to operate at below full capacity, so that output can respond to changes in final demand without firms increasing their capital stock. A more realistic scenario in the long-term would be for firms to increase their capacity requirements through the purchasing of investment goods. This would induce additional industrial impacts on other sectors in the economy; what Almon has referred to as "doubly indirect" impacts (Almon 1970, p.285).

The original formulation of investment effects in an input-output model was provided by Leontief (1953). Leontief derived his "dynamic" input-output model through the introduction of a capital coefficients matrix (B) in which the typical element (b_{ij}) shows the output of capital goods produced by industry i per unit of output in industry j over time period t. By introducing the capital coefficients matrix to the Leontief Type I model (see Equation 2.3) we obtain:

$$y^t = Ay^t + B(\Delta y) + f^t, \qquad (3.1)$$

where

Δy = a vector representing changes in output for each industry.

The demand for investment goods adjusts to the change in output over time according to the structure of the matrix B. In this original Leontief formulation time is continuous, but the model can be operationalised more easily using a discrete period analysis. Richardson (1972) has presented a two-period version of the dynamic model which has the following structure:

$$y^t = Ay^t + B(y^t - y^{t-1}) + f^t \qquad (3.2)$$

Investment responds according to the difference between required capacity in the period t and actual capacity in period t-1, assuming a direct correspondence between output and capacity. The assumption of excess capacity is relaxed, for if excess capacity existed firms would not need to increase investment in response to changes in final demand. Firms could merely increase output in the short-run by using up excess capacity. The relaxation of the excess capacity assumption means that firms respond to changes in final demand through the creation of additional capacity requirements over a long-term time profile.

The formulation in Equation (3.2) involves a *backward* integration procedure whereby investment responds to differences between past and current outputs. There are a number of difficulties associated with this formulation, including the possible singularity of the capital coefficients matrix, and the generation of negative inputs to investment. The latter problem is particularly pertinent if several time periods are considered. In order to avoid these problems a *forward* integration procedure is often used (see Leontief 1970). In the following application of the dynamic model, however, only two time periods are included, so that the backward looking integration can be safely adopted.

The backward integration procedure was used by

Miernyk et al (1970) for their analysis of the West Virginian economy, which is widely regarded as the most sophisticated regional application of the dynamic model (see Hewings 1985). We have shown that Miernyk et al also placed great emphasis on the importance of disaggregating household activities (see Section 2.3.4). In subsequent household extensions, however, particularly in the area of demographic-economic input-output analysis, the dynamic extension has been neglected.

Madden and Batey (1983) have provided some insight into how the Type IV model can be dynamized. They interpret the component By^{t-1} - the investment activity in the previous time period - as a known rather than an unknown entity. Through a manipulation of Equation (3.1) this component can be subtracted from final demand so that

$$(I - A - B)y^t = f^t - By^{t-1}, \qquad (3.3)$$

although obviously we assume that final demand is reduced by this component. We also assume that there is no depreciation of the capital stock - extra investment in period t is directed to the formation of expansion rather than replacement capital.

Madden and Batey (1983) observed that the Type IV input-output model, as shown in Equation (2.35), can be dynamized by replacing the matrix (I - A) by the (I - A - B) matrix. This extension can also be attached to the one-equation format of the Type IV model (see Equation 2.40) so that

$$y = Ay + Q\hat{\ell}y + c(x - \ell y) + By + f. \qquad (3.4)$$

This can be called the dynamic Type IV input-output model. A specific feature of this equation is the exclusion of time subscripts which are usually shown explicitly in dynamic models. For ease of exposition, the time subscripts are not shown here, although this should not obscure the long-term time profile associated with the response of investment to changes in output.

Using the one-equation format contained in Equation (3.4) we can derive the dynamic Type IV matrix of output multipliers. As with the derivation of the static Type IV multipliers, the exogenous component cx is subsumed into final demand, together with the component By^{t-1}. By manipulation

$$y = (I-A)^{-1}Q\hat{\ell}y + (I-A)^{-1}[-c\ell y + By + f], \tag{3.5}$$

so that

$$y = -(I - (I-A)^{-1}Q\hat{\ell})^{-1}(I-A)^{-1}c\ell y + (I - (I-A)^{-1}Q\hat{\ell})^{-1}(I-A)^{-1}[By + f], \tag{3.6}$$

and

$$y = (I + (I - (I-A)^{-1}Q\hat{\ell})^{-1}(I-A)^{-1}c\ell)^{-1} (I - (I-A)^{-1}Q\hat{\ell})^{-1}(I-A)^{-1}[By + f]. \tag{3.7}$$

In abbreviated form

$$y = c_{T4}c_{T2}m_{t1}[By + f]. \tag{3.8}$$

Therefore,

$$y = [I - c_{T4}c_{T2}m_{T1}B]^{-1}c_{T4}c_{T2}m_{T1}f.$$

The dynamic Type IV matrix of output multipliers has the structure:

$$m_{DT4} = c_{DT4} c_{T4} c_{T2} m_{T1}, \tag{3.9}$$

where

$$c_{DT4} = [I - c_{T4} c_{T2} m_{T1} B].$$

The component c_{DT4} shows the relationship between the dynamic Type IV multiplier and the Type IV multiplier. In the next section the dynamic component is incorporated as part of an interregional extension to the Type IV model.

3.3. A TWO-REGION EXTENSION

The intellectual case for the input-output model rests, according to Richardson (1972), very largely on its application as an operational general equilibrium system. It provides a large book-keeping system through which the interdependence of the economic system can be measured. Leontief asserted that

> "The idea of general interdependence existing among the various parts of the economic system has become by now the very foundation of economic analysis."
>
> (Leontief 1936, p.105)

According to Richardson (1972), however, it is this *general* characteristic of the input-output model which becomes difficult to maintain once new dimensions such as space and distance are introduced to the model. In particular, Richardson argues that the commonly used single region model involves a *partial* approach, in which the measurement of economic impacts is limited to one particular study region. The single region model is capable of modelling industrial interdependence within a particular region, but the interdependence between different economic regions is not considered.

A more general equilibrium approach involves the specification of an interregional input-output model in which two or more regions are considered. Interregional multipliers can be derived which model both the spill-over and feedback effects between regions in response to a change in final demand. A feedback effect can be defined as a leakage from a region that "ultimately feeds back upon itself" (Round 1979, p.145). For example, in a two-region model an increase in final demand in region k will induce extra output in region p (via exports from p to k) which will feedback to region k (via exports from k to p). The spill-over effects can be defined as the knock-on effects between regions, over and above the feedback effects previously defined.

There has been some controversy over the extent to which feedback effects are significant in an interregional economy. For example, Miller (1966) found, for a set of hypothetical tables, that the average error incurred from omitting feedback effects was one-half of one per cent. In contrast, Greytak (1970) found for a regionalized model of the U.S. economy, that the average error was 21.4 per cent. Richardson (1978) remarks that the evidence is inconclusive, but the degree of significance of feedback effects is obviously an important indicator with regards to the utility of an interregional approach.

The utility of an interregional approach often depends on the type of impact analysis for which the model is required. Both Richardson (1978) and more recently Miller and Blair (1985), have highlighted the viability of an interregional framework for calculating the effects on different regions of a change in national government spending. For example, the allocation of defence contracts to several different regions would induce an increase in output for each region, and an increase in trade between regions. An interregional input-output model would measure both the feedback and spill-over effects resulting from these exogenous injections. In this context the utility of the interregional approach does not depend purely on the significance of feedback effects, but also on the spill-over effects which one would expect to be much more significant.

In view of the suitability of the interregional framework to measuring the impacts of overall government spending, an interregional extension can be introduced to the demographic-economic model. The demographic-economic models considered to date have been concerned with the analysis of one spaceless economy (see Chapter Two and Section 3.2). Schinnar (1976b), for example, applied a version of the Type II model to the Hungarian economy, whilst the Batey-Madden Type IV model was applied to Merseyside, England. In the following analysis the demographic-economic model is extended to a two-region context using a model which has been proposed by Stone and Weale (1986).

The introduction of an interregional extension to the demographic-economic model is more easily implemented using a social accounts format. This is accomplished through the derivation of the Stone-Weale model from the Batey-Madden Type IV model.[1] The one-equation format of the Batey-Madden model is tailor made for the construction of a social accounts matrix (SAM). Each factor which depends on output can be allocated to a different account in the SAM.

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1. Oosterhaven (1981) has also constructed an interr-egional model in which a Type IV component is included, but we concentrate on the Stone-Weale model for its explicit incorporation of a social accounts matrix.

Stone and Weale (1986) set up a schematic SAM which is constructed from a set of inter and intra-regional building blocks (Table 3.1). In its rudimentary form this schematic SAM can be reduced to three basic accounts: production, consumption and accumulation. This disaggregation is basically the same as that used by Stone (1961b) for his schematic three-region SAM (see Table 2.2). The SAM shown below also includes a government account, which was contained in the original Stone-Weale version. Unlike the original Stone-Weale SAM, however, there is no role for either foreign aid or migration. This latter omission eliminates a major demographic component of the model, but due to the limitations of the present study a less elaborate version of the Stone-Weale model has been employed. The modelling of migration will provide a focus for future research.

TABLE 3.1 A Schematic Social Accounts Matrix

(all flows measured in money units)

RECEIPTS \ EXPENDITURES			REGION 1				REGION 2			
			1	2	3	4	1	2	3	4
REGION 1	PRODUCTION	1	T^{1}_{11}	T^{1}_{12}		T^{1}_{14}	T^{12}_{11}	T^{12}_{12}		T^{12}_{14}
	HOUSEHOLDS	2	T^{1}_{21}							
	GOVERNMENT	3		T^{1}_{32}						
	ACCUMULATION	4		T^{1}_{42}						
REGION 2	PRODUCTION	1	T^{21}_{11}	T^{21}_{12}		T^{21}_{14}	T^{2}_{11}	T^{2}_{12}		T^{2}_{14}
	HOUSEHOLDS	2					T^{2}_{21}			
	GOVERNMENT	3						T^{2}_{32}		
	ACCUMULATION	4						T^{2}_{42}		

On the diagonal blocks the entries T^k_{ij} show the receipts of the ith account resulting from expenditure by the jth account in region k. The off-diagonal blocks contain the entries T^{kp}_{ij} which show the receipts of the ith account in region k from expenditure by the jth account in region p. For example, the entry T^{12}_{11} represents the receipts of the production account in region 1 for inter-industry commodity flows directed towards the production account in region 2. The entries T^k_{21} show the payments of wages from the production account to the household account, whist T^k_{32} and T^k_{42} show flows of taxes and savings from the household accounts.

The original Stone-Weale equations, which represent the flows within and between the various accounts in the two-region SAM, can be derived directly from the one-equation format of the Type IV model (see Equation 2.40).[2] The principal difference for Stone and Weale is that employed and unemployed consumption propensities are defined as separate columns in the same matrix of consumption coefficients. Another difference for the Stone-Weale model is that income is modelled explicitly by including wage rates and the rate of unemployment benefit in the formulation. This latter feature can be introduced to the Type IV model through the specification of two vectors of consumption propensities, one relating to employed consumption (β) and the other relating to unemployed consumption (α). With the inclusion of a vector of wage rates (w)

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2. To recap, Equation (2.40) has the structure:

$$y = Ay + \hat{Q}\ell y + c(x - \ell y) + f.$$

and a scalar representing unemployment benefit (s), we obtain[3]

$$y = Ay + \beta w\hat{\ell}y + \alpha s(x - \ell y) + f. \qquad (3.10)$$

This formulation involves the relaxation of the previous assumption that a constant wage rate exists across all sectors (see Section 2.3). Wages are now allowed to vary between industrial sectors.

The Type IV formulation shown in Equation (3.10) forms the basis for the two-region Stone-Weale model. The extension to a two-region model involves the specification of two equations showing the interdependence of the economies of the two regions. In the analysis that follows the Stone-Weale model is based on the dynamic Type IV model (see Equation 3.4).[4] Apart from the introduction of capital coefficients, the two-region equations have the same basic Type IV structure as the original Stone-Weale model. The coefficients of the model are defined as follows:

A^1_{11} and A^2_{11} = matrices of domestic interindustry coefficients,

β^1 and β^2 = column vectors of domestic propensities to

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3. This equation has the same structure as Equation (2.40), apart from the expressions:

$$Q = \beta w, \text{ and}$$

$$c = \alpha s.$$

4. In the new notation, in which income is modelled explicitly, the one-equation format of the dynamic Type IV model has the structure:

$$y = Ay + \beta w\hat{\ell}y + \alpha s(x - \ell y) + By + f$$

consume out of employed income,

w_1^1 and w_1^2 = row vectors of wage rates per industrial sector,

$\hat{\ell}_{21}^1$ and $\hat{\ell}_{21}^2$ = diagonal matrices of industrial labour coefficients,

α^1 and α^2 = column vectors of domestic propensities to consume out of unemployed income,

s = a scalar representing the rate of unemployment benefit,

x_2^1 and x_2^2 = scalars representing the exogenous stocks of labour supply,

A_{14}^1 and A_{14}^2 = matrices of domestic capital consumption coefficients,

A_{11}^{12} and A_{11}^{21} = coefficient matrices of exports of intermediate goods per unit of the other region's output,

β^{12} and β^{21} = coefficient column vectors of exports of consumption goods per unit of the other region's employed income,

α^{12} and α^{21} = coefficient column vectors of exports of consumption goods per unit of the other region's unemployed income,

A_{14}^{12} and A_{14}^{21} = coefficient matrices of exports of capital goods per unit of the other region's output, and

f^1 and f^2 = column vectors of final demand for goods produced in each region.

For region 1 we obtain

$$y_1^1 = A_{11}^1 y_1^1 + \beta^1 w_1^1 \hat{\ell}_{21}^1 y_1^1 + \alpha^1 s(x_2^1 - \ell_{21}^1 y_1^1) + A_{14}^1 y_1^1 + A_{11}^{12} y_1^2 + \beta^{12} w_1^2 \hat{\ell}_{21}^2 y_1^2 + \alpha^{12} s(x_2^2 - \ell_{21}^2 y_1^2) + A_{14}^{12} y_1^2 + f^1. \tag{3.11}$$

This equation relates all the entries on the top row of the SAM to output in both regions. Note that unemployment is derived as a residual after subtracting employment ($\ell_{21}^k y_1^k$) from the exogenous stock of labour supply (x_2^k) - this is the Type IV effect. For region 2 we have

$$y_1^2 = A_{11}^2 y_1^2 + \beta^2 w_1^2 \hat{\ell}_{21}^2 y_1^2 + \alpha^2 s(x_2^2 - \ell_{21}^2 y_1^2) + A_{14}^2 y_1^2 + A_{11}^{21} y_1^1 + \beta^{21} w_1^1 \hat{\ell}_{21}^1 y_1^1 + \alpha^{21} s(x_2^1 - \ell_{21}^1 y_1^1) + A_{14}^{21} y_1^1 + f^2. \tag{3.12}$$

This equation accounts for the fifth row of the SAM, with region two's output directed to the various accounts. The coefficients in Equations (3.11) and (3.12) can be re-arranged in order to analyse the structure of the derived two-region multiplier. Re-arranging Equation (3.11) we obtain

$$y_1^1 = A_{11}^1 y_1^1 + A_{11}^{12} y_1^2 + E^{11} y_1^1 + E^{12} y_1^2 - F^{11} y_1^1 - F^{12} y_1^2 - A_{14}^1 y_1^1 + A_{14}^{12} y_1^2 + f^1, \tag{3.13}$$

where

$E^{11} = \beta^1 w_1^1 \hat{\ell}_{21}^1$,

$E^{12} = \beta^{12} w_1^2 \hat{\ell}_{21}^1$,

$F^{11} = \alpha^1 s \ell_{21}^1$, and

$F^{12} = \alpha^{12} s \ell_{21}^2$.

The terms $\alpha^k s x_2^k$ relate to the subsistence consumption of all workers out of unemployment benefit, and can be subsumed into exogenous final demand. Assuming an increase in final demand, the matrices E^{11} and E^{12} represent induced employed consumption with F^{11} and F^{12} showing induced unemployed consumption. Re-arranging Equation (3.12) yields

$$y_1^2 = A_{11}^2 y_1^2 + A_{11}^{21} y_1^1 + E^{22} y_1^2 + E^{21} y_1^1 - F^{22} y_1^2 - F^{21} y_1^1 + A_{14}^2 y_1^2 + A_{14}^{21} y_1^1 + f^2, \tag{3.14}$$

where

$$E^{22} = \beta^2 w_1^2 \hat{\ell}_{21}^2,$$

$$E^{21} = \beta^{21} w_1^1 \hat{\ell}_{21}^1,$$

$$F^{22} = \alpha^2 s \ell_{21}^2, \text{and}$$

$$F^{21} = \alpha^{21} s \ell_{21}^1.$$

Grouping Equations (3.13) and (3,14) together in a block matrix format we have

$$\begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} = \begin{bmatrix} A_{11}^1 & A_{11}^{12} \\ A_{11}^{21} & A_{11}^2 \end{bmatrix} \begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} + \begin{bmatrix} E^{11} & E^{12} \\ E^{21} & E^{22} \end{bmatrix} \begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} - \begin{bmatrix} F^{11} & F^{12} \\ F^{21} & F^{22} \end{bmatrix} \begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} + \begin{bmatrix} A_{14}^1 & A_{14}^{12} \\ A_{14}^{21} & A_{14}^2 \end{bmatrix} \begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} + \begin{bmatrix} f^1 \\ f^2 \end{bmatrix} . \tag{3.15}$$

In abbreviated form[5]

$$y = A_{11}y + Ey - Fy + A_{14}y + f. \qquad (3.16)$$

This equation is analogous to the one-region version of the dynamic Type IV model (see Equation 3.4). The decomposition used for the one-region model can be applied to the case of two regions. The two-region dynamic Type IV multiplier has the structure

$$M_{DT4} = C_{DT4}C_{T4}C_{T2}M_{T1}, \qquad (3.17)$$

where

$$M_{T1} = (I - A_{11})^{-1},$$

$$C_{T2} = (I - (I - A_{11})^{-1}E)^{-1},$$

$$C_{T4} = (I + C_{T2}M_{T1}F)^{-1}, \text{and}$$

$$C_{DT4} = (I - C_{T4}C_{T2}M_{T1}A_{14})^{-1}.$$

The matrix M_{T1} is the two-region Type I multiplier, C_{T2} is the two-region Type II component, C_{T4} is the two-region Type IV component, and C_{DT4} is the two-region dynamic Type IV component.

Apart from the component C_{DT4}, the multiplier in Equation (3.17) has the same structure as the original two-region multiplier derived by Stone and Weale. The introduction of capital coefficients can be interpreted as one of the 'next steps' suggested by Stone and Weale (1986) as possible developments of the model. A further extension to the model is outlined in the next section where a different numeraire is proposed as a unit of value.

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5. From now on y is a stacked vector of industrial gross outputs in two regions.

3.4. THE CHOICE OF NUMERAIRE

The social accounts matrix developed in the previous section involved the use of money as the unit of measurement. But, as Stone has argued, "there is, however, no reason why the application of accounting ideas should be restricted to concepts expressible in terms of money" (Stone 1966, p.365). In the field of demography the individual human being becomes the unit of measurement. Stone and Weale (1986) partly adopted such an approach for the empirical part of their analysis, in which they constructed two types of social accounts matrices. The first contained money based flows only, whereas the second showed both money and demographic flows in the same SAM. The demographic entries included flows from the household to the production accounts (employment) and flows between regions (migration). In this section we show how all the entries in the SAM can be transformed into demographic flows. Instead of actual flows of people *labour time* is the numeraire.

Commodity flows can be measured in units of labour time using the concepts of Marxian economics; in particular using Marx's labour theory of value. Since the 1970's there has been a revival of interest in Marxian economics. This can be partly explained by the breakdown of the post-war boom, which led economists to question the validity of mainstream economic theories (see Desai 1979). Under the full employment and steady economic growth of the fifties and sixties, economists placed great faith in the established neoclassical synthesis between Keynesian macroeconomic policy and Walrasian microeconomic theory. Using a collection of elaborate techniques and instruments, economists believed that they had finally come to understand the complexities of the economic system. The return of world recession and mass unemployment in the 1970's destroyed this confidence. Some economists began to look towards more radical schools of economic thought in an effort to explain this re-emergence of economic recession.

A feature of this revival in Marxian economics has been the application of Leontief's input-output model to the Marxian value system. According to Mandel (1984) this application originates from the famous von Bortkiewicz critique which was developed by Sweezy (1942) in *The Theory of Capitalist Development* (see Section 5.4). This book initiated a protracted discussion concerning the so-called transformation problem, which centred on the inconsistencies of the value schema developed by Marx (1894) in *Capital* Volume III. As part of this discussion, Winternitz (1948) and Seton (1957) generalized von Bortkiewicz's analysis of three departments (means of production, consumer goods, and luxury goods) to an n industry input-output formulation; and with the theoretical application of the input-output model by Sraffa (1960), the focus moved away from a technical discussion of the transformation problem, towards an attempt to show the irrelevance of the labour theory of value to economic analysis. These theoretical applications of the input-output model contrast with Leontief's emphasis on statistical and empirical analysis (see Leontief 1951). Morishima (1973), however, has shown that labour values can be calculated, as part of an empirical analysis, using an input-output formulation.

From Marx's *Capital* Morishima has derived two definitions of value. The first defines value as the human labour crystallized or embodied in a commodity; and the second defines value as the labour time socially necessary for a commodity's production. Morishima proves mathematically that both definitions of value provide the same result:

$$\Lambda = \Lambda A + L, \qquad (3.18)$$

where

Λ = a row vector representing the direct and indirect labour time required per unit of each sector's output,

A = a matrix of interindustry coefficients, and

L = a row vector of direct labour time coefficients.

The labour value of a commodity consists of the labour time directly employed in the production process (L) and the labour time embodied in the inputs of intermediate commodities required in the production process (ΛA). Rearranging Equation (3.18) yields

$$\Lambda(I - A) = L. \qquad (3.19)$$

Therefore,

$$\Lambda = L(I - A)^{-1}. \qquad (3,20)$$

The vector of labour values (Λ) is calculated by pre-multiplying the Leontief inverse by the direct labour time coefficients. The labour values derived in Morishima's value system were calculated per unit of physical output. In this formulation, however, we assume that labour values are calculated per unit of money output. This approach is necessary in order to relate labour values to the money flows shown in a standard input-output table.

Morishima argues, on the basis of Equation (3.20), that labour values are concrete phenomena observable in the real world. Furthermore,

> "It is clear from the second definition of value that values are no more than the employment mult-pliers discussed by Kahn and later by Keynes, which can be calculated from Leontief's input-output table,..."
>
> (Morishima 1973, p.18)

Indeed the structure of Equation (3.20) is analogous to the employment multipliers used by Miernyk to project employment by sector and occupation for the West Virginian economy in the U.S. (Miernyk et al 1970, p.91).

In recent years there have been a number of studies in which labour values have been empirically estimated. Wolff (1979) calculated labour values using the U.S. input-output tables for 1947, 1958, 1963, and 1967. This empirical work was used to test Marx's 'law of the tendency of the falling rate of profit.' Other recent studies have concentrated on the measurement of unequal exchange between spatial locations. Marelli (1983), for example, applied Morishima's value system to the estimation of surplus value transfers between the regions of Italy, whilst Webber and Foot (1984) estimated the degree of unequal exchange between Canada and The Philippines.

Morishima (1973) recognized that a number of assumptions need to be specified in order to operationalise a system of labour values in an input-output framework. These assumptions are particularly necessary in view of the post-Sraffian interpretation of the transformation problem; also referred to as the neo-Ricardian critique (see Samuelson 1971; Hodgson 1974). Not only has it been shown that the value rate of profit differs from the money rate of profit, and that total surplus value is not equal to total profit; it has also been proven that under certain conditions positive profits can be realised with a negative rate of surplus value (see Steedman 1975, 1977). At the present juncture, however, we are only concerned with the calculation of individual labour values for commodity outputs. Questions of surplus value and profits are not considered.

The main tenets of the neo-Ricardian critique of the labour theory of value have been the introduction of joint production and alternative manufacturing processes to the value determining equations. One form of joint production is the inclusion of fixed capital goods, which have been used up in the previous time period, as outputs of the production process in the current time period. Morishima (1973) demonstrated that the inclusion of fixed capital goods can produce the 'bizarre' result that for some commodities negative labour values are derived. Steedman (1977) also derived negative labour values for the case of pure joint production in which industries produce by-products other than fixed capital goods.

The inclusion of alternative manufacturing processes for each industry results in labour values which cannot serve as solid weights for aggregation. Morishima (1973) demonstrated that if the same types of commodity can be produced simultaneously by different processes, then these commodities can have different values. The inclusion of different processes can therefore violate the uniqueness of the value system.

In order to ensure the generation of non-negative and unique labour values it is therefore necessary to assume that there is no joint production in the economic system, and that only one production process is available to each industry. It is worth noting that these assumptions are not specific to the generation of labour values, but also apply to the standard Leontief input-output model. The assumption of no joint production has already been presented as one of the core input-output assumptions (see assumption 3, Section 2.3). This assumption precludes the possibility of both pure joint production and the production of fixed capital goods from the previous time period. In addition, the assumption that each industry uses only one production process is implicit in assumptions 2 and 4 in Section 2.3 which establish fixed input coefficients and no substitution between factors of production. These fixed input coefficients relate to one production process for each industry, in which proportions of factors of production required per unit of output are constant.

The limitations associated with a labour value analysis are therefore closely related to those associated with the Leontief input-output model. The conceptualisation of the labour value system in input-output terms, to some extent protects the labour value analysis from the neo-Ricardian critique. The adoption of the input-ouput method does not provide a theoretical defence against this critique, but it does provide a practical application of the labour value system using certain well established assumptions.

The application of a labour value analysis to a two-region input-output model requires the specification of two simultaneous labour value equations:

$$\Lambda^1 = \Lambda^1 A^1_{11} + \Lambda^2 A^{21}_{11} + \Lambda^1 A^{61}_{11} + \Lambda^1 A^{71}_{11} + \Lambda^1 A^1_{14} + \Lambda^2 A^{21}_{14} + \Lambda^1 A^{61}_{14} + \Lambda^1 A^{71}_{14} + L^1, \text{and} \tag{3.21}$$

$$\Lambda^2 = \Lambda^2 A^2_{11} + \Lambda^1 A^{12}_{11} + \Lambda^2 A^{62}_{11} + \Lambda^2 A^{72}_{11} + \Lambda^2 A^2_{14} + \Lambda^1 A^{12}_{14} + \Lambda^2 A^{62}_{14} + \Lambda^2 A^{72}_{14} + L^2, \tag{3.22}$$

where

Λ^1 and Λ^2 = row vectors representing labour values for each region,

L^1 and L^2 = row vectors of direct labour time coefficients,

A^{61}_{11} and A^{62}_{11} = coefficient matrices of imports of intermediate goods from region 6 (the rest of the U.K.),

A^{71}_{11} and A^{72}_{11} = coefficient matrices of imports of intermediate goods from region 7(the rest of the world),

A_{14}^{61} and A_{14}^{62} = coefficient matrices of imports of capital goods from region 6 (the rest of the U.K.),

A_{14}^{71} and A_{14}^{72} = coefficient matrices of imports of capital goods from region 7 (the rest of the world).

These coefficients relate to flows of capital (A_{14}) and intermediate goods (A_{11}) between regions 1 and 2, and from region 6 (the rest of the U.K.) and region 7 (the rest of the world). The estimation of labour values for imports from outside the two-region economy is not practicable. In this formulation we assume that all imports from the rest of the U.K. and the rest of the world have the same values as the equivalent goods produced in the region of consumption. Another limiting assumption is that all the value embodied in capital goods is immediately transferred to the value of commodity outputs. This is clearly unrealistic because capital goods will transfer their value over a period of years, depending on the life of the capital good. However, Webber and Foot (1984) have noted that this error is balanced by the omission of fixed capital formation in previous years.

The solution to Equations (3.21) and (3.22) first requires the derivation of an expression for labour values in region 2. From Equation (3.22) we have

$$\Lambda^2[I - A_{11}^2 - A_{11}^{62} - A_{11}^{72} - A_{14}^2 - A_{14}^{62} - A_{14}^{72}] = \Lambda^1 A_{11}^{12} + \Lambda^1 A_{14}^{12} + L^2. \quad (3.23)$$

Let

$$N^2 = [I - A_{11}^2 - A_{11}^{62} - A_{11}^{72} - A_{14}^2 - A_{14}^{62} - A_{14}^{72}],$$

so that

$$\Lambda^2 N^2 = \Lambda^1 A_{11}^{12} + \Lambda^1 A_{14}^{12} + L^2. \tag{3.24}$$

Therefore,

$$\Lambda^2 = \Lambda^1 [A_{11}^{12} + A_{14}^{12}](N^2)^{-1} + L^2 (N^2)^{-1}. \tag{3.25}$$

Substituting this expression for region 2's labour values into Equation (3.21) we obtain

$$\begin{aligned} \Lambda^1 = {} & \Lambda^1 A_{11}^{1} + \Lambda^1 [A_{11}^{12} + A_{14}^{12}](N^2)^{-1}[A_{11}^{21} + A_{14}^{21}] \\ & + \Lambda^1 A_{11}^{61} + \Lambda^1 A_{11}^{71} + \Lambda^1 A_{14}^{1} + \Lambda^1 A_{14}^{61} \\ & + \Lambda^1 A_{14}^{71} + L^1 + L^2 (N^2)^{-1}[A_{11}^{21} + A_{14}^{21}]. \end{aligned} \tag{3.26}$$

Let

$$\begin{aligned} N^1 = {} & [I - A_{11}^{1} - (A_{11}^{12} + A_{14}^{12})(N^2)^{-1}(A_{11}^{21} + A_{14}^{21}) \\ & - A_{11}^{61} - A_{11}^{71} - A_{14}^{1} - A_{14}^{61} - A_{14}^{71}), \end{aligned}$$

so that

$$\Lambda^1 N^1 = L^1 + L^2 (N^2)^{-1}(A_{11}^{21} + A_{14}^{21}). \tag{3.27}$$

Therefore, the vector of labour values for region 1 has the structure

$$\Lambda^1 = (L^1 + L^2 (N^2)^{-1}(A_{11}^{21} + A_{14}^{21}))(N^1)^{-1}, \tag{3.28}$$

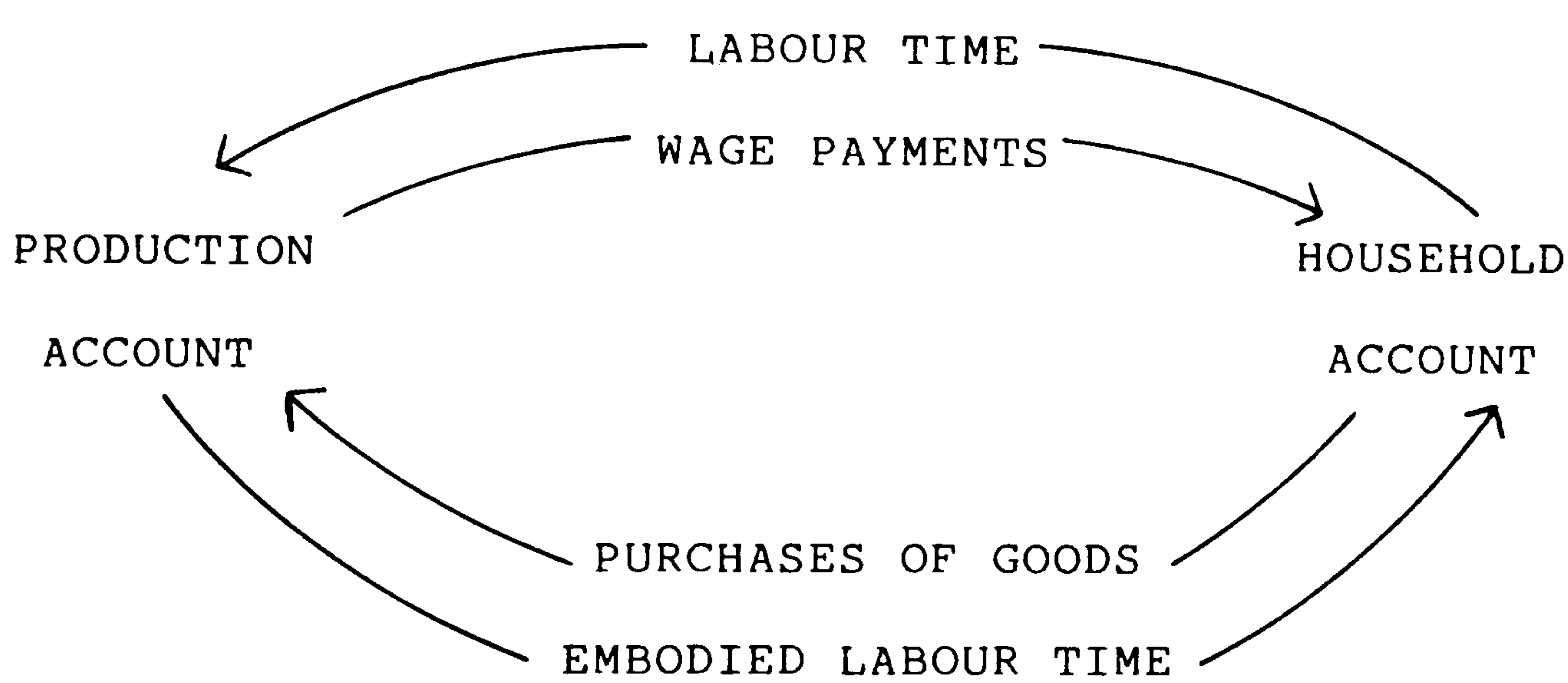
and for region 2

$$\Lambda^2 = [L^2 + (L^1 + L^2 (N^2)^{-1}(A_{11}^{21} + A_{14}^{21}))(N^1)^{-1}(A_{11}^{12} + A_{14}^{12})](N^2)^{-1}. \tag{3.29}$$

These labour value equationscan be used to transform completely the structure of the two-region SAM.

The schematic SAM which was developed in relation to the Stone-Weale model, considered the money flows between various accounts (Table 3.1). For example, the production account purchased labour services from the household account (T_{21}) and the household account purchased goods and services from the production account (T_{12}). Short and Nicholas (1981) have noted that often these entries do not represent actual money flows, but merely provide measures of the real flows of labour, goods and services in money terms. A circular flow diagram illustrates the argument (Figure 3.1).

FIGURE 3.1. Labour Time As A Contra Flow To Money Flows



In the money-based SAM wage payments provide a measure for the flows of labour time, whilst purchases of consumer goods measure the real flow of direct and indirect labour time received by the household account. The real flow of value in the economy provides a contra flow to the units of money used to measure it. This contra flow of labour time, if explicitly modelled, reveals a surplus which marks the difference between the direct labour time contributed by households and the embodied labour time received in the form of consumer goods. As Marx puts it, "The transaction is veiled by the commodity form of the product and the money-form of the commodity" (Marx 1867, p.713). The use of labour time as the numeraire provides an opportunity to model explicitly the relationships of unequal exchange, which are inherent in a capitalist economy, and yet can be obscured by the use of the money unit as a proxy measure for the real flows of labour, goods and services.

The transformation of the SAM, using labour time as the numeraire, involves a number of modifications (see Table 3.2). All commodity flows are transformed into labour values using diagonal matrices derived from the vectors in Equations (3.28) and (3.29), whilst wage payments are replaced by flows of direct labour time from the household to the production accounts. A natural extension of the Marxian approach would be to disaggregate the household sector into workers and capitalists. Such a formulation would involve the derivation of a Kalecki type multiplier through which non-wage income from profits is rechanneled into the economy via capitalist consumption. The Kalecki type multiplier has been discussed in the input-output literature (see Miyazawa 1976 ; Batey and Madden 1981), but has not been estimated in a regional context due to the empirical and conceptual problems associated with such a household disaggregation. In view of these difficulties, in Table 3.2 the household sector is not disaggregated into social classes, although this obviously involves the treatment of profits as a leakage from the system - we assume that all profits are saved.

TABLE 3.2 A Schematic Social Accounts Matrix

(all flows measured in labour time)

OUTFLOWS \ INFLOWS		Region 1: 1	Region 1: 2	Region 1: 3	Region 1: 4	Region 2: 1	Region 2: 2	Region 2: 3	Region 2: 4
REGION 1	PRODUCTION 1	V^1_{11}	V^1_{12}		V^1_{14}	V^{12}_{11}	V^{12}_{12}		V^{12}_{14}
	HOUSEHOLDS 2	D^1_{21}							
	GOVERNMENT 3								
	ACCUMULATION 4								
REGION 2	PRODUCTION 1	V^{21}_{11}	V^{21}_{12}		V^{21}_{14}	V^2_{11}	V^2_{12}		V^2_{14}
	HOUSEHOLDS 2					D^2_{21}			
	GOVERNMENT 3								
	ACCUMULATION 4								

The entries in this SAM provide a contra flow to those shown in Table 3.1 (the money-based SAM). On the diagonal blocks the elements V^k_{ij} denote the flow of direct and indirect labour time from account i to account j in region k. The off-diagonal blocks contain the entries V^{kp}_{ij} which show the flows of embodied labour time from account i in region k to account j in region p. The elements D^k_{ij} show the flows of direct employed labour time - these flows are proportional to the number of workers employed. Note that savings and taxes, which appeared in the money-based SAM, are no longer included because they do not constitute actual physical flows. Note also that the accounts in the Marxian SAM do not balance due to the inherent unequal exchange in a capitalist economy. In region 1's household account, for example, workers contribute D^1_{21} hours of labour time but receive only $(V^1_{12} + V^{21}_{12})$ in return. Assuming a positive rate of exploitation, workers receive less than they contribute, so the household account will not balance.

Although the adoption of labour time as the numeraire is theoretically straightforward, there are a number of empirical difficulties which limit the application of the Marxian SAM. These difficulties apply particularly to the measurement of the impacts of government spending on the social distribution of labour time. In Chapter Six the structure of the Marxian SAM is developed further, and related to the constraints imposed by the availability of data.

3.5. SUMMARY AND CONCLUSIONS

The impact assessment framework constructed in this chapter incorporates a number of extensions which build upon the one-region Batey-Madden Type IV model. Linkages between regional activities are further expanded through the development of a dynamic extension to the model. This involves the incorporation of capital coefficients in the one-equation format of The Type IV production multiplier. A backward looking integration procedure is adopted for modelling the response of investment activity to changes in industrial output. Although the dynamic extension involves the introduction of a long-term time dimension, the capital coefficient matrices are presented without time subscripts.

In order to expand the scope of the one-region model from a partial to a more general equilibrium approach, a set of interrelationships have been specified between two separate economic regions. This two-region extension has been conceptualised using a model formulated by Stone and Weale (1986). A direct mathematical relationship has been identified between this Stone-Weale model and the one-equation format of the Batey-Madden Type IV model. With the introduction of the dynamic extension to the Stone-Weale model, a two-region dynamic Type IV multiplier framework is constructed. The linkages between industrial, household, and investment activities are conceptualised both within and between the two economic regions.

The adaptation of the Stone-Weale model involves the conceptualisation of linkages between regional activities in a social accounts matrix (SAM). Each account in the SAM displays the expenditures and receipts relating to a particular form of activity. The inclusion of extra accounts in the SAM is analogous to the addition of extra rows and columns in the block matrix format of the extended input-output model. The derivation of the Stone-Weale model from the Batey-Madden model involves a fusion between the traditions of social accounting and demographic-economic input-output analysis.

A natural extension to the demographic-economic model is the introduction of labour time as the numeraire. Using Morishima's (1973) interpretation of Marx's labour theory of value, all flows in the two-region SAM can be measured in units of labour time. A system of two-region labour value equations is developed, with the limiting constraint that the labour embodied in commodities imported from outside the two-region economy cannot be calculated. By measuring the flows of direct and indirect labour time in the SAM, the labour value analysis offers the potential to reveal the degree of unequal exchange between different sectors of the economy, which is otherwise obscured by the money-based SAM. The structural relationships between accounts in the SAM are modified by the labour value extension, but the accounts retain their separate identities. Although the impetus for the labour value analysis derives from a Marxian tradition, the accounts of the SAM are not disaggregated according to the activities of different social classes. Such a disaggregation would entail severe conceptual and empirical problems, and should provide the focus for future research.

We have therefore developed a conceptual two-region dynamic Type IV multiplier framework which relates to a SAM in which all flows are measured in units of labour time. In the next chapter we operationalise this model for the regions of Strathclyde and the rest of Scotland.

CHAPTER FOUR

THE DERIVATION OF DATA FOR STRATHCLYDE AND THE REST OF SCOTLAND

4.1. INTRODUCTION

The operationalisation of the two-region impact assessment framework requires the collection of data from a number of sources. The core requirement of the model is a set of bi-regional interindustry tables. Although numerous examples of small area input-output tables exist worldwide, it was decided, due to the familiarity of data sources, that the model would be most easily applied within the confines of the U.K. economy.

A fairly comprehensive review of the various urban and regional input-output tables constructed for the U.K., has been undertaken by Morrison (1979). Only four of these studies were identified to include an explicitly interregional dimension, two of which model the regions of Wales and the rest of the U.K. (Nevin, Roe and Round 1966; Ireson and Tomkins 1978), whilst Gordon (1974, 1977) derived interregional flows for eleven U.K. regions. The fourth study of note is the set of Scottish tables for 1973 which contains estimates of trade flows between Scotland and the rest of the U.K. (Fraser of Allander Institute et al 1978).

Bi-regional tables are therefore available for Scotland and the rest of the U.K.; and for Wales and the rest of the U.K. The main disadvantage or these models is the incompatibility of the regions in terms of size. In

1973 Scotland produced 8.7% of the U.K.'s gross domestic product at factor prices, whilst Wales produced only 4.3% (Regional Statistics 1980). For the purposes of measuring the impacts of government spending in *both* regions, impacts on output and employment would be much smaller in Scotland, for example, when compared with the U.K. The smaller region would be saturated with imports due to the economic dominance of the larger region.

A more illuminating analysis of the interdependence between regions would involve the construction of an input-output model for regions of similar population size, and equivalent activity levels of output and employment. In this case the trade relationships which are specific to the two-region economy, would derive from the comparative industrial structures of the two regions, and not from the overall relative size of each economy. For the purposes of an impact analysis, an equal injection of government spending for each region would be plausible both in terms of the relative requirements of each region for government services, and the relative impacts of the proposed injection on output and employment in each region. An impact analysis for regions of comparable size would be more straightforward in terms of the simulation of equal injections of public expenditure.

In view of the attractions associated with a study area in which both regions are of comparable size, a bi-regional input-output model has been derived for Strathclyde and the rest of Scotland. The model has been derived for 1973 from the Scottish input-output tables (Fraser of Allander Institute 1978), and from the Strathclyde input-output tables.[1] The economies of Strathclyde and the rest of Scotland are very similar in terms of population size - Strathclyde has a population of 2,534,900 compared to 2,676,800 for the rest of Scotland (Scottish Abstract of Statistics 1974). The total number of people employed in Strathclyde is 1,024,792 compared to 1.039,562 for the rest of Scotland, whilst Strathclyde's total industrial output is £4,950.4 million compared to £4979.19 million for the rest of Scotland.

The derivation of a full bi-regional model for Strathclyde and the rest of Scotland requires the application of a selection of established input-output techniques. Section 4.2 outlines a series of manipulations for the derivation of interindustry flows within and between the two regions. In Section 4.3 consumption propensities are derived for employed workers (the Type II extension) and for unemployed workers (the Type IV extension). Section 4.4 outlines the derivation of capital coefficients matrices, which provide the required information for an investment extension to the Type IV model. In Section 4.5 a number of supplementary data requirements of the model are accounted for; including wage rates by sector, employment and labour time by sector, and the rate of unemployment benefit. The final section provides a brief assessment of the various techniques required for the derivation of data.

4.2. THE DERIVATION OF BI-REGIONAL INTERINDUSTRY FLOWS

4.2.1. The Aggregation Of The Scottish And Strathclyde Input-Output Tables

A manipulation of the Scottish and Strathclyde input-output tables requires that the industrial classification schemes be compatible with each other. The Scottish input-output tables (1973) comprise 76 industrial sectors (Table 4.1), whilst there are 63 sectors in the Strathclyde input-output tables (1973, Table 4.2). At the outset, therefore, both tables need to be aggregated to the same number of sectors.

An aggregation to 19 industrial sectors was considered appropriate in terms of computer space, and the need to supplement the basic transactions information with other data such as household consumption and employment (see Tables 4.3 and 4.4). This aggregation scheme is partly based on the 30 sector model derived for Scotland by Henderson (1980). Sectors which are obviously responsive to household expenditure, such as Food and Drink/Tobacco, remain separate in order to conform with the categories used in the Family Expenditure Survey.

A problem with this simple aggregation scheme is the occurrence of aggregation bias (see Malinvaud 1956; Theil 1957). If the components of the unaggregated model $y = (I - A)^{-1}f$ (see Equation 2.5) are aggregated from n to k sectors, then the aggregated k sector model generates a vector of gross outputs $y^* = (I - A^*)^{-1}f^*$. By applying an aggregation matrix (S) to the n sector vector of gross

TABLE 4.1 Industrial Classification For The Scottish Input-Output Table

SECTOR	SECTOR NUMBER
AGRICULTURE	1
FORESTRY	2
FISHING	3
COAL MINING	4
OTHER MINING & QUARRYING	5
OIL AND GAS EXPLORATION	6
BAKERY PRODUCTS	7
MEAT & FISH PRODUCTS	8
SUGAR & CONFECTIONARY	9
OTHER FOOD PRODUCTS	10
BREWING & SOFT DRINKS	11
WHISKY & OTHER SPIRITS	12
TOBACCO PRODUCTS	13
OIL PRODUCTS & GENERAL CHEMICALS	14
PHARMACEUTICAL PRODUCTS	15
PAINT & OTHER CHEMICALS	16
FERTILIZERS	17
IRON, STEEL AND ALUMINIUM	18
OTHER NON-FERROUS METALS	19
AGRICULTURAL MACHINERY	20
MACHINE TOOLS	21
INDUSTRIAL ENGINES	22
CONSTRUCTION EQUIPMENT	23
OFFICE EQUIPMENT	24
INDUSTRIAL PLANT & STEELWORK	25
OTHER MECHANICAL ENGINEERING	26
INSTRUMENT ENGINEERING	27
ELECTRICAL MACHINERY	28
COMMUNICATIONS EQUIPMENT	29
COMPUTERS & ELECTRONICS	30
DOMESTIC ELECTRICAL APPLIANCES	31
OTHER ELECTRICAL GOODS	32
SHIPBULDING/MARINEENG	33
VEHICLES	34
AEROSPACE EQUIPMENT	35
WIRE PRODUCTS	36
CANS AND METAL BOXES	37
OTHER METAL GOODS	38
MAN-MADE FIBRES	39
SPINNING & WEAVING	40
WOOLLEN & WORSTED	41
HOSIERY & KNITTED GOODS	42
CARPETS	43
OTHER TEXTILES	44
LEATHER	45
CLOTHING	46
FOOTWEAR	47
BRICKS	48
OTHER BUILDING MATERIALS	49
GLASS	50
TIMBER PRODUCTS	51

FURNITURE & FITTINGS	52
PAPER & BOARD	53
PACKAGING PRODUCTS	54
STATIONARY & OTHER PAPER	55
PRINTING & PUBLISHING	56
RUBBER PRODUCTS	57
PLASTIC PRODUCTS	58
OTHER MANUFACTURING	59
CONSTRUCTION	60
GAS	61
ELECTRICITY	62
WATER	63
RAILWAYS	64
ROAD TRANSPORT	65
SEA TRANSPORT & PORTS	66
AIR TRANSPORT	67
COMMUNICATIONS	68
DISTRIBUTION & MOTOR TRADES	69
FINANCIAL SERVICES	70
OTHER BUSINESS SERVICES	71
EDUCATION	72
HEALTH SERVICES	73
HOTELS & CATERING	74
OTHER SERVICES	75
OWNERSHIP OF DWELLINGS	76

TABLE 4.2 Industrial Classification For The Strathclyde Input-Output Table

SECTOR	SECTOR NUMBER
AGRICULTURE	1
WOOL	2
FORESTRY	3
FISHING	4
MINING/QUARRYING	5
BREAD AND BUSCUITS	6
MEAT & FISH PRODUCTS	7
HIDES	8
SUGAR & CONFECTIONARY	9
GRAINMILLING & OTHER FOODS	10
BREWING & SOFT DRINKS	11
WHISKY & TOBACCO	12
OIL REFINING & OTHER CHEMICALS	13
ALL OTHER CHEMICALS	14
IRON, STEEL, ALUMINIUM	15
OTHER NON-FERROUS METALS	16
MACHINE TOOLS	17
INDUSTRIAL ENGINES	18
CONSTRUCTION EQUIPMENT	19
INDUSTRIAL PLANT & STEELWORK	20
OTHER MECHANICAL ENGINEERING	21
INSTRUMENT ENGINEERING	22
ELECTRICAL MACHINERY & COMMUNICATIONS EQUIPMENT	23
COMPUTERS & ELECTRONICS	24
DOMESTIC ELECTRIC APPLIANCES	25
OTHER ELECTRICAL GOODS	26
SHIPBUILDING & MACHINE ENGINEERING	27
VEHICLES	28
AEROSPACE EQUIPMENT	29
OTHER METAL GOODS	30
SPINNING & WEAVING	31
WOOLLEN & WEAVING	32
HOSIERY & KNITTED GOODS	33
OTHER TEXTILES	34
LEATHER & FOOTWEAR	35
CLOTHING	36
BRICKS	37
OTHER BUILDING MATERIAL	38
GLASS	39
TIMBER PRODUCTS	40
FURNITURE & FITTINGS	41
PAPER & BOARD	42
PACKAGING PRODUCTS	43
STATIONARY & OTHER PAPER	44
PRINTING & PUBLISHING	45
PLASTIC & RUBBER PRODUCTS	46
OTHER MANUFACTURING	47
CONSTRUCTION	48
GAS	49

ELECTRICITY	50
WATER	51
ROAD TRANSPORT	52
SEA TRANSPORT & PORTS	53
AIR & RAIL TRANSPORT	54
COMMUNICATION	55
DISTIBUTIVE TRADES	56
FINANCE SERVICES	57
BUSINESS SERVICES	58
EDUCATION	59
MEDICAL SERVICES	60
HOTELS & CATERING	61
OTHER SERVICES	62
OWNERSHIP OF DWELLINGS	63

TABLE 4.3 An Aggregation Scheme For The Scottish Input-Output Tables

AGGREGATED SECTORS	ORIGINAL SECTORS
1 AGRICULTURE/FORESTRY/FISHING	1 + 2 + 3
2 MINING	4 + 5 + 6
3 FOOD	7 + 8 + 9 + 10
4 DRINK/TOBACCO	11 + 12 + 13
5 OIL/CHEMICALS	14 + 15 + 16 + 17
6 METAL MANUFACTURE	18 + 19
7 ENGINEERING	20 - 32
8 SHIPBUILDING	33
9 VEHICLES	34 + 35
10 METAL GOODS	36 + 37 + 38
11 TEXTILES	39 - 44
12 LEATHER/CLOTHING	45 + 46 + 47
13 TIMBER/BUILDING MATERIALS	48 + 49 + 50 + 51 + 52
14 OTHER MANUFACTURE	53 - 59
15 CONSTRUCTION	60
16 PUBLIC UTILITIES	61 + 62 + 63
17 TRANSPORT/COMMUNICATIONS	64 + 65 + 66 + 67 + 68
18 OTHER SERVICES	69 + 70 + 71 + 74 + 75
19 OWNERSHIP OF DWELLINGS	76

N.B. Education (sector 72) and Medical services (sector 73) have been taken out of the interindustry tables, and shall be used as final demand sectors in the ensuing impact analysis.

TABLE 4.4 An Aggregation Scheme For The Strathclyde Input-Output Tables

AGGREGATED SECTORS	ORIGINAL SECTORS
1 AGRICULTURE/FORESTRY/FISHING	1 + 2 + 3 + 4
2 MINING	5
3 FOOD	6 + 7 + 8 + 9 + 10
4 DRINK/TOBACCO	11 + 12
5 OIL/CHEMICALS	13 + 14
6 METAL MANUFACTURE	15 + 16
7 ENGINEERING	17 - 26
8 SHIPBUILDING	27
9 VEHICLES	28 + 29
10 METAL GOODS	30
11 TEXTILES	31 + 32 + 33 + 34
12 LEATHER/CLOTHING	35 + 36
13 TIMBER/BUILDING MATERIALS	37 + 38 + 39 + 40 + 41
14 OTHER MANUFACTURE	42 - 57
15 CONSTRUCTION	48
16 PUBLIC UTILITIES	49 + 50 + 51
17 TRANSPORT/COMMUNICATIONS	52 + 53 + 54 + 55
18 OTHER SERVICES	56 + 57 + 58 + 61 + 62
19 OWNERSHIP OF DWELLINGS	63

N.B. Education (sector 59) and Medical services (sector 60) have been taken out of the interindustry tables, and shall be used as final demand sectors in the ensuing impact analysis.

outputs (y), we obtain a measure of aggregation bias:

$$\tau = y^{*} - Sy \qquad (4.1)$$

The aggregation bias is the difference between the vector of gross outputs generated by the aggregated model (y^{*}), and the vector of gross outputs generated by the n sector vector of gross outputs generated by the unaggregated model (Sy). The existence of these errors is a limiting constraint on the accuracy of the aggregated input-output model as a tool for measuring economic impacts.[2]

The simple aggregation to 19 industrial sectors has been performed for the following vectors and matrices of the Strathclyde input-output tables:[3]

E^{1} = a vector representing total Strathclyde exports (industry by commodity),

I^{1} = an import matrix showing details of imports of commodities into Strathclyde (commodity by industry),

T^{11} = a matrix of Strathclyde interindustry flows (industry by industry),

V^{1} = a make matrix showing the details of commodity production by Strathclyde industry (industry by commodity),and

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2. The author is aware that various sophisticated techniques are available for the minimisation of aggregation bias, but due to the time and resources available, and due to the main objectives of this study, these techniques have not been employed.

3. In the SAM constructed in Chapter Three (Table 3.1) interindustry flows were included as part of flows within and between the production accounts (T_{11}^{kp}). For the purposes of simplification these subscripts are not shown at this juncture, except for the consideration of typical elements of each intersectoral flows matrix.

U^1 = a total flows absorption matrix showing details of domestically (i.e. Strathclyde) produced and imported commodities (commodity by industry).

From the Scottish input-output tables a similar collection of vectors and matrices have been aggregated, except that the trade flows are defined for the rest of the U.K. (region 6) and the rest of the world (region 7).[4] From the Scottish tables we have aggregated the following vectors and matrices:

T^{S6} = a vector representing Scottish exports to the rest of the U.K. (industry by 1),

T^{S7} = a vector representing Scottish exports to the rest of the world (industry by 1),

T^{6S} = an import matrix showing details of imports of commodities into Scotland from the rest of the U.K. (commodity by industry),

T^{7S} = an import matrix showing details of imports of commodities into Scotland from the rest of the world (commodity by industry),

T^{SS} = a matrix of Scottish interindustry flows (industry by industry),

V^S = a make matrix showing the details of commodity production by Scottish industry (industry by commodity)

U^S = a total flows absorption matrix showing details of domestically (i.e. Scotland) produced and

4. These regions are labelled 6 and 7 so as to conform with the SAM shown in Chapter Three (Table 3.1)

imported commodities by Scottish industry (commodity by industry).

The information collected from the Scottish tables can be illustrated using an inverted 'L' shaped format (Table 4.5).

TABLE 4.5 Interindustry Flows Available From The Scottish Input-Output Tables

	S	6	7
	SCOTLAND	R OF UK	R OF WORLD
SCOTLAND S	T^{SS}	T^{S6}	T^{S7}
REST OF UK 6	T^{6S}		
R OF WORLD 7	T^{7S}		

The data required for our bi-regional model is displayed below (Table 4.6).

TABLE 4.6 Interindustry Flows Required For The Bi-Regional Input-Output Model

	1	2	6	7
	STRATHCLYDE	R OF SCOTLAND	R OF UK	R OF WORLD
STRATHCLYDE 1	T^{11}	T^{12}	T^{16}	T^{17}
R OF SCOTLAND 2	T^{21}	T^{22}	T^{26}	T^{27}
REST OF UK 6	T^{61}	T^{62}		
REST OF WORLD 7	T^{71}	T^{72}		

The only information which is already available is the interindustry matrix for Strathclyde (T^{11}). An ad hoc residual method is therefore employed, by which the interindustry flows associated with the rest of Scotland are derived as a residual from the two input-output tables. Such an approach is analogous to the work of Oosterhaven (1979) in which an interindustry table for the rest of the Netherlands was derived as a residual.

4.2.2. The Derivation Of Interindustry Imports From The Rest Of Scotland To Strathclyde

The first stage of the analysis involves the derivation of import matrices of commodity flows from the rest of the U.K. and the rest of the world, which are directed to Strathclyde (T^{61} and T^{71}) and the rest of Scotland (T^{62} and T^{72}) separately. The Scottish import matrices (T^{6S} and T^{7S}) need to be disaggregated into imports to Strathclyde and the rest of Scotland.

A standard technique which could be applied to such a disaggregation is the location quotient. Round (1983) refers to a 'legion' of studies in which location quotients have been used to generate input-output tables. Notable examples include the work of Schaffar and Chu (1969), and Morrison and Smith (1974); both of whom conducted tests establishing the simple location quotient as the best estimator, when compared to other members of the location quotient family such as the cross-industry quotient. The simple location quotient has the following structure:

$$LQ_i = \frac{\frac{x_i}{x}}{\frac{X_i}{X}}, \qquad (4.2)$$

where

x_i = the regional output of industry i,

x = the total regional output,

X_i = the national output of industry i, and

X = the total national output.

This quotient compares the relative importance of an industry in a region to its relative importance in the national economy. It is usually used to weight the coefficients of a national coefficients table.

The simple location quotient was considered for the disaggregation of the Scottish import matrices. Take the example of the matrix of imports from the rest of the U.K. to Scotland (T^{6S}). Both Strathclyde and the rest of the Scotland consume a proportion of Scotland's imports from the rest of the U.K. A basis for each region's share of Scottish imports could be the relative total absorptions of the two regions. A simple location quotient could be derived, and based on the elements of the total absorption matrices (U^1 and U^S). The problem with such an approach, however, is that it would not relate to the overall constraint of the Scottish import matrix. In short the location quotient is too complex a tool for the simple disaggregation of an import matrix into two parts. We therefore rely on a simple pro rata mechanism for disaggregating imports.

Each entry in the Strathclyde total absorption matrix (U^1) can be compared with the corresponding entry of the Scottish total absorption matrix (U^S) - the Scottish imports are divided according to this proportion. Imports from the rest of the U.K. to Strathclyde are derived as follows:

$$T^{61}_{ij} = \frac{U^1_{ij}\, T^{6S}_{ij}}{U^S_{ij}}, \qquad (4.3)$$

where

T^{61}_{ij} = a typical element of the derived import matrix of flows from the rest of the U.K. to Strathclyde,

T^{6S}_{ij} = a typical element of the Scottish import matrix of flows from the rest of the U.K.,

U^1_{ij} = a typical element of the Strathclyde total absorption matrix, and

U^S_{ij} = a typical element of the Scottish total absorptions matrix.

For the derivation of imports from the rest of the world to Strathclyde, the same disaggregation is used:

$$T^{71}_{ij} = \frac{U^1_{ij}\, T^{7S}_{ij}}{U^S_{ij}}, \qquad (4.4)$$

where

T^{71}_{ij} = a typical element of the derived import matrix of flows from the rest of the world to Strathclyde, and

T^{7S}_{ij} = a typical element of the Scottish import matrix of flows from the rest of the world.

These disaggregations involve the imposition of limiting assumptions concerning the relative structure of Strathclyde and Scottish trade. It is assumed that imports to Strathclyde constitute the same proportion which total absorptions to Strathclyde make up of Scottish total absorptions. Imports to Strathclyde, therefore, are estimated purely on the basis of total absorptions. The problem with this approach is that Strathclyde is a smaller economy than Scotland; and therefore it should, in theory, be less self-contained or more likely to import goods from outside, in proportion to its size. The derivations in Equations (4.3) and (4.4) ignore the possibility of different Strathclyde import propensities which do not relate to the magnitude of total absorptions. The problem with any pro rata or location quotient adjustment, is the inability to take into account trade relationships which may be peculiar to a particular industry, in a particular region, and which cannot be accounted for by a general theory of trade patterns.

The pro rata disaggregation can be categorized as a non-survey form of data derivation. In assessing the validity of this approach, it is pertinent to mention the survey/non-survey debate which has featured in the input-output literature over the last two decades.[5] An example which points to the inaccuracy of the non-survey approach is the findings of Harrigan et al (1981) in which location quotient estimates were compared with survey-based estimates obtained from the 1973 Scottish Input-Output Tables.

5. A comprehensive review of this debate has been provided by Round (1983).

Their conclusion was that location quotients produce "extremely unsuitable" estimates of trade flows between Scotland and the rest of the U.K. These results reinforce an earlier debate on the efficacy of non-survey techniques, in which Miernyk (1969) questioned the optimism of Czamanski and Malizia (1969) concerning the interpretation of results obtained from the Washington State Input-Output Table.

In defence of the non-survey approach we can invoke the practical argument of Schaffer and Chu (1969), that although non-survey models cannot be adequately substituted for survey models, they provide a quick and inexpensive method for generation data. Survey tables are criticised for being expensive, out of data when published, and rarely updated. Often only a simple multiplier analysis is used in the application of these models, with the result that studies fail to demonstrate the potential of the input-output method. In addition, there is some evidence that non-survey methods *can* generate reasonable results. Morrison and Smith (1974) produced a non-survey table for Peterborough which, measured against criteria such as mean absolute difference, mean similarity index, and regression estimates, proved to be close to the survey table.

The results generated by tests which compare survey and non-survey techniques depend, however, on the region of study. Round argues that "there is no clearly defined acceptable region which can be used as a benchmark for these measures" (Round 1983, p.201). For the application of non-survey methods to the derivation of Strathclyde trade as a proportion of Scottish trade, the accuracy of the estimates will depend on the specific nature of the trade relationships. We can qualify the results by emphasising that the derived trade flows are only surrogate estimates of the actual survey estimates which are not available.

Using the derived Strathclyde import matrices (T^{61} and T^{71}), we can estimate imports from the rest of Scotland to Strathclyde. The Strathclyde total imports matrix (I^1) consists of imports from the rest of Scotland (${}^cT^{21}$),[6] from the rest of the U.K. (T^{61}), and from the rest of the world (T^{71}):

$$I^1 = {}^cT^{21} + T^{61} + T^{71}. \qquad (4.5)$$

Therefore,

$${}^cT^{21} = I^1 - T^{61} - T^{71}. \qquad (4.6)$$

At this juncture the commodity classification which characterises the derived trade flows (${}^cT^{21}$) can be converted into an industrial classification. This is accomplished using a market share matrix for the rest of Scotland. Firstly, a make matrix for the rest of Scotland is derived as a residual from the Scottish and Strathclyde make matrices:

$$V^2 = V^S - V^1. \qquad (4.7)$$

6. The superscript c denotes that the derived trade flows from the rest of Scotland are of commodity by industry technology.

The market share matrix is derived by post-multiplying the transpose of the rest of Scotland's make matrix $(V^2)^T$ by the inverse of a diagonal matrix of gross commodity outputs $(\hat{q}^2)^{-1}$ for the rest of Scotland:

$$D^2 = (V^2)^T (\hat{q}^2)^{-1}. \qquad (4.8)$$

A typical element of the market share matrix (D^2_{ij}) shows the market share of industry i in the production of commodity j. Therefore, if we pre-multiply the import matrix of commodity flows from the rest of Scotland to Strathclyde industries $({}^cT^{21})$ by the market share matrix, a new industry by industry import matrix is derived:

$$T^{21} = D^2 \, {}^cT^{21}. \qquad (4.9)$$

4.2.3. The Derivation Of Interindustry Exports From Strathclyde To The Rest Of Scotland

The next stage of the manipulation involves the derivation of exports from Strathclyde to the rest of Scotland. A pro rata mechanism is used to disaggregate the Scottish export vectors of flows to the rest of the U.K. (T^{S6}) and to the rest of the world (T^{S7}). We employ the row sums of the Strathclyde and Scottish make matrices, which are in fact the gross outputs of each industry. Exports from Strathclyde to the rest of the U.K. are derived as follows:

$$T_i^{16} = \frac{g_i^1}{g_i^S} T_i^{S6}, \qquad (4.10)$$

where

g_i^1 = a typical element of the vector representing the gross outputs of Strathclyde industries,

g_i^S = a typical element of the vector representing the gross outputs of Scottish industries,

T_i^{S6} = a typical element of the vector representing Scottish exports to the rest of the U.K., and

T_i^{16} = a typical element of the vector representing Strathclyde exports to the rest of the U.K.

For exports from Strathclyde the rest of the world:

$$T_i^{17} = \frac{g_i^1}{g_i^S} T_i^{S7}, \qquad (4.11)$$

where

T_i^{S7} = a typical element of the vector representing exports from Scotland to the rest of the world,

T_i^{17} = a typical element of the vector representing exports from Strathclyde to the rest of the world.

For both these derivations we assume that the proportion which Strathclyde exports take of Scottish exports, is identical to the proportion which Strathclyde gross outputs take of Scottish gross outputs.

Exports from Strathclyde to the rest of Scotland are estimated as a residual:

$$E^{12} = E^1 - T^{16} - T^{17}. \qquad (4.12)$$

A feature of this derived exports vector is that the goods exported consist of both intermediate and final demand commodities. In order to develop further the derivation of a bi-regional input-output model we need to separate the intermediate from final demand commodities.

We therefore generate separate trade flows for final demand commodities.

The five categories of final demand - household expenditure, public current expenditure, stock changes, fixed capital formation, and tourist expenditure - are aggregated into one final demand sector. Scottish imports of final demand, obtained from the published import tables, are disaggregated using the pro rata adjustments:

$$F_i^{61} = \frac{{}^{F}U_i^{1}}{{}^{F}U_i^{S}} F_i^{6S}, \qquad (4.13)$$

$$F_i^{71} = \frac{{}^{F}U_i^{1}}{{}^{F}U_i^{S}} F_i^{7S}, \qquad (4.14)$$

where

F_i^{61} = a typical element of the vector of imports of final demand commodities from the rest of the U.K. to Strathclyde,

F_i^{71} = a typical element of the vector of imports of final demand commodities from the rest of the world to Strathclyde,

${}^{F}U_i^{1}$ = a typical element of the vector of total absorptions of final demand commodities by Strathclyde,

${}^{F}U_i^{S}$ = a typical element of a vector of total absorptions of final demand commodities by Scotland,

F_i^{6S} = a typical element of the vector of imports of final demand commodities from the rest of the U.K. to Scotland, and

F_i^{7S} = a typical element of the vector of imports of final demand commodities from the rest of the world to Scotland.

A vector of total imports of final demand commodities into Strathclyde (${}^{F}I^{1}$) is obtained from the published Strathclyde import matrix. The flow of final demand commodities from the rest of Scotland to Strathclyde is therefore estimated as a residual:

$$ {}^{C}F^{21} = {}^{F}I^{1} - F^{61} - F^{71}. \qquad (4.15) $$

The market share matrix (see Equation 4.8) is employed in order to generate an industrial classification:

$$ F^{21} = D^{2}\ {}^{C}F^{21} \qquad (4.16) $$

The next stage of the derivation involves the derivation of final demand commodities in the opposite direction, from Strathclyde to the rest of Scotland. In view of the fact that final demand commodities cannot be separated from intermediate products in the export vector (E^{12}), we need to make an additional assumption about the structure of regional trade. The export vector E^{12} can be disaggregated according to the comparative proportions of intermediate and final demand commodities in the opposite direction.

The import matrix T^{21} is condensed into a vector of trade flows by taking the row sums. The proportion which these intermediate imports take of total imports from the rest of Scotland to Strathclyde, is then used to isolate intermediate flows in the opposite direction:

$$ d_i^{12} = \frac{T_i^{21}}{T_i^{21} + F_i^{21}} E_i^{12}, \qquad (4.17) $$

where

d_i^{12} = a typical element of the derived vector representing flows of intermediate commodities from Strathclyde to the rest of Scotland.

The structural mix of trade flows between intermediate and final demand commodities is assumed to be the same in both directions between the two regions.

4.2.4. An Application Of The Chenery-Moses Technique

We are now able to derive the full set of inter-industry matrices in a bi-regional input-output format (see Table 4.7). On the left-hand side, matrices of interindustry flows have been derived for trade within the Strathclyde economy (T^{11}) and for flows from the rest of Scotland to Strathclyde (T^{21}). On the right hand side we have a vector of trade flows from Strathclyde to the rest of Scotland (d^{12}). A vector of flows wholly within

TABLE 4.7 A Half Matrix/Half Vector Input-Output Table

	1	2
	STRATHCLYDE	R OF SCOTLAND
STRATHCLYDE 1	T^{11}	d^{12}
R OF SCOTLAND 2	T^{21}	d^{22}

the rest of Scotland (d^{22}) can be derived by taking the row sums of T^{11} and T^{21}, together with d^{12}, from the row sums of T^{SS} (see Table 4.5):

$$d_i^{22} = T_i^{SS} - T_i^{11} - T_i^{21} - d_i^{12}. \qquad (4.18)$$

The interindustry flows matrix for Scotland (T^{SS}) can also be used to derive the interindustry flows specific to the right hand side of Table 4.7:

$$T^{2} = T^{SS} - T^{11} - T^{21}. \qquad (4.19)$$

This information can be further manipulated using the Chenery-Moses point estimate formulation, which was derived independently by Chenery (1953) and Moses (1955). Models which are generated by this procedure are usually labelled 'multiregional', in contrast to the 'interregional' model which is associated with the original framework designed by Isard (1951). Riefler (1973) called the Isard model the 'ideal' interregional input-output model for its reliance on full interregional trade information. Subsequent reformulations of the Isard model have been interpreted by Riefler (1973) as largely an attempt to reduce the data requirements of the model,so as to render it operational.

Moses (1955) reduced the data requirements of the model by separating the trade coefficients from the regional technical coefficients. Regional technical coefficients relate to flows from both regions to the region of consumption. Consider a simple two-region, two-industry table (Table 4.8).

TABLE 4.8 Block Matrices Of Regional Technical Coefficients

		REGION 1		REGION 2	
REGION 1	INDUSTRY 1	a_{11}^{1}	a_{12}^{1}		
	INDUSTRY 2	a_{21}^{1}	a_{22}^{1}		
REGION 2	INDUSTRY 1			a_{11}^{2}	a_{12}^{2}
	INDUSTRY 2			a_{21}^{2}	a_{22}^{2}

where

a_{ij}^{k} = the total absorption of goods from industry i (i.e. produced in both regions) per unit of output of industry j in region k.

The trade coefficients refer to flows of commodities between regions (Table 4.9).

TABLE 4.9 Block Matrices Of Trade Coefficients

		REGION 1	REGION 2	REGION 1	REGION 2
INDUSTRY 1	REGION 1	t_{1}^{11}	t_{1}^{12}		
	REGION 2	t_{1}^{21}	t_{1}^{22}		
INDUSTRY 2	REGION 1			t_{2}^{11}	t_{2}^{12}
	REGION 2			t_{2}^{21}	t_{2}^{22}

where

t_{i}^{kp} = the proportion of region p's purchases of good i which originate in region k.

The derivation of trade coefficients requires two sets of information. Firstly, region p's consumption of commodity i consists of flows from within the region (d^{pp}) and trade flows from the second region (d^{kp}). Secondly, from these trade flows the region's total receipts (X_i^p) are obtained by summation. A typical trade coefficient has the structure

$$t_i^{kp} = \frac{d_i^{kp}}{X_i^p}. \qquad (4.20)$$

Moses (1955) links the trade coefficients with the technical coefficients so that

$$b_{ij}^{kp} = a_{ij}^{p} \; t_i^{kp}, \qquad (4.21)$$

where

b_{ij}^{kp} = the amount of good i purchased by region p from region k per unit of good j produced in region p.

Table 4.10 displays the interregional and intersectoral flows of the two-region economy.

TABLE 4.10 Block Matrices Of Intra- And Interregional Coefficients

		REGION 1		REGION 2	
		INDUSTRY 1	INDUSTRY 2	INDUSTRY 1	INDUSTRY 2
REGION 1	INDUSTRY 1	$b_{11}^{11} = a_{11}^{1}(t_1^{11})$	$b_{12}^{11} = a_{12}^{1}(t_1^{11})$	$b_{11}^{12} = a_{11}^{2}(t_1^{12})$	$b_{12}^{12} = a_{12}^{2}(t_1^{12})$
	INDUSTRY 2	$b_{21}^{11} = a_{21}^{1}(t_2^{11})$	$b_{22}^{11} = a_{22}^{1}(t_2^{11})$	$b_{21}^{12} = a_{21}^{2}(t_2^{12})$	$b_{22}^{12} = a_{22}^{2}(t_2^{12})$
REGION 2	INDUSTRY 1	$b_{11}^{21} = a_{11}^{1}(t_1^{21})$	$b_{12}^{21} = a_{12}^{1}(t_1^{21})$	$b_{11}^{22} = a_{11}^{2}(t_1^{22})$	$b_{12}^{22} = a_{12}^{2}(t_1^{22})$
	INDUSTRY 2	$b_{21}^{21} = a_{21}^{1}(t_2^{21})$	$b_{22}^{21} = a_{22}^{1}(t_2^{21})$	$b_{21}^{22} = a_{21}^{2}(t_2^{22})$	$b_{22}^{22} = a_{22}^{2}(t_2^{22})$

For the Scottish data the Chenery-Moses technique need only be applied to the two right hand side blocks in Table 4.7. Vectors have been derived for exports from Strathclyde to the rest of Scotland (d^{12}) and flows within the rest of Scotland (d^{22}). The total consumption of industry i in the rest of Scotland is defined as:

$$X_i^2 = d_i^{12} + d_i^{22}. \qquad (4.22)$$

The typical trade coefficients have the structure

$$t_i^{12} = \frac{d_i^{12}}{X_i^2}, \text{ and} \qquad (4.23)$$

$$t_i^{22} = \frac{d_i^{22}}{X_i^2}. \qquad (4.24)$$

Moses (1955) linked the trade coefficients with the technical coefficients, but in this formulation we employ the total flows matrix (T^2) (see Equation 4.19). This matrix, which includes total purchases by industries in the rest of Scotland, is disaggregated using the trade coefficients derived in Equations (4.23) and (4.24):

$$T_{ij}^{12} = T_{ij}^2 \; t_i^{12}, \qquad (4.25)$$

$$T_{ij}^{22} = T_{ij}^2 \; t_i^{22}. \qquad (4.26)$$

The trade coefficients are effectively factors of 1 which weight the total flows according to the available information on trade flows. The generation of the interindustry matrices T^{12} and T^{22} completes the derivation of bi-regional interindustry flows.

The employment of the Chenery-Moses technique involves a number of limiting assumptions. The model assumes a uniformity of trade relationships for all sectors in a region. For example, the trade coefficients associated with the flows of commodity 1 from region 1 to region 2, all have the same value:

$$t_{11}^{12} = t_{12}^{12} = \ldots\ldots = t_{1n}^{12} = t_{1}^{12}. \qquad (4.27)$$

This means that all sectors in region 2 have the same propensity to import commodity 1. Moses (1955) concedes that this procedure is imperfect, but argues that it is the best alternative to the Isard model, which is impossible to implement. This complies with the argument of Riefler (1973) that all subsequent reformulations of Isard's model are largely an attempt to reduce the data requirements of the model.

Brodersohn (1965) points to the impossibility of gathering data for the interregional model, but also interprets the reformulations as part of a theoretical dispute as to how trade relationships can be most efficiently represented. A criticism of the Chenery-Moses model is provided by Isard (1960). In compliance with his earlier work, Isard regarded the heterogeneity of different industries to be an important feature that should be reflected in the model. Each consuming industry in a region has its own individual supply pattern for the inputs it uses; and the imposition of uniform trade coefficients ignores this important factor.

A theoretical justification for uniform trade coefficients was provided by Chenery (1953). He argued that one region constitutes a single market, so the supply patterns are determined more by total demand than by individual supply patterns. This is not to say that individual characteristics of supply are not important; only that an emphasis on individual supply patterns would be misplaced.

These theoretical arguments, however, were not conclusive, so that ultimately the defence of the Chenery-Moses model must depend on the inapplicability of Isard's model. It must be noted that this latter model has been applied to the Japanese economy (MITI 1970), but this is an isolated example of a country in which the government has taken an unusual interest in the collection of inter-regional trade. For most contries - in particular the United States - a full interregional data set is not available. For the United Kingdom not even the trade vectors needed for the Chenery-Moses technique are available. As we have seen, the required vectors have been derived as residuals from the Scottish and Strathclyde input-output tables. Any large errors in the derived trade flows are more likely to be generated by the nonsurvey methods used to generate these residual vectors, than by the supplementary application of the Chenery-Moses technique.

4.3. THE SPECIFICATION OF CONSUMPTION PROPENSITIES

In this section we present a procedure by which the consumption profiles of individual employed and unemployed workers can be derived from the Family Expenditure Survey (1973). These consumption propensities are required to model the Type II and Type IV extensions to the Type I input-output model (see Section 2.3). The main reference point for this derivation is the Type IV model generated by Madden, Batey and Worrall (1981) for the Merseyside economy.

The original Merseyside model incorporated a *household* consumption framework, which was later found to be too rigid (see Section 2.3.5). To recap, this model involved the disaggregation of households according to the employment status of the heads of households (see Batey and Madden 1981). In the original Type IV model, therefore, consumption coefficients were derived according to the classification of households with employed and unemployed heads. When the Merseyside model was later remoulded into a *personal* consumption framework (Batey and Madden 1983), the personal consumption coefficients were derived from the household consumption coefficients of the original model. Therefore, in the original Batey-Madden model the personal consumption coefficients were arrived at in an ad hoc manner - for the purposes of the present study a more direct approach can be derived for the derivation of personal consumption coefficients.

The published tables provided by the Family Expenditure Survey (FES) are framed mainly in terms of household income and consumption. From Table 1 of the 1973 FES, we obtain the average weekly household expenditure for a sample of households contained in fourteen income groups (see Table 4.11). We also obtain the average number of persons 'working' and 'not working' for each income group. The average weekly household income for each income group is obtained from Table 36 of the 1973 FES (again, refer to Table 4.11).

The first objective is to determine in which household income group the average employed worker can be found. From Table 4.11 we derive the frequency of employed workers in each of the fourteen income groups. For households earning under £10 in income, for example, there are only 0.077 workers per household. There are 300 of these households in the sample, so the number of workers which are members of households earning under £10 is

$$300 \times 0.077 = 23.1.$$

Using this method of calculation for each income group, the total frequency of employed workers can be derived for all of the fourteen income groups (see Table 4.12).

These frequencies (f) are used as weights which are multiplied by the mid-point of each household income group. Each employed worker is assigned an amount of household income, depending on the household income group in which the individual can be found. The household income associated with the typical worker - the mean of the distribution of these derived household incomes over employed workers - is calculated by employing the formula for the arithmetic mean:

$$Y = \frac{\sum_{1}^{14} f_i x_i}{\sum f_i} = \frac{622552.9}{9671.9} = £64.37 \text{ per week.}$$

TABLE 4.11 A Summary Of U.K. Data From The 1973 Family Expenditure Survey

	UNDER £10	£10 & UNDER £15	£15 & UNDER £20	£20 & UNDER £25	£25 & UNDER £30	£30 & UNDER £35	£35 & UNDER £40	£40 & UNDER £45	£45 & UNDER £50	£50 & UNDER £60	£60 & UNDER £70	£70 & UNDER £80	£80 & UNDER £100	£100 OR MORE
TOTAL NUMBER OF HOUSEHOLDS	300	622	461	380	393	442	488	487	540	939	671	474	473	456
PERSONS WORKING	0.077	0.143	0.347	0.658	0.959	1.165	1.348	1.441	1.530	1.739	1.923	2.137	2.260	2.342
PERSONS NOT WORKING	0.083	0.156	0.191	0.268	0.331	0.387	0.344	0.384	0.322	0.243	0.167	0.08	0.129	0.266
AVERAGE TOTAL WEEKLY HOUSE-HOLD INCOME	£8.87	£12.25	£17.27	£22.48	£27.53	£32.61	£37.61	£42.43	£47.63	£54.82	£64.58	£74.73	£88.55	£138.57
AVERAGE TOTAL WEEKLY HOUSE-HOLD EXPEND-ITURE	£10.21	£13.45	£18.57	£23.45	£27.30	£31.34	£33.83	£37.14	£40.02	£44.36	£48.71	£56.80	£63.33	£87.88

TABLE 4.12 A Frequency Distribution For The Calculation Of The Average Employed Worker's Household Income

HOUSEHOLD INCOME GROUP	PERSONS WORKING	NUMBER OF HOUSEHOLDS	f_i	MID-POINT x_i	$f_i x_i$
< £10	0.077 ×	300 =	23.1 ×	8.87 =	204.9
£10-£15	0.143	622	88.9	12.25	1089.0
£15-£20	0.347	461	159.9	17.27	2761.5
£20-£25	0.658	380	250.0	22.48	5620.0
£25-£30	0.959	393	376.8	27.53	10373.3
£30-£35	1.165	442	514.9	32.61	16790.8
£35-£40	1.348	448	657.8	37.61	24739.9
£40-£45	1.441	487	701.7	42.43	30474.8
£45-£50	1.530	540	826.2	47.63	39351.9
£50-£60	1.739	939	1632.2	54.82	89515.6
£60-£70	1.923	671	1290.0	64.58	83308.2
£70-£80	2.137	474	1012.9	74.73	75694.0
£80-£100	2.260	473	1068.9	88.55	94651.0
> £100	2,342	456	1067.9	138.57	147978.0
TOTAL		Σf_i =	9671.9	$\Sigma f_i x_i$ =	622552,9

The typical employed worker is a member of a household with an estimated income of £64.37, which is in the £60-£70 income group. This is because households in such high income earning groups contain proportionately more employed workers.

From Table 1 of the 1973 FES we can obtain the total expenditure of the average household in the £60-£70 income group. A breakdown of this expenditure is provided by the FES for eleven groups of commodities and services. If the total expenditure of the £60-£70 income group is £48.71 and the total income is £64.58,[7] then the overall consumption propensity is 48.71/64.58. This consumption propensity can be disaggregated into eleven consumption propensities relating to each commodity group. Although these propensities relate to household expenditure within the £60-£70 income group, we assume that the typical employed worker adopts the same propensity to consume out of income.

The technique used for employed workers' consumption propensities can also be applied to the typical unemployed worker (see Table 4.13). The household income associated with this worker is calculated as

$$\frac{81671.5}{2574.8} = £31.70 \text{ per week,}$$

which locates the typical unemployed worker in the £30-£35 income group. The overall consumption propensity of the typical unemployed worker is calculated as 31.34/32.61,

7. This figure is the mid-point of the £60-£70 income group.

TABLE 4.13 A Frequency Distribution For The Calculation Of The Average Unemployed Worker's Household Income

HOUSEHOLD INCOME GROUP	PERSONS NOT WORKING	NUMBER OF HOUSEHOLDS	f_i	MID-POINT x_i	$f_i x_i$
< £10	0.083	300	24.90	8.67	220.8
£10-£15	0.156	622	97.03	12.25	1188.3
£15-£20	0.191	461	88.00	17.27	1519.8
£20-£25	0.268	380	101.80	22.48	2288.5
£25-£30	0.331	393	130.00	27.53	3578.9
£30-£35	0.387	442	171.00	32.61	5576.3
£35-£40	0.344	488	167.80	37.61	6310.9
£40-£45	0.384	487	187.00	42.43	7934.4
£45-£50	0.322	540	173.80	47.63	8278.0
£50-£60	0.243	939	228.00	54.82	12498.9
£60-£70	0.167	671	112.00	64.58	7232.9
£70-£80	0.080	474	37.92	74.32	2833.7
£80-£100	0.129	473	61.0	88.55	5401.6
> £100	0.266	456	121.3	138.57	6808.5
TOTAL		Σf_i	= 2574.8	$\Sigma f_i x_i$	= 81671.5

with eleven separate propensities provided for each commodity group. In addition to the higher overall propensity to consume for unemployed workers, their low income generates a different commodity mix of the total expenditure.

The consumption propensities derived from Tables 4.12 and 4.13 relate to the whole of the U.K. Some data is provided by the FES which relates specifically to Scotland, but this data is not presented in enough detail to provide estimates for employed and unemployed workers. The Scottish data relates to the consumer expenditure of all Scottish households, regardless of income. The comparative Scottish and U.K. data for all households is obtained from Table 59 of the 1973 FES.

In the next stage of the analysis Scottish data is used to weight the U.K. consumption propensities derived for individual and unemployed workers. This is necessary because Scottish households adopt slightly different consumption profiles than households in the U.K. as a whole. The consumption propensity of the typical employed worker is adjusted as follows:

$$\varepsilon_i = \frac{S_i}{R_i} \rho_i, \tag{4.28}$$

where

ε_i = the adjusted consumption propensity for good i per unit of employed income,

S_i = the share of total household expenditure allocated to good i for all Scottish households,

R_i = the share of total household expenditure allocated to good i for all U.K. households, and

ρ_i = the unadjusted consumption propensity for good i per unit of employed income.

In this formulation we apply the expenditure differential between all Scottish and U.K. households, in order to adjust the U.K. consumption propensities calculated for employed workers. This procedure can also be applied to the consumption propensities of unemployed workers. The overall propensities to consume for employed and unemployed workers are slightly increased due to the effect of the different commodity mix associated with Scottish consumption profiles.

The next stage of the derivation is to adapt the vectors of consumption propensities for employed and unemployed workers to the input-output framework. In the FES there are eleven commodity groups, which need to be converted into nineteen industrial/commodity groups, as classified in the bi-regional input-output model. This is achieved using a procedure employed by Henderson (1984) in the construction of a vector of consumption propensities for the 1979 Scottish input-output tables. A conversion table divides each of the eleven commodity groups into disaggregated groups which are conformable to an input-output table. This conversion table has been aggregated to nineteen industrial sectors, in order to derive two 19 by 1 vectors of consumption propensities - for employed and unemployed workers.

These two vectors of consumption propensities can be adapted to model the flows of goods and services within and between Strathclyde and the rest of Scotland. We assume that both regions have the same *total* propensities to consume as Scotland as a whole. The derivation of *local* propensities is achieved using vectors of actual flows of consumption goods from the Scottish and Strathclyde input-output tables.

In Section 4.4.3 an ad hoc residual procedure was used to derive exports (both intermediate and final demand) from Strathclyde to the rest of Scotland, and imports of final demand commodities from the rest of Scotland to Strathclyde. This procedure can be used to generate exports and imports of consumption goods, which are represented by one of the five final demand categories - household expenditure. We can therefore derive eight vectors representing flows of consumption goods, from within and outside the two-region economy (Table 4.14).

TABLE 4.14 A Collection Of 19 by 1 Vectors Representing Flows Of Consumption Goods

		1 STRATHCLYDE	2 R OF SCOTLAND
STRATHCLYDE	1	F^{11}	F^{12}
R OF SCOTLAND	2	F^{21}	F^{22}
R OF U.K.	6	F^{61}	F^{62}
R OF WORLD	7	F^{71}	F^{72}
TOTAL		F^{*1}	F^{*2}

A vector F^{kp} represents the flows of consumption goods for nineteen sectors from region k to p. The vector F^{*p} represents the total consumption of consumer goods for region p. The proportion which each vector takes of a region's total expenditure is calculated by the equation

$$S_i^{kp} = \frac{F_i^{kp}}{F_i^{*p}} \qquad (4.29)$$

These proportions are effectively trade coefficients which can be applied to the vectors representing employed and unemployed consumption propensities for each region. We have therefore derived 8 vectors of consumption propensities relating to employed workers, and 8 vectors relating to unemployed workers. An assumption implicit in this derivation is that the trade structure for employed and unemployed consumer expenditure is the same as the structure of total consumer expenditure. In addition, we note the limitations of employing average consumption proopensities, when compared with marginal propensities (see Blackwell 1978). The latter approach would provide a more accurate measure of the response of consumer expenditure to changes in income, but this would require some form of time series consumption data; and this was considered not feasible within the confines of the present study. The average propensities used for the household component of the impact assessment framework are likely to overstate the relationship between income and expenditure.

4.4. THE DERIVATION OF CAPITAL COEFFICIENT MATRICES

In this section we operationalise the investment extension to the Type IV model. Capital coefficient matrices relating to both Strathclyde and the rest of Scotland, are derived from the 1979 Scottish Input-Output Tables (see Henderson 1984).[8] In Volume Three of these tables an investment matrix is given which contains flows of 34 categories of investment goods to 83 industrial sectors. The derivation of capital coefficients for Strathclyde and the rest of Scotland involves the backdating of this 1979 matrix.

It is more usual in input-output studies for tables to be updated over a short period, in order to render them more applicalbe to current issues. Evidence suggests that there are significant changes in input-output coefficients over time (Carter 1970; Leontief 1953); and the importance of taking into account these changes is accentuated by the usual lag between base and published years for most input-output studies. Davis, Lofting and Sathage (1977) note that the lags between the construction and publication of the U.S. national input-output tables for 1958,1963 and 1967 are seven, six and seven years, respectively. For the present study we need to backdate for the six year period between 1973 and 1979.

In principle thereis no reason why a table cannot be backdated if it is needed for a particular purpose. The most commonly used technique is the RAS procedure, which was

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8. Investment matrices were derived as part of the original 1973 Scottish and Strathclyde I-O Tables, but these matrices could not be obtained for the present study.

developed by Stone (1961a), and Stone and Brown (1962). Another procedure, which is sometimes used, is the linear programming technique, but tests by Davis, Lofting and Sathage (1977) have revealed that the RAS procedure provides better results. In the following derivation we therefore employ the RAS technique, due to its relative accuracy, and also because it is easy to apply to a straightforward updating/backdating problem.

The RAS procedure is usually applied to the updating of interindustry coefficients which relate interindustry flows to gross outputs in each specific year. The original base year coefficients are adjusted using target year row and column totals (see Appendix B). For the generation of capital coefficients in a dynamic model, however, flows of investment goods are usually related to *changes* in gross outputs over a specific time period (see Equation 3.2). Therefore, the RAS procedure would require target and base year vectors representing changes in gross outputs over time. The backdating of the Scottish investment matrix would require a vector representing changes in gross outputs for Scotland, over a specified time period before 1979, and for Strathclyde and the rest of Scotland over a specified period before 1973. In view of the difficulty of obtaining information on gross outputs by industrial sector and for different time periods, particularly for Strathclyde and the rest of Scotland, the capital coefficient matrices have been derived using actual gross outputs for 1979 and 1973.

The capital coefficients have therefore been derived in the same way as interindustry coefficients are generated in an updated/backdated static Leontief model. The endogenisation of investment using these capital coefficients cannot be defined as a truly 'dynamic' model, and it shall therefore be referred to as the investment augmented Type IV model.

The 1979 Scottish investment matrix maps out the flows of investment goods from 34 industrial sectors (Table 4.15) to 83 commodity groups (Table 4.16). This matrix is aggregated to a 19 by 19 investment matrix (see Tables 4.17 and 4.18). The aggregation scheme is consistent with that used for the 1973 tables, the principal difference being the use of the 1968 Standard Industrial Classification (SIC) for the 1973 tables, and the 1980 SIC for the 1979 tables. Given the revision of the SIC system in 1980, an exact match between the two sets of tables is not possible; although Weeks (1986a) has developed a method by which sectors which caused problems could be divided according to proportions provided by the British Statistics Office (BSO). In addition to the investment matrix, the 1979 Scottish make matrix is aggregated to 19 sectors using the same procedure.

The RAS procedure involves the adjustment of elements in an input-output table according to the constraint of 'target' year column and row sums.[9] In order to operationalise this iterative procedure we have employed a FORTRAN

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9. An outline of the RAS procedure is shown in Appendix B.

TABLE 4.15 Industrial Classification Of The 1979 Scottish Investment Matrix

SECTOR	SECTOR NUMBER
AGRICULTURE	1
FORESTRY & FISHING	2
SOLID FUEL	3
OIL & GAS EXPLORATION	4
MINING/OIL	5
ELECTRICITY	6
GAS	7
WATER SUPPLY	8
EXTRACTION OF ORES	9
METAL MANUFACTURE	10
BUILDING MATERIALS	11
CHEMICALS	12
METAL GOODS	13
MECHANICAL ENGINEERING	14
ELECTRICAL ENGINEERING	15
MOTOR VEHICLES	16
SHIPS & OTHER VEHICLES	17
INSTRUMENT ENGINEERING	18
FOOD PRODUCTS	19
DRINK & TOBACCO	20
TEXTILES	21
LEATHER/CLOTHES/FOOTWEAR	22
TIMBER & WOOD PRODUCTS	23
PAPER PRODUCTS	24
OTHER MANUFACTURE	25
CONSTRUCTION	26
WHOLESALING	27
RETAILING	28
GARAGES/HOTELS/CATERING	29
TRANSPORT	30
POST/TELECOMMUNICATIONS	31
MISCELLANEOUS SERVICES	33
PUBLIC SERVICES	33
DWELLINGS	34

TABLE 4.16 Commodity Classification For The 1979 Scottish Input-Output Tables

COMMODITY GROUP	GROUP NUMBER
AGRICULTURE	1
FORESTRY PLANTING	2
FORESTRY HARVESTING	3
FISHING	4
COAL AND COKE	5
MINERAL OIL & GAS EXTRACTION	6
MINERAL OIL PROCESSING	7
ELECTRICITY	8
GAS	9
WATER	10
EXTRACTION OF ORES	11
FERROUS METALS & ALLUMINIUM	12
OTHER NON-FERROUS METALS	13
BRICKS	14
GENERAL BUILDING MATERIALS	15
GLASS	16
POTTERY	17
BASIC CHEMICALS	18
FERTILISERS	19
GENERAL CHEMICALS	20
PHARMACEUTICAL PRODUCTS	21
SOAP & TOILET PREPERATIONS	22
INDUSTRIAL PLANT & STEELWORK	23
OTHER METAL GOODS	24
AGRIC MACHINERY & TRACTORS	25
MACHINE TOOLS	26
CONSTRUCTION EQUIPMENT	27
OTHER MECHANICAL ENGINEERING	28
INDUSTRIAL ENGINES	29
COMPUTERS	30
BASIC ELECTRIC EQUIPMENT	31
COMMUNICATION EQUIPMENT	32
INSTRUMENT ENGINEERING	33
DOMESTIC ELECTRICAL APPLIANCES	34
ELECTRICAL EQUIPMENT FOR INDUSTRY	35
MOTOR VEHICLES	36
SHIPS & MARINE ENGINEERING	37
AEROSPACE & OTHER VEHICLES	38
MEAT PRODUCTS	39
SLAUGHTERHOUSE	40
FISH PRODUCTS	41
BREAD & BUSCUITS	42
SUGAR & CONFECTIONARY	43
OTHER FOOD & TOBACCO	44
SPIRITS & WHISKY	45
BREWING	46
SOFT DRINKS	47
WOOLLEN & WORSTED	48
COTTON & SILK	49
HOSIERY & KNITTED GOODS	50

TEXTILE FINISHING	51
CARPETS	52
OTHER TEXTILES	53
LEATHER	54
FOOTWEAR	55
CLOTHING	56
FURNITURE	57
TIMBER PROCESSING	58
PAPER & BOARD	59
PACKAGING PRODUCTS	60
OTHER PAPER PRODUCTS	61
PRINTING & PUBLISHING	62
RUBBER PRODUCTS	63
PLASTICS PROCESSING	64
OTHER MANUFACTURING	65
CONSTRUCTION	66
HIRING OF CONST EQUIPMENT	67
WHOLESALING	68
RETAILING	69
MOTOR TRADES	70
HOTELS & CATERING	71
RAIL	72
ROAD TRANSPORT	73
SEA TRANSPORT	74
AIR TRANSPORT	75
MIXED TRANSPORT	76
POSTAL SERVICES & TELECOMMUNICATIONS	77
INSURANCE/BANKING/FINANCE	78
OTHER BUSINESS SERVICES	79
PUBLIC ADMIN,DEFENCE ETC	80
DOMESTIC SERVICES	81
OWNERSHIP OF DWELLINGS	82
OTHER SERVICES	83

TABLE 4.17 An Aggregation Scheme For Commodity Groups In the 1979 Scottish Input-Output Tables

AGGREGATED SECTORS	ORIGINAL SECTORS
1 AGRICULTURE/FORESTRY/FISHING	1 + 2 + 3 + 4
2 MINING	(0.87)5 + 11
3 FOOD	39 - 43 + (0.55)44
4 DRINK/TOBACCO	45 - 47 + (0.45)44
5 OIL/CHEMICALS	(0.13)5 + 6 + 7 + 18 - 22
6 METAL MANUFACTURE	12 + 13
7 ENGINEERING	23 + 25 - 35
8 SHIPBUILDING	37
9 VEHICLES	36 + 38
10 METAL GOODS	24
11 TEXTILES	48 - 53
12 LEATHER/CLOTHING	54 + 55 + 56
13 TIMBER/BUILDING MATERIALS	14 + 15 + 16 + 17 + 57 + 58
14 OTHER MANUFACTURE	59 - 65
15 CONSTRUCTION	66
16 PUBLIC UTILITIES	8 + 9 + 10
17 TRANSPORT/COMMUNICATIONS	72 - 77
18 OTHER SERVICES	68 + 71 + 78 + 79 + 81 + 83
19 OWNERSHIP OF DWELLINGS	82

TABLE 4.18 An Aggregation Scheme For The Industrial Sectors Of The 1979 Scottish Investment Matrix

AGGREGATED SECTORS	ORIGINAL SECTORS
1 AGRICULTURE/FORESTRY/FISHING	1 + 2
2 MINING	3 + 9
3 FOOD	19
4 DRINK/TOBACCO	20
5 OIL/CHEMICALS	4 + 5 + 12
6 METAL MANUFACTURE	10
7 ENGINEERING	14 + 15 + 18
8 SHIPBUILDING	(0.83)17
9 VEHICLES	16 + (0.17)17
10 METAL GOODS	13
11 TEXTILES	21
12 LEATHER/CLOTHING	22
13 TIMBER/BUILDING MATERIALS	11 + 23
14 OTHER MANUFACTURE	24 + 25
15 CONSTRUCTION	26
16 PUBLIC UTILITES	6 + 7 + 8
17 TRANSPORT/COMMUNICATIONS	30 + 31
18 OTHER SERVICES	27 + 28 + 29 + 32
19 OWNERSHIP	34

programme developed by Weeks (1986b), in which the matrix adjustments are continued until the gap between target and revealed totals is less than 0.002. As we shall discover, however, there are certain conditions which need to be satisfied before the convergence of the RAS procedure is guaranteed.

Two runs of the RAS procedure are required in order to derive separate capital coefficient matrices for Strathclyde and the rest of Scotland. The target row sums are derived from the 1973 Strathclyde and Scottish input-output tables. From the Strathclyde total absorption tables, a vector of total gross fixed capital formation (TGFCF) provides the target row sums for the Strathclyde investment matrix. From the Scottish absorption tables, a similar TGFCF vector provides the target row sums for the rest of Scotland, as a residual from the Strathclyde vector.

The column totals of an investment matrix consist of gross expenditure on investment goods by each industry. These column totals have been partly derived from figures published in the Scottish Economic Bulletin (1983), which were derived form the Annual Census of Production. These figures, however, only feature net capital expenditure by manufacturing sectors for the whole of Scotland. Net capital expenditure for some of the non-manufacturing sectors, such as mining and public utilities, were provided by referring directly to figures published in the Annual Census of Production for Scotland in 1973. In addition, some data for specific sectors was obtained from the Scottish Abstract of Statistics. However, for some non-manufacturing sectors, such as agriculture/forestry/fishing and services, no data for Scottish net capital expenditure was obtained.[11]

For the sectors in which no information on capital expenditure has been obtained, we rely on target year gross outputs multiplied by the 1979 capital coefficient matrix (see Appendix B, Equation B.8) The column sums generated by this calculation are taken to be the gross capital expenditure for those sectors in which no information is available. This procedure is carried out for capital expenditure in both regions. Matuszewski, Pitts and Sawyer (1963) have referred to the generation of column totals in this fashion as a 'half-constrained' derivation - the capital coefficients are only constrained by row sums, with the column sums generated from the original coefficient matrix. Although the accuracy of this type of derivation is in question, it must be noted that in the present context only a small number of sectors are half-constrained.

The 1973 figures on net capital expenditure in Scotland, need to be converted into gross capital expenditure for Strathclyde and the rest of Scotland. Firstly, the net capital expenditures can be divided between the two regions according to the share of gross outputs enjoyed by each region. Therefore, if Strathclyde enjoys 70% of

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11. The lack of data for service sectors is a serious problem, especially in view of the increasing economic importance of service sectors relative to manufacturing. Dewhurst (1984) has tried to redress the balance by deriving data for output, employment and labour productivity, but a shortfall for capital expenditure still exists.

Scottish engineering production, then 70% of net capital expenditure is allocated to the Strathclyde engineering sector. This assumes that there is a fixed linear relationship between capital expenditure and output.

The second stage involves the conversion of the derived net capital expenditure figures, for Strathclyde and the rest of Scotland, into gross capital expenditures. The figures on net capital expenditures can be reconciled with the row totals which were obtained from the input-output tables. Assume that total gross fixed capital formation (the sum of the row totals) is equal to total gross capital expenditure (the sum of the column totals). The column totals derived for net capital expenditure provide a shortfall to the total fixed capital formation. Therefore, the entries derived for net capital expenditure are grossed up according to the constraint of the overall fixed capital formation. The entries relating to gross capital expenditure, which were derived using the half-constrained method, remain untouched.

We have therefore derived the row and column sums which are necessary to operationalise the RAS procedure. The adjustment of an investment matrix, however, is more complicated than the adjustment of a standard interindustry table. The problem is that some commodity groups do not contain any investment goods, so that the investment matrix is relatively sparse. In order to assess the significance of this feature, we need to consider the conditions under which the RAS procedure will converge.

A formal discussion concerning the proof of convergence and uniqueness of the RAS solution is outlined by Bacharach (1970). The core assumptions are that the estimated matrix and the R and S ratios, which make up the RAS procedure, should be nonnegative (see Appendix B) Of more relevance in the present context are the assumptions of strict positivity for the target row and column sums. The 19 sector vectors derived for Strathclyde and the rest of Scotland contain *zero* entries for some sectors, and therefore break the latter assumption.

In order to render the row and column sums strictly positive, all the data required for the RAS procedure has been aggregated from 19 to 12 sectors (see Table 4.19). The RAS procedure now converges, so that two 12 by 12 capital coefficient matrices can be derived - one for each region. The problem with this derivation is that each 12 by 12 matrix needs to be converted back to a 19 by 19 matrix. The disaggregation of rows is straightforward because each row, which was previously aggregated, originally contained zero entries. However, the aggregated columns contain non-zero elements, so a procedure is needed by which the relevant columns can be disaggregated in order to return from 12 to 19 columns. The relative proportions of each entry in the aggregated columns will have changed due to the adjustments which take place through the RAS iteration; and therefore the proportions which are contained in the base year 19 by 19 matrix are of no use for disaggregating the adjusted matrix. We therefore employ target column totals using a procedure which is analogous to the Chenery-Moses method

TABLE 4.19 An Aggregation Scheme For The 19 Sector Capital Coefficient Matrix - To 12 Sectors

	AGGREGATED SECTORS	ORIGINAL SECTORS
1	AGRICULTURE/FORESTRY/FISHING/ MINING/FOOD/DRINK/TOBACCO/OIL/ CHEMICALS/METAL MANUFACTURE	1 + 2 + + 4 + 5 + 6
2	ENGINEERING	7
3	SHIPBUILDING	8
4	VEHICLES	9
5	METAL GOODS	10
6	TEXTILES/LEATHER/CLOTHING	11 + 12
7	TIMBER/BUILDING MATERIALS	13
8	OTHER MANUFACTURING	14
9	CONSTRUCTION	15
10	PUBLIC UTILITIES	16
11	TRANSPORT/COMMUNICATIONS	17
12	OTHER SERVICES/DWELLINGS	18 + 19

(see Section 4.2.4).

For illustrative purposes we can consider a 3 by 3 matrix (J), for which two of the sectors are aggregated. Arbritary figures are given for each entry, with the bottom row consisting of zero entries:

$$J^0 = \begin{bmatrix} 1 & 2 & 3 \\ 4 & 6 & 1 \\ 0 & 0 & 0 \end{bmatrix} . \tag{4.30}$$

Sectors 2 and 3 are aggregated in order to derive a 2 by 2 matrix:

$$J^1 = \begin{bmatrix} 1 & 5 \\ 4 & 7 \end{bmatrix} . \tag{4.31}$$

Assume that the RAS procedure is employed, using target column and row totals, so that J^1 is transformed into

$$J^2 = \begin{bmatrix} 2 & 3 \\ 6 & 9 \end{bmatrix} . \tag{4.32}$$

This adjusted matrix has to be disaggregated back to a 3 by 3 format. The extra row contains zeros and can be added to J^2:

$$J^3 = \begin{bmatrix} 2 & 3 \\ 6 & 9 \\ 0 & 0 \end{bmatrix} . \tag{4.33}$$

The extra column is derived by using the target column totals:

$$V(1) = [\ 8 \quad 5 \quad 7\ ] \tag{4.34}$$

From the two right hand side column totals we derive the proportions:

$$\frac{5}{5+7} = \frac{5}{12} \text{, and} \tag{4.35}$$

$$\frac{7}{5+7} = \frac{7}{12} \text{ .} \tag{4.36}$$

These proportions can be applied to column 2 in J^3, so as to derive two separate columns:

$$J^4 = \begin{bmatrix} 2 & \left({}^5/_{12}\right)3 & \left({}^7/_{12}\right)3 \\ 6 & \left({}^5/_{12}\right)9 & \left({}^7/_{12}\right)9 \\ 0 & 0 & 0 \end{bmatrix} \text{ .} \tag{4.37}$$

The utilisation of these 'proportions' is based on the same principle as the trade coefficients used for the Chenery-Moses technique. Both techniques rely on overall flows, whether they be trade flows or column totals, in order to derive specific interindustry coefficients. The procedure followed for the 3 by 3 matrix has been applied to the disaggregation of the 12 columns for the Strathclyde and rest of Scotland capital coefficient matrices.

The final empirical exercise with regards to the investment data, involves the employment of the Chenery-Moses technique in its more usual trade dimension. From the RAS procedure we have derived two matrices of technical coefficients (Table 4.20).

TABLE 4.20 Two Capital Coefficient Matrices For The Two-Region Economy

	1 STRATHCLYDE	2 R OF SCOTLAND
STRATHCLYDE 1 R OF SCOTLAND 2 R OF U.K. 6 R OF WORLD 7	$[B^{*1}]$	$[B^{*2}]$

These coefficient matrices need to be disaggregated according to the origin of investment goods from the regions considered. For this purpose eight vectors of trade flows of investment goods have been derived. We can refer to Table 4.14 (Section 4.3) for a similar derivation of final demand flows for consumption goods. Exactly the same procedure used for the derivation of trade coefficients for consumption goods, can be applied to investment goods. The structure of the typical trade coefficient (S_i^{kp}) is shown in Equation 4.29. Each element of the capital coefficient matrix is disaggregated using the relevant trade coefficients. A typical element of a new capital coefficient matrix, relating to flows from region k to region p, is

$$B_{ij}^{kp} = B_{ij}^{*p} \, S_i^{kp}. \qquad (4.38)$$

We therefore derive eight commodity by industry capital coefficient matrices. It now remains to transform those matrices relating to flows within the Scottish economy into industry by industry technologies. This is achieved using the relevant market share matrices (see Equation 4.8, Section 4.2.2)

The derivation of capital coefficients in this section, has involved a series of manipulations. In addition to the problems of convergence and the availibility of data we can briefly consider the accuracy of the RAS procedure per se. Morrison and Smith (1974) found for their Peterborough study that the RAS procedure produced results which were superior to all other non-survey methods. Harrigan, McGilvray and McNicoll (1980) also found the RAS procedure to produce superior results, and regarded it as a 'benchmark' against which other techniques could be evaluated. Egan (1982), however, has argued that these superior results are due to the RAS procedure being of a quasi-survey nature. The derivation of investment matrices for Scotland has illustrated how survey data can be employed, and indeed is sometimes required for the RAS procedure to be made operational. Due to the incorporation of survey information into the derivation, it is quite plausible that the RAS procedure should generate superior results to less data hungry non-survey techniques.

The derivation of investment matrices for Scotland was only quasi-survey in the sense that row totals were available from the Scottish tables. Nevertheless, by several manipulations the method outlined in this section has incorporated as much information as possible. Of course the degree of accuracy derived from the quasi-survey nature of the derivation is reduced by the manipulations which were necessary for convergence.

4.5. SUPPLEMENTARY DATA REQUIREMENTS

A number of supplementary data requirements remain, in order to render the impact assessment framework operational. These include the calculation of a scalar value for the rate of unemployment benefit; and wage rates, employment, and labour time by sector. The bulk of the discussion concerns the derivation of labour time coefficients.

An estimate of the rate of unemployment benefit is required for the typical unemployed worker. A figure of £15.71 has been calculated by Liverpool University's Department of Economics, by taking into account national insurance, unemployment benefit, child benefit, earnings related supplement, supplementary benefit, rent rebates, and school meals (see Social Security Statistics 1973).

The calculation of wage rates per industrial worker requires two sets of information. Firstly, total wage payments per industrial sector are derived from the relevant input-output tables. Secondly, estimates of employment by sector for Scotland have been obtained from a research paper by the Dundee Scottish Economic Modelling Group(DSEMG 1981).[12] Employment estimates by sector are not available in published form, and have been obtained directly from the Department of Employment. Therefore, employment by sector for the rest of Scotland has been derived as a residual from the Scottish and Strathclyde data. These estimates allow the calculation

12. These figures are also available in the Department of Employment Gazette.

of wage rates by sector:

$$w_i = \frac{W_i}{E_i}, \qquad (4.39)$$

where

W_i = total wage bill in sector i, and

E_i = total employment in sector i.

Labour coefficients by sector are calculated by the equation:

$$\ell_i = \frac{E_i}{y_i}, \qquad (4.40)$$

where

y_i = total output in sector i.

In order to operationalise the labour value extension (Section 3.4), we need to calculate direct labour time coefficients. Webber and Foot (1984) calculated labour time by sector from Canadian wage data, by making the restrictive assumption of a uniform length for the working day. In contrast, the following derivation employs labour time figures obtained directly from the New Earnings Survey (1973).

Before estimating labour time by sector, the employment figures for Strathclyde and the rest of Scotland need to be disaggregated into the following subgroups:

- full-time male manual
- part-time male manual
- full-time male non-manual
- part-time male non-manual

- full-time female manual
- part-time female manual
- full-time female non-manual
- part-time female non-manual

This disaggregation is carried out using data provided by the DSEMG. Figures contained in the New Earnings Survey are used to calculated weekly labour time rates for each subgroup. One difficulty is that no data is available on labour time for part-time male workers. In view of the small proportion of part-time male workers, however, this was not considered too significant a defect. Labour time magnitudes for female workers were used as a surrogate measure.

The labour time rates calculated for each subgroup were aggregated so as to derive the total labour time per worker in each sector (LT_i). The direct labour time coefficient has the structure

$$L_i = \frac{LT_i \ E_i}{y_i}, \qquad (4.41)$$

where

L_i = the volume of labour time per unit of output in sector i, and

LT_i = the total labour time per worker in sector i.

This derivation was carried out for both Strathclyde and the rest of Scotland. It is assumed that rates of labour time activity are the same for both regions - the figures are derived from U.K. data.

For the calculation of labour values, Webber and Foot (1984) argued that higher wages reflect higher levels of skill content for employed labour time; so that the direct labour time coefficients were weighted according to the wages paid to workers. The problem with this approach is that once these modified labour time coefficients are introduced into the labour value equations, the derived labour values are no longer actual multipliers expressing the direct and indirect labour time required for production. In order to maintain uniformity in the social accounts matrix, we therefore assume that all labour time is homogeneous.

4.6. CONCLUSIONS

The necessary data for the operationalisation of the full two-region Type IV multiplier framework has been derived for the comparable regions of Strathclyde and the rest of Scotland. The core interindustry flows have been derived from the Strathclyde and Scottish input-output tables (1973) using an ad hoc residual procedure, which incorporates a series of non-survey pro rata manipulations and Chenery-Moses trade coefficients. Any large errors are likely to be generated by the non-survey part of the derivation, but the risk of incurring such errors is necessitated by the lack of interregional trade data for the U.K.

Using data from the Family Expenditure Survey (FES), consumption propensities have been derived for individual employed and unemployed workers. This derivation involves a number of manipulations, including the adaptation of household income and consumption data into individual consumption propensities; the weighting of U.K. consumption propensities to account fo Scottish consumption patterns; the matching of FES commodity classifications to the input-output sectors; and the application of the ad hoc residual procedure in order to derive local propensities to consume in each region. The latter derivation means that the trade configuration of consumer spending involves the sameconstraints as the interindustry flow data.

The derivation of capital coefficients has incurred a number of difficult problems which derive mainly from the lack of available data. The investment data must be backdated, using the RAS procedure, from the 1979 Scottish tables; static capital coefficients have been related to actual gross outputs rather than to changes in gross outputs; the target column totals are only available in the form of net capital expenditures which do not relate to all of the 19 industrial sectors; for the convergence of the RAS procedure the data has to be aggregated to 12 sectors and then disaggregated back to 19 sectors; and the ad hoc residual procedure must be employed in order to derive the trade dimension of investment flows. All these manipulations reduce the accuracy of RAS procedure. Compared with the household extension, the investment extension is more difficult to implement. For an impact analyst considering these two extensions, a straightforward procedure can be derived for the derivation of consumption propensities from the Family Expenditure Survey. In contrast, the investment extension involves severe problems in relation to the availability of data and the technical problems associated with the convergence of the RAS procedure.

The satisfaction of the supplementary data requirements of the model involves a series of simple calculations. Employment coefficients are calculated according to the proportional relationship between output and employment. This represents a much more simple formulation than the marginal employment coefficients which have been a feature of recent input-output studies (see Blackwell 1978). The formulation of labour time coefficients from national data, however, provides a considerable improvement on the crude derivation of labour time rates by Webber and Foot (1984) from wage data.

The derivation of data outlined in this chapter provides a basis for the operationalisation of the investment augmented Type IV multiplier. In the next chapter, Chapter Five, the main components of this multiplier framework are assessed. Further data preparation is required in Chapter Six for the investigation of the impacts of a demand side injection of government spending.

CHAPTER FIVE

AN ASSESSMENT OF THE MAIN EXTENSIONS TO THE INPUT-OUTPUT MODEL

5.1. INTRODUCTION

In this chapter an assessment is provided of each of the main extensions to the input-output model. The specific relevance of each extension is related to the overall objectives of applying an impact assessment framework to the measurement of the impacts of government spending in a regional context.

In Section 5.2 we compare the main components of the extended input-output multipliers, by taking the column sums of extended multiplier matrices, and by deriving ratios between the production (output) multipliers for each industrial sector. Using a multiplicative decomposition, we start with the Type I one-region model and compare the household (Type II and Type IV) extensions with the interregional ('closed loop' and 'open loop') extensions. The analysis then turns to the comparison of the investment and interregional extensions to the Type IV model. The purpose of these comparisons is to measure the significance of each linkage specified by a particular extension to the model, and thereby provide an assessment of the function which each extension performs for the measurement of economic impacts. If a linkage is identified to be significant relative to linkages specified by other extensions of the model, then this demonstrates the utility of a particular extension to the impact analyst.

Section 5.3 investigates the two-region structure of the investment augmented Type IV multiplier. This multiplier is disaggregated using the multiplicative decomposition, which provides a set of production multipliers for the intra-regional, spill-over and feedback linkages between regions. The overall bias of the investment augmented Type IV multiplier, in terms of the relative impacts of final demand on industrial outputs in each region, is subdivided into each of these linkages. In addition, the regional bias of labour values is considered through the derivation of two-region labour value multipliers.

In Section 5.4 we examine the application of the labour value extension to the input-output model to an understanding of uneven development between regions. This theoretical analysis concentrates on the theory of unequal exchange, which in recent years has been one of the most popular applications of Marx's labour theory of value to the regional context. The role of government spending as a stimulant to regional economic development provides the main focus of the analysis. In Section 5.5 the main conclusions to this chapter are summarised.

5.2. A COMPARISON OF EXTENDED INPUT-OUTPUT MULTIPLIERS

5.2.1. A Two-Region Multiplicative Decomposition

For the input-output modeller a number of extensions to the interindustry core can be considered (see Chapters Two and Three). Using a basic Type I intra-regional multiplier, one can assess the direct and indirect impacts of a change in final demand. In the context of a social accounts format, this multiplier would monitor the interdependence of industries *within* the production account of the SAM (see Table 3.1, p.72). A part of the injection in final demand, however, will result in extra economic activity in other accounts - in particular, the household account receives extra income which is translated into induced consumption,and the accumulation account receives extra savings in order to fund investment in capital goods. In order to make the impact multipliers more comprehensive, therefore, the model can be extended so as to account for feedback effects from other accounts. In the present context these extra accounts also include the activities of a second region.

A comparison of multipliers generated by these extensions can provide an assessment of their relative importance in a regional context. The regions of Strathclyde and the rest of Scotland provide a test case for such an assessment. The extended multipliers can be derived using a multiplicative decomposition developed by Round (1986; pp. 390-91) for a two-region economic system.[1] In order to adapt this decomposition to a two-region model, we present two equations showing the interdependence between two regions:

$$y_1^1 = R^{11}y_1^1 + R^{12}y_1^2 + f^1, \text{ and} \tag{5.1}$$

$$y_1^2 = R^{21}y_1^1 + R^{22}y_1^2 + f^2, \tag{5.2}$$

where

R^{11} and R^{22} = matrices of domestic technical coefficients, and

R^{12} and R^{21} = coefficient matrices of exports of commodities per unit of the other region's industrial output.

In matrix form we have

$$\begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} = \begin{bmatrix} R^{11} & R^{12} \\ R^{21} & R^{22} \end{bmatrix} \begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} + \begin{bmatrix} f^1 \\ f^2 \end{bmatrix}, \tag{5.3}$$

which can be solved as

$$\begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} = \begin{bmatrix} (I - R^{11})^{-1} & 0 \\ 0 & (I - R^{22})^{-1} \end{bmatrix} \left\{ \begin{bmatrix} 0 & R^{12} \\ R^{21} & 0 \end{bmatrix} \begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} + \begin{bmatrix} f^1 \\ f^2 \end{bmatrix} \right\}. \tag{5.4}$$

By further manipulation we obtain

$$\begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} = \begin{bmatrix} 0 & D^{12} \\ D^{21} & 0 \end{bmatrix} \begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} + \begin{bmatrix} (I - R^{11})^{-1} & 0 \\ 0 & (I - R^{22})^{-1} \end{bmatrix} \begin{bmatrix} f^1 \\ f^2 \end{bmatrix}, \tag{5.5}$$

---

1. This multiplicative decomposition was used to conceptualise each extension to the Type I input-output model developed in Section 2.3 and chapter 3.

where

$$D^{12} = (I - R^{11})^{-1}R^{12}, \text{ and}$$
$$D^{21} = (I - R^{22})^{-1}R^{21},$$

so that

$$\begin{bmatrix} y_1^1 \\ y_1^2 \end{bmatrix} = \begin{bmatrix} I & -D^{12} \\ -D^{21} & I \end{bmatrix}^{-1} \begin{bmatrix} (I - R^{11})^{-1} & 0 \\ 0 & (I - R^{22})^{-1} \end{bmatrix} \begin{bmatrix} f^1 \\ f^2 \end{bmatrix}, \tag{5.6}$$

or

$$y = M^x M^1 f. \tag{5.7}$$

The matrix M^1 is the intra-regional multiplier matrix, which captures the linkages wholly within each of the regions. The component M^x is referred to by Round (1985) as the 'interregional' multiplier matrix, showing all the (spatial) repercussions both within and between the two regions. The interregional multiplier matrix can be decomposed as follows:

$$M^x = \begin{bmatrix} I & -D^{12} \\ -D^{21} & I \end{bmatrix}^{-1}$$

$$= \begin{bmatrix} (I - D^{12}D^{21})^{-1} & (I - D^{12}D^{21})^{-1}D^{12} \\ (I - D^{21}D^{12})D^{21} & (I - D^{21}D^{12})^{-1} \end{bmatrix}$$

$$= \begin{bmatrix} (I - D^{12}D^{21})^{-1} & 0 \\ 0 & (I - D^{21}D^{12})^{-1} \end{bmatrix} \begin{bmatrix} I & D^{12} \\ D^{21} & I \end{bmatrix}$$

$$M^x = M^3M^2 \quad (5.8)$$

The matrix M^3 is the interregional 'closed loop' multiplier matrix, for which an increase in final demand in region k will induce extra industrial output in region p (via exports from p to k) which will feedback to region k (via exports from k to p). The matrix M^2 represents the interregional 'open loop' multiplier, which shows the knock-on effects between regions, over and above the 'own region' effects contained in M^3.

5.2.2. A Comparison Of The Interregional And Household Extensions To The Input-Output Model

The interregional multiplicative decomposition can be used to show the effects of an interregional extension on the size of the impact multipliers. For the scenario of an injection of final demand into a single region, we can derive a matrix multiplier which accounts for feedback effects from a second region in addition to the intra-regional effects. This is accomplished by pre-multiplying the intra-regional multiplier (M^1) by the 'closed loop' multiplier (M^3):[2]

$$M^F = M^3M^1, \quad (5.9)$$

where

M^F = a matrix multiplier incorporating intra-regional linkages for each region and the 'closed loop' feedback effects from the second region.

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2. Note that although we are interested, in this instance, in the injection of final demand in one region, the derived matrix multipliers display impacts for both regions.

This multiplier decomposition can be applied initially to the Type I input-output model. Assume that the interindustry coefficients, A^{k}_{11} and A^{kp}_{11} (see Section 3.3), take on the values of the technical coefficients shown in Equations (5.1) and (5.2):

$$R^{11} = A^{1}_{11}, \quad R^{12} = A^{12}_{11},$$
$$R^{21} = A^{21}_{11}, \quad R^{22} = A^{2}_{11}. \tag{5.10}$$

Substituting these identities into the multiplicative decomposition shown in Equations (5.1) through to (5.8), we can decompose the Type I two-region multiplier so that

$$M^{F}_{T1} = M^{3}_{T1}M^{1}_{T1}, \tag{5.11}$$

which is a Type I multiplier displaying both intra-regional and feedback linkages for each of the two regions.

The significance of the interregional extension can be compared with the demographic-economic extension to the Type I model. This latter extension is represented by the Type IV Batey-Madden model, which constitutes a more refined version of the simple Type II model (see Section 2.3.4). The structure of the Type IV intra-regional multipliers has been derived in Equations (2.13) and (2.44):

$$m^{1}_{T4} = c^{1}_{T4}c^{1}_{T2}m^{1}_{T1}, \text{ and} \tag{5.12}$$

$$m^{2}_{T4} = c^{2}_{T4}c^{2}_{T2}m^{2}_{T1}, \tag{5.13}$$

so that the block matrix Type IV intra-regional multiplier, showing intra-regional linkages for both regions, has the structure

$$M^{1}_{T4} = \begin{bmatrix} m^{1}_{T4} & 0 \\ 0 & m^{2}_{T4} \end{bmatrix} \qquad (5.14)$$

The derivation of the multipliers M^{F}_{T1} and M^{1}_{T4} has been carried out using the data set for interindustry flows within and between Strathclyde and the rest of Scotland. By finding the column sums of each 38 by 38 matrix multiplier, a collection of production (output) multipliers can be derived for the 19 industrial sectors in each region.[3] A typical column sum C_i shows the effect of a unit change in final demand in sector i on total gross outputs in the two-region economy as a whole. Due to the block diagonal structure of the multipliers M^{F}_{T1} and M^{1}_{T4}, however, the column sums of these matrix multipliers relate to the total effects on each regional economy separately.

A comparison of the significance of the Type IV and 'closed loop' interregional extensions involves the calculation of the magnitudes by which the Type I intra-regional multipliers are increased due to each extension.

3. The analysis concentrates on production multipliers instead of, for example, employment and income multipliers, because for the impact analysis carried out in the next chapter, Chapter Six, the measurement of the impacts of final demand on industrial production is central to the application of the two-region SAM. The measurement of the impacts of final demand on income and employment in this SAM, derives from the basic production multipliers.

We therefore take the ratios of the Type IV output multipliers, obtained from M^1_{T4}, to the Type I output multipliers, obtained from M^1_{T1} (Table 5.1). The 'closed loop' interregional extension is measured by taking the ratios of the output multipliers, obtained from M^F_{T1}, to the Type I intra-regional multipliers (Table 5.2).

In all but 2 sectors the Type IV extension results in a greater increase in the size of the output multipliers, as compared to the 'closed loop' extension.[4] Not only does this result signify to the input-output modeller the relative importance of the demographic-economic extension, it also shows the importance of household income and expenditure to the Strathclyde and rest of Scotland economies. This is despite the reduction in the overall size of the output multiplier which is generated by the inclusion of unemployed income and expenditure in the Type IV extension to th Type II model.

The interregional extension presented above has only concerned feedback effects between regions - the investigation has assumed a change in final demand for a single region. An alternative scenario would be to consider a change in government spending in both regions. Central government could, for example, allocate national education expenditure or defence procurements between various regions of the economy. In this case the injection of government spending in each region will induce

4. In Table 5.2 the symbols < denote the smaller size of the ratios derived for the 'closed loop' extension in comparison to the ratios for the Type IV extension in Table 5.1.

TABLE 5.1 RATIO 1: Ratios Of The Type IV Intra-Regional Multipliers To The Type I Intra-Regional Multipliers (column sums)

	SECTOR	RATIOS
STRATHCLYDE	1	1.04526
	2	1.11618
	3	1.01934
	4	1.03551
	5	1.04203
	6	1.05744
	7	1.06138
	8	1.07176
	9	1.06505
	10	1.06337
	11	1.03388
	12	1.00477
	13	1.06695
	14	1.06213
	15	1.05993
	16	1.04966
	17	1.10599
	18	1.03370
	19	1.00000
R OF SCOTLAND	1	1.06933
	2	1.12425
	3	1.04354
	4	1.05657
	5	1.03219
	6	1.05310
	7	1.07163
	8	1.04992
	9	1.03485
	10	1.05630
	11	1.02206
	12	1.01780
	13	1.06068
	14	1.05470
	15	1.05962
	16	1.05420
	17	1.10773
	18	1.05857
	19	1.00000

TABLE 5.2 RATIO 2: Ratios Of The Type I 'Closed Loop' Interregional Multipliers To The Type I Intra-Regional Multipliers(column sums)

	SECTOR	RATIOS
	1	1.02405 <
	2	1.00195 <
	3	1.00875 <
	4	1.00496 <
	5	1.00162 <
	6	1.00207 <
	7	1.00113 <
	8	1.00085 <
	9	1.00109 <
STRATHCLYDE	10	1.00226 <
	11	1.00299 <
	12	1.00406 <
	13	1.00290 <
	14	1.00241 <
	15	1.00279 <
	16	1.00524 <
	17	1.00056 <
	18	1.00141 <
	19	1.00000
	1	1.00753 <
	2	1.00239 <
	3	1.02154 <
	4	1.00483 <
	5	1.00232 <
	6	1.00250 <
	7	1.00209 <
	8	1.00263 <
	9	1.00218 <
R OF SCOTLAND	10	1.00367 <
	11	1.00321 <
	12	1.00815 <
	13	1.00428 <
	14	1.00201 <
	15	1.00240 <
	16	1.00296 <
	17	1.00085 <
	18	1.00120 <
	19	1.00000

< denotes a smaller interregional ratio (RATIO 2) than the corresponding ratio associated with the Type IV intra-regional extension (RATIO 1).

spill-over effects between regions, over and above the feedback effects generated by each region. In order to model both spill-over and feedback effects we can examine the full interregional extension to the Type I model. Assuming that the identities in Equation (5.10) still hold, the full two-region Type I multiplier has the structure[5]

$$M_{T1} = M^{x}_{T1} M^{1}_{T1}, \qquad (5.15)$$

which consists of the intra-regional Type I matrix multiplier (M^{1}_{T1}) pre-multiplied by the interregional Type I matrix multiplier (M^{x}_{T1}; see Equation 5.7).

By taking the column sums of M_{T1}, so as to reveal the two-region Type I output multipliers, the full two-region Type I multipliers can be compared with the intra-regional Type I multipliers. We therefore calculate the ratios of the two-region Type I output multipliers to the intra-regional Type I output multipliers (Table 5.3). For this full two-region extension the increase in the magnitude of the output multipliers is significantly greater than for the Type IV household extension - the ratios in Table 5.3 are higher than those in Table 5.1 for all but 2 sectors. This result means that if central government were to allocate public spending to several regions - in particular to Strathclyde and the rest of Scotland - the trade linkages between these regions would be more important than the incorporation of linkages

5. The two-region Type I multiplier is also shown in Chapter Three, Equation (3.17).

TABLE 5.3 RATIO 3: Ratios Of The Type I Two-Region ('Open And Closed Loop') Interregional Multipliers To The Type I Intra-Regional Multipliers

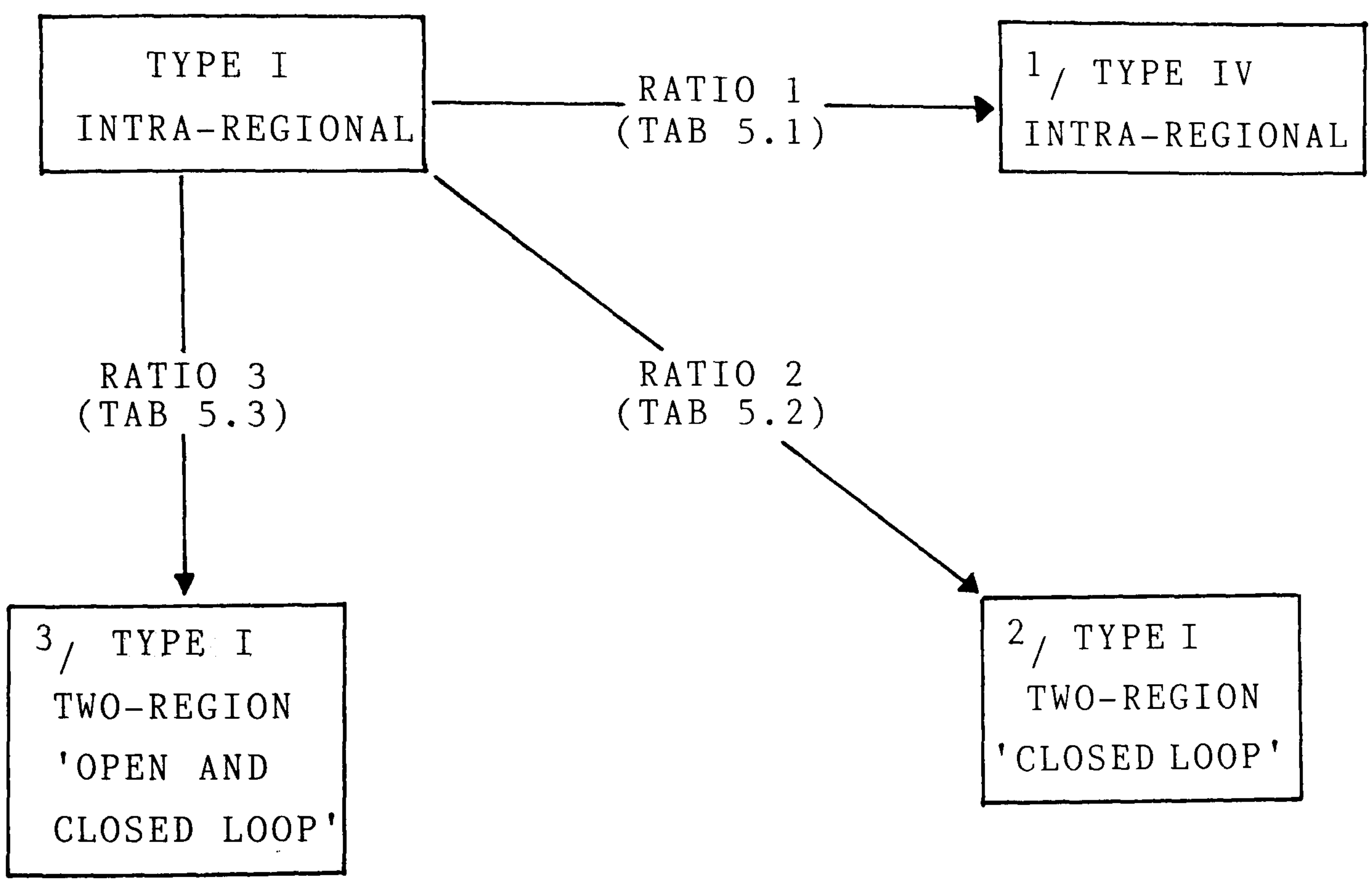
	SECTOR	RATIOS
	1	1.10291>
	2	1.25934>
	3	1.06817>
	4	1.08784>
	5	1.10362>
	6	1.12556>
	7	1.14368>
	8	1.16766>
	9	1.12708>
STRATHCLYDE	10	1.15936>
	11	1.12462>
	12	1.11312>
	13	1.15083>
	14	1.16290>
	15	1.14074>
	16	1.14584>
	17	1.23335>
	18	1.17084>
	19	1.00000
	1	1.15060>
	2	1.29888>
	3	1.11699>
	4	1.14162>
	5	1.07275>
	6	1.13733>
	7	1.18823>
	8	1.20732>
	9	1.13174>
R OF SCOTLAND	10	1.17135>
	11	1.13925>
	12	1.18127>
	13	1.14934>
	14	1.14934>
	15	1.14802>
	16	1.12400>
	17	1.27906>
	18	1.23012>
	19	1.00000

> denotes a larger interregional ratio (RATIO 3) than the corresponding ratio associated with the Type IV intra-regional extension (RATIO 1)

within the household accounts of each region.

The relative importance of the three extensions to the Type I model can be shown in a simple diagram (Figure 5.1)

FIGURE 5.1 The Relative Importance Of The Household And Interregional Extensions To The Type I Intra-Regional Multiplier



In general: RATIO 1 > RATIO 2

RATIO 3 > RATIO 1

where

RATIO i = the ratios of the output multipliers generated by extension i to the Type I intra-regional output multipliers.

To summarise, the ratios derived from the Type I 'closed loop' interregional extension (RATIO 2) are smaller than the ratios derived for the Type IV intra-regional extension (RATIO 1); but the ratios derived from the full two-region extension (RATIO 3) are larger than those derived for the Type IV extension.

5.2.3. A Comparison Of The Interregional And Investment Extensions To The Input-Output Model

The comparative analysis conducted for the extensions to the Type I model can also be applied to the Type IV model. Assume that an impact analyst has already decided to implement a household endogenous Type IV intra-regional model. The researcher may wish to further extend this model, and would be faced with a number of alternatives. These could include an interregional extension, as before, and/or a new investment extension incorporating the creation of additional capacity requirements by firms in response to changes in final demand (see Section 3.2). This investment extension can be compared to the 'closed loop' and 'open and closed loop' interregional extensions to the Type IV model. Note in this instance that the interregional extension would include trade flows of consumption goods, in addition to flows of inter-industry goods.

For the interregional extension we assume that the technical coefficients of the two-region equations (see Equations 5.1 and 5.2) take on the following identities:[6]

---

6. The E^{kp} components represent the Type II (employed expenditure) extensions, whilst the F^{kp} components represent the Type IV (unemployed expenditure) extensions (see Section 3.3, Equations 3.13 and 3.12).

$$R^{11} = A_{11}^{1} + E^{11} - F^{11}, \qquad R^{12} = A_{11}^{12} + E^{12} - F^{12},$$

$$R^{21} = A_{11}^{21} + E^{21} - F^{21}, \qquad R^{22} = A_{11}^{2} + E^{22} - F^{22},$$

(5.16)

Substituting these identities into Equations (5.1) through to (5.8), we can decompose the two-region Type IV multiplier:

$$M_{T4}^{F} = M_{T4}^{3} M_{T4}^{1}, \tag{5.17}$$

This is a Type IV multiplier incorporating intra-regional linkages within each region and 'closed loop' linkages from a second region.

The investment extension to the Type IV model is introduced using the multiplicative decomposition adopted for the dynamic Type IV model (see Equation 3.9, Section 3.2). The intra-regional investment augmented Type IV multipliers have the structure

$$m_{DT4}^{1} = c_{DT4}^{1} m_{T4}^{1}, \text{ and} \tag{5.18}$$

$$m_{DT4}^{2} = c_{DT4}^{2} m_{T4}^{2}. \tag{5.19}$$

In its block matrix form the Type IV intra-regional multiplier has the structure

$$M_{DT4}^{1} = \begin{bmatrix} m_{DT4}^{1} & 0 \\ 0 & m_{DT4}^{2} \end{bmatrix}. \tag{5.20}$$

The full two-region investment augmented Type IV multiplier, including 'open and closed loop' effects can be derived, assuming the identities in Equation (5.16), from the decomposition contained in Equation (5.7):

$$M_{T4} = M^{x}_{T4} M^{1}_{T4}. \tag{5.21}$$

We have therefore derived matrix multipliers which include an intra-regional investment extension (M^{1}_{DT4}); a 'closed loop' interregional extension (M^{F}_{T4}); and an 'open and closed loop' interregional extension (M_{T4}). The column sums of these 38 by 38 matrices have been taken in order to derive three sets of output multipliers. We first take the ratios of the output multipliers in M^{1}_{DT4} to the intra-regional Type IV multipliers in M^{1}_{T4} (Table 5.4). Secondly, we take the ratios of the output multipliers in M^{F}_{T4} to the multipliers in M^{1}_{T4} (Table 5.5). Lastly, we take the ratios of the multipliers in M_{T4} to the multipliers in M^{1}_{T4} (Table 5.6). These ratios are compared in Figure 5.2.

FIGURE 5.2 The Relative Importance Of The Interregional And Investment Extensions To The Type IV Intra-Regional Multiplier

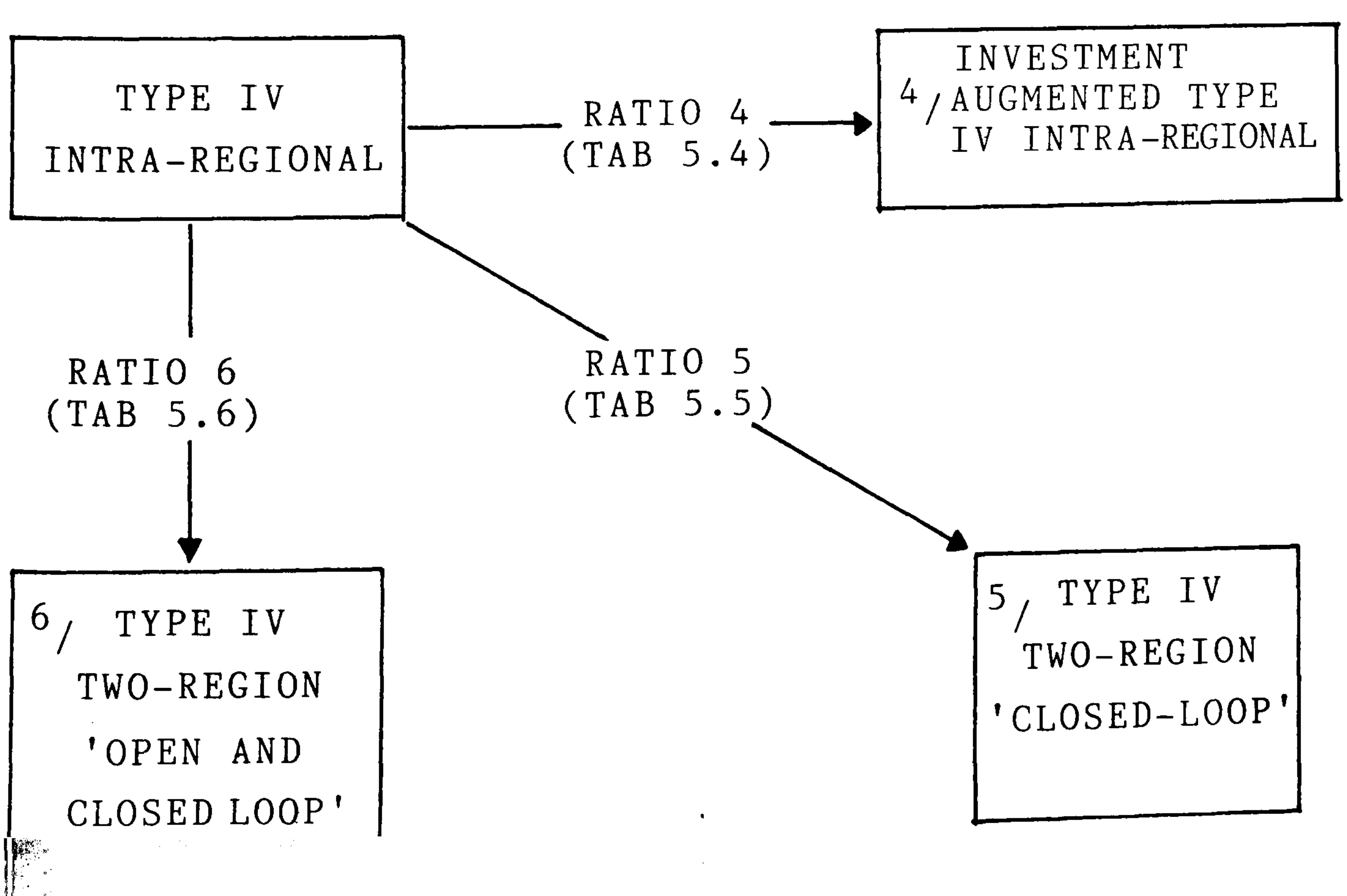


TABLE 5.4 RATIO 4: Ratios Of The Investment Augmented Type IV Intra-Regional Multipliers To The Type IV Intra-Regional Multipliers (column sums)

	SECTOR	RATIOS
STRATHCLYDE	1	1.11988
	2	1.07967
	3	1.03862
	4	1.05375
	5	1.19569
	6	1.04069
	7	1.04664
	8	1.04942
	9	1.03028
	10	1.04779
	11	1.05407
	12	1.03035
	13	1.05954
	14	1.06224
	15	1.03120
	16	1.35871
	17	1.17555
	18	1.25496
	19	1.00000
R OF SCOTLAND	1	1.07365
	2	1.06638
	3	1.05657
	4	1.07867
	5	1.13726
	6	1.05857
	7	1.05244
	8	1.04147
	9	1.02294
	10	1.05333
	11	1.03742
	12	1.05681
	13	1.05817
	14	1.04301
	15	1.02696
	16	1.32648
	17	1.15442
	18	1.24147
	19	1.00000

TABLE 5.5 RATIO 5: Ratios Of The Type IV 'Closed Loop' Interregional Multipliers To The Type IV Intra-Regional Multipliers (column sums)

	SECTOR	RATIOS
STRATHCLYDE	1	1.03062 <
	2	1.00521 <
	3	1.01102 <
	4	1.00710 <
	5	1.00335 <
	6	1.00407 <
	7	1.00307 <
	8	1.00286 <
	9	1.00306 <
	10	1.00448 <
	11	1.00448 <
	12	1.00483 <
	13	1.00550 <
	14	1.00501 <
	15	1.00507 <
	16	1.00877 <
	17	1.00332 <
	18	1.00263 <
	19	1.00000
R OF SCOTLAND	1	1.01026 <
	2	1.00623 <
	3	1.02469 <
	4	1.00735 <
	5	1.00402 <
	6	1.00488 <
	7	1.00488 <
	8	1.00558 <
	9	1.00412 <
	10	1.00663 <
	11	1.00447 <
	12	1.00974 <
	13	1.00712 <
	14	1.00397 <
	15	1.00497 <
	16	1.00546 <
	17	1.00395 <
	18	1.00301 <
	19	1.00000

< denotes a smaller interregional ratio (RATIO 5) than the corresponding ratio associated with the investment intra-regional extension (RATIO 4)

TABLE 5.6 RATIO6: Ratios Of The Type IV Two-Region ('Open And Closed Loop') Interregional Multipliers To The Type IV Intra-regional Multipliers (column sums)

	SECTOR	RATIOS		
STRATHCLYDE	1	1.48572	>	
	2	1.10538	>	
	3	1.16445	>	
	4	1.12664	>	
	5	1.07460		<
	6	1.08493	>	
	7	1.06180	>	
	8	1.05428	>	
	9	1.05949	>	
	10	1.09107	>	
	11	1.09470	>	
	12	1.08438	>	
	13	1.11091	>	
	14	1.12795	>	
	15	1.09427	>	
	16	1.18161		<
	17	1.06457		<
	18	1.06133		<
	19	1.00000		
R OF SCOTLAND	1	1.07713	>	
	2	1.06405		<
	3	1.11888	>	
	4	1.06227		<
	5	1.04664		<
	6	1.05380		<
	7	1.05700	>	
	8	1.07821	>	
	9	1.04940	>	
	10	1.07912	>	
	11	1.05427	>	
	12	1.07855	>	
	13	1.06785	>	
	14	1.03520		<
	15	1.05278	>	
	16	1.05421		<
	17	1.04031		<
	18	1.02967		<
	19	1.00000		

> (<) denotes a larger (smaller) interregional ratio (RATIO 6) than the corresponding ratio associated with the investment augmented intra-regional extension (RATIO 4)

In general: RATIO 4 > RATIO 5

RATIO 6 > RATIO 4

where

RATIO j = the ratios of output multipliers generated by extension j to the Type IV intra-regional multipliers.

The investment extension generates higher multipliers in comparison to the Type IV multiplier. Therefore, the response of investment to changes in output is adjudged to be more pronounced than the feedback effects from a second region. Once the 'open loop' effects are included, in addition to the feedback effects, then overall the spill-over effects are large enough to generate higher multipliers than the investment extension. However, these results are not as conclusive as before (see Table 5.6). For Strathclyde, output multipliers are greater for the full two-region extension relative to the investment extension in 14 sectors; but for the rest of Scotland output multipliers are higher for only 10 sectors. The full two-region extension has a greater impact on the size of production multipliers relative to the intra-regional investment extension, but for only 24 of the 38 industrial sectors in the two-region economy. Since the objectives of the study focus on the measurement of the impacts of government spending across all industrial sectors, however, we can conclude that the full two-region extension is a more important component of the impact assessment framework than the investment extension, in terms of the magnitude of production multipliers.

5.2.4. Conclusions

In this section we have obtained the results that in general the one-region investment and household extensions are more important than the 'closed loop' feedback effects from a second region. The linkages between industrial output, investment, and household activity, within the regions of Strathclyde and the rest of Scotland, are more significant than the feedback linkages from a second region. Once the 'open loop' effects are introduced, however, the output multipliers generate higher ratios than those derived for the one-region extensions. We can therefore conclude that if an impact analyst is concerned with the assessment of an impulse of final demand into one region, then there is evidence from this case study to suggest that it would be more pertinent to consider linkages between additional accounts within that region than to consider linkages with a second region. Conversely, if the research is concerned with changes in final demand in both regions, then the consideration of interregional linkages is more important than the linkages within each region.

These results provide an ex-post validation of the interregional component of the impact assessment framework. Of course, this analysis only relates to the magnitudes of production multipliers - an impact analyst may employ various extensions to the input-output model, according to the specific characteristics of a regional economy, and according to the specific types of economic impacts which may be of interest. The multiplier analysis in this section only provides a test case for the modelling of linkages within the Scottish economy. Obviously an impact analyst does not have this type of information available before constructing an input-output model, but case studies such as this provide evidence as to the 'likely' magnitudes of linkages for a small area study within the U.K. economy.

5.3. AN ASSESSMENT OF THE REGIONAL STRUCTURE OF THE TWO-REGION INVESTMENT AUGMENTED TYPE IV MULTIPLIER

For the purposes of an impact analysis, a two-region input-output model provides information on the differential response of economic activity between regions, subsequent upon an injection of government spending. This information offers an insight into which of the regional economies benefits most from equal injections of government spending, thereby providing a useful assessment of any regional policy objectives which central government might consider for the allocation of public expenditure. In this section we consider the response of gross outputs - measured in both money and labour value units - to an impulse of final demand. Such a focus concentrates specifically on the supply side of the economy, assuming a uniform change in final demand for each sector.

In order to examine the relative structural responses of the Strathclyde and the rest of Scotland economies to changes in final demand, we can decompose the two-region investment augmented Type IV multiplier using the multiplicative procedure. Before employing this decomposition, however, we can examine the structure of the fully extended investment augmented Type IV multiplier (see Equation 3.17). For an examination of the regional structure of the economy, we calculate the *row* sums of the investment augmented Type IV multiplier. A typical row sum R_i shows the total impact of a uniform change in final demand in all sectors (in both regions) on output in sector i. Using these row sums we can isolate the total impact of this uniform change on outputs in each region. The column totals employed in Section 5.2, for the comparison of various extensions to the input-output model, are not applicable because they include the total effects of an impulse of final demand on output in both regions.

The row sums of the two-region investment augmented Type IV multiplier reveal an overall bias towards the rest of Scotland (see Table 5.7). The row sum multipliers for 14 out of 19 sectors are higher for the rest of Scotland than for Strathclyde. This shows that a uniform change in final demand over all sectors in both regions, will result in a higher increase in output in the rest of Scotland than for Strathclyde. A decomposition of the investment augmented Type IV multiplier can be used to understand this bias in more detail.

For the multiplicative decomposition of the two-region investment augmented Type IV multiplier, the technical coefficients of the two-region equations (see Equations 5.1 and 5.2) take on the following identities:

$$
\begin{aligned}
R^{11} &= A^{1}_{11} + E^{11} - F^{11} + A^{1}_{14}, \\
R^{12} &= A^{12}_{11} + E^{12} - F^{12} + A^{12}_{14}, \\
R^{21} &= A^{21}_{11} + E^{21} - F^{21} + A^{21}_{14}, \text{ and} \\
R^{22} &= A^{2}_{11} + E^{22} - F^{22} + A^{2}_{14}.
\end{aligned}
\tag{5.22}
$$

Substituting these identities into the multiplicative decomposition shown in Equations (5.1) through to (5.8), we can decompose the two-region investment augmented Type IV multiplier so that

TABLE 5.7 Row Sums Of The Two-Region Investment Augmented Type IV Multiplier

	SECTOR	ROW SUMS
	1	1.62518<
	2	1.26039<
	3	1.66847<
	4	1.32897<
	5	1.47088<
	6	1.53517 >
	7	1.53945<
	8	1.15367 >
	9	1.09059 >
STRATHCLYDE	10	1.26460 >
	11	1.19825<
	12	1.05056<
	13	1.52857<
	14	1.27249<
	15	3.31122<
	16	1.31126<
	17	2.22427<
	18	3.15076<
	19	1.00000
	1	2.57899
	2	1.48616
	3	1.70416
	4	1.35809
	5	1.69946
	6	1.42400
	7	1.53949
	8	1.11520
	9	1.05385
R OF SCOTLAND	10	1.20794
	11	1.35146
	12	1.05616
	13	1.66054
	14	1.27985
	15	3.36971
	16	1.68572
	17	3.43909
	18	3.28246
	19	1.00000

> (<) denotes a larger (smaller) production multiplier for an industrial sector in Strathclyde relative to the corresponding sector in the rest of Scotland.

$$M_{DT4} = M^3_{DT4} M^2_{DT4} M_{DT4}, \qquad (5.23)$$

where

M_{DT4} = the two-region investment augmented Type IV matrix multiplier,

M^2_{DT4} = the two-region 'open loop' investment augmented Type IV matrix multiplier,

M^3_{DT4} = the two-region 'closed loop' investment augmented Type IV matrix multiplier, and

M^1_{DT4} = the intra-regional investment augmented Type IV matrix multiplier.

The intra-regional investment augmented Type IV multiplier (M^1_{DT4}) displays a bias towards Strathclyde (Table 5.8). This bias, however, is only marginal - 10 out of 19 sectors display higher row sum multipliers in Strathclyde than for the rest of Scotland. What becomes crucial is the structure of the interregional multipliers. The 'closed loop' interregional multiplier (M^3_{DT4}) also displays a bias towards Strathclyde - in 11 out of 19 sectors (Table 5.9). The most significant bias, however, is displayed by the 'open loop' interregional multiplier (M^2_{DT4}). For the 'open loop' multiplier 14 out of 19 sectors display a bias towards the rest of Scotland (Table 5.10). Due to the marginal bias towards Strathclyde associated with the intra-regional multiplier, and due to the weakness of the 'closed loop' feedback effects, we can conclude that the bias displayed by the 'open loop' multiplier is significant enough to shift the overall bias of the investment augmented Type IV multiplier towards the rest Scotland.

This overall bias towards the rest of Scotland is

TABLE 5.8 Row Sums Of The Intra-Regional Investment Augmented Type IV Multiplier

SECTOR	ROW SUMS
1	1.47620<
2	1.22329<
3	1.49340 >
4	1.16208 >
5	1.26610<
6	1.43657 >
7	1.36505 >
8	1.09764<
9	1.05522 >
10	1.13098<
11	1.14416<
12	1.02590<
13	1.39864<
14	1.20080 >
15	3.15532 >
16	1.22471<
17	2.11635<
18	2.92134 >
19	1.00000
1	1.88795
2	1.34832
3	1.44841
4	1.16069
5	1.39302
6	1.33689
7	1.34952
8	1.09912
9	1.03593
10	1.15802
11	1.27295
12	1.03080
13	1.47736
14	1.17089
15	3.05366
16	1.41749
17	3.08838
18	2.78335
19	1.00000

> (<) denotes a larger (smaller) production multiplier for an industrial sector in Strathclyde relative to the corresponding sector in the rest of Scotland.

TABLE 5.9 Row Sums Of The 'Closed Loop' Interregional Investment Augmented Type IV Multiplier

	SECTOR	ROW SUMS
STRATHCLYDE	1	1.01493<
	2	1.00315<
	3	1.01724 >
	4	1.01326 >
	5	1.01818 >
	6	1.00505 >
	7	1.01193 >
	8	1.00332 >
	9	1.00233 >
	10	1.00632 >
	11	1.00230<
	12	1.00153 >
	13	1.00831 >
	14	1.00528 >
	15	1.01281<
	16	1.00719<
	17	1.00828<
	18	1.01902<
	19	1.00000
R OF SCOTLAND	1	1.03684
	2	1.00556
	3	1.01285
	4	1.00821
	5	1.01331
	6	1.00457
	7	1.00887
	8	1.00066
	9	1.00074
	10	1.00192
	11	1.00234
	12	1.00098
	13	1.00640
	14	1.00503
	15	1.01430
	16	1.01176
	17	1.01634
	18	1.02229
	19	1.00000

> (<) denotes a larger (smaller) production multiplier for an industrial sector in Strathclyde relative to the corresponding sector in the rest of Scotland.

TABLE 5.10 Row Sums Of The 'Open Loop' Interregional Investment Augmented Type IV Multiplier

	SECTOR	ROW SUMS
	1	1.10174<
	2	1.02409<
	3	1.11932<
	4	1.10051<
	5	1.13952<
	6	1.06952 >
	7	1.12102<
	8	1.03562 >
	9	1.02051 >
STRATHCLYDE	10	1.10570 >
	11	1.04425<
	12	1.01704<
	13	1.07367<
	14	1.04818<
	15	1.10234<
	16	1.05702<
	17	1.07127<
	18	1.15275<
	19	1.00000
	1	1.47604
	2	1.09865
	3	1.17884
	4	1.13317
	5	1.21504
	6	1.06592
	7	1.14035
	8	1.01156
	9	1.01274
R OF SCOTLAND	10	1.02645
	11	1.06617
	12	1.01799
	13	1.09293
	14	1.06900
	15	1.21797
	16	1.18783
	17	1.24487
	18	1.34641
	19	1.00000

> (<) denotes a larger (smaller) production multiplier for an industrial sector in Strathclyde relative to the corresponding sector in the rest of Scotland.

further accentuated once the labour value extension is introduced to the model. In 13 out of 19 sectors the labour values associated with commodities produced by the rest of Scotland are higher than the labour values associated with Strathclyde production (Table 5.11). By pre-multiplying the two-region investment augmented Type IV multiplier (M_{DT4}) by a diagonal matrix of labour values ($\hat{\Lambda}$) we obtain

$$M^{*}_{DT4} = \hat{\Lambda} M_{DT4}, \tag{5.24}$$

which is the investment augmented Type IV labour value multiplier. The bias of labour values in favour of the rest of Scotland is reflected in the row sums of this multiplier for 14 out of 19 sectors (Table 5.12).

In this section, therefore, we have obtained the result that the overall two-region multiplier displays a bias towards the rest of Scotland relative to Strathclyde. The intra-regional and 'closed loop' multipliers work to the advantage of Strathclyde but the 'open loop' interregional multiplier, along with the labour value extension, displays a bias towards the rest of Scotland.

TABLE 5.11 Labour Values Of Commodities Produced In Strathclyde And The Rest Of Scotland

	SECTOR	LABOUR VALUES	
	1	1.09643	
	2	1.08064	
	3	0.67346	
	4	0.72530	
	5	1.07526	
	6	0.86575	
	7	0.84310	
	8	1.20339	
	9	0.41062	
STRATHCLYDE	10	0.93890	
	11	1.01651	
	12	0.99581	
	13	0.98946	
	14	1.35031	
	15	0.80652	
	16	1.16613	
	17	1.09718	
	18	0.90571	
	19	0.00000	
	1	0.81434<	
	2	1.18434	>
	3	1.12056	>
	4	0.88915	>
	5	1.18048	>
	6	0.90100	>
	7	1.10088	>
	8	1.37927	>
	9	0.64137	>
R OF SCOTLAND	10	1.15243	>
	11	1.17337	>
	12	1.82148<	
	13	1.10654	>
	14	1.40355	>
	15	0.73328<	
	16	0.89942<	
	17	1.18935	>
	18	0.87302<	
	19	0.00000	

> (<) denotes a larger (smaller) labour value for a commodity produced in the rest of Scotland relative to the corresponding labour value in Strathclyde.

TABLE 5.12 Row Sums Of The Two-Region Investment Augmented Type IV Labour Value Multiplier

	SECTOR	ROW SUMS	
STRATHCLYDE	1	1.78191<	
	2	1.36203<	
	3	1.12364<	
	4	0.96391<	
	5	1.58159<	
	6	1.32908	>
	7	1.29790<	
	8	1.38832<	
	9	0.44782<	
	10	1.18733<	
	11	1.21804<	
	12	1.04615	>
	13	1.51246<	
	14	1.71827<	
	15	2.67056	>
	16	1.52910	>
	17	2.44042<	
	18	2.85366<	
	19	0.00000	
R OF SCOTLAND	1	2.10017	
	2	1.76012	
	3	1.90962	
	4	1.20755	
	5	2.00618	
	6	1.28302	
	7	1.69480	
	8	1.53818	
	9	0.67591	
	10	1.39208	
	11	1.58575	
	12	1.92377	
	13	1.83745	
	14	1.79634	
	15	2.47094	
	16	1.51617	
	17	4.09029	
	18	2.86564	
	19	0.00000	

> (<) denotes a larger (smaller) labour value multiplier for an industrial sector in Strathclyde relative to the corresponding sector in the rest of Scotland.

5.4. ON THE INAPPLICABILITY OF THE THEORY OF UNEQUAL EXCHANGE TO A REGIONAL CONTEXT

In this section an assessment is provided of the labour value extension to the input-output model. We explore how this extension can be used to monitor the relationship between government spending and uneven development between regions. In contrast to the multiplier analysis in the previous sections of this chapter, a purely theoretical analysis is conducted in order to prepare the ground for the impact analysis in Chapter Six.

The impetus for the labour value extension to the input-output model in this study, derives partly from its relevance to theory of unequal exchange, as popularised by Emmanuel (1969). Using this theory one can measure unequal flows of socially necessary labour time between spatial locations, and thereby deduce unequal rates of development as a corollary. In recent years there has been an increasing interest in the applicability of the theory of unequal exchange to intranational regions, in contrast to its more usual application to the modelling of relationships between developed and developing/Third World nations (see Liossatos 1980; Marelli 1983; Sheppard 1983; Ferrao and Butler 1984; Barnes 1985). In the discussion that follows we show why this application of the theory of unequal exchange to intranational regions is misplaced. An alternative application for the labor value extension is suggested.

Unequal exchange derives from the deviation of prices of production from labour values which is concomitant with the transformation procedure used by Marx (1894) in *Capital* Volume III. This deviation, in Marx's schema, results from the equalisation of profits between industries with different organic compositions of capital. In Emmanuel's (1969) conceptualisation of unequal exchange an additional reason for the deviation of prices from values is included - namely the occurrence of different rates of surplus value between industries. This second cause of unequal exchange is categorized by Emmanuel as unequal exchange in the 'narrow sense', whilst the first cause is unequal exchange in the 'broad' sense. Unequal exchange takes place because when prices deviate from values, an equal exchange of commodities between industries (in money terms) can engender an unequal transfer of socially necessary labour time. Once industrial activity is disaggregated across regions then this transfer of value is deemed to fuel unequal development between regions.

Emmanuel argued that unequal exchange in the 'narrow' sense, due to different rates of surplus value, was specific to international trade. This argument is based on the empirical observation that significant differences in wage rates exist between developed and less developed countries; and this will cause different rates of surplus value in favour of the developed country. Differences in organic compositions of capital will, of course, be a factor in determining the degree of unequal exchange between countries, but according to anuel such differences will occur with every exchange in the capitalist system. Unequal exchange could, for example, occur between different regions of France *and* between France and Guinea. Emmanuel asks,

> "How then can one talk of an inequality peculiar to international trade if exactly the same phenomenon occurs between regions and between branches of production inside one country.
>
> (Emmanuel 1969, p.161)

It follows from this interpretation that only unequal exchange in the 'broad' sense is relevant to regions inside a country - differences in rates of surplus value are peculiar to international trade and are not, therefore, pertinent to the occurrence of unequal exchange between regions. In concentrating on unequal exchange in the 'broad' sense we effectively discount the significance of differing wage rates between intranational regions. In the analysis that follows we examine Emmanuel's empirical example in which organic compositions of capital are allowed to differ between regions (see Emmanuel 1969, p.162).

Consider a simple two-region economy in which the organic compositions of all industries in each region are aggregated together. The labour value of each commodity consists of the constant capital required for production (e.g. raw materials and machinery); the variable capital (payments to labour); and the surplus value expropriated from the workforce:

$$\lambda = c + v + s, \qquad (5.25)$$

where

λ = the direct and indirect labour time required for production,

c = constant capital,

v = variable capital, and

s = surplus value.

These additive values can be represented using a simple example (Table 5.13).[7]

TABLE 5.13 Value Calculation In A Two-Region Economy

	c	v	s	λ	r_i	Π_i	$c/_v$	p
REGION 1	180	60	60	300	25%	80	3	320
REGION 2	60	60	60	180	50%	40	1	160
TOTAL	240	120	120					

If we assume initially that commodities exchange at their values, then by using the formula $^s/_{c+v}$ for each region, two different rates of profit (r_i) are derived. Region 1 produces industrial output at a profit rate of 25%, whilst region 2 receivesthe higher rate of 50%. As Marx (1894) recognized, however, there is a tendency under capitalism for capital to be mobile so that profit rates are equalized. In the two-region economy a uniform rate of profit will prevail and take on the value

$$r = \frac{120}{360} = 33\tfrac{1}{3}\% .$$

7. For purposes of simplification, in this example all constant capital is used up in the production period, whereas in Emmanuel's version only a part of constant capital is depreciated. Also the rate of surplus value ($^s/_v$) is uniform across regions.

Once this rate of profit is applied to both regions, then the price of industrial outputs in each region is determined as a mark up on total capital:

$$p = c + v + r(c + v). \qquad (5.26)$$

This revised price calculation involves a rise in the price of output in region 1 (from 300 to 320) and a fall in the price of output in region 2 (from 180 to 160). The volumes of surplus value generated by each region are pooled together and redistributed according to the size of each region's total capital (constant and variable). Effectively region 2 does not realise the 60 units of surplus value it produces - only 40 units are realised. There is a transfer of 20 units of value from region 2 to region 1. In view of the assumption concerning a uniform rate of surplus value ($^s/_v$), this transfer is determined by the relative organic compositions of capital ($^c/_v$) in each region. Region 1 has the higher organic composition of the two regions, and therefore it realises the greatest profits in proportion to the size of its total capital. The greater the size of constant capital, relative to variable capital, then the greater is the volume of surplus value realised in the region, via a transfer of value (as profits), and the smaller is the amount of surplus value actually generated in that region.

An important criticism of Emmanuel's argument is that the schema is based on an incorrect transformation procedure. The problem is that Marx (1894), in *Capital* Volume III, did not transform the inputs of constant and able capital from values to prices. To quote Sweezy,

> "Now it is obvious that in a system in which price calculation is universal both the capital used in production and the production itself must be expressed in price terms."
>
> (Sweezy 1942, p.115)

Throughout this century a number of solutions to this inconsistency have been offered. Bortkiewicz (1907) was the first to transform all inputs into prices, but due to his choice of assumptions found that the identity, which Marx had asserted, between total prices and total values, did not hold. Winternitz (1948) incorporated this latter identity as an assumption, but found as a result that total profits are not equal to total surplus value; and that the money rate of profit, which prevails under capitalism,differs from the value rate of profit. Seton (1957) concluded that the results obtained from the transformation procedure depend on the postulation of arbitrary assumptions which are necessary to 'close' the system of equations. With the onslaught of the so called neo-Ricardian attack on Marxian economics in the 1970's (see Section 3.4), Steedman (1977) proved that none of the above identities could hold under a correct transformation of values into prices.

The non-identity between the money and value rates of profit has serious ramifications for the theory of unequal exchange. The value rate of profit, which Emmanuel employs, is equalized according to the relative sizes of total capital in each region, measured in value terms; but the money rate of profit, which prevails under competition, is equalized according to the relative sizes otal capital measured in money terms. Therefore, the redistribution of surplus value between sectors depends on the relative sizes of total capital in each sector, measured in *money* terms. The mechanistic relationship between the organic composition of capital, which measures the degree of capital intensity in value terms, and transfers of socially necessary labour time, will no longer hold once a correct transformation procedure is adopted.

Liossatos (1980) has developed indices of unequal exchange in the 'broad' sense which depend on capital-intensity differentials expressed in money terms. Unequal exchange, therefore, can still take place between regions, but this will depend on the relative capital structures measured in money terms. There is a direct relationship between the level of capital intensity measured in value terms (the organic composition of capital) and capital intensity measured in money terms. This relationship depends on the value of constant capital relative to its price, and the value of labour power (variable capital) relative to the money outlay on wages. As will become apparent, however, the crucial question is not what determines the magnitude of unequal exchange; of more importance to a regional analysis is *how* the deviation of prices from values relates to the unequal development of regions.

Assume that the industries in both regions invest all their profits into the accumulation of capital (c + v). The amounts of profit realised in each region are calcul-ated by the equation

$$\Pi_i = r(c + v), \tag{5.27}$$

which shows the mark up of profits on total capital. If all profits are reinvested, then for region i the growth in total capital is

$$\Delta(c + v)_i = \Pi_i. \tag{5.28}$$

The rate of growth of capital is calculated by taking the growth in capital as a proportion of the original capital stock. For region 1:

$$\text{rate of growth} = \frac{\Delta(c + v)_1}{(c + v)_1}$$

$$= \frac{80}{240}$$

$$= \underline{33\tfrac{1}{3}\%}$$

For region 2:

$$\text{rate of growth} = \frac{\Delta(c + v)_2}{(c + v)_2}$$

$$= \frac{40}{120}$$

$$= \underline{33\tfrac{1}{3}\%}$$

Even though unequal exchange takes place between the two regions, the rates of growth are the same if all profits are invested. This is because both the rate of profit and the rate of growth depend on the size of total capital. How then can unequal exchange result in unequal rates of :lopment between regions?

Emmanuel considers the relaxation of the assumption that all profits are reinvested. If region 1, which realises more profits than region 2, decides to take advantage of its wealth by consuming part of these profits, then this would allow region 1 to catch up by reinvesting all its profits. Emmanuel does not, however, provide a theoretical reason for why this scenario should take place. As will be explained, the link between unequal exchange and uneven development which he relies upon, does not rely on such a scenario.

The crucial factor relating to development in each region is the absolute size of the realized surplus values (profits). Region 1 realizes 80 units of surplus, whilst region 2 realizes only 40 units. Emmanuel considers the absolute sizes of these volumes of surplus value to be important, because of the potential provided for the richer region to invest more resources into 'unproductive expenditure' such as education and defence spending. Such spending will promote collective consumption in each region and provide "a kind of social wage" (Emmanuel 1969, p.170), in addition to the money wage paid out of wages. If each region devotes half its surplus value to social consumption - effectively there is a 50 per cent rate of tax on profits - then each region will have enough profits left for a $16\frac{2}{3}$ per cent rate of capital accumulation. Region 1, however, will have 40 units of surplus value left for unproductive expenditure, whilst region 2 has only 20 units. Emmanuel quotes Bettleheim's example in which two countries have the same rates of capital growth but different organic compositions of capital; and this

> "makes it possible to deduct more easily from this mass of profit the sums needed to finance, directly or indirectly, expenditure on education, scientific and technical research, and the like all of which are things that will contribute to make possible a better use of labour, natural resources and capital itself in the countries benefiting from unequal exchange."
>
> (quoted from Emmanuel 1969, p.196)

Although Emmanuel labels government spending as 'unproductive', it is the indirectly productive nature of such spending that provides the linch pin between unequal exchange and uneven development. In a regional context, however, this linch pin snaps completely. Intranational regions can realise different pools of surplus value as profits, but the actual control of these resources is directed by *central government*. In Emmanuel's example, the 60 units of surplus value extracted from both regions will be transferred, via a tax on profits, to central government. There is no theoretical reason why all the 40 units of surplus value realised in region 2 should be directed to unproductive expenditure in that region. Central government could just as easily redirect 20 of these units to the less well off region 2.

In considering the transfer of value which is concomitant with a deviation of prices from values, we must add a new dimension of value transfer - namely the transfer of value from intranational regions to central government. Of course, in some countries, such as the United States, intranational regions share control over tax revenues with central government, in which case there be a partial relationship between regionally generated profits and regional public expenditure. In the U.K., however, and in particular for Strathclyde and the rest of Scotland, all tax revenues from profits are transferred to Whitehall.

In concentrating on the link between unequal exchange and uneven development, we therefore reach a damaging conclusion with regards to the relevance of unequal exchange to a regional context. Although the inconsistencies of Marx's transformation procedure, as adopted by Emmanuel, do not help the credibility of the theory of unequal exchange, these problems are not crucial to the argument. Whichever rate of profit is equalized, and whichever measure of capital intensity is employed, the tendency under competition for profit rates to equalize also leads to an equalization of capital growth rates; and as such the only reason for which unequal exchange might fuel uneven development is the comparative advantage a region might enjoy from public expenditure. Due to the control which central government exerts over tax revenues, the generation of uneven development via public expenditure relies on the specific policy measures adopted by that government. If we are to consider the relationship between regional development and the social distribution of labour time, therefore, government spending must be considered as an exogenous impulse[8] - the degree of

8. Of course, a large part of public expenditure, such as expenditure on infrastructure and communications, is endogenous, depending on the requirements of capital within a particular region. Such endogenous expenditure, however, cannot be considered as a prime mover of unequal development, because it depends on the unequal growth of capital in the first place.

unequal exchange between regions is incidental to the plot. The consideration of the regional impacts of exogenous public expenditure, using an input-output formulation in which labour time is the numeraire, provides the focus for Chapter Six.

5.5. CONCLUSIONS

The dynamic Type IV multiplier incorporates a number of linkages which expand the regional input-output model into a more integrated impact assessment framework. The analysis in this chapter has produced some clear empirical and theoretical conclusions with regards to the importance and applicability of each extension to the model.

The application of a multiplicative interregional decomposition has provided a comparison of the main extensions to the Type I intra-regional production multiplier. This decomposition has allowed the isolation of the intra-regional multiplier, and the 'closed loop' and 'open loop' components of the interregional multiplier. Production multipliers have been compared by taking the column sums of each matrix multiplier. Firstly, the isolation of feedback effects via the 'closed loop' interregional extension has a lesser impact on the size of the Type I production multipliers than the incorporation of an intra-regional household extension. The Type IV model is taken to be the most refined version of the household endogenous model. Secondly, however, the incorporation of both spill-over and feedback effects with the inclusion of the 'open loop' multiplier, results in higher Type I production multipliers than the household extension.

The modelling of spill-over effects is pertinent to an impact analysis in which final demand is increased in both regions, whilst the isolation of feedback effects is only relevant to an increase of final demand in one region. Th efore, for the first scenario the interregional extension generates more significant linkages than the household extension to the Type I multiplier, and this provides a justification for the estimation of interregional trade flows. The estimation of interregional flows is also more important relative to the endogenisation of investment, using the Type IV one-region model as the starting point. The impact of the investment extension on the size of the production multipliers is larger, however, than the feedback effects. Only for a scenario in which final demand is increased in *both* regions, is the interregional extension more important relative to the intra-regional extensions to the model.

The multiplicative decomposition has been adopted for an assessment of the regional structure of the two-region matrix multiplier. Each component has been compared by taking the row sums of the matrix multipliers in order to isolate the comparative impacts of changes in final demand. The intra-regional and feedback effects generate higher production multipliers in Strathclyde relative to the rest of Scotland, but the spill-over effects display a bias towards the rest of Scotland. Due to the importance of these spill-over effects, the investment augmented Type IV multiplier displays a bias towards the rest of Scotland relative to Strathclyde. In addition, the estimates for labour values are higher in the rest of Scotland relative to Strathclyde, and this is reflected in the structure of the two-region labour value multiplier.

A theoretical analysis has concluded that the theory ̂ nequal exchange, as popularised by Emmanuel (1969), is not relevant to the labour value extension to the two-region input-output model. Although there are a number of technical problems with Emmanuel's adoption of Marx's value scheme - in particular the failure to transform values into prices for the inputs to the production process - the most important aspect of the theory of unequal exchange is the relationship between unequal transfers of value and uneven development. Emmanuel postulates that unequal transfers of value between regions result in different levels of tax revenues and consequently different levels of government expenditure; and this provides the impetus for unequal rates of economic development between regions. However, in an intranational context, such as Strathclyde and the rest of Scotland, all tax revenue is directed to central government. The introduction of this additional transfer destroys the link between unequal exchange and uneven development. It is concluded that government expenditure should be interpreted as an exogenous impulse to the two-region economy, with the labour value analysis included as part of an impact analysis, without recourse to a theory of unequal exchange.

The relationship between government expenditure and the growth and development of economic activity within the Scottish economy provides the focus for Chapter Six.

CHAPTER SIX

THE SPATIAL AND DISTRIBUTIONAL IMPACTS OF PUBLIC EXPENDITURE PROGRAMMES

6.1. INTRODUCTION

In this chapter we expand the two-region SAM in order to measure the spatial and distributional impacts of public expenditure programmes. This analysis requires the consideration of the *demand* side of the economy, which is conjoined with the supply side multiplier framework (see Chapter Three). Instead of considering the impacts on the Strathclyde and rest of Scotland economies of a uniform change in final demand across all industrial sectors, a series of different final demand vectors are derived for separate categories of public expenditure.

In Section 6.2 the direct consumption of industrial commodities out of state expenditure, and indirectly via the consumption of government employees, is incorporated as part of the two-region SAM. These linkages are placed in the Keynesian/Leontief tradition of public expenditure impact analysis. In addition, various Marxian approaches to the analysis of state expenditure are discussed, and a synthesis of these perspectives is used to further expand the linkages between accounts in the SAM.

Section 6.3 provides an empirical analysis of the impacts of health, education and defence expenditure. This constitutes a more specific application of the modified SAM. Firstly, an aggregate analysis compares the overall impacts of each category; and secondly the overall results of this analysis are explained using a disaggregation of the economic impacts for each industrial sector. Thirdly, an aggregate assessment of the internal structural response of the two-region economy is conducted; and lastly the impacts of each category of expenditure on the volumes of surplus labour time produced in each region are measured. Section 6.4 summarises the conclusions to this penultimate chapter.

6.2. STATE EXPENDITURE AND THE SOCIAL ACCOUNTS MATRIX

6.2.1. A Keynesian/Marxian Approach To State Expenditure

A fundamental component of Keynesian economics is the role of public expenditure as a stimulant to economic activity. The traditional Keynesian approach is to measure the aggregate multiplier effects of such expenditure in order to assess the impacts of fiscal policy. As an extension of this approach one can also consider the *composition* of government expenditure, whereby the government is treated as "an ultimate buyer whose purchases are traced to particular industries through an input-output model" (Kubursi and Frank 1975, p.132). In an early paper Peacock and Stewart (1958) argued that the consideration of government purchases is crucial to the development of a generalized theory of fiscal policy. The disaggregation of the Keynesian multiplier into industrial activities releases the theory from an aggregate "one commodity world" (Peacock and Stewart 1958, p.136). Not only does such a disaggregation generalize the multiplier analysis, both Roskamp (1969) and Kubursi and Frank (1975) argue that it provides an opportunity to compare and assess different categories of public expenditure. The same amount of public expenditure on separate programmes will result in different economic impacts, depending on the industrial mix of government purchases and the consequent responses of employment and income.

In addition to the purchase of industrial commodities by the state sector, there are a number of other ctors which can be considered as part of an assessment of state expenditure. From a Marxian perspective, state expenditure is inextricably linked with the accumulation of capital, the reproduction of labour power, the legitimization of social order, and the balance of class struggle. The weight which one places on the importance of each of these linkages depends on the method of classification adopted for state expenditure; and this in turn depends on the formulation of a specific theoretical perspective of the relationship between state expenditure and the social distribution of labour time. The development of such a perspective is central to the fusion of the dynamic Type IV multiplier framework with the Marxian labour value extension to the input-output model (see Chapter Three). In the discussion that follows we draw from the classification schemes used by O'Connor, Gough, Fine and Harris, and Kidron.

6.2.2. A Non-Functionalist Approach

O'Connor (1973) provides a functional classification whereby government spending is distributed according to its productiveness. The capitalist state performs the two basic functions of *accumulation* and *legitimization*. On the one hand state expenditure must foster conditions in which capital accumulation is possible, for this is the source of state revenue; and on the other hand the state must maintain social harmony through outlays such as welfare relief and military expenditure - this becomes a drain on state income. These two functions are therefore contradictory, as the state tries to promote conditions social harmony without retarding accumulation.

O'Connor employs these two functions for a simple classification of state expenditure which is based on the three Marxist economic categories, which correspond to Marx's three departments of production: constant capital (means of production), variable capital (wage goods) and luxuries. All state expenditure which assists profitable private accumulation is categorized as social capital. This consists of two further subcomponents:

Social Capital

(a) Social Constant Capital

This is state investment which indirectly increases the productiveness of a given amount of labour power; e.g. expenditure on roads, research and development etc.

(b) Social Variable Capital

This aids the reproduction of labour power by reducing its reproduction costs; e.g. social insurance.

State expenditure which performs the function of 'legitimization' is categorized as social expenses:

(c) Social Expenses

Expenditure which is not even indirectly productive; e.g. the police, welfare payments to the unemployed.

In support of this classification, Gough (1975) has commented that "O'Connor has provided the only serious and comprehensive attempt to categorize state expenditures, by allocating them to Marx's departments of production" (p.70). The problem for Gough, however, is that O'Connor places too much emphasis on the functional role of state expenditure. T. basis for allocating state expenditure to a particular category is dependent, in O'Connor's schema, on the function which it performs for the ruling capitalist class, be it accumulation or legitimization. Unemployment benefit, for example, is "designed chiefly to keep the peace among unemployed workers" (O'Connor 1973, p.71).

In place of this functional approach, Gough places *class struggle* at the heart of his conceptualisation. For Gough the provision of social services since the Second World War has been particularly relient on high levels of class struggle and the consequent advances made by the labour movement worldwide. To reduce such improvements to a process of legitimization by which the state "keeps the peace", is a trivialisation of the class struggles which have taken place; and furthermore it reduces the basis for classification of state expenditure to an inherently functional approach. Although Gough recognizes that O'Connor did not neglect the importance of class struggle, he argues that for the latter to be incorporated correctly into a classification scheme an explicitly non-functional approach must be adopted. In considering the basis for classifying various public projects into O'Connor's three categories, Gough argues,

> "The basis, however, will not be so much the forces instrumental in setting up the project etc., as a material input-output analysis of their predominant use-value."
>
> (Gough 1975, p.71)

State expenditure, therefore, should be classified according to which social group in society it benefits, rather than according to the functions of accumulation/legit- :ation which the capitalist class might apply to the allocation of such expenditure. These social groups dispute the distribution of state expenditures between different categories according to the use-values of these expenditures.

6.2.3. Labour Time In The State Sector

In an attempt to link activity in the state sector to production in the capitalist sector, Gough (1975) considers the role of labour time performed by state employees. If workers employed by the state, such as teachers, perform more labour than that embodied in the wage goods they consume, then they are deemed to perform *surplus labour*. This surplus is over and above the necessary labour which is paid to state employees out of state revenues. Gough quotes Rowthorn's hypothesis that

> "Surplus labour performed in education may be transferred to the capitalist sector where it appears as surplus value, apparently originating there. In reality, however, this surplus value is merely the converted form of surplus labour performed outside of the capitalist sector."
>
> (Rowthorn 1974, p.3)

For Gough, therefore, labour time performed in the state sector could feasibly be included as part of a "material input-output analysis" of the use-value of government expenditure.

Fine and Harris (1976) launched a substantive attack on the ideas set out in Gough's (1975) paper, arguing that he embraces the ideas and methods of the so-called neo-Ricardian school of thought. Central to their objection is Gough's dismissal of the law of the tendency of the falling rate of profit which is "central to the laws of development of capitalism" (Fine and Harris 1976, p.2). A crucial post-war component of the falling rate of profit thesis has been the theory of the permanent arms economy, in which state expenditure involves a drain of surplus value which serves to reduce the tendency of the rate of profit to fall. The argument runs that if surplus value was not drained off into state expenditure then it would be reinvested into constant capital (c). This would induce a rise in the organic composition of capital (c/v) and a fall in the rate of profit.[1] According to Fine and Harris, a corollary of Rowthorne's 'conversion' of state produced surplus labour into surplus value involves an assertion of the productive nature of state expenditure; in which case the state sector cannot be a vehicle for the drainage of surplus value.

The crux of Fine and Harris's approach is their distinction between 'indirectly productive' and 'productive' labour. In the case of the education sector, labour can be indirectly productive in so far as it contributes to the social conditions of production, but it is also unproductive because it does not directly produce

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1. If Marx's formula for the rate of profit (r = s/c+v) is divided through by v then

$$r = \frac{\frac{s}{v}}{\frac{c}{v} + 1},$$

so that, assuming a constant rate of surplus value (s/v), a rise in the organic composition of capital (c/v) will result in a fall in the rate of profit.

surplus value. The state cannot produce surplus value because this can only occur under conditions of capitalist production. The process by which state expenditure aids capitalist production is much more indirect than Gough's 'conversion' would suggest. The state can foster conditions which are favourable to capitalist production, but this production does not take place as a direct response to state expenditure.

Furthermore, Fine and Harris place emphasis on the different conditions of organization and control which govern labour in the state sector compared to the capitalist sector. Labour in the state sector is organized and controlled according to the balance of class struggle, whilst labour in the capitalist sector is employed by capital according to the constraints of production and circulation. As a consequence, labour performed in the state sector cannot be aggregated with labour in the capitalist sector into a pool of undifferentiated labour time. In the capitalist sector firms must attain productivity levels which enable them to sell commodities at competitive prices, and therefore the labour time required in the production process is reduced to a minimum. This is the process by which different concrete labours become commensurable as values. No such forces of value formation exist in the state sector.

In contrast, both Gough (1975) and Rowthorne (1974) argue that for each particular skill there are national norms on the average intensity of labour across sectors. Labour time does not become commensurable just through exchange, although this is obviously important, but through technical conditions which are uniform across both state and capitalist sectors. This argument provides a partial defence against the two pronged attack of Fine and Harris on the concept of undifferentiated labour time. The other part of the attack does not require a defence.

The point to make here is that the seemingly conflicting arguments of Gough and Fine and Harris are not mutually exclusive. Gough's aggregation of undifferentiated labour time across state and capitalist sectors can be adopted without formulating an implicit attack on the law of the tendency of the falling rate of profit and its supplementary thesis concerning state expenditure. Labour time can be aggregated across both state and capitalist sectors without the assumption that labour time performed by state employees is of a productive nature. If labour time in the state sector is unproductive, then surplus labour time from the capitalist sector can be siphoned off by the state sector, thereby acting as a countervailing tendency against a rise in the organic composition of capital and the associated fall in the rate of profit. We can therefore concur with the arguments of Fine and Harris that state expenditure is essentially unproductive, whilst discounting their objections to Gough's aggregation of undifferentiated labour time.

6.2.4. The Dissipation Of Labour Time

Fine and Harris (1976) have criticised Gough for having no theory of crisis, and indeed Gough's analytical framework can be enriched by some of the concepts used in Marxian crisis theory. Kidron (1974) provides a sharp distinction between productive and unproductive labour as the basis for a Marxian theory of crisis. He argues that the fundamental basis for the survival of capitalism is the growth of its productive apparatus. As such "only workers employed directly by capital *to make more* capital can be more productive; the others are not although they might be necessary for society and even essential for capital itself" (Kidron 1974, p.36). This distinction is more specific than that used by Fine and Harris (1976) - they argue that labour is productive only if it is employed by capital in the production of surplus value. For Kidron, if labour employed by capital does not produce a surplus which is usable for the expansion of capital, then it is surplus absorbing and not surplus-creating. Any economic activity which is not directed to the expansion of capital is defined as *waste* production.

Kidron has provided a detailed classification of the various categories of economic activity which make up the waste sector. One of the primary components of waste is military expenditure, but most of central government outlays other than defence are also defined as unproductive. Waste sectors in the capitalist sector include finance and insurance, business services, business travel, entertainment and gifts. Production generated by the expenditure of workers employed directly or indirectly in waste production is defined as waste; as is induced production generated by consumption out of unearned income. In addition, every industry involved in the production of inputs which are drained off into waste production, is defined as a partially-waste industry.

Kidron used the 1970 input-output tables for the U.S. in order to estimate the size of the waste sector. A new reduced transactions table was derived after deleting waste activities from the input-output matrix. He obtained the result that three-fifths of the work undertaken in 1970 was wasted according to the productive/unproductive distinction. Although, by Kidron's own admission, these results are very crude, they provide an indicator of the mass of unproductive labour which has become a feature of post-war capitalism.

This notion of the leakage of surplus labour time into a waste sector can be applied to a more specific analysis of state expenditure. In terms of Gough's material input-output analysis of the use-value of various projects, state expenditure is classified on the basis of which social group benefits from such expenditure. As an appendage to this approach, a proportion of state expenditure can be defined as a leakage from the economy. For example, the construction of nuclear weapons can be regarded as waste production, in so far as it benefits neither the working class in terms of the standard of living, or the capitalist class in terms of the accumulation of capital. For such expenditure, however, we introduce the term *dissipation* in order to distinguish it from Kidron's more general concept of waste. The concept of waste, based on the productive/unproductive labour distinction, involves the leakage of all labour time involved directly and indirectly in waste production in both the state and capitalist sectors. All state activity, apart from perhaps the nationalised industries, is deemed to be involved in waste production. The concept of dissipation, however, concerns only the labour time directly involved in government activity. This labour time is classified as dissipation if it cannot be imputed to any social group in the economy according to the benefits provided by the category of government expenditure in which it is performed.

6.2.5. A Modification To The SAM

In the discussion to date we have developed a specific theoretical perspective on the relationship between public expenditure and the social distribution of labour time. From the work of Gough (1975) we can formulate a non-functional categorization of state expenditure in which the 'material use-value' of projects is the main criteria for classification. This classification scheme can provide an insight into the benefits which different social classes gain from public expenditure; and thereby contribute to an understanding of the distribution of public expenditure and its relationship to the balance of class struggle.

A second part of Gough's work which we utilize is cept of undifferentiated labour time across both capitalist and state sectors. Although this approach, along with Gough's classification scheme, has been attacked by Fine and Harris (1976), we have argued that the measurement of labour time in the state sector does not necessarily constitute a refutation of Marxian crisis theory. Indeed the ideas of Kidron (1974), from a more orthodox Marxian school of thought, have been used to formulate the concept of dissipation which provides an extra dimension to Gough's framework. This theoretical perspective can be used to modify the structure of the two-region social accounts matrix (SAM).

In Chapter Three a schematic SAM was formulated in which all flows were measured in units of labour time (see Table 3.2, p.90). This SAM, however, did not include labour time flows which relate to government activity, and as such the government account was empty. At the present juncture we are able to include both inflows and outflows of labour time into the government account (see Table 6.1). The input-output analysis of labour time flows is extended to include the consumption of labour and industrial commodities (inputs to the production account) and the measurement of imputed flows to other accounts in the SAM (outputs of the government account).

TABLE 6.1 A Schematic SAM Modified To Include Government Activity

(all flows measured in labour time)

OUTFLOWS \ INFLOWS			REGION 1: 1	2	3	4	5	REGION 2: 1	2	3	4	5
REGION 1	PRODUCTION	1	V^1_{11}	V^1_{12}	V^1_{13}	V^1_{14}		V^{12}_{11}	V^{12}_{12}	V^{12}_{13}	V^{12}_{14}	
	HOUSEHOLDS	2	D^1_{21}		D^1_{23}							
	GOVERNMENT	3	V^1_{31}	V^1_{32}		V^1_{34}	V^1_{35}					
	ACCUMULATION	4										
	DISSIPATION	5										
REGION 2	PRODUCTION	1	V^{21}_{11}	V^{21}_{12}	V^{21}_{13}	V^{21}_{14}		V^2_{11}	V^2_{12}	V^2_{13}	V^2_{14}	
	HOUSEHOLDS	2						D^2_{21}		D^2_{23}		
	GOVERNMENT	3						V^2_{31}	V^2_{32}		V^2_{34}	V^2_{35}
	ACCUMULATION	4										
	DISSIPATION	5										

Reading column wise, the government in region k purchases direct employed labour time from the household account (D^k_{23}); and direct and indirect labour time embodied in goods and services purchased from its own production account (V^k_{13}), and from the production account in region p (V^{pk}_{13}). Apart from the choice of numeraire, these purchases reflect a standard Keynesian/Leontief type linkage between public expenditure and output and employment. A Marxian approach is introduced via the third row of the SAM in each

on. Using the ideas of Meerman (1978), we can channel the benefits from public services to households via the estimation of imputed flows. This idea is extended to include all accounts in the SAM which might receive imputed benefits from government spending.[2] Meerman, however, in his case study of Malaysia, estimated imputed monetary flows from public services, whereas in this formulation we measure imputed flows of labour time (V^k_{3j}). A final innovation in this modified SAM is the introduction of a dissipation account to accomodate items such as defence expenditure which constitute a leakage of government produced labour time from the economic system (see Section 6.2.4.)

The SAM in Table 6.1 can be used to show the relationship between government expenditure and the social distribution of labour time. This is partly accomplished through the measurement of the relationship between final demand (government expenditure) and industrial outputs using the two-region investment augmented Type IV multiplier. An injection of government expenditure can be broken down into two main components: government purchases of goods and services, and purchases of labour. In order to model these components we define the following coefficients:

w^1_3 and w^2_3 = scalars representing the wage rates of government employees,

ℓ^1_{23} and ℓ^2_{23} = scalars representing the labour required per unit of government expenditure,

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2. Pyatt and Round (1980) set up a special "wants" account with the estimation of such flows in mind, but in Table 6.1 these flows are imputed directly to each account from the government account.

A^1_{13} and A^2_{13} = coefficient vectors of domestic government consumption of industrial commodities per unit of government expenditure,

A^{12}_{13} and A^{21}_{13} = coefficient vectors of exports of commodities per unit of the other region's total government expenditure.

These coefficients can be collected in a series of four vectors (G^{kp}) in order to channel the direct impacts of government consumption of commodities and the induced consumption of government employees. The induced consumption effects are modelled using a Type IV formulation, which is more commonly applied to the construction of multipliers rather than to final demand (see Section 3.3). An increase in government spending results in the extra employment of government workers and an increase in induced consumer expenditure out of the received income. Under the Type IV formulation these newly employed workers are assumed to be previously unemployed, so that their previous expenditure out of unemployment benefit is subtracted from their new level of expenditure. The four vectors of government expenditure have the following structure:[3]

$$G^{11} = \beta^1 w^1_3 \ell^1_{23} - \alpha^1 s \ell^1_{23} + A^1_{13}, \qquad (6.1)$$

$$G^{12} = \beta^{12} w^2_3 \ell^2_{23} - \alpha^{12} s \ell^2_{23} + A^{12}_{13}, \qquad (6.2)$$

3. The coeffients β^k and β^{kp} represent the propensities to consume of employed workers, whilst the coefficients α^k and α^{kp} represent the propensities to consume of unemployed workers (see Section 3.3, p.75, for a complete definition.

$$G^{21} = \beta^{21} w_3^1 \ell_{23}^1 - \alpha^{21} s \ell_{23}^1 + A_{13}^{21}, \text{ and} \quad (6.3)$$

$$G^{22} = \beta^2 w_3^2 \ell_{23}^2 - \alpha^2 s \ell_{23}^2 + A_{13}^2. \quad (6.4)$$

The typical component G^{kp} channels government spending in region p to output in region k. These components can be collected in a 38 by 2 block matrix (19 sectors for each region) through which a lump sum injection of government spending in each region (Δy_3^k) is allocated to the 38 industrial sectors:

$$\begin{bmatrix} \Delta f^1 \\ \Delta f^2 \end{bmatrix} = \begin{bmatrix} G^{11} & G^{12} \\ G^{21} & G^{22} \end{bmatrix} \begin{bmatrix} \Delta y_3^1 \\ \Delta y_3^2 \end{bmatrix}, \quad (6.5)$$

or in abbreviated form:

$$\Delta f = G(\Delta y_3). \quad (6.6)$$

The injections of government spending in the two regions induce changes in final demand which depend on the structure of the matrix G. If we employ the fully extended two-region multiplier (see Equation 3.17), then the relationship between a change in government spending (Δy_3) and output (Δy) can be modelled:

$$\Delta y = M_{DT4} G(\Delta y_3) \quad (6.7)$$

This relationship provides the basis for modelling the impacts of government spending on the social distribution of labour time using the two-region SAM. In the next section this framework is applied to a comparative analysis of health, education and defence expenditure. Although the adoption of the Marxian SAM is straightforward, there [a] number of empirical constraints which shape the [...] of this analysis.

6.3. AN INVESTIGATION INTO THE IMPACTS OF HEALTH, EDUCATION AND DEFENCE EXPENDITURE

6.3.1. Introduction

The most serious problem which is engendered by the data requirements of the Marxian SAM is the estimation of imputed flows of labour time from the public sector to other accounts in the SAM. Both Gough (1975) and O'Connor (1973) have conceded that such a classification is very difficult to carry out empirically. Transport services, for example, can be classified as social consumption when used by households and as part of the means of production when used by industry. To determine who benefits from each category would be near impossible. The analysis that follows, therefore, concentrates on only three categories: education, health and defence expenditure. This makes a solution to the problem more practicable, but it means that only a part of public expenditure and its relationship to the economy is under consideration. We are not able to obtain a static glimpse of the overall economy: but an insight into some of the structural relationships.

A comparison of the economic impacts of social spending (education and health) with defence expenditure is very pertinent to the arguments in which political factions engage concerning the level of defence expenditure. At the 1983 British general election The Labour Party advocated a reduction of defence expenditure from a level just over 5 per cent of GDP to about the European average of 3.5 per cent. According to Dunne and Smith), however, they were unable to counter claims by the then Conservative Defence Secretary, Michael Heseltine, that this policy would cost 400,000 jobs.

Dunne and Smith argue that in the technical literature there is a general consensus that disarmament is not a costly policy measure in terms of the impacts on output and employment, but in fact represents a stimulant to economic activity. For disarmament to take place successfully, however, three conditions must be met:

> "There must be a clear political program for conversion, a compensatory expansion in civilian demand to offset the decrease in civilian demand, and aggregate supply-side policies to co-ordinate the transfer of resources to civilian use."
>
> (Dunne and Smith 1984, p.298)

The importance of the second condition concerning the compensatory increase in civilian demand, has been highlighted by Rosenbluth (1978). Since the beginning of the 1930's, times of depression have been associated with low levels of military expenditure. The only exception is the late 1940's when both unemployment and defence expenditure were very low. In consequence a reduction in arms expenditure represents a potential threat to many ordinary peoples' livelihoods. A systematic investigation into the impacts of a replacement of defence expenditure by civilian expenditure, is therefore of major importance to the achievement of the goal of disarmament. Without such an investigation a cut in defence expenditure could generate reductions in output and employment which are not compensated for.

In the input-output literature there is a disting-
...ed tradition of investigation into the impacts of

defence expenditure. Leontief (1965) used national input-output tables for the U.S. for an investigation into the impacts of a hypothetical reduction in military spending accompanied by a compensating increase in non-military demand. A more specific input-output analysis was conducted by Isard and Langford (1969) for an assessment of the impacts of a contraction of Vietnam war expenditures on the Philadelphia economy. Bezdek (1974) has provided a more recent study in order to estimate the likely effects of a compensated 30 per cent decrease in military spending on 14 subnational regions of the U.S.

A comparison of different categories of government expenditure requires the derivation of final demand vectors for each category. Both the Scottish and Strathclyde input-output tables contain consumption vectors for the health and education sectors. This information can be manipulated using the ad hoc residual technique developed in Chapter Four, in order to derive trade flows of inputs to the education and health sectors within and between the regions of Strathclyde and the rest of Scotland. A vector for the industrial consumption of the defence sector has been obtained from the U.K. input-output tables (1974).[4] This vector has been disaggregated into trade flows within and between the two Scottish regions using trade coefficients which have been derived for total government consumption (for all categories). A labour coefficient

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4. A vector of defence consumtpion was estimated for Scotland in 1973 but the Scottish Office will not allow these figures to be released.

for defence expenditure has been derived using employment figures obtained by Kennedy (1975, p.91) from *The Statement on Defence Estimates*. Labour coefficients for health and education expenditure were constructed using employment figures obtained from the Department of Employment Gazette (1973).

6.3.2. An Aggregate Analysis

An incremental SAM, based on the work of King (1985), is used to reduce the data requirements of the model. Only entries which are likely to change in response to the injection of government spending are included. For purposes of simplification we consider equal injections of £5 million in public expenditure for each region, in contrast to the input-output tradition outlined above, in which a cut in defence expenditure was usually considered. In the scenario which we consider, central government has to allocate expenditure between the three categories of public expenditure. Effectively an increase, for example, in health expenditure relative to defence expenditure could be interpreted, by comparison of the two impacts, as a compensation to a cut in defence expenditure. An increase in spending on one particular category of public expenditure will involve an opportunity cost for the other category which it might displace.

Incremental SAMs are shown in Tables 6.2, 6.3 and 6.4 for injections of education, health and defence expenditure respectively. Each entry in the SAM is calculated in response to either a change in output, via the investment augmented Type IV multiplier (see Equation 6.7), or directly in

An Incremental SAM for Education Expenditure
(all flows measured in labour time)

OUTFLOWS \ INFLOWS			STRATHCLYDE 1	STRATHCLYDE 2	STRATHCLYDE 3	STRATHCLYDE 4	STRATHCLYDE 5	THE REST OF SCOTLAND 1	THE REST OF SCOTLAND 2	THE REST OF SCOTLAND 3	THE REST OF SCOTLAND 4	THE REST OF SCOTLAND 5	TOTAL
STRATHCLYDE	PRODUCTION	1	0.66	0.50	0.85	0.18		0.10	0.06	0.09	0.01		2.45
	HOUSEHOLDS	2	1.00		3.00								4.00
	GOVERNMENT	3		4.19					$\Sigma_{12} = 0.26$				
	ACCUMULATION	4											
	DISSIPATION	5											
REST OF SCOTLAND	PRODUCTION	1	0.19	0.16	0.15	0.01		1.01	0.58	1.01	0.20		3.31
	HOUSEHOLDS	2						1.23		3.22			4.45
	GOVERNMENT	3		$\Sigma_{21} = 0.51$					4.32				
	ACCUMULATION	4											
	DISSIPATION	5											
	REST OF THE U.K.	6	0.28	0.39	0.42	0.04		0.40	0.56	0.67	0.09		
	REST OF THE WORLD	7	0.10	0.12	0.07	0.02		0.20	0.14	0.12	0.05		
	TOTAL			5.36					5.66				

An Incremental SAM for Health Expenditure
(all flows measured in labour time)

OUTFLOWS \ INFLOWS			STRATHCLYDE					THE REST OF SCOTLAND					TOTAL
			1	2	3	4	5	1	2	3	4	5	
STRATHCLYDE	PRODUCTION	1	0.55	0.47	0.72	0.16		0.08	0.06	0.07	0.01		2.12
	HOUSEHOLDS	2	0.88		3.09								3.97
	GOVERNMENT	3		4.90					$\Sigma_{12} = 0.22$				
	ACCUMULATION	4											
	DISSIPATION	5											
REST OF SCOTLAND	PRODUCTION	1	0.16	0.16	0.12	0.00		0.73	0.58	0.55	0.15		2.45
	HOUSEHOLDS	2						0.91		3.20			4.11
	GOVERNMENT	3							5.00				
	ACCUMULATION	4		$\Sigma_{21} = 0.44$									
	DISSIPATION	5											
	REST OF THE U.K.	6	0.24	0.39	0.85	0.03		0.30	0.55	1.01	0.06		
	REST OF THE WORLD	7	0.10	0.11	0.13	0.02		0.18	0.14	0.17	0.03		
	TOTAL			6.03					6.33				

An Incremental SAM for Defence Expenditure
(all flows measured in labour time)

OUTFLOWS \ INFLOWS			STRATHCLYDE					THE REST OF SCOTLAND					TOTAL
			1	2	3	4	5	1	2	3	4	5	
STRATHCLYDE	PRODUCTION	1	0.56	0.46	0.57	0.14		0.07	0.05	0.35	0.01		2.21
	HOUSEHOLDS	2	0.96		2.08								3.04
	GOVERNMENT	3					4.23		$\Sigma_{12} = 0.48$				
	ACCUMULATION	4											
	DISSIPATION	5											
REST OF SCOTLAND	PRODUCTION	1	0.12	0.16	0.10	0.00		0.65	0.51	0.60	0.14		2.28
	HOUSEHOLD	2						0.90		2.08			2.98
	GOVERNMENT	3										4.96	
	ACCUMULATION	4		$\Sigma_{21} = 0.38$									
	DISSIPATION	5											
REST OF THE U.K.		6	0.29	0.35	1.16	0.03		0.27	0.52	1.48	0.05		
REST OF THE WORLD		7	0.11	0.11	0.32	0.02		0.16	0.12	0.46	0.03		
TOTAL				1.08					1.20				

response to a change in government spending.

A number of different themes can be discerned from these incremental SAMs, with the preliminary analysis concentrating on the overall impacts of each category of expenditure. The increase in education spending results in the highest increase in output for both regions: Strathclyde's increase in output is measured as 2.45 million hours of direct and indirect embodied labour time, whilst output for the rest of Scotland increased by 3.31 million. Health expenditure results in smaller increases of 2.12 million for Strathclyde and 2.45 million for the rest of Scotland. The higher increases in output for education, compared to health expenditure, are complemented by higher increases of direct employed labour time: education results in increases of 4.00 and 4.45 million hours of employed labour time compared to increases of only 3.97 and 4.11 for health spending.

Despite the superior performance of education spending in terms of output and employment, households receive relatively more direct and indirect labour time in response to the injections of health expenditure. The column sums for the household accounts in both regions show total flows of 6.03 and 6.33 million hours for health spending, compared to only 5.36 and 5.66 for education. These differences can be explained by the higher imputed flows of labour time from the government to the household accounts (4.90 and 5.00). Education expenditure, therefore, has a greater impact on output and employment but health expenditure involves a redistribution of more direct and indirect labour time to the household account.

Defence expenditure performs poorly in comparison to the other two categories (see Table 6.4). An exception is the case of Strathclyde, where defence spending results in a higher increase in output (2.21) than that generated for health (2.12). Apart from this latter result, increases in output, employment and flows to the household account are less for defence spending relative to education and health expenditure. These results conflict with the findings of Markusen (1986) that input-output studies usually generate large multipliers for defence expenditure relative to social spending. In order to explain this poor performance of defence expenditure in the Scottish economy, we need to conduct a detailed analysis of the coefficients involved.

6.3.3. A Disaggregate Analysis

The main difference between final demand generated by the defence sector, in comparison for example with the education sector, is the higher proportion of defence expenditure allocated to the consumption of industrial commodities. Expenditure on education is more labour intensive with a smaller part of total spending allocated to expenditure on commodity inputs. In assessing the impacts of defence expenditure, it would therefore be pertinent to compare its direct consumption vectors with those associated with education spending, for it is in this sphere that defence spending has an advantage.

The consumption vectors for defence and education spending can be assembled in sets of four vectors (Tables 6.5 and 6.6).

TABLE 6.5 Vectors Of Industrial Consumption Coefficients For The Education Sector[5]

	1	2
	STRATHCLYDE	R OF SCOTLAND
STRATHCLYDE 1	E^{11}	E^{12}
R OF SCOTLAND 2	E^{21}	E^{22}
TOTAL	E^{*1}	E^{*2}

where

E^{kp} = a vector representing the consumption of commodity inputs produced in region k per unit of education spending in region p, and

E^{*p} = a vector representing the total consumption of commodity inputs from within the two-region economy per unit of education spending in region p.

TABLE 6.6 Vectors Of Industrial Consumption Coefficients For The Defence Sector

	1	2
	STRATHCLYDE	R OF SCOTLAND
STRATHCLYDE 1	D^{11}	D^{12}
R OF SCOTLAND 2	D^{21}	D^{22}
TOTAL	D^{*1}	D^{*2}

5. The E^{ij} and D^{ij} coefficients feed through to final demand in the impact equations via the coefficients A_{13} (see Equations 6.1 to 6.4).

where

D^{kp} = a vector representing the consumption of commodity inputs produced in region k per unit of defence spending in region p, and

D^{*p} = a vector representing the total consumption of commodity inputs from within the two-region economy per unit of defence spending in region p.

We now compare the total consumption vectors for education and defence, and sum the resultant difference vectors to scalar values. We obtain

$$\Sigma(D^{*1} - E^{*1}) = 0.08, \text{ and}$$
$$\Sigma(D^{*2} - E^{*2}) = 0.01,$$

so that the overall difference between the consumption of commodities in the defence and education sectors is 0.09. This advantage depends, however, on the industrial mix of the consumption vectors, and for this to be assessed a key sector analysis is required.

A key sector can be defined as a sector which, through various linkages, exercises a greater than average impact upon an economy (see Hewings 1982). If an injection of one type of government spending is more heavily weighted towards specific sectors which are more responsive, then it will generate greater economic impacts. Two traditional tools of key sector analysis are the Rasmussen indices, which essentially involve the taking of row and column sums from the Leontief inverse (Rasmussen 1952). Hazari (1970), however, has recognized that the demand side of the economy should also be taken into account. Key sector identification should be related to a policymaker's preference function which is mapped into the final demand sectors. Final demand in each sector (f_j) is taken as a proportion of total final demand (Σf_j) so that

$$p_j = \frac{f_j}{\Sigma f_j} . \tag{6.8}$$

If we multiply these final demand proportions by the column sums of the Leontief inverse (b_{*j}), which are commonly referred to as production multipliers, then the following indices are derived:[6]

$$W_j = b_{*j} p_j . \tag{6.9}$$

Therefore, if final demand is heavily distributed towards a specific sector j *and* the output multiplier for that sector is high, then there will be a high reading for the Hazari index (W_j), and this sector will be identified as a key sector.

We can examine the interaction between production multipliers and final demand for education and defence expenditure. The 19 by 1 consumption vectors in Tables 6.5 and 6.6 can be merged together into two 38 by 1 vectors, so that

$$E^* = \begin{bmatrix} E^{11} + E^{12} \\ E^{21} + E^{22} \end{bmatrix} , \text{ and} \tag{6.10}$$

6. Hazari also defined a similar index for row sums, but we concentrate on column sums.

$$D^{*} = \begin{bmatrix} D^{11} + D^{12} \\ D^{21} + D^{22} \end{bmatrix} . \qquad (6.11)$$

If we take the column sums of the investment augmented Type IV multiplier (M_{DT4}) and derive a 38 by 38 diagonal matrix of production multipliers ($\hat{M}_{DT4}$), then two vectors of Hazari indices can be derived:

$$W^{E} = \hat{M}_{DT4} E^{*}, \text{ and} \qquad (6.12)$$

$$W^{D} = \hat{M}_{DT4} D^{*}. \qquad (6.13)$$

By taking the difference between these two vectors and summing to scalar values, we obtain

$$\Sigma(W^{D} - W^{E}) = 0.07,$$

which constitutes a reduction in the advantage which defence expenditure enjoys over education in terms of the consumption of commodities within the two-region economy. We can conclude that education expenditure is more heavily distributed towards industrial sectors with high output multipliers. The industrial mix of education spending has a greater economic impact on output than the industrial mix of an equivalent volume of defence expenditure.

Such a small reduction in the advantage of defence expenditure, however, cannot explain the considerable underperformance of defence in the incremental SAM analysis. For a complete explanation we need to examine beyond the distribution of public expenditure between sectors within the two-region economy. If we examine the case of Strathclyde, 53 per cent of defence expenditure is allocated to the consumption of commodities, whilst for education expenditure only 23 per cent is allocated to such consumption. Why then are there only 8 per cent more commodities consumed by the defence sector, relative to the education sector, actually from within the two-region economy?

The answer to this question must be that the trade configuration of consumption by the defence sector involves a higher propensity to import commodities from outside the Scottish economy than the trade configuration associated with education spending. In contrast to the derivation of trade proportions for health and education spending, however, we were not able to derive such proportions for defence using the ad hoc residual method. The vector of total consumption was disaggregated according to the derived trade coefficients associated with general government expenditure. It could be hypothesised, therefore, that if consumption by the defence sector had the same trade proportions as the education sector then it would not underperform so badly. We cannot say what would be the performance of defence expenditure using the correct trade coefficients, but we can compare its performance with education expenditure using the same trade coefficients.

The trade coefficients for education expenditure on industrial commodities are derived as part of total consumption from within and outside the Scottish economy (see Table 6.7).

TABLE 6.7 A Complete Set Of Industrial Consumption Coefficients For The Education Sector[7]

	1	2
	STRATHCLYDE	R OF SCOTLAND
STRATHCLYDE 1	E^{11}	E^{12}
R OF SCOTLAND 2	E^{21}	E^{22}
R OF U.K. 6	E^{61}	E^{62}
R OF WORLD 7	E^{71}	E^{72}
TOTAL	$E^{\cdot 1}$	$E^{\cdot 2}$

The typical trade coefficient for sector j has the structure:

$$e_j^{kp} = \frac{E_j^{kp}}{E_j^{\cdot p}} \quad . \tag{6.14}$$

For defence expenditure the total consumption vectors ($D^{\cdot 1}$ and $D^{\cdot 2}$) can be disaggregated according to the trade coefficients derived for education expenditure. The new consumption coefficients for defence expenditure have the typical structure

$$eD_j^{kp} = e_j^{kp} \; D_j^{\cdot p}. \tag{6.15}$$

These new defence coefficients can be incorporated as part of final demand in the public expenditure impact equations (Equations 6.1 to 6.6). A new incremental SAM

7. The superscript · denotes total consumption both from within and outside the Scottish economy

is derived for the measurement of the impacts of defence expenditure (Table 6.8). All coefficients remain the same apart from the application of trade coefficients for education expenditure to the consumption of industrial commodities by the defence sector.

The results from this new SAM reveal an actual reduction in the impacts of defence expenditure relative to the original incremental SAM for defence expenditure (Table 6.4). Output, measured in direct and indirect labour time, is reduced from 2.21 for Strathclyde to 1.81, whilst for the rest of Scotland there is a slight reduction from 2.28 to 2.23. Direct employed labour time and flows to the household account are also reduced for both regions. We can conclude that the poor performance of defence expenditure relative to education is not due to the mis-pecification of trade coefficients for defence. The trade coefficients employed in the original SAM for defence are in fact more advantageous to the economic impacts of defence expenditure than are the trade coefficients for education expenditure.

We can explain why the use of education trade coefficients has the effect of reducing the impacts of defence expenditure, by concentrating on the coefficients relating to consumption within Strathclyde. From the vector of total consumption coefficients for defence expenditure in Strathclyde ($D^{\cdot 1}$) we can identify 7 key sectors which make up the 93.8 per cent of all defence expenditure on industrial commodities (Table 6.9). The trade coefficients associated with the consumption of the

An Incremental SAM For Defence Expenditure Using

Trade Coeffients From The Education Sector
(all flows measured in labour time)

OUTFLOWS \ INFLOWS			STRATHCLYDE 1	STRATHCLYDE 2	STRATHCLYDE 3	STRATHCLYDE 4	STRATHCLYDE 5	THE REST OF SCOTLAND 1	THE REST OF SCOTLAND 2	THE REST OF SCOTLAND 3	THE REST OF SCOTLAND 4	THE REST OF SCOTLAND 5	TOTAL
STRATHCLYDE	PRODUCTION	1	0.48	0.43	0.58	0.13		0.06	0.05	0.07	0.01		1.81
	HOUSEHOLDS	2	0.78		2.08								2.86
	GOVERNMENT	3					4.23		$\Sigma_{12} = 0.19$				
	ACCUMULATION	4											
	DISSIPATION	5											
REST OF SCOTLAND	PRODUCTION	1	0.11	0.15	0.11	0.00		0.63	0.50	0.59	0.14		2.23
	HOUSEHOLDS	2						0.87		2.08			2.95
	GOVERNMENT	3		$\Sigma_{21} = 0.37$								4.96	
	ACCUMULATION	4											
	DISSIPATION	5											
	REST OF THE U.K.	6	0.21	0.35	0.55	0.03		0.27	0.51	0.73	0.06		
	REST OF THE WORLD	7	0.08	0.11	0.12	0.02		0.16	0.12	0.16	0.03		
	TOTAL			1.04					1.18				

TABLE 6.9 The Vector Of Total Consumption Coefficients For Defence Expenditure In Strathclyde

SECTOR	CONSUMPTION COEFFICIENTS
1	0.00000
2	0.00058
3	0.00000
4	0.00000
5	0.02709*
6	0.00025
7	0.12333*
8	0.07660*
9	0.15409*
10	0.00059
11	0.00220
12	0.00818
13	0.00491
14	0.00631
15	0.04559*
16	0.00837
17	0.02157*
18	0.04925*
19	0.00000

* denotes key sectors

TABLE 6.10 A Vector Of Differences Between Trade Coefficients For Defence And Education Ependiture In Strathclyde

SECTOR	DIFFERENCES
1	-0.96000
2	0.39855
3	-0.44801
4	0.00000
5	0.00390*
6	-0.06818
7	-0.00887*
8	0.00140*
9	0.05242*
10	0.05809
11	-0.94064
12	-0.00556
13	0.14816
14	-0.01181
15	0.00493*
16	-0.01504
17	-0.12649*
18	0.11508*
19	0.00000

defence sector from within the Strathclyde economy can be derived as follows:

$$d_j^{11} = \frac{D_j^{11}}{D_j^{\cdot 1}}, \qquad (6.16)$$

and for education

$$e_j^{11} = \frac{E_j^{11}}{E_j^{\cdot 1}}. \qquad (6.17)$$

These coefficients are compared by taking the differences

$$h_j^{11} = d_j^{11} - e_j^{11}, \qquad (6.18)$$

which are shown in Table 6.10.

Out of the 7 key sectors for defence expenditure, 5 enjoy positive values in the h^{11} difference vector. For these 5 sectors, therefore, the trade coefficients associated with defence are higher than those associated with education expenditure. This result explains why the adoption of trade coefficients from the education sector reduces the impacts of defence expenditure. We can conclude that the key sectors which make up the bulk of defence expenditure on industrial commodities are particularly open with respect to imports from outside the Strathclyde region, and this accounts for the relatively greater impacts of education expenditure.

6.3.4. A TWO-REGION ANALYSIS

A further analysis of the incremental SAMs concentrates on the internal structural response of the two-region economy to the injections of public expenditure. This analysis supplements Section 5.3 in which, for the supply side of the economy, the regional structure of the overall two-region multiplier was examined. This latter investigation concluded that the investment augmented Type IV multiplier displays a significant bias towards the rest of Scotland relative to Strathclyde, in terms of the response of economic activity to a uniform change in final demand across all sectors. In the analysis that follows we assess the relative responses of the two regions once a demand side injection of government spending is introduced. In addition, we examine the structural relationship between these two regions.

For all three categories of public expenditure the rest of Scotland increases its output, measured in direct and indirect labour time, by more than Strathclyde. Education expenditure results in an increase of 3.31 million hours of embodied labour time, compared to an increase of only 2.45 for Strathclyde; whilst for health expenditure there is an increase of 2.45 for the rest of Scotland compared to 2.12 for Strathclyde. In the case of defence expenditure there is a much smaller margin of advantage for the rest of Scotland of only 0.07. Compared to the impacts of social spending, defence expenditure generates a relatively even economic impact over the two regions. The significance of this latter result is compounded by a higher increase in direct employed labour time for defence expenditure in Strathclyde (3.04) relative to the rest of Scotland (2.98). Although the increase in output is higher in the rest of Scotland, the increase in direct employed labour time is higher for Strathclyde.

This apparent anomaly is explained by the result, not shown in Table 6.3, that in response to the injections of defence expenditure *money outputs* increase by £2.60 million in Strathclyde compared to an increase of only £2.41 million in the rest of Scotland. Since direct employed labour time in the SAM is computed by applying direct labour time coefficients to the increases in money outputs, as derived from the investment augmented Type IV multiplier, then it is the magnitude of change in money outputs which determines the relative structural responses employed labour time.

Note that for defence expenditure, even though direct employed labour time increases more for Strathclyde relative to the rest of Scotland, there is a flow of more direct and indirect labour time to the household account in the rest of Scotland. This can be explained by the higher labour values associated with imports from outside the Scottish economy to the rest of Scotland. Due to limitations in the availability of data, the labour values of imports from the rest of the U.K. and the rest of the world are assumed to be the same as for commodities produced in the region (see Section 3.4.). From the analysis in Section 5.3. we know that labour values are higher for commodities produced in the rest of Scotland relative to Strathclyde, and this bias is reflected in the imports of commodities from outside the two-region economy.

Interregional trade responds differently to defence spending in comparison with social spending. For the injections of health and education expenditure, Strathclyde is dependent on the rest of Scotland for trade. For example, education expenditure results in an increase of imports into Strathclyde of 0.51 million hours of embodied labour time, whilst exports increase by only 0.26. In the case of defence expenditure the opposite occurs. There is an inflow of 0.38 into Strathclyde and an outflow of 0.48 from Strathclyde to the rest of Scotland. These contradictory trade structures can be explained by the direct consumption of goods by the defence sector. The rest of Scotland imports 0.35 million hours of embodied labour time, as a component of defence expenditure, compared to a contra flow of only 0.10. This net leakage of labour time for government consumption goods is large enough to provide an overall leakage of labour time for Strathclyde. The high proportion of defence spending which is attributed to the direct consumption of goods has important ramifications for the response of trade flows to an injection of defence expenditure.

The results of the two-region analysis can be used to analyse a scenario in which a cut in defence expenditure is compensated for by an increase in social spending. Whilst a cut in defence expenditure of £5 million would have similar ramifications for economic activities in Strathclyde and the rest of Scotland, a compensatory increase in social spending would work to the advantage of the rest of Scotland. We have seen that social spending also induces a surplus for the rest of Scotland on trade between the two regions, whilst defence expenditure generates a deficit for the rest of Scotland. Furthermore, an examination of the incremental SAMs reveals that although in general social spending is more stimulative to the Strathclyde economy relative to defence expenditure, the margins of difference are small compared to the superiority of social spending in the rest of Scotland. All this would suggest that any cuts in defence expenditure would be more easily compensated for in the rest of Scotland than in Strathclyde, if we assume in isolation that the magnitude of economic impacts is the main criteria for resource allocation.

For the objective of compensating for the reduction of defence expenditure in the rest of Scotland, education expenditure provides an increase of 3.31 hours of labour time embodied in industrial outputs, compared to an increase of only 2.45 for health expenditure. In addition, the increase in direct employed labour time is 4.45 for education expenditure compared to only 4.11 for health expenditure. However, education expenditure results in an induced flow of only 5.66 million hours of labour time to the household account in the rest of Scotland, compared to an increase of 6.33 for health expenditure. A compensatory increase in education expenditure would therefore be most favourably directed towards the objectives of increasing output and employment, whilst health expenditure would be more suitable for an increase in household consumption.

6.3.5. An Analysis Of Surplus Labour Time

The incremental SAMs in Tables 6.2, 6.3 and 6.4 can be interpreted as part of an approach in which the response of surplus labour time is monitored for each region. Defence and social spending generate different scenarios with respect to the volume of surplus labour time extracted from the household account. For both education and health expenditure there is a redistribution of labour time in favour of households. The net gain enjoyed by households in each region is calculated by subtracting the increase in employed labour time from the volume of labour time (including imputed flows) directed to the household account:

Education

net gain for households in Strathclyde = 5.36 - 4.00
= 1.36

net gain for households in the rest of Scotland = 5.66 - 4.45
= 1.21

Health

net gain for households in Strathclyde = 6.03 - 3.97
= 2.06

net gain for households in the rest of Scotland = 6.33 - 4.11
= 2.22

In contrast, defence spending results in a net loss:

Defence

net gain for households in Strathclyde = 1.08 - 3.04

-1.96

net gain for households in the rest of Scotland = 1.20 - 2.98

= -1.78

The net gain received by households from social spending constitutes a reduction in the volume of surplus labour time produced within the two-region economy. The net loss received by households from defence expenditure involves an increase in the overall surplus. These contradictory results can be explained by the inclusion of imputed flows of labour time from social spending to the household account - labour time produced by the defence sector is allocated to the dissipation account.

For the scenario in which defence expenditure is reduced by £5 million, there would be a reduction in the net loss for households in the rest of Scotland of 1.78 million hours of direct and indirect labour time. If this reduction was compensated for by an increase of £5 million in health expenditure, for example, there would be a net gain for households in the rest of Scotland of 2.22 million hours. Overall there would be a reduction of 4.00 million hours in the volume of surplus labour time produced in the rest of Scotland. This figure measures the extent to which the share of households in the social distribution of labour time is increased by the compensated reduction in defence expenditure. A more detailed analysis would monitor the magnitude of this reduction for various sub programmes of each category of expenditure, but such an approach must provide the focus for future research. For the present analysis an overall cut in defence expenditure is compensated for by the broad categories of health and education expenditure.

For health expenditure households receive higher net gains of surplus labour time relative to education spending. Therefore, the compensation of a cut in defence expenditure with an increase in health spending, involves more of a reduction of the overall volume of surplus labour time relative to education expenditure; and more of an increase in the share of households in the social distribution of labour time. In addition, a reduction of defence expenditure in Strathclyde, which is compensated for by health spending, would reduce the total volume of surplus labour time by 4.02 million hours, which is only marginally different from the reduction incurred from a compensated defence cut in the rest of Scotland. Therefore, whilst health expenditure is more favourable relative to education expenditure with respect to its effect on the share of households in the social distribution of labour time, the compensated defence cut produces more or less equal impacts on the reduction of surplus labour time in each region.

For a relation of state expenditure to the balance of class struggle, the measurement of a change in the volume of surplus labour time is also a measure of the change in the level of exploitation. This measure reveals the extent to which households reap the benefits from the labour which they expend in response to the injections of public expenditure. The importance of the concept of surplus labour time, however, is reduced by the theoretical limitations associated with the aggregation of labour time across state and capitalist sectors. From the analysis of Section 6.2, we have concluded that surplus labour time cannot be 'converted' into surplus value; and therefore we are not concerned with the magnitude of surplus labour time in the state sector as a direct stimulant to profits in the capitalist sector. In addition, once we reject the notion that labour in the state sector can be productive, we also reduce the importance of any surplus produced in the state sector, for this surplus is by definition wasted. In Marxian crisis theory all labour time produced in the state sector is wasted, and what is important is the total level of waste extracted by each category of expenditure, and not the surplus that category produces. In the incremental SAMs more total labour time is activised (both output and employment) by the social spending categories relative to defence expenditure. An assessment of this result, however, must provide the basis for future research in which the incremental SAM would be applied to a Marxian theory of crisis. In the present context the social distribution of labour time within and between the accounts of the two-region SAM has been the main focus of attention.

6.4. CONCLUSIONS

The application of the two-region SAM to the measurement of the economic impacts of government spending has generated a number of theoretical and empirical findings. In the theoretical discussion a synthesis of seemingly opposed schools of Marxian thought has been achieved without damaging the fundamental tenets of each set of theories. The neo-Ricardian level of analysis, to which the balance of class struggle is central, has been employed without damaging the more traditional law of the tendency of the falling rate of profit and its supplementary theories. The latter tradition has in fact been used to enrich the former through the intoduction of the concept of dissipation.

The theoretical synthesis has been used to modify the structure of the two-region Marxian SAM. A special dissipation account has been introduced in order to channel imputed flows from items such as defence expenditure, whilst other categories of state expenditure are imputed to the main accounts of the SAM. The impact equations which drive the SAM have been expanded to include a Type IV formulation for the demand side of the analysis.

Due to the limitations of data, the two-region SAM has been applied in incremental form, and only three categories of public expenditure - education, health and defence - have been considered. The comparison of social spending and defence expenditure relates to the theoretical conclusions concerning the central role of class struggle to the allocation of different categories of public expenditure. An aggregate analysis has revealed that the social spending categories constitute more of a stimulant to economic activity within the Strathclyde and rest of Scotland economies. This result must be interpreted in the context of the limitations associated with the data base used in this study. The series of non-survey derivations which have been employed (see Chapter Four), particularly with respect to the measurement of trade flows and investment, necessitate a cautious evaluation of the significance of any results derived from the impact analysis.

A disaggregate analysis has been used to explain the underperformance of defence expenditure, for in most input-output studies defence expenditure is a better stimulant to economic activity than social spending. A key sector analysis has revealed a slightly more favourable industrial mix for education expenditure relative to defence expenditure, but this explains only a small part of the underperformance of defence spending. The main reason for this underperformance is the configuration of trade associated with the consumption of commodity inputs by the defence sector. It has been shown that the seven key sectors which make up the bulk of defence expenditure, are particularly open with respect to imports from outside the Strathclyde region, and this reduces the impacts of defence expenditure relative to education.

The result that defence expenditure performs badly relative to social spending, is not only qualified by the limitations of the data base, but also by the specificity of the structure of trade associated with the Scottish economy. This result does not constitute a refutation of results provided by other studies, but rather is an example of a study for a particular regional economy in which defence expenditure *can* generate less economic impact than social spending.

A two-region analysis reveals that economic activity is stimulated more in the rest of Scotland relative to Strathclyde, in response to an injection of social spending. In contrast, defence expenditure provides a relatively even economic impact over the two regions, although there is a small margin of advantage for the rest of Scotland. In addition, social spending induces a trade deficit for Strathclyde relative to the rest of Scotland; and the margin of difference between impacts of social spending and defence expenditure is smaller in the rest of Scotland relative to Strathclyde. In view of the limitations of the data base, these results must receive the same qualifications as those made for the aggregate analysis. The comparisons of economic impacts derived for each region depend crucially on the non-survey derivation of residual input-output coefficients for the rest of Scotland.

The investigation into the impacts of public expenditure on the production of surplus labour time in each region provides an insight into the net gain of households from each category of expenditure. Under the classification scheme adopted for the incremental SAM, there is a net gain for households from the injection of social spending, but a net loss for households from the injection of defence expenditure. Therefore, a cut in defence expenditure accompanied by a compensated increase in social spending generates a two-fold reduction in the volume of surplus labour time produced in the two-region economy. Such a scenario provides an increase in the share of households in the social distribution of labour time. Health expenditure generates more of a reduction in surplus labour time relative to education expenditure, whilst the magnitude of the reduction is evenly spread over the two regions. Although these measures provide an insight into the relationship between government spending and the exploitation of households in the two-region economy, the importance of these results is diminished by the theoretical limitations associated with the concept of surplus labour time. Part of the surplus labour time is produced in the state sector and should not be confused with the more traditional Marxian concept of surplus value. The appraisal of the relationship between government spending and the volume of surplus produced in each region is based on a purely distribution-orientated perspective.

In the final chapter these conclusions are assessed in relation to the overall themes and objectives of the study.

CHAPTER SEVEN

CONCLUSIONS

7.1. INTRODUCTION

The main theme of the study has been the development of an integrated approach to regional impact analysis. The analysis has concentrated on a set of specific objectives which focus on the construction of an integrated impact assessment framework. These objectives have concentrated on the conceptual development of intra and interregional linkages; the integration of different types of models and different modelling traditions; the selection of a case study area and the derivation of data for each component of the model; the theoretical and empirical assessment of the main components of the model; the conceptualisation of government spending as an exogenous impulse; and a comparative analysis of the impacts of different categories of government spending. In Section 7.2 we consider the main findings of the research in relation to these objectives and identify the contributions of the study to regional impact analysis. Section 7.3 provides some recommendations for future research.

7.2. CONCLUSIONS OF THE RESEARCH

The conceptualisation of intra and interregional linkages has involved the formulation of a lineage of input-output multipliers (Chapters Two and Three). Starting with the Type I input-output model, intra-regional linkages are developed with the introduction of the household extension (the Type II model), the demographic-economic extension (the Schinnar model), the incorporation of previously unemployed residents (the Type IV model), and the endogenisation of investment (the dynamic model). An innovation in this analysis is the conceptualisation of these extensions using a multiplicative decomposition of the matrix multipliers. Using this decomposition it has been proven that the Schinnar model, in its rudimentary form, generates the same production multipliers as the Type II model. This discovery reduces the importance of the demographic-economic tradition, although this tradition provides the impetus for a number of important developments in extended input-output analysis - in particular the Type IV model. A review of the literature relating to this latter model concludes that the personal consumption framework provides the most refined version. The dynamic extension to the Type IV model is incorporated using a backward integration procedure, without the usual inclusion of time subscripts.

The conceptualisation of interregional linkages has involved the adaptation of the Stone-Weale demographic-economic input-output model. This model has been shown, by mathematical investigation, to derive directly from the Batey-Madden Type IV framework. Not only does this discovery place the Stone-Weale model in a lineage of extended multipliers, it provides a direct mathematical connection between the demographic-economic input-output tradition and the parallel tradition of social accounting - the Stone-Weale multiplier equations relate directly to the format of the social accounts matrix (SAM). By introducing a dynamic extension to the Stone-Weale equations, we obtain a two-region dynamic Type IV multiplier framework.

The integration of different modelling traditions has been developed further with the fusion of the impact assessment framework with Marx's system of labour values. The adoption of labour time as the numeraire has been interpreted as a natural extension to the demographic-economic tradition. The dynamic version of the Stone-Weale model is extended by developing a schematic SAM in which all flows are measured in units of labour time. Another innovation of the analysis is the development of a system of two-region labour value equations. There is, however, a limiting condition that the values of commodities imported from outside the two-region economy cannot be calculated. In addition, although the adoption of labour time as the numeraire derives from a Marxian perspective, the accounts of the SAM retain their separate identities; there is no explicit disaggregation of accounts according to the activities of different social classes.

A case study area for the derivation of data for the impact assessment model, has been selected for Strathclyde and the rest of Scotland (Chapter Four). The derivation of data has involved the selection of various established input-output techniques. Although these techniques have been applied to the specific problem of data availability in Scotland, the exercise provides a detailed insight into the problems which an impact analyst may confront in the construction of an input-output model.

An ad hoc residual procedure has been developed for the derivation of interregional trade data, which may apply to any two-regiona economy in which two input-output tables are available. In addition, the procedure developed for the derivation of consumption propensities from the Family Expenditure Survey could provide the basis for any further developments of the Type IV input-output model within the confines of the U.K. economy. Also the derivation of capital coefficient matrices demonstrates the problems which a dynamic extension incurs, particularly when compared with the simple procedure derived for the household extension. The empirical model has been defined as the investment augmented Type IV model, due to the difficulties associated with the making the truly 'dynamic' model operational.

The assessment of the main components of the impact assessment framework (Chapter Five) has provided three main conclusions. Firstly, the interregional linkages (both feedback and spill-over effects) are more significant, in terms of their impact on the size of production multipliers, than the intra-regional household and investment linkages. This conclusion only applies to a scenario in which final demand is increased for both Strathclyde and the rest of Scotland. For a scenario in which final demand is increased for one of the two regions, the intra-regional linkages are more important than the interregional feedback effects. However, since the analysis of government spending, for which the model is designed, is conducted for both regions, the results relating to the first scenario demonstrate the relevance of the interregional extension to the objectives of the study.

Secondly, although both the intra-regional effects and the interregional feedback effects display a bias towards Strathclyde relative to the rest of Scotland, the interregional spill-over effects are siginificant enough to modify the overall bias of the investment augmented Type IV multiplier towards the rest of Scotland. Without the inclusion of the full interregional linkages, Strathclyde would enjoy a greater increase in industrial output relative to the rest of Scotland in response to a uniform increase in final demand across all sectors. Therefore, the modelling of interregional linkages is crucial to the measurement of the relative impacts of changes in final demand in different regions - more specifically the interregional linkages are central to an assessment of the relative impacts of government spending.

Thirdly, a theoretical analysis has concluded that the labour value extension should not be applied to the measurement of unequal exchange between Strathclyde and the rest of Scotland. Within the confines of the U.K. economy, the benefits from unequal exchange which may be enjoyed by industries in a region, in the form of profits, are not automatically channelled into the economic development of that region, due to an additional transfer of value to central government. An application of the labour value system to the analysis of regional development, therefore, should concentrate on the appraisal of exogenous impulses of central government expenditure. These conclusions confront a recent trend in the literature towards the application of the theory of unequal exchange to intra-national regions.

The appraisal of government expenditure has involved an integration of demand and supply side linkages in the two-region economy (Chapter Six). A review of the Marxian literature relating to the role of state expenditure has provided a synthesis of seemingly opposed schools of thought. By focusing on the role of class struggle in relation to the allocation of public expenditure, a theoretical perspective has been formulated in which public expenditure is assessed according to the benefits it provides for different social groups in the economy. This perspective has been enriched by the supplementary theories associated with Marx's law of the tendency of the falling rate of profit. A new dissipation account is introduced to the SAM, which channels categories of expenditure which are deemed to provide no benefits to the social groups represented in the standard accounts of the SAM.

The input-output analysis is extended to include the consumption of labour and industrial commodities (inputs to the government account) and the measurement of imputed flows to other accounts in the SAM (outputs of the government account). Inputs to the government account are incorporated as part of final demand in the multiplier equations. A Type IV formulation is introduced in order to model the linkage between public expenditure and the induced consumer expenditure of public employees.

Although a schematic SAM is designed which accounts for all categories of government expenditure, in practice only three categories could be considered: education, health and defence expenditure. An aggregate analysis has revealed that the social spending categories (education and health) provide more of a stimulant to economic activity in the two-region economy than defence expenditure. This result is important because it conflicts with the findings of other input-output studies in which defence expenditure performs better than social spending. A disaggregate analysis has explained the poor performance of defence expenditure by examining the trade configuration associated with the consumption of commodities by the defence sector. For the key sectors in which defence expenditure is concentrated, more goods and services have to be imported from outside the two-region economy relative to education expenditure. These results demonstrate the importance of an impact assessment framework in identifying where certain categories of public expenditure are regionally relevant.

A two-region analysis reveals that social spending generates a bias towards the rest of Scotland relative to Strathclyde, in terms of the response of output, employment and household consumption. A number of other contributory factors relating to the structure of interregional trade, and the margins of difference between the impactsof social spending and defence spending in the rest of Scotland, lead to the conclusion that a cut in defence expenditure could be more easily compensated for in the rest of Scotland. Education expenditure provides the best alternative for a compensatory increase in output and employment, whilst health expenditure is better for an increase in household consumption.

Finally, the empirical analysis has focused on the measurement of the response of surplus labour time to each category of expenditure. The social spending categories generate a net gain for households; a reduction in the volume of surplus labour time. For defence spending, however, there is a net loss of labour time for households; an increase in the volume of surplus labour time. These results have been used to measure the total impact of a compensated reduction in defence expenditure on the volume of surplus labour time produced in the two-region economy. Such an empirical analysis provides an assessment of the share of households in the social distribution of labour time. Health expenditure provides more of a stimulant to this share relative to education spending, and this result complies with the two-region analysis in which health expenditure also provided a better stimulant to household consumption.

All of these results are qualified by the limitations associated with the non-survey techniques used to derive the data base. In addition, the generality of these results is diminished by the specific configuration of trade flows associated with the Scottish economy. Furthermore, the focus of the study on 1973 means that the results cannot be used to interpret the present structure of the Scottish economy. The value of this study is in the main its demonstration of the capacity of an integrated impact assessment framework for analysing the impacts of public expenditure.

7.3. RECOMMENDATIONS FOR FUTURE RESEARCH

The empirical analysis demonstrates the capacity of the impact assessment framework to assess the various impacts of different categories of government spending in different regions. The results of this type of analysis could feed into the government decision-making process, by providing an assessment of the indirect impacts of public expenditure programmes. More specifically, the analysis relates to the distributional arguments which form part of the struggle between different social classes and pressure groups over the allocation of public resources. The labour movement in Scotland, for example, could use the results of an impact analysis in order to argue how best a cut in defence expenditure might be compensated for. The interpretation of findings from an impact analysis would add credibility to the arguments for disarmament, and would also provide an input to the information available to planners in the decision-making process.

The labour value extension to the input-output framework provides a radical dimension not only to the disarmament debate, but to the overall assessment of public expenditure. The measurement of labour values in the regional context is a relatively new field of research, and has hitherto been mainly concerned with the theory of unequal exchange. In this study we have shown that the theory of unequal exchange is not relevant to the intra-national context, and argued that a focus on the exogenous impacts of government spending is more pertinent to the analysis of regional development. The measurement of labour values for such an impact analysis has been a voyage in uncharted waters. Consequently, a great deal of future research is required in order to develop this extension to the input-output model as part of a more comprehensive assessment of public expenditure.

Possible developments include the assessment of all government expenditure rather than a focus on several specific categories of expenditure. In this case the social accounts matrix (SAM) could be used to provide a static glimpse of the overall relationship between government spending and the social distribution of labour time. The *actual* distribution of labour time could be estimated rather than just the *change* in the distribibution of labour time due to an injection of government spending. An impact analysis could be used to show the social distribution of labour time before and after an injection of government spending, instead of just a measurement of the magnitudes of change provided by the incremental SAM.

The SAM could be transformed in order to model an explicity Marxian approach, with the accounts of the SAM disaggregated according to the economic activity of different social classes. Such an analysis would measure the relationships of unequal exchange which exist between different social classes, and the role of government spending in relation to these disparities. This disaggregation would include the operationalisation of Kalecki type multipliers in which the consumption out of profits received by non-wage earning classes would be modelled alongside household expenditure out of wage income.

The further development of a distributional dimension to regional impact analysis depends on the adoption of an integrated approach to regional modelling. For the scope of an impact assessment framework to include the distributional impacts of public expenditure, an integration of linkages between different regional activities and different types of models is required. In this study, for example, the modelling of household activities has been crucial to the measurement of surplus labour time in the distributional analysis, whilst the investment extension has been crucial to the calculation of labour values. The integration of different modelling traditions has been intrinsic to the integration of regional activities. In addition, one of the main conclusions of this study is that the specification of interregional linkages has been one of the most important components of the impact assessment framework. An old but still relevant request, if not more so, is the call for more data and more research into the estimation of interregional trade flows. Without the availability of interregional trade data, especially in the U.K., studies in interregional input-output analysis can only be isolated examples which do not form part of an integrated modelling framework.

A last recommendation for future research involves the modelling of Marxian crisis theories. In the Marxian literature measurements of labour values have been used to test Marx's law of the tendency of the rate of profit to fall. The model developed in this study could also be applied to such an analysis. In particular, a measurement of the role of state expenditure as a countervailing tendency to the falling rate of profit, could provide the focus for the measurement of labour time across both state and capitalist sectors. In the regional context an investigation into the formation of economic crises would provide an insight into the factors which have determined the decline of problem regions in times of economic recession.

APPENDIX A

PROBLEMS WITH THE HOUSEHOLD CONSUMPTION FRAMEWORK

Batey and Madden (1983) adopted an individual consumption framework in place of the original household disaggregation of economic activity. The household consumption framework (Batey and Madden 1981), in which households were disaggregated according to the employment status of heads of households, was found to be too rigid. However, in a recent paper (Madden and Batey 1986) the household consumption framework has been resurrected in a slightly different form. For an input-output analyst intending to use the Batey-Madden Type IV model, therefore, it is still not clear which consumption framework should be adopted. The following discussion of the problems associated with the household consumption framework, is intended to demonstrate the superiority of the individual consumption framework.

The new version of the Batey-Madden household consumption framework involves the disaggregation of households into employed and unemployed households. A diagonal matrix $\hat{W}$ is used to map out the ratios of employed workers to households (see Madden and Batey 1986, p.280). However, the version of the household consumption framework shown here is more simple, in that the total number of employed and unemployed households are calculated as scalar quantities. Therefore, a scalar w is used to show the ratio of employed workers to employed households. The model has the following structure:

$$\begin{bmatrix} (I - A) & -\beta_h & -\alpha_h \\ -\ell & w & 0 \\ 0 & 1 & 1 \end{bmatrix} \begin{bmatrix} y \\ h_e \\ h_u \end{bmatrix} = \begin{bmatrix} f \\ 0 \\ h \end{bmatrix}, \qquad (A.1)$$

where

β_h = a column vector of consumption coefficients per employed household,

α_h = a column vector of consumption coefficients per unemployed household,

ℓ = a row vector of labour demand coefficients,

w = a scalar representing the ratio of employed workers to employed households,

h_e = a scalar representing the total number of employed households,

h_u = a scalar representing the total number of unemployed households, and

h = the total number of households.

The second simulataneous equation of the model shows that

$$\ell y = wh_e. \qquad (A.2)$$

If output increases, in response to an exogenous increase in final demand, then the volume of employment increases by ℓy and the number of employed households increases according to the ratio of employed workers to employed households (w). The increase in the number of employed households results in an induced increase in employed household expenditure. The expenditure of unemployed households is reduced as the number of such households falls.

The problem with this process is that all the increase in employment is taken from unemployed households. The correct scenario would be for the extra employment to be taken from the pool of unemployed in both employed and unemployed households. In Equation (A.1) unemployed workers living in employed households are unaffected by the increase in employment. In the analysis that follows we attempt a consistenthousehold disaggregation of the Type IV model.

For the Type IV household consumption framework to be specified correctly, two separate labour demand coefficients are defined according to the origin of newly employed workers. Assume that if employment increases, in response to an increase in output, then newly employed workers are drawn in a fixed proportion from employed and unemployed households. We can interpret labour demand from already existing employed households as intensive labour demand - the number of households does not change. Labour demand from unemployed households can be called extensive labour demand, because the extra employment results in an increase in the number of employed households. [1]

Let

ℓ^i = intensive labour demand - demand for unemployed

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1. This intensive-extensive distinction was used by Tiebout (1969) in order to distinguish between income received by workers already resident in a region (intensive income) and the income received by in-migrants (extensive income).

workers resident in employed households,

ℓ^e = extensive labour demand - demand for unemployed workers resident in unemployed households,

U = total number of unemployed,

U^{he} = total stock of unemployed workers resident in employed households, and

U^{hu} = stock of unemployed workers resident in unemployed households.

The labour demand coefficients are derived as follows:

$$\ell^i = \frac{U^{he}}{U} \ell , \tag{A.3}$$

$$\ell^e = \frac{U^{hu}}{U} \ell , \tag{A.4}$$

Intensive labour demand is proportional to the number of unemployed workers living in employed households, whilst extensive labour demand is proportionalto the number of unemployed living in unemployed households. Note that

$$\ell^i = \left(1 - \frac{U^{hu}}{U} \right) \ell , \tag{A.5}$$

and that

$$\ell = \ell^i + \ell^e . \tag{A.6}$$

An additional problem is that as unemployed households change into employed households, through extensive labour demand, not all of the members of unemployed households will gain employment. A household can change from unemployed to employed status and retain some of its unemployed members. We can model this change in household status for some unemployed workers by using the ratio of unemployed to employed workers in employed households:

$$\gamma = \frac{U^{he}}{E^{he}}, \tag{A.7}$$

where

E^{he} = the number of employed workers in employed households,

U^{he} = the number of unemployed in employed households, and

γ = the ratio of unemployed to employed workers in employed households.

This ratio can be multiplied by the extensive labour coefficient in order to derive the number of unemployed workers moving from unemployed to employed households:

$$\Delta U^{ext}_{he} = \frac{U^{he}}{E^{he}} \frac{U^{hu}}{U} \ell \, (\Delta y) . \tag{A.8}$$

The coefficients contained in this expression are included in the first column of the overall model, which has the following structure:

$$\begin{bmatrix} (I - A) & -\beta & 0 & 0 & -\alpha & -\alpha \\ -\ell & 1 & 0 & 0 & 0 & 0 \\ -\frac{U^{hu}}{U} \ell & 0 & 1 & 0 & 0 & 0 \\ -\frac{U^{he}}{U} \ell & 0 & 0 & 1 & 0 & 0 \\ -\frac{U^{he}}{E^{he}} \frac{U^{hu}}{U} \ell & 0 & 0 & 1 & 1 & 0 \\ +\frac{U^{he}}{E^{he}} \frac{U^{hu}}{U} \ell & 0 & 1 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \Delta y \\ E^{he}_2 \\ \Delta E^{ext}_{he} \\ \Delta E^{int}_{he} \\ U^{he}_2 \\ U^{hu}_2 \end{bmatrix} = \begin{bmatrix} \Delta f \\ E^{he}_1 \\ 0 \\ 0 \\ U^{he}_1 \\ U^{hu}_1 \end{bmatrix}, \tag{A.9}$$

where

U_1^{he} = the initial pool of unemployed in employed households,

U_2^{he} = the pool of unemployed in employed households households after the impulse of final demand,

U_1^{hu} = the initial pool of unemployed in unemployed households,

U_2^{hu} = the pool of unemployed in unemployed house-households after the impulse of final demand,

E_1^{he} = the initial pool of employed workers,

E_2^{he} = the pool of employed workers after the impulse of final demand,

β = a column vector of consumption coefficients per employed worker, and

α = a column vector of consumption coefficients per unemployed worker.

This model is a disaggregated version of the household consumption framework, showing the mechanism by which employed and unemployed workers move between the two household categories. Once the household consumption framework is considered in such detail, however, it reduces to a personal consumption framework. The consumption coefficients β and α relate to individual workers. This model could in theory be transformed into a household consumption framework, but this would involve a formulation which would be even more complex.

The problem with the model shown in Equation (A.9) is that it is essentially *iterative*. Many of the coefficients contained in the block matrix are also derived endogenously in the left hand vector. Therefore, as each variable is determined endogenously the coefficients in the block matrix will change, and the endogenously determined variables will change again, and so on. An iterative framework such as this constitutes a regression for the Type IV model. In particular, the absence of fixed coefficients in the block matrix means that fixed multipliers cannot be derived from the model. We can therefore conclude that the individual consumption framework is relatively more consistent and straightforward relative to the household disaggregation of the Type IV model.

APPENDIX B

AN OUTLINE OF THE RAS PROCEDURE

The outline of the RAS procedure in this appendix is based on the notation used by Miller and Blair (1985; pp.276-284). For the case of an economy with 3 industries, one can assume there is a 'base' year coefficients table:

$$A(0) = \begin{bmatrix} a_{11}(0) & a_{12}(0) & a_{13}(0) \\ a_{21}(0) & a_{22}(0) & a_{23}(0) \\ a_{31}(0) & a_{32}(0) & a_{33}(0) \end{bmatrix} . \qquad (B.1)$$

For the target year there is a column vector of row sums U(1), a row vector of column sums V(1), and a column vector of gross outputs X(1):

$$X(1) = \begin{bmatrix} X_1(1) \\ X_2(1) \\ X_3(1) \end{bmatrix} , \qquad (B.2)$$

$$U(1) = \begin{bmatrix} U_1(1) \\ U_2(1) \\ U_3(1) \end{bmatrix} , \qquad (B.3)$$

$$V(1) = \begin{bmatrix} V_1(1) & V_2(1) & V_3(1) \end{bmatrix} . \qquad (B.4)$$

At the outset it is assumed that the technical coefficients are stable between the two time periods:

$$H_0 \; : \; A(0) = A(1) \qquad \text{(B.5)}$$

This hypothesis is tested by deriving a vector of row sums, using the original technical coefficient matrix A(0) and the target year gross outputs:

$$U^1 = A(0)\,X(1) \qquad \text{(B.6)}$$

A possible scenario is that the no-change hypothesis (H_0) fails so that $U^1 \neq U(1)$ - the row sums generated by the base year coefficient matrix are different from the target year row sums. If this is the case, the matrix of coefficients is adjusted according to the target row sums. The ratio $U_i(1)/U_i^1$, defined as r_i^1, is part of a diagonal matrix of coefficients (R^1), which is used to generate a surrogate matrix of coefficients:

$$A^1 = \begin{bmatrix} r_1^1 & 0 & 0 \\ 0 & r_2^1 & 0 \\ 0 & 0 & r_3^1 \end{bmatrix} A(0) . \qquad \text{(B.7)}$$

The ratios r_i^1 have the effect of reducing or increasing each element in the coefficient matrix according to the relative sizes of the derived row sums and the target row sums. Once the surrogate matrix A^1 is multiplied by the target year gross outputs, it will sum to U(1) exactly. The superscript in A^1 refers to the first step in the RAS procedure, namely the adjustment of the technical coefficient matrix according to target row sums.

We can now examine whether or not the column sum information for the target year ($V(1)$) is captured by the improved matrix A^1. This latter matrix is pre-multiplied by a row vector of target year gross outputs so that

$$V^1 = X(1)^T A^1 . \qquad (B.8)$$

This row vector contains the derived column sums from using the surrogate coefficient matrix. Assume that $V^1 \neq V(1)$, so that these new column sums differ from the target columns sums. The ratio $V_i(1)/V_i^1$ (defined as S_i^1) is part of a diagonal coefficient matrix S^1, which is pre-multiplied by the surrogate coefficient matrix:

$$A^2 = A^1 \begin{bmatrix} S_1^1 & 0 & 0 \\ 0 & S_2^1 & 0 \\ 0 & 0 & S_3^1 \end{bmatrix} . \qquad (B.9)$$

Substituting Equation (B.7) into Equation (B.9), we can derive the 'RAS' structure:

$$A^2 = R^1 A(0) S^1 . \qquad (B.10)$$

The problem, however, is that usually the introduction of S^1 in order to modify the column sums, will disturb the row sum properties of the surrogate matrix. Therefore, the process has to be repeated with a new matrix of ratios:

$$A^3 = R^2 A^2 . \qquad (B.11)$$

The use of R^2 ensures that the row sum requirements are met once again. The column sums are met using a new set of S_i^2 ratios:

$$A^4 = R^2 A^2 S^2 . \tag{B.12}$$

This process is repeated until convergence, with the number of adjustments depending on how close the column and row totals of the original matrix are to the target column and row sums.

REFERENCES

Adams, F.G., Brooking, C., and Glickman, N.J. 1973. On the specification and simulation of a regional econometric model: a model of Mississippi. Philadelphia: University of Pennsylvania, Department of Economics, Discussion Paper 2661.

Almon, C. 1970. Investment in input-output models and the treatment of secondary products. In Applications of input-output analysis, vol 2, eds. A.P. Carter and A. Brody, pp. 103-116. Amsterdam: North-Holland Publishing Company.

Armstrong, H. and Taylor, J. 1985. Regional economies and policy. Oxford: Philip Allan.

Artle, R. 1965. The structure of the Stockholm economy. New York: Cornell University Press.

Bacharach, M. 1970. Biproportional matrices and input-output change. Cambridge: Cambridge University Press.

Barnes, T.J. 1985. Theories of interregional trade and theories of value. Environment and Planning A 17: 729-746.

Batey, P.W.J. 1985. Input-output multipliers for regional demographic-economic analysis: some structural comparisons. Environment and Planning A 16: 73-99.

Batey, P.W.J. and Madden, M. 1981. Demographic-economic forecasting within an activity-commodity framework: some theoretical considerations and empirical results. Environment and Planning A 13: 1067-84.

Batey, P.W.J. and Madden, M. 1983. The modelling of demographic-economic change within the context of regional decline: analytical procedures and empirical results. Socio-Economic Planning Sciences 17: 315-28.

Batey, P.W.J. and Madden, M. 1986. Introduction. In Integrated analysis of regional systems. London Papers In Regional Science 15, eds. P.W.J. Batey and M. Madden, pp. 1-7. London: Pion.

Batey, P.W.J. and Weeks, M.J. 1987. A comprehensive extended input-output model: theoretical development and an empirical example. Liverpool: University of Liverpool, Department of Civic Design, Working Note 55.

Beaumont, P., Isserman, A., McMillen, D., Plane, D., and Rogerson, P. 1986. The ECESIS economic-demographic model of the United States. In Population change and the economy: social science theories and models, ed. A.M. Isserman, pp. 203-39. Lancaster: Kluwer-Nijhoff Publishing.

Berman, R.B., Chintz, B. and Hoover, E.M. 1960. Projection of a metropolis: technical supplement to the New York metropolitan regional study. Cambridge, Massachusetts: Harvard University Press.

Beyers, W.B. 1974. On geographic properties of growth center linkage systems. Economic Geography 50: 203-18.

Bezdek, R.H. 1975. The 1980 economic impact - regional and occupational - of compensated shifts in defence spending. Journal of Regional Science 15: 67-75.

Blackwell, J. 1978. Disaggregation of the household sector in regional input-output analysis: some models specifying previous residence of worker. Regional Studies 12: 367-77.

Bortkiewicz, L.von. 1907. On the correction of Marx's fundamental theoretical construction in the third volume of Capital. In Karl Marx and the close of his system, ed. P. Sweezy. 1966. New York: Dobson.

Bradley, I.E. and Gander, J.P. 1969. Input-output multipliers: some theoretical comments. Journal of Regional Science 9: 309-17.

Brodersohn, M.S. 1965. A multiregional input-output analysis of the Argentine economy. Instituto Torcuato Di Tella, Centro de Investigaciones Economicas.

Brown, C.V. and Jackson, P.M. 1986. Public sector economics. Oxford: Basil Blackwell.

Bulmer-Thomas, V. 1982. Input-output analysis in developing countries. Chichester: John Wiley & Sons.

Carson, C.S. 1975. The history of the United States national income and product accounts: the development of an analytical tool. Review of Income and Wealth 21: 25-31.

Carter, A.P. 1970. Structutal changes in the American economy. Cambridge, Massachusetts: Harvard University Press.

Chander, R., Gnasegarah, S., Pyatt, G., and Round, J.I. 1980. Social accounts and the distribution of income: the Malaysian economy in 1970. Review of Income and Wealth 26: 67-85.

Chenery, H. 1953. Regional anlaysis. In The structure and growth of the Italian economy, eds. H. Chenery and P. Clark, pp.96-115. Italy: United States Mutual Security Agency.

Chenery, H. and Clark, P. 1959. Interindustry economics. New York: John Wiley & Sons.

Chiang, A.C. 1974. Fundamental methods of mathematical economics, 2nd Ed. Tokyo: McGraw-Hill.

Cockle, P. 1985. Public expenditure policy, 1985-86. Basingstoke: Macmillan Press.

Conway, R.S. 1979. Simulation properties of a regional interindustry econometric model. Papers of The Regional Science Association 43: 45-57.

Czamanski, S. 1973. Regional and interregional social accounting. Lexington, Massachusetts: Lexington Books.

Czamanski, S. and Malizia, E.E. 1969. Applicability and limitations in the use of national input-output tables for regional studies. Papers of The Regional Science Association 23: 65-77.

Davis, H.C., Lofting, E.M., and Sathage, J.A. 1977. A comparison of alternative methods of updating input-output coefficients. Technological Forecasting and Social Change 10: 79-87.

Department of Economic Affairs (DEA). 1968. Economic planning in the regions. H.M.S.O.

Dundee Scottish Economic Modelling Group. 1981. A manual/non-manual division of employees in employment by sex and industrial order: Scotland 1959-80. Dundee: University of Dundee, Department of Economics, Research Paper 81/D/1.

Desai, M. 1979. Marxian economics. Oxford: Basil Blackwell.

Dewhurst, J.H.Ll., Lythe, C.M., and Peterson, J.C. 1984. The measurement of output and employment in the Scottish service sector (1962-1980). Scotland: Industry Department of Scotland, E.S.U. Research Papers No.7.

Dorfman, R., Samuelson, P.A., and Solow, R.M. 1958. Linear programming and economic analysis. New York: McGraw-Hill.

Dunne, J.P. and Smith, R.P. 1984. The economic consequences of reduced U.K. military expenditure. Cambridge Journal of Economics 8: 297-310.

Egan, D. 1982. Input-output analysis at the regional level. Sheffield: Sheffield City Polytechnic, Department of Urban and Regional Studies, Occasional Papers in Urban and regional Studies, Working Paper No 4.

Emmanuel, A. 1969. Unequal exchange: a study of the imperialism of trade. London: New Left Books.

Ferrao, J. and Jensen-Butler, C. 1984. The centre-periphery model and industrial development in Portugal. Environment and Planning D: Society and Space 2: 357-402.

Fine, B. and Harris, L. 1976. State expenditure in advanced capitalism: a critique. *New Left Review* 98: 97-112.

Fraser of Allender Institute, The Scottish Council Research Institute Limited, and IBM United Kingdom Scientific Centre. 1978. *Input-output tables for Scotland*. Edinburgh: Scottish Academic Press.

Fullerton, H.H. and Prescott, J.R. 1975. *An economic simulation model for regional development planning*. Mich: Ann Arbour.

Gerking, S.D. 1976. Reconciling "rows only" and "column only" coefficients in an input-output model. *International Regional Science Review* 1.2: 30-46.

Glickman, N.J. 1974. Son of "the specification of regional econometric models." *Papers of The Regional Science Association* 32: 155-177.

Glickman, N.J. 1977. *Econometric analysis of regional systems*. London: Academic Press.

Gordon, I.R. 1974. A gravity flows approach to an interregional input-output model for the U.K. In *Space time concepts in urban and regional models. London Papers in Regional Science 4*, ed. E.L. Cripps, pp.56-73. London: Pion.

Gordon, I.R. 1977. Regional interdependence in the United Kingdom economy. In *Structure, system and economic policy*, ed. W. Leontief, Chapter 8. Cambridge: Cambridge University Press.

Gordon, P. and Ledent, J. 1979. Towards an interregional demoeconomic model. *Journal of Regional Science* 21: 79-87.

Gough, I. 1975. State expenditure in advanced capitalism. *New Left Review* 92: 52-92.

Greytak, D. 1970. Regional impacts of interregional trade in input-output analysis. *Papers of The Regional Science Association* 25: 203-217.

Harrigan, F.J., McGilvray, J.W., and McNicoll, I.H. 1980. Simulating the structure of a regional economy. *Environment and Planning A* 12:927-936.

Harrigan, F.J., McGilvray, J.W., and McNicoll, I.H. 1981. The estimation of interregional trade flows. *Journal of Regional Science* 21.1: 65-78.

Harrison, F.K. and Lund, R.E. 1967. *Application of an input-output framework to a community economic system*. Columbia: University of Missouri Press.

Hazari, B.R. 1970. Empirical identification of key sectors in the Indian economy. Review of Economics and Statistics 52.

Henderson, D.S. 1980. The 1973 Scottish input-output tables: some definitional issues. Edinburgh: Economics and Statistics Unit, Discussion Paper no. 8.

Henderson, D.S. 1984. Scottish input-output tables for 1979: volume 3 - further results and analysis. Edinburgh: Industry Department of Scotland.

Hewings, G.J.D. 1971. Regional input-output models in the United Kingdom: some problems and prospects for the use of nonsurvey techniques. Regional Studies 5: 11-22.

Hewings, G.J.D. 1977. Regional industrial analysis and development. London: Methusen Co Ltd.

Hewings, G.J.D. 1982. The empirical identification of key sectors in an economy: a regional perspective. The Developing Economies 20.2: 173-95.

Hewings, G.J.D. 1985. Regional input-output analysis. California: Sage Publications.

Hewings, G.J.D. and Romanos, M.C. 1981. Simulating less developed regional economies under conditions of limiting information. Geographical Analysis 13: 373-90.

Hicks, J.R. 1942. The social framework: an introduction to economics. Oxford: Clavenon Press.

Hirsch, W.Z. 1959. Inter-industry relations of a metropolitan area. Review of Economics and Statistics 41: 360-69.

Hirsch, W.Z. 1962. Design and use of regional accounts. American Economic Review: 183-227.

Hochwald, W., ed. 1961. Design of regional accounts. Baltimore, MD: The John Hopkins University Press.

Hodgson, G. 1974. Marxistepistemology and the transformation problem. Economy and Society 1: 357-92.

Hoyt, H. 1933. One hundred years of Land Values in Chicago. Chicago: University of Chicago Press.

Ireson, R. and Tomkins, C. 1978. Inter-regional input-output tables for Wales and the rest of the U.K. 1968. Cardiff: The Welsh Council.

Isard, W. 1951. Interregional and regional input-output analysis: a model of a space-economy. Review of Economics and Statistics 33: 318-328.

Isard, W. 1960. Methods of regional analysis: an introduction to regional science. Cambridge, Massachusetts: M.I.T. Press.

Isard, W. and Kuenne, R. 1953. The impact of steel upon the Greater New York-Philadelphia Industrial Region. Review of Economic and Statistics 35: 289-301.

Isard, W. and Langford Jr, T.W. 1969. Impact of Vietnam war expenditures on the Philadelphia economy: some initial experiments with the inverse of the Philadelphia input-output table. Papers of The Regional Science Association 23: 105-115.

Katz, J.L. 1980. The relationship between type I and type II income multipliers in an input-output model. International Regional Science Review 5: 51-56.

Kennedy, G. 1975. The economics of defence. London: Faber and Faber.

Kidron, M. 1974. Capitalism and theory. London: Pluto Press.

King, B.B. 1985. What is a SAM? In Social accounting matrices: a basis for planning, eds. J.Pyatt and J.I. Round, pp. 17-51. Washington, D.C.: World Bank.

Klein, L.R. 1969. The specification of regional econometric models. Papers of The Regional Science Association 23: 105-115.

Klein, L.R. and Glickman, N.J. 1977. Econometric model-building at the regional level. Regional Science and Urban Economics 7: 3-23.

Kubursi, A.A. and Frank, R.H. 1975. Differential impacts of provincial government expenditures: an application of input-output analysis. Public Finance Quarterly 3: 131-151.

Kushnirsky, F.I. 1982. A joined input-output and econometric approach to endogenous calculation of final demands and outputs. Journal of Policy Modelling 4.3: 412-23.

Leontief, W. 1936. Quantitative input-output relations in the economic system of the United States. Review of Economics and Statistics 18.3: 105-25.

Leontief, W. 1951. The structure of the American economy. New York: Oxford University Press.

Leontief, W. 1953. Dynamic analysis. In Studies in the structure of the American economy, ed. W. Leontief, pp. 53-92. New York: Oxford University Press.

Leontief, W. 1970. The dynamic inverse. In Contributions to input-output analysis, ed. A.P. Carter and A.Brody, pp. 17-47. Amsterdam: North-Holland Publishing Co.

Leontief, W., Morgan, A., Polenska, K., Simpson, D., and Tower, E. 1965. The economic impact - industrial and regional - of an arms cut. Review of Economics and Statistics 47: 217-41.

L'Esperance, W.L., King, A.E., Sines, R.H. 1977. Conjoining an Ohio input-output model with an econometric model of Ohio. Regional Science Perspectives 7, no.2: 54-77.

Liossatos, P. 1980. Unequal exchange and regional disparities. Papers of The Regional Science Association 45: 87-103.

Madden, M. and Batey, P.W.J. 1980 Achieving consistency in demographic-economic forecasting. Papers of The Regional Science Association 44: 91-106.

Madden, M. and Batey, P.W.J. 1983. Linked population and economic models: some methodological issues in forecasting analysis and policy optimization. Journal of Regional Science 23.2: 141-163.

Madden, M. and Batey, P.W.J. 1986. A demographic-economic model of a metropolis. In Developments in spatial demography, eds. R. Woods and P.H. Rees, pp. 273-95. London: George Allen and Unwin.

Madden, M., Batey, P.W.J., and Worrall, L. 1981. A demographic-economic forecasting framework for regional strategic planning. Liverpool: University of Liverpool, Department of Civic Design, Working Paper 14.

Malinvaud, E. 1956. Aggregation problems in input-output models. In The structural interdependence of the economy, eds. T. Barna, pp. 189-202. New York: John Wiley & Sons.

Marelli, E. 1983. Empirical estimation of interregional transfers of surplus value: the case of Italy. Journal of Regional Science 23: 49-70.

Markusen, A. 1986. Defence spending: a successful industrial policy? International Journal of Urban and Regional Research 10: 105-122.

Marx, K. 1867. Capital: Volume I. London: Lawrence & Wishart.

Marx, K. 1894. Capital: Volume III. London: Penguin Books.

Matuszewski, T.I., Pitts, P.R., and Sawyer, J.A. 1963. L'adjustment periodique des systemes de relations interindustrielles, Canada, 1949-58. Econometrica 31: 90-110.

Meerman, J. 1978. The household distribution of government services for agriculture and education in Peninsular Malaysia 1974. Review of Income and Wealth 24: 161-176.

Miernyk, W. 1969. Comment on Czamanski and Malizia. Papers of The Regional Science Association 23: 81-82.

Miernyk, W.H. 1976. Comments on research developments in regional input-output analysis. International Regional Science Review 1.2: 30-46.

Miernyk, W.H., Bonner, E.R., Chapman Jr., J.H., and Shellhamer , K.K. 1967. Impact of the space program on a local economy. Morgantown: West Virginia University Library.

Miernyk, W.H., Shellhamer, K.L., Brown, D.M., Gallagher, C.J., , and Wineman, W.H. 1970. Simulating regional economic development: an interindustry analysis of the West Virginia economy. Lexington: Heath Lexington.

Miller, R.E. 1966. Interregional feedback effects in input-output models: some preliminary results. Papers of The Regional Science Association 48: 149-164.

Miller, R.E. and Blair, P.D. 1985. Input-output analysis: foundations and extensions. New Jersey: Prentice Hall.

Ministry of International Trade and Industry (MITI). 1970. Interregional input-output tables for Japan. Unpublished.

Miyazawa, K. 1976. Input-output analysis and the structure of income distribution. Berlin: Springer-Verlag.

Moore, F.T. and Peterson, J.W. 1955. Regional analysis: an interindustry model of Utah. Review of Economics and Statistics 37: 363-83.

Morishima, M. 1973. Marx's economics - a dual theory of value and growth. Cambridge: Cambridge University Press.

Morrison, W.I. 1973. The development of an urban inter-industry model: 1 Building the input-output accounts. Environment and Planning 5: 369-83.

Morrison, W.I. 1979. The construction of urban and regional input-output tables in the British Isles. London: Centre for Environmental Studies, Working Paper.

Morrison, W.I. and de Kanter, J. 1978. The Merseyside input-output study and its application in structure planning. In Theory and method in urban and regional analysis. London Papers in Regional Science 15, ed. P.W.J. Batey, pp. 120-149. London: Pion.

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.

Moses, L. 1955. The stability of interregional trading patterns and input-output analysis. American Economic Review 45: 803-832.

Nevin, E., Roe, A.R., and Round, J.I. 1966. The structure of the Welsh economy. Cardiff: University of Wales Press, Welsh economic studies no.4.

Ng, L.S. 1974. An income distribution and employment consistency model for the Philippines. Ph.D. dissertation, Iowa State University.

O'Connor, J. 1973. The fiscal crisis of the state. New York: St. Martins Press.

Oosterhaven, J. 1979. Construction of an interregional input-output table for The North, The Rijnmond Area and The Rest of The Netherlands, for 1970. Gronigan: University of Gronigen, Institute of Economic Research, Memorandum nr. 54.

Oosterhaven, J. 1981. Interregional input-output analysis and Dutch regional policy problems. Aldershot: Gower.

Peacock, A.T. and Stewart, I.G. 1958. Fiscal policy and the composition of government purchases. Public Finance 13, 2: 134-144.

Pindyck, R.S., Rubinfeld, D.L. 1981. Econometric models and econometric forecasts. Auckland: McGraw Hill.

Pleeter, S. 1980. Economic impact analysis: methodology and applications. Boston: Martins Nijholf.

Polenske, K.R. 1972. The implementation of a multiregional input-output model for the United States. In Input-output techniques, ed. A.P. Carter and A. Brody. Amsterdam: North-Holland Publishing.

Polenske, K.R. 1979. Energy analysis and the determination of multiregional prices. Papers of The Regional Science Association 43: 83-99.

Polenske, K.R. 1980. The U.S. multiregional input-output accounts model. Lexington: Lexington Books.

Pyatt, G., Roe, A.R., and associates. 1977. Social accounting for development planning with special reference to Sri Lanka. Cambridge: Cambridge University Press.

Pyatt, G. and Round, J.I. 1984. Improving the macroeconomic data base: a SAM for Malaysia 1970. Washington, D.C.: World Bank.

Pyatt, F. and Thorbecke, E. 1976. Planning techniques for a better future. Geneva: International Labour Office.

Pyatt, G., and others. 1972. Employment and income policies for Iran: methodology for macroeconomic projections. Geneva: International Labour Office.

Quesnay, F. 1758. Tableau Economique. In Quensay's Tableau Economique, ed. M. Kuczynski and R.L. Meek. 1972. London: Macmillan.

Rasmussen, P. 1952. Studies in intersectoral relations. Amsterdam: North-Holland.

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

Richardson, H.W. 1978. The state of regional economics: a survey article. International Regional Science Review 3: 1-48.

Richardson, H.W. 1979. Regional economics. Illinois: University of Illinois Press.

Richardson, H.W. 1985. Input-output and economic base multipliers: looking backward and forward. Journal of Regional Science 25: 607-661.

Riefler, R.F. 1973. Interregional input-output: a state of the arts survey. In Studies in economic planning over space and time, ed. G.G. Judge and T. Takayama, pp. 133-162. Amsterdam: North-Holland Publishing Co.

Romanoff, E. 1974. The economic base model. A very special case of input-output analysis. Journal of Regional Science 14: 86-101.

Rosenbluth, G. 1978. The Canadian economy and disarmament. Toronto: McClelland and Stewart.

Roskamp, K.W. 1969. Fiscal policy and effects of government purchases. Public Finance 24,1: 33-43.

Round, J.I. 1979. Compensating feedback effects in interregional input-output models. Journal of Regional Science 19: 145-155.

Round, J.I. 1983. Nonsurvey techniques: a critical review of the theory and evidence. International Regional Science Review 8, no.3: 89-212.

Round, J.I. 1985. Decomposing multipliers for economic systems involving regional and world trade. Economic Journal 95: 383-99.

Round, J.I. 1986a. Decomposition of input-output and economy-wide multipliers in a regional setting. Paper delivered at the Regional Science Association Meetings, Columbus.

Round, J.I. 1986b. Social accounts for regional economic systems. In Integrated analysis of regional systems. London Papers in Regional Science 15, eds. P.W.J. Batey and M. Madden, pp. 90-106. London: Pion.

Rowthorne, B. 1973. Skilled labour in the marxist system. Bulletin of the Conference Of Socialist Economists: 25-45.

Samuelson, P.A. 1971. Understanding the Marxian notion of exploitation: a summary of the so-called transformation problem between Marxian values and competitive prices. Journal of Economic Literature 9: 399-431.

Schaffer, W.A. and Chu, K. 1969. Nonsurvey techniques for constructing regional interindustry models. Papers of The Regional Science Association 23: 83-101.

Schinnar, A.P. 1976a. A multidimensional accounting model for demographic and economic planning interactions. Environment and Planning A 8: 455-75.

Schinnar, A. 1976b. Models for eco-demographic planning and forecasting. Ph.D. dissertation, School of Urban and Public Affairs, Carnegie-Mellon University.

Seton, F. 1957. The "transformation problem". Review of Economic Studies 24: 149-160.

Sheppard, E. 1983. Commodity trade, corporate ownership and urban growth. Papers of The Regional Science Association 52: 175-186.

Short, J. 1981. Public expenditure and taxation in the U.K. regions. Aldershot: Gower.

Short, J. and Nicholas, D.J. 1981. Money flows in the U.K. regions. Aldershot: Gower.

Sraffa, P. 1960. Production of commodities by means of commodities: prelude to a critique of economic theory. Cambridge: Cambridge University Press.

Steedman, I. 1975. Positive profits with negative surplus value. Economic Journal 85: 114-23.

Steedman, I. 1977. Marx after Sraffa. London: New Left Books.

Stevens, B.H., Treyz, G.I., and Kindall, J.K. 1981. Conjoining an input-output model and policy analysis model: a case study of the regional economic effects of expanding a port facility. Environment and Planning A 13, no.8: 1029-38.

Stone, J.R.N. 1961a. Input-output and national accounts. Paris: O.E.E.C.

Stone, J.R.N. 1961b. Social accounts at the regional level: a survey. In Regional economic planning: techniques of analysis, eds. W. Isard and J. Cumberland, pp. 263-296. Paris: O.E.C.D.

Stone, J.R.N. 1966. Input-output and demographic accounting: a tool for education planning. Minerva IV: 365-80.

Stone, J.R.N. 1970. Mathematical models of the economy and other essays. London: Chapman Hall.

Stone, J.R.N. 1973. Economic and demographic accounts and the distribution of income. Acta Oeconomica 11: 165-76.

Stone, J.R.N. and Brown, A. 1962. A computable model of economic growth. Vol 1, a programme for growth. London: Chapman and Hall.

Stone, J.R.N. and Weale, M. 1986. Two populations and their economies. In Integrated analysis of regional systems. London Papers in Regional Science 15, eds. P.W.J. Batey and M. Madden. London: Pion.

Sweezy, P.M. 1942. The theory of capitalist development. New York: Dobson.

Tiebout, C.M. 1957. Regional and interregional input-output models: an appraisal. Southern Economic Journal 24: 140-47.

Tiebout, C.M. 1969. An empirical input-output projection model: the state of Washington 1980. Review of Economic Studies 51: 334-340.

Theil, H. 1957. Linear aggregation in input-output analysis. Econometrica 25: 111-22.

Thorbecke, E. 1985. The social accounting matrix and consistency-type planning models. In Social accounting matrices: a basis for planning, eds. G.Pyatt and J.I. Round, pp. 207-256. Washington, D.C.: World Bank.

Thorbecke, E. and Sengputa, J. 1972. A consistency framework for employment, output and income distribution applied to Columbia. Washington, D.C.: World Bank.

Trigg, A.B. 1987. The spatial and distributional impacts of public expenditure programmes: a social accounts approach. Papers of The Regional Science Association. forthcoming.

Tyler, G.P. and Roe, A.R. 1977. an approach to social accounting for welfare planning. Paper delivered to the 15th World Conference of The Society for Industrial Development, Amsterdam.

United Nations Statistical Office. 1953. A system of national accounts and supporting tables, studies in methods, series F., No.2. New York: United Nations.

United Nations Statistical Office. 1968. A system of national accounts, studies in methods, series F, No.2. New York: United Nations.

Webber, M.J. and Foot, S.P.H. 1984. The measurement of unequal exchange. Environment and Planning A 16: 927-48.

Weeks, M.J. 1986a. A proposal for aggregating the Strathclyde transactions table. Liverpool: University of Liverpool, Department of Civic Design, Unpublished.

Weeks, M.J. 1986b. Updating and projecting coefficients: the R.A.S. approach: technical details and a computer programme. Liverpool: University of Liverpool, Department of Civic Design, Working Note 54.

Winternitz, J. 1948. Values and prices: a solution to the so-called transformation problem. Economic Journal 58: 276-80.

Wolff, E.N. 1979. The rate of surplus value, the organic composition and the general rate of profit in the U.S. economy, 1947-1967. American Economic Review 69.3: 329-341.

Additional References

Birdsall, N. 1977. Analytical approaches to the relationship of population growth and development. In Population and Development Review 3:63-102.

Coale, A.J. and Hoover, E.M. 1958. Population growth and economic development in low-income countries: a case study of India's prospect. Princeton, New Jersey: Princeton University Press.

Denton, F.T. and Spencer, B.G. 1973. A simulation analysis of the effects of population change in a neoclassical economy. Journal of Political Economy LXXI: 356-375.

Enke, S. 1966. The economic aspects of slowing population growth. The Economic Journal LXXVI: 44-56.

Mandel, E. 1984. Introduction. In Ricardo, Marx, Sraffa: The Langston Memorial Volume, ed. E.Mandel. London: Verso.

Moreland, R.S. 1984. Population, development and income distribution - a modelling approach (BACHUE-International). New York: St.Martins, Gower.

Rodgers, G.B., Hopkins, M.J.P., and Wery, R. 1978. Population, employment and inequality (BACHUE-Philippines). Farnborough, Hampshire: Saxon House.

Suits, D.B., Mordfin, W., Paitoonpong, S., and Yu, T.P. 1975. Birth control in an econometric simulation. International Economic Review 16: 92-111.