MODELLING SHORT-RUN URBAN LABOUR MARKET BEHAVIOUR

MODELLING SHORT-RUN URBAN LABOUR MARKET BEHAVIOUR:

TWENTY NINE CITIES IN THE NORTH-EASTERN U.S.A.,

1964-1973

by

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ABSTRACT: This dissertation is concerned with the problems of constructing testable models of the short-run dynamics of urban labour markets, given the currently available data sources. Bimonthly data for manufacturing production workers in U.S. cities were considered the most complete for the purpose. Twenty-nine cities were chosen (Indiana, 1 city; Michigan, 1 city; New York State, 7 cities; Ohio, 8 cities; Pennsylvania, 12 cities). The period of the study, 1964-73, was chosen to avoid changes in data-base definition and to avoid the impact of the oil embargo of late 1973.

Two types of model were estimated for each city, with different specifications for each model. The first model consisted of three linear, simultaneous difference equations determining, for each city, the number of hours worked per period (number of employees x number of hours worked per employee), the supply of hours available per period and the average weekly wage rate. When tested empirically this model was successful in explaining all these variables. The second model consisted of five equations, determining the number of people employed per period, the number of hours worked per employee per period, the size of the labour force, the hourly wage rate and the voluntary quit rate from employment. This model was considered the theoretically superior of the two in that it allowed for employers substituting between the number of their employees and the number of hours worked by each employee per period. This model also proved the more empirically succesful of the two models. The models were tested using the Two-Stage Least-Squares estimation technique. It is believed that this is the first time that such models have been tested in order to analyse short-run urban labour market behaviour.

It was hypothesised that the level of manufacturing production is a major determinant of labour market activity in each city. Unfortunately no short-run urban manufacturing production data are available either for the U.S.A. or elsewhere. This fundamental deficiency in the data base was overcome by the development of a synthetic urban manufacturing production time-series, using national U.S.A. production time-series weighted by the proportions of each of

nine manufacturing categories in each city. The technique cannot be validated directly but the results from the models are consistent with the synthetic series being excellent proxies for the true series.

The results indicated that the cities all had labour markets that behaved in remarkably similar ways, despite the fact that the labour forces involved ranged in size from 57,000 to 5,558,400 people. In particular the labour markets all exhibited highly stable dynamic behaviour. This result indicated that the labour markets were unlikely to be the generators of boom or slump in their respective cities. When estimated labour market parameters were mapped there appeared to be only weak spatial groupings of the parameter values. Similarly weak groupings appeared when the parameter values were plotted against labour force size. No firm conclusions could be drawn from the groupings. Originally it was intended to model the inter-urban labour market interactions but this proved impossible. All the results are based, therefore, on the assumption that those inter-urban interactions are weak enough to be ignored in the short-run.

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TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF DIAGRAMS AND FIGURES

LIST OF MAPS

NOTATION

(The same notation is used throughout the dissertation except in Chapter II. For Chapter II, given the number of different models involved, it was thought clearer to define some of the notation in the text as required.)

A_1 — nm x nm structural matrix representing the relationships between all current endogenous labour market variables at both the inter-urban and intra-urban levels.

A_2 — nm x nm structural matrix representing the impact of all lagged endogenous labour market variables upon all current endogenous labour market variables at both the inter-urban and intra-urban levels.

A_3 — nm x g structural matrix representing the impact of all the g exogenous variables upon current endogenous labour market variables.

A_{1ij} — m x m submatrix of A_1 representing the impact of current endogenous labour market variables in city i upon the current endogenous labour market variables in city j. (i, j = 1,..., n).

A_{2ij} — m x m submatrix of A_2 representing impact lagged endogenous labour market variables in city i upon current endogenous labour market variables in city j. (i, j = 1, ..., n).

A_{1i} — m x m structural matrix representing the relationships between all current endogenous labour market variables in city i, ignoring all inter-urban relationships.

A_{2i} — m x m structural matrix representing the impact of the lagged endogenous labour market variables in city i upon the current endogenous labour market variables in city i upon the current endogenous labour market variables in city i, ignoring all inter-urban relationships.

A_{3i} — m x g_i structural matrix representing the impact of all the g_i exogenous variables upon current endogenous labour market variables in city i, ignoring all inter-urban relationships.

C_{it} — Average costs of hiring, firing and retaining an employee per time period in city i.

$R^C{}_{it}$ — Regional cyclical component of some time series for locality (city) i at time t

$L^C{}_{it}$ — Local cyclical component of some time series for locality (city) i at time t.

D — n x n matrix of dominance relationships between cities.

D_M — dummy variable representing the impact of season (May).

D_J — dummy variable representing the impact of season (July).

D_S — dummy variable representing the impact of season (September).

E — Employment

H — Total hours worked per period (= h x E).

s^H — Total hours the labour force is willing to supply

d^H — Total hours demanded by employers.

I — Identity matrix

I_{ij} — Strength of a link for interaction from labour market i to j.

K — n x n matrix inter-urban labour market links

K_{it} — capital inputs to production in city i at time t.

L Labour force size.

$_dL_{it}$ Demand for labour in city (region) i at time t.

$_sH_{it}$ Supply of labour in city (region) i at time t.

M_i Some measure of labour market size (potential for influencing other labour markets) of city i.

N_{it} National component in some time series at locality (city) i at time t.

N (Subscript) National level of a variable.

P Population.

Q Production (Manufacturing Output per period).

R Rates of growth.

S n x n matrix of measure of inter-urban proximity (e.g. physical distance) of labour markets.

T Technical progress.

T_{it} Trend component in some time series at locality (city) i at time t.

U Unemployment level (or Unemployment depending upon context).

V Vacancies (available jobs not filled by workers).

W n x 1 vector of wage rates in cities.

X nm x 1 vector of m endogenous labour market variables for n cities.

X_i m x 1 vector of endogenous labour market variables for city i.

Y_{it} Inputs into production in city i at time t.

Z g x 1 vector of exogenous variables affecting endogenous labour market variables in the n cities of an inter-urban labour market system.

Z_i g_i x 1 vector of exogenous variables affecting the m labour market variables in city i (Z_i may include aggregate variables representing the impact of other cities or groups of cities upon city i).

a	Elements of matrices A, where appropriately subscripted.
d	Elements of matrices D, where appropriately subscripted.
g	Number of exogenous variables in a complete inter-urban labour market model.
g_i	Number of exogenous variables affecting a given city where inter-urban links are not considered.
h	Hours worked per employee (worker) per period (week).
$_d{}^h$	Hours demanded per employee (worker) per period (week).
$_L{}^h$	Leisure hours per person per period (week).
$_s{}^h$	Supply of hours per person per period (week).
i	Subscript. City i; i = 1, ..., n (or region i).
j	Subscript. City j; j = 1, ..., n (or region j).
k	Elements of matrices K, where appropriately subscripted.
k	Subscript. Industry k; k = 1, ..., .
m	Number of labour market variables.
n	Number of cities in an inter-urban system or number of regions comprising a national system.
p	Consumer price index.
q	Voluntary rate of employees leaving (quitting) employment.
r	Residual.
s	Elements of matrices S, where appropriately subscripted.
t	Time used as surrogate for Technical progress.
t	Subscript. Time period.
v	Subscript. Represents a difference in time from t of v periods, either forward in time (t + v) or backward in time (t - v)
w	wage rate
x	Elements of vectors X, X_i where appropriately subscripted.
z	Elements of matrices Z, Z_i where appropriately subscripted.

β	the partial adjustment coefficient (e.g. β_E = partial adjustment coefficient of employment). Elsewhere variables used as subscripts, except time, denote the derivative with respect to that variable (e.g. h_E = (partial) derivative of hours per worker with respect to employment).
Δ	discrete change in a variable (e.g. $\Delta y = y_t - y_{t-1}$)
λ	characteristic root (eigenvalue)
λ_1	largest eigenvalue
λ_2	smallest eigenvalue
Π	reduced form matrix $\Pi_1 = A_1^{-1}A_2$ $\Pi_2 = A_1^{-1}A_3$ $\Pi_{1i} = A_{1i}^{-1}A_{2i}$ $\Pi_{2i} = A_{1i}^{-1}A_{3i}$
Σ	summation
f ( )	is a function of (e.g. f(y) = is a function of y)
y	any arbitrary or undefined variable or vector, depending upon context
B	any arbitrary or undefined matrix depending upon context
*	superscript: desired or equilibrium value of a variable
.	superscript: time derivative of a variable
max	superscript: maximum possible value of a variable
| |	determinant of a matrix (e.g. $\|G\|$ = determinant of matrix G)
$\exists$	there exists
= {1} {0}	the variable can take only either the value 1 or 0

CHAPTER ONE

LABOUR MARKETS IN A CONTEMPORARY URBAN SETTING

The joint presence of high unemployment and high wage inflation has appeared as a massive challenge to both the social sciences and to social policy. One result of this challenge has been renewed activity in all fields of labour market analysis, particularly at the national level. Although national labour markets can be studied in their own right, in one sense they are merely aggregates of the sub-national labour markets. If the sub-national labour markets have their own laws of mutual interaction and internal operation it may be argued it is largely those laws that will determine levels of the national labour market aggregates. This thesis explores the possibility of modelling and testing the interactions and internal operations of urban labour markets in a developed capitalist country.

A question of prime importance appears then to be: what are the divisions of the national labour market that represent most nearly the "true" sub-national labour markets? Presumably these labour markets are to be defined in terms of the impeded factor mobilities existing between them. The markets may be divided by skill, occupation or industry classification, and many other classifications are possible. The especial concern of geographers has been the relationship of spatial structure to labour markets and the implications of the resultant market segmentation. In particular, there is the possibility that labour markets may be analysed fruitfully at the urban and inter-urban levels of aggregation. Although not analysed here, at an even greater level of spatial disaggregation it is highly probable that intra-urban spatial structure may play a large role in labour market activities.

Four problems arise for any labour market analysis at the urban and inter-urban levels. The first is fundamental in that it involves the question: whether labour markets behave in a sufficiently coherent manner, at the urban and inter-urban levels of aggregation, such that the concept of urban and inter-urban markets has theoretical and empirical validity?

The second problem is that of characterising the modes of behaviour that are common to all labour markets. These modes are held here to be invariant, irrespective of whether the labour market is industrial, occupational or spatial. For example, all markets may adhere to the neoclassical demand and supply model.

The third problem is given that urban labour market can be considered to exist, what is the specific nature of urban labour markets that distinguishes them from other types of labour markets? If this urban specificity is not demonstrated then the problem of the existence of coherent urban labour markets remains arguable.

A fourth, although less fundamental point but one which is operationally of the greatest significance, concerns the availability of data that will allow for the testing or partial testing of the above questions and problems. In urban labour market analysis, it appears that the lack of a good data base continues to have a profound effect upon the questions which are posed and the degree of certainty with which answers are given. This study provides no exception to this data problem.

These problems are tackled in the following manner. The answer to the fundamental question is taken to be affirmative, i.e. urban and inter-urban labour markets do operate in a coherent manner. The rest of the dissertation stems from this major premise.

The premier feature of this coherence is the short-run spatial immobility of all factors of production. This immobility implies that urban labour markets might be treated as being isolated spatially with regard to their short-run behaviour. On the other hand, if there is some form of short-run interaction between urban labour markets such a treatment may be invalidated. The immediate and free flow of information between urban centres allows the possibility of such interactions. Isolation may then be destroyed, given the role of information,in the wage determination process and, hence, the demand and supply of labour. Upon the demand side for example, information about changes in wage rates and available labour force capacity, could lead to commodity production being moved from one urban centre to another. The supply of labour may be influenced by inter-urban transmission of wage rate and unemployment information. The resultant phenomena could be wage rate change leadership in the short-run.

The inter-urban information flows are not unstructured, however, and any such spatial structure apparent in the information flows may be reflected in the behaviour of the individual labour markets. The flow of information between centres is determined by many factors but those that are particularly important are the distances between centres, the sizes of the centres and their rankings in the inter-urban hierarchy. Another distinguishing feature of urban labour markets then is the relationship between inter-urban structure on the one hand, with urban centres regarded as nodes in a spatial and hierarchical network, and the short-run dynamic behaviour of urban labour markets on the other.

Migration is a form of inter-urban labour market behaviour that poses important analytical problems both in this thesis and in other research contexts. Migration represents an explicitly spatial flow of a factor of production, although the flows have a much more complex origin than a purely economic one. Given high movement costs migration does not occur as an instantaneous adjustment to spatial inequalities in the returns to labour. Although the process of migration appears to be something other than a short-run phenomenon its impact on short-run behaviour of labour markets could be of great importance. This importance stems from the facts that migration flows:

(i) are highly correlated with inter-urban structure,

(ii) tend to be towards urban places which are both large and have high money returns to labour,

(iii) do not necessarily perform an equilibrating role in the labour market or in the inter-urban system as a whole, and

(iv) exhibit such a complex set of relationships that it is difficult to model them adequately, while the lack of good time series data makes empirical testing virtually impossible (Archibald, 1967; Brechling, 1973; Muth, 1967).

Another feature that could distinguish urban labour markets and is possibly testable is that urban centres can be seen as distinct production units. Hence, they should behave in many ways as might individual firms or industrial sectors producing commodities which are either complementary and/or substitutable. An alternative manner of viewing them as production units is to see them as producing commodities which are inputs to other centres as well as being final demand products. Industrial mix and urban production time series data acquire new significance if this is the case. Similarly, spatial and temporal lags would inevitably be fused in such a production system. The types of competition or complementarity existing between urban centres might also be testable.

This thesis formulates a general model which is capable of tackling at least some of these problems. Using data for twenty-nine urban centres in the United States of America, an attempt to test parts of a more specific model is reported. The results seem to indicate that some of the processes considered above are operating. The modelling approach adopted is unusual for cases where the primary objective is the analysis of the spatial and inter-urban aspects of urban labour markets. The usual approach is to start with a consideration of the spatial interaction mechanisms specifying them at the expense of a detailed model of the internal mechanisms of the urban labour markets. An example of this approach is the analysis of relative wage rate diffusion without a complete model of the individual urban labour markets being specified (Weissbrod, 1974). The term "internal mechanisms" is used to define the relationships that exist between labour market entities within the urban centre, that is with each centre being regarded as a labour market. This thesis takes the specification of the internal mechanisms as its starting point. The interactions of the urban markets are then seen as modifications to those internal mechanisms, whilst still obeying the same laws of labour market operations. Using this approach no prior assumptions need be made about the relative importance of the internal mechanisms and of the external interactions with respect to labour market operations. This allows a much more general model to be built.

However, this generality is achieved at the expense of creating a more complex model. With n urban labour markets and m variables there are a potential $(nm)^2$ relationships to be considered. Of these relationships, nm^2 are within markets, and $(n-1)nm^2$ are between markets. This complexity, allied with the overall paucity of urban labour market data, has led to attention being concentrated upon the internal mechanisms of the labour markets in this study. The specification and estimation of these internal relationships is determined to a large degree by the available data, but much less formidably so than in the general model. This data problem stems from the fact that even the analysis of a single urban centre requires the use of time-series data for several labour variables. This has prevented the specification and unification of complete dynamic urban labour market models to the present. Nevertheless, it has proved possible to specify and test a series of short-run, dynamic labour market models at the urban level of aggregation in this study.

The pursuit of this course created two problems in view of the overall concern with urban labour market interactions. The first concerns the validity of the models if the inter-urban interactions are ignored. It is shown that, in the short-run, inter-urban interactions are both quantitatively and qualitatively much less important than the internal market mechanisms. The second problem is that no immediate insights into spatial aspects of urban labour markets are yielded from such models. But it is shown that it is possible to gain such insights by considering the spatial variations in the estimated parameters of the models.

The outline of the thesis is as follows. The following chapter reviews some of the recent literature and seeks to synthesise some of it into a coherent framework.

The third chapter presents a general means of testing the various hypotheses by use of a very broad, dynamic structure. To allow for such breadth the model is interpreted in very broad terms without reference to specific hypotheses. In the second part of that chapter a set of more specific models are given.

The fourth chapter discusses the data used in the testing of the latter models. More attention is given than is usual to the impact of data availability upon model specification. The reason for this attention is that studies in this area have had, to a large extent, their structure and form dictated by the form of the data available.

The fifth and sixth chapters discuss the results of testing the models. In particular, the fifth chapter discusses those results obtained in relation to intra-urban labour markets adjustment processes. The sixth chapter discusses those results relating to the overall problem of the inter-urban processes and their relationships to the observed spatial structures.

The final chapter is an attempt to synthesise the results.

CHAPTER TWO

A COMPARATIVE SURVEY OF MODELS RELATING TO SPATIAL LABOUR MARKET ANALYSIS

1. Introduction

There is a steadily growing literature on urban labour markets, but it remains small and it might be argued that it is possible to cover the whole of the literature in a single review. On the other hand, the relevant literature that overlaps with urban labour market analysis is massive, for example, that on labour economics.

This survey concentrates almost entirely upon the urban labour market literature. This makes it possible to analyse some individual contributions, rather than classes of contributions. In addition, the present survey seeks to synthesise by identifying and analysing the links between the contributions. It is shown, for example, that many individual contributions are special cases of more general models.

The review is presented in five sections. The starting point for the first section is the work of Brechling which was one of the earliest attempts to analyse urban or regional unemployment time series and remains as one of the simplest available models (Brechling, 1967). The work of Jeffrey in enlarging upon this model is then considered (Jeffrey, 1974). The survey is continued by showing that

Jeffrey's work leads from the single-equation Brechling model to the (incomplete) formulation of an inter-urban interaction model of labour markets using simultaneous equations. Such work remains, however, purely empirical (as was Brechling's) as no labour market mechanisms are suggested within the models. Finally, in this section, the work of Bennett on spatio-temporal process identification is discussed as a more sophisticated empirical model but still one with little explanatory power (Bennett, 1975, a,b,c,d).

Turning to theoretical models the Phillips' curve mechanism is examined in its simplest single equation expression, then with the introduction of market interactions and the use of simultaneous equation forms, and finally, with the possibility of dynamic stability analyses for complete urban systems considered.

A third set of models is different from those mentioned above in that they are developed ab initio as fully specified simultaneous equation econometric models of urban labour markets. However, their real significance lies in their explicit treatment of both labour supply and demand, supply having been neglected in the previous models. In addition, they are basically long-run growth models and, as such, have the role of labour migration much more clearly developed in their structures. These econometric models, however, have the very great disadvantage that they are estimated only in cross-section.

The fourth section of this review deals with current labour market models that have been applied but rarely to spatial or urban labour markets. These models involve both empirical and theoretical analyses of labour market disequilibrium behaviour in the short-run.

2. Empirical Models

The presence of any complex spatio-temporal patterns leads to attempts to explain those patterns in way which reduce the complexity to understandable proportions. In the absence of any well-developed theory, the procedure has been to use analytical and statistical methods to decompose these patterns, and then to interpret the results. These decomposition techniques have ranged from the simplest of statistical techniques to cross-spectral techniques.

An early model of this type was proposed by Brechling (1967) and later taken up by Jeffrey (1972). The model is an empirical one, consisting of a single equation that is applied separately to all urban centres or regions of interest. Essentially, the regional or urban unemployment rate, over a given time series, is decomposed into several cyclical and trend components. The model has a linear or log-linear form, and since there is no theoretical reason stated for choosing between the two forms the selection usually revolves around best fit or convenience.

The model has allowed the classification of urban centres or regions according to:

(i) the goodness-of-fit of the model for the individual regions or centres.

(ii) the time-lag structures of the regions, particularly whether they are "leading" or "lagging" areas in relation to changes of the national unemployment rate,

(iii) spatial analysis of the relative quantitative and qualitative aspects of the estimated parameters and residuals.

The forms of the model are:

$$U_{it} = A_i + {}_RC_{it} + N_{it} + T_{it} + {}_LC_{it}$$

and

$$U_{it} = A_i \cdot {}_RC_{it} \cdot N_{it} \cdot T_{it} \cdot {}_LC_{it}$$

where

U_{it} = percentage unemplpyment rate of urban centre (region) i at time t.

A_i = constant term

${}_RC_{it}$ = regional cyclical component for region i at time t.

N_{it} = national cyclical component for region i at time t.

T_{it} = local structural trend component.

${}_LC_{it}$ = local cyclical component.

with each of the components contributing to the local unemployment rate.

The estimated form for the log-linear model is given by the following surrogates:

$$U_{it} = A_i . U^{a_i}_{Nt\pm v_i} . e^{b_{i1}+b_{i2}t+b_{i3}t^2} . r_{it} + \text{seasonal dummy}$$

variables where the surrogates are

$$T_{it} = C^{b_{i1}+b_{i2}t+b_{i3}t^2}$$

$$L^C_{it} = r_{it}$$

$$N_{it} + R^C_{it} = U^{a_i}_{Nt\pm v_i}$$

$\pm v_i$ = "lead" or "lag" of the region i with respect to national conditions

t, t^2 = time used as a variable representing "local trend component"

A_i, a_i, b_{i1}, b_{i2}, b_{i3} = parameters. The parameter, a_i, is particularly important, its value being intepreted as representing the sensitivity of the regions unemployment level to the national unemployment level.

This form gives rise to several problems which cast doubt upon the interpretations of the parameters, particularly if the residual term is given some systematic interpretation, such as being either the local or regicnal cyclical component. These problems include

(a) the dummy variables are difficult to disentangle from the coefficients b_{i1}, b_{i2} and b_{i3}. In the multiplicative model it seems impossible to disentangle them from the proportionality constant, A_i,

(b) it is difficult to give any meaningful interpretation to the parameters, at least in the single equation formulation, as no labour market mechanism is adopted explicitly,

(c) the effects of a decrease or of an increase of U_{Nt} need not have equal impacts upon U_{it}. Some centres are more sensitive to downswings then they are to upswings, for example, and this is not reflected in this model,

(d) if the local labour force constitutes a significant proportion of the national labour force, then U_{it} and $U_{Nt} \pm v_i$ cannot be considered as stochastically independent variables. This is particularly true of Brechling's 1967 paper where London is one of the regions used and yet this region contributes approximately 20% of the United Kingdom labour force. Consequently U_{it} and U_{Nt} are strongly related via the identity,

$$\sum_{i=1}^{n} U_{it} = U_{Nt} \quad ;$$

where n = the number of regions in the national system,

(e) a further implication of (c) and the lagged relationship for U_{it} is that the single equation regression approach used is an invalid estimation technique for a dynamic, simultaneous equation model; by definition

$$\sum_{i=1}^{n} U_{it} L_{it} = U_{Nt} L_{Nt}$$

Then we have (ignoring dummy variables)

$$U_{Nt} = \sum_{i=1}^{n} [A_i \cdot U_{Nt\pm v_i}^{a_i} \cdot e^{b_{i1}+b_{i2}t+b_{i3}t^2} \cdot r_{it}]$$

which is an intrinsically non-linear, feedback system of national unemployment rates.

This last criticism suggests that there is little point in the further estimation of the model without its complete refurbishment. Nevertheless, remarkably clear spatial groupings of parameters with similar values have emerged in this model's various applications and these deserve explanation and investigation.

Jeffrey (1972, 1974) developed a similar model in which he employed factor analysis and principal component analysis to decompose the local unemployment series.

This model had the form -

$$U_{it} = T_{it} + N_{it} + r_{it} \text{ (seasonally adjusted)}$$

where

$$T_{it} = b_{i1} + b_{i2}t + b_{i3}t^2 = \text{structural component of unemployment}$$

$$N_{it} = \sum_{i=1}^{n} a_i U_{it\pm v_i} = \text{national cyclical component,}$$

where N_{it} is a "weighted" national unemployment series. The weightings were found by assuming that the unemployment rate for an industry in i was the same as the rate for that industry at the national level. If this assumption holds true, then the parameter, a_{i1}, "is a measure of the city's sensitivity to national cyclical fluctuations after allowance has been made for its industrial composition," (Jeffrey, 1974 p. 112)

yielding

$$U_{it} = b_{i1}+b_{i2}t+b_{i3}t^2+ \sum_{i=1}^{n} a_iU_{it}\pm v_i + r_{it}$$

This equation was estimated using O.L.S. and the residuals were termed the "regional cyclical components", that is, $r_{it} = {}_RC_{it}$. It was then assumed that a set of m distinct but as yet unknown regional forces existed, varying in their intensity from region to region and expressed as

$$_RC_{it} = \sum_{k=1}^{m} b_{ik}c_{kt}$$

with

$k = 1, .. , m$; the number of regional force components

C_{kt} = kth regional cyclical (force) component, and

b_{ik} = a parameter indicating the extent to which $_RC_{it}$ is comprised of each of the r_{kt}

Unfortunately the C_{kt}'s are unknown and Jeffrey used factor analysis to break the set of time-series for all centres into a set of m reference curves. Principal components analysis was then used to further reduce the number of reference curves (to seven) to a point where eighty percent of the variation in the ${}_{R}C_{it}$ series was explained by the principal components. Thus, seven parameters were obtained for each centre on the seven reference curves with varying degrees of overall fit.

It is tempting to associate these reference curves with industrial linkage systems, that is sets of spatially linked industries, rather than those industries in the S.I.C. classification. For example, one reference curve had very significant parameters for the steel centres and all the spatial groupings appeared to conform to various industrial zones. It appears plausible that the above framework can be systematically related to another regional-industrial decomposition model, shift-share analysis, particularly if the reference curves are used in the shift-share analysis, rather than industries drawn from the Standard Industrial Classification. This point is explained below.

Shift-share analysis has been a common decomposition method for regional economic time-series, notably for employment by sector in regions (Czamanski, 1972). It can be used, however, for any data which have at least two time periods and for which a regional and sectoral disaggregation is possible. Shift-share analysis attempts to explain the temporal change of a given economic measure, in a given region, by decomposing that change into three elements.

These are:

(i) a national growth element,

(ii) a sectoral growth element, and

(iii) a residual element or regional competitiveness effect.

The equation for shift-share is

$$E_{kit} - E_{kit-1} = E_{kit-1}(R) + E_{kit-1}(R-R_k) + E_{kit-1}(R_k-R_{ki})$$

where

E_{kit} = total employment in industry i in region j at time t,

R = national rate of growth of employment in all industries,

R_k = national rate of growth of employment in industry k,

R_{ki} = rate of growth of employment in industry k in region i.

This equation is merely an identity. Where theory enters, if at all, is in the attempt to explain the residual component, $E_{kit-1}(R_k-R_{ki})$, interpreted as a measure of the competitiveness of industry k, if based in region i.

This represents a decomposition of regional employment into elements which include a residual term and are related explicitly to industrial structure. Jeffrey, on the other hand, decomposed local unemployment series in terms of unemployment rate time series for industries. Consequently the models are related in two ways. Both use industrial mix in their decomposition techniques implying that industrial structure can be used to explain local labour market. Neither model addresses the question of why some industries perform better in some areas than in others. Finally, both models are related analytically by the accounting identity existing between unemployment, employment and labour force size.

A later, and more promising, set of models are those which try to identify the spatial processes underlying a region's short-run changes. They do this by linking changes in the region with changes in all other regions, rather than with the national level. Such models have used only one variable in the main and consequently have eschewed the use of economic theory. On the other hand, there is an attempt to handle time-series for different points in space simultaneously. In the United Kingdom such work has focussed on the spatio-temporal diffusion of a measles outbreak, population diffusion and short-term forecasting of cyclical economic behaviour in a system of cities (Cliff et al., 1975; Bassett and Haggett, 1971). In North America Bannister has analysed short-run changes for the Southern Ontario urban hierarchy of unemployment and the flow of cheques in the banking system (Bannister, 1974). His method of analysis was to decompose the spatial autocovariances and covariances into identified and interpreted processes. He identified a system of large places covarying simultaneously whilst there is a hierarchical process occurring at the lower levels of the hierarchy. There was also identified a distance dependent effect combined with a nearest neighbour effect. When these short-run changes were combined with a strong "aggregate system growth" there were additional growth spillover and centre-periphery effects. Thus, although he did not postulate any specific mechanisms, Bannister was able to identify a complex set of spatially expressed processes.

It is difficult to arrive at any firm conclusion as to the status of these models for they do not have results that are interpretable within any theoretical framework. Nevertheless it seems that they serve certain functions. The analysis of systems where data are weak is one such function. Too often, however, they seem to take the place of developing and testing theory. The identification of spatial and temporal lags is surely the precursor of theoretical developments that attempt to explain the spatial and temporal mechanisms rather than an end in itself.

3. The Phillips' Curve Models

The simplest form of Phillips' curve model, relating changes in wage rates to the unemployment rate, was an empirical approach in its original form (Phillips, 1958). On the other hand, later work postulated an explicit mechanism in the relationship. The Phillips' curve mechanism can be taken either to operate at each urban centre or region independent of surrounding centres or a whole series of regional interaction can be formulated from the mechanism. This has formed the basis of its use in spatial labour market analysis.

The Phillips' curve mechanism derives from the postulate that wage rate changes are related to excess demand for labour, in the labour market. Thus, where i is the centre, region or area of interest,

$$\dot{w}_i / w_{it} = a_i \frac{({}_dL_{it} - {}_sL_{it})}{({}_sL_{it})} + r_{it}$$

where the parameter a_i is positive. The residual term, r_{it}, represent factors other than the supply and demand for labour that influence the wage rate. In this version of the model no factors outside the city of interest influence the wage rate changes occurring within that city. Shifts in the demand and supply curves lying behind ${}_dL_{it}$ and ${}_sL_{it}$ are represented by additional independent variables in the equation. Change in consumer price indices are often used in this context, as illustrated below. Thus

$$\dot{w}_i / w_{it} = a_i \frac{({}_dL_{it} - {}_sL_{it})}{({}_sL_{it})} + b_i\, p_{it} + r_{it}$$

As a surrogate of excess demand many variables have been used, but chiefly job vacancy rates and/or unemployment levels. The relationship between unemployment and excess demand for labour is non-linear and assymetric by virtue of the constrained range of positive values U_{it} can take, whereas excess demand can be either negative or positive. Consequently,

$$\dot{w}_i / w_{it} = f_i(U_{it}) + b_i\, p_{it} + r_{it}.$$

It is in this form that the Phillips' curve has been used by urban and regional labour market researchers. The parameter values and residuals are then examined in the same ad hoc manner for spatial groupings as for the Brechling-Jeffrey model. As an example, in a study of United States S.M.S.A.'s,(Standard Metropolitan Statistical Areas) Albrecht (1966) used a model of this type. It had the form

$$\dot{w}_i / w_{it} = a_{i0} + a_{i1} U_{it}^{-b} + a_{i2} \bar{U}st + r_{it}$$

where variables are as previously defined and,

$\bar{U}_{st}$ = regional (state) unemployment rate,
or
national unemployment rate.

All three unemployment variables were taken as surrogates for excess demand for labour, and Albrecht's problem was to determine within which labour market (local, regional or national) the urban centre operated. Although the model was naive and fraught with estimation problems, Albrecht concluded:

> "In metropolitan areas which are near or east of the Mississippi and north of the Mason-Dixon Line, national conditions are almost always more important. In western cities, local conditions usually have a greater effect; and in the South, the cities are more equally divided between the two categories." (p. 340).

In fact, Albrecht's spatial groupings appear to be consistent with those of Jeffrey, although less detailed in the number of centres considered. Despite the weaknesses of both the Albrecht and Jeffrey models, taken together, their results were suggestive of distinct and systematic spatial variation in labour market behaviour. The Phillips' relationship applied to those centres which could be regarded as most closely resembling isolated markets, suggesting the possibility that, elsewhere, spatial labour market interactions masked the Phillips' relationship, if any such relationship existed.

A whole series of works on regional Phillips' curves has been completed by economists who do not have regional labour market analysis as their prime concern (Thomas and Stoney, 1971). The regional aspects have stemmed from an availability of regional data, combined with a desire to study the effects of labour market disaggregation, whether this disaggregation be spatial or otherwise. Consequently, the theory embodied in their models applies equally to industrial, sectoral and other labour market types: their models are not intrinsically spatial.

On the other hand, the establishment of the true nature and division of spatial sub-markets is a continuing problem in the geographical and regional science literature. There are still, unfortunately, substantial problems. The model should work best with the greatest disaggregation but the reverse seems to be true. Secondly, it is neither known what the correct sub-markets are nor on what criteria they should be identified. This applies to all studies of labour market, not just to Phillips; curve analyses. In the case of urban centre data this problem is eased, for the centre does represent a recognised economic entity, but such is not the case for planning or other administrative regions. Yet, it is for these latter regions that data are collected. In addition, in the case of urban centres there are theories of urban interaction, hierarchy and structure to fall back upon. The work of Weissbrod (1974), discussed later in this Chapter, made use of central place theoretic notions. Presumably these spatial labour market differences arise from spatial immobility of factors and the costs of immediate spatial spread of information.

Another possible interaction mechanism, related to a Central Place model, is that of the leading market. With this mechanism a specific market or set of markets 'lead' with regard to wage rate changes. Implicit in this model is some transfer mechanism to the 'lagging' markets. In a simple form, this can be modelled from a Phillips' curve relationship for the leading market, i, as

$$\dot{w}_i / w_{it} = a_0 + a_1 U_{it}^{-b_i}$$

and for any lagging centre, j, as

$$\dot{w}_j / w_{jt} = c_0 + c_1 U_{jt}^{-b_j} + c_2 \left[\dot{w}_i / w_{it} - a_0 - a_1 U_{it}^{b_i} \right]$$

In other words, wage-rate change in the nonleading market is a function of the local unemployment rate and a term (in square brackets) which measures the deviation between the wage-rate change in the leading market and that which would have resulted in the nonleading one in the absence of any transfer mechanism. Thomas and Stoney (1971) used a similar model at a highly aggregated regional level in the United Kingdom with some success.

Brechling (1973), in the most complete work of this type, considered a leading-lagging sectors approach in an overall attempt to "combine the neoclassical and multisector approaches". But again the regional and spatial ramifications were little considered, unless with regard to the forms of data. The neoclassical approach held that there was a tradeoff between unemployment and inflation in the long-run, as expectations are fully realised. Brechling's model for the leading m sectors was

$$\dot{w}_i / w_{it} = b_1 g_1(U_{it}) + c_1(\dot{w}_i / w_{it})^e + k_1 p_t$$

and

$$(\dot{w}_i / w_{it})^e = f_1(U_{it-1}) \qquad i = 1, \ldots, m$$

and for the n-m lagging sectors

$$(\dot{w}_j / w_{jt}) = b_2 g_2(U_{jt}) + c_{21}(\dot{w}_j / w_{jt}) + k_2 p_t$$

and

$$(\dot{w}_j / w_{jt})^e = c_{22} \overline{w}_{it} \qquad j = m+1, \ldots, n$$

The subscripts i and j refer to individual leading and lagging sector regions respectively, whilst subscripts 1 and 2 refer to the leading and lagging sectors as entire groups of regions respectively; b, c, f, g, k are functional relationships;

e = expected

$\overline{w}$ = the mean of leading sector wage rate changes

Here the leading sectors were defined as those with the highest relative wage rates. There are no a priori reasons why this postulated transfer mechanism of wage rate expectations should work from these centres to others. It could well be argued that those with the lowest relative wage rates, or lowest or highest unemployment rates, should be the leaders. All of the leader-follower models formulate some spatial transfer mechanism, although not necessarily using the internal labour market mechanism as given by the Phillips' curve. In addition the transfer mechanisms, such as Brechling's hypothesised transfer mechanism, are formulated on a purely ad hoc basis. Indicative of this, is that in the testing of his model, Brechling used 3, 6, 9, 12, 15, and 18 and finally, 24 states in the U.S.A. as the leaders. It made little difference to the results. The use of an explicit prior model of inter-urban or spatial structure as the basis for the transfer mechanism is theoretically far more satisfying.

A related question of interest is the definition of the leading labour market(s) in a spatial context. If it is assumed that some form of distance-decay effect is important, then the leading market could be the nearest neighbouring market that has a higher (lower) rate of wage change or unemployment. King and Forster (1973) have suggested such a distance-decay effect model.

An alternative, then, would be to define the leading market as the nearest neighbouring one of a larger size and to allow for the possibility that at some points in time the transfer effect from that centre might be a negative or dampening one.

A further alternative, and indeed a more appealing one, would be to attempt to define the leading market in both spatial and structural terms. That is to say, allowance could be made for the fact that the transfer mechanism and its effects, if they exist, are likely to be closely tied to developments in a particular industry, and this could be coupled to a distance decay effect such that the transfer would be strongest in the case of closely spaced markets having similar industrial structures. The work of Bannister (1974) in Southern Ontario indicated several possibilities in this direction.

Further possibilities in regard to this formulation might be as follows. Wage-rate change in any market might reflect the influence of transfer effects from more than one leading market. Also, among the leading markets themselves there could be transfer effects incorporated in the model. Also a strong hierarchical effect might be assumed to exist, whereby conditions in each of the leading markets would be affected by exogenous national factors while, for the nonleading markets, the transfer effects would be regional in character. An attempt to show how this might be accomplished is made below. To take account of the interaction of all centres a system of n structural equations is required.

Thus

$$\dot{w}_i / w_{it} = a_{10} + \sum_{\substack{j=1 \\ i \neq j}}^{m} a_{ji1} (\dot{w}_j / w_{jt}) + \sum_{\substack{j=1 \\ i \neq j}}^{m} b_{ji2} U_{jt} + a_{i3} U_{it} + r_{it}$$

where there are m centres $i, j = 1, \ldots, m.$ This may be expressed in structural form in matrix notation as

$$A \dot{W}_t = A_o + BU_t + r_t$$

where A_o is the nx1 vector of constant terms and U_t and r_t and $\dot{W}_t$ are nx1 vectors of unemployment, residuals and wage rate changes respectively. Thus, each wage rate change in city i, at time t, is not only affected by excess demand at i at t, but also by

(a) wage rate changes at other centres in the system, and

(b) excess demand in other centres.

If there is a theoretical construct that can yield the expected labour market interactions prior to estimation, then the $\dot{w}_i / w_{it}$ and U_{it} variables may be suitably weighted prior to estimation.

It may be noted that this system can accommodate the Thomas and Stoney model as a special case. In that case the only non-zero a_{ij}'s are those pertaining to the single leading market. Hierarchical effects can also be built into the model such that there may be some markets which lead others and are themselves led. Unless the system contains lags, hierarchically interacting labour markets may be difficult to distinguish from a single leading centre, unless the weightings can be established with a high degree of certainty. This, in fact, implies a model very similar to that of Weissbrod (1974), dealt with later.

Analysing a simple system for equilibrium, based on the structural equation below yields the Thomas-Stoney result as a special case. In this system of labour markets the interactions are through the impact of expected wage rate changes in all centres upon the actual wage rate changes in each centre. The parameters, a_{ji}, reflect the spatial and hierarchical structure of the urban or regional system

$$\dot{w}_i / w_{it} = a_{i0} + a_{i1} U_{it} + \sum_{\substack{j=1 \\ i \neq j}}^{m} a_{ji} (\dot{w}_j / w_{jt})^e$$

where $(\dot{w}_j / w_{jt})^e$ = expectations, of other centres, about wage rate changes in centre j.

In matrix form this becomes

$$\dot{W}_t = A_1 U_t + A_2 \dot{W}_t^e$$

and, if it is further assumed that wage expectations are always fulfilled, then

$$\dot{W}_t^e = \dot{W}_t$$

and consequently

$$\dot{W}_t = [I - A_2]^{-1} A_1 U_t \quad ; \; I = \text{nxn identity matrix}$$

A similar result is obtained if an alternative assumption for wage rate expectations is used, namely

$$\dot{W}^{e}_{it} = f(U_{it})$$

in that one reduces the system to all wage rate changes being dependent upon all unemployment rates.

Two major problems arise with these formulations. The first is that the $[I - A_2]^{-1}A_1$ will be a very large matrix for any reasonably sized inter-urban system. The second problem concerns the nature of the Phillips' curve and this problem is dealt with below.

So far the models discussed have been static in the sense that they do not allow self-sustaining cycles and growth; the only time element included is the lag in the relationship of endogenous to purely exogenous variables. It is unlikely, however, that this is the way the system operates. For example, if excess demand for labour causes wage rate changes then it can be argued that wage rate changes will affect excess demands for labour. It is here that alternatives exist: one is that excess demand in centre i is only affected by its own (city i) wage rate changes. But more plausible from the point of view of a general equilibrium system is that excess demand for labour varies (with some lag, perhaps) with both the centre's own and other centres' wage rate changes.

The simplest possible model of this type is that for a perfectly isolated centre, which may be written as,

$$w_{it} - w_{it-1} = f_1(U_{it}) + r_{1t}$$

$$U_{it} = f_2(w_{it-k}) + r_{2t}$$

This system may be solved as a kth-order difference equation.

One of the simplest cases is,

$$w_{it} - w_{it-1} = a_{10} + a_{11}U_{it}$$

$$U_{it} = a_{20} + a_{21}w_{it-1}$$

with

$$a_{10}, a_{20} \geq 0$$

$$a_{11} < 0$$

$$a_{21} > 0$$

This yields the first-order difference equation

$$U_{it} = b_o + b_1 U_{it-1}$$

where

$$b_o = \frac{a_{10}}{a_{21}} , \quad b_1 = (1 + \frac{a_{11}}{a_{21}}) \text{ and } U_i^* = (\frac{b_o}{1-b_1})$$

This result may be generalised to an n^{th} order system where cycles are a possibility, given the bounds $0 \leq U\% \leq 100$. It is a distinct possibility in this model that wages (being unbounded) may rise continuously, both in periods of high and low unemployment, given the unemployment rate is a very imperfect surrogate for excess demand for labour.

The system above is one in which the dynamic properties cannot be known without the numerical values of them being known. This is due to the fact that it is not known whether the slope, b_1 of the line relating this period's unemployment rate and the previous period's unemployment rate is positive or negative. Assuming $1>b_1>0$ the diagram (Diagram 2. 1) illustrates one possible relationship that could exist between the two unemployment rates. A phase diagram is not strictly necessary for the solution of a linear model but is used illustratively as they are an important part of the stability analysis of simple non-linear systems. The thick line represents the relationship existing between unemployment rates at periods t and t-1. The arrows represent the movement of the unemployment rate from some initial position. In this case the model is stable but other values of b_1 could lead to different results thus indicating one severe limitation of phase diagram analysis.

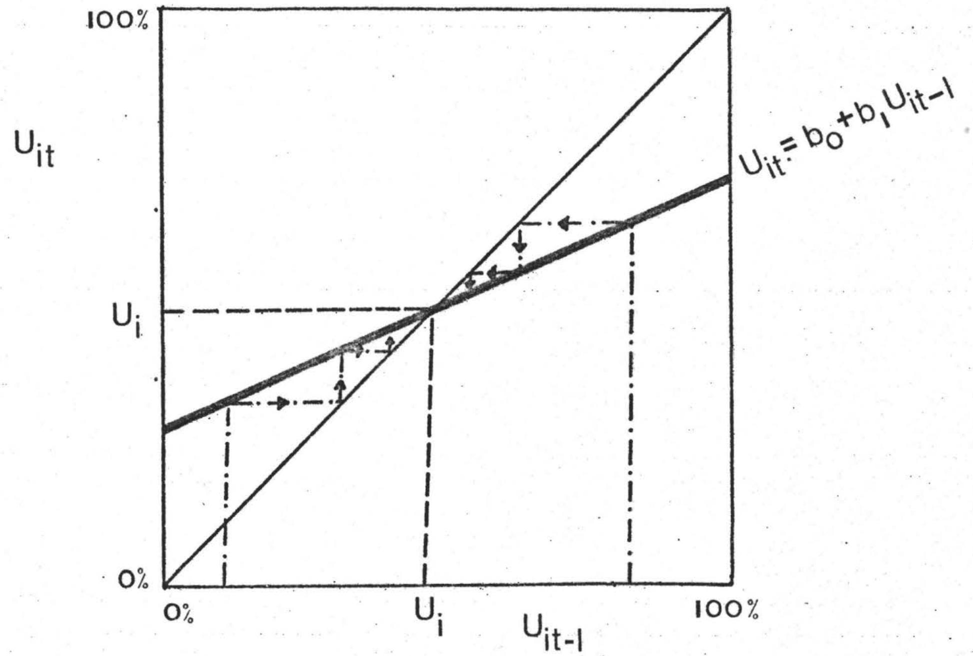


Diagram 2.1. Phase Diagram of the Wage/Unemployment Relationship.

The notion that the centre's labour market operates in isolation may now be dropped in favour of an assumption that labour takes cognisance of wage changes occurring in other centre. The model now becomes similar to those employed by Thirsk (1973), Brechling (1973) and Weissbrod (1974), except that it includes feedback from wages to unemployment.

For each centre there are two structural equations

(1) $$w_{it-1} = a_{10} + \sum_{\substack{j=1 \\ j \neq i}}^{n} a_{ji} w^{e}_{it} + a_{ii} f(U_{jt}) + r_{i1t}$$

(2) $$U_{it} = b_{i0} + \sum_{\substack{j=1 \\ j \neq i}}^{n} b_{ji} f(w_{jt}) + b_{ii} f(w_{it}) + r_{i2t}$$

Thus equation (1) becomes

(1a) $$w_{it} - w_{it-1} = a_{i0} + \sum_{\substack{j=1 \\ j \neq i}}^{n} a_{ji} f(U_{jt}) + a_{ii} f(U_{it}) + r_{i1t}$$

This model is more general than those at present in the literature but it still remains a special case: there may be lags in the expectations, unemployment in one centre may be a lagged function of unemployment in other centres, and so forth. The model is simplified further if it is assumed that it is linear in both parameters and variables. This allows for a similar set of equilibrium and stability conditions as for the isolated centre. Now there are n centres where, for equilibrium, $U_{it} = U_{it-v}$ must hold simultaneously for all centres and for all v, > 0.

In equilibrium wages increase at a constant rate in all cities, not necessarily at the same rate. Note that in this system it is possible for cities to have higher unemployment rates than others and yet have higher wage inflation rates. This is because the wage rate change depends not only upon the coefficients of the Phillips' relationship (the a_{ji}'s) and the wage impact coefficient (b_{ii}), within each city, but also upon the size of linkages with other cities (the b_{ji}'s. and a_{ji}'s).

This system can be generalised further such that specific spatial mechanisms operating in an equilibrating manner are included in the system. Such an attempt is not made here, but it would involve at least two other mechanisms.

(a) the impact of each city's demand for commodities upon commodity demand in other cities.

(b) the flow of labour from one centre to another.

Both these flows are presumable in response to economic return differentials. In this case, static spatial equilibrium in a perfect neoclassical world would imply spatially constant wage and unemployment rates.

An approach which employed the notion of an inter-urban structure explicitly, and which appears to be the first model of this type, was that of Weissbrod (1974). Weissbrod attempted to explain the phenomenon of wage rate changes at the urban level by taking the Phillips' curve hypothesis for the multimarket case and making it explicitly spatial. He wrote:

> " From the geographer's point of view, the spatial arrangement of cities and the relations between these cities offers a special insight into a multi-market formulation of economic activity. By including spatial considerations in the wage adjustment mechanism, two additions to understanding the wage inflation process are possible. One, some modification of the equilibrium solution may be obtained. While this is an important criterion in evaluating the contribution of geographic space, the second objective, constructing an interregional diffusion-adjustment mechanism and assessing it rhough empirical tests equally important in understanding wage inflation.
>
> Spatial diffusion theory is useful in constructing such a mechanism. The notion of asymmetric information flows and corresponding asymmetric interregional adjustments are foreign to the present multimarket economic formulation, but have an important role in establishing the character of relations between regions. Integrating the notion of asymmetric information flows into the interregional adjustment process is also an objective of the dissertation." (p.3)

Essentially Weissbrod's approach was to graft the Phillips' curve relationship onto Central Place theory and inter-urban differences in industrial structure. He then had both hierarchical and distance effects in determining the speed at which wage rate changes are transmitted through the inter-urban system. The model was tested for six centres in Pennsylvania using spectral analysis and cross-spectral analysis to determine the dominance of one centre over another. Weissbrod tested two major hypotheses by this method

(i) that no dominance existed between centres of the same hierarchical level, because processes of wage rate change would be simultaneous at these places,

(ii) that a dominance relation existed between central places at different levels in the hierarchy.

The assumed diffusion process between two cities i and j was a simple lagged model of the form

$$\dot{w}_i/w_{it} = a\ (\dot{w}_j/w_{jt-k}) + r_{it}$$

Weissbrod was able to show that his two hypotheses were correct. He analysed the Phillips' curve hypothesis using cross-spectral analysis and was able to find no support for it whatsoever. This agreed with the results of King and Forster (1973), and also of Albrecht (1966), for the same area of the United States of America. Albrecht stated that national unemployment effects were the most important factors in determining wage rate changes in this part of the United States of America.

The models reviewed so far have been simplistic in terms of the mechanisms portrayed at work at the urban level. All involved single equation models of the labour market mechanism which were modified to include interaction terms. Attention is now focussed upon models which have been formulated as more complete descriptions of the urban labour market process. It is suggested that all but one of these are urban growth models rather than labour market models. The exception was never intended to have any relevance to urban labour markets, and only has so by happenstance and by possible misinterpretation by its author (Neild, 1971). All the models now considered are simultaneous equation econometric models.

Although it is not discussed here in detail, since it has been superseded by other models, Muth's formulation undoubtedly has been one of the most influential of all the urban economic growth models (Muth, 1967). The model was developed in explanation of why cities grow at different rates. As such it was a long-run model and of interest in that growth in employment was seen as being due to growth in labour demand in the urban centre's export sector. As such, it can be regarded as an attempt to remedy the failings of elementary export base theory in that it treated demand for commodities and labour as other than perfectly price inelastic. Similarly, Muth allowed for less than an infinitely elastic supply of labour at a given centre. In particular, there was an explicit formulation of migration (labour supply) in the model. Muth stated;

> " This study is concerned primarily with differential growth in population, employment, and earnings among large U.S. cities in the period 1950 to 1960. Methodologically it differs from ... (previous works) ... in that it treats the growth in employment and migration as simultaneously determined."
>
> (Muth, p.1)

Greenwood's (1973) model analysed gross in-migration, gross out-migration, change in total urban income, total urban employment and total unemployment. The model, as with Muth's, was cross-sectional and was also concentrated upon the one hundred largest United States S.M.S.As. for the period 1950-1960. With three exceptions, the parameters were of the expected signs as estimated using two-stage least-squares.

Neild's (1971) model had a similar form to Muth's and

Greenwood's, but it is of more immediate interest as it dealt with a shorter time period (a five year period). It was an attempt to fully specify a macro theoretical model of a national labour market. The units of observation were a sample of New Zealand's urban areas. The eighteen largest centres were considered for the year 1966, and they ranged in size from Auckland (548, 293) to Nelson (27,615). The model had six simultaneous equations, whose parameters were estimated using two stage least squares.

The equations were:

(i), (iii) Female and Male Labour Supply Schedules

(ii), (iv) Female and Male Labour Demand Schedules

(v), (vi) Female and Male Earnings Schedules

and can be written as

(i) $P_f = a_{10}+a_{11}w_f+a_{12}w_m+a_{13}R+a_{14}G_m+a_{15}A_f+e_1$

(ii) $D_f = a_{20}+a_{21}w_f+a_{22}w_m+a_{23}R+a_{24}G_m+a_{27}I_f+e_2$

(iii) $P_m = a_{30}+a_{32}w_m+a_{33}R+a_{34}G_m+a_{36}A_m+a_{38}S+a_{39}B_m+e_3$

(iv) $D_m = a_{40}+a_{41}w_f+a_{42}w_m+a_{43}R+a_{44}G_m+a_{48}S+e_4$

(v) $w_f = a_{50}+a_{53}R+a_{510}(D_f-P_f)+e_5$

(vi) $w_m = a_{60}+a_{56}R+a_{64}G_m+a_{610}(D_m-P_m)+e_6$

Parameter subscripts follow Neild, all other omitted parameters (e.g. a_{16}, a_6) being set equal to zero. The notation below follows that of Nield.

f = female

m = male

P = participation rate

D = demand for labour

w = wage rate

R = dummy variable (1=N. Island)

(0=S. Island)

A = national participation rate age-sex index

G = industry growth rate (short-run)

B = percentage of population as full-time students

S = seasonal employment percentage index

I = industrial structure index

e = error term

The model was regarded as a national model but for it to be correct it must be

> " assumed that within each urban area there exists a labour demand and a labour supply schedule for each sex, such that the current labour market situation in each area may be completely described with reference to these schedules and the going wage rates." (p.108)

Despite the fact that the model is cross-sectional it is cast in a "dis-equilibrium setting" as it

> " is not necessary to stipulate that each area is in equilibrium at the point (time) of the observation." (p.109)

This disequilibrium can be interpreted as due to the spatio-temporal factors that do not allow for instant mobility of factors both within and between centres. In particular, it is noted that $(D_f - P_f) \neq 0$

and $(D_m - P_f) \neq 0$, which implies non-zero excess demands for labour. If it is assumed, as is implicit in the model, that the centres exist as separate labour markets then parameter estimates are estimates of the averaged parameters for all eighteen centres. In this particular case each centre is given equal weighting. If one wishes to find the national values then a weighting of observations as a proportion of total national male and female labour force in each centre would seem more correct.

There also appear to be various problems of mis-specification and omission with the Neild model. (1). The first of these concerns the impact of migration between areas. In particular this should have been incorporated explicitly into the male schedules. Neild recognised this problem. (2). It is also noted that Neild did not test the model in log-linear form to distinguish empirically whether the better model form was additive or multiplicative. In many ways a log-linear form is also easier to interpret in terms of the parameters. (3). The equilibrium conditions also are found to be rather strange. In short-run equilibrium it must be that $(P_f = D_f)$ and $(P_m = D_m)$. These terms thus disappear from the model. This yields (ignoring the irrelevant dummy variable and the residuals)

(i) $P_f = a_{10} + a_{11} w_f + a_{12} w_m + a_{14} G_m + a_{15} A_f$

(ii) $D_f = a_{20} + a_{21} w_f + a_{22} w_m + a_{24} G_m + a_{27} I_f$

(iii) $P_m = a_{30} + a_{32} w_m + a_{34} G_m + a_{36} A_m + a_{38} S + a_{39} B_m$

(iv) $D_m = a_{40} + a_{41} w_f + a_{42} w_m + a_{44} G_m + a_{48} S$

(v) $w_f = a_{50}$

(vi) $w_m = a_{60} + a_{64} G_m$

It becomes obvious, from equation (v), that Neild's model implies no long run equilibrium growth in women's wages rates in New Zealand. This is completely unjustified, both theoretically and empirically, given productivity growth. Given this mis-specification a systematic upward bias can be expected in the parameter estimates in equation (v). In particular it is expected that the estimate of a_{510} is overly large as long-run increases in w_f, due to growth, are attributed to short-run (excess demand) factors. Despite these strong criticisms, Neild's model is similar to the other models in form, and is of more direct interest as it is intended as a labour market model, not a growth model.

The simultaneous equation models examined above have several common features, or ommissions, that are important in the study of the short-run urban labour market behaviour. The first is that the models were all tested in cross-section. This is a more fundamental weakness than just the inability to test dynamic models. An implication of this is that all parameter estimates are averaged across the whole urban system. Thus the estimate of some parameter, b, will be given by

$$b = \sum_{i=1}^{m} w_i b_i \quad (i=1, 2, \ldots, m)$$

where,

$$w_i = X_i^2 / \sum_{i=1}^{m} X_i^2$$

in the case where the standard regression model holds, as below,

$$Y = a + bX + e$$

A "more correct" system of parameter weightings might be

$$b = \sum_{i=1}^{m} L_i b_i \quad \text{where} \quad \sum_{i=1}^{m} L_i = 1, \text{ and } L_i \text{ represents}$$

the proportion of the total labour force that works in city i. A test of the hypothesis that $b > 0$, for example, may hinge heavily upon the method used. If the hypothesis that $b > 0$ is a proxy for for multiple hypotheses that $b_i > 0$; then $b > 0$ may hide cases where $b_i \leq 0$, for some cities i.

The second major problem is that it is usually impossible to test short-run models when only cross-section data are available. Cross-sectional models are usually only able to accommodate lags that are annual, and usually are quintennial or decennial. The lag is usually determined by periods between censuses. This has been the major stumbling block in the development of short-run econometric models of urban labour markets.

A third problem is that cross-section formulations make it very difficult, if not impossible, to study dynamic interactions between urban labour markets. This stems from the fact that it becomes impossible with inter-urban interaction, to treat the observations (the urban centres) as independent. It becomes difficult to treat the dynamic aspects because of the point already noted, that there are no data for the lags.

One model that did have both an explicitly dynamic formulation and an explicit spatial element was that of Bennett

(1975 a, b, c, d) who sought to model and forecast the dynamics of the North-West regional system in terms of "evolution and spatio-temporal dependency". This model had the form; using Bennett's notation,

(i) $L_{tx} = f(E_{tx}, L_{tx}) + g(U_t)$

(ii) $E_{tx} = f(E_{tx}, L_{tx}, R_t) + g(U_t) + L_{tx}$

(iii) $P_{tx} = f(P_{tx}) + M_{tx}$

(iv) $M_{tx} = f(E_{tx}, L_{tx}, M_{tx}, G_t)$

(v) $I_{tx} = f(E_{tx}, L_{tx}, I_{tx}, C_t, N_t)$

(vi) $T_{tx} = f(E_{tx}, P_{tx}, T_{tx})$

where all variables are vectors or matrices, which are either time (t) or region (x) subscripted, or both.

U = gross regional product

E = total employment

L = total unemployment

M = net migration

I = industrial net migration

T = net receipts of journey to work

C = strength of industrial development commission

R = dummy variable, application of Regional Employment Premium

N = dummy variable, labour training and/or movement grants

P = population

Bennett wrote

> " The system is driven by national product demands registered at the local level by the gross regional product (GRP), and this will become translated to each sector by an input-output matrix which will modify the demand and supply sectors of the labour market."
>
> (1975 b, p. 541)

The labour market was given as the simultaneous relationship in (i) and (ii). This system, in its turn, generated the journey to work and migration system via the spatially differentiated demand for labour. This, in turn,had a longer-run effect on the population, migration and industrial movement structures of the system. It is noticeable that prices of factors did not enter explicitly, although they were implicit in the use of the policy variables such as the employment premiums. The labour market was mis-specified as Bennett admitted, in that he considered equations (i) and (ii) to be only a partial description (1975 b, p. 540).

There are some types of labour market models, and other labour market related models such as those dealing with the theory of the firm, that have only rarely used, if at all, in urban and regional labour market analysis. Some, nevertheless, notably employment adjustment models, seem to have at least some potential in urban labour market analysis. All of these models discussed have one major common element. They all deal explicitly with disequilibrium adjustment mechanisms, being inherently dynamic in their formulation.

Employment adjustment models often have adjustment mechanisms similar to those of the multiplier accelerator models of business cycles. Models of the accelerator type have been applied at the regional level by several workers (Casetti, 1972, Hartman and Seckler, 1967, and Guccione and Allen, 1974). The basic elements of this model, and their application to urban growth theory are now discussed.

Metzler's inventory cycle model had an accelerator mechanism which can be used at the urban level as an employment adjustment model of the labour market.

The model may be written

(i) $Y_{it} = S_{it} + I_{it} + V_{it}$

where

Y_{it} = level of income in city i

S_{it} = production for anticipated sales in city i

I_{it} = non-induced investment in city i

V_t = production of inventory in city i

and

(ii) $C_{it} = bY_{it}$ consumption (sales) function

(iii) $S_{it} = C_{it-1}$ production for sales function

also,

(iv) $V_{it} = (C_{it} - S_{it})$ inventory maintenance function

where

C_{it} = consumption (sales)

Thus (iv) represents a model of producer's inventory behaviour which states that entrepreneurs try to maintain a constant treats the spatial unit as having a well-defined production function.

$$\text{(i)} \quad Q_{it} = a_i + b_i E_{it-1} + 1/2\ C_i E^2_{it-1}$$

Here centre i is assumed to have a quadratic production function with a single input, employed labour (E_i). Output at centre i at time t is measured as Q_{it}. It is now assumed that there is a cost (C_{it}) in changing the employed labour force size such that,

$$\text{(ii)} \quad C_{it} = 1/2\ C_i (E_{it} - E_{it-1})^2.$$

Again a quadratic is assumed. The city can then be assumed to try to maximise present value of discounted profits (V_i) where

$$\text{(iii)} \quad V_i = \sum_{t=0}^{T} \left(\frac{\Pi_{it}}{(1+r_i)^t} \right)$$

where T is the time horizon used for forward planning in the city and r_i is the discount rate applied to future profits in that city. Profits per period are

$$\text{(iv)} \quad \Pi_{it} = P_i\ Q_{it} = w_i E_{it} - C_{it}$$

with P_i being the price per unit of outpur received by city i. In other words,the city is treated as if it behaved as a single, coherent production unit. An aggregative treatment such as this is common in adjustment models for whole industrial sectors (Fair, 1969). A second order difference equation for employment in the city is found capable of yielding a inventory level. In (iv) inventory investment is written as a function of the difference between actual sales (C_{it}) and anticipated sales (S_{it}) in the current period. Successive substitutions yield the accelerator mechanism

$$\text{(v)} \quad V_{it} = b(Y_{it-1} - Y_{it-2})$$

and substituting equations (ii), (iii) and (v) into equation (i) yields the second-order difference equation

$$\text{(vi)} \quad Y_t = 2bY_{t-1} + bY_{t-2} + I_t$$

This has the characteristic equation

$$\lambda^2 - 2b\lambda + b = 0$$

with the roots

$$\lambda_{1,2} = b \pm \sqrt{b(b-1)},$$

which yields dampened oscillatory behaviour if it is assumed, as is normal, that the marginal propensity to consume, b, is less than unity and greater than zero. In this case the marginal propensity to consume was assumed constant for ease of analysis.

Later adjustment models have been couched specifically in employment terms, rather than income, and the adjustment mechanisms are derived from optimisation principles within the model itself.

Usually the Metzler model is used at the national level of aggregation rather than at the city level, as it has been used in this survey. Similarly the Brechling model was designed for the analysis of individual firms rather than cities. The use of these models at the city level implies at least some attempt should be made to relate both models more directly to urban analysis. This can be done in numerous ways of which only three are suggested below.

(i) The urban centre may have two or more sectors which behave according to some adjustment principle. These sectors can correspond to the export base and the service sectors of urban economic base theory. Obviously the sectors interact in competing for the same labour force, with costs of adjustment changing and expectations not always being fulfilled.

(ii) Constraints operate within the urban area that do not operate at other levels of aggregation. In particular, the labour force must be regarded as limited; thus the maximisation of present value of discounted profits must be constrained or, if the centre is myopic in its optimisation, notably in expanding as though there were no operative constraints, the full employment ceiling may cause cycles as in the Hick's trade cycle model (Dernburg and Dernburg, pp. 162- 166).

(iii) The city operates within an urban system. This implies the city's decisions may cause reactions from other centres with expectations being unfulfilled. This may be through migration of labour, induced changes in orders, output prices and wages and adjustment costs.

The analytic solution of such multisectoral, dynamic optimisation models seems unlikely at present, nor is the data available for their direct empirical implimentation. These are some of the reasons for the use of the simpler models, such as the Phillips' curve, in urban labour market models to the present. On the other hand at least one analysis of an urban employment adjustment model has been completed and applied empirically (Alperovich, et al., 1975). The work of Alperovich and his associates appears as the only model of the adjustment type to be applied in a spatial or urban context. They specified a non-linear partial adjustment model,

$$E_{ikt} - E_{ikt-1} = A_{ik} (E^*_{ikt} - E_{ikt-1})$$

where

E = employment

E*= desired employment

A_{ik} = adjustment coefficient for industry k in city i

t = 1970, t-1 = 1965

and where A_{ik} was not a constant but depended upon the unemployment and growth rates of the labour force and employment. It was this definition of the adjustment coefficient that introduced the non-linearities. The desired employment level was given by the calculation of production potentials for city i. The production potentials were based upon the inputs of commodities k required by other cities, where their level of demand for i's production was determined by their size and their distance from city i. Unfortunately "the data are not consistent with this partial adjustment model". A "full-adjustment" model was then tried which set A_{ik} = 1.0 and added E_{ikt-1} to both sides. The model then became,

$$E_{ikt} = E^*_{ikt-1}$$

which has little theoretical appeal. Empirically this was the more successful model, but nevertheless the results were not encouraging

The reasons for the poor results of the Alperovich model remain something of a mystery: there seems to be no explanation for those results except that the nature of A_{ik} must have been gravely mis-specified or the cross-sectional data used were not adequate. It is possible that the five-year time lag used was much too long and that urban employment adjustments take place at much faster rates.

The use of "Probabilistic economics" in labour market analysis has been developed from Stigler's paper on the role of information in labour markets (Stigler, 1962). The uncertainties faced by both employers and employees are translated into risk measures which depend upon the information they have available. Thus, wages are not taken as certain by the potential employee but as having a well defined probability distribution. The role of search, subject to limited initial information and constraints upon the resources that can be allocated to search, can then be used to explain aggregate phenomena such as the Phillips' curve, structural unemployment and so forth. In most cases this work has been associated with a resurgence of interest in the micro-economics of employment and inflation theory (Phelps, 1970; Burdett, 1976). It has also found a natural extension in the theory of labour migration where information and economic opportunity have been emphasised in many studies (Cragg, 1973). Only recently, however, have explicit models of search and risk behaviour entered into the literature on migration. (David, 1975).

It can be assumed to be that of an urban labour market which interacts with other urban labour markets, including at the inter-urban level. In this sense, there is a generalisation of the model for the search processes involved now include the possibility of searching other urban labour markets with the possibility of migration (David, op. cit.). Thus the model of search can be generalised although the search principles involved in intra- and inter-urban search stay the same; the searcher wishes to allocate resources so as to maximise his/her expected net lifetime flow of income. The uncertainties that now play a major role, plus the cost of overcoming them, particularly when workers are racially, sexually, spatially, and skill differentiated, implies that movement from low to high economic welfare regions will not be instananeous. Perhaps most importantly, these models can be used to explain migration flows that would otherwise appear economically irrational. The distribution of wage rates within each urban centre, for example, allows the possibility of an individual migrating from a higher to a lower wage centre, given that search has revealed the possibility of a high wage offer to that individual.

Essentially the search models still follow Stigler's original optimal search rule; search systematic sampling from a frequency distribution of economic reqards is not continued beyond the point at which the increment in search costs is equal to the increment in search benefits. Thus search can be expected to be concentrated in higher wage centres, but a calculable probability of finding the best offer in a lower wage centre implying some search effort being allocated those lower wage centres.

The role of the spatial mobility of labour in general is now examined briefly. Some of the models already discussed impinge on this discussion. The main purpose here is to point to a significant gap in the data and the models that are presently available, particularly concerning the possibility of job migration without residential relocation. In the literature and in the data, migration usually implies job change (David, op. cit.). The major exception is intra-urban level migration where housing relocation is often considered separately from job search. However, what evidence there is suggests that both job and residential mobility in North America are extremely high. It seems possible, therefore, that in a very closely linked inter-urban system with overlapping commuting zones, job migration at the inter-urban level, without corresponding residential migration, may be common. It seems probable that this type of job-migration can take place much more quickly than job-migration that also involves residential relocation. However, as with much short-run urban labour market phenomena, apart from wage rate change and unemployment change, there seems to be a considerable lacuna in the literature.

Conclusion

This survey has been taken in five broad sections, some with a great deal of overlap. The earlier sections dealt with models that have been used in urban labour market analysis up until the present. The penultimate section dealt with two model types that may be of use in the future. In each section an attempt has been made to discuss the problems associated with their application and errors that have been made.

In the past, the major body of work related to this thesis has been purely empirical and inductive. This has resulted in a great deal of mis-specification, particularly in the form of single equation bias. This also has led to a dearth of dynamic models even when the theoretical situation demands this. In some cases, but not all, these faults can be attributed to the poor data base that exists for the analysis of short-run urban phenomena. There also appears to be a lack of any model that attempts to integrate intra-urban processes and their interaction with inter-urban processes and inter-urban structure. This could well be a problem not only of data but also of the different time scales that may be involved in considering structure and process. This lack of an integrative model seems likely to stay given the problems involved, but it does seem that it is possible to go some way to overcoming the dearth of short-run urban labour market models.

CHAPTER THREE

A FAMILY OF DYNAMIC URBAN LABOUR MARKET MODELS

The Problem Stated and a Vocabulary

The existence and operation of urban labour markets, at any and all spatial scales, albeit with differing degrees of cohesion of operation, is hardly in doubt. Nevertheless, the stance adopted here is that the term "labour market" is an abstract social-scientific construct. The construct "urban labour market" is much more so, in that it requires additional abstractions: it is argued that from these additional abstractions stem many of the problems of both theoretical and empirical analysis. That this is particularly true of short-run urban labour market analysis is suggested, at least in part, by the comparative rarity of such models. The problem posed here is one of constructing short-run labour market models that may be tested empirically and which indicate the impact of urban structure upon labour market operations. Any attempt to resolve this problem requires a definition of the terms used. The definition of the required terms follows. After the definitions are given a series of models of urban labour markets are presented that are based upon those definitions.

A labour market is defined as the orderly interaction of potential employers and employees, determining the qualities and quantities of labour to be hired and their respective rates of payment. In the case of a sufficiently small labour market there is no discernible impact of these ordered operations upon the overall economic environment. Some labour markets, however, are sufficiently large that they can be conceived of as playing a dominant role in some part of the general economic environment. Thus, in the United States of America, the New York city labour market plays a dominant regional role and has a national role, whilst the Binghamton labour market in the same state, by contrast, has no discernible impact at either of these spatial scales. Labour markets are often defined by industrial or skill types but here the segmentation is spatial. Thus an urban labour market is regarded as any labour market whose mechanisms of interaction between employers and employees are influenced to some defree by their urban milieu. The urban milieu is intended to imply all of the structural characteristics of urban areas, both physical and social. An urban system is taken to mean a set of cities where interaction occurs at both the intra-urban and inter-urban levels. An inter-urban system then is one in which the modeller considers only the rules of interaction operating at the inter-urban level. Similarly an intra-urban system is one in which the modeller considers only intra-urban interactions. The terms inter-urban labour market and intra-urban labour market are now readily understood as systems where the interactions considered, whether inter-urban or intra-urban, are those occurring solely between labour market variables. A space-dependent labour market is one in which the interactions of participants are significantly affected by relative locations. A space-neutral labour market, then, is one in which the participants are not significantly affected in their interactions by their relative locations. To justify this distinction it is noted that an important class of labour markets is spatially dependent and non-urban, that is agricultural labour markets.

Finally short-run, medium-run and long-run, all general modelling concepts, are defined in terms relating directly to the problems of modelling urban labour markets. By the short-run is meant a period in which labour market variables, such as unemployment rates, can be changing in value. On the other hand, although the urban structure may be in disequilibrium, it exhibits only marginal changes and can be regarded as fixed. Nevertheless, it is averred that urban structures, change in response to persistent labour market changes. For example, a persistent increase in unemployment in a city will probably mean it will grow less than other cities. Consequently the long-run is defined as the period in which not only labour markets but also the urban structures themselves, can reach equilibrium. The long-run structural equilibrium therefore also implies an unchanging structure, but from a different analytical viewpoint than that of the unchanging structure assumed for the short-run. This long-run equilibrium of urban structure is important in its several implications for labour market operations, but particularly so for labour migration. Migration not only affects urban structure, through its impact upon urban size, but also affects labour market operations in the role spatially redistributing the labour supply.

The medium-run is now definable as the period during which urban structural change can be considered to occur. As migration is of importance not only in urban labour market terms but in urban structural change as well, in determining city sizes, the analysis of migration rates forms a principal component of medium-run models. A necessary condition for equilibrium in the structure of an urban system is that net-migration be zero for all cities. Only then, assuming no natural increase affects relative city size, can the urban system be considered in long-run equilibrium.

The choice of which of the three time horizons, and the spatial scale to be used, depends largely upon the problem to be analysed. They are all clearly modelling constructs for reducing the complexity of any analysis. In the case of empirical work, however, the choice is often dictated by the data. Similarly, it is frequently data availability that dictates the choice of region for empirical tests.

The Conceptual Framework

The conceptual framework is woven into the vocabulary, but the framework requires some expansion before the specific models are set forth.

The intra-urban labour market models are distinguished here by two major features. First, they conform to a simple, aggregate, economic model of demand and supply. Second, they are considered explicitly in a disequilibrium framework. Models of demand and supply of either commodities or factors of production have been cast usually in an equilibrium framework. To overcome this absence of disequilibrium models a simple partial adjustment mechanism is used to describe the dynamic or disequilibrium behaviour of the system. The use of this mechanism for urban labour markets implies that the system adjusts from the actual level of a variable, toward the equilibrium or desired level of the variable, though the adjustment will not be instantaneous. This conception of the urban labour market has to be modified substantially if there is interaction with other urban centres. Each centre can be in competition with, as well as being complementary to all other centres. This will be seen in the interdependencies of labour markets, as changes in the urban system's production are reflected in changes in the desired levels of inputs to the production process. Each centre's labour market will then attempt to adjust to the desired levels. These desired levels are determined by the economic system as a whole often as an expression of national economic policy. This competition/ complementarity will be channelled as a series of inter-urban interactions whose form will be determined largely by the inter-urban structure.

In the short-run, however, the type of interactions will be largely dependent upon the assumption of the spatial immobility of all factors of production. The labour market influences that are channelled between centres in the short-run will be the spatially mobile ones such as expectations, production orders, information and, perhaps, commodity shipments from inventory. The spatial immobility of some labour market entities might, therefore induce compensating movements to occur in the levels of more spatially mobile labour market entities. For example, unfilled orders for one centre's production can be shifted to another centre with excess production capacity much more quickly than capacity can be increased at the original place of order by capital movements.

These interactions are not random and the urban structure can be expected to evolve to accommodate recurrent secular and spatial shifts in trade. This implies that there will be some redundancy in the channels between the labour markets to accommodate the recurrent and expected, as well as any unexpected, trade shifts. If a shift is persistent then, in the long-run, changes in the urban structure will occur as a response. For example, a temporary increase in demand for a centre's production will not affect its size. If the demand increase is permanent the centre's size will increase in the medium-run, changing the city's overall urban structure. This response will itself influence the pattern of production and labour markets until a new equilibrium system is reached. The system's response will be via changes in the size of urban centres, due to factor relocation, and to changes in the interaction channels between centres.

This conception of urban labour market operations is one in which only economic variables have any meaning. Social and cultural factors, except in so far as they impinge upon the operation of each labour market, are ignored. The system is considered both efficient and stable in terms of its overall economic urban structure. The urban centres then are considered solely as the spatial loci of the production process as expressed through their labour markets.

A General Model of Labour Markets in an Urban System

The model presented here is general in the sense that no specific hypotheses concerning the relationship between individual variables are made and, more importantly, because it encompasses both inter-urban and intra-urban labour markets. The model is specified as a set of simultaneous, constant coefficient, linear, first-order difference equations. The model is developed by looking first at the form, and the equilibrium and the stability conditions of an intra-urban labour market. Second, the relationships between these labour markets are then examined at the inter-urban scale using a simple model of inter-urban structure. The equilibrium and stability conditions for the whole system are examined. Finally, a more detailed model is specified for the urban level. It is this more detailed but smaller model that is tested, given the difficulties in analysing and testing the larger model that incorporates inter-urban interactions.

The Internal Urban Labour Market : A Mode of Analysis

At the intra-urban level in any urban centre, a mass of labour market types exist, many of which are not only space dependent but also overlap in space and function. Commuting zones for employment centres are a sommon expression of this spatial overlapping.

They also overlap in the sense that separate markets often demand the same types of skills and consequently have a common labour supply. In reality, of course, there is only a single, but overwhelmingly complex, labour market and the use of any typology is a modelling simplification. A full dynamic model of such intra-urban systems has yet to be developed. Here the internal urban labour market is simplified by an aspatial treatment. Nevertheless, in any model with interdependent labour demand and supply functions the spatial element can be represented indirectly. The speeds of adjustment, relative costs of labour and so forth are indirect reflections of the impedance of space and, consequently, these elements of labour market interaction can be correlated with inter-urban location after model estimation.

The model for each centre's internal labour market can be written as a series of equations in matrix form such that

(1) $$A_{1i}X_{it} = A_{2i}X_{it-1} + A_{3i}Z_{it}$$

It has been demonstrated that any simultaneous system of linear, constant-coefficient, higher-order (order of 2 or greater) difference equations can be reduced to a simultaneous system of linear, constant-coefficient, first-order difference equations (Baumol, pp.332-334; Wallis, pp.125-127). Consequently only first-order systems of equations have to be considered in this analysis. The analysis of these constructed first-order systems proceeds exactly as for ordinary first order systems (Wallis, pp.125-127).

A completely autonomous urban centre is free from all external influences and its labour market will have the form

(2) $$A_{1i}X_{it} = A_{2i}X_{it-1}$$

This special model is unduly unrealistic and is likely to be accurate only for the very short-run. In the less restrictive model of (1) it can be seen that the centre itself does not influence the inter-urban, regional or national system to which it belongs, as represented by the vector, Z_{it}. This can be due to either the size of the centre being comparatively small or the time-period of the model being too short for the impacts to be discernible. The much larger inter-urban, regional or national systems do, however, have a discernible impact upon the centre and this is vital in the interpretation of the equilibrium of the model.

By solving (1) explicitly for X_{it}, the system below is found,

(3) $$X_{it} = \Pi_1 X_{it-1} + \Pi_{2i} Z_{it}$$

where

$$\Pi_{1i} = A_{1i}^{-1} A_{2i}$$

$$\Pi_{2i} = A_{1i}^{-1} A_{3i}$$

assuming that the inverse of A_{1i} exists. Equation (3) is the reduced form of the system shown in structural form in equation (1).

The equilibrium properties of a system are defined as, those properties obtaining when there is no tendency for change in the endogenous variables of the system, so long as the external influences (exogenous variables) upon the system are held constant. The equilibrium properties can be found by assuming the external influences are constant, i.e. the vector of exogenous variables is held stationary at some value $\overline{Z}_i$. The equilibrium values of the indogenous variables can then be calculated for their response to any arbitrarily defined $\overline{Z}_i$. The labour market is in equilibrium when there is a vector of endogenous variables, X_i^*, such that $X_{it} = X_{it-v}$, for every value of the time lag v. Substituting X_i^* and $\overline{Z}_i$ into the reduced form gives

(4) $$X_i^* = \Pi_{1i} X_i^* = \Pi_{2i} \overline{Z}_i$$

which is explicitly solved for X_i^* as

(5) $$X_i^* = [I - \Pi_{1i}]^{-1} \Pi_{2i} \overline{Z}_i$$

where I is the m x m identity matrix and the inverse of $[I - \Pi_{1i}]$ exists. The equilibrium values of the labour-market variables are, therefore, expressed entirely in terms of Π_{1i},Π_{2i} and $\overline{Z}_i$. This allows information to be gained about the equilibrium state of the labour market with respect to the overall state of the internal economic system as represented by $\overline{Z}_i$. A specific example is the response of any or all labour market endogenous variables, such as employment or the wage rate; to the level of production in city i. In this case the production level is assumed to be determined by factors other than labour market conditions and is, therefore, an exogenous variable. The matrix $[I - \Pi_{1i}]^{-1}\Pi_{2i}$ is of order m x g_i and the element of its <u>yth</u> row (y=1,...,m) and <u>uth</u> column (u=1,..., g_i), from equation (6), represents the equilibrium response of the yth endogenous variable to a sustained unit change in the uth exogenous variables. These elements are known as the <u>equilibrium</u> multipliers of the system.

Conversely, the <u>impact</u> multipliers measure the response of an endogenous variable to a unit change in an exogenous variable, during the same time period within which the change in the exogenous variable takes place. Thus values of X_{it} are related to values of Z_{it} via the impact multiplier. They are related via the elements of the Π_{2i} matrix in the reduced form, equation (3), where

$$(3) \qquad X_{it} = \Pi_{1i}X_{it-1} + \Pi_{2i}Z_{it}$$

The elements of Π_{2i} are, therefore, the impact multipliers. Similarly, Goldberger defines the <u>delay</u> multipliers as being, those multipliers relating a previous,period t-v (v.>o), one unit change in an exogenous variable, lasting only one period, to the resultant change in the value of an endogenous variable at time t. The delay of the multiplier is measured as v. To find the one period (v=1) delay multipliers the relationship of Z_{it-1} to X_{it} is required. Changing time periods only,the reduced form is written as

(3a) $$X_{it+1} = \Pi_{1i}X_{it} + \Pi_{2i}Z_{it+1}$$

In (3a) the vector X_{it} is replaced by the right hand side of (3) yielding

(3b) $$X_{it+1} = \Pi_{1i} (\Pi_{1i}X_{it=1} + \Pi_{2i}Z_{it}) = \Pi_{2i}Z_{it+1}$$

and

(3c) $$X_{it+1} = \Pi^2_{1i}X_{it-1} + \Pi_{1i} \Pi_{2i}Z_{it} + \Pi_{2i}Z_{it+1}$$

Lagging the whole of (3c) by one period shows the relationship between X_{it} and Z_{it-1} to be given by $\Pi_{1i} \Pi_{2i}$. The elements of this m x g_i matrix are defined as the delay multipliers. Further manipulation following (3), (3a), (3b) and (3c) yields the higher order (i.e. v>1) delay multipliers. It can be shown that the v period delay multipliers are given as the elements of the matrix $\Pi^v_{1i}.\Pi_{2i}$ for v>0 (Goldberger, p.374).

If, rather than a one period economic impulse from the external economic system, the interest is in the effects of a given persisting change in the level of economic impulses upon the level of activity in the labour market, this can also be translated into multiplier terms. The interest then is in the effects of the persisting change in the level of the exogenous variable upon the levels of the endogenous variables. The equilibrium multiplier defined in (5) is the limiting example of this, when the persistent change in the levels of exogenous variables can be regarded as permanent. The dynamic multipliers are found by summing the impacts of the persisting change for each period that it has persisted. Consequently for period zero the impact multiplier and dynamic multiplier are identical. The multipliers can be listed as

t = period	Delay Multipliers	Dynamic Multipliers
t = 0	Π_{2i}	Π_{2i}
t = 1	$\Pi_{1i}\Pi_{2i}$	$\Pi_{1i}\Pi_{2i}\ \Pi_{2i}$
t = 2	$\Pi^2_{1i}\Pi_{2i}$	$\Pi^2_{1i}\Pi_{2i}\ \Pi_{1i}\Pi_{2i}\ \Pi_{2i}$
⋮	⋮	⋮
t = v	$\Pi^v_{1i}\Pi_{2i}$	$\sum_{t=0}^{v}\Pi^t_{1i}\Pi_{2i}$

where, by definition

$$(6) \qquad \sum_{t=0}^{v} \Pi^t_{1i}\ \Pi_{2i} = (I + \Pi_{1i} + \Pi^2_{1i} + \ldots + \Pi^t_{1i} + \ldots + \Pi^v_{1i})\Pi_{2i}$$

If the $\lim_{v \to \infty} \Pi^v_{1i} = 0$, where 0 is the m x m null matrix, it can be shown that the series expansion

$$(7) \qquad [I-\Pi_{1i}]^{-1} = (I + \Pi_{1i} + \Pi^2_{1i} + \Pi^3_{1i} + \ldots + \Pi^t_{1i} + \ldots + \Pi^v_{1i})$$

holds (Dernburg and Dernburg, pp.70-73). The relationship of the equilibrium multiplier to the dynamic multipliers can now be seen, for the equilibrium multiplier may be defined as

$$(5a) \qquad [I- \Pi_{1i}]^{-1}\Pi_{2i} = \sum_{t=o}^{\infty} \Pi^t_{1i}\ \Pi_{2i}$$

The use of combinations of impact and dynamic multipliers can show the effects on the endogenous variables of any regular or irregular time profile of changes in the exogenous variables. The effects of the different exogenous variables can be treated separately or together.

The multiplier analyses, however, being concerned with the response of the endogenous variables to the exogenous variables only implicitly analyse the relationships existing between the current endogenous variables and the lagged endogenous variables. Nevertheless, these relationships do have a considerable effect on the behaviour of the system that will appear in the multiplier analyses other than for the impact multipliers. This is due to the appearance of the Π_{1i} in all except the impact multiplier analyses. It is this matrix that expresses the relationships that exist between the current endogenous variables and the lagged endogenous variables. Consequently it is upon this matrix that the ability of the labour market depends, to autonomously maintain cycles, growth and oscillations. Esentially, the matrix Π_{1i} determines the dynamic behaviour of a system. Here the dynamic behaviour of a system, such as a labour market, is defined as its behaviour when the system is disturbed from equilibrium (i.e. when $X_{it} = X_i^*$, given the values of the exogenous variables, Z_{it}). For analysis the vector of exogenous variables is assumed stationary at some level $\overline{Z}_i$. This allows the influence of the external impulses to the labour market to be ignored. The "inherent dynamic properties" of the labour market can, therefore be discovered by an analysis of the Π_{1i} matrix alone, where

> "The inherent dynamic properties refer to the characteristics of the time path undertaken by the endogenous variables following an initial displacement from equilibrium without further exogenous changes or disturbances."
> (Goldberger, p.376)

The characteristic roots (eigenvalues) of the matrix Π_{1i} determine the dynamic properties of the system in full, where the characteristics roots are found as the solution to the characteristic equation of the matrix Π_{1i}. The characteristic equation is found by forming the matrix

(8) $$G = [\Pi_{1i} - \lambda I]$$

where λ is an unknown scalar and I is an m x m identity matrix. The characteristic equation is the determinantal equation of matrix G set equal to zero, i.e.

(9) $$|G| = 0$$

The expanded form of (9) is given by (9a)

(9a) $$\begin{vmatrix} \Pi_{11}-\lambda & \Pi_{12} & & \Pi_{1m} \\ \Pi_{21} & \Pi_{22}-\lambda & & \\ & \cdot & & \\ & \cdot & & \\ & \Pi_{uu}-\lambda & & \\ & & \cdot & \\ & & \cdot & \\ & & \cdot & \\ \Pi_{m1} & & & \Pi_{mm}-\lambda \end{vmatrix} = 0$$

and solve for all possible values of λ. In general an analytic solution is not possible for these forms, but they are solvable by computer. The dynamic properties are then inferred from the values of the characteristic roots as follows

(i) Stability of the system requires that

(10) $$\lim_{t\to\infty} \Pi_{1i}^{t} = 0$$

which has the necessary condition that the greatest absolute value of the real part of any and all roots be less than unity.

The dynamic properties of a system refer to the behaviour of that system when it is in disequilibrium. Two major aspects of the dynamics are considered. The first is the stability of the system as a whole. The stability of a system refers to the tendency of forces acting within that system to move it towards equilibrium, given the level of the external forces operating upon the system. In the case of multivariable systems, as in the urban labour market model, stability obviously refers to all of the variables moving interdependently toward their mutual equilibrium values. However, the stability of the system can be measured by the analysis of single statistic, the characteristic root or eigenvalue, rather than independently examining the properties of the variables.

The second aspect is the nature of the time path taken by the system when it is in disequilibrium. Types of time behaviour, other than a monotonic movement of the variables towards or away from equilibrium are possible, depending upon the characteristic roots of the system.

(ii) The presence of any complex root implies that fluctuations will occur in the time path of the model. A complex root is any characteristic root or eigenvalue that is a complex number (Gandolfo, pp. 50-56). The fluctuations occur irrespective of the stability of the system. Baumol (1970) refers to them as "an element in the solution which fluctuates more or less cyclically and that the length of the cycle varies from case to case" (p. 211). If the modulus of any complex root is greater than unity then the system will exhibit explosive cycles in that fluctuations will continue to increase through time. If all complex roots have a modulus less than unity then the fluctuations will die down, or become "damped", through time.

The presence of negative roots yields saw-tooth behaviour in the time path of the model (Gandolfo, pp. 121-138; Baumol, pp. 323-378). Saw-tooth refers to the behaviour of the values of a variable of a system with a negative root. It is also referred to as an oscillation, as opposed to the fluctuations occurring as a result of the presence of a complex root.

> "an oscillation is necessarily two periods in length and is what we expect to result from negative roots, while a fluctuation is generally over two periods in length and is what we expect to occur from complex roots. We might not expect oscillations to occur in economic problems as frequently as do fluctuations" (Baumol, 1970, p.213)

Each negative root produces behaviour of the system that put the value of the variable above some other given value on alternate periods (e.g. t, t+2, t+4, t+6) and below it on the other periods (e.g. t+1, t+3, t+5, t+7). This behaviour is symmetric in that the amplitude of the oscillations are constant through time.

For the general mathematical form of the model presented, the values and signs of the coefficient of Π_{1i} are unknown. There is no specific theory from which coefficient values can be deduced. Consequently specific equilibrium and stability properties cannot be deduced. They can only be known after empirical estimation of the matrix, Π_{1i}. Nevertheless, it is expected that for urban labour markets, equilibrium solutions exist and that the labour markets are stable. This is inferred from the assumption that urban labour markets are not the prime-movers in the economy: they respond to changes in the national and regional product markets but do not determine the state of such markets. In the case of the largest urban labour markets, again New York is the outstanding example, the possibility of internally generated cycles, decline and/or growth is much greater. It is argued that such large urban economies are much more autonomous than the others and are therefore much more capable of autonomously generating cycles and growth. It is recognised, however, that such an argument is suggestive rather than conclusive. In analysing the behaviour of all of the urban centres it is possible, as judged from the relative sizes of the largest roots, that the largest centres show themselves empirically to be the more unstable. Consequently, stability analysis of these models has direct economic interpretations. It is also possible that urban labour markets have stability characteristics that have a spatial expression. There could be regional groupings of markets according to their relative stability, their ability to generate cycles and saw-tooth behaviour. On the other hand, without any strong arguments to suggest that cities in close proximity will have similar dynamic properties, it can equally will be argued that industrial structure or some other structural social and economic factors are more important in determining those properties.

(ii) Construction of an Inter-Urban Labour Market Model

The internal urban labour market model is now used as a basis for constructing an iter-urban labour market model. The internal model forms a basis in that it operates as a sub-model of the full inter-urban model. The inter-urban labour market model uses identical mathematics for equilibrium and stability analyses to that of the internal labour market model. The internal model was of an autonomous or semi-autonomous urban labour market. The undoubted interactions existing between any and all pairs of urban labour markets are now fully specified, as opposed to being either aggregated in the vector of exogenous variables, Z, as one modelling strategy, or ignored completely as in the case of the completely autonomous model. The relevant labour market variables remain but they are now repeated n times; once for each of the n urban centres. For example, there are now n different wage rates for a particular skill to be considered. This model is given in the form

$$A_1X_t = A_2X_{t-1} + A_3Z_t \tag{11}$$

or more fully

(11a)

$$\begin{bmatrix} A_{111} & A_{112} & & & & \\ A_{121} & A_{122} & & & & \\ & & \ddots & & & \\ & & & A_{1ii} & A_{1ji} & \\ & & & A_{1ij} & A_{ijj} & \\ & & & & & \ddots \\ & & & & & & A_{1nn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_i \\ X_j \\ \vdots \\ X_n \end{bmatrix}_t = \begin{bmatrix} A_{211} & A_{212} & & & & \\ A_{221} & A_{222} & & & & \\ & & \ddots & & & \\ & & & A_{2ii} & A_{2ij} & \\ & & & A_{2ji} & A_{2jj} & \\ & & & & & \ddots \\ & & & & & & A_{2nn} \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ \vdots \\ X_i \\ X_j \\ \vdots \\ X_n \end{bmatrix}_{t-1} + \begin{bmatrix} \\ A_3 \\ \\ \end{bmatrix} \begin{bmatrix} Z \end{bmatrix}_t$$

Z_t is a g x 1 vector representing national, regional and other influences unaffected by the entire urban system. This is an exogenous vector; the equivalent of the Z_{it} vector of the internal labour market model. In general, however, the size of the Z_{it} and Z_t vectors will vary for some variables exogenous to any given centre will be endogenous to the urban system as a whole. For example, the average inter-urban system wage rate, which may have an important role in wage expectations, is exogenous to a single centre. It is obviously endogenous to the inter-urban system as a whole. Some of these exogenous variables may still apply uniquely to one centre or to a sub-set of centres of the inter-urban system. In many cases the variables in this vector will be the same as those in the Z_{it} vector for a single centre.

A_3 is a nm x g matrix representing the instantaneous impact of the exogenous variables upon the overall inter-urban system. In the internal labour market the mathematically equivalent matrix is also A_3.

The reduced form conditions for equilibrium and stability for the inter-urban system as a whole can be analysed as for the internal labour market given that this system is also expressed as a set of simulations, linear, constant-coefficient difference equations. The specific forms of the A_{1i} and A_{2i} internal labour market model matrices are determined largely by the use of an aggregate, dynamic demand and supply model. The equivalent sub-matrices in the inter-urban system are those labelled A_{111}, A_{122}, ..., A_{1ij}, ..., A_{1nn} and the A_{211}, A_{222}, ..., A_{2ii}, A_{2jj}, ..., A_{2nn} denoting internal interactions. They form rhe block-diagonal part of the A_1 and A_2 matrices. The off block-diagonal elements of A_1 and A_2 denote the interactions between labour market variables that operate between centres such as production orders, wage rate information and labour migration. These inter-urban interaction submatrices represent the dual influence of the demand and supply model of multiple markets and a model of the inter-urban structure. The strength of interactions between any pair of labour markets will be largely determined by the inter-urban structure. For example, wage expectations in one centre may be affected, not only by unemployment in that centre, but wages in other centres closely allied to it in the inter-urban system. Alternatively wage expectations in any given centre may be related to other variables such as migration. This type of matrix can be used empirically to deal with either case and to verify either alternative explanation.

It is unlikely that labour market variables that do not interact directly at the intra-urban level will do so at the inter-urban level. However, labour market theory itself cannot be the sole guide to inter-urban labour market interactions as the inter-urban structure will, to a large degree, regulate those interactions. A model of the inter-urban structure is required.

In Geography the analysis of inter-urban structures and relationships has long been a major theme, although very few attempts have been made to develop such models specifically for labour market process analysis (Forster, 1978). Central Place Theory has usually provided the basis for inter-urban labour market analysis, despite some serious failings in that area. Weissbrod (1974) is a major example of the use of Central Place Theory in the labour market context. One failing of the Theory is that a complete interpretation of its otherwise abstract geometry is required. Although spatial consumer theory provides the most natural interpretation for the geometry it is certainly not relevant for labour market analyses. Weissbrod interprets the Central Place hierarchy as being largely of job skills,providing only a partial theory of the labour market. A second failing is that Central Place Theory does not allow for any interaction between urban centres; a considerable failing if it is wished to analyse labour market interactions. Consequently a model has to be grafted onto the Theory to explain the role of the inter-urban structure as a processor and transmitter of labour market changes. Associated with this is a third failing, which is that Central Place Theory does not allow any complementarity between centres. The use of one centre's output by another centre ensures that such complementarity exists between the labour markets of those centres.

In innovation diffusion studies models of inter-urban structure have long been used to show how those structures determine the spatio-temporal patterns of diffusion processes. In some studies, notably Hudson's, the work has been entirely theoretical (Hudson, 1969). In that study, Central Place Theory and a gravity model were used to define the inter-urban structure. The most probable pattern of diffusion of any innovation, adhering to some simple set of rules governing its adoption,could then be found. The work of Cliff and others is very different in that it deals with a specific diffusion subject (measles) and for a specific time period, (1966-1970). More impostantly, for this study, a specific inter-urban structure (for S.W. England) is described, and the nature of the spatial links directly relevant to the diffusion of measles is stated (Cliff et. al. pp.96-98). In the study of labour markets a gravity model of interaction seems most plausible, the sizes of cities and the distances between them affecting the strength of interactions. The inter-urban structure is not likely to be relevant for all labour market variables and different facets of inter-urban structure are likely to affect some variables more than others. Consequently it may be necessary to use different models simultaneously but, here, only one model is used for exemplification. If this model were to be used for wage rate expectation links, for example, I_{ij} would be some measure of wage rate information.

Two major parts of the model of inter-urban structure are,

(i) the presence or not of an inter-urban structural link between any arbitrary pair of centres i and j, and

(ii) given that the link exists, the strength of that link must be known.

The strength of the link can be determined by a simple spatial interaction model outlined here, although other specifications are possible. The strength of the link is given by

(12) $I_{ij} = f(M_i, M_j, d_{ij})$; iff $k_{ij}=1$

$I_{ij} = 0$; iff $k_{ij}=0$

$i \neq j$; $i,j=1,\ldots,n$

where

I_{ij} = capacity of the link between labour market impulse-generating centre i and impulse-receiving centre j,

M_i = potential of labour market at centre i for generating impulses,

M_j = potential of labour market at centre j for receiving impulses,

d_{ij} = measure of the proximity of centre i and centre j. (This proximity measure might be a function of physical distance, industrial structures and the competition of other labour markets.)

k_{ij} = 1. This implies a link exists between from centre i to centre j. Labour market interaction is possible.

k_{ij} = 0. This implies that a link does not exist. Labour market interaction is not possible.

The more important part of the inter-urban structure is that of the existence or absence of a structural link. It is this that determines the prior specification of the properties of the A_1 and A_2 matrices. This follows directly from the assumptions that either

(13a) $k_{ij} = 1; \quad A_{1ij}, A_{2ij} \neq 0$

(13b) $k_{ij} = 0; \quad A_{1ij} = A_{2ij} = 0$

when the absence of an inter-urban link from i to j implies no labour market interaction in that direction.

A binary element matrix, K, can be specified to enumerate these prior specifications of inter-urban links such that

(14) $$K = \begin{bmatrix} k_{ii} = 1 \\ k_{ij} = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \\ \end{bmatrix} \quad ; \quad K = n \times n$$

for all i, j ; i, j = 1, ..., n.

$k_{ii} = 1$ indicates that inter-urban structure does not, by definition, impede internal urban labour market operations.

It now remains to put restrictions upon K, (and correspondingly upon A_1, A_2,) that reduce its generality. Two extremes of inter-urban interdependence are used to illustrate this point. If all urban centres are autonomous there can be no inter-urban interactions. Thus $k_{ii} = 1$, $k_{ij} = 0$ for all i, j ; i, j = 1, ..., n. This creates a diagonal matrix, K, and block diagonal matrices for A_1 and A_2. The models then reduce to n models of the internal urban labour market type analysed above.

This means

(15)

$$A_1 = \begin{bmatrix} A_{111} & & & & & & \\ & A_{122} & & & & & \\ & & \ddots & & & & \\ & & & A_{1ii} & & & \\ & & & & A_{1jj} & & \\ & & & & & \ddots & \\ & & & & & & A_{1nn} \end{bmatrix} \quad A_2 = \begin{bmatrix} A_{211} & & & & & & \\ & A_{222} & & & & & \\ & & \ddots & & & & \\ & & & A_{2ii} & & & \\ & & & & A_{2jj} & & \\ & & & & & \ddots & \\ & & & & & & A_{2nn} \end{bmatrix}$$

where, consequently $A_{1ii} = A_{1i}$ and $A_{2ii} = A_{2i}$.

The other limiting case is where all centres interact directly with all other centres, denoted by

$$k_{ij} = 1; \ i,j=1,...,n$$

Consequently, K has no zero entries. If A_1 and A_2 are to have zero entries in this case they must occur via an analysis of the relationships of the labour market variables, rather than an analysis of the inter-urban structure.

The importance of the prior specification of the inter-urban structure can now be noted. As the number of urban centres in the system increases so the potential number of inter-urban interactions increases. All urban labour markets might interact with all other urban labour markets to some degree but it is often not practical or enlightening to enumerate all interactions. Consequently, theory is used in a simplifying role: in this case giving rise to a model of inter-urban structure that qualifies the number of urban labour market interactions. Indeed the exigencies of statistical identification were such that an even stronger method of simplification was required. This method is outlined in Chapter Four but it played little role in theory development.

A simple model of inter-urban structure can be based upon two principles:

(i) that if a centre belongs to a system it interacts directly with at least one other centre in that system,

(ii) that if a centre, j, is dominated either directly or indirectly by another centre i, then the centre j cannot dominate that centre i, either directly or indirectly.

These principles describe an urban hierarchy where certain towns dominate others economically and are in turn, dominated by other centres. There is, however, at least one centre that dominates another centre but it is not dominated itself and at least one centre is dominated without, in turn, dominating another centre. Such centres occupy, respectively, the top and bottom ranks of the hierarchy. The labour market impulses move from the dominating centres to the dominated centres. Inter-urban labour market domination, therefore, is a specific form of inter-urban labour market interaction. This inter-urban structure gives the matrix K an upper block triangular form such that

(16)

$$K = \begin{bmatrix} k_{11} & & & & & k_{ij} = \begin{Bmatrix} 1 \\ 0 \end{Bmatrix} \\ & k_{22} & & & & \\ & & \ddots & & & \\ & & & k_{ii} & & \\ & & & & k_{jj} & \\ k_{ji} = 0 & & & & \ddots & \\ & & & & & k_{nn} \end{bmatrix}$$

That k_{ij} is not necessarily unity indicates that a given centre i does not dominate all centres below it in the hierarchy. The advantages of such a model are several-fold. It simplifies both theoretical and empirical analysis by reducing the number of interactions to be dealt with and by restricting the inter-urban influences to only one direction.

Within the two general principles stated above it is possible to add further restrictions that rule out certain forms of hierarchical dominance. For example, it is possible to specify a model of dominance such that any centre is directly dominated by only one other centre. Or there may be a limit to the number of centres that can be directly dominated by a single centre. Any number of restrictions can be envisaged consistent with the two major principles, and they imply that the majority of the elements, k_{ij}, will be zero.

In most inter-urban systems, however, there is a great deal of mutual itneraction of centres in addition to dominance relationships. This means the upper block triangular nature of the A_1 and A_2 matrices and the corresponding desirable analytic qualities may disappear. In some cases it may be possible to rearrange the matrices into an upper triangular form to use the properties of such matrices. Such matrices are decomposable (Shone, pp. 170-174). An example is the following: a four centre system (1, 2, 3, 4) has two-way interaction between centres 1 and 3 and between centres 2 and 4. In addition centre 2 dominates centre 3. The corresponding K matrix is

(17)

$$K = \begin{array}{c} \\ 1 \\ 2 \\ 3 \\ 4 \end{array} \begin{array}{c} \begin{array}{cccc} 1 & 2 & 3 & 4 \end{array} \\ \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 \\ 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \end{bmatrix} \end{array}$$

The prior specification of the K matrix, as representative of an inter-urban structure, reduces the interactions to be dealt with in the A_1 and A_2 matrices. With m variables and 4 centres the total possible interactions for A_1 and A_2 combined are $2(4m)^2 = 32m^2$. This particular inter-urban structure reduces the interactions to $9m^2$. The saving becomes greater as larger and larger inter-urban systems are modelled. Two factors make it so. First, the number of potential interactions rises much more rapidly than the number of new centres. If I is the total number of interactions possible in the inter-urban model,

$$(16) \qquad A_1X_t = A_2X_{t-1} + A_3Z_t$$

then

$$(17a) \qquad I = 2(mn)^2$$

and $dI/dn = 4m^2n$, implying huge increases in the number of interactions for each additional centre when m and n are large.

It is also possible to rearrange the K matrix in the example allowing an upper block-triangular form. This enables the use of simpler estimation methods applicable to the block-triangular form. The re-arranged matrix is

(17b)

$$K = \begin{array}{c} \\ 4 \\ 2 \\ 3 \\ 1 \end{array} \begin{array}{c} \begin{array}{cccc} 4 & 2 & 3 & 1 \end{array} \\ \left[\begin{array}{cccc} 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 1 \end{array}\right] \end{array}$$

Dropping the subscripts of the submatrices A_{1ij}, A_{2ij} ; $j=1,\ldots, 4$, the general model of (16) can be written out for the particular four centre system of (17b) as (16a).

(16a)

$$\begin{bmatrix} A & A & 0 & 0 \\ A & A & A & 0 \\ 0 & 0 & A & A \\ 0 & 0 & A & A \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix}_t = \begin{bmatrix} A & A & 0 & 0 \\ A & A & A & 0 \\ 0 & 0 & A & A \\ 0 & 0 & A & A \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \end{bmatrix}_{t-1} + \begin{bmatrix} \\ A_3 \\ \\ \end{bmatrix} \begin{bmatrix} \\ V \\ \\ \end{bmatrix}_t + \begin{bmatrix} r_1 \\ r_2 \\ r_3 \\ r_4 \end{bmatrix}_t$$

It should be noted that this inter-urban labour market system is essentially two sub-systems connected by the domination of labour market 3 by labour market 2. Consequently, centres 3 and 4 are sensitive to labour market changes in 1 and 2, but not vice-versa.

A strong possibility for use in determining the links is Central Place Theory (Christaller, 1966). Hudson has made use of Central Place ideas in the context of inter-urban innovation diffusion (Hudson, 1972). The relationship between centres is purely a dominance one, the economic impulses only travelling down the urban system. This implies K is upper triangular. The limiting nature of such pure dominance relationships is probably best suited to only certain aspects of urban labour markets, notably the diffusion of wage rate expectations (Weissbrod, 1974).

The inter-urban structure is important in another sense. In analysing the equilibrium and stability of this model, the inter-urban structure, denoted by K and reflected in the A_1 and A_2, is considered time-invariant. It must be assumed, therefore, that either the inter-urban structure is in equilibrium or that the time horizon of the model allows the structure to be considered constant. In both cases the equilibrium and stability analyses are with respect to the formation of excess demands and supplies of labour at urban centres and with the impact of these localised disequilibria upon the system as a whole. In this model the analysis proceeds in the same manner as for the internal labour markets, though the results relate to the system as a whole rather than one centre. The internal labour market model must be considered the shorter in time horizon of the two, as the internal market model specification implies no (time for) impact of the centre upon the system.

In the medium-run and the long-run the specification changes drastically, since inter-urban structure variables, such as city size, are treated as endogenous variables. For the long-run, a time horizon is implied in which inter-urban structure variables can reach equilibrium. This means that labour market sizes and the strength of the links between them will be equilibrium ones. Several possible equilibrating mechanisms exist and will prob ably operate contemporaneously. Migration will be a major mechanism in determining labour market size, whilst some adjustment will occur through changes in relative labour market conditions with the structure remaining unchanged. In both the long-run and the medium-run models, all excess demands and supplies are considered zero. Thus, with short-run labour market equilibrium assumed all changes will be due to structural differentiation of centres rather than transient labour market phenomena.

Assuming labour migration occurs as the major mechanism of urban centre size change, then the conditions for equilibrium can be considered. In a simple deterministic framework migration continues until economic opportunities at all centres are equalised. At the period of equalisation all migration ceases and the inter-urban structure is in equilibrium. This seems restrictive in that zero net migration will also achieve the same structural equilibrium result, without the implication of complete equalisation of returns to labour in all centres. This can occur if there is a distribution of wage rate offers in each centre. With skill differentiation, incomplete information and so forth, it will sometimes pay a person to move from a higher average wage rate centre to a lower average wage rate centre solely on the basis of economic opportunity. Thus, it is conceivable for centres to have strong economic inequalities, particularly with respect to the average wage rate and aggregate unemployment and, simultaneously, for gross migration to be occurring and for the urban system to be in structural equilibrium due to zero net migration between centres.

The stability of this system is impossible to analyse with this information and, given that there are many radically different model specifications possible, it is unrealistic to state definitively that the system will be stable or unstable. The analysis of such stability properties is most likely to be via simulation, as the relationships between inter-urban structure and labour market mechanisms will be complex, discontinuous and non-linear with long time lags. If the links between the centres have surplus capacity built into them, to accommodate the cyclical and seasonal changes in markets, it seems probable that a very high degree of secular inertia will be built into the system.

The medium-run is defined as the time-horizon of a model in which urban structural change will be occurring, unless the structure is already in its long-run equilibrium state. Migration is considered again as the major labour market mechanism of urban structural shifts. In an economic model labour migration is in response to inequalities in wage rates and employment opportunities. Consequently, a medium-run model will be concerned with persistent non-zero net migration rates. Equilibrium in any such model is defined as the achievement of a persistent rate of net migration in each centre, in reality part of the disequilibrium phase of the long-run model.

A Specific Model of the Internal Urban Labour Market

A specific form of an aggregate urban labour market model is presented now, which is consistent with the overall model and modelling approach adopted thus far. In particular, it is formulated as a set of simultaneous, linear difference equations. The choice of model specification is a compromise: a compromise between theory and the availability of a data base that allows empirical testing.

The single urban centre then has the form of the short-run, semi-autonomous centre,

(1) $$A_{1i}X_{it} = A_{2i}X_{it} + A_{3i}Z_{it}$$

The centre is regarded as behaving in a manner analogous to a single producer, employing and dismissing labour in the short-run as a response to exogenous production demands. The labour force is treated similarly, as a single worker offering labour in response to wage offers and employment conditions. This aggregate model differs from the behaviour of individuals, however, in that these aggregates have an impact upon the market through their behaviour. Thus, the overall labour supply affects the wage rate, whereas the supply of labour of one person does not.

A production function of the form

(18) $$Q_{it} = f(Y_{it})$$

is assumed. In this model there are two sub-models of the production factors. One has the hours worked per employee per week, h_{it}, and the number of employees employed per period, E_{it}, as the two elements of Y_{it}. In the other h_{it} and E_{it} are combined to form a single factor. This factor is total hours worked by the employed work force per period, H_{it}, which is equal to the product, $h_{it} \times E_{it}$. By use of t, to represent technical progress the production function now has the specific forms

(19) $$Q = Q(t, h, E) \qquad Q_t, Q_h, Q_E > 0$$

and

(20) $$Q = Q(t, H) \qquad Q_t, Q_H > 0$$

where Q_t, Q_h, Q_E and Q_H represent the first derivatives of the function, and the other subscripts have been dropped for conveniences.

The production totals are assumed to be given exogenously. Along with relative input prices, and the level of technology, the production totals determine the desired or demanded levels of employment, E*, hours per employee, h*, and total hours worked, H*. The two factor model has the form,

$$(21) \qquad h^* = h^*(w, q, t, Q) \qquad h_w < 0, h_q > 0, h_t < 0, h_Q > 0$$

$$(22) \qquad E^* = E^*(w, q, t, Q) \qquad E_w > 0, E_q < 0, E_t < 0, E_q > 0$$

where the derivatives indicate that demand for both factors rises with production and falls with the level of technology. Comparing equations (21) and (22) with equation (19) illustrates the interdependence of production and the factors of production. Equation (19) is the production function and equations (21) and (22) essentially represent the equilibrium input demands. The same comments also pertain to equations (20) and (23). The input costs are given by w, the wage rate, and by q, the non-wage costs of an employee. As the ratio w/q increases so more employees will be substituted for extra hours per employee. As it declines so hours per employee are relatively less expensive and they are substituted for increased numbers of employees. It is assumed that this substitution is over some normal range of numbers of employees and numbers of hours for neither makes sense, ultimately, without the presence of the other.

Substitution of hours per employee and the number of employees does not arise as a possibility in the one factor model where

$$(23) \qquad H^* = H^*(w, t, Q) \qquad H_w < 0, H_t < 0, H_Q > 0.$$

Strictly speaking w is not a relative input cost as only one factor enters the production function. Nevertheless it can be used as a surrogate for relative input costs, against other implicit factors such as capital. This model was ultimately unattractive, compared with the two factor model assuming away, as it does, all possibilities of substituting hours (as in overtime) for the hiring of new employees and that producers are insensitive to the relative costs involved. Nevertheless the possibility existed that it was empirically superior to the two-factor model and, therefore, it was not immediately discarded.

The supplies of factors are given as the total labour force willing to work at a given set of pecuniary and non-pecuniary returns to labour: thus both those employed and those actively seeking employment at a given rate are included. In the two factor model this is the total number of individuals who are willing to be employed, L*, and who wish to work a desired number of hours, ${}_{s}h^*$, at a given wage rate and other non-wage returns to employment in the measures of supply. For the one factor model the total number of hours that the potential labour force wish to supply, ${}_{s}H^*$, at a given wage rate, is the equivalent measure of labour supply. The two factor model is the more satisfactory of the two as it contains potentially more information about labour force desires.

The two factor model allows the incorporation of the constraint

(24) $\quad {}_s h^* < {}_s h^{max}$

where ${}_s h^{max}$ is the maximum possible number of hours for any individual to work in any period. Similarly in the short-run a constraint

(25) $\quad L^* \leq P$

operates, where P is the potentially economically active population of the urban centre. This, in turn, leads to the constraint on employers

(26) $\quad E \leq L^*$

This implies that employment cannot be greater than the total numbers desiring work, given the wage rate. This puts a capacity constraint on any urban centre in the short-run, implying the shifting of orders from one centre to others as constraints are reached. This is irrespective of the competitive position of the centres with respect to input costs at that point. The number wishing to be employed can then be expressed as

(27) $\quad L^* = L^*(w, q) \qquad L_w > 0, \; L_q > 0$

For the individual the decision to seek work is dichotomous: to either work or not to seek employment. Aggregation of those individuals ensures a variable that can be regarded as continuous, the labour supply, L*. This eases the modelling problem substantially for dichotomous variables are more difficult to deal with than continuous variables.

The number of hours desired to work depends only upon the wage rate. This yields

(28) $${}_{s}h^{*} = {}_{s}h^{*}(w) \qquad {}_{s}h^{*}_{w} > 0.$$

The simplicity of the equation hides a complex supply relationship, reflected only in the uncertainty about the sign of the first derivative of the function. The determination of the desired number of hours to be supplied implies a decision for individuals to divide total time available between leisure and work.

(29) $${}_{s}h^{max} = {}_{s}h^{*} + {}_{L}h^{*}$$

where ${}_{L}h^{*}$ = desired leisure hours. The expenditure of income takes place as consumption during leisure hours. This can give rise to situations where, as income rises, desired leisure time increases. If individuals are similar enough in tastes and incomes this phenomenon can appear in the aggregate supply of labour. As leisure and work uses of total hours are mutually exclusive, the possibility exists of an increase in the wage rate leading to a decrease in desired work hours. The usual expression of this is the "backward-bending supply curve of labour". The "backward-bending" effect can also occur if families with more than one potentially economically active individual make joint decisions about seeking employment. As wages rise so one or more may withdraw from the labour force. For the one factor model the information is reduced into one equation, derived by multiplication of the two forms above:-

$$(30) \qquad {}_{s}H^{*} = {}_{s}H^{*}\ (w,\ q) \qquad {}_{s}H^{*}_{w} > 0,\ {}_{s}H^{*}_{q} > 0$$

Both the one factor and two factor models have been formulated in the price-adjustment framework of a Walrasian market. The static form of the two factor model is

(31a)	$E^{*} = E^{*}\ (Q,\ t,\ w,\ q)$	Demand
(31b)	$L^{*} = L^{*}\ (w,\ q)$	Supply
(31c)	$h^{*} = h^{*}\ (Q,\ t,\ w,\ q)$	Demand
(31d)	${}_{s}h^{*} = {}_{s}h^{*}\ (w)$	Supply

and the equilibrium conditions are that demand equals supply of both factors. Thus, for equilibrium

$$(32a) \qquad E^{*}\ (Q,\ t,\ w,\ q) \ = \ L^{*}\ (w,\ q)$$

$$(32b) \qquad h^{*}\ (Q,\ t,\ w,\ q) \ = \ {}_{s}h^{*}\ (w)$$

Adjustment in the model is with respect to the price variables in the Walrasian model. In particular

$$(33a) \qquad \Delta w \ = \ f\ (h^{*} - {}_{s}h^{*},\ E^{*} - L^{*})$$

$$(33b) \qquad \Delta q \ = \ f\ (E^{*} - L^{*})$$

Δw = change in wage rate

Δq = change in non-wage employment benefits

As the demand for employees exceeds those desiring employment so the employer reacts by increasing wage rates and/or non-wage employment benefits. As demand for hours per employee exceeds supply of hours so the employer increases the wage rate. If demand for either factor is below the supply, so the corresponding payment decreases.

For the one factor model the equations are

(34a) $H^* = H^*(Q, t, w)$

(34b) $_sH^* = {}_sH^*(w)$

(34c) $H^*(Q, t, w) = {}_sH^*(w)$

(34d) $\Delta w = f(H^* - {}_sH^*)$.

A complete dynamic specification of the model requires recognition of the fact that adjustments in the market cannot be made instantaneously. This is particularly true for employers who can move immediately, only very rarely, from their actual employment, E, and the number of hours worked by their employees, h, to their respective demanded levels, E* and h*. A simple partial-adjustment mechanism is used to model this problem. In general the partial-adjustment mechanism has the form, in discrete terms, where y represents any variable such as employment, hours per worker or total hours that is subject to such an adjustment mechanism.

(35) $\Delta y_t = \beta (y^*_t - y_{t-1})$

(35a) $\Delta y_t = y_t - y_{t-1}$

β = adjustment coefficient ; $0 \leqslant \beta \leqslant 1$

The actual change in any variable, Δy, between two periods is some proportion of the desired level of that variable in the final period, and the actual level of that variable in the previous period. Generally the desired level of the variable is determined by some function of a series of exogenous variables, Z,

(35b) $$y_t^* = f(Z_t)$$

Then, by substitution, the model takes the form

(35c) $$\Delta y_t = \beta(f(Z_t) - y_{t-1})$$

These mechanisms are repeated, in their particular forms, in the demand equations of the two models.

In the two factor model it is assumed that, as the hours per employee and number of employees are substitutes, these are reflected in the adjustment mechanism. The specification is then

(36) $$h_t - h_{t-1} = \beta_h(h_t^* - h_{t-1}) + \beta_{hE}(E_t^* - E_{t-1})$$

and

(37) $$E_t - E_{t-1} = \beta_E(E_t^* - E_{t-1}) + \beta_{Eh}(h_t^* - h_{t-1})$$

The cross-adjustment effects, operating through the coefficients β_{hE} and β_{Eh}, act as follows. Assume a large gap between actual hours per employee and the desired hours per employee in the next period. The employer can make this up by a partial adjustment of actual hours per employee via the coefficient β_h. Workers' resistance to rapid rises and falls in their hours imply the adjustment can only be partial. To help overcome this the employer can also adjust the level of his substitute factor, the number of employees.

For the one factor model the adjustment process is quite simple,

(38) $$H_t - H_{t-1} = \beta_H(H_t^* - H_{t-1})$$

for there are no cross-adjustments by the definition of this demand variable.

The labour force is in a different position with respect to adjustment. Implicit in this model is the argument that the employers have more power in the market. Consequently any adjustments in the actual level of hours and employment are in the hands of the employer. It would be inconsistent to have two entirely separate adjustment processes (one from the supply and one from the demand side of the market) independently determining the level of the same variable. However, the size of the labour force is open to adjustment independent of the employers. Defining the labour force as L, the adjustment mechanism applied yields

(39) $$L_t - L_{t-1} = \beta_L(L_t^* - L_{t-1}) \quad 0 < \beta_L \leq 1$$

For labour supply adjustments in the single factor model it is assumed

(40) $${}_sH_t - {}_sH_{t-1} = \beta_{sH}({}_sH_t^* - {}_sH_{t-1})$$

This mechanism is not as plausible for the decision to suppl hours, as opposed to entering the work force, are separate. The one factor mod does not allow that distinction.

It is now possible to specify the two models in their complete form:-

(a) <u>One Factor Model</u>

(41a) $H_t - H_{t-1} = \beta_{11}(H^*_t - H_{t-1})$

(41b) $_sH_t - {}_sH_{t-1} = \beta_{12}({}_sH^*_t - {}_sH_{t-1})$

(41c) $w_t - w_{t-1} = \beta_{13}(H^*_t - {}_sH^*_t)$

(41d) $H^*_t = H^*_t(Q_t, t, w_t)$

(41e) $_sH^*_t = {}_sH^*(w_t)$

This is a fully dynamic model with equilibrium specified as

(42) $H^*_t = {}_sH^*_t$

the system being solved for equilibrium by setting

(43) $H^*(Q_t, t, w_t) = {}_sH^*(w_t)$

Assuming a linear or log-linear form, and substituting for desired levels, the model is re-written as

(44a) $H_t - H_{t-1} = \beta_{11}(b_{10}+b_{11}Q_t+b_{12}t+b_{13}w_t - H_{t-1})$

(44b) $_sH_t - {}_sH_{t-1} = \beta_{12}(b_{20}+b_{21}w_t-H_{st-1})$

(44c) $w_t - w_{t-1} = \beta_{13}(b_{10}+b_{22}Q_t=b_{12}t+b_{13}w_t-b_{20}-b_{21}w_t)$

In matrix notation the structural form is

(45)
$$\begin{bmatrix} 1 & 0 & -\beta_{11}b_{13} \\ 0 & 1 & -\beta_{12}b_{21} \\ 0 & 0 & -1 \end{bmatrix} \begin{bmatrix} H \\ H_s \\ w \end{bmatrix}_t = \begin{bmatrix} 1-\beta_{11} & 0 & 0 \\ & 1-\beta_{12} & 0 \\ 0 & 0 & v_1 \end{bmatrix} \begin{bmatrix} H \\ H_s \\ w \end{bmatrix}_{t-1}$$

$$+ \begin{bmatrix} \beta_{11}b_{11} & \beta_{11}b_{12} & \beta_{11}b_{10} \\ 0 & 0 & {}_{12}b_{20} \\ v_2\beta_{13}b_{11} & v_2\beta_{13}b_{12} & v_2v_3 \end{bmatrix} \begin{bmatrix} Q \\ t \\ 1 \end{bmatrix}_t$$

which is the structural form,

(1)
$$A_{1i}X_{it} = A_2X_{it} + A_{3i}Z_{it}$$

where

$$v_1 = (1 - \beta_{13}b_{13} + {}_{13}b_{21})^{-1}$$

$$v_2 = (1 - \beta_{13}b_{13} + {}_{13}b_{21})^{-1}$$

$$v_3 = (\beta_{13}b_{10} - \beta_{13}b_{20})$$

For stability the reduced form is calculated

(3a)
$$X_{it} = A_{1i}^{-1}A_2X_{it-1} + A_{1i}^{-1}A_{3i}Z_{it}$$

such that

(46)
$$A_{1i}^{-1} = \begin{bmatrix} 1 & 0 & \beta_{11}b_{13} \\ 0 & 1 & \beta_{12}b_{21} \\ 0 & 0 & 1 \end{bmatrix}$$

yielding

$$(47)\quad A_{1i}^{-1}A_{2i} = \begin{bmatrix} 1-\beta_{11} & 0 & \beta_{11}b_{13}v_1 \\ 0 & 1-\beta_{12} & \beta_{12}b_{21}v_1 \\ 0 & 0 & v_1 \end{bmatrix}$$

It is this matrix whose properties determine the stability of the system. These are dealt with at the same time as the properties of the analogous matrix of the two factor model.

(b) Two Factor Model

This is written as

$$(48a)\quad h_t - h_{t-1} = \beta_{11}(h_t^* - h_{t-1}) + \beta_{12}(E_t^* - E_{t-1})$$

$$(48b)\quad E_t - E_{t-1} = \beta_{22}(E_t^* - E_{t\ 1}) + \beta_{21}(h_t^* - h_{t\ 1})$$

$$(48c)\quad L_t - L_{t-1} = \beta_{31}(L_t^* - L_{t-1})$$

$$(48d)\quad w_t - w_{t-1} = \beta_{41}(h_t^* - {}_sh_t^*) + \beta_{42}(E_t^* - L_t^*)$$

$$(48e)\quad q_t - q_{t-1} = \beta_{51}(E_t^* - L_t^*)$$

$$(48f)\quad h_t^* = b_{10}+b_{11}Q_t+b_{12}t+b_{13}w_t+b_{14}q_t$$

$$(48g)\quad E_t^* = b_{20}+b_{21}Q_t+b_{22}t+b_{23}w_t+b_{24}q_t$$

$$(48h)\quad {}_sh_t^* = b_{30}+b_{31}w_t$$

$$(48i)\quad L_t^* = b_{40}+b_{41}w_t+b_{42}q_t$$

Rearranging and putting into matrix notation this model is also of the form

$$(1)\quad A_{1i}X_{it} = A_{2i}X_{it-1} + A_{3i}Z_{it}$$

and written in the same form, in full, is

(49)

$$\begin{bmatrix} 1 & 0 & 0 & c_{14} & c_{15} \\ 0 & 1 & 0 & c_{24} & c_{25} \\ 0 & 0 & 1 & c_{34} & c_{35} \\ 0 & 0 & 0 & 1 & c_{45} \\ 0 & 0 & 0 & c_{54} & 1 \end{bmatrix} \begin{bmatrix} h \\ E \\ L \\ w \\ q \end{bmatrix}_t = \begin{bmatrix} d_{11} & d_{12} & 0 & 0 & 0 \\ d_{21} & d_{22} & 0 & 0 & 0 \\ 0 & 0 & d_{33} & 0 & 0 \\ 0 & 0 & 0 & d_{44} & 0 \\ 0 & 0 & 0 & 0 & d_{55} \end{bmatrix} \begin{bmatrix} h \\ E \\ L \\ w \\ q \end{bmatrix}_{t-1} +$$

$$\begin{bmatrix} e_{11} & e_{12} & e_{13} \\ e_{21} & e_{22} & e_{23} \\ 0 & 0 & e_{33} \\ e_{41} & e_{42} & e_{43} \\ e_{51} & e_{52} & e_{53} \end{bmatrix} \begin{bmatrix} Q \\ t \\ 1 \end{bmatrix}_t$$

where, for A_{1i} the matrix elements in the fourth and fifth columns are

$c_{14} = (\beta_{11}b_{13}+\beta_{12}b_{23})$ $\qquad$ $c_{15} = (\beta_{11}b_{14}+\beta_{12}b_{24})$

$c_{24} = (\beta_{22}b_{23}+\beta_{21}b_{13})$ $\qquad$ $c_{25} = (\beta_{22}b_{24}+\beta_{21}b_{14})$

$c_{34} = \beta_{31}b_{41}$ $\qquad$ $c_{35} = \beta_{31}b_{42}$

$c_{44} = 1$ $\qquad$ $c_{45} = (\beta_{41}b_{14}+\beta_{42}b_{24}-\beta_{42}b_{42})$

$c_{54} = \beta_{51}b_{23}-\beta_{51}b_{13}$ $\qquad$ $c_{55} = 1$

All other elements of A, are either 1 or 0, as in equation (49).

and for A_{2i},

$$d_{11} = (1 - \beta_{11}) \qquad d_{12} = -\beta_{12}$$

$$d_{21} = -\beta_{21} \qquad d_{22} = (1 - \beta_{22})$$

$$d_{33} = -\beta_{31}$$

$$d_{44} = 1$$

$$d_{55} = 1$$

All other elements are either 1 or 0 as in equation (49), and for A_{3i}, the elements are

$$e_{11} = (\beta_{11}b_{11}+\beta_{12}b_{21}) \qquad e_{12} = (\beta_{11}b_{12}+\beta_{12}b_{22})$$

$$e_{21} = (\beta_{22}b \quad +\beta_{21}b_{11}) \qquad e_{22} = (\beta_{22}b_{22}+\beta_{21}b_{12})$$

$$e_{31} = 0 \qquad e_{32} = 0$$

$$e_{41} = (\beta_{41}b_{11}+\beta_{42}b_{21}) \qquad e_{42} = (\beta_{41}b_{12}+\beta_{42}b_{22})$$

$$e_{51} = \beta_{51}b_{21} \qquad e_{52} = \beta_{51}b_{22}$$

$$e_{13} = \beta_{11}b_{10}+\beta_{12}b_{20}$$

$$e_{23} = \beta_{22}b_{20}+\beta_{21}b_{10}$$

$$e_{33} = \beta_{31}b_{40}$$

$$e_{43} = (\beta_{41}b_{10}-\beta_{41}b_{30}+\beta_{42}b_{20}-\beta_{42}b_{40})$$

$$e_{53} = \beta_{51}(b_{20}-b_{40})$$

The inverse of A_{1i} is

(50)

$$A_{1i}^{-1} = \begin{bmatrix} 1 & 0 & 0 & \frac{c_{15}c_{54}-c_{14}}{p} & \frac{c_{14}c_{45}-c_{15}}{p} \\ 0 & 1 & 0 & \frac{c_{25}c_{54}-c_{24}}{p} & \frac{c_{24}c_{45}-c_{25}}{p} \\ 0 & 0 & 1 & \frac{c_{35}c_{54}-c_{34}}{p} & \frac{c_{34}c_{45}-c_{35}}{p} \\ 0 & 0 & 0 & \frac{1}{p} & \frac{-c_{45}}{p} \\ 0 & 0 & 0 & \frac{-c_{54}}{p} & \frac{1}{p} \end{bmatrix}$$

where $p = (1-c_{45}c_{54})$

For the reduced form

(3a) $$X_{it} = A_{1i}^{-1} A_{2i} X_{it-1} + A_{1i}^{-1} A_{3i} Z_{it}$$

the elements of the matrices are

(51)

$$A_{1i}^{-1}A_{2i} = \begin{bmatrix} d_{11} & d_{12} & 0 & d_{44}\frac{c_{15}c_{54}-c_{14}}{p} & d_{55}\frac{c_{14}c_{45}-c_{15}}{p} \\ d_{21} & d_{22} & 0 & d_{44}\frac{c_{24}c_{54}-c_{24}}{p} & d_{55}\frac{c_{24}c_{45}-c_{25}}{p} \\ 0 & 0 & d_{33} & d_{44}\frac{c_{35}c_{54}-c_{34}}{p} & d_{55}\frac{c_{34}c_{45}-c_{35}}{p} \\ 0 & 0 & 0 & d_{44}\frac{1}{p} & -d_{55}\frac{c_{45}}{p} \\ 0 & 0 & 0 & -d_{44}\frac{c_{54}}{p} & d_{55}\frac{1}{p} \end{bmatrix}$$

In both models the specifications lead to complex $A_{1i}^{-1} A_{2i}$ matrices in the reduced form. They are complex in the triple sense that some elements are large combinations of structural coefficients; the signs of the reduced form coefficients are unknown; and the arrangement of the elements in the $A_{1i}^{-1} A_{2i}$ matrix is complex. The arrangement of the elements of $A_{1i}^{-1}A_{2i}$ in both cases does not allow the matrix to be formed into a diagonal or upper triangular matrix with the resulting easing of manipulation (i.e. they are indecomposable matrices). Similarly, the unknown nature of the signs of the reduced form elements means that analytical methods cannot be used to discover the stability of the system (Gandolfo, pp. 130-138). Thus, for stability to be examined, numerical estimates of the reduced form $A_{1i}^{-1}A_{2i}$ matrix element have to be made under the present specification.

Alternative specifications for the models can be used but, it is found, only in a special case is a simple pattern in $A_{1i}^{-1}A_{2i}$ implied. Two major specifications are possible, both in terms of the desired values of the endogenous variables. In the present case, current endogenous variables appear among determining variables for the current desired values of variables. An alternative is to use lagged endogenous variables, rather than current ones, in the determination of desired values. This involves a change in the way in which perceptions are seen to operate in the model. In the specification used above the implication is that those in the labour market see ahead one time period with absolute accuracy. Thus, for example, they use the wage rates that <u>will</u> be operating in that period (w_t), rather than those they have experienced (w_{t-1}), in determining desired levels of labour or employment. On the other hand, the alternative specification of using the already experiencing levels, implies they have no means other than immediate past experiences for making desired level judgements.

The decision between these two alternative hypotheses is a matter for empirical falsification of one or the other or possibly,the empirical falsification of both. In both cases comples $A_{1i}^{-1}A_{2i}$ reduced form matrices are developed. Symbolically the specification with current endogenous variables determining, in part, the desired values of the current endogenous variables is

(52) $$y_t - y_{t-1} = B_1 (y_t^* - y_{t-1})$$

(52a) $$y_t^* = B_2 y_t + B_3 z_t$$

where the vectors, y, can be held to represent any set of endogenous variables that can be modelled in this way. They need not, for example, be interpreted as the endogenous variables of an urban labour market. Similarly the vector, z, is held to represent any set of exogenous variables. No interpretation beyond this is necessary for the vectors for it is the form of the models that is considered here, rather than any theory which the interpreted models may embody. Consequently the matrices B_1, B_2 and B_3 have no interpretation beyond the fact that their elements form the links between the variables of the model, and that those matrix elements can potentially be estimated as parameters of an interpreted model. To allow estimation then, both an interpretation and data are required.

It is important to note that the different model specifications, as used in a specific empirical context, may be determined as much by the length of the time interval of the available data, as by the theoretical reasoning embodied in the model. The longer the time interval between observations upon variables the more likely it will be that the values of some current endogenous variables, rather than their past values, will be related to the desired or expected values of other current endogenous variables.

Equation (52a) can be solved in reduced form as

(52b) $$y_t = (1 - B_1B_2)^{-1}(1 - B_1)y_{t-1} + (1-B_1B_2)^{-1}B_1B_3z_t$$

where the interpretation

(52c) $$A_{1i}^{-1}A_{2i} = (1 - B_1B_2)^{-1}(1 - B_1)$$

is possible in an urban labour market context.

If the second specification is used then, symbolically

(53) $$y_t - y_{t-1} = B_1(y_t^* - y_{t-1})$$

(53a) $$y_t^* = B_2y_{t-1}+B_3z_t$$

which is solved in reduced form as

(53b) $$y_t = (1+B_1B_2 - B_1)y_{t-1} + B_1B_3z_t$$

Obviously in both of the above cases the matrix determining the stability properties is likely to be complex.

A third possibility is that the desired values of endogenous variables depend solely upon purely exogenous variables. In this case, symbolically

(54) $$y_t - y_{t-1} = B_1(y_t^* - y_{t-1})$$

(54a) $$y^* = B_3z_t$$

with the reduced form

$$(54b) \qquad y_t = (I - B_1)y_{t-1} + B_1B_3z_t$$

The $(I-B_1)$ matrix is much more likely to have a form whose stability properties than can be handled analytically, rather than having to be numerically evaluated (Gandolfo, Ch. 6; Dernburg and Dernburg, pp. 255-259).

A Modelling Strategy for Urban Labour Markets

What emerges from the preceding discussion is the point that in order to model labour markets in general there is required a formulation which is a simplification of reality and which specifies mechanisms common to all labour markets. However, all labour markets exist in some regional economic milieu and to model then in the specific milieu desired, requires both a model of labour market mechanism in general and also one of the specific regional or urban milieu involved. In addition there is the complication of the dynamic interaction of the mechanisms and the milieu specified. For example, migration is mechanism which both affects and is affected by the inter-urban structure. If the model is to be tested empirically then these aims have to be modified to allow for a robustness in an area of study where data are generally incomplete. Unfortunately, it is seen that even a very simple aggregate model of the urban labour market can give rise to very complex model forms. These will prove impossible to estimate in a model that also involves inter-urban interactions. Given the data available, justification must then be sought for testing the internal urban labour market models in isolation from any inter-urban market mechanisms.

The explicit construction of a model framework, larger than that which can be tested, is justifiable in terms of the context it provides for the smaller part which is testable. Explicit recognition is provided that the empirical results can only be regarded as partial. They do not fully represent a system. As such there are areas where they can be either misleading or have only a specific frame of reference. Again labour migration is relevant, for the models provide a supply curve for urban labour which does not include migration. As such, the supply curves are incorrect and, therefore, misleading. The alternative argument is that the models are specified for short-run changes in the labour markets. To those short-run changes the local labour supply must be assumed to adjust, but that migration is determined by other factors and has little or no impact in the short-run.

To a large degree the validity of these assertions is not testable unless migration data are available but, it is argued, short-run models are unlikely to work well empirically if excluded phenomena, such as migration, are important.

The sorts of difficulties that are discovered with respect to the inter-urban level of analysis are equally apparent at the intra-urban level, if disaggregation of the labour market is pursued to any degree. If, for example, the labour force in each city is disaggregated by skill-groups, then this almost certainly implies that other disaggregations must also be used. The differentiation of workers by skills has no rationale unless disaggregated industry groups, with differing skill requirements, are also used in the analysis. Similarly labour force differentiation by skills implies differentiation by wage levels. It is also readily apparent that within any urban area there is variation in both industry and labour force location patterns associated with the disaggregation. For the labour force these spatial variations (of place of residence) will also be by factors such as age, sex and education. All of these spatial variations will affect the adaptability and responsiveness of the labour force, as a whole, to short-run change. Relative adjustments in employment levels and the length of the working week, for example, will in part be determined by the degrees of spatial immobility and heterogeneity of the labour force. The impact of the exclusion of these influences from the modelling effort cannot be discovered, but some of the effects may be discernible in the results for any aggregate urban labour market model. It may be possible that differences in aggregate urban labour market behaviour between cities, as represented by differing parameter estimates, can be related to intra-urban differences between those cities.

These short-comings must be recognised as unavoidable in dynamic analyses of urban labour markets whatever modelling strategy is adopted.

CHAPTER FOUR

MODEL SPECIFICATION AND INCOMPLETE DATA

In a purely theoretical study of urban labour markets no heed of data shortcomings would be necessary. The development of such models is, nevertheless, partly dependent upon prior empirical work. Unfortunately social data are not always collected in the form most suitable for analysis and, in many cases, are often completely unobtainable. Quite often then, the data to test specific theories are made unavailable by the very specificity of those theories. One modelling strategy, in those cases where empirical evidence is being sought, is

> " to specify and quantify empirically valid behavioural hypotheses about the decisions and actions of various economic agents, and to integrate the estimated relationships into a complete system"
> (Hickman, 1, p.1)

In the case of urban, dynamic labour-market modelling even this strategy is stringent. To specify a "complete system" is impossible for three reasons:-

(i) the data for all labour market variables are not available in any complete form,

(ii) the data for urban structural change are completely unavailable, except for census periods, and

(iii) the labour market variables, by urban centre in any integrated inter-urban system, exhibit very high degrees of correlation.

The last problem implies a high degree of multicollinearity between similar labour market variables at the inter-urban level. A simple example is the movement in urban wage rates for corresponding skills between urban centres. The resulting lack of unique statistical identification implies parameter estimates that, although they are unbiased, are untrustworthy (Wonnacott and Wonnacott, pp. 353-354). The attempted estimation of a large inter-urban system also presents a fundamental identification problem in that the number of exogenous variables are likely to be reduced as the system becomes all-inclusive,as it is enlarged by the modeller. Though it remains impossible to test and estimate a model, in Hickman's sense, for a complete urban system, it can be shown that it is possible to do so for individual urban centres. It is shown that this is possible given the available data if individual urban centres are isolated in the short-run.

The data available for the study of dynamic, urban economic systems are very few, given the stringent requirement of compatible temporal and spatial data series. It is none too surprising then that few empirical studies of complete urban systems have been completed. An oft-used alternative is the construction of a disequilibrium or quasi-dynamic model around cross-sectional data (Neild, 1972). The other alternative is an emphasis on long-run dynamics using census data (Muth, 1967). The advantage of these approaches is the availability of large, reliable bodies of data with high degrees of disaggregation by spatial, industrial and population categories. This is certainly true of urban labour data. Unfortunately such models are restrictive in that they cannot be used easily in analysing the different quantitative and qualititative reactions of individual urban centres to internal and external forces. For example, in Neild's New Zealand study there are eighteen observations on each variable, each city representing one observation on each labour market variable (Neild, 1972). It is impossible to say much about the dynamic behaviour of individual cities in such circumstances, except in so far as the individual city diverges from the estimated values of the labour market variables.

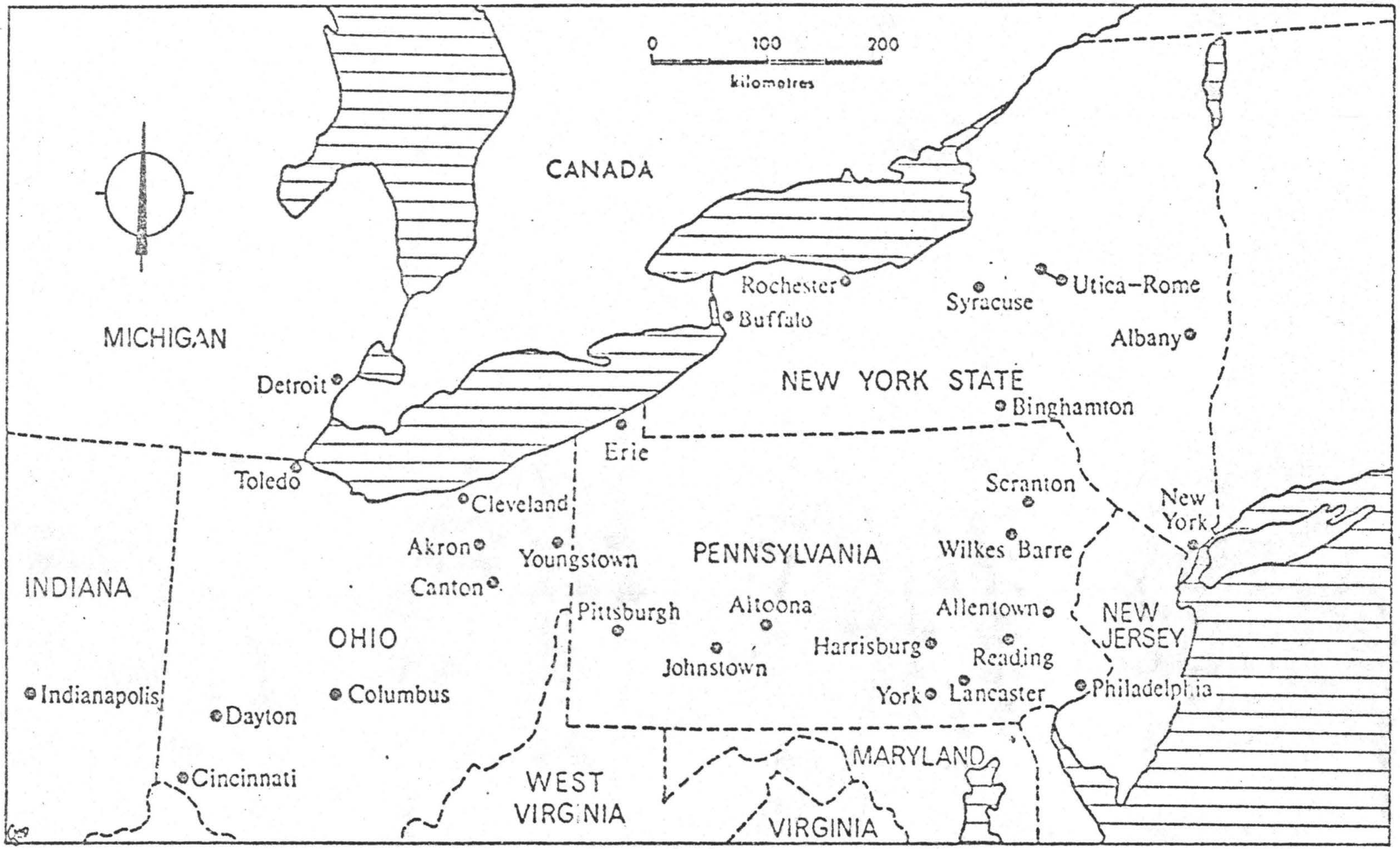
The validity of decomposition of the inter-urban system is considered, followed by an examination of the data available for the urban centres. The data are from the North-Eastern United States of America for twenty-nine urban centres (map 4.1, p. 113). The data sources are listed in Appendix A.1.

Decomposition of the Complete Inter-Urban System

It is assumed that the model for the complete inter-urban system is correctly specified as

(1) $$A_1X_t = A_2X_{t-1} + A_3Z_t$$

where matrices A_1 and A_2 describe the links between the m labour variables both within and between the n urban centres. Each matrix



Map 4.1 Location Map

then has the order mn x mn and the form

(2)

$$A_1 = \begin{bmatrix} A_{111} & & & & & & & \\ & A_{122} & & & & & & \\ & & A_{133} & & & & & \\ & & & \cdot & & & & \\ & & & & \cdot & & A_{1ij} & \\ & & & & & A_{1ii} & & \\ & A_{iji} & & & & & A_{1jj} & \\ & & & & & & & \cdot \\ & & & & & & & & \cdot \\ & & & & & & & & & A_{1nn} \end{bmatrix} \qquad A_2 = \begin{bmatrix} A_{211} & & & & & & & \\ & A_{222} & & & & & & \\ & & A_{233} & & & & & \\ & & & \cdot & & & & \\ & & & & \cdot & & A_{2ij} & \\ & & & & & A_{2ii} & & \\ & A_{2ji} & & & & & A_{2jj} & \\ & & & & & & & \cdot \\ & & & & & & & & \cdot \\ & & & & & & & & & A_{2nn} \end{bmatrix}$$

as specified in equation 1. The reduced form is

(3) $$X_t = A_1^{-1} A_2 X_{t-1} + A_1^{-1} A_3 Z_t$$

with the stability determined by $A_1^{-1} A_2$

The problem is, how far can the off-diagonal sub-matrices of $A_1^{-1} A_2$ be ignored? This means, how far can the inter-urban labour market interactions, that the off-diagonal sub-matrices represent, be ignored? If they are disregarded this implies each urban centre, i, has the model form

(4) $$A_{1ii} X_{it} = A_{2ii} X_{it-1} + A_{3i} Z_t$$

With the reduced form

(5) $$X_{it} = A_{1ii}^{-1} A_{2ii} X_{it-1} + A_{1ii}^{-1} A_{3i} Z_t$$

The theoretical conditions under which this approach is valid have been discussed in a series of papers by Ando, Fisher and Simon (Ando and Fisher, 1963); Fisher and Ando, 1962; Simon and Ando, 1961). Unfortunately it was not possible to know whether the conditions held for the models, as they were specified in this study, as a knowledge of the elements of the off-diagonal sub-matrices is required. A brief review of the Ando, Fisher and Simon analysis given as this illustrates some of the difficulties of interpretation of this study.

A few definitions are necessary. A completely decomposable matrix is one in which identical rearrangements of all elements in either all matrix rows or all matrix columns can yield a series of square sub-matrices on the principal diagonal of the matrix with all other elements being zero.

Such matrices would be

(6)
$$A_1 = \begin{bmatrix} A_{111} & & & & & & & & 0 \\ & A_{122} & & & & & & & \\ & & A_{133} & & & & & & \\ & & & \ddots & & & & & \\ & & & & A_{1ii} & & & & \\ & & & & & A_{1jj} & & & \\ & & & & & & \ddots & & \\ & & & & & & & & A_{1nn} \end{bmatrix} \qquad A_2 = \begin{bmatrix} A_{211} & & & & & & & & 0 \\ & A_{222} & & & & & & & \\ & & A_{233} & & & & & & \\ & & & \ddots & & & & & \\ & & & & A_{2ii} & & & & \\ & & & & & A_{2jj} & & & \\ & & & & & & \ddots & & \\ & & & & & & & & A_{2nn} \end{bmatrix}$$

This is also referred to as a block-diagonal matrix. A nearly decomposable matrix is one in which the zero elements are replaced by elements, e, which are "very small" in relation to the elements of the submatrices of the major diagonal. In this case

(7)

$$A_1 = \begin{bmatrix} A_{111} & & & & & & & \\ & A_{122} & & & e_{1ij} & & & \\ & & A_{133} & & & & & \\ & & & \ddots & & & & \\ & & & & A_{1ii} & & & \\ & & & & & A_{1jj} & & \\ & e_{1ji} & & & & & \ddots & \\ & & & & & & & A_{1nn} \end{bmatrix} \qquad A_2 = \begin{bmatrix} A_{211} & & & & & & & \\ & A_{222} & & & e_{2ij} & & & \\ & & A_{233} & & & & & \\ & & & \ddots & & & & \\ & & & & A_{2ii} & & & \\ & & & & & A_{2jj} & & \\ & e_{2ji} & & & & & \ddots & \\ & & & & & & & A_{2nn} \end{bmatrix}$$

To properly analyse the dynamic properties of the individual urban labour markets with each city treated as isolated from all other cities, requires that the matrices A_1 and A_2 be at least nearly decomposable, if not completely decomposable.

A simple example of a nearly completely decomposable system composed of two labour markets, Los Angeles and New York, may be instructive. The reduced form of the system, ignoring exogenous variables is

(8) $$X_t = A_1^{-1}A_2X_{t-1}$$

(8a) where $A_1^{-1}A_2 = \Pi_1$

or more fully

$$(9)\quad \begin{bmatrix} X_i \\ X_j \end{bmatrix}_t = \begin{bmatrix} \Pi_{ii} & \Pi_{ji} \\ \Pi_{ij} & \Pi_{jj} \end{bmatrix} \begin{bmatrix} X_i \\ X_j \end{bmatrix}_{t-1}$$

where $A_1^{-1} A_2$ = order 2m x 2 m

i = Los Angeles

j = New York

Π_{ii} = Los Angeles to Los Angeles interactions

Π_{jj} = New York to New York interactions

Π_{ij} = Los Angeles to New York interactions

Π_{ji} = New York to Los Angeles interactions

The dynamic behaviour of the system as a whole depends upon the characteristic roots of the matrix Π_1. The calculation of these roots involves the interactions from New York to Los Angeles (Π_{ji}) and from Los Angeles to New York (Π_{ij}). The interactions within the Los Angeles labour market (Π_{ii}) and that of New York (Π_{jj}) will presumably be much stronger than the inter-urban interactions. If the time period of the analysis is very short it can be expected that the inter-urban interactions are negligible,,particularly when compared to the intra-urban interactions. In such a case this is a nearly decomposable system in terms of short-run behaviour which may be accurately, though approximately, represented by the form,

$$(10) \quad \begin{bmatrix} X_i \\ X_j \end{bmatrix} = \begin{bmatrix} \Pi_{ii} & 0 \\ 0 & \Pi_{jj} \end{bmatrix} \begin{bmatrix} X_i \\ X_j \end{bmatrix}_{t-1}$$

which is a block diagonal matrix. In this case,

$$(11a) \quad \Pi_{ii} = A_{1i}^{-1} A_{2i}$$

$$(11b) \quad \Pi_{jj} = A_{ij}^{-1} A_{2j}$$

and the 2m simultaneous equations can be solved completely separately as

$$(12a) \quad X_{it} = A_{1i}^{-1} A_{2i} X_{it-1} \quad \text{and}$$

$$(12b) \quad X_{jt} = A_{1j}^{-1} A_{2j} X_{jt-1}$$

The short-run stability of each labour market now depends solely upon the roots of either the $A_{1ii}^{-1} A_{2ii}$ matrix or the $A_{1jj}^{-1} A_{2jj}$ matrix. For nearly decomposable systems the following is stated:

> " To put it another way, our theorem shows that if these feedbacks are sufficiently weak relative to the direct influences, that is, if the theoretical assumptions are sufficiently good approximations, there exists a time $T_1 \geq 0$ such that before T_1 the behaviour and stability of the economic system can be analysed in isolation without regard for the difficulties raised by the presence of such feedbacks. For sufficiently weak feedbacks.....it is meaningful to discuss the existence and stability of economic equilibrium in these circumstances."
>
> (Ando and Fisher, p.62)

Consequently reliance had to be placed both upon this theorem, although it was not necessary for the parameter estimation procedure itself, and upon the inter-urban labour market interactions being much weaker than the intra-urban labour market interactions in the short-period. Although the theorem is proven (Simon and Ando, 1961), the existence of the conditions required for its application in this study necessarily remain conjecture.

Thus it is possible to calculate the largest roots of subsystems, knowing these are approximations. From the modulus of that root and the imaginary parts of any roots it is then possible to discuss the short-run stability of the subsystem. In urban labour markets it is to be expected that they are highly stable in the short-run. That is to say in the short-run, when an urban labour market can be regarded as fixed in labour force size, capital, and there are constraints on physical expansion and so forth, it seems unlikely that the labour market alone can generate growth or decline for the economy of the city.

Given these justifications for estimating a single centre, dynamic, short-run urban labour market model the data available for such estimation are discussed.

Production and Labour Demand

Unless the position that a market is in equilibrium is taken, data are not available for (labour) demand. In any dynamic model such an assumption is tenuous and self-defeating. Usually a surrogate for labour demand is achieved by equating desired employment levels with labour demand and then relating desired employment to actual and expected production, assuming relative input costs constant.

As a concrete illustration allow a production function of the form:

$$(13) \qquad Q_{it} = f\ (K_{it}, L_{it}, Y_{it})\ .$$

That is to say production in city i depends upon the level of capital, labour and other factors of production utilised in that city. This implies a very large data set, given all possible input combinations for all time periods unless simplifying assumptions are made. In this study no input data are either used or available other than -

(a) hours worked per manufacturing production worker per week in each city,

(b) number of manufacturing production workers employed per city per period, and

(c) time, used as a surrogate for technical progress.

Consequently some 'heroic' assumptions have to be made and justified. In addition a link must be found between actual and desired number of hours and employees.

The first assumption is that the level of capital inputs is fixed. This assumption has two aspects. One is that for such a bi-monthly period (the time period of the data used here) the assumption is probably justifiable. The constancy of capital inputs both in quantity and quality over the complete ten year period of the study is a much less justifiable assumption. Unfortunately, given no capital input data whatsoever, there is little that can be done except use a time trend component as a surrogate for such changes. It must also be assumed either that changes in the qualitative nature of the labour force do not occur during this period or that they are sufficiently compensated for by the time trend. Such qualitative changes would be increased technical education. The implication is that a much simplified version of (1b) is used, such that

(14) $Q_{it} = f\ (t,\ h_{it},\ E_{it})$

For the present it is assumed that production levels are exogenously determined although this assumption can be modified. Given equation (17) one can find desired employment and hours per worker by:

(14a) $E^{*}_{it} = f(Q_{it}, t, w_{it}, C_{it})$

(14b) $h^{*}_{it} = f(Q_{it}, t, w_{it}, C_{it})$,

Consequently data for production, employment, hours per worker, wage rates and employee retention costs and a time trend are required. The production time-series, input costs and the time trend are discussed below. The data for employment and hours per worker are obtained directly from the United States Department of Labor Statistics sources. A detailed list of all data sources is given in Appendix A.1.

The data for city production time-series do not exist and a synthetic index had to be created. This absence of time-series data seems to be the primary reason behind the dearth of complete dynamic short-run and medium-run labour market models. Without such data only sub-systems of models may be tested such as single equation Phillips' curve studies. Two other alternatives: cross-section studies or the use of a labour demand index similar to Neild's (1972) have been discussed briefly already. The cross-section studies obscure any variation between cities in parameter values, also assuming that all cities have the same qualitative urban labour market structure. If cities have qualitatively different relationships in their labour market the use of cross-sectional studies, imposing the same qualitative structure on all cities, would be absolutely misleading.

Neild's measure for desired (demanded) employment is an alternative that was considered for use in this study. His measure is

(15) $E^*_{it} = (E_{it} + V_{it})$

where

V_{it} = "advertised" vacancies.

Unfortunately no vacancy data whatsoever are available by urban area for the United States of America. In addition, if production data are available however, Neild's approach seems much less satisfactory than the use of derived demand from the production levels, given the use of equations (14a) and (14b). It can also be argued that vacancies, however measured, are not a good indicator of the differences between desired and actual employment.

The synthetic manufacturing production series used here is calculated via the identity.

$$(16) \qquad Q_{it} = \sum_{k=1}^{n} Q_{ikt}$$

where n is used here to denote the number of industries for a given level of industrial aggregation in the Standard Industrial Classification (S.I.C.). The nine manufacturing industries used are listed in Appendix A.1. The unknown Q_{ikt} are constructed as

$$(17) \qquad Q_{ikt} = (Q_{Nkt}/E_{Nkt}) \quad (Q_{ik})$$

The use of (17) relies upon several assumptions. The primary assumption is that industrial sectors in any given centre behave temporally in the same manner as the national series for that sector. The evidence suggests that this is a reasonable assumption, although industries can be seen to grow at different rates in different centres. In addition the data for production are for shipments rather than production itself. The work of Zarnowitz is exhaustive in this context with the implication that the use of shipments should make little difference (Zarnowitz, pp. 9-244). Zarnowitz shows that manufacturing shipments are generally:-

(a) lagged or coincident with new orders and that there is generally a one to one correspondence of cycle peaks and troughs in the two time series,

(b) lagged or coincident with production, but with almost all peaks and troughs coincident and in one to one correspondence although shipments have a more irregular monthly pattern. Indeed, Zarnowitz suggests that production series involve more rounding errors than shipment series (Zarnowitz, 1973).

One cannot be happy with the use of such a synthetic series but there is no alternative given present data sets.

<u>Input Costs</u>

The discussion above involves the use of two costs for labour inputs in the demand equations. The data for wages exist but not for employee retention costs, other than wages. Nevertheless even the use of the wage data was fraught with problems of interpretation. In both cases the question was whether the model should be respecified to obviate the need for the data, or to use the data from imperfect surrogates?

(a) Wage Rates

These data were used for both total hours worked and for hours worked per employee. The major problem was that the wage rates are averaged over hours worked per week per employee, and as such, the differences existing between overtime hours and normal hours and overtime and normal time pay rates were hidden. The problem has occurred in many studies where the distinction between average and marginal rates of pay may be of vital interest. Nadiri and Rosen (1969), for example, admit this difficulty but conclude that there is little that can be done, whilst Weissbrod (1974) attempted the solution of trying varying possible combinations of a normal work week and an overtime rate. Nadiri and Rosen do attempt a solution in that they allow

$$(18) \qquad w_{it} = f(h_{it})$$

where the function, f, "is assumed smooth and differentiable, although typically this is not the case" (Nadiri and Rosen, p.16) Although unstated it is assumed that $f_h > o$ $f_{hh} > o$. This quotation illustrates the inevitable contradictions that the desire to test a well specified model based upon sound theory can lead to when the data base is only partially adequate.

In Weissbrod's study, which concentrated upon spectral and cross-spectral of wage rate change and unemployment rates, the normal work week was variously and fairly arbitrarily classified as 35.0, 37.5 and 40.0 hours per week with an overtime rate of 1.5 times the normal time rate assumed. Weissbrod came to no clear conclusion on the impact of his adjustment and non-adjustment of these data. With workers within a city distributed over many employers, industries and even union affiliations it would be surprising that one particular normal work-week and overtime rate dominate. With workers distributed in any number of ways between overtime/normal time hours and wage rates it is suggested that the variations in normal/overtime for total workers will not be subject to abrupt variations. There seems to be no possibility of disentangling the relationships at work for the aggregation process is completely unknown. Nor is it known whether the marginal or average cost of an additional overtime hour is the relevant variable upon which to base estimates of the parameters of behavioural relationships.

(b) Non-Wage Employment Costs

The use of a hiring and retention cost may also involve considerable differences between marginal and average costs. As no data are available whatsoever a surrogate is used following Nadiri and Rosen, although of a much simpler form (Nadiri and Rosen pp.16-19). They define this input cost as being dependent upon the hiring and other retention costs (subsidised canteens, pension plans and so forth), the rate of interest applicable to those hiring and retention expenditures, and the rate of turnover of production workers.

None of the variables in the equation was available with the exception of a measure of labour turnover. Quit rates are available for urban centres over time as a direct measure of labour turnover and as a more indirect measure of the per period costs of hiring and retaining workers. In addition, there are also the costs of hiring new labour, and these costs are related presumably to the stock of unemployed labour available in that period. The level of unemployment may be a reasonable measure of such costs. Thus, whilst there are theoretically better measures of C_{it}, the data are not available.

Assuming that

$$C_{it} = f(q_{it}, U_{it}) \tag{19}$$

there is still no guide to the possible format of the function except that it can be suspected that $f_q > o$, $f_u < o$. In the present study, however, unemployment is related by an accounting identity to some of the other variables. Consequently the surrogate for this input cost was given simply as q_{it}.

Labour Supply

No time-series data are available for labour participation rates although there are reliable urban area time-series data for labour force size. These data do not distinguish between categories of labour and it has to be assumed that total labour force size is a reasonable indicator of the relative supply of manufacturing labour. There still remained problems of interpreting and using even this variable. These problems are particularly related to the types of demand that can exist for labour, implying that a measure is also needed for the supply of each type of labour.

The demand for labour has been categorised above as being of three sorts:

(a) demand for total employee hours per period,

(b) demand for total number of employees per period, and

(c) demand for hours per employee per period.

As labour force size can only be related to number of employees and as no other data exist a further assumption is necessary. In this case the assumption seems relatively innocuous. It is that employees and those in the labour force either are forced to accept or are always willing to accept the number of hours per week that are offered to them by employers. This can be accomplished by assuming that the number of hours supplied is always equal to, or greater than, hours demanded. In other words this section of the labour market is always either in equilibrium or is in a condition of excess supply. It is impossible, in these circumstances, to state unequivocally what the implications for wages and non-wage employment costs are, in any given set of circumstances where excess-supply and excess-demand for the two factors coexist. The fact that hours per employee and number of employees cannot be regarded strictly as either substitutes or as complementary factors further complicates this problem. Thus the interpretation of one variable is affected by the definition of the others. The definition of labour supply is affected by employer's requirements and the interpretation of wages and other employment costs are affected by both labour supply and wages.

Employment

In common with much of the other data these relate to total manufacturing production workers, and are for both number of employees and number of hours worked per employee per week. An advantage of the data being restricted to production workers is that a greater sensitivity to production changes is likely than is likely for total employees in manufacturing. Hopefully, this greater variation leads to better estimation. Additionally, production data are for whole months whilst employment and other labour force data refer only to the second week of the month. Consequently it has to be assumed that that week is representative of employment and hours for the whole of the month. Nevertheless employment and hours worked per worker per week are probably the most easily interpretable of the data sets.

Quit Rates

The quit rate was mentioned as a possible surrogate measure of non-wage employment costs. The quit rate also exists as an important labour market variable in its own right and apart from its possible use as a surrogate. The quit-rate is determined within labour markets and, as such, is a variable that can probably be explained in a fully-specified labour market model. It is used as such in the models specified given that data are available for quit rates. The quit-rate represents the willingness of individuals to give up present employment for alternative employment opportunities, ignoring retirement and so forth as reasons for quitting employment (Burdett, 1977). As such it is a very good measure of the "tightness" of a labour market; much more so than many other variables such as the unemployment rate, as it measures a flow within the labour market. The quit rate was used, rather than the number of quits, in the estimation of the models. This was for two reasons. First, the size of the urban labour market affects the number of quits as well as the tightness of that labour market. Second, there is an accounting identity,

(Change in Employment = Hires minus fires (Layoffs) minus Quits)

relating two of the variables in the model if the number of quits were used. This can create problems of estimation for the complete explanation of one (employment change)must also imply the complete explanation of any of its component parts (quits). The use of the quit rate avoids this accounting identity relationship occurring in the model.

Technical Progress and Labour Market Seasonality

Both technical progress and seasonality involve a relationship between time and the measured levels of labour market variables.

(a) Technical Progesss

The data were available for technical progress, However, the use of a time trend as a surrogate for technical progress is common and, by definition, involves no extra data collection (Nadiri and Rosen, pp. 55-59). The level of technical progress is assumed to affect employment levels in that fewer employees, and fewer inputs in general, are required per unit of production. It was further assumed that technical progress is time-dependent and that, therefore, a time-trend would be a reasonable surrogate for technical progress. The drawback of the method was that the time trend will also pick up the effects of other variables that vary consistently with time. Unfortunately it was not possible to avoid this latter problem.

(b) Seasonality

Economic activities of many different types are affected by the season. Probably the best example is the impact of Winter upon construction activity. Consequently, the seasons can be expected to affect the levels of labour market activity indirectly. There are, however, seasonal labour market effects that are direct and which can be expected to vary from place to place. The major impact is that of Summer college vacations upon the size of the labour force. The changes in labour force size due to these vacations can be expected in June/July (Labour force increase) and September (Labour Force decrease). Again no data are required to be collected to measure these effects. Artificial variables are constructed that take on arbitrary values depending solely upon the season. These "dummy" variables then allow the impacts of seasonality to be measured.

Excluded Data Sets

Certain data directly applicable to labour market analyses were excluded from the modelling process. Two variables were involved: Manufacturing Production Worker Layoffs, Manufacturing Production Worker Hires.

In the case of Layoffs and Hires the data are not published before May 1965 for Altoona and Johnstown. The inclusion of these variables in the model would, therefore, have implied the time-period running from May 1965. The major reason for their exclusion, however, was that no explanatory variables were available for these variables. To include both hires and fires (layoffs) would have needed a disaggregation of all the data by either firms or by skills or by both. This disaggregation would be needed to explain why some firms were hiring workers whilst others were firing workers. If some firms were simultaneously hiring and firing this would have to be seen as implying that some skills were required whilst other skills were not required. Given the absence of these data the Hires and Layoff data sets were also excluded.

The Choice of Area and Time Period

The choice of area and time period chosen were almost completely interdependent. The end of the study period, however, was determined by the Arab Oil Embargo. After the end of 1973 it had to be assumed that the structure of urban labour markets would change as a response to the embargo and to the rapid series of oil price increases that occurred after the embargo. This is particularly true of the relationships in the wage rate change equations in all of the models. Given that wage rate changes were in current dollars, as no price indices were available for individual cities to calculate wage rates in constant terms, the impact would almost certainly have been very large.

The start of the study time period, on the other hand, was very much entwined with the choice of study area. The area required was one which had

(i) cities with a high proportion of their employment in manufacturing. Manufacturing employment could in those cities be more relied upon as indicator of overall labour market conditions.

(ii) cities which were not undergoing particularly rapid population shifts, implying perhaps an important role to migration, with which the models could not deal.

(iii) a broad spectrum of city types, particularly with respect to size and industrial structure, to examine whether or not these factors influenced the parameter estimates for individual cities.

At the same time sufficiently long time periods were required for problems of statistical significance to be minimised. In addition a very important, though not entirely essential choice criterion, was that all of the cities were tested over exactly the same time and for the same variables and models so that comparability was ensured.

Only the North Eastern part of the United States fulfilled all of these criteria. In addition the North East provided enough cities (29 cities: Appendix A.6) that allowed the possibility of an analysis of the spatial pattern of parameter estimates.

Conclusion

The conclusions drawn were simple but all important. They were that, although the data to a large degree determined the form of the estimated models, there was also a considerable amount of freedom in model specification. More importantly the conclusion was drawn that it was possible to empirically test dynamic, short-run urban labour market models whose form was consistent with labour market theory.

CHAPTER FIVE

THE ESTIMATED FORMS OF THE MODELS

Introduction

The models were presented in as general a form as was possible given the constraints imposed by the data. They are general in that the same labour market structure was expected to be applicable to all twenty-nine urban centres. It was expected, nonetheless, that variations in labour market behaviour would exist between these centres. These variations could be expected to stem from a variety of causes ranging from differences in industrial structure and social and demographic composition of the population to the relative location of the centre within the urban system. As a consequence, no attempt was made to try to find a specific model that fitted the centres best in any overall fashion. Instead an attempt has been made to estimate a specific form of the general model for each urban centre, that suiting each urban centre best by some statistical criterion. The specification difference between centres were seen to be on the basis of differing lag structures of variables and the omission or inclusion of particular variables in given equations. Surprisingly, given the potential and actual differences between the urban labour markets, the same specification worked best for virtually all of the centres.

The estimated models presented here represent four stages of empirical investigation of the general models. These stages were

(i) an Ordinary Least-Squares estimation of the factor adjustment equations for both the one-factor and two-factor models,

(ii) a Two-Stage Least-Squares estimation of the one-factor model.

(iii) a Two-Stage Least-Squares estimation of the two-factor model in four alternative specifications, and

(iv) a Two-Stage Least-Squares estimation of a fifth and final form of the two-factor model, based upon the results of the four previously estimated forms. The relevant eigen-values of these final models were also calculated.

The one-factor model was tested, although it was considered theoretically inferior to the two-factor model, in case this was not the case for their relative empirical merits. Although Two-Stage Least-Squares was necessary for most of the estimation carried out,this was not the case for the factor adjustment equations. This stemmed from the fact that no current endogenous variables entered these equations as explanatory variables (Wonnacott and Wonnacott, pp. 172-195, 343-364). The factor adjustment equations are estimated separately as experiments in specification particularly with respect to the role of lags on the synthetic production series.

These results are analysed in terms of the statistical trustworthiness of the results and the interpretation of the parameter estimates in terms of both their actual and expected qualitative and quantitative properties. Inter-urban model comparisons and the correlation of the model results with urban and spatial structures are considered in the following chapter.

The models are formulated explicitly as simultaneous equation systems. This implies the use of an estimation technique applicable to such systems. As the models are composed of simultaneous linear equations the use of Two-Stage Least-Squares is one valid technique, amongst others, that may be used (Wonnacott and Wonnacott, pp. 364-400). Given no other specific criteria for choice the use of Two-Stage Least-Squares was based largely on convenience. The final estimation was completed using the SPSS program, but, in addition, several identical models were tested using the identical data to test the comparability of results. In the simultaneous equation specifications of the models many of the equations are overidentified. Overidentification implies that Orindary Least-Squares parameter estimates can give rise to more than one unique estimate of a given parameter value, from the reduced form. Two-Stage Least-Squares is one of several techniques that yield unique estimates for a structural parameter, whilst retaining the Ordinary Least-Squares virtues of consistency, unbiasedness and efficiency.

Ordinary Least-Squares Estimation of the Factor Adjustment Equations.

The major force operating upon each urban labour market is the level of production in the city. It is in the factor adjustment (or input adjustment) equations that the synthetic urban production series appear. Consequently the models are dependent upon a significant relationship existing between production and the demand for factors of production. Initial tests of this vital relationship were carried out, therefore, before the rest of the models were specified. The use of the Ordinary Least-Squares was proper in these equations for all explanatory variables used were exogenous or lagged endogenous variables. Only if current endogenous variables were used as explanatory variables would the Two-Stage Least-Squares technique have been necessary. The use of Ordinary Least-Squares estimates at this stage also allowed the later possibility of comparison of the estimates of the two techniques. A wide divergence of the two sets of results for the factor adjustment equations would cast doubt upon both sets of estimates. Finally the use of Ordinary Least-Squares enables the use of the adjusted $\bar{R}^2$ as an approximate measure of the proportion of the variance of the dependent variable accounted for by the independent variables. No $\bar{R}^2$ value can be used when Two-Stage Least-Squares are used. The $\bar{R}^2$ measure was to be regarded as only an approximate measure if it proved that Two Stage Least Squares was the more appropriate estimation technique. The equations estimated are in order for each centre,

$$\text{(i)} \quad E_{it}/E_{it-1} = k(Q_{it}^{a_1} e^{a_2^t}/E_{it-1})^{a_3}$$

$$\text{(ii)} \quad E_{it}/E_{it-1} = k(Q_{it-1}^{a_1} e^{a_2^t}/E_{it-1})^{a_3}$$

$$\text{(iii)} \quad h_{it}/h_{it-1} = k(Q_{it}^{a_1} e^{a_2^t}/h_{it-1})^{a_3}$$

$$\text{(iv)} \quad h_{it}/h_{it-1} = k(Q_{it-1}^{a_1} e^{a_2^t}/h_{it-1})^{a_3}$$

$$\text{(v)} \quad E_{it}/E_{it-1} = k(Q_{it}^{a_1} e^{a_2^t}/h_{it-1})^{a_3}$$

$$\text{(vi)} \quad h_{it}/h_{it-1} = k(Q_{it}^{a_1} e^{a_2^t}/h_{it-1})^{a_3} E_{it-1}^{a_4}$$

$$\text{(vii)} \quad H_{it}/H_{it-1} = k(Q_{it}^{a_1} e^{a_2^t}/H_{it-1})^{a_3}$$

$$\text{(viii)} \quad H_{it}/H_{it-1} = k(Q_{it-1}^{a_1} e^{a_2^t}/H_{it-1})^{a_3}$$

The hypothesised signs for the estimated parameters are

ln k	±
a_1	±
a_2	−
a_3	+
a_4	±

The equations all have the general form

$$y_{it}/y_{it} = (y^*_{it}/y_{it-1})^b$$

where the optional or desired levels of the dependent input variables are determined by urban manufacturing production and a time trend and b is the adjustment parameter. Apart from the simultaneous equation problem there is the possibility that one or more variables have been omitted from the right hand side of the equation. Of particular consequence could be the exclusion of the relative cost(s) of a factor; a variable which should have a negative sign. However it has already been shown that relative costs are difficult to identify exactly in the available data. This fact, plus the fact that the estimation here was intended as experiment rather than final estimation led to their omission. Consequently the estimation of equations (i) and (ii) was designed to test if the general specification of the employment factor adjustment equation was correct and, in particular, whether current or lagged production was the more relevant variable. Equations (ii) and (iii) were designed in exactly the same manner for the adjustment of hours worked per week per worker. Assuming current production to be the more relevant variable, equation (v) examined the possibility of cross-effects between hours per worker per week and the number of employees in the determination of employment adjustment. Equation (vi) performed the same role for the adjustment of hours worked per worker per week. The equations (vii) and (viii) represent analogous equations to (i) and (ii) assuming that employers do not distinguish between hours per employer and number of employees but are solely interested in their labour force totality. The results are presented in Appendix A.2.

The results represented comprehensive analysis of factor adjustment mechanisms in labour markets at the urban level of aggregation, despite the experimental nature of the results. The consistency of the results, across all of the centres, with respect to the anticipated parameter signs is an indication of the strength of the results. For example, two hundred and thirty-two estimates of parameters on the synthetic production series produced only forty-six estimates with incorrect (negative) signs. In addition, the incorrect signs are heavily concentrated in a few centres, suggesting that the basic model is correct.

The $\bar{R}^2$ values require some explanation for they do provide a disturbing element in that the values are so consistently and abnormally high for equations (iii), (iv) and (vi), dealing with hours worked per worker per week. These results are reflected partially in equations (vii) and (viii), where total hours are obviously the product of employment and hours worked per worker per week. The $\bar{R}^2$ values for equations (iii) and (iv) varied between 0.999 and 0.957, with a potential range of 0.0 to 1.0. Only two of the values, those for Toledo, fall below 0.993. The values are not spurious but result from the very high simple linear correlations that exist between $\ln(h_{it}/h_{it-1})$ and $\ln(h_{it-1})$. These very strong relationships have their foundation in the fact that employers face rigid limits on their abilities to impose longer working weeks, whether or not they are opposed in this by their employees. Consequently increases in one period are matched frequently by corresponding decreases in the length of work week in the immediately following period. Decreases in the work week also seem to involve immediate compensatory pressure, either from unions or, perhaps, from employers themselves who may recognise some number of hours per worker as optional regardless of the size of the employed work force. The speed of adjustment of actual hours worked to the desired level of hours is very rapid, as measured by the values of the parameter, a_3, which is consistent with this argument. Complete adjustment of the actual hours to desired hours, within the bi-monthly period, would imply $a_3 = 1.0$. A value between zero and plus unity implies a less than complete adjustment, whilst values of a_3 greater than one would imply overshooting of the desired number of hours. The values for a_3 lie in the range +1.016 to +0.786. For the current production equation (iii) the values fall in the narrower range of +1.000 to +0.981 inclusive. This suggests that equation (iii) may be superior to equation (iv). This is borne out by the estimates of the parameter a_1 on current and lagged production. The estimates of a_1 are of the wrong sign only ten times for current production (Q_{it}) compared to sixteen for lagged production (Q_{it-1}). In addition, although these estimates are rarely statistically significant, where both equation (iii) and (iv) have the correct sign for a_3 then invariably the estimate for the third equation is the more significant of the two. The indications then are very strong that equation (iii) is a better specification of the adjustment mechanism for hours per employee per week than is equation (iv). Nevertheless in both models it is important to note that despite the impact of the lagged hours variable upon the $\bar{R}^2$ value the other variables overwhelmingly give rise to parameter estimates of the hypothesised sign. Time appears having the correct sign (negative), and often statistically significant, but having only a small impact on the hours worked per week per worker. This implies an only just discernible downward trend in the average manufacturing working week in these cities for the study period. Only in Pittsburgh and York was there any evidence of an upward trend.

The employment adjustment equation results are very similar to those of the hours worked per week. There are, however several distinct and explicable differences between them. The $\bar{R}^2$ values vary between 0.536 and 0.469 rather than being clustered close to the upper limit of 1.0. This implies the equations have much less explanatory power compared to the hours per week per worker equations. Statistically this items from the much weaker relationship that exists between $\ln(E_{it}/E_{t-1})$ and $\ln(E_{it-1})$ compared to $\ln(h_{it}/h_{it-1})$ and $\ln(h_{it-1})$. The strength of the latter relationship has already been explained. The former is much the weaker of the two relationships for several very important reasons: reasons which reflect the operation of the labour markets. The primary reason must be that employers have much less ability to hire and fire employees than they have ability to control the amount of time worked by their employers. The latter is much more an internal decision whereas the former is to a much greater degree affected by external market forces. The adjustment parameter a_3 has very similar values to the adjustment parameter for weekly hours, though with a much greater range of values, from +0.225 to +0.692. The range for the first equation, dealing with current production, is much narrower being inclusively between +0.992 and+0.955. This indicates again that current production determines factor levels rather than lagged production. More of the a_3 estimates in (i) are statistically significant than for (ii), as are the parameter estimates for a_1 generally more significant for current rather than lagged production. Only two of the a_1 estimates are of the wrong sign, both of these being for the lagged production variable.

The possibility of cross-effects between the two factors is examined in equations (v) and (vi), using the current production values based upon the arguments and results noted above. The cross-effects occur when the actual values of a given variable influence the rate of adjustment of another factor from the actual to desired values. If the factors act as substitutes the effect should be a negative one, and a positive one if they are complementary factors. The fact that neither numbers of employees nor hours worked per employee are inseperable, despite the fact that they can be substituted within limits, implies that they are both complements and substitutes. The results are rearranged in table 5. 1. Only effects that are significant at the 0.05 level are shown.

Table 5.1 Factor Cross-Adjustment Effects

Jointly Dependent Variable	Positive Cross Effects	Negative Cross Effects
E_{it}/E_{it-1}	1	4
h_{it}/h_{it-1}	0	17

As can be seen from the table above, the impact of lagged hours on employment change was generally not significant with a total spread of 11 positive cross effects and 18 negative cross effects. This seemed to indicate that employment changes are neither consistently nor strongly affected by labour market pressures leading to increases in the working week. The exception was a single centre, Youngstown, with an overwhelmingly strong positive cross effect. No explanation for this phenomenon could be found. However the impact of employment levels on changes in the hours worked per week was seen to be very different with a total of only three positive effects, all very small. The three positive effects were all small. The three cities concerned were Dayton, Toledo and Youngstown. No explanation was found for this phenomenon. The fact that employment levels had an impact on hours can be explained. The employer has a much greater ability to change the length of the work week rather than the number of employees. This enables the employer to respond to production and employment levels by adjustment of the work week.

The employer cannot respond as readily to production and the length of the work week by altering employment. Consequently the substitution cross-effect appears to be one way.

The total hours factor adjustment equations, (vii) and (viii), follow these general patterns. Current production appears again as being of greater significance than lagged production and, although the results are often not statistically significant, the estimates are almost invariably of the expected sign. As the variable in H_{it}, is a linear combination of $\ln h_{it}$ and $\ln E_{it}$ these results are none too surprising. Nevertheless they point to the one factor model as a possibly viable alternative if the two factor model should fail in its complete multi-equation form.

The One-Factor Model; Estimates of Three Fully Specified Models.

Although the one factor model was considered as theoretically inferior to the two-factor model and the results of the two-factor model were satisfactory in the factor adjustment equations, results for three fully specified one-factor models are presented. The reason was that of completeness: to enable a full empirical comparison of the one-factor and two-factor models, should it be necessary. As both models have satisfactory factor-adjustment equations, the emphasis in this section was upon those equations describing the changes in the size of the labour force and of the wage rate. It remained possible that the one-factor model was empirically superior in explaining labour supply and wage rates. There was also an addition of the input cost variable to the factor adjustment equation in two of the models which requires later comment. All of the one factor models are described in Table 5.2.

Table 5.2 The Form of the One-Factor Models

I	i	$H_{it}/H_{it-1} = k_1(Q_{it}^{a_1} w_{it-1}^{a_2} e^{a_3 t}/H_{it-1})^{a_4}$
	ii	${}_sH_{it}/{}_sH_{it-1} = k_2 w_{it}^{a_1} + a_2 D_M + a_3 D_S$
	iii	$w_{it}/w_{it-1} = k_3(H_{it}/H_{sit})^{a_1} w_{it-1}^{a_2} \quad (k_3 = 1)$
II	i	$H_{it}/H_{it-1} = k_1(Q_{it}^{a_1} q_{it-1}^{a_2} e^{a_3 t}/H_{it-1})^{a_4}$
	ii	${}_sH_{it}/{}_sH_{it-1} = k_2 q_{it}^{a_1} + a_2 D_M + a_3 D_S$
	iii	$w_{it}/w_{it-1} = k_3(H_{it}/H_{sit})^{a_1} q_{it-1}^{a_2}$
III	i	$H_{it}/H_{it-1} = k_1 Q_{it}^{a_1} e^{a_2 t}/H_{it-1})^{a_3}$
	ii	${}_sH_{it}/{}_sH_{it-1} = k_2 q_{it-1}^{a_1} + a_2 D_M + a_3 D_S$
	iii	$w_{it}/w_{it-1} = k_3(H_{it}/H_{it-1})^{a_1} + a_2 D_S$

The parameter estimates for these models are set out in Appendix A.3 in the configuration shown in Table 5.3.

Table 5.3 Layout of Parameter Estimates in Appendix A.3

I	i	ln k	a_1/a_4	a_2/a_4	a_3/a_4	a_4
	ii	ln k	a_1	a_2	a_3	
	iii		a_1	a_2		
II	i	ln k	a_1/a_4	a_2/a_4	a_3/a_4	a_4
	ii	ln k	a_1	a_2	a_3	
	iii	ln k	a_1	a_2		
III	i	ln k	a_1/a_3	a_2/a_3	a_3	
	ii	ln k	a_1	a_2	a_3	
	iii	ln k	a_1	a_2		

The expected signs of the parameter estimates are shown in Table 5.4

Table 5.4 Expected Signs of the Parameters of the One Factor Model

I	i	±	+	-	-	+
	ii	±	±	+	-	
	iii	k=1	+	-		
II	i	±	+	-	+	
	ii	±	+	+	-	
	iii	±	+	±		
III	i	±	+	-	+	
	ii	±	+	-	+	
	iii	±	+	±		

The results were as shown in Appendix A.3.

The models presented yielded mixed results. Some parameter estimates were of the wrong sign but the majority were as hypothesised. Whilst many of the parameters estimates were not statistically significant individually, this was offset by the fact that virtually all estimates in the majority of cities were consistent in having the hypothesised parameter signs.

In model I the first equation worked well, as expected, given the previous results examined. The inclusion of the lagged wage-rate was almost completely unsuccessful as a proxy for the impact of labour costs. The associated parameter estimate was of the correct (negative) sign in only 12 of the 29 centres. In equation I.i, the current wage rate was used as the measure of the pecuniary inducement to join the labour force. In this case the possibility of a backward bending supply curve of labour makes the sign ambiguous. In terms of overall consistency with an expected sign this estimate cannot be evaluated. More reliance must be placed upon the statistical significance of the estimates. In this particular case all but two of the estimates were negatively signed, seemingly indicating a backward bending labour supply curve, for the short-run at least. The positive estimates (Indianapolis, Albany) were not significant but sixteen of the twenty-seven negative values were significant at the 5% level or better. The two dummy variables, for May and September, are an attempt to measure the impact of the long college vacation upon the size of the labour force. Consequently, May should see a positive sign and September a negative one. Neither of these variables was in any way successful in Model I, both being often of the incorrect sign and significant when of tbe incorrect sign in several cases. Equation I.iii attempts to show the impact of short-run labour market tightening. The constant term was assumed to be unity. Neither of the variables in this equation were successful in either terms of significance or of consistency of estimate of the correct sign.

The second model was the same as the first, except that the quit-rate rather than the wage rate was used as the proxy for labour costs. In addition, the constant term in the third equation was not constrained to unity. Overall the second model was not much more successful than the first. The parameter estimate for labour costs in the first equation was correct (negative) in twenty-three of the centres, compared with twelve for the wage-rate version. This probably stems from the fact that the quit-rate will have an immediate impact upon production whilst the wage-rate does not. Thus an increase in the quit-rate may deter production plans whilst wage-rate changes, particularly with cost-plus pricing, will not do so. The other parameters in this equation, as with the previous results, are virtually all of the correct sign. The quit-rate is unambiguous in terms of its hypothesised effect on the labour force. An increasing or high quit-rate was regarded as representing the perception of workers of the ease of finding new work. In only one case (Albany) was the parameter estimate of the correct (positive) sign. Similarly, the dummy variables did not correspond to their hypothesised signs. The third equation was much more successful, however, if the equation is treated with some caution. The sign of the parameter, representing the impact of the excess demand for labour ($H_{it}/_{s}H_{it}$) was correct in all but four centres, (Reading, Scranton, Wilkes-Barre and York) and often significant. On the other hand the sign on the quit-rate was, without exception, of the incorrect (negative) sign. This seems to indicate some statistical relationship between the quit-rate and the wage-rate, given that they have been posited as alternative proxies for labour costs in these two models, that allows the time relationship between excess demand and wage-rate change to be estimated.

The third model estimated had a similar form to the two previous models with the following differences. The first equation had no labour-cost variable included and, consequently, the results are identical to those of equation (vii) in Appendix A.2. The second equation is identical in form to that of the second model except that the quit-rate is lagged. The results here are also poor. For the third equation the quit-rate variable was replaced by a dummy variable for September. This was an attempt to enquire into the effects of the Summer labour force on wage-rates. This equation was also unsuccessful.

None of the models can be considered a complete success but, again, they do point toward the possibility of modelling and evaluating urban labour markets with the data presently available. Considered in their own right, problems appear in the relationship between the quit-rate and the wage-rate, for both can act as a labour factor cost. One possibility is that a fourth equation could be added to include the quit rate as an endogenous variable. Within the three equation framework, it is also probably possible to ensure that equations (ii) and (iii) are made more adequate by a respecification of the two equations and by testing for more appropriate lag structures. These two possibilities plus the good fits of the two-factor adjustment equations in Appendix A.2 point to the testing of the two-factor model in a complete five-equation model. These results plus the theoretical superiority of the two-factor model lead to its specification and empirical verification.

The Two-Factor Model

The results gained from the two-factor model indicate that it is a viable model of the short-run dynamic behaviour of urban labour markets. Four alternative specifications were tested before the fifth and final model was distilled from them. This section enumerates and comments upon the results of the four specifications. The tables and Appendix relating to the results are as follows:

5.5 The Form of the Two-Factor Models

5.6 Layout of Parameter Estimates in Appendix A.4

5.7 Expected Signs of the Parameters

Appendix
A.4 The Estimated Parameters

Table 5.6 Forms of the Two Factor Models

Model I

I.1 $$E_{it}/E_{it-1} = k_1(Q_{it}^{a_{11}}(q_{it}/w_{it})^{a_{12}}e^{a_{13}t}/E_{it-1})^{a_{14}}$$

I.2 $$h_{it}/h_{it-1} = k_2(Q_{it}^{a_{21}}(q_{it}/w_{it})^{a_{22}}e^{a_{23}t}/h_{it-1})^{a_{24}}$$

I.3 $$L_{it}/L_{it-1} = k_3 w_{it-1}^{a_{31}} + a_{32}D_M + a_{33}D_S$$

I.4 $$q_{it}/q_{it-1} = k_4 E_{it-1}^{a_{41}} L_{it-1}^{a_{42}} + a_{43}D_S$$

I.5 $$w_{it}/w_{it-1} = k_5 Q_{it}^{a_{51}} e^{a_{52}t} L_{it-1}^{a_{53}} + a_{54}D_M + {}_{55}D_S$$

Model II

II.1 $$E_{it}/E_{it-1} = k_1(Q_{it-1}^{a_{11}}(q_{it}/w_{it})^{a_{12}}e^{a_{13}t}/E_{it-1})^{a_{14}}$$

II.2 $$h_{it}/h_{it-1} = k_2(Q_{it-1}^{a_{21}}(q_{it}/w_{it})^{a_{22}}e^{a_{23}t}/h_{it-1})^{a_{24}}$$

II.3 $$L_{it}/L_{it-1} = k_3 w_{it}^{a_{31}} + a_{32}D_J + a_{33}D_S$$

II.4 $$q_{it}/q_{it-1} = k_4 E_{it}^{a_{41}} L_{it}^{a_{42}} + a_{43}D_S$$

II.5 $$w_{it}/w_{it-1} = k_5(h_{it}/h_{it-1})^{a_{51}}(E_{it}/E_{it-1})^{a_{52}}(L_{it}/L_{it-1})^{a_{53}}$$

(Table 5.5 continued)

Model III

III.1	E_{it}/E_{it-1}	$= k_1(Q_{it}^{a_{11}} q_{it-1}^{a_{12}} w_{it-1}^{a_{13}} e^{a_{14}t}/E_{it-1})^{a_{15}}$
III.2	h_{it}/h_{it-1}	$= k_2(Q_{it}^{a_{21}} q_{it-1}^{a_{22}} w_{it-1}^{a_{23}} e^{a_{24}t}/h_{it-1})^{a_{24}}$
III.3	L_{it}/L_{it-1}	$= k_3(w_{it}/w_{it-1})^{a_{31}}(q_{it}/q_{it-1})^{a_{32}}$
III.4	q_{it}/q_{it-1}	$= k_4(h_{it}/h_{it-1})^{a_{41}} + a_{42}D_S$
III.5	w_{it}/w_{it-1}	$= k_5(h_{it}/h_{it-1})^{a_{52}}(E_{it}/E_{it-1})^{a_{52}}(L_{it}/L_{it-1})^{a_{53}}$

Model IV

IV.1	E_{it}/E_{it-1}	$= k_1(Q_{it-1}^{a_{11}} q_{it-1}^{a_{12}} w_{it-1}^{a_{13}} e^{a_{14}t}/E_{t-1})^{a_{25}}$
IV.2	h_{it}/h_{it-1}	$= k_2(Q_{it-1}^{a_{21}} q_{it-1}^{a_{22}} w_{it-1}^{a_{23}} e^{a_{24}t}/h_{t-1})^{a_{25}}$
IV.3	L_{it}/L_{it-1}	$= k_3(w_{it}/w_{it-1})^{a_{31}} q_{it}^{a_{32}} + a_{33}D_M + a_{34}D_S$
IV.4	q_{it}/q_{it-1}	$= k_4(E_{it}/E_{it-1})^{a_{41}} + a_{42}D_S$
IV.5	w_{it}/w_{it-1}	$= k_5(h_{it}/h_{it-1})^{a_{51}}(E_{it}/E_{it-1})^{a_{52}}$

The definition of the variables is as before with the addition of D_{M}, D_{J} = dummy variables for May and July (school and university vacations commence) and D_S = dummy variable for September (school and university vacations cease) and with k = constant term.

Table 5.6 Table of Parameter Estimate Layouts

The models were estimated using two-stage least-squares, and the results are set out in the form:

Model I

I.1	$\ln k_1$	a_{11}/a_{14}	a_{12}/a_{14}	a_{13}/a_{14}	a_{14}
I.2	$\ln k_2$	a_{21}/a_{24}	a_{23}/a_{24}	a_{24}/a_{24}	a_{24}
I.3	$\ln k_3$	a_{31}	a_{32}	a_{33}	
I.4	$\ln k_4$	a_{41}	a_{42}	a_{43}	
I.5	$\ln k_5$	a_{51}	a_{52}	a_{53}	

Model II

II.1	$\ln k_1$	a_{11}/a_{14}	a_{12}/a_{14}	a_{14}
II.2	$\ln k_2$	a_{21}/a_{24}	a_{22}/a_{24}	a_{24}
II.3	$\ln k_3$	a_{31}	a_{32}	a_{34}
II.4	$\ln k_4$	a_{41}	a_{42}	a_{43}
II.5	$\ln k_5$	a_{51}	a_{52}	a_{53}

(Table 5.6 continued)

Model III

III.1	$\ln k_1$	a_{11}/a_{15}	a_{12}/a_{15}	a_{13}/a_{15}	a_{14}/a_{15}	a_{15}
III.2	$\ln k_2$	a_{21}/a_{25}	a_{22}/a_{25}	a_{23}/a_{25}	a_{24}/a_{25}	a_{25}
III.3	$\ln k_3$	a_{31}	a_{32}			
III.4	$\ln k_4$	a_{41}	a_{42}			
III.5	$\ln k_5$	a_{51}	a_{52}	a_{53}		

Model IV

IV.1	$\ln k_1$	$a_{11}a_{15}$	a_{12}/a_{15}	a_{13}/a_{15}	a_{14}/a_{15}	a_{15}
IV.2	$\ln k_2$	a_{21}/a_{25}	a_{22}/a_{25}	a_{23}/a_{25}	a_{24}/a_{25}	a_{25}
IV.3	$\ln k_3$	a_{31}	a_{32}	a_{33}	a_{34}	
IV.4	$\ln k_4$	a_{41}	a_{42}			
IV.5	$\ln k_5$	a_{51}	a_{52}			

Table 5.7 Expected Signs of the Parameters of the Two-Factor Model

The hypothesised signs of the parameters are:

Model I						
I.1	±	−	+	+	+	
I.2	±	−	+	+	+	
I.3	±	±	+	−		
I.4	±	+	−	+		
I.5	±	+	+	−	±	±
Model II						
II.1	±	−	+	+	+	
II.2	±	−	+	+		
II.3	±	±	+	−		
II.4	±	+	−	+		
II.5	±	+	+	−		
Model III						
III.1	±	−	−	−	+	+
III.2	±	−	+	−	+	+
III.3	±	±	+			
III.4	±	+	−			
III.5	±	+	+	−		
Model IV						
IV.1	±	−	−	+	+	+
IV.2	±	−	+	−	+	+
IV.3	±	+	−			
IV.4	+	+	+			
IV.5	±	+	+			

The models have similar structures, all having the same five jointly dependent variables. Equations one and two in each model are the factor adjustment equations, similar in form to the ordinary least-squares estimates but including labour cost variables. In addition the equations four and five are the structural equations for those labour costs; wage-rates and quit-rates. The third equation is concerned with the size of the labour force. In general the models work well though unevenly.

In model I the two factor adjustment equations both include a variable (q_{it}/w_{it}) that hopefully is proportional to the relative costs of increasing employment as opposed to increasing hours worked per worker. Unfortunately the variable's parameter estimates, though very often statistically significant, are usually not consistent with the hypotheses. Very often the same sign appears on the parameter estimates for both equations one and two. Apart from this these two equations work well. The third equation offers the ambiguity of sign associated with the supply curve of labour and the wage rate. The evidence would suggest a backward bending labour supply curve, though the parameters demonstrated a lack of statistical significance. Similarly the dummy variables for May and September lack statistical significance and are generally inconsistent with respect to sign. The fourth equation has the September variable as both of the correct sign and generally statistically significant. September, as the beginning of the academic year, implies higher than usual quit rates in industry. The effects of employment and labour force levels on changes in the quit-rate do not have consistent signs throughout the twenty-nine centres. The labour force size variable gave rise to a parameter estimate that is usually of the correct (negative) sign. The parameter for employment is usually of the incorrect (negative) sign. The fifth equation attempted to place changes in wages in relation to desired and actual amounts of labour, had always the wrong sign. Other variables in the equation turn out to have no significant relationships with the wage rate change variable.

The second model had the same variables as the first in its first four equations. In the fifth equation, however, the change in the wage rate depends upon three of the other four jointly dependent variables rather than on production. In the first two (factor-adjustment) equations current production is replaced by lagged production, with relative labour costs rrtained as a variable. The estimation and statistical significance of the equation as a whole suffered from this simple change. The lagged production parameter was usually statistically not significant when of the correct sign and usually significant when of the incorrect sign. The other variables in the equation do not perform as well as in the first model. In the third equation the current rather than lagged wage rate is used. The change in this equation is dramatic. All twenty-nine parameter estimates were positive indicating a "normal" rather than backward-bending labour supply curve. All but three of the estimates were significant at the 1% level. This specification taken alone indicates that higher-wage rates (remembering that they include a strong overtime component in any increases) induce more rather than less people to enter the labour force. The labour force definition is those actively seeking employment. Compared with Model I the statistical evidence seems to indicate that this is more likely to be the true situation rather than that of a backward-bending supply curve. This problem is discussed later in the context of Models III and IV. In this equation the pair of dummy variables had the correct sign for both parameters in twelve of the twenty-nine cases, an improvement on equation I.3 which also suggests that this equation, II.3, is the better specification. The fourth equation varied from that in the first model in that the employment and labour force variables used are current rather lagged variables. The hypothesised pair of signs (positive, negative) were found in only five. In the fifth equation the first parameter represents the effect of changes in the work week upon changes in the wage rate. Given the overtime-wage rate relationship, it was not surprising that the sign of the parameters is correct (positive) in all but four of the centres. The inclusion of the hours change variable helps remove the overtime effect and the influence it could have exerted on other parameter estimates. It was found that changes in employment gave rise to positive parameter estimates in all but five urban centres. The size of the labour force was hypothesised to have the opposite effect (i.e. negative) but only in five cases was the sign correct. This seemed almost certainly due to the fact that the labour force increased more quickly in buoyant periods, as was found in the third equation.

The third model had a similar structure. In the factor adjustment equations the ratio of quit-rate was separated into the two distinct variables. The associated parameter estimates, as a set of two pairs, were not consistent with their hypothesised signs, but a consistency was found in the signs of these parameters. The determinants of changes in the labour force were taken as the change in the wage rate and change in the quit-rate. No dummy variables were used. The first parameter had no specifically hypothesised sign, whilst that of the second parameter was positive. The results were that all of the quit-rate parameter estimates were of the correct sign. Nineteen of the wage rate parameter estimates were negative and twenty were positive. In the fourth equation both hypothesised signs were positive and only in two cases were these expectations unfulfilled. These cases were a negative quit-rate parameter in Wilkes-Barre and a negative September parameter in York. For virtually all of the correct parameter estimates the results were significant at the 1% level. The structure of the fifth equation is exactly that of the fifth equation in Model II. In the third Model the results are inferior to those in the second in terms of yielding the hypothesised signs. In particular the employment change parameter was generally of the wrong sign.

The fourth model differs from the third model in the third, fourth and fifth equations. In the third equation dummy variables (May and September) are used to delineate the impact of the Summer student labour force arrivals and departures. In thirteen of the twenty cities the estimated signs (positive, negative) are those expected. In virtually all cases those of the September dummy variable are correct, and more often significant than for the May dummy variable. This probably reflects the fact that virtually all schools and colleges return in September. The variety of starting dates for college Summer vacations can be used to explain the poorer fit for May. The change in wage rate and the current value of the quit-rate were used as the two other explanatory variables. The sign of the parameter estimate was positive in all cities for the wage-rate change variable and in all but six cities for the quit-rate. These results indicate that labour forces in all of the cities responded to inducements to enter the labour force, both with respect to changes in remuneration and the perceived likelihood of finding employment. For the fourth equation the quit-rate change equation gave rise to two parameters, both expected to be positive. One was a September dummy variable, again related to return to college. Only in Scranton and York was the sign found to be negative, though statistically insignificant. In nearly all the other cities the estimated positive signs were significant at the 1% level. The change in employment variable generated twenty-eight correct signs almost all being significant at the 1% level. Only in Wilkes-Barre was the sign negative and, hence, incorrect. In the fifth equation the change in hours worked per worker per week was included to pick up the overtime effects in wage-rate change. In all cases the sign was positive and correct. Change in employment was expected to account for the rest of the change in a positive manner, but the sign of the estimate was incorrect in every case.

Overall the four models were successful particularly in equations 1, 2 and 4. Equation 3 was less successful and 5 was the least successful. Nevertheless there were strong indications of the expected behaviour of labour force and wage rates in both those equations. One problem that occurred was that the success of an equation in a particular model did not ensure its success in any other model, although the equation in question was to have its structure unchanged. This was due to the simultaneity of the equations whence the estimates of one equation affected all of the other simultaneous equations in their estimated parameters. In the light of this problem it was decided that such a final model would have certain properties. These properties were that the model should be common to all centres and that, as far as was possible, all expectations (of parameter signs) were fulfilled. It was thus to form a minimal underlying labour market behavioural structure for all of the centres. Other additions to the final model, not dealt with here, were to be on the basis of an individual examination of the centres. The advantages of this system were that it probed the underlying mechanisms at work in all centres and that it allowed comparison of centres. Comparison of centres in relation to estimated parameter values and spatial structure, for example, would be made more difficult by a unique specification for each centre. The disadvantage of the approach was to omit possible relevant variables to the specification.

Table 5.8 The Form of the Final Model

The final model has the form

1. $E_{it}/E_{it-1} = k(Q_{it}^{a_{11}} e^{a_{12}t}/E_{it-1})^{a_{13}}$

2. $h_{it}/h_{it-1} = k(Q_{it}^{a_{21}} e^{a_{22}t}/h_{it-1})^{a_{23}} E_{it-1}^{a_{24}}$

3 $L_{it}/L_{it-1} = k\ (w_{it}/w_{it-1})^{a_{34}+a_{32}D_S}$

4 $q_{it}/q_{it-1} = k\ (E_{it}/E_{it})^{a_{41}+a_{42}D_S}$

5 $w_{it}/w_{it-1} = k\ (h_{it}/h_{it-1})^{a_{51}} (E_{it}/E_{it-1})^{a_{52}}$

The parameter estimates in Appendix A.5 are laid out in the form of Table 5.9 and with the expected signs shown to Table 5.10.

Table 5.9 Parameter Estimate Layout for the Final Model

1	lnk	a_{11}/a_{13}	a_{12}/a_{13}	a_{13}	
2	lnk	a_{21}/a_{23}	a_{22}/a_{23}	a_{23}	a_{24}
3	lnk	a_{31}	a_{32}		
4	lnk	a_{41}	a_{42}		
5	lnk	a_{51}	a_{52}		

Table 5.10 The Expected Signs of the Parameters of the Final Model

1	±	+	-	+	
2	±	+	-	+	±
3	±	+	-		
4	±	+	+		
5	±	+	+		

The results on the estimated signs of the parameters are summarised by indicating the few incorrect parameter estimates and the centres associated with those estimates.

a_{21}	=	Three incorrect (negative):	Reading, Scranton, York
a_{22}	=	Nine incorrect (positive):	Rochester, Canton Cincinnati, Toledo, Youngstown, Altoona, Reading, Scranton, York.
a_{32}	=	Three incorrect (positive):	New York, Rochester, Toledo
a_{42}	=	Two incorrect (negative):	Scranton, York
a_{52}	=	Six incorrect (negative):	Syracuse, Akron, Cincinnati, Allentown, Altoona, Pittsburgh.

The model can be regarded in this light as substantially correct. The implication is that the aggregate, neoclassical model used, incorporating a division of employment into two factors of production, is a useful one in this area of study. The partial adjustment mechanism is seen also to be empirically accurate despite its simplistic formulation. The negative cross-effect values of the impact of lagged employment on the change in hours worked per worker per week are more plausible than if positive. The negative sign indicates that higher employment deters employers from increasing hours worked per worker, given levels of production and the level of technology.

Given the success of the final model and the interpretations already placed upon the models, equations, the variables and their associated parameters, the properties of each of the twenty nine labour markets as complete entities were examined. This implied the calculation and examination of their stability and equilibrium properties. The properties of the centres with respect to stability were remarkably alike. Consequently, and given the forcing of the same model upon each centre, the equilibrium properties were also alike.

The models were estimated in the structural form

$$A_{1i}X_{it} = A_{2i}X_{it-1} + A_{3i}Z_{it} + r_{it}$$

Dropping the error terms as irrelevant to the argument and premultiplying both sides by A_{1i}^{-1} yields

$$X_{it} = A_{1i}^{-1} A_{2i} X_{it-1} + A_{1i}^{-1} A_{3i} Z_{it}$$

The stability of the system being determined by the matrix $A_{1i}^{-1} A_{2i}$, it was calculated and the eigen values of that matrix computed.

The structural model, written in full, in terms of the rearranged parameters of the final tested model was

$$\begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & a_{35} \\ a_{41} & 0 & 0 & 1 & 0 \\ a_{51} & a_{52} & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} E \\ h \\ L \\ q \\ w \end{bmatrix}_{it} = \begin{bmatrix} 1+a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & 1+a_{22} & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & a_{35} \\ a_{41} & 0 & 0 & 0 & 0 \\ a_{51} & a_{52} & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} E \\ h \\ L \\ q \\ w \end{bmatrix}_{it-1}$$

$$+ \begin{bmatrix} b_{11} & b_{12} & b_{13} & 0 \\ b_{21} & b_{22} & b_{23} & 0 \\ b_{31} & 0 & 0 & 0 \\ b_{41} & 0 & 0 & b_{44} \\ b_{51} & 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} 1 \\ Q \\ t \\ D_S \end{bmatrix}_{it}$$

(All variables are natural logs apart from 1, t and D_s)

The inverse of that Matrix, A_{1i}^{-1}, was calculated as,

$$A_{1i}^{-1} = \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ a_{21} & 1+a_{22} & 0 & 0 & 0 \\ a_{35}a_{51} & a_{35}a_{52} & 1 & 0 & -a_{35} \\ -a_{41} & 0 & 0 & 1 & 0 \\ -a_{51} & -a_{52} & 0 & 0 & 1 \end{bmatrix}$$

Consequently,

$$A_{1i}^{-1}A_{2i} = \begin{bmatrix} 1+a_{11} & 0 & 0 & 0 & 0 \\ a_{21} & 1+a_{22} & 0 & 0 & 0 \\ \begin{matrix} a_{35}a_{51}(1+a_{11}) \\ + \\ a_{35}\,{}_{52}a_{22} \\ - \\ a_{35}a_{51} \end{matrix} & \begin{matrix} a_{35}a_{52}(1+a_{22}) \\ - \\ a_{35}a_{52} \end{matrix} & 0 & 0 & a_{35} \\ \begin{matrix} a_{41} \\ -a_{41}(1+a_{11}) \end{matrix} & 0 & 0 & 0 & 0 \\ \begin{matrix} a_{51} \\ -a_{52}a_{22} \\ -a_{51}(1+a_{11}) \end{matrix} & \begin{matrix} a_{52} \\ -a_{52}(1+a_{22}) \end{matrix} & 0 & 0 & 0 \end{bmatrix}$$

and

$$A_{1i}^{-1}A_{3i} = \begin{bmatrix} b_{11} & b_{12} & b_{13} & 0 \\ b_{21} & b_{22} & b_{23} & 0 \\ \begin{matrix} a_{35}a_{51}b_{11} \\ + \\ a_{31}a_{52}b_{21} \\ + \\ b_{31}-a_{35}b_{51} \end{matrix} & \begin{matrix} a_{35}a_{51}b_{13} \\ + \\ a_{35}a_{52}b_{22} \end{matrix} & \begin{matrix} a_{35}a_{51}b_{13} \\ + \\ a_{35}a_{52}b_{23} \end{matrix} & 0 \\ \begin{matrix} b_{41} \\ -a_{41}b_{11} \end{matrix} & -a_{41}b_{12} & -a_{41}b_{13} & b_{44} \\ \begin{matrix} b_{51} \\ -a_{51}b_{11} \\ -a_{52}b_{21} \end{matrix} & \begin{matrix} -a_{51}b_{12} \\ -a_{52}b_{22} \end{matrix} & \begin{matrix} -a_{51}b_{13} \\ -a_{52}b_{23} \end{matrix} & 0 \end{bmatrix}$$

This system, linear in natural logarithms, yielded the eigenvalues presented for each city in Appendix A.5. The results, which apply to all centres were summarised as follows:

(i) no eigenvalues had modulo greater than or equal to unity,

(ii) no eigenvalues had any complex parts (i.e., all eigenvalues were real).

(iii) all centres (with two exceptions) had one positive eigenvalue and one negative eigenvalue: the two exceptions had two positive eigenvalues rather than one,

(iv) all centres had only two non-zero eigenvalues.

From these results the various inferences about the behaviour of the labour markets could be made. The most important of these inferences was that the labour markets were stable sub-systems of the overall urban space economy. Their behaviour was not seen then as conducive to producing growth or decline in their urban economies. However this conclusion is one that could be modified in the light of the specification of a model that, in particular, includes the production and distribution sub-systems. In the case of the two centres (Toledo and Youngstown) with two positive eigenvalues the sub-system will approach equilibrium values smoothly and without oscillation. In the case of the vast majority of centres they will approach their respective equilibrium values, being stable, but will do so with oscillations. These oscillations will be to point alternatively above and then below the ultimate equilibrium values of the variables concerned on a bimonthly basis. The negative values, however, were very small compared to the positive eigenvalues and these oscillatory effects will not be strong. The dominant (positive) eigenvalues are themselves small compared to unity, only one (Pittsburgh, 0.6856) being above 0.5. These small values imply a very rapid path to the equilibrium values, again reducing the temporal impact of any oscillatory behaviour in the labour market sub-systems. The speed of these adjustments suggests that much of the behaviour of urban labour markets is in response to changes in exogenous or other sub-system variables, rather than the urban labour market's own dynamics.

Concluding Comments

The immediate conclusion is that the data do allow an empirically verifiable specification of a dynamic urban labour market model; at least in the Northeastern United States. The synthetic production series could probably be constructed for urban centres in other regions but, such a synthetic series could not be of value in isolation. The synthetic series gained its importance only in the context of an accompanying set of urban labour markets with which it was mutually supportive.

Using the data it was possible to show, based upon the results presented, that urban labour markets can be described adequately by an aggregate, dynamic, neoclassical model. It was further shown that the urban labour markets thus modelled are extremely passive in their short-run dynamic behaviour. They are passive in the sense that no centre investigated appeared capable of generating its own growth or cycles purely from within the labour market. This latter conclusion also includes implicitly the role of migration in the system, for this was necessarily part of overall labour force size change. To fully analyse such changes, however, would require the formal respecification and enlargement of the model. The data at this point fail completely unless it were possible to incorporate data with different temporal aggregations within the same model. It is only through this type of model that any possibility exists for including an explicit recognition of inter-urban labour market interactions.

Apart from the success of the model itself the most striking result was the homogeneity of the parameter estimates across the twenty-nine centres. Particularly in the final case the models seemed to fit all centres equally well: though parameter estimates were often different in absolute magnitude, they were only infrequently different in terms of their signs. Allied with this aspect was the fact that most of the estimates' signs conformed to expectations. Such results are extremely encouraging for future work.

CHAPTER SIX

THE LABOUR MARKET PARAMETERS IN THEIR URBAN AND SPATIAL CONTEXT

The models were estimated as the short-run labour market sub-systems of much larger systems. These larger systems were the complete distributional and production systems at both the urban and inter-urban levels of the national economic system. Consequently, each estimated sub-system was expected to reflect not only an adherence to a postulated theory of aggregate labour market behaviour but also to the urban and spatial milieu of each centre. Adherence to the postulated theory of market behaviour was a prior condition for such analysis and this condition was fulfilled. The use of twenty-nine centres of very different economic types implied some difficulty in this analysis for factors other than spatial structure and urban size could be expected to influence the model estimates. Twenty-nine cities, therefore, was considered as an insufficient number of conduct statistical tests on spatial structure. The location map (Map 4.1) suggested further difficulties of analysis in the very uneven spatial distribution of the twenty-nine cities. As a consequence the simplest method of analysis was chosen. This was a visual analysis of maps and graphs relating estimated parameter values to urban size and location. Statistical analysis was to be used only if it was deemed profitable after such visual analyses were conducted. Each parameter's spatial pattern and its relationship to labour market size is briefly considered. Conclusions are then drawn from the complete set of patterns and relationships generated by those parameter estimates considered amenable to such treatment. For reasons which are given these conclusions could only be tentatively drawn.

The mapping and examinations of parameter estimates has been conducted with some success in the past (King et. al., 1969). In those analyses, however, the parameters mapped involved a relationship between the centre and some external driving force. The general form of one such model was

$$U_{it} = f(U_{Nt \pm v})$$

which implied that some proposition of the variance of the local unemployment rate could be explained by the national unemployment rate. The proportion of variance explained by the national unemployment was maximised by choosing an appropriate time lag (±v) for each centre.

This simple model yielded pronounced regional groupings of centres in the present study area (King et. al., 1969, see Table 2). A crucial difference between this and the present approach was that the variables used in the complete specification of the urban labour market sub-system were internal to the city. This implied less likelihood of the external relationships of the centre being reflected in parameter estimates. Conversely, the complete specification of the sub-system for each model represented less reliance being made on the "black-box" approach which has characterised previous works (King et. al., 1969,1972;Jeffrey, 1972). Thus the parameter estimates here, whether mapped or not, have direct and simple theoretical interpretations. The use of national and local unemployment rates as indices of the overall urban economic system yields no such interpretation.

The final model had the following estimated form, dropping the subscript i,

$$E_t/E_t = k_1(Q_t^{a_{11}} e^{a_{12}t}/E_{t-1})^{a_{13}}$$

$$h_t/h_{t-1} = k_2(Q_t^{a_{21}} e^{a_{22}t}/h_{t-1})^{a_{23}} E_{t-1}^{a_{24}}$$

$$L_t/L_{t-1} = k_3(w_t/w_{t-1})^{a_{31}+a_{32}D_S}$$

$$q_t/q_{t-1} = k_4(E_t/E_{t-1})^{a_{41}+a_{42}D_S}$$

$$w_t/w_{t-1} = k_5(h_t/h_{t-1})^{a_{51}}(E_t/E_{t-1})^{a_{52}}$$

along with the estimated eigenvalues (two per centre). The parameter estimates graphed, mapped and examined are:-

Figure 6.1 and Map 6.1	Largest Eigenvalue
Figure 6.2 and Map 6.2	Smallest Eigenvalue
Figure 6.3 and Map 6.3	a_{13}
Figure 6.4 and Map 6.4	a_{24}
Figure 6.5 and Map 6.5	a_{32}
Figure 6.6 and Map 6.6	a_{41}
Figure 6.7 and Map 6.7	a_{42}

The graph is of the parameter estimate against labour force size of the relevant city (Labour Force Size measured July 1971).

The following parameter estimates were not analysed for the stated reasons:

- k_1, k_2, k_3, k_4, k_5 - the constant terms. They act as scale factors having no particular economic interpretation.

- a_{11},a_{21} These parameters are on production, the synthetic time series. The synthetic nature of the series implied, by definition, an arbitrariness in the parameter estimates.

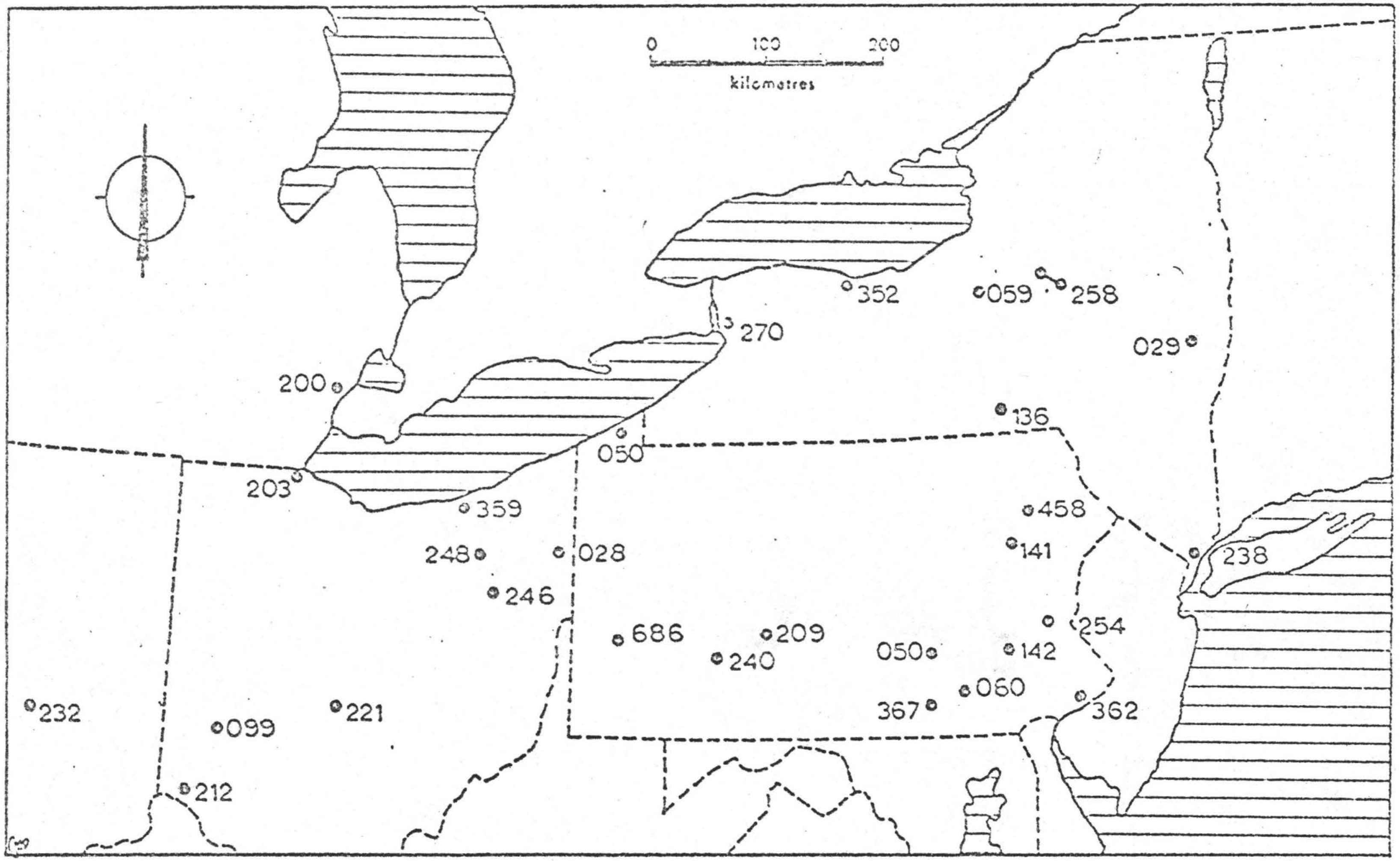
- a_{12},a_{22} The time variable is a surrogate for, amongst other variables, technological progress in the period 1964-1973. As such these parameter estimates would be much influenced by the synthetic production series.

- a_{23} The parameters a_{23} and a_{24}, when summed, are always close to the value 1.0. Consequently mapping one implies that mapping the other is redundant.

- a_{31},a_{52} These parameter estimates have built in size-scale factors which hide behavioural relationships for they relate an urban size variant series (such as the labour force) to a time series largely invariant with respect to urban size (such as changes in the wage rate).

- a_{51} The influence of overtime is a strong determinant of this parameter estimate. Its interpretation, therefore, is determined bv the average overtime worked in a citv rather than size or spatial structure.

The largest eigenvalue is vitally important, representing the stability of the labour market sub-system and of primary concern in this study. In neither the map (Map 6.1) nor the graph (Figure 6.1) were any patterns apparant. The most notable feature was the size of the Pittsburgh eigenvalue in relation to all others. There at least two possible explanations for the large relative size of the Pittsburgh eigenvalue. The first is the high degree of cyclical sensitivity to general national economic conditions of production in the basic iron and steel industry in Pittsburgh (Zarnowitz, 1973, p. 655). However, as production was an exogenous variable in the models, and the eigenvalues are determined solely by the parameters relating the current values of the endogenous variables to the lagged values of the endogenous variables, this should not be the case. Mis-specification of the model, however, could have led to parameter estimates being biased by this sensitivity. Consequently this is purely a specification problem implying the eigenvalue given is incorrectly estimated. On the other hand, the conditions prevailing in the Pittsburgh labour market may be different in some way from those in other labour markets. For example, it could be argued that union practices in the iron and steel industry (or any other industry) in Pittsburgh add an extra degree of urban labour market instability in that city. If this were the case then the eigenvalue estimate was a true reflection of a different pattern of labour market behaviour in that city. It is possible to argue that if the above argument was correct, Detroit, for example, would exhibit similar eigenvalues to Pittsburgh given similarities in their production



Map 6.1 Spatial Distribution of Largest Eigenvalues

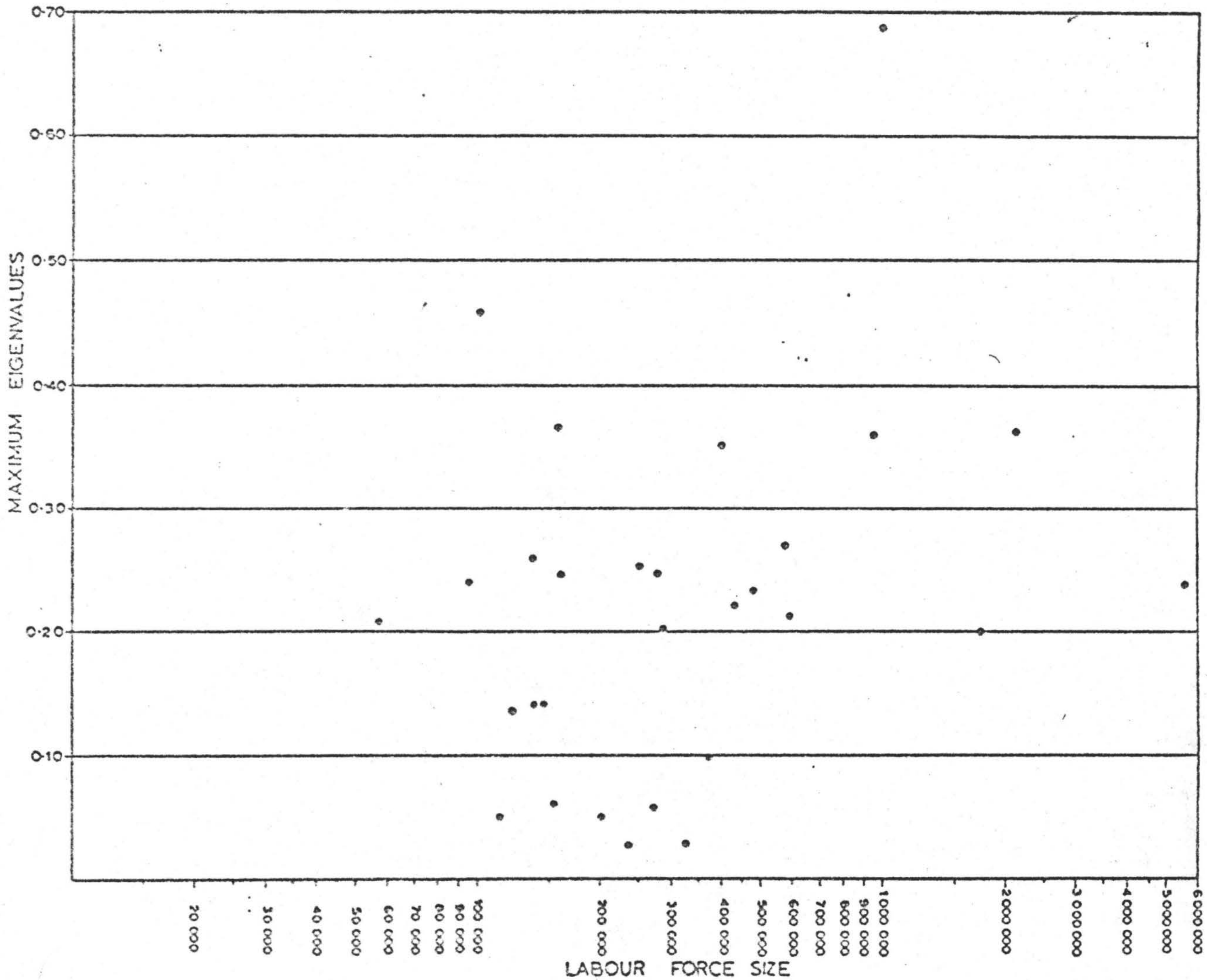
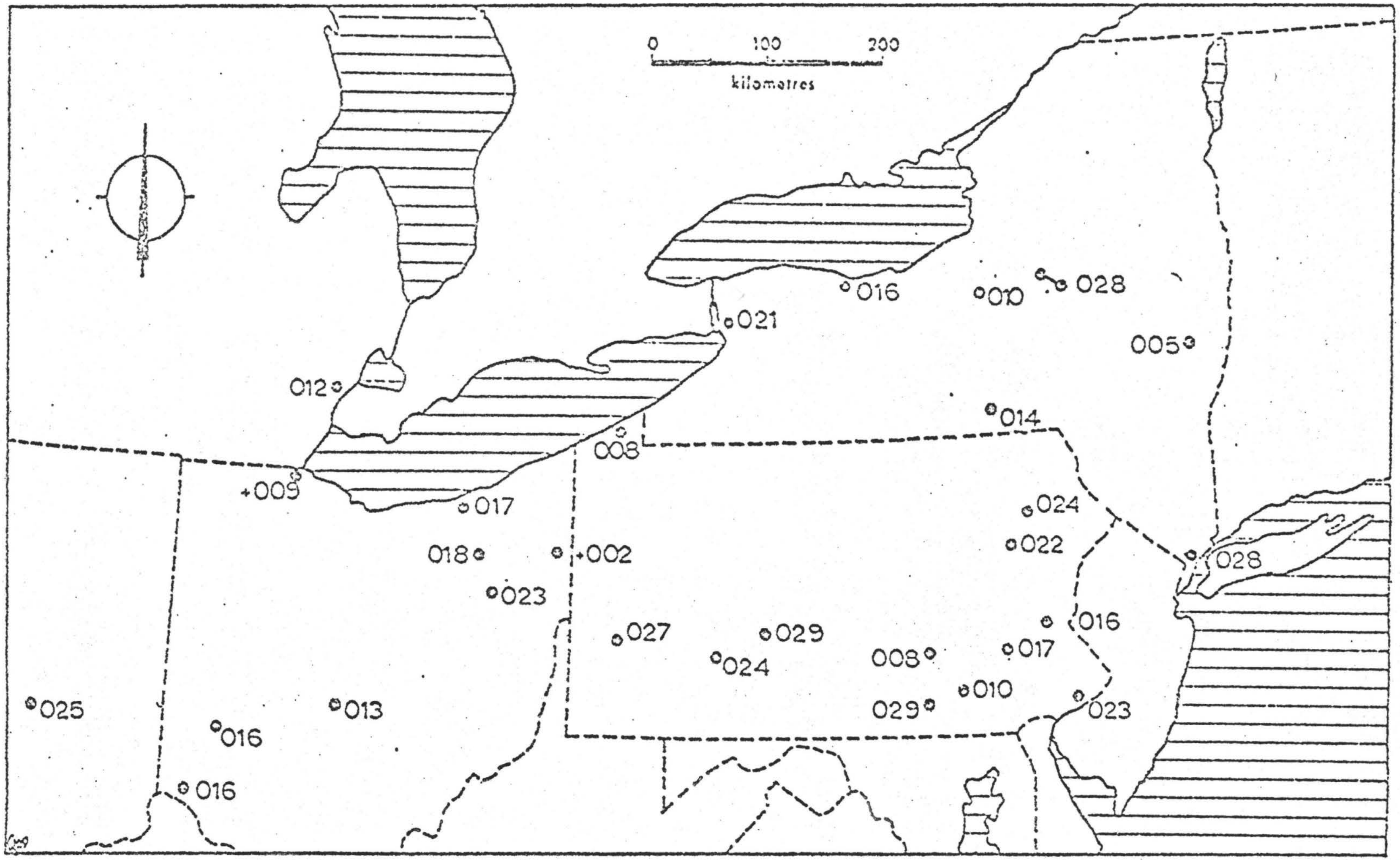


Figure 6.1 Largest Eigenvalues and Labour Market Size Relationship

sensitivities and degrees of unionisation. This type of question will probably only be solvable by making exhaustive studies of the dynamics of one city with a very detailed labour market model. The smallest eigenvalues had one outstanding feature: they are all negative with the exception of those of Toledo and Youngstown. No explanation was found for these exceptions. No spatial pattern was discernible in Map 6.2. Little pattern is visible on the labour force size graph though the values are more clustered than for the largest eigenvalue.

The parameter estimates of a_{13}, the employment adjustment coefficient, showed no discernible pattern when mapped (Map. 6.3). Graphed against labour force size, however, there is a distinct curvilinear relationship (Figure 6.3). At first the parameter estimates rise with labour force size, peak at a labour force size of approximately 300,000 and then decline to the value shown for New York. If, however, the New York observation is omitted the curve can be seen as rising continuously but at constantly diminishing rate. This omission could only be on the grounds that New York is either quantitatively or qualititively different from the other cities. This parameter represents the speed of adjustment of employment to changing production levels. Consequently, it should be seen in relation to the adjustment speed of hours worked per worker. To accomplish this the estimate of a_{24} was examined (Map 6.4 and Figure 6.4). Again no spatial pattern was discernible on the map. Nonetheless the possibility of a pattern exists on the graph of parameter values against labour force size.



Map 6.2 Spatial Distribution of Smallest Eigenvalues (negative signs omitted)

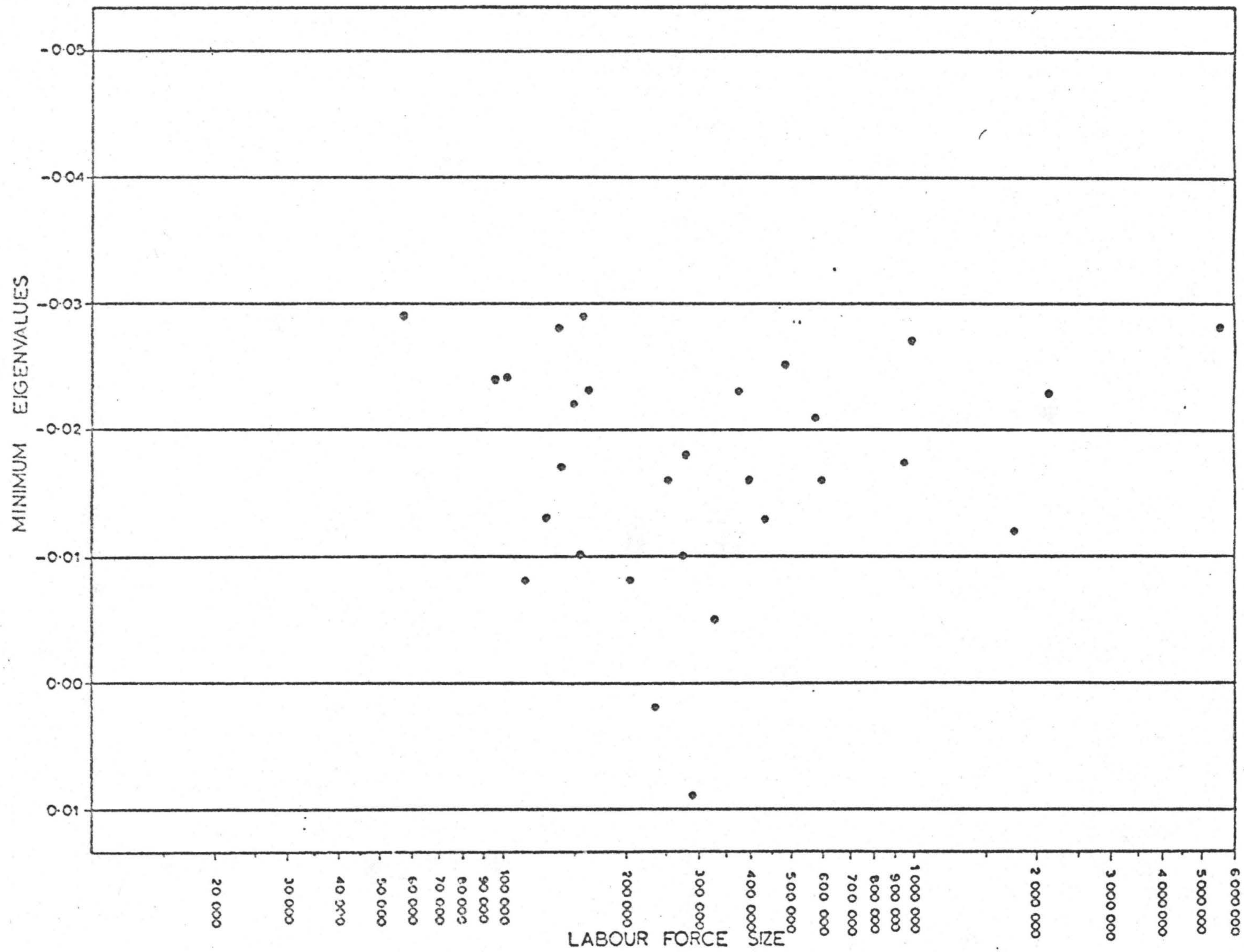
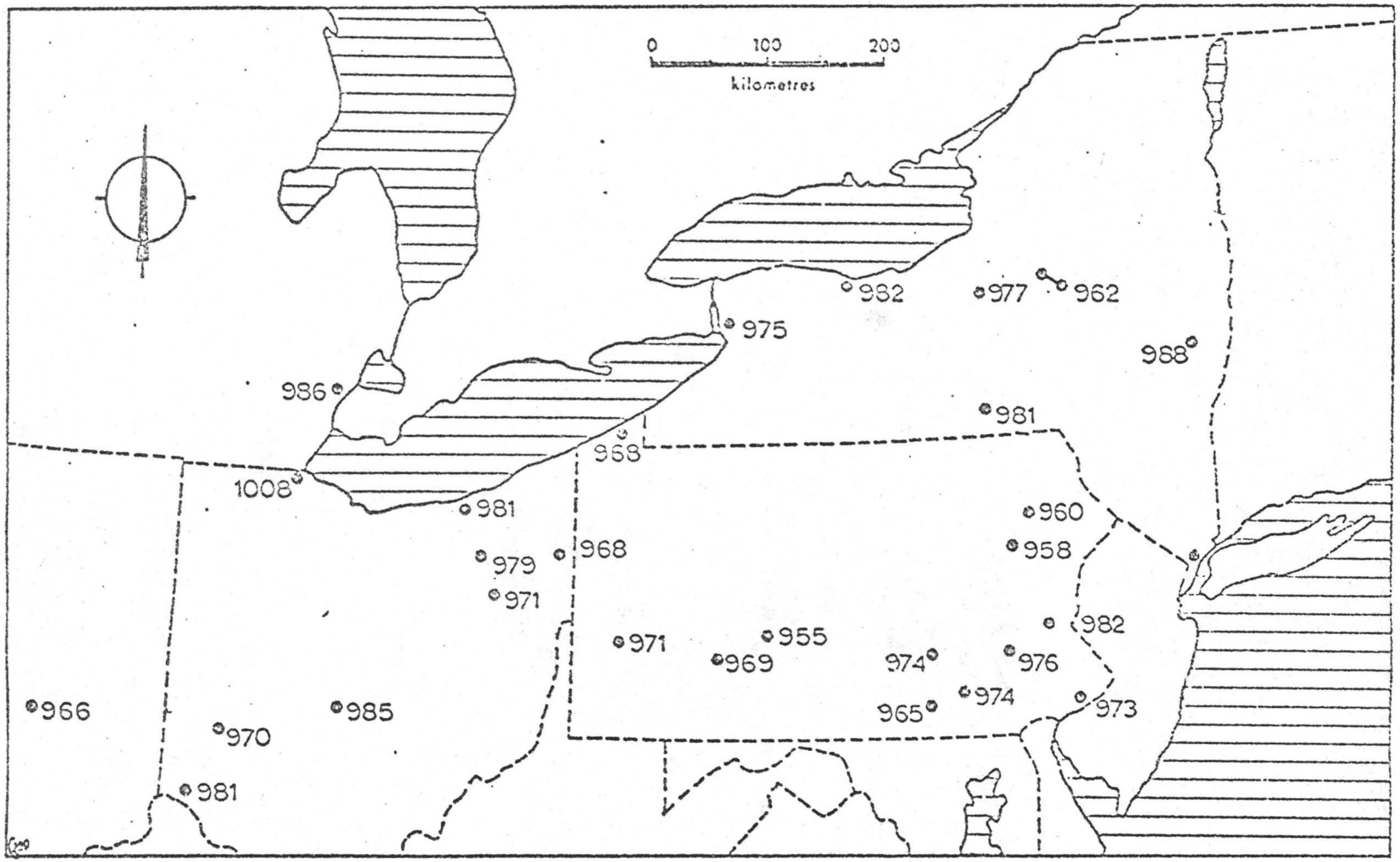


Figure 6.2 Smallest Eigenvalues and Labour Market Size Relationships



Map 6.3 Spatial Distribution of Parameter a_{13}

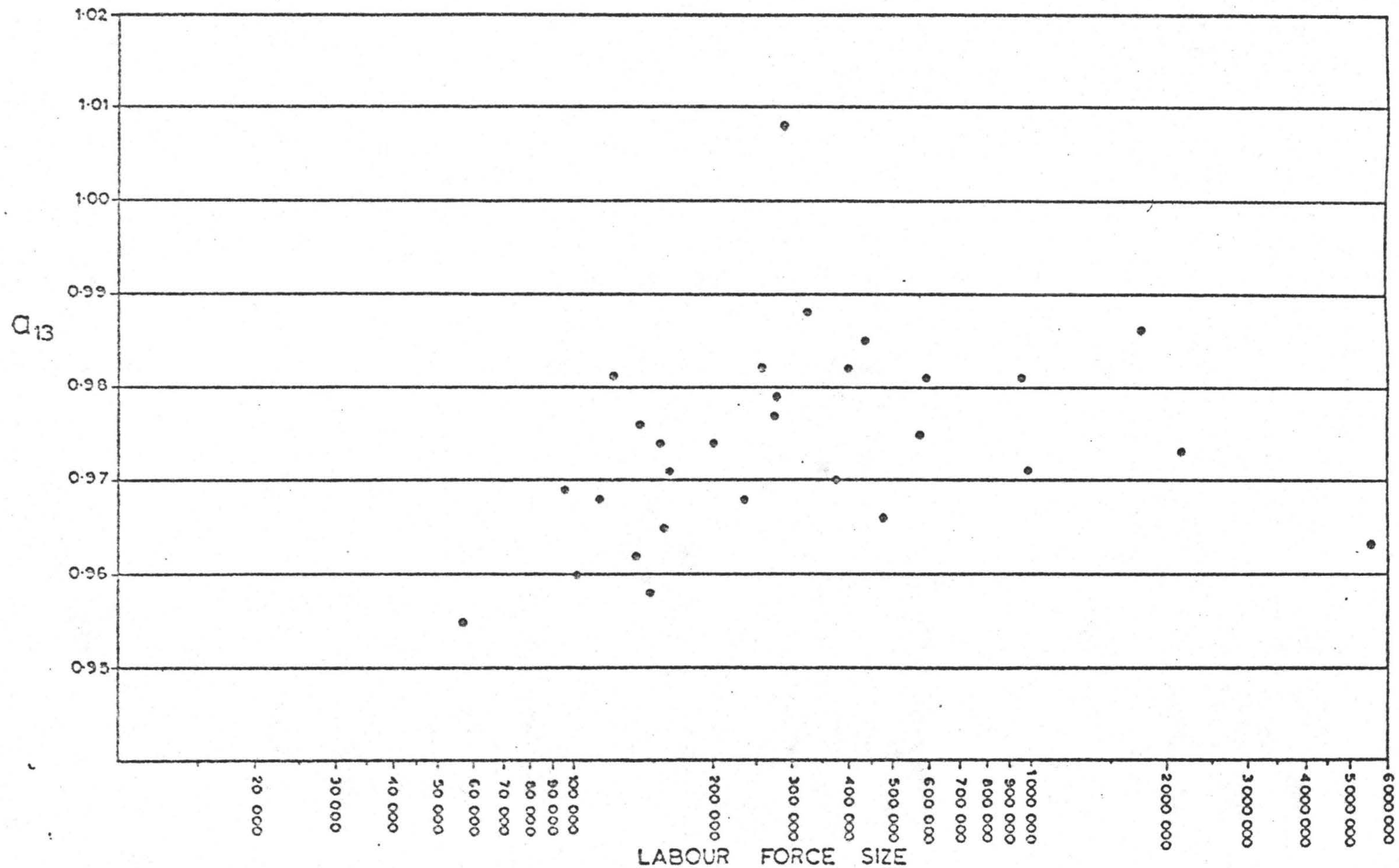


Figure 6.3 Parameter a_{13} and Labour Market Size Relationship

A group of centres appeared distinct from the others in having particularly low parameter values. However,,this group of cities appeared to have no common factor. In order of labour force size this group was:-

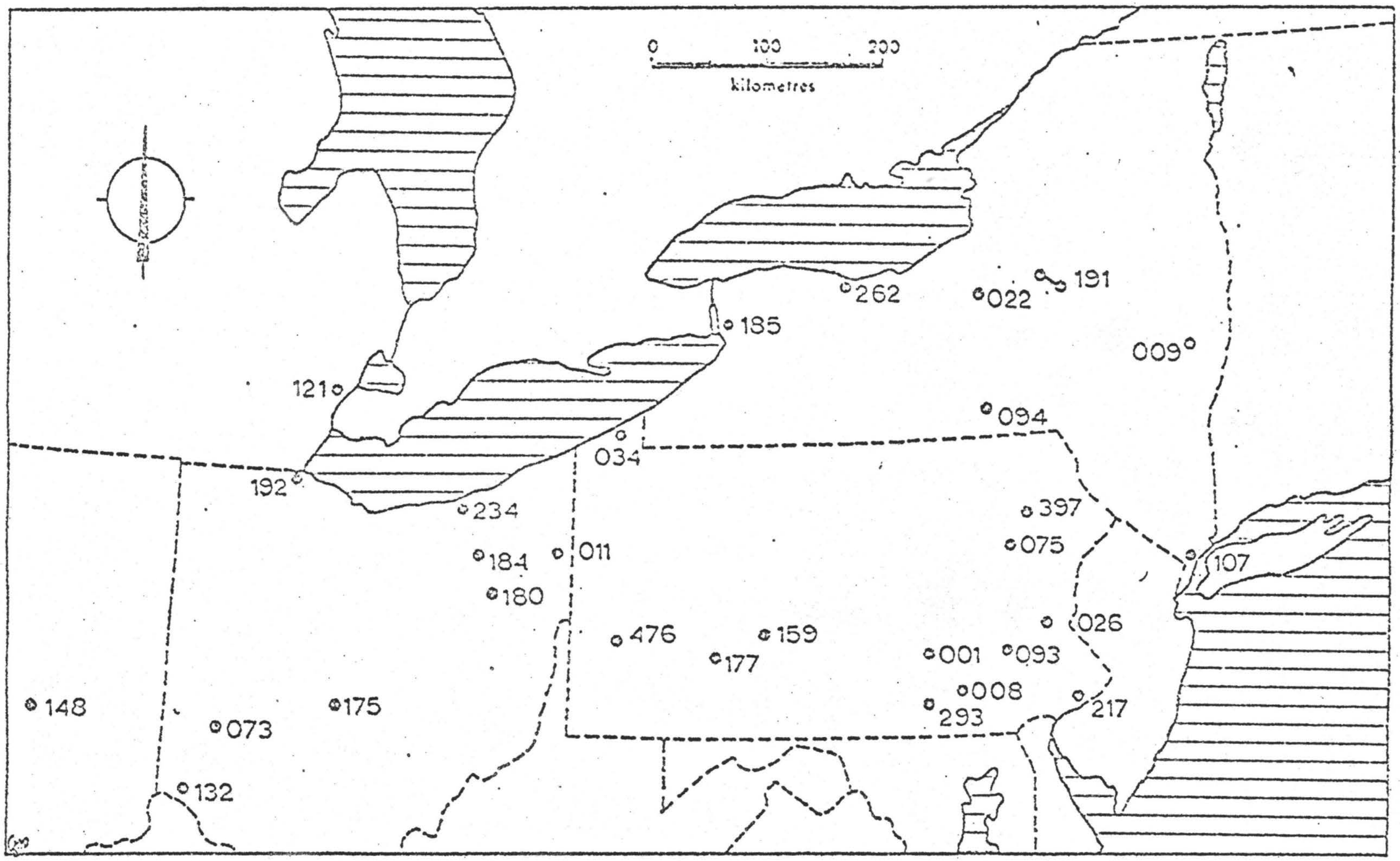
Dayton
Albany
Syracuse
Allentown
Youngstown
Harrisburg
Binghamton
Erie.

Perhaps a common factor was that none of these cities had labour forces greater than three hundred and fifty thousand people.

The parameter estimates, a_{32}, reflect the relationship between changes in labour force to the dummy variable for September. All of these estimates are negative with the exception of those for, descending order of labour force size,

New York
Rochester
Toledo
Syracuse.

A relationship did appear to exist between these centres. The map (Map 6.5) showed no relationship between the parameter estimates but the graph (Figure 6.5), however, showed a relationship of some kind. The values for New York and Altoona (largest and smallest labour forces) are ignored as outliers. The estimates rise in value



Map 6.4 Spatial Distribution of Parameter a_{24} (negative signs omitted)

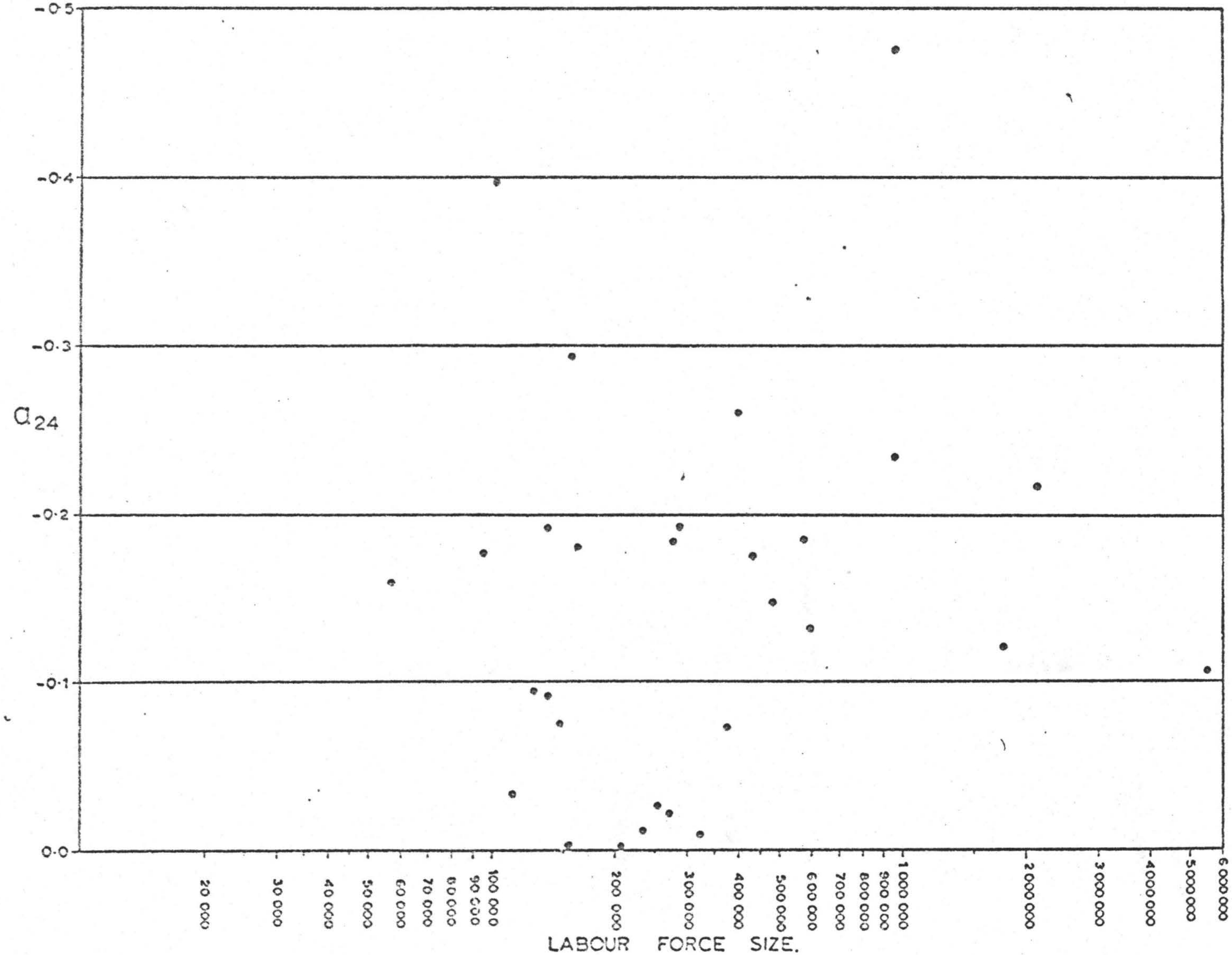


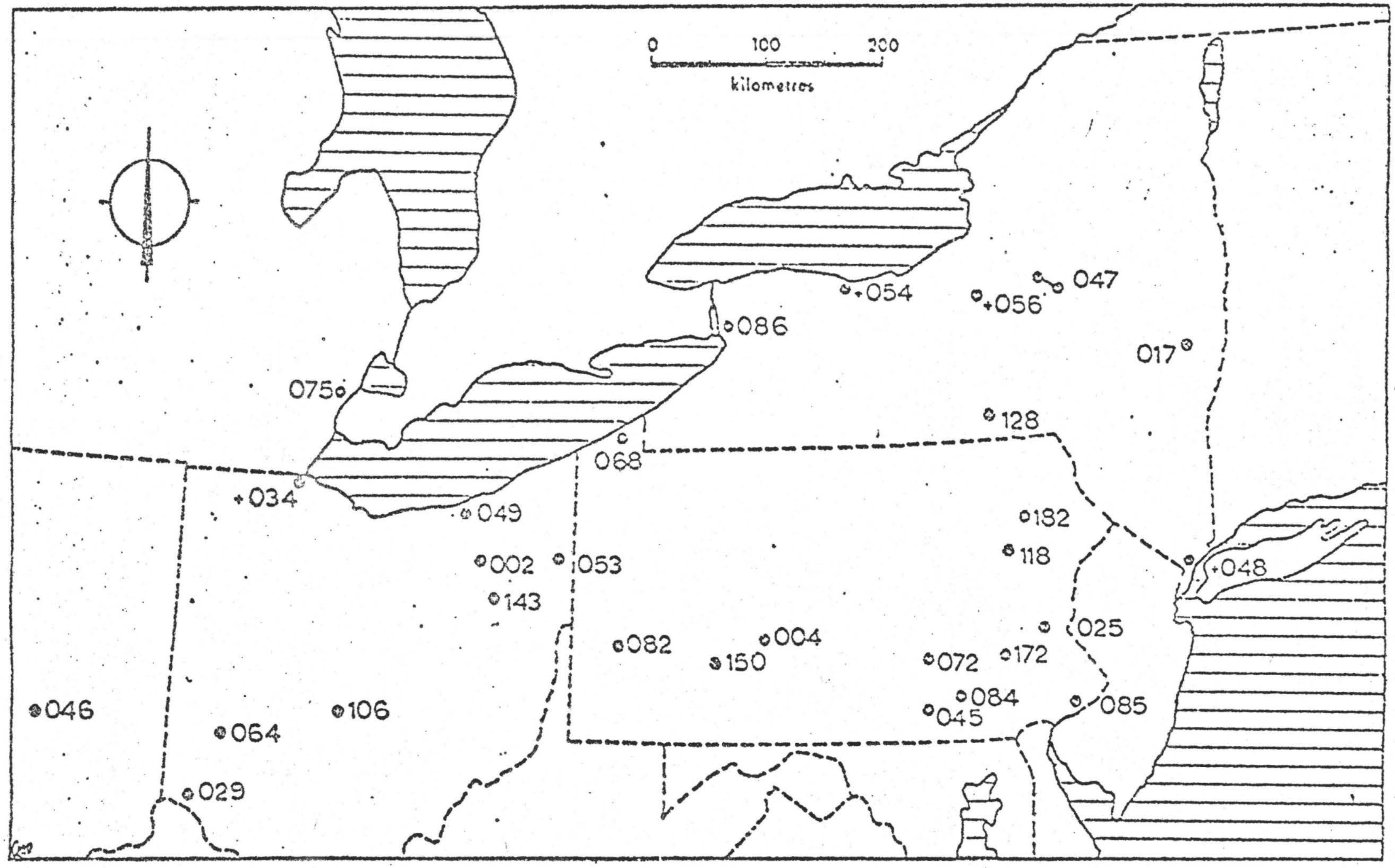
Figure 6.4 Parameter a_{24} and Labour Market Size Relationship

with labour force size to approximately 250,000 after which they decline. If all positive estimates are ignored this relationship is clearer. A major problem with interpretation is that this pattern can also be viewed in a different way. It could be suggested that two groups of cities exist. For those below a labour force size of 300,000 the parameter value rises sharply with size. Above 300,000, however, the size appeared to have little or no effect on the parameter value.

The parameter estimate, a_{41}, links change in the quit rate to the change in employment. The map (Map 6.6) does show a region, entirely within Pennsylvania, where the quit rate change variable appears relatively insensitive to the changes in local employment. This set of centres was, in order of labour force size,

Pittsburgh
Harrisburg
Wilkes-Barre
Johnstown
Altoona

This was interpreted as due to industrial structure and relatively low opportunities for other employment. Nevertheless, there are cities (e.g. Youngstown) with similar industrial structure that do not conform to the pattern. Detroit, having an industry dominated by giant firms, also had a relatively low value for this parameter. Conversely, Scranton, very close to Wilkes-Barre, is remarkably insensitive in its quit rate to employment changes. This suggested that inter-urban spatial structure is not a determinant of this



Map 6.5 Spatial Distribution of Parameter a_{32} (negative signs omitted)

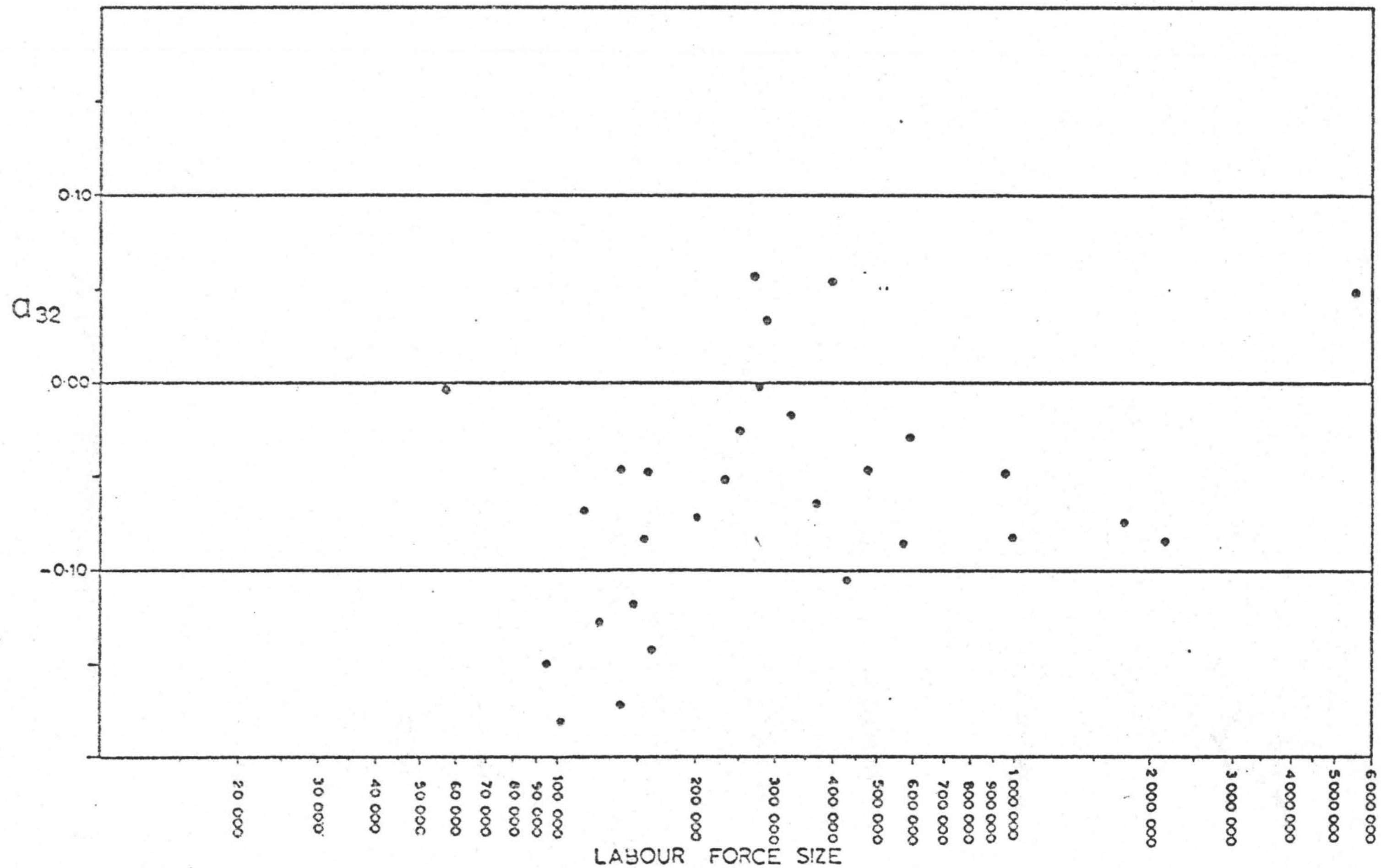


Figure 6.5 Parameter a_{32} and Labour Market Size Relationship

relationship, as Scranton and Wilkes-Barre would otherwise have had similar parameter values. A group of towns, also all in Pennsylvania, namely

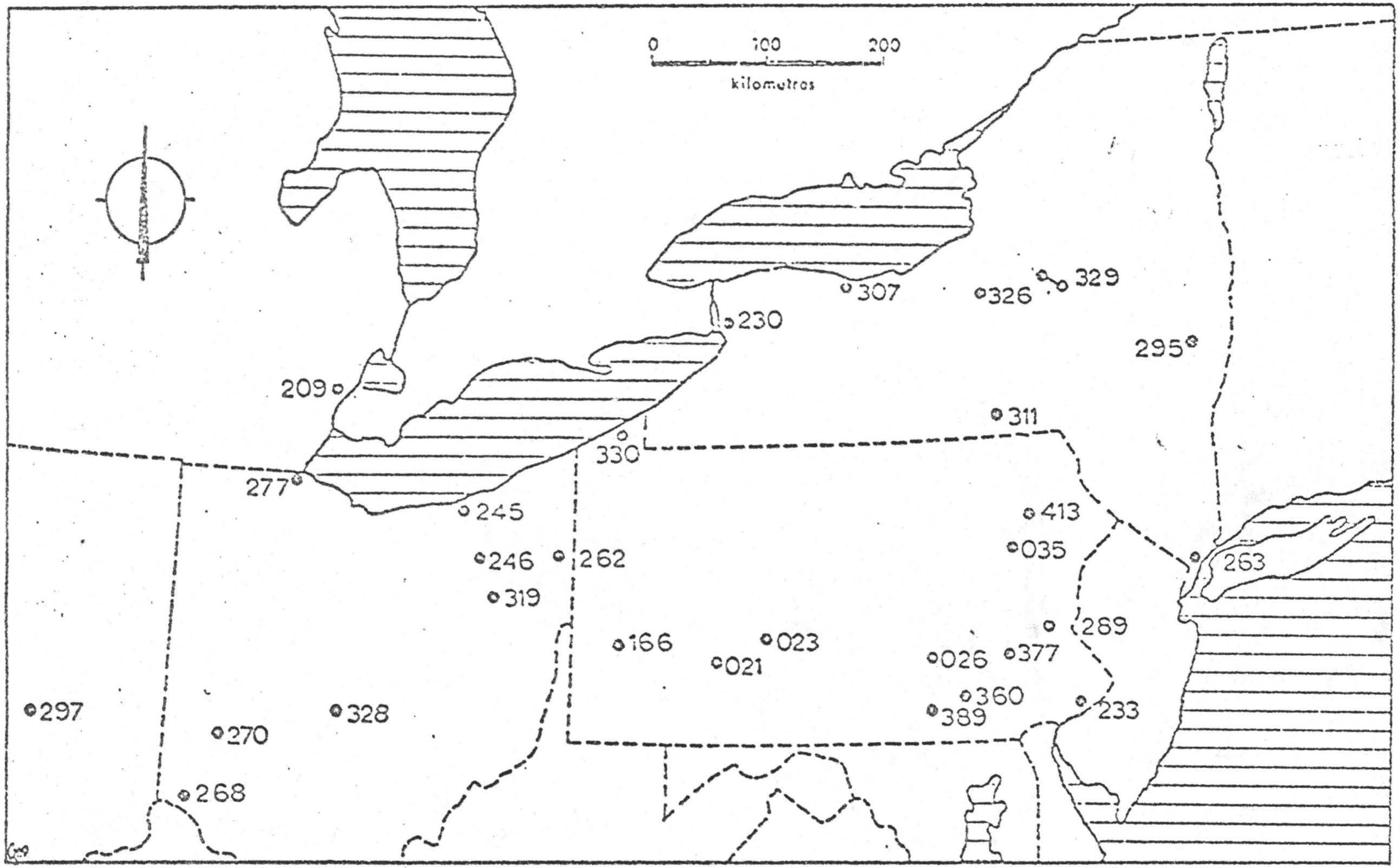
Lancaster

Reading

York

have very similar parameter estimates to each other. These cities are all textile towns and this would seem to be the reason for the similarity of parameter values, rather than spatial structure. Other towns not far distant, such as Allentown, have very different parameter estimates as well as very different industrial structures. Philadelphia, though close to these, did not appear to influence this aspect of labour market behaviour having another very different parameter estimate value.

The associated graph (Figure 6.6) shows a quite distinct relationship between labour force size and the parameter. Again, New York stood out as having atypical behaviour. Four of the five Pennsylvanian centres (Pittsburgh was the exception) in the original group of Pittsburgh, Harrisburg, Wilkes-Barre, Johnstown and Altoona, registered very low estimates compared to the overall trend. At least one explanation can be given for the trend. This explanation is that larger cities give rise to much greater opportunities for alternative employment, with respect to their greater size all other factors being held constant. Certainly the relative location of the centre seemed to play a very small role compared to size and industrial structure.



Map 6.6 Spatial Distribution of Parameter a_{41}

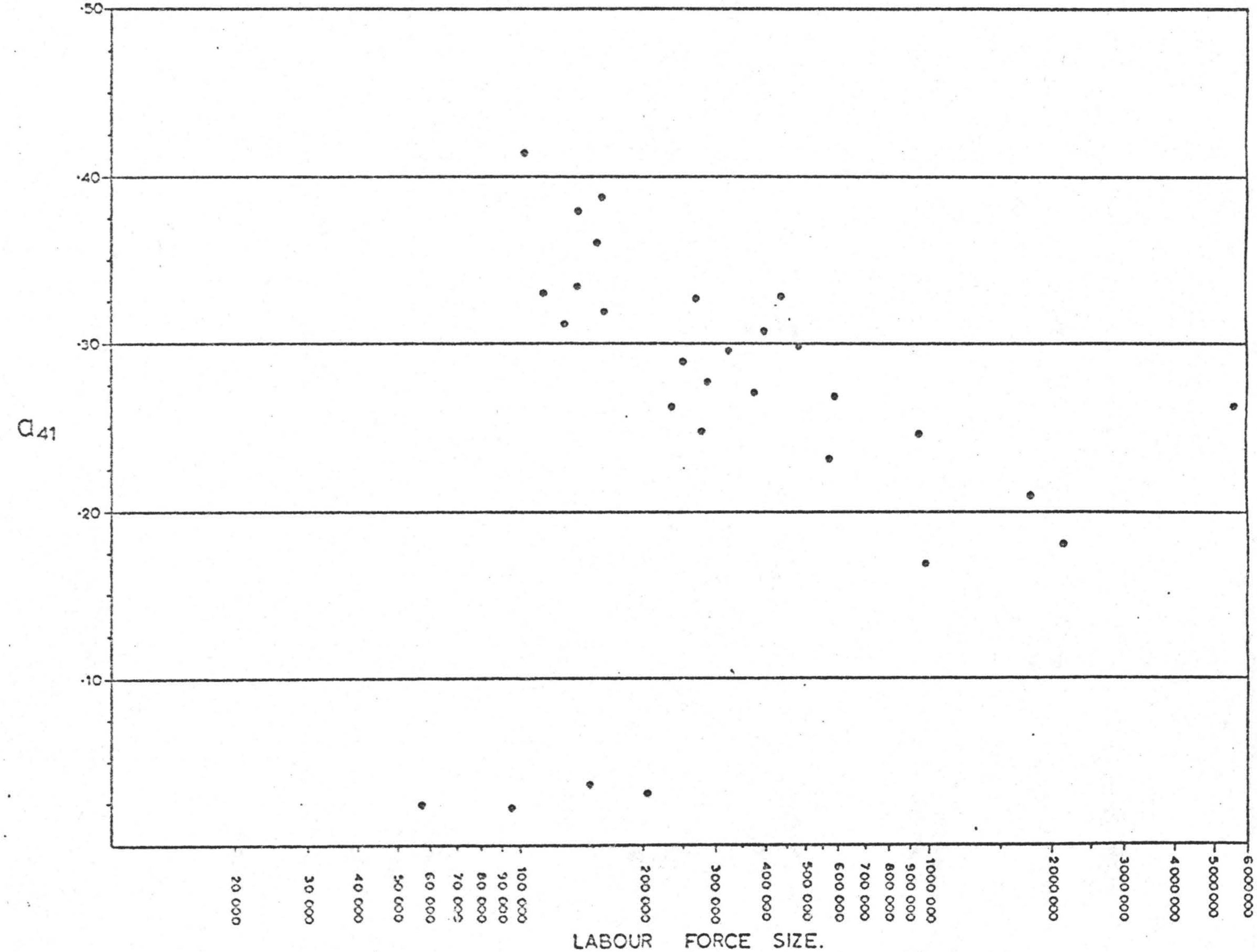


Figure 6.6 Parameter a_{41} and Labour Market Size Relationship

The effect of the beginning of the academic year in September is reflected in parameter estimate a_{42}. The return to college increases the quit rate in a one period burst. The map (Map. 6.7) shows little spatially systematic variation in the estimated value although groupings of particularly low values were found. The lowest values, from lowest to highest, were found in

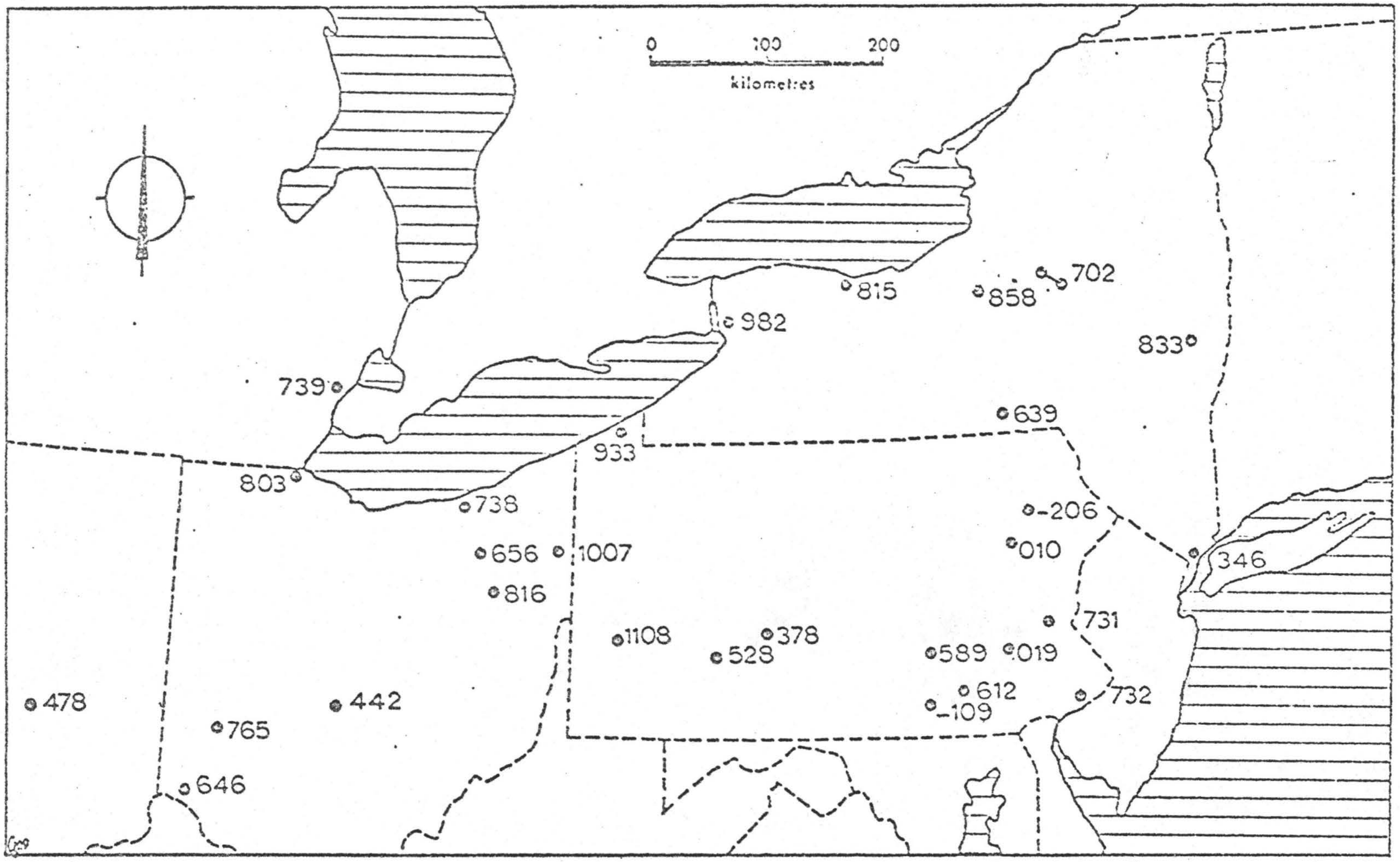
York

Scranton

Wilkes-Barre

Reading

all in Eastern Pennsylvania. Of all the cities York had the lowest value for this parameter, it being one of the only two cities with a negative value. The parameter thus had the opposite of the expected sign for its estimate, although that estimate was not statistically significant (Appendix A.5). No explanation could be found for the negative value except that summer student labour is probably insignificant, with September quit rates dominated by other factors in this city. The other negative value, also not statistically significant, was for Scranton and the same rationale was applied to explain the value in that city. Conversely, by far the highest values were for Youngstown and Pittsburgh. In those two centres the steel industry probably has easy use of unskilled labour. The reverse is probably true of the four lowest centres which include textiles in their declining industrial structures. These generate little need for extra student labour. New York, in relative decline in this period, supported this contention, having the fifth lowest parameter estimate. Industrial factors,



Map 6.7 Spatial Distribution of Parameter a_{42}

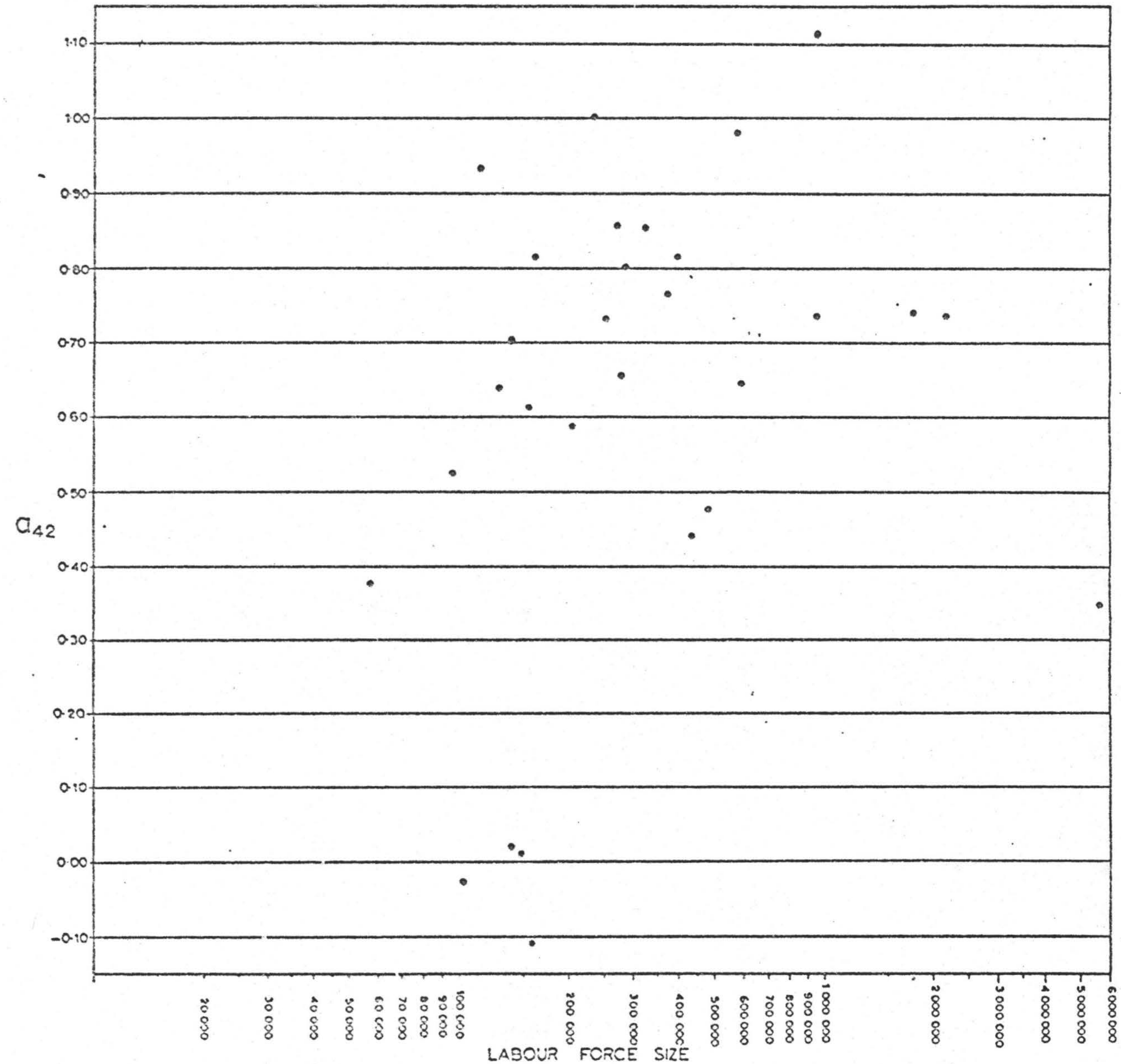


Figure 6.7 Parameter a_{42} and Labour Market Size Relationship

therefore, seem to be indicated rather than spatial factors. Graphed against size of labour force (Figure 6.7) no patterns emerged except for the group of the four lowest estimates, including the two York and Scranton, that were (marginally) negative. New York and Altoona, with the largest and smallest labour forces respectively, appear again as individual cities rather than being associated with any group of cities.

The parameter estimates overall showed little that could be construed as systematic spatial variation, although patterns appeared to exist for some parameters. Similarly they showed little relationship to the urban hierarchy as reflected by the parameter estimates for locally dominant cities. However, the estimates also appeared, in part, to be determined by industrial structure and labour force size. In the case of some Pennsylvanian cities, therefore, it was impossible to disentangle industrial structure and spatial pattern. On the other hand, the "black-box" representations have given results which reflect a regional and spatial structure. The black-box approach, nevertheless, also appears to have industrial structure determined results, difficult to disentangle from spatial pattern (King et. al. ; 1969). The question arises as to why the spatial patterns appeared much more clearly in one analysis than the other. The answer may be that the index used in black-box approaches (usually unemployment) is a surrogate for the behaviour of the several economic sub-systems operating at any mode or centre including the production sub-system. The short-run operations of the urban labour sub-market on the other hand, appear to be drawn entirely from the internal structure of the centres rather than from the inter-urban system. Consequently, it seems likely that the inter-urban transmission of economic impulses is not directly through the labour markets. In a neo-classical world the most likely inter-urban economic interaction is through the production sub-systems via the demand for capital inputs from one centre to another. This would certainly explain the relationship between industrial structure and the spatial structure of economic impulse transmission. Changes in unemployment rates are then an indirect reflection of the product sub-system impulses. Thus the unemployment rate in a given centre can be seen as a result of the inter-urban system links of the production sub-system, whilst the labour market sub-system for the same centre is extremely stable. This allows the paradox of a city that has perhaps a violently fluctuating and cyclically sensitive level of unemployment, having a labour market that, if not a stabilising force, is certainly not the cause of the fluctuations and sensitivity. These results, therefore, reflect internal urban mechanisms which are not necessarily influenced in any important way by inter-urban structure, but are very much influenced, perhaps, by intra-urban structure. Intra-urban structure in this case could mean such diverse factors as the efficiency of the city administration, its racial mix and the efficiency of its transit system.

Unfortunately production sub-system time-series data are not available which would be suitable for short-run analyses combining both production and labour market sub-systems. As a consequence it seems likely that much of the work in this field will remain interpretive, rather than consisting of the testing of rigorously derived hypotheses.

CHAPTER SEVEN

CONCLUSION

The primary aim of this work has been to explore the possibilities of modelling the dynamics of urban labour markets, within an urban system, in such a way that the models produced are amenable to empirical testing. To this end the models were constructed in the light of the most suitable and complete data available, partial though they may be. The urban labour market data set for the North Eastern United States best fulfilled these criteria of suitability and completeness. The most glaring gap in the data proved to be the absence of any urban centre manufacturing production time series. This gap meant that no studies had been made of short-run urban labour market dynamics with a fully specified model. To accomplish the study's primary aim, therefore, a synthetic manufacturing production time series was constructed at the same levels of temporal and spatial aggregation as the other data, for consistency and compatibility within the model. The synthetic production time-series thus created were successful in overcoming the data deficiency in at least two major respects: first, they allowed the construction and testing of the models as complete entities and, second, the series had the expected positive relationships between production and employment and hours. Failure in the second respect would certainly have cast grave doubt upon the success of the model building exercise as a whole, as production is taken as the driving force of the urban labour markets. This success was measured in terms of the consistency of the results with respect to hypothesised relationships for all the centres used rather than with the statistical significance of individual parameter estimates. This consistency criterion, given that sufficient centres were used to allow for its adoption, provided the basis for the interpretation of the mass of results. If only one centre had been used as a test-bed for the models the results would have had to be based entirely upon statistical significance of the results for that one centre. In some cases the interpretation of the results would have been altered by the use of this method with respect to a single centre, as

(i) some centres behaved in a different manner to the mass of centres for certain relationships,

(ii) some relationships were not of the hypothesised signs, and

(iii) certain relationships, notably the supply function of labour with respect to the wage rate, did not have an unambiguously hypothesised relationship.

The lack of statistical significance in individual centres, given the overall consistency of results, can be explained in different ways. The first is that it is due entirely to data problems such as those associated with accuracy and timing of collection and definition of the data. Given the source of the data this seemed unlikely to be true, with the possible exception of the synthetic production series. It could be that the use of the actual series would have improved significance levels for the structural estimation of the whole market system, via an improved estimation of the reduced form of the system.

The other major possibility was that relevant variables were omitted from the specification, thereby reducing the level of statistical significance. There can be no real means of checking these assertions until complete data sets are available, particularly the data for urban manufacturing production. Indeed, even if such data were to commence publication immediately it would be some years before usefully long time-series existed. Consequently the combined use of already available data sets and synthetic time-series seems to be the only means of empirical work at present.

The specification of the models was at the level of aggregation of the urban centres, being treated initially as models within an inter-urban network. This specification was a largely forced one given the nature of the data. The increasingly detailed specification of the short-run labour market dynamics of the models, particularly for structural, parametric estimation purposes, implied that the complete inter-urban network could not be handled empirically. This was because of the high number of interactions and equations required and the very high correlations of variables in closely linked cities. Geographers generally, have chosen to concentrate upon the inter-urban network interactions, eschewing parametric estimation and using correlation and spectral analytic techniques to discover the strength and timing of simply defined economic impulses between centres (Weissbrod, 1974). They, therefore, have made a virtue of these high inter-urban correlations (Cliff et al., 1975). The fact that it is the internal dynamics of the urban centres which enable the reception, transformation and transmission of those impulses is sufficient to warrant their study. Nevertheless, for the short-run it has been shown that the urban centres can be regarded as isolated from the inter-urban network by virtue of the high degree of empirical success achieved by the models. Similarly, it is implicit in these models that the short-run dynamics of the (manufacturing) labour market can be regarded in isolation from the other economic subsystems within an urban centre. Consequently the implications of the results for urban economic dynamics as a whole must not be taken too far. Thus, the stability results achieved here do not imply that cities, particularly the largest cities, are neither capable of initiating and sustaining autonomous economic growth and business cycles nor of transmitting growth and cycles to other cities. Rather they show that the labour-market short-run dynamics are inherently stable. In the model here production was treated as exogenous but, in a model where it was treated in some way as endogenous, the stability results for the city's economy could be quite different. Indeed some cities might be found to be generators of instability while others would not appear so. Here it was found that all of the urban labour markets under consideration, without exception, enjoyed short-run stability and are unlikely to be the cause of growth, decline or even self-sustaining oscillations. Consequently, the model tested is seen as a vital link in the process of specifying larger, more complete and empirically verifiable, dynamic urban models whether the spatial context be inter-urban or intra-urban.

Alternatively, a more limited view of the success of the model can be taken. Cast in an aggregate neo-classical mould the model is successful in those terms. The signs of the estimated parameters concur overwhelmingly with the expected signs of parameters to be derived from such a model and its variants. This is a strong indication that the neo-classical framework has an empirical relevance for work in urban labour market analysis, whether or not the context is an explicitly or implicitly spatial one.

Even more limited than this view if the observation that the tests demonstrate the superiority of the two-factor model over the one-factor model. It is stressed that this is for the specific levels of aggregation chosen in the study. No inferences can be made with certainty concerning other levels of aggregation or dis-aggregation, whether they be spatial, temporal or otherwise. The choice between the two models, given that both are empirically successful, must be determined largely by the fact that the one-factor model gives a more restrictive view of the urban labour market. It is more restrictive in that it attempts to explain fewer labour market variables than the two-factor model. The virtue of the two-factor model is, therefore, its generality. If the model is to be developed further, in whatever direction, it is this generality that makes the two-factor model the more appealing of the two. The virtue of the one-factor model lies in its parsimony, which indicates that in cases of very few variables being available in a data set the one-factor model can be utilised more easily.

Given the above properties of the final model, its spatial dimension can be examined only in an indirect manner. This was achieved by an examination of the spatial distribution of the parameter estimates and their relationship to the urban hierarchy and size. The choice of centres, their uneven spatial distribution and their small (in this spatial context) number mitigated against any truly general results. Nevertheless, it was possible to identify, though very tentatively, groupings of the cities. The results demonstrate that fully specified urban models, rather than those that deal with single variables such as wage-rate changes, can be used to some small degree at least in a spatial context whether this be implicit or explicit. However, it is not necessarily the case that strong spatial linkages will be demonstrated. A major result is that despite distinct differences in these spatial and structural correlates, the urban labour markets behaved in remarkably similar fashions. It remains to be seen if this result is specific to this set of cities. More important is the reassurance that these centres appear to behave according to the same economic principles.

APPENDIX A.1

Data Sources and Programs Used

The bimonthly, rather than monthly publication of data in Area Trends in Employment and Unemployment dictated the use of all data at bimonthly intervals. The observations on each variable (60 observations per variable were for January, March, May, July, September and November, 1964 to 1973 inclusive.

THE SYNTHETIC URBAN PRODUCTION TIME SERIES

The data for bimonthly national levels of manufacturing output in each industry were taken from

Manufacturers' Shipments, Inventories and Orders,

U.S. Govt. Printing Office, Washington, D.C.,

and

Current Industrial Reports

U.S. Govt. Printing Office, Washington, D.C.

The levels of manufacturing output in each centre were determined by their level of output in each industry for 1967 from

1967 Census of Manufactures, Volume III. Area Statistics

U.S. Bureau of Census, Washington D.C.

Nine groupings of industries were used to given comparable groupings for the two data sets. These were

Grouping	Standard Industrial Classification Number	Standard Industrial Classification Name
A	20	Food
	21	Tobacco
B	22	Textile Mill Products
	23	Apparel
C	24	Lumber and Wood Products
	25	Furniture and Fixtures
	26	Paper and Allied Products
D	28	Chemicals and Allied Products
	29	Petroleum and Coal Products
	30	Rubber and Miscellaneous Plastics
E	32	Stone, Clay and Glass
F	33	Primary Metals
	34	Fabricated Metals
G	35	Machinery (excl. Electrical)
	36	Electric and Electronic Machinery
H	37	Transportation Equipment
I	27	Printing and Publishing
	31	Leather
	38	Instruments
	39	Miscellaneous Manufacturing

The industrial classification is from

Standard Industrial Classification Manual, 1967

U.S. Bureau of the Budget, Washington, D.C.

The national industrial employment levels are from

Employment and Earnings, 1964-1974, Volumes 11-21,

U.S. Department of Labor, Washington, D.C.

URBAN LABOUR FORCE SIZE

Area Trends in Employment and Unemployment, 1964-1974,

U.S. Department of Labor, Washington, D.C.

The spatial collection areas are labour areas which in most cases, have the same definition as the Standard Metropolitan Statistical Areas used for all other urban data in this study. In cases where they do differ the difference is small.

URBAN EMPLOYMENT, WAGE RATES, QUIT RATES, HOURS WORKED PER WEEK; MANUFACTURING PRODUCTION WORKERS

Employment and Earnings, 1964-1973, Volumes 11-21,

U.S. Department of Labor, Washington, D.C.

UNUSED DATA

Other urban data not used in the model but collected on a comparable basis for manufacturing production workers and published in Employment and Earnings were for

Accessions, Layoffs, New Hires and Separations

THE PROGRAMS USED

Three Two-Stage Least-Squares Programs were used as checks upon each other. With identical data and identical model specifications they all yielded identical results.

The program used for final analyses was from the Statistical Package for Social Sciences.

No Author Cited, No Title, Mimeo, Origin: Australian National University; Department of Economics Library, University of Sydney, Australia. No Date.

No Author Cited, Reference Manual for TSTSLS Mimeo; McMaster University, No. Date. Based upon

A. Stroud, A.Zellner, L.C. Chau, Program for Computing Two - and Three-Stage Least Squares Estimates and Associated Statistics,

Social Systems Research Institute, University of Wisconsin, Systems Formulation and Methodology Workshop Paper 6308, December 11, 1963 (Revised by H. Thornber and A. Zellner, July 4, 1965).

Nie, N.H., Hadlai Hull, C., Jenkins, J.G., Steinbrenner, K.and Bent, D.H. SPSS Manual 2nd Edition, 1975. (Program G3SLS, SPSS Version 7.0).

The Eigen values were computed from the program BASMAT contained in Melsa and Jones (1973).

Melsa, J.L. and Jones, S.K. Computer Programs for Computational Assistance in the Study of Linear Control Theory, 2nd Edition, McGraw-Hill, 1973.

APPENDIX A. 2

O.L.S. Estimates of the Production/Factor Demand Relationship Equations

(** denotes significant at =0.01: One-Tailed)

(* denotes significant at =0.05: One Tailed)

(The tests were two-tailed for a_4)

City	Equation	lnk	a_1/a_3	a_2/a_3	$-a_3$	a_4	$\bar{R}^2$
Detroit							
	i	5.150	0.635	-0.017*	-0.986**		0.536
	ii	8.684	1.250	-0.020*	-1.786*		0.515
	iii	6.187	-0.202	-0.001*	-0.997**		0.997
	iv	6.078	-0.016*	-0.000*	-0.935**		0.997
	v	2.387	1.158	-0.017**	-3.049	2.916	0.510
	vi	6.021	0.010	-0.001**	-0.826**	-0.122	0.997
	vii	9.980	0.912	-0.029*	-0.977		0.928
	viii	14.89	2.099	-0.037**	-1.217**		0.929
Indianapolis							
	i	4.434	0.685	-0.140	-0.966**		0.495
	ii	6.946	0.577	-0.013	-1.275*		0.493
	iii	5.991	0.005	0.000	-1.000**		0.999
	iv	6.012	-0.391**	0.334	-0.974**		0.999
	v	5.498	0.400	-0.013	-0.698	-0.367	0.486
	vi	5.725	0.077**	-0.000	-0.827**	-0.148**	0.999
	vii	9.582	0.940	-0.025*	-0.922**		0.915
	viii	13.041	1.061	-0.025	-1.084**		0.914

Albany						
i	5.271	0.368	-0.013**	-0.988**		0.516
ii	6.508	0.487	-0.014**	-1.245**		0.517
iii	5.861	0.038**	-0.000**	-0.988**		0.999
iv	5.991	0.050	-0.000*	-0.999**		0.999
v	3.864	0.763	-0.017**	-3.888**	3.133	0.528
vi	5.856	0.039**	-0.000**	-0.988**	-0.009	0.999
vii	10.358	0.676	-0.024*	-0.997**		0.908
viii	12.634	1.133	-0.027*	-1.098		0.908
Binghamton						
i	3.955	0.673	-0.014**	-0.981		0.512
ii	6.002	0.460	-0.014*	-1.197**		0.508
iii	5.811	0.046*	-0.000**	-0.997**		0.999
iv	5.983	0.014	-0.000	-0.997		0.998
v	3.694	0.755	-0.015*	-1.179	0.198	0.503
vi	5.717	0.086	-0.000**	-0.897**	-0.944*	0.999
vii	9.145	0.927	-0.026*	-0.990**		0.903
viii	11.950	0.391	-0.024	-1.017**		0.903
Buffalo						
i	4.719	0.585	-0.017**	-0.975**		0.515
ii	7.444	0.618	-0.018**	-1.358**		0.514
iii	5.718	0.056**	-0.000**	-0.996**		0.999
iv	5.981	0.0281	-0.000**	-1.016		0.999
v	5.609	0.395	-0.014	0.034	-1.253	0.507
vi	5.553	0.093**	-0.001**	-0.766**	-0.185	0.999
vii	9.344	0.898	-0.029	-0.994		0.919
viii	13.534	1.484	-0.348*	-1.150**		0.919

New York						
i	3.008	0.744	-0.024**	-0.961**		0.518
ii	9.140	-1.281	-0.086	0.225		0.520
iii	6.166	-0.183	-0.000	-0.995**		0.999
iv	6.014	-0.027	-0.000	-0.957**		0.999
v	13.418	-0.499	-0.000	2.251	-4.980*	0.537
vi	5.811	0.024	-0.000**	-0.822**	-0.107**	0.999
vii	9.297	0.953	-0.035**	-0.990**		0.932
viii	15.148	-1.373	-0.017	-0.788*		0.932
Rochester						
i	4.629	0.500	-0.014**	-0.977**		0.514
ii	6.472	0.502	-0.015**	-1.252**		0.513
iii	5.878	0.031**	-0.000**	-0.998**		0.999
iv	5.996	0.017	-0.000**	-1.008**		0.999
v	3.094	0.912	-0.019*	-2.708	1.862	0.508
vi	5.858	0.037**	-0.000**	-0.974**	-0.022	0.999
vii	9.669	0.780	-0.020**	-0.994**		0.908
viii	12.547	0.995	-0.028*	-1.087**		0.908
Syracuse						
i	3.213	0.729	-0.015**	-0,962**		0.501
ii	5.791	0.127	-0.012	-1.004		0.498
iii	5.965	0.017	-0.000**	-0.998**		0.999
iv	6.026	-0.031	-0.000	-0.974**		0.999
v	7.075	-0.319	-0.007	1.499	-2.418*	0.523
vi	5.663	0.101**	-0.001**	-0.808**	-0.191**	0.999
vii	8.380	0.987	-0.026*	-0.990**		0.902
viii	11.883	0.560	-0.026	-1.041**		0.901

Utica - Rome						
i	4.519	0.595	-0.013*	-0.979**		0.502
ii	6.756	0.855	-0.012	-1.164*		0.499
iii	5.709	0.079**	-0.000**	-0.997**		0.999
iv	6.009	0.019	-0.000	-1.006**		0.998
v	6.790	0.002	-0.013*	1.336	-2.589	0.500
vi	5.528	0.127**	-0.000**	-0.791**	-0.184**	0.999
vii	9.336	0.922	-0.024*	-0.994**		0.912
viii	12.836	0.865	-0.024	-1.072**		0.912
Akron						
i	4.974	0.492	-0.012*	-0.971**		0.500
ii	6.288	0.517	-0.012*	-1.187**		0.500
iii	6.177	-0.071**	0.000**	-0.994**		0.998
iv	5.987	-0.071**	0.000**	-0.963**		0.998
v	6.655	-0.125	-0.010	1.151	-2.231	0.49
vi	6.035	-0.017	0.000**	-0.816**	-0.180**	0.998
vii	10.561	0.718	-0.022	-0.996**		0.907
viii	12.475	1.185	-0.024*	-1.081**		0.907
Canton						
i	3.962	0.644	-0.013	-0.981**		0.500
ii	7.292	0.535	-0.013	-1.352		0.498
iii	5.820	0.009	0.000	-0.984**		0.999
iv	5.871	-0.018	0.000	-0.967**		0.999
v	4.799	0.488	-0.013	-0.456	-0.639	0.492
vi	5.614	0.04 9**	0.000	-0.827**	-0.132**	0.999
vii	8.623	0.886	-0.024	-0.992**		0.916
viii	13.210	0.957	-0.024	-1.105**		0.916

Cincinnati						
i	4.411	0.663	-0.017*	-0.981**		0.510
ii	7.977	0.712	-0.018*	-1.458**		0.509
iii	5.782	0.028	-0.001**	-0.978**		0.999
iv	5.910	-0.013	-0.001	-0.973		0.999
v	-4.468	2.306	-0.022	-5.465	5.940	0.518
vi	5.316	0.110**	-0.001**	-0.677**	-0.233**	0.999
vii	9.044	0.897	-0.029*	-0.991**		0.922
viii	13.855	0.510	-0.028	-1.046**		0.921
Cleveland						
i	4.348	0.557	-0.011	-0.985**		0.498
ii	6.670	0.431	-0.013	-1.248		0.496
iii	5.859	0.040**	-0.000**	-0.999**		0.999
iv	6.030	0.012	-0.000	-1.006**		0.999
v	7.574	-0.207	-0.015	1.834	-3.084	0.495
vi	5.658	0.088**	-0.000	-0.807**	-0.175**	0.999
vii	9.222	0.856	-0.022	-0.996**		0.911
viii	12.811	1.197	-0.012	-1.122**		0.911
Columbus						
i	4.412	0.708	-0.147*	-0.970**		0.499
ii	6.933	0.457	-0.140	-1.188*		0.496
iii	5.830	0.022	-0.000	-0.986**		0.999
iv	5.911	0.016	-0.000	-0.995**		0.999
v	9.992	-0.554	-0.010	2.001	-3.465	0.501
vi	5.779	0.036	-0.000	-0.941	-0.033**	0.999
vii	9.460	0.967	-0.026*	-0.991**		0.914
viii	12.906	0.900	-0.026	-1.065**		0.914

Dayton						
i	4.337	0.605	-0.011	-0.992**		0.499
ii	6.605	0.427	-0.010	-1.226*		0.497
iii	6.240	-0.085	0.000	-0.995**		0.933
iv	5.918	-0.050	0.000	-0.946**		0.993
v	4.468	0.570	-0.011	-0.913	-0.861	0.490
vi	6.296	-0.100	0.000	-1.030**	0.033	0.993
vii	9.708	0.766	-0.021	-0.995**		0.909
viii	12.580	0.691	-0.020	-1.061**		0.909
Toledo						
i	5.701	0.450	-0.010	-0.968**		0.490
ii	6.587	-0.302	-0.010	-1.049**		0.489
iii	6.236	-0.142	0.000	-0.990**		0.957
iv	5.966	-0.130	-0.000	-0.951**		0.957
v	5.740	0.449	-0.10	-0.958	-0.010	0.481
vi	6.238	-0.145	0.000	-1.002**	0.011	0.957
vii	11.538	0.569	-0.021	-0.992**		0.912
viii	12.609	0.370	-0.020	-1.008		0.912
Youngtown						
i	5.067	0.482	-0.013	-0.983**		0.506
ii	6.932	0.741	-0.014*	-1.405**		0.508
iii	5.818	0.032	-0.000	-0.991		0.999
iv	5.941	0.013	-0.000**	-0.999**		0.999
v	-3.533	2.680**	-0.010	-15.371**	16.499**	0.585
vi	5.820	0.031*	-0.000	-0.998**	0.006	0.999
vii	9.998	0.770	-0.024	-0.995**		0.912
viii	12.982	1.398	-0.027*	-1.128**		0.913

Allentown						
i	3.765	0.662	-0.013*	-0.983**		.530
ii	7.128*	0.747	-0.012*	-1.53*		.522
iii	6.040**	-0.005	-0.000	-0.994**		.999
iv	6.016**	-0.054**	-0.000	-0.944		.999
v	5.010	0.420	-0.013	-0.736	-0.736	.523
vi	5.517**	0.982**	0.000	-0.687**	-0.263**	.999
vii	8.574	0.923	-0.012*	-0.996**		.916
viii	13.267**	1.689	-0.036*	-1.198**		.917
Altoona						
i	3.457	0.526	-0.007	-0.955**		0.500
ii	4.693	0.266	-0.006	-1.044**		0.469
iii	5.986	-0.008	-0.000	-0.911**		0.999
iv	5.965	-0.026	-0.000	-0.980**		0.999
v	6.623	-0.766	-0.014**	2.594	-2.838*	0.493
vi	5.845	0.049**	0.000	-0.865**	-0.159**	0.999
vii	8.935	0.739	-0.017	-0.986**		0.881
viii	10.669	0.307	-0.017	-1.006**		0.880
Erie						
i	4.525	0.352	-0.009	-0.968**		0.490
ii	5.932	0.298	-0.009	-1.164*		0.493
iii	5.694	0.060**	-0.000**	-0.990**		0.999
iv	5.934	0.032	-0.000*	-1.010**		0.999
v	4.296	0.404	-0.007	-2.107	1.136	0.486
vi	5.687	0.061**	-0.000**	-0.956**	-0.034	0.999
vii	0.289	0.663	-0.021	-0.991**		0.901
viii	11.954	0.874	-0.022	-1.089**		0.901

Harrisburg						
i	4.895	0.400	-0.009	-0.974**		0.493
ii	5.846	0.270	-0.008	-1.077**		0.492
iii	5.602	0.100**	-0.001**	-0.986**		0.999
iv	5.841	0.081**	-0.001**	-1.017**		0.999
v	4.450	0.580	-0.001	-3.868	2.676	0.487
vi	5.001	0.100**	-0.001**	-0.984**	-0.001	0.999
vii	9.997	0.719	-0.021	-0.989**		0.898
viii	11.699	0.480	-0.020	-1.019		0.898
Johnstown						
i	4.797	0.358	-0.012*	-0.969**		0.510
ii	5.504	0.279	-0.012*	-1.62**		0.510
iii	5.763	0.014	-0.000	-0.981**		0.999
iv	5.791	-0.014	-0.000	-0.975**		0.999
v	4.430	0.538	-0.014	-2.035	1.001	0.503
vi	5.703	0.045**	-0.000**	-0.815**	-0.177**	0.999
vii	10.150	0.609	-0.023*	-0.988**		0.892
viii	11.353	0.490	-0.023*	-1,016**		0.892
Lancaster						
i	4.439	0.463	-0.010	-0.974**		0.496
ii	6.185	0.458	-0.010	-1.249**		0.495
iii	5.762	0.046**	-0.000**	-0.985**		0.999
iv	5.939	0.038**	-0.000**	-1.008**		0.999
v	-0.069	1.647	-0.002	-7.564	6.761	0.505
vi	5.756	0.048**	-0.000**	-0.976**	-0.008	0.999
vii	9.357	0.743	-0.022	-0.990**		0.904
viii	12.159	0.774	-0.022	-1.067**		0.904

Philadelphia						
i	4.574	0.630	-0.018*	-0.973**		0.510
ii	8.567	0.348	-0.018	-1.218		0.508
iii	6.006	0.003	-0.000**	-0.997**		0.999
iv	6.026	-0.013	-0.000**	-0.926**		0.999
v	12.188	-0.565	-0.009	3.225	-5.971	0.515
vi	5.609	0.066**	-0.001**	-0.688**	-0.217**	0.999
vii	9.076	0.882	-0.030*	-0.994**		0.927
viii	14.681	1.119	-0.033	-1.130**		0.927
Pittsburgh						
i	5.545	0.477	-0.017*	-0.971**		0.511
ii	7.918	0.435	-0.017*	-1.233		0.511
iii	7.277	-0.255**	0.001**	-0.990**		0.997
iv	6.010	-0.244**	0.001**	-0,786**		0.998
v	8.643	-0.141	-0.012	0.693	-1.357	0.502
vi	5.858	0.032	-0.000**	-0.370**	-0.471**	0.999
vii	11.578	0.495	-0.027*	-0.993**		0.922
viii	14.033	0.667	-0.029*	-1.063*		0.922
Reading						
i	4.407	0.504	-0.012*	-0.976**		0.504
ii	6.262	0.348	-0.012	-1.17*		0.502
iii	6.219	-0.057**	0.000**	-0.996**		0.999
iv	6.007	-0.041**	0.000**	-0.972**		0.999
v	4.072	0.593	-0.012*	-1,318	0.356	0.492
vi	6.128	-0.032	0.000*	-0.899**	-0.093	0.999
vii	9.803	0.666	-0.023	-0.991**		0.905
viii	12.205	0.262	-0.021	-1.013**		0.905

Scranton						
i	4.096	0.442	-0.011*	-0.960**		0.498
ii	5.669	-0.034	-0.010	-0.915		0.496
iii	6.816	-0.221**	0.000**	-0.993**		0.998
iv	6.020	-0.204**	0.000**	-0.872**		0.998
v	8.870	-0.874	-0.006	2.009	-2.826	0.510
vi	6.177	-0.42	0.000	-0.616**	-0.397**	0.999
vii	10.062	0.450	-0.022	-0.987**		0.892
viii	11.680	-0.228	-0.019	-0.958**		0.897
Wilkes-Barre						
i	4.104	0.498	-0.011	-0.958**		0.491
ii	6.014	0.121	-0.010	-0.692		0.488
iii	5.988	0.006	-0.000	-0.998**		0.999
iv	6.011	0.008	-0.000	-1.003**		0.999
v	6.026	0.012	-0.013*	1.633	-1.646	0.494
vi	5.932	0.020	-0.000	-0.921**	-0.754	0.999
vii	0.243	0.724	-0.022	-0.998**		-.903
viii	12.010	0.108	-0.020	-0.994**		0.903
York						
i	4.388	0.567	-0.010	-0.965**		0.484
ii	6.116	0.164	-0.008	-1.025*		0.481
iii	6.632	-0.201**	0.125**	-0.996**		0.997
iv	6.013	-0.204**	-0.002**	-0.892**		0.997
v	9.779	-1.151	-0.012*	2.148	-3.198*	0.507
vi	6.127	-0.036	0.001**	-0.697**	-0.293**	0.998
vii	10.295	0.633	-0.020	-0.992**		0.905
viii	12.239	0.409	-0.018	-1.024**		

APPENDIX A.3

The Parameter Estimates of the One Factor Model

Detroit						
I						
	i	16.860	-0.368	-14.347	0.029**	-0.656
	ii	-127.628	-202.171*	-10.093	-7.788	
	iii		0.007**	-0.014*		
II						
	i	-0.475**	2.826	-1.081	-0.003*	-0,955**
	ii	-20.150**	-79.673**	-9.002	41.323*	
	iii	0.012	0.221*	-0.187		
III						
	i	9.980	0.912	-0.002*	-0.997**	
	ii	-193.388**	83.182**	-8.772	46.382*	
	iii	0.008	-0.000	-0.791		
Indianapolis						
I						
	i	4.734	2.254	10.830	-0.058	-1.275**
	ii	-149.204	-264.781*	-10.916	-10.838	
	iii		-0.002	-0.000		
II						
	i	7.079	1.611	-0.408	-0.028*	-0.968**
	ii	-242.537**	-82.848**	11.325	33.218	
	iii	0.914*	0.282**	-262*		
III						
	i	9.582	0.940	-0.025*	-0.992**	
	ii	-279.923**	68.605**	7.387	25.392	
	iii	0.014	-0.000	-0.528		

Albany

I

i	0.255	3.683*	25.236**	-0.098**	-1.714**
ii	-92.455	251.192	10.024	-9.869	
iii		-0.009**	0.004		

II

i	8.166	1.325	-0.276	-0.262*	-0.984**
ii	-157.333	92.247**	-20.473	58.573	
iii	1.382**	0.189	-0.579**		

III

i	10.358*	0.676	-0.244*	-0.997*
ii	-155.771	-92.896**	-20.547	59.059
iii	0.001	-0.000	-0.878**	

Binghampton

II

i	4.245	2.490	18.451*	-0.089**	-1.474**
ii	-77.213	-249.536**	-9.308	-6.086	
iii		0.001	0.001		

II

i	6.655	1.744	-0.726*	-0.028**	-0,946**
ii	524.951	0356.457*	-68.545	219.194	
iii	0.993*	0.279	-0.502**		

III

i	9.45*	0.927	-0.026*	-0.900**
ii	123.857	-190.133**	-40.426	112.829*
iii	0.002	-0.000	0.678**	

Buffalo					
I					
i	11.508	0.432	-3.193	-0.017	-0.910**
ii	-145.890	-213.206	-9.246	-9.941	
iii		0.002	0.000		
II					
i	3.011	3.541	-1.162**	-0.034	-0.947**
ii	-219.882**	-86.787**	-0.844	75.792*	
iii	0.571	0.400**	-0.364*		
III					
i	9.344	0.898	-0.029*	-0.944**	
ii	-253.081**	-71.438**	-2.468	60.461	
iii	0.008	-0.000	1.024**		
New York					
I					
i	-3.440	2.245	18.158	-0.093	-1.313**
ii	-183.094	-313.471	-12.867	-14.297	
iii		-0.003	0.001		
II					
i	-11.802	4.002	-2.268	-0.034**	-0.893**
ii	-128.202	-138.370*	-10.294	45.438	
iii	0.326	0.165**	-0.125		
III					
i	7.297	0.953	-0.038**	-0.900**	
ii	-114.082	-131.289*	-10.306	42.415	
iii	0.002	0.000	-0.403**		

Rochester					
I					
i	-1.980	2.990	26.474**	-0.122**	-1.659**
ii	-125.614	-222.617**	-7.600	-11.963	
iii		-0.010	0.000		
II					
i	5.388	3.645*	-1.626**	-0.038**	-0.907**
ii	161.289	-89.741**	-7.098	61.768	
iii	0.300	0.305**	-0.217		
III					
i	8.574	0.923	-0.024	-0.995**	
ii	214.692**	-68.696*	-7.564	44.740	
iii	0.022	-0.000	0.865**		
Syracuse					
I					
i	4.766	2.111	18.988	-0.080*	-1.511**
ii	-22.812	-310.921*	-8.635	-10.812	
iii		-0.006**	0.001**		
II					
i	2.400	2.729	-1.134**	-0.035**	-0.925**
ii	-154.558*	-85.400**	0.166	63.954*	
iii	0.629	0.383**	-0.304		
III					
i	9.669	0.780	-0.026*	-0.994**	
ii	-193.850**	-69.915**	-1.404	50.636	
iii	0.002	-0.000	0.905**		

Utica-Rome					
I					
i	7.785	1.150	3.004	-0.033	-1.070**
ii	-22.316	-313.967	-10.880	-9.263	
iii		-0.000	-0.001		
II					
i	3.990	2.193	-0.653	-0.031**	-0.950**
ii	-157.498**	-74.230**	4.313	44.533	
iii	0.593	0.372**	-0.330*		
III					
i	8.380	0.987	-0.026*	-0.990**	
ii	-207.356**	-53.916**	0.925	29.678	
iii	0.006	-0.000	0.753**		
Akron					
I					
i	5.516	19.399	12.634	-0.049*	-1.374**
ii	218.395	-161.869**	-13.007		
iii		-0.004	0.004		
II					
i	1.235	3.063	-0.913	-0.034*	-0.955**
ii	-239.637**	-62.220**	-1.354	33.832	
iii	0.400	0.349**	-0,342**		
III					
i	9.366	0.922	-0.024*	-0.994**	
ii	-239.180**	-62.453**	-1.326	33.993	
iii	0.003	-0.000	0.700**		

Canton					
I					
i	10.705*	0.664	-0.365	-0.021	-0.985**
ii	-116.178	-191.734	-8.594	-7.435	
iii		0.002	-0.000		
II					
i	2.361	3.575*	-1.568**	-0.038**	-0.906**
ii	-161.734**	-75.110**	1.384	51.603*	
iii	0.232	0.361**	-0.226		
III					
i	10.561**	0.718	-0.022	-0.996**	
ii	-215.980**	-52.859**	-1.489	33.468	
iii	0.027	-0.000	0.853**		
Cincinnati					
I					
i	10.478	0.529	-2.631	-0.017	-0.926**
ii	-107.129	-266.315	-8.970	-10.067	
iii		0.001	0.000		
II					
i	3.362	3.190	-1.130	-0.028*	-0.940**
ii	-188.569**	-86.633**	15.538	50.347*	
iii	0.316	0.343**	-0.196		
III					
i	8.623	0.886	-0.024	-0.992**	
ii	-197.097**	-83.524**	1.097	47.962	
iii	0.013	-0.000	0.694**		

Cleveland						
I						
	i	12.465	0.259	-7.159	-0.007	-0.817**
	ii	87.838	-283.690	-9.402	-10.888	
	iii		0.002	0.000		
II						
	i	-9.168	4.266*	-1.678**	-0.048**	-0.912
	ii	-172.021*	-101.340**	-2.426	68.125*	
	iii	0.421	0.324**	-0.234		
III						
	i	9.044	0.897	-0.029*	-0.991**	
	ii	-274.596**	-61.229**	-5.557	36.597	
	iii	0.026	-0.000	0.786**		
Columbus						
I						
	i	10.246	0.611	-3.263	-0.016	-0.907**
	ii	48.593	-379.971**	-9.938	-7.723	
	iii		0.002	-0.000		
II						
	i	3.951	2.110	-0.703	-0.024*	-0.959**
	ii	-190.907**	-78.261**	76.540	34.730	
	iii	0.585	0.313*	-0.262		
III						
	i	9.222	0.856	-0.022	-0.996**	
	ii	-199.466**	-74.926**	6.928	32.811	
	iii	0.039	-0.000	0.497**		

Dayton						
I						
	i	4.734	2.281	25.287	-0.090**	-1.716**
	ii	140.540	-411.510**	-9.453	-7.957	
	iii		-0.002	0.003		
II						
	i	-0.408	3.704*	-1.384**	-0.037**	-0.925**
	ii	-152.115*	-100.259**	-1.183	67.095**	
	iii	0.432	0.333**	-0.287		
III						
	i	9.400	0.967	-0.026*	-0.991**	
	ii	-207.045**	-76.710**	-3.151	48.935	
	iii	0.011	-0.000	0.804**		
Toledo						
I						
	i	9.432	0.838	0.790	-0.023	-1.014**
	ii	-34.294	-271.099**	-7.327	-12.619	
	iii		-0.003	0.003		
II						
	i	3.448	2.419	-0.661	-0.027*	-0.961**
	ii	-243.791**	-54.502**	-0.143	45.075	
	iii	0.477	0.468*	-0.299		
III						
	i	9.708	0.766	-0.021	-0.995**	
	ii	-239.326**	-56.397**	0.159	46.961	
	iii	0.004	-0.000	0.937**		

Youngstown					
I					
i	12.986**	-0.084	-4.053	-0.011	-0.870**
ii	-78.233	-223.895	-8.225	-6.985	
iii		0.004	-0.001		
II					
i	7.395*	2.675	-1.046**	-0.003**	-0.946**
ii	-251.762**	-56.427	2.158	47.849	
iii	0.381	0.527**	-0.406		
III					
i	1.153**	0.564	-0.021	-0.992**	
ii	-255.183**	-54.363	1.747	45.731	
iii	0.028	-0.000	1.047**		
Allentown					
I					
i	10.400	0.665	-1.074	-0.021	-0.969**
ii	-203.246	-151.580	-10.835	-8.561	
iii		-0.000	0.004		
II					
i	5.313	1.978	-0.927	-0.028**	-0.941**
ii	98.402	-180.948**	7.518	126.044**	
iii	0.544	0.400*	-0.352		
III					
i	9.996	0.700	-0.024	-0.995**	
ii	-12.060	-138.032**	3.416	93.650	
iii	0.017	-0.000	0.745**		

Altoona

I						
	i	8.765	0.809	1.328	-0.021	-1.023**
	ii	-103.171	-216.736**	-7.473	-9.057	
	iii		-0.003	0.005		
II						
	i	9.507**	0.506	0.054	-0.020	-0.987
	ii	-260.264	-13.777**	-3.555	0.469	
	iii	-0.052	0.226	-0.027		
III						
	i	8.935**	0.736	-0.019	-0.986**	
	ii	-250.582	-17.438**	-2.482	2.826	
	iii	0.018	-0.000	0.434**		

Eyrie

I						
	i	5.649	1.577	8.589	-0.044	-1.241**
	ii	-77.311	-231.318*	-8.128	-8.852	
	iii		-0.029	0.004		
II						
	i	6.370	1.388	-0.435	-0.021	-0.964**
	ii	-111.356*	-83.529**	4.254	63.933**	
	iii	0.767	0.377	-0.401**		
III						
	i	9.298	0.663	-0.021	-0.991**	
	ii	-112.281*	-83.175**	4.202	63.627**	
	iii	0.041	-0.004	0.979**		

Harrisburg						
I						
	i	10.373**	0.560	-1.127	-0.015	-0.962**
	ii	-252.716**	-105.346*	-8.669	-9.450	
	iii		0.000	0.003		
II						
	i	8.205*	1.457	-0.360	-0.019	-0.971**
	ii	-103.268	-102.957**	13.522	81.398**	
	iii	0.895**	0.224	-0.358		
III						
	i	9.997**	0.719	-0.021	-0.989**	
	ii	-152.471**	-82.955**	9.234	63.604**	
	iii	0.059	-0.000	0.633**		
Johnstown						
I						
	i	12.609**	-0.627	-10.166**	0.005	-0.651**
	ii	-185.024	-121.684	-9.163	-7.173	
	iii		0.013*	-0.003		
II						
	i	9.937**	0.715	-0.030	-0.023*	-0.988**
	ii	-276.112	-22.224**	-9.513	5.644	
	iii	0.311	0.016	-0.149**		
III						
	i	10.151**	0.610	-0.023*	-0.989**	
	ii	-255.474**	-32.190**	-10.010	12.080	
	iii	0.014	0.000	0.574**		

Lancaster					
I					
i	6.279	1.563	8.920	-0.049	-1.202**
ii	-123.561	-226.394*	-9.304	-9.868	
iii		-0.003	0.005		
II					
i	4.861	1.930	-0.834	-0.021	-0.936**
ii	24.644	-127.035**	20.013	80.555**	
iii	0.594	0.416*	-0.322		
III					
i	9.357	0.743	-0.022	-0.980**	
ii	-20.710	-111.319**	16.581	61.382**	
iii	0.036	-0.000	0.662**		
Philadelphia					
I					
i	2.704	1.889	19.088	-0.084	
ii	-37.512	-388.881*	-12.646	-0.480	
iii		-0.028	0.003		
II					
i	-5.012	3.096	-1.447	-0.028*	-0.935**
ii	-34.421	-169.144**	-2.479	107.347**	
iii	0.522	0.284**	-0.252		
III					
i	9.075	0.882	-0.303*	-0.994	
ii	-34.421	-169.144**	-2.479	107.347**	
iii	0.522	0.284**	-0.252		

Pittsburgh						
I						
	i	15.648	-0.327	-0.433	-0.007	-0.759**
	ii	266.227	-138.204	-11.179	-11.293	
	iii		0.004	-0.001		
II						
	i	0.348	2.742	-1.190**	-0.032**	-0.958**
	ii	-89.407	-197.999**	4.834	196.871**	
	iii	0.759	0.352*	-0.510**		
III						
	i	11.578	0.495	-0.027*	-0.993**	
	ii	-108.195	-187.194**	3.988	185.486**	
	iii	0.019	-0.000	1.128**		
Reading						
I						
	i	11.715	0.142	-6.895	0.000	-0.827**
	ii	-206.583*	-138.427	-8.607	-8.034	
	iii		0.006	-0.004		
II						
	i	22.217**	-2.681**	2.760	-0.013*	-1.182**
	ii	-270.969**	-24.460	-3.426	-5.963	
	iii	0.040	-0.022	-0.128		
III						
	i	9.803	0.666	-0.023	-0.991**	
	ii	-181.644**	-55.651**	3.311	-2.703	
	iii	-0.010	-0.000	0.383**		

Scranton						
I						
	i	9.876	0.506	4.455	-0.038	-1.082**
	ii	-198.550**	-148.253	-9.077	-7.682	
	iii		-0.000	0.003		
II						
	i	1.384	-0.574	2.531**	-0.015*	-1.187**
	ii	-271.760**	-19.819	-4.122	-7.378	
	iii	0.314	-0.082	-0.087		
III						
	i	10.062	0.450	-0.022	-0.987**	
	ii	-195.297**	-48.222	2.495	-5.029	
	iii	-0.000	-0.000	0.313**		
Wilkes Barre						
I						
	i	9.227	0.728	0.066	-0.023	-0.989**
	ii	-156.653**	-212.054*	-9.248	-8.488	
	iii		0.003	0.000		
II						
	i	17.158**	-1.287	1.836**	-0.020**	-1.113**
	ii	-136.133**	-75.752**	16.146	0.450	
	iii	0.290	-0.030	-0.093		
III						
	i	9.243	0.724	-0.022	-0.988**	
	ii	-61.917	-103.098**	25.313	4.080	
	iii	-0.009	-0.000	0.356**		

York

I						
	i	13.064**	-0.268	13.344	-0.066	-1.267**
	ii	-143.712**	-217.191**	-11.576	-7.815	
	iii		-0.003	0.007		
II						
	i	20.074**	-2.537	2.597**	-0.007	-1.193**
	ii	-255.668**	-27.903*	-4.599	-6.448	
	iii	0.367	-0.020	-0.105		
III						
	i	10.295*	0.633	-0.020	-0.992**	
	ii	-22.957	-101.925**	15.956	0.134	
	iii	0.015	-0.000	0.306**		

APPENDIX A.4

The Parameter Estimates of the Two-Factor Model

Detroit

I.1	3.642	0.995	-0.102	-0.010	-1.051**		
I.2	6.813	-0.144**	0.051**	-0.000*	-0.994**		
I.3	7.214**	-5.385**	-0.001	0.011			
I.4	1.879**	-0.367	0.140	0.759**			
I.5	1.519**	-0.048	0.016	0.001**	-0.154**	0.000	0.000
II.1	8.578**	1.028	0.217	-0.019**	-1.656		
II.2	6.075**	-0.073*	0.006	-0.000	-0.931		
II.3	0.001	6.475**	-0.000	-0.075			
II.4	0.003	0.032	0.008	0.121			
II.5	-0.115**	0.037	0.195	0.785**			
III.1	3.127	1.015	-0.633	-8.624	-0.015	-0.015	-0.408
III.2	6.201	-0.021	0.025**	0.846**	-0.003**	-1.179**	
III.3	-0.010	-0.052**	6.510				
III.4	-0.119**	0.310**	0.787**				
III.5	1.399	-0.023	-0.168**	0.007			
IV.1	3.127	1.015	-0.633	-8.624	-0.015	-0.408	
IV.2	6.201	-0.021	0.025**	0.846**	-0.003**	-1.179**	
IV.3	-0.423*	6.534*	0.172**	-0.001	-0.192**		
IV.4	-0.080	0.214**	0.739**				
IV.5	0.113*	0.187**	-0.082*				

Indianapolis

I.1	4.931	0.522	0.123	-0.012	-0.978**		
I.2	6.005**	-0.001	0.004	-0.000	-0.997**		
I.3	8.625**	-7.319**	0.009	-0.070			
I.4	2.151**	-0.691	0.278	0.550**			
I.5	1.198**	-0.022	0.008**	0.000	-0.115**	-0.002	-0.010**
II.1	6.678**	0.596	0.320	-0.011	-1.311*		
II.2	6.014	-0.037**	-0.002	0.000**	-0.095**		
II.3	0.006	8.628**	-0.058	-0.058			
II.4	0.002	-0.000	0.006	0.111			
II.5	-0.059	0.171	0.098	0.500**			
III.1	0.830	1.657	-0.252	4.473	-0.030	-1.580*	
III.2	5.829**	0.050))	-0.006	0.636**	-0.001**	-1.114**	
III.3	-0.012	-0.050	8.730**				
III.4	-0.083	0.359**	0.522**				
III.5	0.226	0.146**	-0.026	-0.003			
IV.1	0.830	1.657	-0.252	4.473	-0.030	-1.580*	
IV.2	5.829**	0.050**	-0.006	0.636**	-0.001*	-1.114**	
IV.3	-0.214	9.663**	-0.083	-0.081*	-0.103*		
IV.4	-0.039	0.341**	0.477**				
IV.5	0.056	0.174**	-0.046				

Albany

I.1	6.431*	-0.046	0.243	-0.012	-0.933**		
I.2	5.890**	0.027	0.003	-0.000**	-0.997**		
I.3	7.276**	-6.362**	0.005	-0.016			
I.4	2.028**	-0.625	0.229	0.894**			
I.5	1.120**	-0.007	0.000	0.001**	-0.138**	-0.001	-0.002
II.1	6.423**	0.588	0.104	-0.013*	-1.200**		
II.2	5.983**	-0.004	0.008	-0.000	-0.994**		
II.3	-0.014	7.269	0.020	-0.013			
II.4	0.003	0.036	0.013	0.096			
II.5	-0.125	0.183	0.112	0.853**			
III.1	-0.871	2.197*	-0.146	12.350**	-0.050**	-3.055**	
III.2	5.897**	0.027	0.010**	0.146	-0.000**	-1.028**	
III.3	-0.012	0.018	8.202**				
III.4	-0.147*	0.344**	0.870**				
III.5	0.988**	0.016	-0.110**	-0.034			
IV.1	-0.871	2.197*	-0.146	12.350**	-0.050**	-3.055*	
IV.2	5.897	0.027	0.010**	0.146	-0.000**	-1.028**	
IV.3	0.168	7.203**	-0.070	0.009	0.041		
IV.4	-0.106**	0.286	0.834**				
IV.5	0.099	0.164**	-0.085				

Binghamton

I.1	2.796	1.143	-0.289	-0.012**	-0.972**		
I.2	5.890	0.025	0.015**	-0.000*	-0.991**		
I.3	6.051**	-5.825**	-0.051	-0.068			
I.4	2.051**	-0.324	-0.026	0.651**			
I.5	0.813	0.042**	0.002	0.000	-0.136	-0.002	-0.006
II.1	5.813**	0.527	0.199	-0.145*	-1.25**		
II.2	5.973**	0.016	0.010	-0.000	-0.999**		
II.3	0.012**	7.143**	0.003	-0.127			
II.4	0.005	0.448	0.025	-0.277**			
II.5	-0.119	-0.105	0.395	0.695**			
III.1	-0.232	2.025**	-0.452**	11.322**	-0.053**	-2.608**	
III.2	5.892**	0.029	0.010	-0.350	0.000	-0.940**	
III.3	-0.008	-0.039	8.221**				
III.4	-0.103**	0.339	0.679**				
III.5							
IV.1	-0.232	2.025**	-0.452**	11.322*	-0.053**	-2.608**	
IV.2	5.892**	0.029	0.010	-0.350	0.000	-0.940**	
IV.3	-0.216	7.188**	0.094	0.020	-0.187**		
IV.4	-0.062	0.358**	0.639**				
IV.5	0.043	0.151**	-0.040				

Buffalo

I.1	5.154	0.739	0.042	-0.012	-1.030**		
I.2	5.689	0.060*	0.002	-0.000**	-0.994**		
I.3	7.865**	-6.390**	0.003	-0.052			
I.4	1.631**	0.029	-0.234	1.039**			
I.5	1.396**	-0.050**	0.016*	0.000**	-0.135**	-0.001	-0.018**
II.1	7.351**	0.432	0.235	-0.016	-1.264		
II.2	5.980**	0.026	0.002	-0.000*	-1.015**		
II.3	0.001	7.333**	-0.017	-0.090**			
II.4	0.002	-0.140	0.003	0.231			
II.5	-0.138*	0.190	0.038	0.989*			
III.1	0.438	1.498	-0.659**	-4.638	-0.006	-0.088	
III.2	5.501**	0.103**	-0.002	0.399**	-0.001**	-1.073**	
III.3	-0.016	-0.042	7.396**				
III.4	-0.168**	0.297**	1.022**				
III.5	0.464	0.116	-0.065**	0.002			
IV.1	0.438	1.498	-0.659**	-4.638	-0.006	-0.088	
IV.2	5.501**	0.103**	-0.002	0.399**	-0.001**	-1.073**	
IV.3	-0.310**	7.404**	0.143	-0.030	-0.232**		
IV.4	-0.130	0.306**	0.980				
IV.5	0.054	0.185**	-0.042				

New York

I.1	3.976	0.539	0.438	-0.025**	-0.955**		
I.2	6.656**	-0.085**	0.041**	0.000	-0.993**		
I.3	10.130**	-9.546**	0.082	0.009			
I.4	1.606**	-o.119	-0.144	0.408**			
I.5	1.083**	-0.007	0.000	-0.002	-0.093**	-0.012**	0.006
II.1	7.806**	-1.588	0.888**	-0.006	0.475		
II.2	5.999**	-0.033*	0.098	-0.000	-0.984**		
II.3	-0.059**	10.744**	0.189**	0.087			
II.4	0.010	0.407**	0.000	-0.132			
II.5	-0.050	0.085	0.168**	0.388**			
III.1	-14.125	2.808	-1.303	4.295	-0.037	-1.086	
III.2	6.411**	-0.047	0.018	-0.068	0.000	-0.991**	
III.3	-0.011	0.048**	10.526				
III.4	-0.065**	0.436**	0.400**				
III.5	-0.897**	0.318**	0.005	0.077**			
IV.1	-14.125	2.808	-1.303	4.294	-0.037	-1.086	
IV.2	6.411**	-0.047	0.018	-0.068	0.000	-0.991**	
IV.3	0.127	0.197**	-0.066	0.188**	0.115		
IV.4	-0.012	0.242**	0.347**				
IV.5	0.057	0.159**	-0.052				

Rochester

I.1	-2.612	2.012	-0.500	-0.022**	-0.979**		
I.2	6.324**	-0.067**	0.028**	0.000	-0.993**		
I.3	6.777	-5.703	-0.005	-0.042			
I.4	2.196	-0.260	-0.057	0.835			
I.5	0.972**	0.025	-0.015	0.005**	-0.134**	-0.006	-0.013*
II.1	6.825**	0.783	0.299	-0.010	-1.568**		
II.2	6.020**	-0.055**	-0.003	-0.000	-0.945**		
II.3	-0.024	7.332**	0.019	0.058			
II.4	0.002	0.112	-0.001**	0.052			
II.5	-0.143**	-0.025	0.317	0.871**			
III.1	-5.063	2.390**	-0.724**	6.576*	-0.043	-1.744	
III.2	6.188**	-0.033	0.016	0.025	-0.000	-1.004**	
III.3	-0.012	0.042	7.170**				
III.4	-0.136**	0.384**	0.863**				
III.5	-0.046	0.187**	-0.004	0.010			
IV.1	-5.063	2.390**	-0.724*	6.576*	-0.043	-1.744	
IV.2	6.188**	-0.033	0.016	0.025	-0.000	-1.004**	
IV.3	-0.114	7.280**	0.034	0.017	0.029		
IV.4	-0.089	0.350**	0.815**				
IV.5	0.067	0.168**	-0.055				

Syracuse

I.1	2.054	1.253	-0.224	-0.019**	-0.967**		
I.2	5.945**	0.010	0.009**	-0.000**	-0.997**		
I.3	7.223	-6.447	0.014	-0.013			
I.4	2.115**	-0.194**	-0.127	0.874**			
I.5	1.097**	-0.008	-0.004	0.000**	-0.135	-0.005	-0.003
II.1	6.360**	0.467	0.120	-0.014*	-1.254**		
II.2	5.986**	0.010	0.009**	-0.000**	-1.005**		
II.3	-0.037**	7.334**	0.066*	0.070**			
II.4	0.006	-0.051	-0.011	0.186			
II.5	-0.137*	0.0512	0.245	0.898**			
III.1	0.350	1.653	-0.528*	3.617	-0.029	-1.377	
III.2	5.896**	0.027**	0.007**	0.374**	-0.001**	-1.067**	
III.3	-0.014	0.045*	7.213**				
III.4	-0.143**	0.370**	0.902**				
III.5	0.138	0.153**	-0.022	0.000			
IV.1	0.350	1.653	-0.528*	3.617	-0.029	-1.377	
IV.2	5.896**	0.027**	0.007**	0.374**	-0.001**	-1.067**	
IV.3	-0.160	7.350**	0.048	0.061*	0.029		
IV.4	-0.098	0.410**	0.857**				
IV.5	0.042	0.169**	-0.036				

Utica - Rome

I.1	2.633	1.059	-0.072	-0.013*	-1.010**		
I.2	6.277**	-0.081**	0.041**	-0.000	-0.995**		
I.3	6.788**	-6.715**	0.006	-0.033			
I.4	2.030**	-0.469	0.091	0.707**			
I.5	1.020**	-0.017	0.012**	0.000	-0.135	-0.005	0.005
II.1	5.381**	0.017	0.482	-0.009	-1.008		
II.2	6.022**	-0.033	0.004	-0.000	-0.973**		
II.3	-0.013	7.392**	0.068**	-0.033			
II.4	0.000	0.207*	-0.001	-0.038			
II.5							
III.1	1.757	1.135	-0.410	-7.638	-0.001	0.412	
III.2	5.976**	0.013	0.008	-0.699**	0.000	-0.888**	
III.3	-0.007	0.010	7.353**				
III.4	-0.119**	0.342**	0.749**				
III.5	-0.473*	0.239**	0.004	0.062*			
IV.1	1.757	1.135	-0.410	-7.638	-0.001	0.412	
IV.2	5.976**	0.013	0.008	-0.699**	0.000	-0.888**	
IV.3	-0.004	7.380**	-0.003	0.068**	-0.031		
IV.4	-0.076	0.358**	0.701**				
IV.5	0.056	0.151**	-0.055				

Akron

I.1	1.831	1.342	-0.248	-0.016*	-0.990**		
I.2	5.791*	0.054	0.009	-0.000**	-0.994**		
I.3	7.311**	-5.720**	0.008	-0.023			
I.4	1.673**	-0.681	0.365	0.699**			
I.5	1.157**	0.015	-0.001	0.000**	-0.158**	-0.008	0.011*
II.1	6.630**	-0.011	0.377	-0.009	-0.974		
II.2	5.998**	-0.014	0.025**	0.000	-0.987**		
II.3	-0.020	6.284**	0.078**	0.013			
II.4	-0.000	-0.008	-0.007	0.172**			
II.5	-0.081	0.190	0.052	0.666**			
III.1	-0.209	1.844	-0.435	3.080	-0.023*	-1.430	
III.2	5.637**	0.099**	-0.002	0.534**	-0.001**	-1.105**	
III.3	-0.004	-0.030	6.301**				
III.4	-0.106*	0.286**	0.686**				
III.5	0.679**	0.088**	-0.134**	0.030			
IV.1	-0.209	1.844	-0.435	3.080	-0.023*	-1.430	
IV.2	5.637**	0.099**	-0.002	0.534**	-0.001**	-1.105**	
IV.3	-0.202	6.316**	0.085	0.069*	-0.044		
IV.4	-0.072	0.286**	0.654**				
IV.5	0.162**	0.174**	-0.126**				

Canton

I.1	3.521	1.153	-0.134	-0.011	-1.037**		
I.2	6.379**	-0.161**	0.040**	0.001**	-0.994**		
I.3	6.591**	-.5.506**	-0.008	-0.034			
I.4	1.983**	0.500	-0.728	0.863**			
I.5	1.167**	-0.011	0.011*	0.000**	-0.159**	-0.007	-0.012**
II.1	6.079**	0.336	0.296	-0.010	-1.146**		
II.2	5.991**	-0.066**	-0.005	0.000**	-0.964**		
II.3	0.011	6.257**	0.020	-0.139**			
II.4	-0.000	-0.831	-0.001	0.856			
II.5	-0.106	0.259	0.059*	0.824**			
III.1	1.789	1.676	-0.792**	-2.370	-0.013	-0.269	
III.2	6.132**	-0.054	0.001	0.209	0.000	-1.035**	
III.3	-0.008	-0.095**	6.428**				
III.4	-0.140**	0.350**	0.857**				
III.5	0.106	0.172**	-0.046	0.026			
IV.1	1.789	1.676	-0.792	-2.370	-0.013	-0.269	
IV.2	6.132	-0.054	0.001	0.209	0.000	-1.035**	
IV.3	-0.153	6.287**	0.067	0.012	-0.193**		
IV.4	-0.097	0.390**	0.818**				
IV.5	0.048	0.182**	-0.039				

Cincinnati

I.1	3.212	0.829	-0.068	-0.010	-1.018**		
I.2	5.937**	-0.015	0.011*	-0.000	-0.983**		
I.3	7.797**	-6.907**	0.034	-0.032			
I.4	2.018**	-0.932	0.553	0.679**			
I.5	1.218**	-0.028	0.008	0.000**	-0.126**	-0.003	-0.008*
II.1	7.024**	0.230	0.333	-0.012	-1.158		
II.2	5.8717**	-0.017	-0.000	-0.968**			
II.3	-0.004	7.840**	-0.001	-0.030			
II.4	0.001	-0.093	-0.000*	-0.193			
II.5	-0.082	0.158	0.103	0.667**			
III.1	0.317	1.345	-0.674	-5.210	-0.002	-0.026	
III.2	5.703**	0.032*	0.006	0.410**	-0.001**	-1.060**	
III.3	-0.009	-0.055	7.924**				
III.4	-0.106	0.349**	0.694**				
III.5	0.079	0.169**	-0.059**	0.042			
IV.1	0.317	1.345	-0.674	-5.210	-0.002	-0.026	
IV.2	5.703**	0.032*	0.006	0.410**	-0.001**	-1.060**	
IV.3	-0.150	7.852**	0.057	-0.008	-0.070		
IV.4	0.063	0.307**	0.645**				
IV.5	0.040	0.175**	-0.034				

Cleveland

I.1	-2.731	2.082	-0.417	-0.020*	-1.018**		
I.2	5.748**	0.029	-0.000	-0.001**	-0.985**		
I.3	8.415**	-6.927**	-0.014	-0.028			
I.4	2.067**	0.794	0.909	0.788**			
I.5	1.186**	-0.005	0.000	0.000**	-0.127**	-0.004	-0.010**
II.1	7.879	0.676	0.115	-0.017	-1.438		
II.2	5.912**	-0.011	-0.002	-0.001**	-0.975**		
II.3	-0.007	7.798**	0.009	-0.047			
II.4	0.002	-0.017	0.007	0.133			
II.5	-0.135*	-0.064*	0.303	0.799**			
III.1	-4.391	2.293	-0.932**	-2.713	-0.017	-0.326	
III.2	5.713**	0.036	-0.000	0.329**	-0.002**	-1.050**	
III.3	-0.013	-0.027	7.846**				
III.4	-0.122**	0.371**	0.781**				
III.5	0.347	0.135**	-0.078**	0.030			
IV.1	-4.391	2.293	-0.932**	-2.713	-0.017	-0.326	
IV.2	5.713**	0.036	-0.000	0.329**	-0.002**	-1.050**	
IV.3	-0.501**	7.886**	0.191**	-0.003	-0.196**		
IV.4	0.037	0.188**	-0.029				

Columbus

I.1	3.905	0.696	0.006	-0.007	-1.032**		
I.2	5.904**	0.027	0.004	-0.000**	-0.997**		
I.3	7.563**	-6.587**	-0.003	-0.075			
I.4	2.038**	1.071	-1.130	0.629**			
I.5	1.135**	-0.013	0.007	0.000**	-0.133**	-0.007*	-0.010**

II.1	6.273**	0.141	0.424	-0.010	-1.092
II.2	6.018**	0.000	0.011**	-0.000	-0.999**
II.3	o.002	7.413**	0.035	-0.098**	
II.4	0.002*	0.415**	-0.001	-0.176**	
II.5	-0.040	0.253	0.054	0.453**	

III.1	3.222	0.822	-0.460	-7.354	0.002	0.370
III.2	5.854**	0.041**	0.003	0.272**	-0.009**	-1.043**
III.3	-0.008	-0.034	7.476**			
III.4	-0.074	0.358**	0.486**			
III.5	0.142	0.156**	-0.074**	0.043**		

IV.1	3.222	0.822	-0.460	-7.354	0.002	0.370
IV.2	5.854	0.042**	0.003	0.272**	-0.009**	-1.043**
IV.3	-0.125	7.434**	0.049	0.025	-0.126**	
IV.4	-0.030	0.358**	0.441**			
IV.5	0.038	0.173	-0.032			

Dayton

I.1	1.360	1.597	-0.271	-0.019**	-0.969**		
I.2	6.023**	-0.035	0.023**	0.000	-0.986**		
I.3	7.513**	-5.858**	0.014	-0.036			
I.4	1.864**	-0.170	-0.094	0.754**			
I.5	1.200**	-0.001	0.005	0.000**	-0.148**	-0.006	-0.007
II.1	6.737**	0.360	0.395	-0.019	-1.182*		
II.2	5.912**	0.016	-0.000	-0.000	-0.995**		
II.3	-0.002	6.687**	0.020	-0.060			
II.4	0.001	-0.099	-0.000	0.223			
II.5	-0.087	0.277	-0.007	0.763**			
III.1	-2.811	2.720**	-0.761**	1.913	-0.050**	-2.804*	
III.2	5.979**	-0.018	0.021**	-0.109	0.000	-0.971**	
III.3	-0.008	-0.072**	6.789**				
III.4	-0.128**	0.323**	0.807**				
III.5	0.299	0.151**	-0.056*	0.012			
IV.1	-2.811	2.720**	-0.761**	11.913	-0.050**	-2.804**	
IV.2	5.979**	-0.018	0.012**	-0.109	0.000	-0.971**	
IV.3	-0.431**	6.770**	0.182**	0.007	-0.199**		
IV.4	-0.089*	0.397**	0.764**				
IV.5	0.113**	0.182**	-0.087*				

Toledo

I.1	5.958	0.730	-0.044	-0.008	-1.024**		
I.2	6.217**	-0.078	-0.002	0.000	-0.994**		
I.3	6.900**	-5.522**	0.006	-0.076			
I.4	1.796**	-0.864	0.486	0.842**			
I.5	1.101**	0.022	-0.005	0.000**	-0.154**	0.000	-0.012*
II.1	6.498**	0.233	0.210	-0.008	-1.137		
II.2	5.927**	-0.031	-0.015	0.000	-0.975**		
II.3	-0.024	6.387**	0.013	0.080**			
II.4	-0.000	-0.018	-0.016	0.186			
II.5	-0.126	0.162	0.110	0.907**			
III.1	1.848	1.259	-0.431	-3.513	-0.005	-0.232	
III.2	6.474**	-0.147*	0.026	0.164	0.000	-1.035**	
III.3	-0.008	0.055**	6.282**				
III.4	-0.149**	0.315**	0.944**				
III.5	0.527	0.109**	-0.092**	0.011			
IV.1	1.848	1.259	-0.431	-3.513	-0.005	-0.232	
IV.2	6.474**	-0.147*	0.026	0.164	0.000	-1.035**	
IV.3	-0.043	6.378	0.008**	0.011	0.071		
IV.4	-0.106	0.354**	0.881**				
IV.5	0.129	0.176**	-0.102*				

Youngstown

I.1	5.957**	0.449	-0.067	-0.005	-1.023**		
I.2	6.104**	-0.069	-0.014	0.000	-0.994**		
I.3	6.964**	-5.469**	-0.016	0.030			
I.4	1.686**	-1.001	0.639	1.009**			
I.5	1.379**	-0.072**	0.012**	0.001*	-0.163**	0.003	-0.005
II.1	6.552**	0.203	0.218	-0.008	-1.045**		
II.2	5.959**	-0.142	0.021	0.001	-0.949**		
II.3	0.008	6.090**	-0.041	-0.062			
II.4	0.001	-0.008	-0.001	0.170**			
II.5	-0.137	0.252	0.015	1.009**			
III.1	5.308**	0.629	-0.501*	-5.295	-0.004	0.158	
III.2	5.615**	0.168	-0.126**	0.405	-0.001	-1.036**	
III.3	0.008	-0.069	6.182				
III.4	-0.173	0.321	1.042				
III.5	1.049	0.029	-0.243	0.077			
IV.1	5.308**	0.629	-0.501*	-5.295	-0.004	0.158	
IV.2	5.615**	0.168	-0.126**	0.405	-0.001	-1.036**	
IV.3	-0.288	6.125**	0.149	-0.070	-0.214**		
IV.4	-0.135	0.356**	1.005**				
IV.5	0.447**	0.125**	-0.350**				

Allentown

I.1	4.121	0.797	-0.124	-0.012	-1.014**		
I.2	5.826	0.027*	0.003	-0.000**	-0.989**		
I.3	6.741**	-6.338**	-0.074	0.048			
I.4	2.037**	0.408	-0.643	0.853**			
I.5	1.167**	-0.044*	0.000	0.000**	-0.129**	0.006	0.005
II.1	7.008*	0.748	-0.072	-0.014*	-1.402**		
II.2	5.936**	0.012	0.004	-0.000**	-0.998**		
II.3	-0.010	7.783**	-0.016	-0.072			
II.4	0.004	0.304	0.003	-0.109			
II.5	-0.125*	-0.029	0.312**	0.754**			
III.1	3.090	0.991	-0.548	-2.276	-0.008	-0.466	
III.2	5.821**	0.031**	0.013**	0.243**	-0.001**	-1.036**	
III.3	-0.024	0.058	7.610**				
III.4	-0.115*	0.367&&	0.742**				
III.5	0.234	0.126	-0.087	0.047			
IV.1	3.090	0.991	-0.58	-2.276	-0.008	-0.466	
IV.2	5.821**	0.031**	0.013**	0.243**	-0.001**	-1.036**	
IV.3	-0.971**	7.927**	0.371**	-0.048	-0,350**		
IV.4	-0.070	0.291**	0.695**				
IV.5	0.040	0.159**	-0.034				

Altoona

I.1	4.527**	0.107	0.123	-0.007	-0.987**		
I.2	5.922**	0.015	-0.006*	-0.000	-0.989**		
I.3	5.397**	-6.026**	0.000	-0.059			
I.4	-0.052	-1.024	0.816	0.367**			
I.5	0.983**	-0.035	0.000	0.000**	-0.130**	-0.004	-0.013*
II.1	4.791**	-0.640	0.348*	-0.012*	-0.697		
II.2	5.965**	-0.004	-0.007	0.000	-0.988**		
II.3	-0.032	7.714**	0.075	0.010			
II.4	0.001	0.807	-0.013	-0.629			
II.5	0.051	0.628	-0.487	0.312			
III.1	3.921*	0.337	0.047	0.312	-0.009	-1.016	
III.2	5.948**	0.007	-0.004	0.194*	-0.000	-1.017**	
III.3	-0.027	0.196**	7.678**				
III.4	-0.011	0.002	0.379**				
III.5	-0.786	0.268**	-0.076**	0.185*			
IV.1	3.921*	0.337	0.047	0.312	-0.009	-1.016	
IV.2	5.948**	0.007	-0.004	0.194*	-0.000	-1.017**	
IV.3	-0.077	7.710**	0.017	0.070	-0.000		
IV.4	-0.015	0.107	0.378**				
IV.5	0.075	0.123**	-0.082				

Erie

I.1	4.910	0.263	0.028	-0.008	-0.984**		
I.2	5.634**	0.073**	-0.003	-0.001**	-0.988**		
I.3	6.202**	-5.659**	0.001	-0.039			
I.4	1.776**	-2.194*	1.691	1.102**			
I.5	1.098**	-0.015	-0.006	0.006**	-0.149**	-0.004	-0.012**

II.1	5.767**	0.136	0.224	-0.009	-1.083
II.2	5.930**	0.027	0.005	-0.000**	-1.008**
II.3	-0.009	6.698	0.051	-0.057	
II.4	0.003	0.360	0.004	-0.165	
II.5	-0.106	0.337	-0.011	0.931**	

III.1	2.508	0.854	-0.167	2.220	-0.015	1.294
III.2	5.630**	0.076**	0.011**	0.401**	-0.002**	-1.064**
III.3	-0.010	0.010	6.658**			
III.4	-0.148**	0.327**	0.974**			
III.5	0.065	0.162**	-0.053	0.037		

IV.1	2.508	0.854	-0.167	2.220	-0.015	-1.294
IV.2	5.630**	0.076**	0.011**	0.401**	-0.002**	-1.065**
IV.3	-0.156	6.726**	0.056	0.043	-0.106	
IV.4	-0.108*	0.360**	0.932**			
IV.5	0.067	0.161**	-0.059			

Harrisburg

I.1	4.282*	0.700	-0.061	-0.009	-0.996**		
I.2	5.637**	0.083**	0.007	-0.001**	-0.986**		
I.3	4.576	-4.586	-0.030	-0.047			
I.4	0.147**	3.055**	-2.439	0.575**			
I.5	1.014**	-0.062**	-0.000	0.000**	-0.113**	-0.008	-0.013
II.1	5.856**	-0.271	0.199	-0.007	-0.890**		
II.2	5.842**	0.077	0.006**	-0.001**	-1.017**		
II.3	-0.042	8.765**	0.011	-0.002			
II.4	0.004	0.006	0.000	0.108**			
II.5	-0.009	0.388	-0.304	0.575**			
III.1	4.200**	0.686	-0.187	-0.858	-0.003	-0.797**	
III.2	5.617**	0.094**	0.006	0.061	-0.001**	-0.996**	
III.3	-0.039	-0.002	8.675				
III.4	-0.051	0.009	0.589				
III.5	0.183	0.114	-0.165	0.197			
IV.1	4.200*	0.686	-0.187	-0.858	-0.003	-0.797**	
IV.2	5.617**	0.094**	0.006	0.061	-0.001**	-0.996**	
IV.3	0.099	8.518**	-0.053	0.060	-0.017		
IV.4	-0.050	0.136	0.587**				
IV.5	0.026	0.140**	-0.021				

Johnstown

I.1	5.900**	0.004	0.089	-0.005	-1.078**		
I.2	5.753**	0.015	0.002	-0.000	-0.979**		
I.3	6.078**	-5.386**	-0.013	0.010			
I.4	0.096	0.471	-0.402	0.484**			
I.5	1.233	-0.061	0.007	0.000**	-0.163**	-0.010	-0.014
II.1	5.513**	0.189	0.068	0.012*	-1.041**		
II.2	5.791**	0.006	-0.013	0.000	-0.980**		
II.3	0.003	6.206**	0.037	-0.143**			
II.4	0.003	-0.086	0.007	0.288			
II.5	-0.007	0.407	-0.330	-0.007			
III.1	5.830**	-0.162	-0.020	-5.048**	0.002	0.020	
III.2	5.756**	0.018	0.002	0.166**	-0.000**	-1.012**	
III.3	-0.007	-0.148*	6.129**				
III.4	-0.051	0.004	0.528**				
III.5	2.966**	-0.324**	-0.210**	-0.263**			
IV.1	5.830**	-0.162	-0.020	-5.048**	0.002	0.020	
IV.2	5.756**	0.018	0.002	0.166**	-0.000**	-1.012**	
IV.3	-0.022**	6.163	0.012	0.0364	-0.151**		
IV.4	-0.051	0.035	0.529**				
IV.5	0.174*	0.157**	-0.153**				

Lancaster

I.1	3.276	0.849	-0.141	-0.009	-0.100**		
I.2	5.752**	0.049**	-0.001	-0.000**	-0.983**		
I.3	6.075**	-6.272**	-0.042	-0.049			
I.4	2.172**	0.355	-0.625	0.822**			
I.5	0.919**	-0.003	-0.007	0.004**	-1.247**	-0.004	-0.010**
II.1	5.897**	0.453	0.212	-0.011	-1.267*		
II.2	5.936**	0.037	0.002**	-0.004**	-1.008**		
II.3	-0.011	7.977**	0.054	-0.073			
II.4	0.003	0.192	0.011	-0.045			
II.5	-0.083	-.117	0.234	0.648**			
III.1	1.926	1.127	-0.407	0.892	-0.012	-0.943	
III.2	5.766**	0.046**	0.013**	0.323**	-0.001**	-1.038**	
III.3	-0.015	0.068**	7.774**				
III.4	-0.098	0.402**	0.662**				
III.5	0.038	0.143**	-0.032	0.023			
IV.1	1.926	1.127	-0.407	0.892	-0.012	-0.943	
IV.2	5.766**	0.046**	0.013**	0.328**	-0.001**	-1.038**	
IV.3	-0.492**	8.062**	0.165*	0.019	-0.190**		
IV.4	-0.049	0.435**	0.612**				
IV.5	0.046	0.142**	-0.459				

Philadelphia

I.1	8.281	-0.006	0.369	-0.017*	-0.980**		
I.2	6.105**	-0.013	0.009	-0.000**	-0.997**		
I.3	9.063**	-0.128**	-0.047	-0.047			
I.4	1.948**	-0.100	-0.121	0.774**			
I.5	1.209**	-0.021	0.012	0.000**	-0.105**	0.000	-0.000
II.1	8.109**	0.315	0.537	-0.019	-1.234		
II.2	6.029**	-0.031	-0.002	-0.000**	-0.963**		
II.3	-0.000	9.392**	-0.002	-0.086*			
II.4	0.002	-0.026	0.002	0.120			
II.5	-0.076	0.242	-0.064	0.730**			
III.1	-7.242	2.490	-0.920*	0.878	-0.041	-1.818	
III.2	6.001**	0.004	0.000	0.058	-0.000	-1,007**	
III.3	-0.014	-0.082**	0.953**				
III.4	-0.199**	0.342**	0.774**				
III.5	0.857	0.158**	-0.190	0.008			
IV.1	-7.242	2.490	-0.920*	0.878	-0.041	-1.818	
IV.2	6.001**	0.004	0.000	0.058	-0.000	-1.007**	
IV.3	-0.344	0.945**	0.132	-0.008	-0.179**		
IV.4	-0.078	0.262**	0.732**				
IV.5	0.067	0.161**	-0.058				

Pittsburgh

I.1	3.833	0.863	-0.109	-0.013	-1.020**		
I.2	7.649**	0.332**	0.036**	0.001**	-0.986**		
I.3	8.629**	-7.117**	0.014	-0.049			
I.4	1.150**	0.250	-0.361	1.149**			
I.5	1.468**	-0.053**	0.008	0.000**	-0.131**	-0.008	-0.011
II.1	7.960**	0.472	0.233	-0.012*	-1.292		
II.2	6.009*	-0.239**	-0.018*	0.001**	-0.791**		
II.3	-0.006	7.651**	0.049	-0.072			
II.4	0.001	0.024	-0.003	-0.025			
II.5	-0.155	0.157	0.003*	1.108**			
III.1	2.991	0.990	-0.656**	-4.995	-0.008	-1.076	
III.2	7.337**	-0.266**	0.013	0.300	0.000*	-1.052**	
III.3	-0.009	-0.049	7.675**				
III.4	-0.179**	0.211*	1.126**				
III.5	-0.673	0.309**	-0.020	0.091			
IV.1	2.991	0.990	-0.656**	-4.995	-0.008	-1,076	
IV.2	7.337**	-0.266**	0.013	0.300	0.000*	-1.052**	
IV.3	-0.321	7.729**	0.179	9.038	-0.261		
IV.4	-0.155**	0.245**	1.111**				
IV.5	0.117	0.178**	-0.096				

Reading

I.1	9.130**	-1.324**	1.533**	-0.000	-1.090**		
I.2	6.252**	-0.072**	0.013**	0.000**	-0.996**		
I.3	6.089**	-0.011**	-0.101				
I.4	2.515**	-1.819	1.236	0.119			
I.5	0.959**	-0.012	0.010	0.000*	-0.130**	-0.006	-0.027**
II.1	5.591**	-0.013	0.494	-0.008	-1.006		
II.2	6.051**	-0.017	-0.031	0.000	-0.983**		
II.3	0.142	7.738**	-0.012	-0.175**			
II.4	-0.000	-0.844	-0.000	0.840			
II.5	0.022	0.564	-0.175	-0.009			
III.1	11.579**	-1.435**	1.412**	-3.025	0.002	-1.133**	
III.2	6.237**	-0.062**	0.011**	0.228**	-0.000	-1.035**	
III.3	-0.015	0.007	7.657**				
III.4	-0.053	0.390**	0.084				
III.5	0.086	0.138	0.086	0.078			
IV.1	11.579**	-1.435**	1.412**	-3.025	0.002	-1.133**	
IV.2	6.237**	-0.062**	0.011**	0.228**	-0.000	-1.035**	
IV.3	0.191	7.646**	-0.061	-0.001	-0.168**		
IV.4	-0.004	0.153**	0.026				
IV.5	0.062	0.142**	-0.061				

Scranton

I.1	4.351	-0.223	1.320**	-0.001	-1.043**		
I.2	6.815**	-0.224**	0.005	0.000**	-0.993**		
I.3	5.267**	-6.107**	-0.072	-0.091			
I.4	2.563**	0.992	-1.216	0.076			
I.5	0.743**	0.009	0.001	0.000	-0.114**	-0.002	-0.011
II.1	3.841**	1.171	0.705**	-0.004	-1.520**		
II.2	6.159**	-0.218**	-0.084**	0.000	-0.856**		
II.3	0.011	8.920**	-0.031	-0.188**			
II.4	0.003	0.721**	-0.000	-0.519			
II.5	0.038	0.691*	-0.234	-0.067			
III.1	5.493**	0.064	1.237**	-0.217	-0.008	-1,523**	
III.2	6.801**	-0.217**	0.004	-0.398*	0.002**	-0.946**	
III.3	-0.017	0.121	8.441*				
III.4	-0.044	0.400**	0.026				
III.5	0.615	0.229**	0.031	0.063			
IV.1	5.493**	0.064	1.237**	-0.217	-0.008	-1.523**	
IV.2	6.801**	-0.217**	0.004	-0.398*	0.002**	-0.946**	
IV.3	-0.158	8.848**	0.062	-0.042	-0.193**		
IV.4	0.003	0.171**	-0.021				
IV.5	0.046	0.120**	-0.052				

Wilkes Barre

I.1	8.611*	-0.647	1.411*	0.001	-1.430**		
I.2	6.012**	-0.000	0.008	-0.000	-1.001**		
I.3	5.285**	-6.314**	-0.070	-0.072			
I.4	0.558	-2.974**	2.477**	-0.033			
I.5	0.735**	0.001	0.005	0.000**	-0.104**	-0.000	-0.010*
II.1	6.082**	-0.023	1.093*	-0.001	-1.329**		
II.2	6.011**	0.023	-0.033	-0.000	-1.001**		
II.3	-0.003	9.797	-0.037	-0.125**			
II.4	0.002	-0.942	0.015	0.880			
II.5	0.091	0.706	-0.609	-0.102			
III.1	7.602**	-0.388	0.940**	2.833	-0.021	-1.674**	
III.2	6.022**	-0.002	0.006	-0.041	-0.000	-0.995**	
III.3	-0.028	0.047	9.689**				
III.4	-0.001	-0.005	0.010				
III.5	0.107	0.104	-0.017	0.000			
IV.1	7.602**	-0.388	0.940**	2.833	-0.021	-1.674**	
IV.2	6.022**	-0.002	0.006	-0.041	-0.000	-0.995**	
IV.3	-0.005	9.673**	0.001	-0.040	-0.126**		
IV.4	-0.002	-0.140	0.014				
IV.5	0.028	0.117**	-0.030				

York

I.1	5.705**	-0.349	0.954**	-0.000	-1.071**		
I.2	6.607**	-0.184**	-0.016	0.001**	-0.995**		
I.3	5.087	-5.445	-0.162	-0.089			
I.4	2.422	-0.816	0.375	-0.051			
I.5	0.801**	-0.014	0.007	0.000**	-0.106**	0.004	-0.015*
II.1	4.300**	-0.198	1.173**	0.000	-1.017**		
II.2	6.133**	-0.158**	-0.072**	0.000	-0.907**		
II.3	0.006	8.859**	-0.127	-0.070			
II.4	0.004*	0.144*	0.008	-0.020			
II.5	0.053	0.640	-0.235	-0.147			
III.1	8.758**	-0.837**	1.366**	-2.661	0.005	-1,280**	
III.2	6.302**	-0.094**	-0.000	-0.978**	0.004**	-0.871**	
III.3	-0.027	-0.037	8.909**				
III.4	-0.030	0.401**	-0.058				
III.5	-0.029	0.135**	-0,002	0,006			
IV.1	8.758**	-0.837*	1.366**	-2.661	0.005	-1.280**	
IV.2	6.302**	-0.094**	-0.000	-0.978**	0.004**	-0.871**	
IV.3	0.040	8.751**	-0.010	-0.125	-0.070		
IV.4	0.017	0.158**	-0.104				
IV.5	0.031	0.124	-0.030				

APPENDIX A.5

Parameter Estimates of the Final Model

Detroit

1	5.149	0.652	-0.017*	-0.986**	
2	6.021**	0.071	-0.000**	-0.826**	-0.121
3	0.001	6.471**	-0.075		
4	-0.089	0.209**	0.739**		
5	0.003	0.195**	0.007		

$\lambda_1 = +0.200$ $\lambda_2 = -0.012$

Indianapolis

1	4.344	0.685	-0.014*	-0.966**	
2	5.727**	0.077**	-0.000	-0.827**	-0.148**
3	-0.005	8.635**	-0.046		
4	-0.039	0.297**	0.478**		
5	0.002	0.180**	0.002		

$\lambda_1 = +0.230$ $\lambda_2 = -0.220$

Albany

1	5.271*	0.368	-0.013*	-0.988**	
2	5.856**	0.039**	-0.000**	-0.988**	-0.009
3	-0.010	7.263**	-0.017		
4	-0.106	0.295**	0.833**		
5	0.004	0.164**	0.015		

$\lambda_1 = +0.029$ $\lambda_2 = -0.005$

Binghamton

1	3.955	0.673	-0.014**	-0.981**	
2	5.717**	0.086**	-0.000**	-0.897**	-0.094**
3	0.012	7.140**	-0.128**		
4	-0.062	0.311**	0.639**		
5	0.002	0.147**	0.010		

$\lambda_1 = +0.136$ $\lambda_2 = -0.014$

Buffalo

1	4.719	0.585	-0.017**	-0.975**	
2	5.553**	0.092**	-0.001**	-0.776**	-0.185**
3	-0.001	7.348**	-0.086**		
4	-0.131**	0.230**	0.982**		
5	0.002	0.192*	0.000		

$\lambda_1 = +0.270$ $\lambda_2 = -0.021$

New York

1	3.008	0.744	-0.024**	-0.961**	
2	5.811**	0.024	-0.000**	-0.829**	-0.107**
3	-0.020	10.706**	0.048		
4	-0.012	0.263**	0.346**		
5	0.001	0.162**	0.003		

$\lambda_1 = +0.238$ $\lambda_2 = -0.098$

Rochester

1	3.765	0.662	-0.012	-0.982**	
2	5.517**	0.098**	0.000	-0.682**	-0.262**
3	-0.023	7.318**	0.054		
4	-0.089	0.307**	0.815**		
5	0.002	0.179**	0.000		

$\lambda_1 = +0.352 \quad \lambda_2 = -0.016$

Syracuse

1	4.629	0.500	-0.014**	-0.977**	
2	5.858**	0.037**	-0.000**	-0.974**	-0.022
3	-0.023*	7.319**	0.056		
4	-0.099	0.326**	0.858**		
5	0.001	0.185**	-0.008		

$\lambda_1 = +0.059 \quad \lambda_2 = -0.010$

Utica - Rome

1	3.213	0.729	-0.015**	-0.962**	
2	5.663**	0.101**	-0.001**	-0.808**	-0.191**
3	0.000	7.380**	-0.047		
4	-0.077	0.329**	0.702**		
5	0.002	0.150**	0.000		

$\lambda_1 = +0.258 \quad \lambda_2 = -0.028$

Akron

1	4.519	0.595	-0.013*	-0.979**	
2	5.528**	0.127**	-0.000**	-0.791**	-0.184**
3	-0.004	6.272**	-0.002		
4	-0.072	0.246**	0.656**		
5	0.000	0.210**	-0.007		

$\lambda_1 = +0.248 \quad \lambda_2 = -0.018$

Canton

1	4.974*	0.492	-0.012*	-0.971**	
2	6.035**	-0.017	0.000**	-0.806**	-0.180**
3	0.015	6.254**	-0.143**		
4	-0.097*	0.319**	0.816**		
5	0.002	0.183*	0.006		

$\lambda_1 = +0.246 \quad \lambda_2 = -0.023$

Cincinnati

1	3.962	0.644	-0.013	-0.981**	
2	5.614**	0.049**	0.000**	-0.823**	-0.132**
3	-0.005	7.842**	-0.029		
4	-0.063	0.268**	0.646**		
5	0.001	0.184**	-0.001		

$\lambda_1 = +0.212 \quad \lambda_2 = -0.016$

Cleveland

1	4.411	0.663	-0.017*	-0.981**	
2	5.318**	0.110**	-0.001**	-0.677**	-0.234**
3	-0.005	7.800**	-0.049		
4	-0.079	0.245**	0.738**		
5	0.002	0.190**	0.002		

$\lambda_1 = +0.359 \ \lambda_2 = -0.017$

Columbus

1	4.348	0.557	-0.011	-0.985**	
2	5.658**	0.088**	-0.000	-0.807**	-0.175**
3	0.009	7.407**	-0.106**		
4	-0.031	0.328**	0.442**		
5	0.002	0.179**	0.000		

$\lambda_1 = +0.221 \ \lambda_2 = -0.013$

Dayton

1	4.412	0.708	-0.014*	-0.970**	
2	5.779**	0.036	-0.000	-0.947**	-0.033
3	0.001	6.685**	-0.064*		
4	-0.089	0.270**	0.765**		
5	0.002	0.192**	0.007		

$\lambda_1 = +0.099 \ \lambda_2 = -0.016$

Toledo

1	5.094	0.434	-0.000	-1.008**	
2	6.042**	-0.030	0.001**	-0.780**	-0.192**
3	-0.014	6.404**	0.034		
4	-0.094	0.277**	0.803**		
5	0.004	0.178**	0.016		

$\lambda_1 = +0.203$ $\lambda_2 = +0.009$

Youngstown

1	5.701**	0.450	-0.010	-0.968*	
2	6.238**	-0.145	0.000	-1.002**	-0.011
3	-0.000	6.096**	-0.053		
4	-0.135*	0.262**	1.007**		
5	0.011	0.114**	0.077**		

$\lambda_1 = +0.028$ $\lambda_2 = +0.001$

Allentown

1	8.581**	-0.403	-0.005	-0.982**	
2	5.817**	0.032**	-0.000**	-0.960**	-0.026
3	-0.020	7.779**	-0.025**		
4	-0.085	0.289**	0.781**		
5	0.003	0.169**	-0.002**		

$\lambda_1 = +0.254$ $\lambda_2 = -0.016$

Altoona

1	3.457**	0.526	-0.007	-0.955**	
2	5.845**	0.049**	0.000	-0.865**	-0.159**
3	-0.017	7.702**	-0.004		
4	-0.011	0.023	0.378**		
5	0.002	0.139**	-0.004		

$\lambda_1 = +0.209$ $\lambda_2 = -0.029$

Erie

1	4.525	0.352	-0.009	-0.968**	
2	5.687**	0.061**	-0.000**	-0.956**	-0.034
3	0.001	6.687**	-0.068*		
4	-0.108	0.330**	0.933**		
5	0.002	0.167**	0.005		

$\lambda_1 = +0.050$ $\lambda_2 = -0.008$

Harrisburg

1	4.895**	0.400	-0.009	-0.974**	
2	5.601**	0.100**	-0.001**	-0.984**	-0.001
3	-0.028	8.727**	-0.072		
4	-0.050	0.026	0.587**		
5	0.005	0.139**	0.004		

$\lambda_1 = +0.050$ $\lambda_2 = -0.009$

Johnstown

1	4.797**	0.358	-0.012**	-0.969**	
2	5.703**	0.045**	-0.000**	-0.815**	-0.177**
3	0.011	6.197**	-0.150**		
4	-0.051	0.021	0.528**		
5	0.002	0.185**	0.002		

$\lambda_1 = +0.240 \quad \lambda_2 = -0.024$

Lancaster

1	4.439	0.463	-0.010	-0.974**	
2	5.756**	0.048**	-0.000**	-0.976**	-0.008
3	-0.001	7.977**	-0.084**		
4	-0.049	0.360**	0.612**		
5	0.002	0.145**	0.004		

$\lambda_1 = +0.060 \quad \lambda_2 = -0.010$

Philadelphia

1	4.574	0.630	-0.018*		
2	5.609**	0.066**	-0.001**	-0.688**	-0.217**
3	-0.001	9.391**	-0.085**		
4	-0.078	0.233**	0.732**		
5	0.002	0.166**	0.004		

$\lambda_1 = +0.362 \quad \lambda_2 = -0.023$

Pittsburgh

1	5.545	0.477	-0.017	-0.971	
2	5.858	0.032	-0.000	-0.379	-0.476
3	0.003	7.638	-0.082		
4	-0.154	0.166	1.108		
5	0.001	0.201	-0.002		

$\lambda_1 = +0.686$ $\lambda_2 = -0.027$

Reading

1	4.407	0.504	-0.012*	-0.976**	
2	6.128**	-0.031	0.000*	-0.899*	-0.093
3	0.011	7.733**	-0.172**		
4	-0.003	0.377**	0.019		
5	0.003	0.144**	0.007		

$\lambda_1 = +0.142$ $\lambda_2 = -0.017$

Scranton

1	4.096	0.442	-0.018*	-0.960**	
2	6.177**	-0.042	0.000	-0.616**	-0.397**
3	0.005	8.925**	-0.182**		
4	0.004	0.413**	-0.026		
5	0.004	0.113**	0.014		

$\lambda_1 = +0.458$ $\lambda_2 = 0.024$

Wilkes Barre

1	4.104	0.498	-0.011	-0.958**	
2	5.932**	0.020	-0.000	-0.921**	-0.075
3	-0.010	9.807**	-0.118*		
4	-0.001	0.035	0.010		
5	0.003	0.118**	0.002		

$\lambda_1 = +0.141$ $\lambda_2 = -0.022$

York

1	4.388	0.567	-0.010	-0.965**	
2	6.127**	-0.036	0.001**	-0.697**	-0.293**
3	-0.018	8.852**	-0.045		
4	0.018	0.389**	-0.109		
5	0.005	0.113**	0.014*		

$\lambda_1 = +0.367$ $\lambda_2 = -0.029$

APPENDIX A.6

Labour Force Size: July 1971

Labour Force Size, July 1971

City and State	Size
Indiana	
Indianapolis	480,000
Michigan	
Detroit	1,756,700
New York State	
Albany	324,400
Binghamton	122,700
Buffalo	572,700
New York City	5,558,400
Rochester	399,800
Syracuse	270,400
Utica-Rome	137,700
Ohio	
Akron	278,100
Canton	160,100
Cincinnati	590,900
Cleveland	950,300
Columbus	431,900
Dayton	373,000
Toledo	287,300
Youngstown	234,900
Pennsylvania	
Allentown	250,600
Altoona	57,000
Erie	114,900
Harrisburg	201,300
Johnstown	95,400
Lancaster	154,000
Philadelphia	2,148,800
Pittsburgh	995,400
Reading	138,900
Scranton	101,900
Wilkes-Barre	146,900
York	157,000

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