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The Ohio State University

PH.D. 1981

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A MULTIREGIONAL ECONOMETRIC MODEL OF OHIO

DISSERTATION

Presented in Partial Fulfillment of the Requirements for
the Degree Doctor of Philosophy in the Graduate
School of The Ohio State University

By

Catherine Ann Baird, B.A., M.A.

* * * * *

The Ohio State University
1981

Reading Committee:

Donald R. Haurin
W. L. L'Esperance
Gene Mumy

Approved By

Advisor

Department of Economics

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VITA

Born February 6, 1954 Pittsburg, Kansas

1974 B.A., Pittsburg State University,
Pittsburg, Kansas

1975-1977 Teaching Associate, Department of
Economics, The Ohio State
University, Columbus, Ohio

1977 M.A., The Ohio State University,
Columbus, Ohio

1977 - 1978 Research Associate, The Academy
for Contemporary Problems,
Columbus, Ohio

1978 - 1981 Teaching Associate, Department
of Economics, The Ohio State
University, Columbus, Ohio

PUBLICATIONS AND PRESENTATIONS

Wilford L. L'Esperance, Catherine A. Baird, and Alexander Shumay. "A Comparison of Estimates of Gross State Product." Regional Science Perspectives, Vol. 9, No. 1, 1979. p. 48-83. Also presented at the Mid-Continent Regional Science Association meeting in Lexington, Kentucky on May 18, 1978.

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FIELDS OF STUDY

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Minor Fields: Public Finance, Econometrics

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Chapter I

INTRODUCTION

Ohio can be regarded as a system of regions called cities, linked economically to each other and to rural areas. Their growth is both endogenous and exogenous. The purpose of this dissertation is to model the system econometrically.

"Regions" is an ambiguous term. Several types have been defined as appropriate to various uses. A Standard Metropolitan Statistical Area (SMSA) fits the specification of a nodal region and a planning or programming region (Richardson, 1969). A nodal region is a group of heterogeneous units, closely related to each other through such visible flows as population and goods. The idea of a nodal region focuses on the dominant center of the region and its interdependence with the area around it. A city and its hinterland is a clear example of a nodal region. A planning or programming region, on the other hand, tends to be thought of as a political jurisdiction for ease of policy formation, though ideally it is a natural geographic area under the influence of cohesive economic forces. Again, a city and its hinterland is an example of a planning region.

Both the theoretical concept of a nodal region and the more practical notion of a planning region are appropriate in this study. An SMSA, as "an integrated economic and social unit with a large population nucleus" (U.S. Department of Commerce, 1973), fits the conceptual and data-gathering needs at hand.

There are seventeen SMSAs which have at least one county in Ohio, including fifteen which can be classified as Ohio SMSAs. A list of the largest Ohio SMSAs and their populations appears in Table 1. Both time and data constraints required that this dissertation include only a few major SMSAs: Cincinnati, Cleveland, Columbus, Dayton, and Toledo. They contain twenty Ohio counties, three Kentucky counties, one Indiana county, and one Michigan county. Consequently, the model of Ohio is structured as six linked submodels: five of the SMSAs and a balance-of-state model. The model is annual over 1950-1977.

Each submodel is intended to capture the economy of its region, within theoretical and data limitations. Each submodel contains equations for demand, supply, the labor market, a construction sector, and local government. The demand, supply, labor demand, and employment equations are disaggregated over the major nonmanufacturing categories and the two-digit SIC level of manufacturing. This means that

there are potentially 139 endogenous variables for each submodel, though in practice there are fewer because no region has all possible manufacturing sectors.

The rest of this dissertation contains a discussion of the relevant literature, a description of the theoretical basis of the model, a description of the data, a presentation of results, and an evaluation of the model.

Chapter II

LITERATURE REVIEW

In this review, two distinct types of models are discussed. The published multiregional models are important for the way they link regions. Several SMSA models are also discussed because their structures and specifications are applicable to the SMSA submodels within the Multiregional Econometric Model of Ohio (MREMO).

The review is divided into discussions of the specification of output, the construction sector, the labor market, and local government. Each SMSA submodel of the MREMO is divided into demand, supply, construction, the labor market, and local government sections. However, since several of the models under review do not have distinct demand and supply equations, these two types of equations are discussed together under output.

The SMSA models that will be reviewed are two versions of Glickman's Philadelphia model (1971, 1977), Loxley's and McCarthy's Cleveland model (1976), Engle's model of Boston (1977), Rubin's and Erickson's model of Milwaukee (1980), and Duobinis' Chicago model (forthcoming).

Four multiregional models will be discussed. One appeared in the Journal of Regional Science in 1977. The other three were presented at the November, 1978 Regional Science Association meeting and were published in the Journal of Regional Science in 1980 as part of a symposium on multiregional forecasting and policy simulation. The papers were written by Ballard and Glickman (1977); Ballard and Wendling (1980); Milne, Glickman, and Adams (1980); and Treyz (1980).

2.1 OUTPUT

There are three ways that output was specified in the 10 models reviewed here: one equation, two equations, and not at all. Most of the models used one equation for a given sector.

Those which did not specify output were Loxley's and McCarthy's Cleveland model, Engle's Boston model, and Treyz's proposed national multiregional model. Loxley and McCarthy and Engle both objected to available output data in their decisions not to specify output. Loxley's and McCarthy's model is quarterly, and its main purpose is to forecast employment. Engle, however, used the reduced form of demand and a production function to specify employment. Treyz has a peculiar description of two equations which have to do with demand and supply. The supply-type equation

makes the average cost of producing a product in a given state (relative to the average national cost) a function of a number of ratios, such as state to national wages. The closest he comes to specifying demand for output is to say that "changes in state k 's national share of consumption demand will be based on changes in relative real personal disposable income and budget studies" (p. 202). He goes on to mention Cobb-Douglas utility functions but does not derive an equation.

The rest of the models except for Duobinis' Chicago model used one equation for output. The approaches will be presented in the following paragraphs.

The original Philadelphia model (Glickman, 1971) had only three output equations: one for manufacturing, one for wholesale and retail trade, and one for all other private nonmanufacturing. The manufacturing equation had output as a function of GNP. In the other two equations, Philadelphia personal income was the explanatory variable. All three of these equations are demand equations without prices.

The latest published Philadelphia model (1977) has 19 output equations, including 12 for manufacturing sectors. Unlike the original model's output equations, these output equations are not identifiable as demand, supply, or a

reduced form of demand and supply, although they resemble demand equations more than supply equations. For most of the manufacturing equations, an export base approach was used, using information from an input-output table for the region. The table identified the industries which export most of their output. Three types of manufacturing output equations were specified. Printing is an example of a sector which Glickman considered to be primarily a local business. Printing output is a function of population and printing output lagged one period. Transportation equipment is one of the export industries. Its output is a function of U.S. transportation equipment, GNP, and time, which is supposed to represent Philadelphia's changing share of transportation output. Finally, the electrical machinery sector exports to the rest of the U.S. as well as selling output locally. Its output is a function of U.S. electrical machinery output, U.S. defense expenditures, and local nonelectrical machinery. Nonmanufacturing output in all sectors but construction is a function of personal income, population, and sometimes national output in the sector.

Rubin's and Erickson's Milwaukee model has 11 manufacturing output equations and six nonmanufacturing output equations. The manufacturing equations have the region's market share in the sector as a dependent variable. The primary variable on the right hand side is relative

labor costs. A regional input-output table was used to determine which sectors were export-based and which were local. The export-based sectors have value added in the national counterpart industry as an additional explanatory variable. Sectors with primarily local demand have personal income per capita and population as additional explanatory variables. (They substituted these variables for value added in linked sectors because the value added terms were insignificant.) In addition, variables such as capital stock and dummies for plant closings were used in a few equations if they were significant. These equations contain both supply and demand variables, but they are not the reduced form of supply and demand.

The nonmanufacturing equations for Milwaukee use population and personal income per capita in the output equations. Services also has the ratio of the Milwaukee consumer price index to the U.S. consumer price index as an explanatory variable. The nonmanufacturing equations are essentially demand equations without prices.

The output equations in the multiregional model by Milne, Glickman, and Adams for the nine Census regions are similar to the Milwaukee equations. The dependent variable for the manufacturing sectors is the log of the market share divided by one minus the market share. It depends on the log of

relative labor costs and the log of relative energy costs. Sometimes a lagged dependent variable or a time trend are also included. Thus these resemble supply equations. Nonmanufacturing output is not disaggregated at all. Its dependent variable is the log of output per capita, and that is a function of the log of real personal income per capita. These resemble demand equations.

In the only published multiregional model for a subnational area (the 12-county Delaware Valley), Ballard and Glickman have output equations in each county for six major sectors. Output is a function of national output in the sector, regional income, and lagged regional output in the sector.

In a similar multiregional model for all 50 states, Ballard and Wendling specify 12 output equations for each state. Agriculture, mining, and manufacturing output are functions of state income, total output in the other states, and sometimes the ratio of the state wage to the national wage in the sector. All the other private output equations are functions of income and population. Thus these equations resemble demand equations.

There seems to be some confusion among researchers as to whether the single output equations are intended to specify demand, supply, their reduced form, or something else. Some

of the authors address this question, but only Engle bothered to derive the specification from standard microeconomic theory. Glickman, in particular, leaves the impression that he cast about for good statistical properties without concern for economic theory, although he does make use of an input-output table. Prices are missing from all the demand-type output equations. (Rubin and Erickson dropped prices from the Milwaukee model because the coefficients were insignificant.) In the sectors with demand-type equations, there is no acknowledgment that factor costs might be important. Likewise, in the supply-type equations, there is often no acknowledgment that the quantity of output also depends on how much is demanded. (Again, the Milwaukee model makes a step in this direction, although they use personal income and population in the manufacturing equations when manufacturing output would be more appropriate.)

The only published model to use both a demand-side and a supply-side output specification and to acknowledge microeconomic foundations is the Chicago model by Duobinis. He specifies a demand equation and a production function for every sector (14 manufacturing and five nonmanufacturing). Manufacturing demand is in log form. Value added is a function of price, the value added of local industries which demand the sector's output, and the value added of national

industries which demand the sector's output. (The local and national demand are derived from a Chicago input-output table.) The demand for nonmanufacturing output is again in log form. Output is a function of price and disposable income (lagged for econometric reasons). Services and finance, insurance, and real estate also include output in national sectors which consume their output, based on the input-output table.

The supply side of output determination used a transcendental logarithmic production function, which is less restrictive than the Cobb-Douglas production function. In log form, output is a function of labor hours and capital stock. (For the complete equation, see Chapter 3 in this dissertation.) For nonmanufacturing, no measure of capital is available, so a different form is used. Employment replaces labor hours, and lagged output in the sector replaces capital stock. The latter proxy is derived from investment theory.

This specification is a major improvement in subnational modeling of output. In the Multiregional Econometric Model of Ohio (MREMO), the demand equations are similar, but they include multiregional linkages. Supply equations are specified instead of production functions so that factor costs (rather than factor levels) are explicit in determining output.

It is interesting that the published multiregional models do not have multiregional linkages in the demand-type equations. Rather, they have only national linkages. Even in the equations with relative costs, "relative" refers to the nation, rather than to other regions. The MREMO has linkages among SMSAs in the demand equations. As this discussion progresses, further comparisons of linkages will be made.

2.2 CONSTRUCTION

In most of the models, construction is specified the same way other nonmanufacturing sectors are specified. The later Philadelphia model, the Milwaukee model, and the Chicago model recognize the fact that construction is special in its cyclical sensitivity.

In the Philadelphia model, construction output depends on total employment, lagged construction output, and time. (The interest rate was excluded because its coefficient was insignificant.) For Milwaukee, unemployment and lagged construction output were included, along with population and personal income per capita. In the Chicago model, the log of construction output depended on the log of price, the log of the value of housing starts, and the log of manufacturing investment (in lieu of total investment, which is unavailable at the SMSA level).

Construction demand comes from outside an SMSA as well as within it, particularly within a state. This is an important place to have multiregional linkages. In the MREMO, the demand equation resembles the Chicago equation, but number of housing starts in each region is used instead of their value, since the price should pick up the value. Manufacturing investment in each region is also included. In addition, housing starts and manufacturing investment in each region are specified so that important variables such as income and interest rates influence construction. The supply equation for construction is the same as the other supply equations.

2.3 LABOR MARKET

It would be tidier to break this section into parts which discuss different types of equations such as employment or wages. However, each model approaches the labor market with a different set of equations. Consequently, each model will be discussed in turn. Then general comments will be made, relating the discussion to the specification in the MREMO.

The Cleveland model, which is primarily for quarterly employment, uses labor hours rather than employment (number of people) in the manufacturing equations, since hours can be adjusted more easily than employment. The labor hours are then converted into employment in an adjustment equation. Labor hours themselves are a function of

"exogenous U.S. variables" (such as GNP, perhaps), labor hours in other industries (from an input-output table), lagged real wage income, seasonal dummies, time (for productivity and technology changes), and lagged labor hours. This is similar to a labor demand equation, but multicollinearity is probably introduced by putting exogenous U.S. variables and time in the equation together. Wage bills, not labor hours, are estimated for the nonmanufacturing sectors, primarily with seasonal dummies and other variables such as lagged personal income or an interest rate, depending on the sector. The purpose of all of these equations is to capture quarterly movement, and they are not very applicable to the MREMO. However, the use of labor hours rather than employment as a dependent variable is a sensible approach for the MREMO.

In the Boston model, manufacturing employment is derived from the reduced form of demand and a Cobb-Douglas production function with additional variables. Employment in each sector is a function of capital, wages, investment, U.S. value added in the sector, U.S. price, and transportation costs. Employment in two exported services (business services and finance, insurance, and real estate) is similar, with disposable income instead of investment and nonprofit employment instead of transportation costs. Five local employment equations include disposable income, wages,

the Boston consumer price index, investment, and U.S. unemployment as a cyclical variable.

The Boston production wage is a function of unemployment and the consumer price index. Twelve sectoral wages depend on the production wage, skill requirements in the sector, and occupational wages. The labor force is an identity incorporating employment and the unemployment rate as explanatory variables. The unemployment rate is a function of employment, the production wage, the Boston consumer price index, the U.S. consumer price index, the net natural population increase, and the U.S. wage rate. This equation is overdone, and several pairs of terms (such as the Boston CPI and the U.S. CPI) are probably collinear.

The Milwaukee employment equations are derived from an inverse production function with other variables added. The equations include output, capital, wages, personal income, a productivity measure, lagged employment, and a dummy for plant closings. Wages are a function of the national wage in the sector and another variable such as the unemployment rate or the ratio of the Milwaukee CPI to the U.S. CPI. The unemployment rate and population are also endogenous. The unemployment rate is a function of the national unemployment rate, total employment, and manufacturing capital (for the substitution effect). Population is a function of the net

natural increase and gross regional product (as a very broad proxy for migration).

The early Philadelphia model had employment (three sectors) as a function of output. Wages (three sectors) were specified as a function of the U.S. wage and unemployment. The labor force depended on total employment and time. Population was a function of the labor force and time. In the latest published version, employment in a particular sector is a function of that sector's output and lagged employment. Sometimes time and output in other sectors are included. The total average wage is a function of the national wage, regional unemployment, and the lagged wage.

In the Chicago model, labor's share of income is derived from the translog production function. (Wages and labor cannot be isolated in this functional form.) It is a function of labor and capital for the manufacturing sectors, and of employment and lagged output for the nonmanufacturing sectors (from investment theory). Labor hours come from an identity, and employment is a function of labor hours. The labor market is completed with identities for the labor force, population, total employment, unemployment, and the unemployment rate, as well as equations for the labor force participation rate and net migration. The labor force

participation rate depends on the lagged average wage rate and the lagged unemployment rate. Net migration is a function of the lagged ratio of the Chicago wage to the Chicago employment rate and the lagged ratio of the U.S. wage to the U.S. employment rate. Both of these equations are based on people's probability of being better off, either by being part of the labor force or by migrating to Chicago.

Three of the multiregional models have fairly standard equations. The fourth, proposed by Treyz for the nine Census regions, has a complex labor market, including employment based on labor intensity, input-output information, and regional linkages. There are also labor force deficit and surplus equations (dealing with excess demand and supply), and gross migration, labor force, labor force participation rate, voluntary departure, and wage equations. Because most of the data are unavailable for the MREMO, judgment will not be passed on this unconventional model.

Ballard and Glickman (12 counties in the Delaware Valley) specified employment as a function of output, the change in productivity, lagged employment, and another term. For larger counties, this term was the U.S. employment in the sector. For smaller counties it was what they call an "interaction variable" times total employment. The

interaction variable, in this case, is a transportation cost coefficient (not fully described) times the sum over counties of employment divided by distance. This is based on a gravity model concept, in which economic influences are eroded by distance. It is unclear, though, why both transportation cost and distance are necessary.

The other labor market equation for the Delaware Valley is for population, which is a function of lagged population, net natural increase, and gross regional product as a proxy for net migration. If it were not for gross regional product, this would be an identity instead of a behavioral equation. However, gross regional product is too broad a proxy to have much to do with net migration.

Ballard and Wendling, in their multiregional model of 50 states, have specified employment and wage equations. Employment in a sector is a function of output, a distributed lag of output divided by employment, national output divided by employment, and the regional wage divided by the national wage for the sector. The wage is usually a function of the U.S. consumer price index and a "behavioral variable" such as the unemployment rate.

Milne, Glickman, and Adams derive an employment function from a CES production function with partial adjustment. The

log of employment is a function of the log of output, the log of the real wage, and the log of lagged employment. The log of the wage rate is a function of the log of the sum of weighted wage rates in other states, the log of the unemployment rate, and the log of the state's share of output. The log of the sum of weighted wage rates is an odd variable, however admirable the attempt at multiregional linkages. It would seem that such a sum would merely be the national wage.

In the SMSA submodels of the MREMO, the important equations are for labor demand. Three different forms are derived from the Cobb-Douglas production function. They all incorporate information from the output market and both input markets (labor and capital), and the wage rate appears in all of them. These are essential elements for a labor demand function, yet one or more is missing from almost all of the specifications listed above. No "partial adjustment" terms are tacked on, because labor hours (if not necessarily employment) should be fairly flexible within a year, and this is an annual model. No wage equations are estimated. Wages are considered as essentially exogenous since they depend on national trends, collective bargaining, and so on. In an effort to keep the models as simple as possible, wages are treated as totally exogenous; the levels of inputs are easier to change on the SMSA level than wages are. However,

imbalances in the labor market must be accounted for, and so a labor force participation rate equation was specified the way it was for Chicago. The labor supply, population, unemployment, and the unemployment rate are treated in identities. (One part of this group must have a behavioral equation in order to make the others meaningful. In this case, it was the labor force participation rate.) Net migration is specified as a function of the lagged ratio of local to national wage rates and the lagged ratio of local to national employment rates. This is similar to the Chicago model in reasoning but less likely to suffer from collinearity.

2.4 LOCAL GOVERNMENT

Most of the SMSA models have rudimentary local government sectors. Milwaukee's is much more elaborate, including revenue, tax rates, expenditures, employment, and wages in behavioral equations which had some thought put into them. The multiregional models again have rudimentary local government sectors, but this is understandable since local government behavior probably has little impact on other regions. The MREMO is not much different, but local government employment needs to be specified to complete employment. It is a function of the average local government wage and tax revenue (as a proxy for total revenue). Tax revenue is specified as a function of personal income.

2.5 SUMMARY

A major difference between the MREMO and most of the SMSA and other multiregional models is that a valiant attempt has been made to gird it in standard microeconomic theory in the belief that economic relationships within and among the regions will be easier to analyze and predict. Thus both demand and supply equations have been specified. The labor demand equations have also been derived according to economic theory.

A comparison of regional linkages is revealing. Ballard and Glickman (Delaware Valley) link some of the employment equations and the retail sales equation by "interaction variables". This links them to the rest of the counties as a total, but not individually. Ballard and Wendling (50 states) also use an "interaction variable". They use some relative factor costs, but these are again relative to the nation as a whole, not to individual regions. Milne, Glickman, and Adams use a weighted sum of wage rates in one of their equations, but it is not clear why this is not the same as the national wage rate. Again, their relative costs are relative to the nation. In the MREMO, explicit links to each region have been included in the demand equations, as well as national links in the demand equations, net migration, and other equations.

Chapter III

THEORY

Each SMSA (including the balance of the state) has essentially the same model. These models are linked through the variables in the equations, forming the Multiregional Econometric Model of Ohio. This chapter describes the form of the basic SMSA model. Generally, whenever "SMSA" is mentioned, this includes the five SMSAs and the balance of the state.

The macroeconometric model has been constructed with close attention to standard microeconomic foundations in the belief that it will be more robust over time than an ad-hoc specification. Of course, in many cases the desired specification has been modified because of lack of appropriate data.

There are five sections of each SMSA model: demand, supply, labor market, construction sector, and local government.

3.1 DEMAND

There are demand equations for six private nonmanufacturing sectors in the model. They are farming; mining and other; wholesale and retail trade; finance, insurance, and real estate; transportation, communications, and utilities; and services. (Construction is discussed later.) The basis of each private nonmanufacturing equation is that demand is a function of price and income. The form of the demand equation¹ is

$$\ln Q(i,j) = \ln C(i,j) + a(i,j) * \ln P(i,j) + \text{SUM}(i=1,6)[b(i) * \ln Y(i)] \quad (1)$$

where $C(i,j)$ = constant

$Q(i,j)$ = output in sector j in SMSA i

$a(i,j)$ = price elasticity of demand

$P(i,j)$ = price of output in sector j in SMSA i

$b(i)$ = income elasticity of demand

$Y(i)$ = personal income in SMSA i .

However, the measure of output used is gross metropolitan product, or $[P(i,j) * Q(i,j)]$, rather than $Q(i,j)$. If $\ln P(i,j)$ is added to both sides of equation 1, the resulting equation will be equivalent to equation 1:

¹ "SUM(i=1,6)" is read as "summation over i where i goes from 1 to 6".

$$\begin{aligned} \ln[P(i,j) * Q(i,j)] &= \ln C(i,j) + \\ &[a(i,j) + 1] * \ln P(i,j) + \\ &\text{SUM}(i=1,6)[b(i) * \ln Y(i)] \end{aligned} \quad (2)$$

It is easy to calculate the price elasticity of demand $a(i,j)$ from equation 2, but the interpretation of the income elasticities $b(i,j)$ has changed. No longer does $b(i,j)$ represent $[\% \text{chg} Q(i,j) / \% \text{chg} Y(i)]$, but $[\% \text{chg}(P(i,j) * Q(i,j)) / \% \text{chg} Y(i)]$, where "%chg" means "% change". The expected sign of such a coefficient is difficult to predict because of the unknown effect of Y on P . The expected sign of $a(i,j)$, the price elasticity of demand, is negative.

Manufacturing demand is disaggregated to the two-digit SIC level. The number of manufacturing equations in the model varies by SMSA, depending on which sectors exist at a measurable level in the SMSA. The equations are similar to the nonmanufacturing demand equations, but gross metropolitan product in manufacturing replaces personal income in the equation. The idea is that manufacturing demand is a derived demand. One could construct a regional input-output table and use the coefficients to indicate which sectors demand the output of a given industry. At this aggregated level, the benefits of such an approach do not outweigh the time costs. Instead, gross metropolitan product in manufacturing is used to represent derived

demand, with a relatively small loss of information. The resulting equation is

$$\begin{aligned} \ln Q(i,j) = & \ln c(i,j) + a(i,j) * \ln P(i,j) + \\ & \text{SUM}(i=1,6) [c(i,j) * \ln QM(i)] + \\ & c(7,j) * \ln [QM(7) - \text{SUM}(i=1,6) [QM(i)]] \end{aligned} \quad (3)$$

where $QM(i)$ = gross metropolitan product in manufacturing in SMSA i

$QM(7)$ = gross national product in manufacturing.

7 = 7th "region", i.e., the U.S.

Again, gross product data are used for output, so that the equation that is estimated is

$$\begin{aligned} \ln [P(i,j) * Q(i,j)] = & [a(i,j) + 1] * \ln P(i,j) + \\ & \text{SUM}(i=1,6) \{c(i,j) * \ln [PM(i) * QM(i)]\} + \\ & c(7,j) * \ln \{PM(7) * QM(7) - \text{SUM}(i=1,6) [\ln [PM(i) * QM(i)]]\} \end{aligned} \quad (4)$$

where $PM(i)$ is the aggregate price of manufacturing output in SMSA i . The price elasticity of demand, $a(i,j)$, is easy to calculate from equation 4, and its expected sign is negative. The interpretation of $c(i,j)$ is $[\% \text{chg}(P(i,j) * Q(i,j))] / [\% \text{chg}(PM(i) * QM(i))]$. This can be expanded as follows:

$$[(QdP + PdQ) / (QMdPM + PMdQM)] * [(PM * QM) / (P * Q)] \quad (5)$$

The second term is positive, but the sign of the first term is unknown. If P rises, Q falls, and if PM rises, QM falls, but we cannot predict the size of the changes in Q or QM compared to the changes in P or PM , respectively. Furthermore, P may or may not rise when PM rises, so we

cannot say whether the numerator and denominator of the first term have the same sign or the opposite sign. Thus the entire coefficient has no expected sign. The intent of the equation is that increased manufacturing activity anywhere in the state will result in an increased demand for the output of sector j in SMSA i , which means that the coefficient should be greater than or equal to zero. However, the prices cloud that effect. Therefore, there is no a priori expectation on the sign of the gross metropolitan products in manufacturing and gross national product in manufacturing.

The interaction among SMSAs in the demand equations is obvious in the personal income and gross metropolitan product in manufacturing terms. An earlier version of the model included delivered prices for each SMSA, but they were dropped due to suspected multicollinearity. It was judged that the price in the SMSA of origin conveyed most of the information, especially within as small an area as Ohio.

3.2 SUPPLY

Many regional models are one-sided in that only demand equations are specified, yet the model of an economy is incomplete without a specification of supply. Researchers rarely estimate supply equations. They estimate either cost functions or production functions without relating either to the analysis of supply and demand.

The supply equation can be derived either by substituting the factor demand equations into the production function or by taking the partial derivative of the cost function with respect to output and setting the resulting equation equal to the output price. Both of these methods assume competitive markets. The production function maximizes output for given levels of input. The cost function, on the other hand, is the solution to a cost minimization problem for a specified output and given factor prices. Only the input quantities are endogenous. Duality analysis has shown that the production function approach and the cost function approach to supply are theoretically, but not necessarily statistically, equivalent (Christensen and Greene, 1976). This means that the existence of a particular production function which satisfies some regularity conditions implies the existence of one and only one cost function that corresponds to it, although it is not always computationally possible to derive the dual directly.

The causal chain in a regional economy suggests that, in a given industry, a certain level of output is demanded both locally and outside the area, taking into consideration the price. Furthermore, input prices depend a great deal on national wages and conditions and may be difficult for a regional industry to change. The industry can, however, change the level of inputs used in production. Hence, a

cost minimization problem more accurately represents local industry behavior than does a production maximization problem. Thus the supply equations in this model are derived from a cost function.

Next, a choice of functional forms must be made. References to both production functions and cost functions will be made because some of the concepts have been developed more explicitly in the production function literature than in the cost function literature.

An interesting class of production functions is generalized by the transcendental logarithmic (translog) production function:

$$\ln Q = \ln a(0) + \sum (\text{over } i) [a(i) * \ln X(i)] + \sum (\text{over } i) \sum (\text{over } j) [a(i,j) * \ln X(i) * \ln X(j)] \quad (6)$$

where Q is the output and $X(i)$, $X(j)$ are the factors of production. The translog places no a priori restrictions on substitutions among factors, and it allows scale economies to vary with the level of output (Christensen and Greene).

The Cobb-Douglas production function is a special case of the translog. If all $a(i,j)$ are zero, then a Cobb-Douglas production function results. If all $a(i,j)$ are zero except coefficients of cross-terms, the variable elasticity of substitution (VES) production function is the result. Thus the translog is a general form.

The translog cost function is

$$\begin{aligned} \ln C = & \ln b(0) + b(Q) * \ln Q + (b(QQ)/2) * ((\ln Q)^2) + \\ & \text{SUM}(\text{over } i)[b(i) * \ln P(i)] + \\ & (1/2) * \text{SUM}(\text{over } i) \text{SUM}(\text{over } j)[b(i,j) * \ln P(i) * \ln P(j)] + \\ & \text{SUM}(\text{over } i)[b(Q,i) * \ln Q * \ln P(i)] \end{aligned} \quad (7)$$

where C is the total cost, Q is the exogenous output, and $P(i)$, $P(j)$ are exogenous input prices. The Cobb-Douglas cost function is a special case of the translog cost function. If $b(QQ)$, $b(i,j)$, and $b(Q,i)$ are zero, then a Cobb-Douglas cost function results. If all $b(i,j)$ are zero except for the coefficients of cross-terms, then the VES cost function results. Again, the translog cost function is a general form.

Derivations of the translog supply curve expressed in two forms and the Cobb-Douglas supply curve can be found in Appendix C.² The results are

Translog (A):

$$\begin{aligned} \ln Q = & A + \text{SUM}(\text{over } i)[c(i) * S(i)] + \\ & \text{SUM}(\text{over } i) \text{SUM}(\text{over } j)[c(i,j) * S(i) * S(j)] \end{aligned} \quad (8)$$

where $S(i)$ are factor shares. For instance, labor's share of value is (WL/PQ) , where W is the wage rate and L is the labor hours.

² I am indebted to Francisco Bataller M. for the derivation of Translog (B).

Translog (B):

$$\begin{aligned} \ln P(Q) = & \ln\{d(Q) + 2*d(Q,Q)*\ln Q + \\ & \text{SUM}(\text{over } i)[d(Q,i)*\ln P(i)]\} + \\ & \ln d(0) + \text{SUM}(\text{over } i)\text{SUM}(\text{over } j)[d(i,j)*\ln P(i)*\ln P(j)] + \\ & \{d(Q) + d(Q,Q)*\ln Q + \text{SUM}(\text{over } i)[d(Q,i)*\ln P(i)] - 1\}*\ln Q \end{aligned} \quad (9)$$

Cobb-Douglas:

$$\begin{aligned} \ln P(Q) = & [\ln g(Q) - \ln g(0)] + \\ & \text{SUM}(\text{over } i)[g(i)\ln P(i)] - (1-g(Q))*\ln Q \end{aligned} \quad (10)$$

Translog (A) is appealing because of its simplicity, the ease with which it can be estimated and the type of data it requires. (Capital expenditure data are published, whereas capital stock is not.) However, if the "true" production function is Cobb-Douglas, translog (A) is meaningless. Not only will the coefficients be infinitely large (because of a division by zero), but the supply curve is absurd because it claims to predict changes in output from factor shares, which are constant for Cobb-Douglas production functions.

Translog (B) is intractable. It cannot be estimated by least squares because of the log-of-a-log terms. Furthermore, the Cobb-Douglas cannot be found by simply setting some coefficients equal to zero.

The problems with both forms of the translog supply curves occur because the production function is

nonhomothetic. Formally, a production function $f(x)$ is homothetic if and only if the corresponding cost function can be written as $c(w,q) = k(q)*c(w)$, where w =input price and q =output (Varian, 1978). The translog is not homothetic because the cost function cannot be written as a separable function of output and factor prices if all coefficients are significantly different from zero (Christensen and Greene). This nonseparability is what causes trouble in the translog supply equations.

As a result, the Cobb-Douglas supply equation will be used in this model. It has the elements essential to a supply curve: output, output price, and factor prices. Changes in output price result in movement along the curve; changes in factor prices shift the curve. Rewritten in terms of the variables used in this model, the supply equation is

$$\ln P(i,j) = \ln c(i,j) + g_L(i,j)*\ln W(i,j) + g_K(i,j)*\ln R - (1-g_Q(i,j))*\ln Q(i,j) \quad (11)$$

where $P(i,j)$ = price of output in sector j in SMSA i

$W(i,j)$ = average annual wage in sector j in SMSA i

R = national price of capital

$Q(i,j)$ = output in sector j in SMSA i

It is shown in Appendix D that if $g_Q(i,j)$ is greater than, equal to, or less than 1, the industry experiences decreasing, constant, or increasing returns to scale,

respectively. $gL(i,j)$ is equivalent to labor's share of value divided by $gQ(i,j)$. $gK(i,j)$ is equivalent to capital's share of value divided by $gQ(i,j)$.

However, the use of GMP, or PQ, for output changes the meaning of the coefficients. Putting equation 10 into antilog form:³

$$P(Q) = g(Q) * g(0) * \{ \text{PROD (over } i) [P(i) ** g(i)] \} * [Q ** (g(Q) - 1)] \quad (12)$$

Multiply both sides by $\{ P(Q) ** (g(Q) - 1) \}$:

$$P(Q) ** (g(Q)) = g(Q) * g(0) * [\text{PROD (over } i) [P(i) ** g(i)]] * [(P*Q) ** (g(Q) - 1)] \quad (13)$$

Solving for $P(Q)$:

$$P(Q) = [(g(Q) * g(0)) ** (1/g(Q))] * \{ (\text{PROD (over } i) [P(i) ** (g(i)/g(Q))] \} * [(P*Q) ** ((g(Q) - 1)/g(Q))] \quad (14)$$

The equation that is estimated, in the terms of equation 11, is:

$$\begin{aligned} \ln P(i,j) = & [(1/gQ(i,j)) * \ln c(i,j)] + \\ & [(gL(i,j)/gQ(i,j)) * \ln W(i,j)] + \\ & [(gK(i,j)/gQ(i,j)) * \ln R] - \\ & [(1-gQ(i,j))/gQ(i,j)] * \ln [P(i,j) * Q(i,j)] \end{aligned} \quad (15)$$

The scale parameter can be easily calculated from the estimated coefficient of $\ln [P(i,j) * Q(i,j)]$. Surprisingly, labor's share of value and capital's share of value are estimated directly.

³ "PROD(over i)" means "take the product of the following terms over the index i". "***" means "to the power".

3.3 LABOR MARKET

Labor demand is influenced by the output market, wages, and the market for other inputs. At least three different forms of labor demand incorporating these influences can be derived from the Cobb-Douglas production function. All three derivations, which can be found in Appendix E, assume that labor's wage equals the value of the marginal product of labor within a given industry. This assumption is violated by the presence of unions and other noncompetitive conditions, but a study of noncompetitive conditions in the labor market is outside the scope of this dissertation.

The three specifications of labor demand will be referred to as the output form, the price form, and the capital form. They are:

(1) Output form:

$$\begin{aligned} \ln L(i,j) = & \ln A(i) + a(1) * \ln GMP(i,j) + \\ & a(2) * \ln (W(i,j)/R) \end{aligned} \quad (16)$$

(2) Price form:

$$\begin{aligned} \ln L(i,j) = & \ln A(2) + b(1) * \ln P(i,j) + \\ & b(2) * \ln W(i,j) + b(3) * \ln R \end{aligned} \quad (17)$$

(3) Capital form:

$$\begin{aligned} \ln L(i,j) = & \ln A(3) + c(1) * \ln (W(i,j)/P(i,j)) + \\ & c(2) * \ln K(i,j) \end{aligned} \quad (18)$$

where $L(i,j)$ = annual labor hours in sector j in SMSA i

$GMP(i,j)$ = gross metropolitan product in sector j
in SMSA i

$W(i,j)$ = hourly wage rate in sector j in SMSA i

R = price of capital

$P(i,j)$ = price of output in sector j in SMSA i

$K(i,j)$ = capital stock in sector j in SMSA i

$A(1), A(2), A(3)$ = constants

The labor for each industry is aggregated over skill levels because of data limitations. The output form is most clearly a derived demand and includes the relative price of labor. The price form expresses essentially the same thing as the output form. The capital form can be used only for manufacturing because of data limitations. Here, the demand for labor depends on a given level of capital. Again, wages and output price are included.

In the output form of labor demand, the coefficient of $\ln GMP$ is expected to be positive, and the coefficient of the log of the relative wage is expected to be negative. In the price form of labor demand, the sign of the coefficient of $\ln W$ is expected to be negative; the coefficients of $\ln R$ and $\ln P$ are expected to be positive. In the capital form of labor demand, the sign of the coefficient of $\ln(W/P)$ is expected to be negative, and the sign of the coefficient of $\ln K$ is expected to be positive. These expectations are derived from the equations in Appendix E and assumptions about factor shares of income, but they also make intuitive sense.

Total labor demand is the sum of sectoral labor demand:

$$L(i) = \text{SUM}(\text{over } j) (L(i,j)) \quad (19)$$

Employment of full-time workers in each sector is determined by an identity:

$$E(i,j) = L(i,j) / AW(i,j) \quad (20)$$

where $E(i,j)$ = employment in sector j in SMSA i

$AW(i,j)$ = average weekly hours in sector j in SMSA i

The labor supply is determined for the SMSA as a whole via two behavioral equations and two identities. First, the labor force participation rate is hypothesized to depend on the unemployment rate in the region in the previous period and on the average wage in the region in the previous period (Duobinis):

$$LFPR(i) = a(1) + a(2)*W(i,-1) + a(3)*UR(i,-1) \quad (21)$$

where $LFPR(i)$ = labor force participation rate in SMSA i

$W(i,-1)$ = lagged average wage in SMSA i

$UR(i,-1)$ = lagged unemployment rate in SMSA i

People participate in the labor market according to their expected wage and the probability of getting a job. These expectations are formed partly by observation of past wage levels and unemployment rates. The lagged wage is expected to have a positive coefficient, while the lagged unemployment rate is expected to have a negative

coefficient. Since expectations need not match current conditions, the labor market need not clear every period. This means that there is no identity in the model saying that labor demand has to equal labor supply.

The labor supply is then defined as

$$LS(i) = LPFR(i) * POP(i) \quad (22)$$

where $LS(i)$ = labor supply in SMSA i

$POP(i)$ = population in SMSA i

The population in each period consists of everybody who lived there in the previous period, plus those born during the period, minus those who died, plus those who moved into the SMSA i , minus those who moved out:

$$POP(i) = POP(i, -1) + B(i) - D(i) + NM(i) \quad (23)$$

where $POP(i, -1)$ = population in SMSA i during previous period

$B(i)$ = births in SMSA i

$D(i)$ = deaths in SMSA i

$NM(i)$ = net migration in SMSA i

It is through net migration that the SMSA is linked to the rest of the nation. There are arguments for estimating gross migration and for estimating net migration. There are many articles on the subject, which will not be reviewed here, since net migration is the only practical approach for

Ohio SMSAs. (For a review of the literature, see Greenwood, 1975.) Net migration data can be calculated at the county level for any useful time span, whereas gross migration data exist only from 1971 on.

The gist of migration theory is that people move to improve their welfare. Although income is not the only influence on welfare, a great portion of migration can be explained by an expected increase in income or a higher expected probability of having a job (and thereby a higher income). A higher relative income can be represented by the ratio of the average wage in the SMSA to the average wage in the U.S.: $W(i)/W(N)$. For the probability of finding a job, we can find a proxy in the employment rate in an area. Again, this should be related to the U.S.: $ER(i)/ER(N)$. Since information does not travel instantaneously and major decisions take time to make, both terms are lagged one period, resulting in the following net migration equation:

$$NM(i) = a(1) + a(2) * [W(i)/W(N)](-1) + a(3) * [ER(i)/ER(N)](-1) \quad (24)$$

where $W(i)$ = average wage in SMSA i

$W(N)$ = average wage in the U.S.

(-1) = lagged one period

$ER(i)$ = employment rate in SMSA i

$ER(N)$ = employment rate in the U.S.

Both variables are expected to have positive coefficients.

Ideally, a multiregional model would include a specification of migration between each region in the model. This requires information about origin and destination of migrants, which is not available. A second approach would be to specify net migration as a function of wages and employment rates relative to each region outside the SMSA, so as to draw conclusions about the migration among SMSAs. However, there is not enough variation among the ratios for this to be done econometrically. So, quite implicitly, the SMSA is linked to the other SMSAs in such a way that information about migration flows through the labor supply equations.

Finally, the labor market equations are closed by total employment, unemployment, and unemployment rate identities:

$$E(i) = \text{SUM (over } j) (E(i,j)) \quad (25)$$

$$U(i) = LS(i) - E(i) \quad (26)$$

$$UR(i) = U(i) / LS(i) \quad (27)$$

where $E(i)$ = total employment in SMSA i

$E(i,j)$ = employment in sector j in SMSA i

$U(i)$ = unemployment in SMSA i

$LS(i)$ = labor supply in SMSA i

$UR(i)$ = unemployment rate in SMSA i

3.4 CONSTRUCTION SECTOR

This section of the model consists of equations for housing starts, manufacturing investment, and demand for construction. (The supply of construction is specified the same way as the supply of other sectors.)

Construction is comprised of both residential and nonresidential (business) activity. The number of housing starts is hypothesized to depend on the level of real savings in banks and savings and loans, the real interest rate on Treasury bills, real income per household, and the change in the number of households:

$$\begin{aligned} HS(i) = & a(1) + a(2)*S(i) + a(3)*RTB + \\ & a(4)*YHH(i) + a(5)*DHH(i) \end{aligned} \quad (28)$$

where $HS(i)$ = number of housing starts in SMSA i

$S(i)$ = real time deposits in banks and savings
and loans in SMSA i

RTB = real interest rate on Treasury bills

$YHH(i)$ = real personal income per household in SMSA i

$DHH(i)$ = change in the number of households in SMSA i

The level of savings is expected to have a positive effect on housing starts because there will be more funds available for loan at higher levels of savings. The interest rate on Treasury bills is expected to have a negative coefficient because higher interest rates make mortgages more expensive and housing starts less attractive.

(Mortgage rate data were not available over a long enough time span to be useful.) The expected sign of the coefficient of income per household is positive, as is the expected sign of the coefficient of the change in the number of households, both for straightforward reasons.

The other part of construction is related to business investment. Unfortunately, manufacturing investment must be used as a proxy for all investment because of lack of data. Investment is crudely hypothesized to depend on the value of manufacturing output (as a proxy for profit) and the corporate bond rate:

$$KX(i) = a(1) + a(2)*GMPM(i) + a(3)*RCB \quad (29)$$

where $KX(i)$ = capital expenditures in manufacturing
in SMSA i

$GMPM(i)$ = gross metropolitan product in manufacturing
in SMSA i

RCB = corporate bond rate

The coefficient of $GMPM$ is expected to be positive, and the coefficient of RCB is expected to be negative.

The demand for construction arises not only within an SMSA but also outside it, from both business and residential sources. It also depends on the price of construction.

Hence,

$$\begin{aligned} \ln GMP(i,4) = & a(1) + a(2) * \ln P(i,4) + \\ & \text{SUM}(\text{over } i)[b(i) * \ln HS(i)] + \\ & \text{SUM}(\text{over } i)[c(i) * \ln KX(i)] \end{aligned} \quad (30)$$

where $GMP(i,4)$ = gross metropolitan product in construction
in SMSA i (4 is the sectoral identification
code for construction)

$P(i,4)$ = price of construction in SMSA i

The coefficient of price can reveal the price elasticity of demand for construction in the same way it did for the other sectors.

3.5 LOCAL GOVERNMENT EMPLOYMENT AND REVENUE

There are three levels of government present in any SMSA: federal, state, and local. (Local includes county, city, and other jurisdictions.) Both state and federal activities are taken as exogenous to short-run economic conditions in an SMSA.

Local government revenue can come from a variety of sources, such as property taxes, sales taxes, income taxes, and excise taxes. A detailed revenue estimating model should include a housing model for property taxes and equations for each of the other taxes. In the interest of simplicity, however, revenue can be condensed to one equation in which revenue depends on personal income. This

is justified by the high correlation between consumption and income for the sales tax, and between property ownership and income for the property tax. Excise taxes are probably not as completely determined by income, but they are a small component of local government revenue (less than 3% in 1971, according to the Statistical Abstract of the United States). The local government revenue equation is

$$T(i) = a(1) + a(2)*Y(i) \quad (31)$$

where $T(i)$ = local government revenue in SMSA i

$Y(i)$ = personal income in SMSA i

The coefficient of Y is expected to be positive.

Local government employment depends to a large extent on the amount of revenue available and on the wages of the employees:

$$LGEMP(i) = a(i) + a(2)*T(i) + a(3)*WGOV(i) \quad (32)$$

where $LGEMP(i)$ = local government employment in SMSA i

$WGOV(i)$ = average wage of local government employees
in SMSA i

The sign of the coefficient of T is expected to be positive. The coefficient of the wage is expected to be negative, in accordance with the theory of labor demand.

3.6 SUMMARY

At this point, it is a good idea to point out the multiregional linkages in the model. They are most explicit in the demand for nonmanufacturing and manufacturing output.

Personal income in each SMSA potentially affects nonmanufacturing output in a given SMSA. Gross metropolitan product in manufacturing in each region potentially influences demand for manufacturing output. Furthermore, housing starts and manufacturing investment in each SMSA influence construction activity, and all the variables which affect housing starts and manufacturing investment thereby work themselves through to total output in each SMSA.

Due to the simultaneous nature of the model, these extraregional influences show up in supply equations via output and in the labor demand equations via either output or output price. Then net migration, insofar as it comes from or goes to other SMSAs in Ohio, affects the supply of labor and thereby unemployment and employment. Recall that the multiregional model covers the entire state because it includes the balance of the state.

Chapter IV

DATA

Subnational and especially substate data are notoriously hard to come by. Solutions to the worst problems deserve attention here. Gross product, capital stock, net migration, and prices will be discussed. A list of data sources appears in Appendix F.

4.1 GROSS PRODUCT

4.1.1 Gross State Product

It was necessary to estimate gross state product (GSP) in a consistent manner before gross metropolitan product (GMP) could be constructed. L'Esperance, Baird, and Shumay (1976) estimated GSP for 1949-1972 by the well-known Kendrick-Jaycox method (1965), but the series needed to be updated to 1977, as well as expanded in the manufacturing sector.

The Kendrick-Jaycox method was simplified by Weber's income received method (1979) for mining and other; wholesale and retail trade; finance, insurance, and real

estate; transportation, communications, and utilities; and services. The income received method is

$$\text{GSP}(i) = [\text{YR}(\text{OH},i) / \text{YR}(\text{US},i)] * \text{GNP}(i) \quad (33)$$

where $\text{YR}(\text{OH},i)$ = income received in Ohio in sector i

$\text{YR}(\text{US},i)$ = income received in the United States in
sector i

$\text{GSP}(i)$ = gross state product in sector i

$\text{GNP}(i)$ = gross national product in sector i

GSP for farming was estimated by the direct method described in Kendrick-Jaycox (1965). The only difference was that imputed rent is no longer published for states. Consequently, the sum of the other components of farm income was adjusted by the national ratio of imputed rent to farm income.

Gross state product in government has traditionally been assumed equivalent to the compensation, which includes wages and supplements, of government employees. Wages are available at the state level, but supplements are not. Therefore, Ohio government wages must be blown up by the ratio of U.S. government supplements to U.S. government wages.

Total manufacturing GSP is constructed by the weighted income received method suggested by Weber (1979):

$$\text{GSP (M)} = [\text{YR (M,OH)} / \text{YR (M,US)}] * \quad (34)$$

$$[[\text{VA (MA,OH)} / \text{P (M,OH)}] / [\text{VA (M,US)} / \text{P (M,US)}]] * \text{GNP (M)}$$

where GSP (M) = gross state product in manufacturing

YR (M,OH) = the income received in manufacturing in Ohio

YR (M,US) = income received in manufacturing in the U.S.

VA (M,OH) = value added in manufacturing in Ohio

P (M,OH) = manufacturing payroll in Ohio

VA (M,US) = value added in manufacturing in the U.S.

GNP (M) = gross national product in manufacturing

The value added-payroll ratio is intended to adjust for productivity differences between Ohio and the U.S. If there is no difference, the ratio will be one.

Gross state product in manufacturing was expanded into 21 sectors, the two-digit SIC sectors from 19 to 39. This was done as follows:

$$\text{GSP (SIC)} = [\text{VA (SIC,OH)} / \text{VA (M,OH)}] * \text{GSP (M)} \quad (35)$$

GSP was completed by summing the major sectors to obtain the total.

4.1.2 Gross Metropolitan Product

Even fewer data are available at the SMSA level, necessitating more ingenious methods of calculating gross metropolitan product (GMP) than GSP. These methods are outlined in L'Esperance and Chall (1979).

GMP in farming was estimated as follows:

$$\text{GMP}(f) = [C(\text{SMSA}) / C(\text{OH})] * \text{GSP}(f) \quad (36)$$

where $C(\text{SMSA})$ is the cash receipts from farm marketing in the counties comprising the SMSA and $C(\text{OH})$ is the cash receipts from farm marketing in Ohio.

All the other major sectors except government and manufacturing were estimated in the following manner:

$$\text{GMP}(i) = [W(\text{SMSA}, i) / W(\text{OH}, i)] * \text{GSP}(i) \quad (37)$$

where $W(\text{SMSA}, i)$ is the total wages in the counties comprising the SMSA for sector i and $W(\text{OH}, i)$ is the total wages in Ohio for sector i .

GMP in manufacturing was calculated as follows:

$$\text{GMP}(M) = [VA(M, \text{SMSA}) / VA(M, \text{OH})] * \text{GSP}(M) \quad (38)$$

It was then expanded into 21 sectors, the two-digit sectors from 19 to 39. This was done as follows:

$$\text{GMP}(\text{SIC}) = [VA(\text{SIC}, \text{SMSA}) / VA(M, \text{SMSA})] * \text{GMP}(M) \quad (39)$$

where $VA(\text{SIC}, \text{SMSA})$ is the value added in the two-digit SIC sector in the SMSA and $VA(M, \text{SMSA})$ is the total value added in manufacturing in the SMSA. (It is not unusual to have GMP equal to zero for several SIC sectors in an SMSA.)

Gross metropolitan product in government (all levels) was calculated in the following way:

$$\text{GMP}(G) = [E(G, \text{SMSA}) / E(G, \text{OH})] * \text{GSP}(G) \quad (40)$$

where $E(G, S\text{MSA})$ is the employment in government in the S\text{MSA} and $E(G, OH)$ is the employment in government in Ohio. Employment was used for lack of payroll data at the S\text{MSA} level.

Total GMP was found by summing GMP in the major sectors.

4.2 CAPITAL STOCK

Although capital data have traditionally been a problem at all levels including national, there is a fairly established method of dealing with the problem. Capital stock data were used for only a few manufacturing sectors in the final version of this model, but a method developed to calculate them may be of interest for other work. To obtain capital stock, one can apply the perpetual inventory method (Christensen and Jorgenson, 1969) to capital expenditures, a benchmark, and a depreciation rate. Each of these items is available for total manufacturing in Ohio. The new problem is to extend this to the two-digit SIC level for S\text{MSAs}.

Before the perpetual inventory method was applied, total gross book value by SIC by S\text{MSA} was estimated. Total manufacturing gross book value was obtained as follows:

$$BV(M, S\text{MSA}) = [VA(M, S\text{MSA}) / VA(M, OH)] * BV(M, OH) \quad (41)$$

where $BV(M, S\text{MSA})$ = book value for manufacturing for a given
S\text{MSA}

$VA(M, S\text{MSA})$ = value added manufacturing for a given

SMSA

VA(M,OH) = value added by manufacturing for Ohio

BV(M,OH) = book value for manufacturing for Ohio

Gross book value by SIC for each SMSA was calculated as follows:

$$BV(SIC, SMSA) = [VA(SIC, SMSA) / VA(M, SMSA)] * BV(M, SMSA) \quad (42)$$

where BV(SIC, SMSA) is the book value by SIC for a given SMSA, and VA(SIC, SMSA) is the value added by SIC in a given SMSA.

The perpetual inventory method was applied to the values for BV(SIC, SMSA).

4.3 NET MIGRATION

Annual net migration was calculated from published data on birth, deaths, and population by county. The following identity was used:

$$POP(t) = POP(t-1) + B(t) - D(t) + NM(t) \quad (43)$$

where POP(t) = population in period t

POP(t-1) = population in period (t-1)

B(t) = births in period t

D(t) = deaths in period t

NM(t) = net migration in period t

Despite the logical nature of the equation and the published data, the data are very erratic-looking and should be taken with a grain of salt. The total Ohio net migration data look reasonable, but substate data vary in magnitude and sign from year to year. Perhaps it is due to the residual nature of the calculation. The published substate data may not be consistent with each other.

4.4 PRICES

There are two components of the price of output of a particular sector in a particular SMSA. The basis for all prices is national published price indexes, which contain both real and nominal price changes for a dollar's worth of goods in a given year. Most of these are published at the one- and two-digit level in the Survey of Current Business or the Economic Report of the President. Some two-digit price indexes come from Eckstein and Wyss (1972).

The other component of the prices is a spatial index. It is well-known that the cost of living varies among cities, but the consumer price indexes published by the federal government are not intended to reveal it. One can see how much prices are changing compared to other cities, but one cannot compare price levels among cities. Furthermore, consumer price indexes are not published for all the cities in this study, either by the federal government or by

independent groups like the American Chamber of Commerce Researchers Association. Also, the time periods of different price indexes vary, and different indexes may not be comparable. Consequently, a spatial Laspeyres price index similar to one developed by Fuchs, Michael, and Scott (1979) for states was constructed for this study.

There are three assumptions underlying the method: 1) there is a composite good sold at retail which does not vary much in price across cities, 2) there is little net cross-city buying of this good, and 3) the ratio of the consumption of this good to a composite of all other goods is constant across cities. This last assumption is disturbing, but it apparently is necessary at this point. It cannot be proven except by a costly consumer survey. Then, with these three assumptions,

$$L(j) = [P(1j) * C(1) + P(2j) * C(2)] / [P(1) * C(1) + P(2) * C(2)] \quad (44)$$

where $L(j)$ = Laspeyres price index for SMSA j

$P(1j)$ = price of composite good $C(1)$ in SMSA j

$C(1)$ = composite good for which price varies across cities

$P(2j)$ = price of composite good $C(2)$ in SMSA j

$C(2)$ = composite good for which price does not vary across cities

$P(1)$ = Ohio price of $C(1)$

$P(2)$ = Ohio price of $C(2)$

By scaling each of the goods so that its price is 1, $P(1) = P(2) = P(2j) = 1$. Income in each region is

$$I(j) = P(1j) * C(1j) + P(2j) * C(2j) \quad (45)$$

(Note that savings are included in the composite good for which prices do not vary across space.) So

$$P(1j) = [I(j) / C(2j) - 1] / [C(1j) / C(2j)] \quad (46)$$

Because $C(1j)$ cannot be measured easily, assume that $C(1j)/C(2j)$ is constant across regions and that $C(1j)/C(2j) = C(1)/C(2)$. By substitutions, the index which can be calculated is

$$L(j) = [I(j) / C(2j)] * [C(2) / I] \quad (47)$$

where $I(j)$ is income in SMSA j , and I is income in Ohio. In other words, ratios of retail sales to personal income are compared. (Fuchs et al exclude several categories of retail sales, but that is not possible here because of lack of data.)

Note that there is a different spatial index for each year for the cities. The indexes appear in Table 55.

The two components of price, the basic price index and the spatial index, are multiplied together to obtain the price indexes used in this model.

Chapter V

IDENTIFICATION AND ESTIMATION OF MODEL

This chapter begins with a discussion of the identification of the model, its structure, and the choice of an estimator. It continues with a detailed discussion of the estimation results for Cleveland and summaries of the results for the other regions in the model.

5.1 IDENTIFICATION

Identification is the process of determining whether each equation can be distinguished from the others in a model. It needs to be done before estimation of parameters because the choice of estimators depends partly on whether the equations are identified. Two and three stage least squares estimates do not exist for underidentified equations.

Table 2 shows the number of predetermined and endogenous variables in the multiregional model. Both numbers are a bit overstated because they assume that all 31 sectors are present in each region. Theoretically, they are present, and the results are not affected by the absence of a few sectors. In Appendix G, the order condition for

identification is applied to the prototype equations to show that the necessary condition for identification is satisfied. The necessary condition is that the number of excluded exogenous variables in an equation must be at least as great as the number of included endogenous variables minus one. Each equation is shown to be overidentified by this condition.

The sufficient condition, or rank condition, for identification is that the rank of the normalized coefficient matrix is one less than the number of endogenous variables in the system. It would be extremely tedious to apply this condition with over 500 coefficients in one SMSA model alone. Fortunately, there are other ways to check the identification of a system of equations.

Although application of the order condition is informative, examination of the model's structure is also revealing. A system of equations is recursive if the endogenous variables can be determined sequentially and if covariances between the disturbance terms of different equations are zero (Pindyck and Rubinfeld, 1976, and Intriligator, 1978). Similarly, a block-recursive equation system can be broken up into groups of equations so that equations within a block are simultaneous, but groups of equations across blocks are recursive. The point is that

equation systems which are recursive rather than simultaneous can be estimated with ordinary least squares.

There are several groups of equations in the model which are block-recursive. In general, pairs of demand and supply equations are simultaneous, forming a block, while the corresponding labor demand equation can be determined as a one-equation block separate from demand and supply. The manufacturing sectors are a bit more complicated in that total manufacturing demand and supply for all SMSAs form a block of 12 equations after which other manufacturing blocks can be estimated. Local government employment and revenue form a separate recursive system. What all this means is that pairs of supply and demand plus the total manufacturing block are the only truly simultaneous equations in the system. All others can be estimated with ordinary least squares without fear of simultaneous equation bias.

Finally, we come to the choice of estimators for the simultaneous portion of the model. Monte Carlo studies of small-sample properties of estimators are not conclusive, but they give some guidelines about the choice of estimators. They also show that results vary more significantly from specification and data than from use of different estimators. The following discussion is drawn from Intriligator (1978).

Ordinary least squares has the largest bias of group of estimators considered (OLS, 2SLS, k-class, IV, 3SLS, and FIML). It appears to be a minimum variance estimator, but the large bias gives it the largest mean squared error of the considered techniques. It is appropriate if the model is recursive or approximately recursive or if the matrix of coefficients of endogenous variables contains many zeros, which is the usual case with large models. It may also be appropriate if the first-stage R-squared values are close to zero or close to one for 2SLS. If R-squared is close to zero in the first stage of 2SLS, the 2SLS estimator is meaningless because the endogenous explanatory variables are essentially replaced by disturbance terms. If R-squared is close to one, there is very little difference between OLS and 2SLS values.

Two-stage least squares is the best of the limited information estimators in terms of bias and mean squared error. (Both OLS and 2SLS are biased in large samples.) It is not greatly affected by specification error but is affected a great deal by multicollinearity.

Full-information techniques, including 3SLS and FIML, have the best record on bias and mean squared error when the specification and data measurement are accurate. They are very sensitive to errors of either type because the error

spreads through the entire system. They are also costly to use.

The full-information techniques can be rejected by all but those who are supremely confident of their model specification and data measurement. A glance at the chapter on data or at the comments in the theory chapter about the use of gross metropolitan product for output should make clear that full-information techniques are not desirable here.

The choice, then, is between OLS and 2SLS. 2SLS can be defended because of simultaneous equation bias within the blocks of the model. This is a powerful argument. Most of the arguments for OLS are that it is as good as 2SLS in certain cases. It has already been pointed out that some equations in the model can be appropriately estimated by OLS because of recursiveness. The matrix of coefficients of endogenous variables has many zeros, and the first-stage R-squared values are frequently close to one. Furthermore, the demand equations appear to be multicollinear. The supply equations tend to be autocorrelated, a condition which can be corrected more feasibly under OLS than under 2SLS. For these reasons, OLS was chosen as the estimator for the model. 2SLS estimates of the Cleveland model were done for comparison, and they will be discussed in the next

section. They did not indicate any great advantages to using 2SLS for the other SMSAs, and there was the disadvantage of autocorrelation in the supply equations.

5.2 ESTIMATION OF THE CLEVELAND SMSA MODEL

Cleveland was chosen to demonstrate the properties and results of the multiregional model. During the period covered by the model (1950-1977), it was the largest SMSA in Ohio and had the richest data base, particularly in manufacturing.

The results of the estimation will be discussed for demand, supply, the labor market, construction, and local government. 2SLS estimates will be discussed after the OLS estimates of demand and supply are reviewed.

5.2.1 Demand

The coefficients for Cleveland's demand equations are in Table 3 and 4. Sectors 2 through 8 are nonmanufacturing. (Construction appears elsewhere.) Sector 10 is total manufacturing, and sectors 12 through 31 are two-digit SIC levels of manufacturing. Sector 1 is total GMP and is the sum of sectors 2 through 10. (The sector codes do not correspond to the well-known SIC codes. Complete lists of sectors and variable names appear in Appendix A and Appendix B.) The table should be self-explanatory except that the

numbers in parentheses below the coefficients are the level of significance of the coefficient. The standard for this study is a level of significance of 5%.

The coefficients of the log of price (LPCL__) are expected to be less than one so that the price elasticity of demand will be negative, according to the theory in Chapter 3. All but sector 3 (mining and other) fulfill the expectation. The price elasticities have been calculated for Table 5 by subtracting one from the coefficient of LPCL__. Out of 26 sectors, nine price coefficients are significant at 5%. Sector 3's coefficient, greater than one, is not among them.

The interpretation of the other coefficients is more difficult for theoretical reasons and because of probable multicollinearity. In Chapter 3, it was explained that there is no expected sign on either LPI__ or LGMP__10 because of the use of gross metropolitan product for output. Multicollinearity is suspected because of the high R-squareds coupled with insignificant coefficients and because the coefficient values are sensitive to the exclusion of variables. It would not be surprising to have multicollinearity in personal income or gross metropolitan product in manufacturing across the state. Multicollinearity can sometimes be alleviated by using a priori information (in this case, about trade flows) to drop

variables, by changing the data sample, or by changing the form of the variables. Unfortunately, there is no known a priori information about trade flows, and there are no good theoretical reasons for dropping any of the variables. Attempts were made to change the sample and the form of the variables, but they were unsuccessful. Another way of dealing with multicollinearity is to live with it, which was the avenue chosen here. It means that few conclusions can be drawn about the individual terms in an equation but that its overall explanatory or forecasting power is retained.

In the nonmanufacturing equations, Columbus personal income had positive and significant coefficients in four out of six equations. Dayton personal income has a negative and significant coefficient in sector 7 and a positive and significant coefficient in sector 8. No other personal income terms are significant at 5%. The R-squareds are high.

Table 6 shows the sectors in which each SMSA's total manufacturing GMP had significant coefficients for Cleveland, and what the signs were. Unfortunately, very little information is gained because of multicollinearity, despite the hope of discovering trade flows among the SMSAs. Nonetheless, the explanatory power of the equations is very good. In general, the R-squareds were above .80. The only

exceptions were sector 14 (textile mill products) and sector 31 (miscellaneous manufacturing), neither of which is very important to Cleveland's economy.

5.2.2 Supply

Table 7 contains the important information from the estimation of the supply curves. The first column contains the calculated scale parameter, $g(Q)$. The underlying production function has increasing, constant, or decreasing returns to scale according to whether $g(Q)$ is greater than, equal to, or less than 1, respectively. All of the scale parameters are in a reasonable range, but only four out of 26 are derived from coefficients which are significant at 5%. The formula used to calculate $g(Q)$ is

$$g(Q) = 1 / [1 - k(Q)] \quad (48)$$

where $k(Q)$ is the estimated coefficient. If $k(Q)$ cannot be distinguished from zero, $g(Q)$ is really one (constant returns to scale). Most of the insignificant calculated $g(Q)$ are close to one anyway.

$h(L)$ and $h(K)$ are the shares of income that labor and capital receive. They should be positive and add to one. Since there are other factors of production which are not included in this model, it is not surprising that they do not add to one. Labor's share of income, $h(L)$, is the coefficient of the log of the hourly wage rate in the supply

equation. Twenty-four out of 26 coefficients have appropriate values. One is negative, but it is insignificant at 5%. The other is greater than one and significant. There are three others which are of a reasonable magnitude that are insignificant at 5%.

Four of $h(K)$, capital's share of income, are significant. Eleven $h(K)$ are negative, but only one of them is significant. Most of the $h(K)$, whether positive or negative, are small.

Since the log of price is the dependent variable in the supply equations, one can conclude that the greatest influence on price is wages. Three exceptions are construction (4), wholesale and retail trade (5), and finance, insurance, and real estate (6). That tended to be the pattern in all the SMSA models. Two-thirds of the supply equations needed correction for autocorrelation. R-squareds were high for most of the equations, with half of them being more than .80 and almost all the rest being more than .60.

5.2.3 Two Stage Least Squares Estimates of Supply and Demand

The supply results are similar to the OLS estimates. Differences that do arise may be due as much to uncorrected autocorrelation as to a different estimator.

The demand equations are also similar. Here, not only autocorrelation but sometimes a different sample size may contribute to the few differences that exist. In 2SLS, the simultaneous equations must have the same sample size. Some of the supply curves have 16 instead of 28 observations for the wage rate because it was calculated from employment and payroll data in some sectors, and early observations did not look reliable. Consequently, some demand equations in the 2SLS estimates have fewer observations than they did for OLS. Twenty out of 26 price elasticities were properly negative. Most of the positive elasticities were insignificant at 5%.

The 2SLS estimates are in Tables 8, 9, 10, and 11.

5.2.4 Labor Demand

The labor demand results appear in Tables 12, 13, and 14. Twelve labor demand equations were estimated by the output form; ten were estimated by the price form; and four were estimated by the capital form of labor demand.

In the output version, a positive coefficient is expected for the log of GMP. A negative coefficient is expected for the log of the wage rate minus the log of the capital price. All twelve coefficients of the log of output were positive, and eight of them were significant at 5%. Seven out of 12

of the coefficients of the log of the relative wage were negative. Of the seven, four were significant. Of the positive coefficients, only one was significant at 5%. The R-squareds ranged from .1069 to .9466. (That was the case for all the functional forms in all the SMSAs.) There are several reasons for the lack of explanatory power in some of the labor demand equations. First is the assumption of perfect competition in factor markets. Second is the fact that these are ex post wages, not the expected wage. Third is the absence of factors besides labor and capital. The most likely is the competitive assumption, since wages tended to rise whether hours rose or fell.

The expected sign of the coefficient of the log of price in the price form of labor demand is positive if labor is a normal factor of production. The expected sign of the coefficient of the log of the wage rate is negative. The coefficient of the log of the price of capital is expected to be positive. Seven out of ten price coefficients are positive. Of the seven, none are significant at 5%. One of the negative coefficients is significant. It is possible that labor is an inferior factor of production in sector 7 (transportation, communications, and utilities). Nine out of ten coefficients of the log of the wage rate are negative. Of the nine, one is significant at 5%. The positive coefficient is also significant. Nine out of ten

coefficients of the log of the price of capital are positive. Of the nine, two are significant. The negative one is not significant. The R-squareds range from .0707 to .8543.

In the capital version of labor demand, the log of wages divided by prices is expected to have a negative coefficient. The log of capital stock is expected to have a positive coefficient. Three of the four wage coefficients are negative. One of the negative coefficients is significant. Three of the four capital coefficients are positive. None of them are significant. The R-squareds range from .1180 to .4672.

The most important sectors in Cleveland's economy had respectable results for the labor demand equations. It may be that in the remaining sectors there is not much information to glean.

The two behavioral equations on the supply side of the labor market are for the labor force participation rate and net migration. The results can be seen in Table 15, where the rest of the Cleveland model equations are. The labor force participation rate is expected to be related positively to the lagged average wage rate and negatively to the lagged unemployment rate. It turns out to be negatively

related to both. The coefficient of the lagged average wage rate is significant at 5%. The explanatory power of the equation is .2790. Despite these results, this part of the model predicts well.

Net migration is expected to be a positive function of the lagged Cleveland-to-U.S. wage ratio and a negative function of the lagged Cleveland-to-U.S. unemployment ratio. It is a negative, significant function of both. R-squared is .3841. Looking at the data, it is easy to see why these results occur. Cleveland has experienced net outmigration over at least the last ten years of the sample, yet wages were consistently above U.S. wages. The unemployment rate ratio probably picks up more of what happened than the wage ratio does.

5.2.5 Construction

This section consists of a housing starts equation, a manufacturing investment equation, and the demand for construction.

Housing starts are hypothesized to be a positive function of real time deposits, a positive function of income per household, a negative function of the real Treasury bill rate, and a positive function of the change in the number of households. Those were the estimation results except for a negative, insignificant coefficient of savings. If savings

and housing starts really have a negative relationship, it may be that inflation caused people to invest in housing rather than time deposits in banks and savings and loans. Income per household is the only variable significant at 5%. The explanatory power of the equation is .4892.

Manufacturing investment is expected to have a positive coefficient on gross metropolitan product in manufacturing and a negative coefficient on the corporate bond rate. These expectations are fulfilled. The coefficient of GMP in manufacturing is significant at 5%. The R-squared is .5791.

The demand for construction includes the price and the housing starts and manufacturing investment from all the SMSAs. The coefficient of the log of price is of the proper magnitude. None of the coefficients is significant, yet 71% of the variation is explained. Probably there is multicollinearity among the variables. (See the discussion of multicollinearity in the other demand curves.)

5.2.6 Local Government

Tax revenue is found to be a positive and significant function of personal income, as expected. R-squared is .8668.

Local government employment is a negative and significant function of the average wage and a positive and significant function of tax revenue, as expected. More than 97% of the variation is explained.

5.3 SUMMARY OF OTHER SMSA ESTIMATES

The results for the other SMSAs can be found in Tables 16 - 51.

5.3.1 Cincinnati

The results of estimating the demand equations were similar to Cleveland's results. All 19 price elasticities were negative and of a reasonable magnitude; two were significant at 5%. The explanatory power of most equations was high.

The supply results were better than Cleveland's, though the levels of significance had the same pattern. Eighteen out of 19 labor-shares were less than one, and 14 out of 19 capital-shares were positive. None of the negative capital shares were significant. The explanatory power was generally high.

A greater proportion of the labor demand equations had good results than was true for Cleveland. This is

encouraging because Cincinnati's industrial mix is less concentrated than Cleveland's, meaning that it is important to model well more of Cincinnati's manufacturing sectors than Cleveland's. Most of the labor demand equations are in the output form. Eight out of 10 have the proper signs on output, and those coefficients are nearly all significant. The signs on $\ln(W/R)$ are mixed, as are the significance levels. Although the R-squareds range from .1207 to .8329, most of them are fairly high.

There were five labor demand equations estimated in the price version and four in the capital version. Four out of five coefficients of price in the price version were positive. It is possible that the negative coefficient, which was significant, indicates that labor is an inferior factor for sector 17 (furniture and fixtures), but this does not seem likely. The wage and capital price coefficients had mixed results, as did the estimation of the capital version of labor demand.

The migration equation did not work well for Cincinnati, even with much experimentation. The data look very strange. The labor force participation rate equation had the proper sign on lagged wages but revealed little.

The construction demand, housing starts, and manufacturing investment equations had the same type of good results as in the Cleveland model, though manufacturing investment had a much higher R-squared.

Local government tax revenue was well-explained by personal income. Local government employment was a positive, significant function of the wage rate, making it more of a labor supply equation than a labor demand equation. Tax revenue was left out of the equation because it was highly correlated with wages.

5.3.2 Columbus

The demand equations are similar to Cleveland's and Cincinnati's. All the price elasticities were negative and of reasonable size. Four out of 25 were significant. The explanatory power of all the equations is quite high.

The supply results are essentially the same. Of the labor-shares, 19 have positive values less than one. Twenty capital-shares are positive. More of them are significant than in previously discussed SMSAs. Explanatory power was generally high.

Eight of the labor demand equations were estimated in the output version. All but two of the coefficients of output

were positive, and all but two of the relative wage coefficients were negative. Despite several significant coefficients, the explanatory power was not good.

Thirteen labor demand equations were estimated in the price version. Nine of the wage coefficients were negative, and seven of those nine were significant. The coefficients of capital price were positive, and some were significant. The coefficients of price were mixed, both in sign and significance. Explanatory power of these equations was much better than for the output version.

Four labor demand equations were estimated in the capital version. All coefficients of $\ln(W/P)$ were negative, and three out of four were significant. Three out of four capital coefficients were positive. Two of the three were significant. R-squared ranged from .3260 to .6161.

The labor force participation rate equation was good, though the sign of the lagged unemployment rate was the opposite of what was expected. Both coefficients were positive and significant, and R-squared was .8447.

Net migration had no apparent relation to any labor market variables tried. The data for Columbus are different from the other SMSA net migration data in that there has

been more net immigration over the past several years. Nonetheless, it is still looks strange.

The housing starts, manufacturing investment, and construction demand equation had the same type of results as Cincinnati's and Cleveland's.

Local government employment is a significant, positive function of tax revenue, and a significant, negative function of wages, as expected. The R-squared is quite high, .9546. The revenue equation has the same good results as the other SMSAs discussed so far.

5.3.3 Dayton

The demand curves had results similar to the others discussed so far. Sixteen out of 17 price elasticities were negative. Three of them were significant. The explanatory power was high for all but sector 31 (miscellaneous manufacturing).

The supply coefficients were generally satisfactory. The scale parameters were reasonable except in Sector 2 (agriculture). Eleven out of 17 labor-share coefficients were less than one. Ten capital-shares were positive, but none of the others were significant. R-squareds were high.

Eleven labor demand equations were estimated in the output form. Output had the proper sign in all of them, and most of the coefficients were significant. The signs and significance were mixed for the relative wage. R-squared ranged from .1328 to .8701.

The price version was used for three sectors. None of the coefficients were significant. For the capital version, all three coefficients of capital were positive and significant. None of the coefficients of $\ln(W/P)$ were significant. R-squareds were good for labor demand curves, ranging from .6532 to .7379.

The labor force participation rate was found to be positively and significantly related to both the lagged wage and the lagged unemployment rate (not expected). R-squared was .4761.

Net migration was found to be a negative but insignificant function of the lagged relative wage and a negative and significant function of the lagged relative unemployment rate. More than 35% of the variation was explained, which makes this one of the more successful net migration equations.

Housing starts, manufacturing investment, and construction demand have essentially the same results as in the SMSAs. Manufacturing investment has an unusually good fit.

Local government revenue has the usual strong relationship with personal income. Local government employment has the proper signs and good R-squared, though the wage coefficient is not significant.

5.3.4 Toledo

Out of 20 sectors, 18 have negative price elasticities. The results are similar to other SMSAs' demand equations.

The supply coefficients are similar to Dayton's. Eighteen scale parameters are of reasonable size. The other two are unusually large. Seventeen of the labor-shares are between zero and one. Fourteen capital-shares are between zero and one; most of the others are insignificant. R-squareds range from .7559 to .9619.

All the coefficients of output in the output version of the labor demand curves are positive, and several are significant. Seven out of nine coefficients of the relative wage are negative, and several are significant. R-squareds fall in the middle range.

In the price version of labor demand, six out of nine price coefficients are positive. All but one capital price coefficient are positive. Four out of nine wage coefficients are negative. R-squared ranges from .1716 to .9449.

The labor force participation rate is a positive and significant function of the lagged wage and a positive, insignificant function of the lagged unemployment rate. The explanatory power is good.

Again, net migration has little apparent relationship to several labor force variables. The data look very strange.

The housing starts, manufacturing investment, and construction demand equations are like those in the other SMSAs except that the change in the number of households has a negative and insignificant coefficient in the housing starts equation.

The local government equations also have similar results. All coefficients have the right sign and are significant.

5.3.5 Balance of State

The balance of the state was treated in same way as an SMSA. The results were essentially the same.

Twenty-two out of 26 price elasticities were negative. All but one equation (sector 13, tobacco, which is a minor sector in Ohio) had good explanatory power.

All the scale parameters in the supply equations were of reasonable size. Twenty-three labor-shares were between zero and one. Eighteen of the capital-shares were between zero and one; the rest were negative but insignificant. The R-squareds were not quite as high as a group as in the SMSAs, but most of them were respectable.

Half of the labor demand equations were in the output form. They all had positive coefficients for output. Most of them were significant. Nine of thirteen relative wage coefficients were negative. R-squared ranged from .1630 to .8388.

In the price form of labor demand, 24 coefficients of price were positive. About half of the wage coefficients were negative. Eight of the capital price coefficients were positive. The explanatory power in this group ranged from practically none to respectable (.0391 to .7944).

Neither the labor force participation rate nor net migration had any results of interest. The construction sector had the same type of results as for the SMSAs. The

local government equations could not be estimated because of lack of data.

Chapter VI

EVALUATION OF THE MODEL

In Chapter 5, the performance of individual equations was evaluated. How the model as a whole behaves may be another matter. If any forecasting or policy simulation is to be done with the model, it is important to know how the equations react with each other. In this chapter, attention will be paid to a solution of the model, the forecasting ability of the model, policy implications of the model, and suggested extensions of research with the Multiregional Econometric Model of Ohio.

6.1 SOLVING THE MODEL

"Solving the model" is used in the sense of finding a mathematical solution to a set of equations. If we have an equation system $BY + GZ = U$ where Y , Z , and U are the values of the endogenous and predetermined variables and the disturbance terms, respectively, and B and G are parameters, then Y , the solution, is equal to $-B(\text{inverse})GZ$, assuming $E(V) = 0$, where V is the matrix of error terms in the reduced form. With a nonlinear model like the present one, an iterative technique must be used to approximate to solution.

The Gauss-Seidel is such a method. It uses the values of the exogenous variables and the initial values of the endogenous variables to solve the equations sequentially. It tests the values after each iteration to see whether they have changed from the previous iteration's values by more than a pre-specified amount. If not, convergence has occurred and a solution exists. When this is done for each period, with the previous year's solution used for the initial value of the endogenous variables, the procedure is referred to as dynamic simulation or ex post forecasting.

"The model" in this study technically refers to all the equations of the six SMSA models with their inter-SMSA linkages. Although simulation packages exist to solve such a model (with over 600 endogenous variables alone), they were not available for this study. Without losing the multiregional flavor, an individual SMSA model can be solved to evaluate the properties and policy simulation potential of the entire model. It simply requires careful thought about the structure of the multiregional model as it applies to an individual SMSA model.

The Cleveland model was chosen for solution. The Gauss-Seidel method was applied, and solution values were obtained. These values were compared with the actual values in order to evaluate the model. How they were compared is the subject of the next section.

6.2 FORECASTING ABILITY OF THE CLEVELAND MODEL

There is no one way to evaluate a model's forecasting ability. Some statistics have been derived which compare the solution values with the actual values, but they are by no means as standard as a t or an F test, and each has limitations. It is also important to be able to forecast turning points. The easiest way to tell whether a model can do this is to look at plots of the solution values and the actual values. Three standards of evaluation have been used to evaluate the forecasting ability of the Cleveland portion of the multiregional model. They are the mean absolute percent error, the root mean square error, and plots of the endogenous variables.

The mean absolute percent error is calculated as follows:

$$\text{MAPE}(i) = \left[\text{SUM}(i=1,n) \{ \text{ABS}[\text{YP}(i,t) - \text{YA}(i,t)] / [\text{YA}(i,t)] \} \right] / n$$

(49)

where $\text{YP}(i,t)$ = predicted value of i th endogenous variable
at time t

$\text{YA}(i,t)$ = actual value of i th endogenous variable
at time t

n = sample size

The MAPE statistic is a units-free index. However, it gives a relatively large weight to a given absolute error when the actual value of the endogenous variable is small, which is often the case with logs and first differences.

The root mean square error is defined as

$$RMSE = \sqrt{\frac{\sum_{t=1}^n [Y_P(i,t) - Y_A(i,t)]^2}{n}} \quad (50)$$

Large errors are given greater weight in the RMSE than in the MAPE. RMSEs are measured in the units of each variable, so care must be used in interpreting them. Because so many of the variables in this model are in log form, it will be easier to compare the RMSEs in this model than in many models.

Table 53 contains a list of all the endogenous variables, their MAPEs, and their RMSEs. About 32% of the MAPEs are 10% or less. These include output for important sectors, labor hours and employment for important sectors, population, unemployment, local government employment, and local government revenue. About one third of the larger MAPEs are for logs of prices, which are close to zero, so that errors are exaggerated.

The RMSEs measure the deviation of the simulated values from the actual values. These need to be studied with reference to the magnitude of the actual values. The output values tend to range from three to seven. The prices are generally between zero and one. Labor hours and employment are between five and thirty. Many of the variables for which the MAPEs were large have quite tolerable RMSEs, .15 or less.

Table 52 contains a list of major variables, their MAPEs, and their RMSEs. This includes output, labor hours, tax revenue, and unemployment. Inspection of the table reveals that the model forecasts well for most of them. Most of the MAPEs are less than 5%, and many are less than 2%. Several of the variables with larger MAPEs have small RMSEs.

The last way of checking the forecasting ability of the Cleveland portion of the model is to look at the plots of the actual vs. simulated values over time. The plots may match closely. The simulated variable may catch most of the upturns and downturns but not with the same magnitude, or the simulated variable may follow the actual values rather closely but with a constant difference. More than two-thirds of the variables follow one of these three patterns. The rest do not match upturns and downturns well. The unemployment rate is an example of a variable which has a MAPE of .263 and a RMSE of .013, but a very accurate plot in terms of turning points. (See Figure 1.) In many of these cases, an adjustment of the constant term is all that is necessary.

A comparison of forecasting ability with other models is worthwhile. It is impossible to do a comprehensive comparison since not every author reports comparison statistics. Those who do report them report MAPEs for

selected variables. Some also present plots of actual and predicted values for selected variables.

The Cleveland portion of the Multiregional Econometric Model of Ohio has been compared with SMSA models and multiregional models where possible. Table 56 contains MAPE statistics for four variables, comparing four other models to the Cleveland model. The Cleveland model forecasts population more accurately than the SMSA models and forecasts total gross product a little better than the early Philadelphia model. The other models are clearly more accurate on three of the variables. A comparison of plots with the Chicago and Milwaukee models shows that the three have similar ability to predict turning points on selected variables. RMSEs are not published for any of the other SMSA models.

It is also appropriate to compare the Cleveland portion of the MREMO to what has been published about other multiregional models. Statistics have been published for the NRIES (states, Ballard and Wendling, 1980) and the Delaware Valley model (counties, Ballard and Glickman, 1977). A summary of them appears in Table 57. A range is given for the other two models since they publish statistics for selected variables for all 50 states (NRIES) and 12 counties (Delaware Valley). The Cleveland part of the MREMO compares favorably on total gross product and population.

The Cleveland portion of the MREMO has its strength in forecasting output for individual sectors and turning points for most variables. The employment equations clearly need to be refined. In almost all cases, a simple adjustment of the constant, a common practice among forecasters, is all that is necessary.

6.3 IMPACT ELASTICITIES AND POLICY IMPLICATIONS

Impact elasticities reflect the first-period effect of a shock in one of the exogenous variables. Specifically, it is the percentage change in an endogenous variable after one period that results from a 1% change in an exogenous variable. This was done with a number of exogenous variables. Three representative ones are shown in Table 54. One national variable, the log of the price of capital, is shown. Its effect is quite pervasive. Because this is a multiregional model, the log of personal income in Columbus and the log of Dayton gross metropolitan product in manufacturing are shown. In this case, they were treated as exogenous variables for demonstration purposes. Columbus personal income affects the nonmanufacturing demand, supply, labor demand, and employment values. It enters through demand. Dayton manufacturing GMP affects several manufacturing demand, supply, labor demand, and employment values. For all three exogenous variables, the effects are positive or negative according to the coefficient in the

equation it enters. Most of the elasticities are small, but several are significant in their effect.

Another experiment that can be done in lieu of solving the entire multiregional model is to solve a block of equations. There is one block which is simultaneous among SMSAs. It is the set of 12 demand and supply equations for total manufacturing. The output results from this block feed into all the other manufacturing demand equations, but nothing goes back to the total manufacturing block. Thus it is part of a block-recursive system. The reduced form coefficients within a block are the same whether they are solved within the entire system or as a block.

The total manufacturing block was solved with both OLS and 2SLS structural coefficients. The results of the 2SLS coefficients were better, indicating that regardless of the properties of the individual equations, the 2SLS estimates are better for forecasting.¹ The reduced form contains impact elasticities since the variables are in log form. These impact elasticities can be seen in Tables 58 - 60. The elasticities are reasonable. For instance, the elasticity of manufacturing GMP in Cincinnati with respect

¹The behavior of the model might be improved if the total manufacturing block were eliminated and the two-digit SIC industries' GMP were forced to sum to total manufacturing, instead. This would be difficult to estimate (because of using both logs and antilogs), but it would not be hard to use in the Gauss-Seidel routine.

to gross national product in manufacturing is .34. For Dayton, it is .37.

Other policy changes could be simulated with the model. National policy, such as wage and price controls or income transfers, could be tested to see what effect they would have on Ohio SMSAs. The experiment with the price of capital begins to test the effects of monetary policy. Regionally, the effect of a large chemical plant, for instance, locating in one of the SMSAs or the balance of the state could be tested by projecting its contribution to manufacturing GMP. The possibilities are limitless.

6.4 CONCLUSION AND SUGGESTED EXTENSIONS

The Multiregional Econometric Model of Ohio is the first of its kind. The only other subnational multiregional model treats three SMSAs as 12 separate county-regions. This study takes the SMSA as its logical economic and geographic unit and builds a model of a state out of those units without ignoring the areas that are not in the SMSAs.

The SMSAs are linked through demand in all sectors, which in turn affects supply and labor demand. Construction is affected by residential and nonresidential investment throughout the state. Net migration affects the labor supply, population, and unemployment in each SMSA. Other

multiregional models have generally linked the regions to the total area (the nation, for instance) and not to each other.

The model was constructed with theory foremost in mind. The interpretation of the demand, supply, and labor demand coefficients was carefully worked out, taking into consideration the compromises on data that had to be made. If other authors have done this for subnational models, they have not discussed it in print.

Inadequate data is the most severe limitation a regional scientist faces. Dealing with it takes more time and ingenuity than is sometimes acknowledged. Two techniques were used in this study that should prove useful for other work. One is the disaggregation of capital stock to the two-digit SIC level in manufacturing. The other is the use of spatial price indexes.

A particularly useful addition would be a state fiscal sector. In the present model, it would be difficult to test the effects of state policy, but with relatively few equations, the effect of economic conditions on state tax revenue could be simulated.

Multiregional effects on the supply of labor need to be more explicit. They need to be tied into the product markets from that end of the market. As more observations are collected, gross migration data may help here. (They are available for 1971 on.)

In addition, the increasing importance of energy costs in production and distribution suggest that they should be incorporated into the model.

Most extensions of the model involve the creative use of data. Prosaic as it may be to some, there is a good deal of work to be done in developing and exploiting data at the subnational level.

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TABLE 1

Ohio SMSAs with Population of at least 200,000

<u>SMSA</u>	<u>Population (1000) in 1970</u>
Akron	679
Canton	394
Cincinnati	1385
Cleveland	2064
Columbus	1018
Dayton	850
Hamilton-Middletown	145
Lima	210
Lorain-Elyria	257
Toledo	763
Youngstown-Warren	536

Source: Statistical Abstract of the United States, U.S.
Dept. of Commerce, 1973.

TABLE 2

Classification of Variables in Multiregional Econometric
Model of Ohio

<u>Predetermined Variables</u>	<u>Number</u>	<u>Endogenous Variables</u>	<u>Number</u>
lnY (i)	6	lnQ (i j)	31x6
ln GNPM	1	lnP (i j)	31x6
lnW (i j)	31x6	lnL (i j)	31x6
lnR	1	l (i)	6
lnK (i j)	22x6	E (i j)	31x6
AW (i j)	31x6	LFPR (i)	6
W (i, -1)	6	LS (i)	6
UR (i, -1)	6	POP (i)	6
POP (i, -1)	6	NM (i)	6
B (i)	6	E (i)	6
D (i)	6	UMP (i)	6
[W (i) / W (N)] (-1)	6	UR (i)	6
[ER (i) / ER (N)] (-1)	6	HS (i)	6
S (i)	6	KX (i)	6
RTB	1	QM (i)	6
YHH (i)	6	lnHS (i)	6
DHH (i)	6	lnKX (i)	6
RCB	1	T (i)	6
Y (i)	6	LGEMP (i)	6
WGOV (i)	6		
 TOTAL:	 586	 TOTAL:	 834

TABLE 3

Cleveland - Demand - OLS - Part I

This table shows half of each equation. The rest of each equation is in the next table.

Dependent variable: LGMPCL__

<u>Sector</u>	<u>Constant</u>	<u>LPCL</u>	<u>LPICI</u>	<u>LPICL</u>	<u>LPICO</u>
2	.917	.163 (.4857)	.793 (.6216)	3.081 (.2401)	.589 (.8129)
3	13.472	1.177 (.0652)	1.150 (.8695)	-13.446 (.1904)	-6.388 (.4459)
5	5.794	.163 (.5722)	-1.249 (.3649)	1.436 (.5035)	4.695 (.0144)
6	8.793	-.704 (.0022)	-1.983 (.0779)	-.546 (.7691)	5.150 (.0016)
7	4.908	.010 (.9547)	-1.412 (.2208)	.578 (.7397)	3.626 (.0172)
8	7.218	.646 (.0111)	-2.136 (.19999)	.852 (.7507)	5.086 (.0426)
		<u>LPCL</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>	<u>LGMPCL010</u>
10	2.103	-.110 (.1765)	.382 (.1866)		-.308 (.0246)
12	2.743	.075 (.1354)	2.114 (.0001)	-.517 (.0696)	-.489 (.0139)

Cleveland - Demand - OLS - Part I, continued

14	-3.646	-.134 (.7734)	.800 (.5973)	2.517 (.0316)	1.118 (.1392)
15	4.588	.807 (.0175)	1.845 (.0818)	-.082 (.9121)	1.426 (.0088)
16	6.163	.305 (.5712)	4.381 (.0525)	-.475 (.7627)	-.245 (.8150)
17	3.704	-.088 (.6475)	1.875 (.0125)	.510 (.3255)	-.503 (.1486)
18	4.307	.350 (.0492)	.245 (.7671)	-.175 (.7736)	.845 (.0485)
19	.499	.176 (.3432)	.227 (.7285)	.327 (.5147)	.502 (.1301)
20	-3.084	-.108 (.2589)	.099 (.8497)	.475 (.2191)	.065 (.7975)
21	11.206	-.010 (.9650)	-.482 (.7746)	.578 (.6373)	.890 (.2856)
22	-3.081	.056 (.8272)	-.704 (.5369)	-.965 (.2553)	1.771 (.0052)
24	.867	.645 (.0427)	-.154 (.8815)	.400 (.6246)	.113 (.8236)
25	.303	.128 (.2597)	-.499 (.3662)	1.170 (.0089)	-.162 (.5502)
26	-10.380	-.385 (.0725)	1.554 (.0220)	.498 (.3154)	-.685 (.0369)
27	-5.876	-.634 (.0094)	.398 (.7023)	1.298 (.1120)	-.602 (.2490)

Cleveland - Demand - OLS - Part I, continued

28	2.770	.563 (.0085)	.751 (.2672)	-.093 (.8568)	.337 (.3094)
29	3.280	.276 (.0020)	-.405 (.3072)	1.900 (.0001)	.647 (.0020)
30	-2.007	.522 (.0870)	.917 (.3313)	-.409 (.5712)	.837 (.0792)
31	-4.726	-2.399 (.0394)	-1.094 (.7066)	.744 (.7350)	.903 (.5287)

TABLE 4
Cleveland - Demand - OLS - Part II

<u>Sector</u>	<u>LPIDA</u>	<u>LPITO</u>	<u>LPIBL</u>	<u>DW</u>	<u>R²</u>
2	.421 (.5596)	-2.564 (.4661)	-1.527 (.1380)	1.91	.6162
3	1.670 (.6301)	11.383 (.3470)	3.761 (.3488)	1.67	.6377
5	1.068 (.0917)	-5.234 (.0585)	-.569 (.5034)	1.17	.9726
6	.457 (.3616)	-3.176 (.1590)	-.590 (.4066)	1.77	.9867
7	-1.443 (.0141)	-1.999 (.3418)	.645 (.3551)	1.31	.9781
8	1.674 (.0451)	-5.188 (.1361)	-.855 (.4287)	1.38	.9635

<u>Sec.</u>	<u>LGMPDA10</u>	<u>LGMPTO10</u>	<u>LGMPBL10</u>	<u>LGNPM</u>	<u>DW</u>	<u>R²</u>
10	.341 (.0271)	.148 (.1868)	.306 (.3164)	.078 (.4330)	2.19	.9840
12	.047 (.8161)	.206 (.1629)	-.338 (.3924)	-.428 (.0083)	2.53	.9197
14	-.763 (.3581)	.001 (.9982)	-2.092 (.2003)	-.301 (.6271)	1.88	.4250
15	.073 (.8956)	-1.428 (.0013)	.195 (.8562)	1.310 (.0048)	2.21	.7330

Cleveland - Demand - OLS - Part II, continued

16	-.557 (.6343)	-.982 (.2342)	.542 (.8130)	-2.175 (.0561)	2.34 .5886
17	.344 (.3695)	.061 (.8203)	-.780 (.2892)	-.906 (.0014)	2.21 .8501
18	.235 (.6034)	-.843 (.0145)	1.550 (.0855)	-1.343 (.0004)	2.37 .8296
19	.345 (.3458)	-.048 (.8487)	.104 (.8792)	-.523 (.0266)	1.71 .9462
20	-.007 (.9799)	.468 (.0278)	-.228 (.6798)	.185 (.3829)	1.76 .9764
21	-.713 (.4375)	-.291 (.6481)	2.012 (.2686)	-2.125 (.0113)	1.45 .7713
22	.499 (.4252)	.708 (.1150)	.965 (.4224)	-.756 (.0866)	1.68 .9764
24	.354 (.5316)	.092 (.8187)	1.605 (.1463)	-.890 (.0197)	2.01 .9455
25	-.223 (.4366)	.248 (.2546)	.753 (.1965)	-.444 (.0474)	2.42 .9386
26	.402 (.2496)	.090 (.7133)	-1.238 (.0706)	1.054 (.0002)	1.71 .9790
27	.380 (.5106)	.534 (.2002)	-.716 (.5137)	.232 (.5275)	1.13 .8448
28	.883 (.0256)	-.114 (.6600)	.260 (.7087)	-1.032 (.0001)	1.99 .9474
29	-.590 (.0117)	-.176 (.2337)	.268 (.5718)	-.888 (.0001)	cor. .8933

Cleveland - Demand - OLS - Part II, continued

30	-.785 (.1421)	.169 (.6378)	.525 (.5916)	-.134 (.6549)	1.84	.9513
31	.301 (.8525)	-.402 (.7171)	-1.668 (.5848)	1.695 (.0979)	2.02	.2940

TABLE 5

Cleveland - Price Elasticities of Demand - OLS

<u>Sector</u>	<u>Elasticity</u>	<u>Significant at 5%</u>
2	-.837	
3	.177	
4	-.865	
5	-.837	
6	-.296	X
7	-.991	
8	-.354	X
10	-1.110	
12	-.925	
14	-1.134	
15	-.193	X
16	-.695	
17	-1.088	
18	-.650	X
19	-.824	
20	-1.108	
21	-1.010	
22	-.944	
24	-.355	X
25	-.872	
26	-1.385	
27	-1.634	X
28	.437	X
29	-.724	X
30	-.478	
31	-3.399	X

TABLE 6

Significant GMP in Manufacturing in Cleveland's
Manufacturing Demand Equations

<u>Cin.</u>	<u>Cle.</u>	<u>Col.</u>	<u>Day.</u>	<u>Tol.</u>	<u>Bal.</u>	<u>U.S.</u>
12+	14+	15+	10+	20+		12-
17+	25+	18+	28+	15-		15-
26+	29+	22+	29-	28-		17-
		29+				18-
		10-				19-
		12-				21-
		26-				24-
						25-
						28-
						29-
						26+

Each number is the sector in which a given SMSA's manufacturing GMP had a significant coefficient. "+" or "-" indicates the sign of the coefficient.

TABLE 7
Cleveland - Supply - OLS

<u>Sector</u>	<u>qQ</u>	<u>hL</u>	<u>hK</u>	<u>DW</u>	<u>R²</u>
2 a	1.585 b	.678	-.115 b	1.63	.8384
3 a	2.299	.648	-.144 b	1.88	.9316
4	1.217	.704	.523	cor.	.9503
5	1.161 b	.143 b	.457	cor.	.8525
6 a	1.256 b	-.043 b	.751	cor.	.7488
7	1.022 b	.580	-.041 b	cor.	.6824
8 a	1.692	.600	.026 b	1.61	.9413
10	1.070 b	.446	.123 b	cor.	.8054
12	.912 b	.848	.045 b	cor.	.3796
14	.999 b	.655	-.204 b	cor.	.6294
15	1.054 b	.454	-.170 b	cor.	.5652
16 a	.883 b	1.181	-.314 b	2.16	.8708
17	.985 b	.429	.117 b	cor.	.6550
18	1.022 b	.439	.199 b	cor.	.6942
19	1.059 b	.371	.200 b	cor.	.7274
20	.868 b	.577	-.007 b	cor.	.6001
21 a	.598	.533 b	-.128 b	1.20	.6766
22 a	.918 b	.554	.002 b	1.28	.6162
24 a	.978 b	.761	-.145 b	1.49	.8715
25	1.100 b	.669	.216 b	cor.	.8305
26	1.019 b	.488	.174 b	cor.	.9358
27	.959 b	.609	.211 b	cor.	.8538
28	1.138 b	.172 b	.131 b	cor.	.5597
29	1.070 b	.395	.169 b	cor.	.6892
30 a	.980 b	.622	-.239	1.87	.8964
31	1.031 b	.434	-.118 b	1.30	.8316

g(Q) is calculated. See text. (Chapter 3)

a: 16 observations. Wages calculated from employment and payroll.

b: Not significant at 5%.

TABLE 8

Cleveland - Demand - 2SLS - Part I

This table shows half of each equation. The rest of each equation is in the next table.

Dependent variable: LGMPCL__

<u>Sector</u>	<u>Constant</u>	<u>LPCL</u>	<u>LPICI</u>	<u>LPICL</u>	<u>LPICO</u>
2 a	-.461	-.498 (.6578)	-2.084 (.5515)	5.627 (.3230)	3.619 (.6454)
3 a	53.5314	.114 (.0568)	-32.607 (.1459)	-19.046 (.3420)	36.748 (.2206)
8 a	16.658	1.114 (.1135)	-3.640 (.4176)	-.719 (.9112)	10.928 (.1560)
5	7.925	1.178 (.3255)	-2.725 (.2624)	.628 (.8274)	3.249 (.2504)
6 a	22.974	1.807 (.0264)	-2.249 (.5318)	-1.040 (.8415)	13.862 (.0455)
7	5.516	.484 (.1686)	-2.527 (.1025)	.925 (.6563)	3.353 (.0576)
		<u>LPCL4</u>	<u>LHOUSCI</u>	<u>LHOUSCL</u>	<u>LHOUSCO</u>
4	-6.343	-.501 (.4718)	.205 (.6714)	.203 (.6483)	.503 (.2427)
		<u>LHOUSDA</u>	<u>LHOUSTO</u>	<u>LHOUSBL</u>	<u>LKXCI10</u>
		-.324 (.6393)	-.014 (.9737)	.060 (.9167)	1.251 (.1512)

Cleveland - Demand - 2SLS - Part I, continued

<u>Sector</u>	<u>Constant</u>	<u>LPCL</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>
10	2.307	-.097 (.8376)	-1.012 (.6156)		-1.646 (.4356)
12	2.833	.101 (.4567)	2.162 (.0001)	-.518 (.0712)	-.484 (.0163)
14	-1.318	.501 (.5391)	1.077 (.5055)	2.378 (.0518)	1.086 (.1696)
15	5.356	1.016 (.0462)	1.936 (.0750)	-.128 (.8656)	1.415 (.0100)
16 a	-10.475	-.329 (.9319)	4.096 (.4257)	3.051 (.4073)	-.051 (.9922)
17	3.740	-.068 (.8338)	1.878 (.0125)	.520 (.3309)	-.500 (.1536)
18	5.378	.624 (.1023)	.365 (.6836)	-.052 (.9381)	.912 (.0496)
19	.833	.307 (.5437)	.198 (.7679)	.434 (.4960)	.528 (.1308)
20	-2.936	-.070 (.6703)	.126 (.8132)	.477 (.2189)	.074 (.7753)
21 a	1.744	-.291 (.5532)	-1.053 (.7018)	3.916 (.1249)	-.196 (.9219)
22 a	-10.800	-.588 (.6733)	-1.822 (.3368)	1.113 (.4462)	1.029 (.4243)
24 a	-2.447	.389 (.7203)	-.715 (.6655)	.554 (.7080)	-.307 (.8031)

Cleveland - Demand - 2SLS - Part I, continued

25	.630	.195 (.2590)	-.474 (.3966)	.220 (.0085)	-.140 (.6138)
26	-8.453	.087 (.7990)	1.351 (.0739)	.897 (.1425)	-.591 (.1077)
27	-4.186	-.148 (.7249)	.383 (.7430)	1.756 (.0738)	-.490 (.4024)
28	2.882	.440 (.3173)	.772 (.2616)	-.199 (.7481)	.324 (.3366)
29	2.665	.165 (.4032)	-.537 (.2536)	1.944 (.0001)	-.640 (.0102)
30 a	.087	.293 (.7485)	-.877 (.6016)	-1.105 (.4564)	.819 (.4938)
31 a	10.216	3.195 (.1751)	5.222 (.1354)	.075 (.9788)	1.058 (.6333)

a: 16 observations

TABLE 9
Cleveland - Demand - 2SLS - Part II

<u>Sector</u>	<u>LPIDA</u>	<u>LPITO</u>	<u>LPIBL</u>	<u>DW</u>	<u>R²</u>
2 a	-4.063 (.4902)	-.919 (.8750)	-1.339 (.8706)	3.00	.8084
3 a	7.097 (.5921)	-3.613 (.8097)	-2.702 (.9000)	1.62	.8040
8 a	.575 (.8887)	-3.731 (.5163)	-4.935 (.5244)	2.09	.8992
5	1.306 (.1244)	-2.687 (.5438)	-.362 (.7436)	.70	.9560
6 a	2.653 (.3668)	-5.682 (.2193)	-9.205 (.1837)	1.75	.9246
7	-.813 (.2813)	-1.684 (.4987)	.516 (.5325)	.89	.9695

<u>Sector</u>	<u>LKXDA10</u>	<u>LKXTO10</u>	<u>LKXBL10</u>	<u>DW</u>	<u>R²</u>
4	.917 (.2287)	-.614 (.1674)	-.280 (.4904)	1.09	.8015

<u>Sec.</u>	<u>LGMPDA10</u>	<u>LGMPTO10</u>	<u>LGMPBL10</u>	<u>LGMPM</u>	<u>DW</u>	<u>R²</u>
10	-.292 (.8210)	1.177 (.3923)	2.133 (.5141)	-.002 (.9974)	1.49	.8387
12	.050 (.8070)	.190 (.2559)	-.314 (.4474)	-.479 (.1068)	2.53	.9179
14	-.893 (.3122)	.088 (.8842)	-1.638 (.3520)	-.876 (.3226)	1.55	.4076

Cleveland - Demand - 2SLS - Part II, continued

15	.030 (.9579)	-1.400 (.0018)	.345 (.7584)	-1.500 (.0104)	2.40	.7201
16 a	-2.888 (.4539)	-1.887 (.3484)	-.375 (.9716)	-.499 (.9431)	2.38	.5827
17	.338 (.3880)	.055 (.8436)	-.770 (.3027)	-.920 (.0063)	2.22	.8498
18	.172 (.7238)	-.944 (.0154)	1.713 (.0817)	-1.660 (.0030)	2.42	.8083
19	.295 (.4720)	-.089 (.7631)	.140 (.8426)	-.595 (.0912)	1.73	.9447
20	-.016 (.9561)	.454 (.0374)	-.184 (.7499)	.130 (.6594)	1.69	.9762
21 a	-3.490 (.1539)	.365 (.7790)	.522 (.9058)	-.218 (.8910)	1.44	.8470
22 a	-.984 (.5123)	.883 (.2773)	.717 (.8411)	.602 (.7639)	1.63	.9255
24 a	-.824 (.5589)	.246 (.7608)	2.136 (.4546)	-.426 (.7254)	1.91	.7901
25	-.241 (.4262)	.213 (.3513)	.773 (.1900)	-.525 (.0578)	2.34	.9375
26	.318 (.4203)	-.043 (.8811)	-1.127 (.1416)	.737 (.0281)	1.20	.9730
27	.190 (.7731)	.300 (.5393)	-.513 (.6778)	-.177 (.7226)	.85	.7994
28	.928 (.0294)	-.075 (.7945)	.259 (.7131)	-1.022 (.0001)	1.86	.9452

Cleveland - Demand - 2SLS - Part II, continued

29	-.615 (.0262)	-.145 (.4465)	.233 (.6322)	-.754 (.0005)	2.51	.8477
30 a	-1.175 (.4069)	-.073 (.9276)	2.926 (.2828)	-.267 (.7647)	1.81	.8901
31 a	.191 (.9423)	-.435 (.7803)	-2.941 (.5653)	-2.277 (.2702)	1.54	.4249

a: 16 observations

TABLE 10

Cleveland - Price Elasticities of Demand - 2SLS

<u>Sector</u>	<u>Elasticity</u>	<u>Significant at 5%</u>
2 a	-1.498	
3 a	3.114	
4	-1.501	
5	.178	
6 a	.807	x
7	-.516	
8 a	.114	
10	-1.097	
12	-.899	
14	-.499	
15	.016	x
16 a	-1.329	
17	-1.068	
18	-.376	
19	-.693	
20	-1.070	
21 a	-1.291	
22 a	-1.588	
24 a	-.611	
25	-.805	
26	-.913	
27	-1.148	
28	-.560	
29	-.835	
30 a	-.707	
31 a	2.195	

a: 16 observations

TABLE 11
Cleveland - Supply - 2SLS

<u>Sector</u>	<u>gQ</u>	<u>hL</u>	<u>hK</u>	<u>DW</u>	<u>R²</u>
2 a	2.849 b	.380 b	.230 b	1.53	.8585
3 a	2.212	.591	.103 b	1.52	.9323
4	1.420	1.153	-.097 b	.73	.9648
5	1.789	.275 b	.003 b	.38	.8858
6 a	1.050 b	.705	.249	1.61	.9607
7	1.094 b	.495	-.078 b	.35	.8054
8 a	1.808	.583	.029 b	1.58	.9417
10	.900 b	.617	-.009 b	.55	.9079
12	.469 b	1.055	-.025 b	.56	.5240
14	.869 b	.497	-.068 b	1.04	.7061
15	1.000 b	.423	-.118	.71	.6818
16 a	.782 b	.778	.116 b	2.16	.8343
17	.912 b	.492	-.018 b	.46	.7921
18	.744 b	.600	.061 b	.62	.7879
19	.901 b	.435	.137 b	.46	.8674
20	.719 b	.796	-.093 b	.77	.7204
21 a	.733 b	1.139	-.367 b	.97	.8499
22 a	.910 b	.510	.142 b	1.23	.6406
24 a	1.010 b	.646	-.001 b	1.23	.8802
25	.810 b	.775	.168 b	.52	.9113
26	.961 b	.574	.112 b	.79	.9639
27	.852 b	.657	.137 b	.51	.9147
28	1.007 b	.157 b	.099 b	.24	.6089
29	.824 b	.362	.096 b	.41	.8477
30 a	.808 b	.615	.014 b	2.23	.8518
31 a	.978 b	.332	.052 b	.96	.4249

gQ calculated.

a: 16 observations. Wages calculated from employment and payroll.

b: not significant to 5%

TABLE 12

Cleveland - Labor Demand - Output Version - OLS

Dependent variable: LHRCL__

<u>Sector</u>	<u>Constant</u>	<u>LGMPCL</u>	<u>L (WCL/R)</u>	<u>DW</u>	<u>R²</u>
2 a	12.759	.500 (.2318)	-.108 (.7675)	1.55	.1228
3 a	15.461	.528 (.0001)	-.670 (.0001)	2.18	.9164
5	17.357	.176 (.0009)	.113 (.2586)	cor.	.3949
6 a	19.430	.333 (.1345)	-1.044 (.0001)	cor.	.9466
8 a	11.287	.673 (.0003)	.924 (.0106)	1.17	.6791
10	19.351	.092 (.0177)	-.124 (.1181)	1.68	.2409
19	16.368	.049 (.2249)	.084 (.3911)	1.80	.1069
22 a	33.275	.167 (.1912)	-.567 (.0280)	1.81	.4139
25	9.536	.592 (.0039)	.613 (.0525)	1.36	.3216
27	15.547	.219 (.0206)	.164 (.4398)	1.44	.1987
29	16.854	.302 (.0125)	-.221 (.0247)	1.36	.3719

Cleveland - Labor Demand - Output Version - OLS, continued

30 a	29.011	.507 (.0012)	-.049 (.8523)	2.33	.5694
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a: 16 observations

TABLE 13

Cleveland - Labor Demand - Price Version - OLS

Dependent variable: LHRCL__

<u>Sec.</u>	<u>Constant</u>	<u>LPCL</u>	<u>LWCL</u>	<u>LR</u>	<u>DW</u>	<u>R²</u>
4	17.453	.179 (.3957)	-.106 (.6439)	.023 (.9395)	cor.	.1947
7	17.785	-.354 (.0005)	.274 (.0054)	.115 (.0781)	1.61	.8543
12	17.808	-.028 (.3546)	-.136 (.0611)	.123 (.0137)	2.46	.3268
14	14.795	.267 (.4399)	-.362 (.3567)	.122 (.6439)	cor.	.0707
15	17.479	.163 (.4235)	-.630 (.0053)	.408 (.0394)	1.60	.6034
16 a	31.093	.337 (.4297)	-.224 (.7496)	.387 (.4090)	2.02	.4012
17	17.523	-.370 (.2182)	-.580 (.0755)	.365 (.0708)	2.08	.5161
24 a	30.753	.167 (.7354)	-.379 (.4344)	-.213 (.4942)	1.58	.5957
26	17.698	.041 (.8543)	-.171 (.2961)	.126 (.2872)	2.11	.1027
28	17.366	.025 (.9053)	-.225 (.1647)	.144 (.3134)	1.77	.1100

a: 16 observations

TABLE 14

Cleveland - Labor Demand - Capital Version - OLS

Dependent variable: LHRCL__

<u>Sector</u>	<u>Constant</u>	<u>L (W/P)</u>	<u>LKCL</u>	<u>DW</u>	<u>R²</u>
18	16.264	-.128 (.1368)	.006 (.8101)	1.68	.1180
20	16.402	-.059 (.5355)	.128 (.1391)	.209	.1755
21 a	32.248	.027 (.7693)	-.425 (.0719)	1.70	.4286
31 a	31.452	-.753 (.0207)	.343 (.7996)	cor.	.4672

a: 16 observations

TABLE 15
Cleveland - Miscellaneous - OLS

Dependent
Variable Constant

		<u>LWCL</u>	<u>LUMPCL</u>	<u>DW</u>	<u>R²</u>
LFPRCL	.597	-.00002 (.0048)	-.015 (.9567)	cor.	.2790

		<u>LWRCL</u>	<u>LURAT</u>		
MIGCL	455385.	-36917. (.0053)	-96098. (.0073)	2.56	.3841

		<u>SAVCL</u>	<u>YHHCL</u>
HOUSCL	-18906.	-1.217 (.1525)	3.220 (.0276)

	<u>RTB</u>	<u>DHHCL</u>	<u>DW</u>	<u>R²</u>
	-88782. (.0948)	.192 (.0930)	1.36	.4892

		<u>GMP10</u>	<u>RCB</u>	<u>DW</u>	<u>R²</u>
KXCL10	-76.433	.104 (.0009)	-278.537 (.7797)	cor.	.5791

		<u>LPCL</u>	<u>LHOUSCI</u>	<u>LHOUSCL</u>	<u>LHOUSCO</u>
LGMPCL4	-.456	.135 (.7734)	.154 (.6756)	.150 (.6575)	.199 (.5034)

Cleveland - Miscellaneous - OLS, continued

		<u>LHOUSDA</u>	<u>LHOUSTO</u>	<u>LHOUSBL</u>	<u>LKXCI10</u>
		-.013 (.9786)	-.094 (.7902)	-.046 (.9163)	-.709 (.2489)
		<u>LKXCL10</u>	<u>LKXCO10</u>	<u>LKXDA10</u>	<u>LKXTO10</u>
		.092 (.8018)	-.004 (.9920)	.309 (.5699)	-.170 (.6291)
		<u>LKXBL10</u>		<u>DW</u>	<u>R²</u>
		-.339 (.2913)		cor.	.7117
		<u>PICL</u>		<u>DW</u>	<u>R²</u>
TCL	-35413.7	58153.6 (.0001)		cor.	.8668
		<u>WGOVCL</u>	<u>TCL</u>		
LGEMPCL	51442.	-3.564 (.0378)	.099 (.0001)	1.68	.9734

TABLE 16

Cincinnati - Demand - OLS - Part I

Dependent variable: LGMPCI__

<u>Sector</u>	<u>Constant</u>	<u>LPCI</u>	<u>LPICI</u>	<u>LPICI</u>	<u>LPICO</u>
2	-2.175	.502 (.0155)	.484 (.7682)	.200 (.0274)	1.80 (.4874)
5	5.266	-.038 (.9364)	-1.450 (.3611)	-.199 (.9329)	4.365 (.0255)
6	8.377	.685 (.0211)	-1.705 (.2257)	-3.340 (.1645)	7.204 (.0015)
7	6.966	.157 (.7336)	.714 (.7381)	-4.758 (.1263)	.903 (.7170)
8	2.802	.128 (.4636)	.018 (.9849)	-.172 (.9128)	1.867 (.1590)
		<u>LPCI</u>	<u>LGMPBL10</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>
10	.412	.021 (.8475)	.638 (.0031)		.218 (.1916)
12	-.816	.084 (.4416)	-.151 (.8441)	.145 (.8481)	-.312 (.5609)
15	-2.490	-.236 (.4835)	.339 (.6949)	1.431 (.0345)	-.234 (.5896)
17	2.464	.099 (.7471)	-.158 (.8427)	1.835 (.0215)	.412 (.4484)
18	-.536	-.122 (.3064)	-.532 (.2770)	1.906 (.0005)	-.492 (.1499)

Cincinnati - Demand - OLS - Part I, continued

19	-1.214	-.074 (.7433)	.326 (.5058)	.945 (.0509)	-.447 (.2054)
20	-2.588	-.080 (.5343)	.146 (.8223)	1.619 (.0144)	-1.467 (.0032)
24	4.010	.277 (.5214)	.301 (.7423)	.193 (.8260)	-1.527 (.0358)
25	-1.797	-.016 (.9353)	-.678 (.3928)	1.418 (.0722)	.940 (.0998)
26	.0	.273 (.1883)	-.334 (.4048)	.873 (.0305)	.342 (.2386)
27	-9.225	-.802 (.0674)	-2.286 (.1150)	.896 (.5014)	2.290 (.0302)
28	.715	-.369 (.4550)	-.914 (.3557)	1.294 (.1768)	-.394 (.5824)
29	4.875	.489 (.0234)	1.344 (.0390)	-1.196 (.0184)	.265 (.3650)

TABLE 17

Cincinnati - Demand - OLS - Part II

Dependent variable: LGMPCI__

This table shows half of each equation. The rest of each equation is in the next table.

Dependent variable: LGMPCL__

<u>Sector</u>	<u>LPIDA</u>	<u>LPITO</u>	<u>LPIBL</u>	<u>DW</u>	<u>R²</u>
2	-.132 (.8600)	-5.292 (.1451)	-1.916 (.0756)	1.71	.8445
5	1.237 (.1122)	-3.740 (.1953)	-.200 (.8173)	cor.	.9523
6	-.639 (.3116)	-2.883 (.3318)	.092 (.9169)	2.09	.9838
7	-1.735 (.0714)	4.182 (.2551)	.993 (.4115)	1.62	.9755
8	-.257 (.6453)	-.072 (.9705)	-.042 (.9417)	cor.	.9927

	<u>LGMPCO10</u>	<u>LGMPDA10</u>	<u>LGMPTO10</u>	<u>LGMPM</u>	<u>DW</u>	<u>R²</u>
10	.119 (.2805)	-.159 (.1889)	.030 (.7249)	-.004 (.9719)	1.70	.9944
12	.272 (.4496)	-.189 (.6363)	1.313 (.0001)	-.034 (.9150)	1.55	.9759
15	-.488 (.2846)	-.164 (.6451)	-.188 (.8184)	-.018 (.9642)	cor.	.4906

Cincinnati - Demand - OLS - Part II, continued

17	-.129 (.7223)	-.459 (.2614)	.143 (.6112)	-.968 (.0116)	1.50 .6824
18	-.256 (.2598)	.331 (.1912)	.233 (.1877)	-.273 (.2040)	1.90 .9627
19	.172 (.4528)	.091 (.7156)	.267 (.1381)	-.337 (.1300)	1.60 .9832
20	.010 (.9736)	.372 (.2637)	.554 (.0233)	.013 (.9623)	1.74 .9888
24	.082 (.8483)	1.167 (.0221)	.667 (.0567)	-.498 (.2429)	1.78 .9348
25	.418 (.2679)	-1.073 (.0157)	.158 (.5858)	-.256 (.4684)	2.09 .7955
26	.269 (.1588)	.233 (.2666)	-.420 (.0074)	-.186 (.3786)	1.75 .9669
27	-1.019 (.1309)	-.358 (.6210)	.915 (.0867)	1.047 (.0883)	1.42 .6819
28	.154 (.7378)	1.144 (.0347)	.346 (.3388)	-.524 (.1064)	1.75 .9046
29	.482 (.1582)	-.033 (.8858)	1.290 (.0844)	-1.329 (.0001)	cor. .9753

TABLE 18

Cincinnati - Price Elasticities of Demand - OLS

<u>Sector</u>	<u>Elasticity</u>	<u>Significant at 5%</u>
2	-.498	x
4	-.935	
5	-1.038	
6	-.315	x
7	-.843	
8	-.872	
10	-.979	
12	-.916	
15	-1.236	
17	-.901	
18	-1.122	
19	-1.074	
20	-1.080	
24	-.723	
25	-1.016	
26	-.727	
27	-1.802	
28	-1.269	
29	-.511	x

TABLE 19
Cincinnati - Supply - OLS

<u>Sector</u>	<u>qQ</u>	<u>hL</u>	<u>hK</u>	<u>DW</u>	<u>R²</u>
2 a	2.053	.274	.097 b	1.57	.8948
4	1.007 b	.615	.455 b	cor.	.8429
5	.988 b	.269 b	.375	cor.	.7528
6 a	1.302 b	.884	-.022 b	1.99	.9396
7	.921 b	.596	-.102 b	cor.	.6154
8 a	1.021 b	.298 b	.625	1.55	.8941
10	.773	.562	.046 b	cor.	.8969
12	.815 b	1.048	-.307	cor.	.4261
15	.913 b	.444	-.243 b	cor.	.3499
17	.895 b	.481	-.099 b	cor.	.6443
18	.745	.570	.124 b	cor.	.7288
19	.862 b	.379	.171 b	cor.	.8223
20	.749	.613	.193 b	cor.	.4344
24 a	.994 b	.045 b	.400	cor.	.6471
25	.906 b	.852	.055 b	cor.	.8604
26	.880 b	.516	.126 b	cor.	.9072
27	.913 b	.502	.143 b	cor.	.8377
28	.924 b	.069 b	.103 b	cor.	.3314
29	.970 b	.322	.068 b	cor.	.6214

qQ is calculated.

a: 16 observations. Wage calculated from employment and payroll.

b: not significant at 5%.

TABLE 20

Cincinnati - Labor Demand - Output Version - OLS

Dependent variables: LHRCI__

<u>Sector</u>	<u>Constant</u>	<u>LGMPCI</u>	<u>L (W/R)</u>	<u>DW</u>	<u>R²</u>
2 a	13.698	-.568 (.1417)	.078 (.8192)	1.82	.1710
3 a	15.035	.677 (.0016)	-.857 (.0114)	1.53	.6054
4	11.684	.436 (.0001)	.554 (.0196)	cor.	.8078
5	15.252	.276 (.0001)	.179 (.2242)	cor.	.5371
7	12.973	.323 (.0001)	.325 (.1752)	cor.	.6345
8 a	12.123	.574 (.0058)	.684 (.2044)	cor.	.4786
19	10.940	.344 (.0105)	.205 (.5933)	1.86	.2360
24 a	27.064	.510 (.2218)	-.027 (.7976)	cor.	.1207
26	11.383	.849 (.0037)	-.268 (.5276)	cor.	.3072
28	27.872	-.199 (.4728)	-3.601 (.0001)	1.50	.5279

a: 16 observations.

TABLE 21

Cincinnati - Labor Demand - Price and Capital Versions - OLS

Dependent variable: LHRCI
Capital Version

<u>Sector</u>	<u>Constant</u>	<u>L(W/P)</u>	<u>LKCI</u>	<u>DW</u>	<u>R²</u>
10	13.817	.090 (.2320)	.501 (.0025)	1.81	.5646
15	15.028	-.592 (.0217)	-.334 (.2418)	1.61	.3546
18	22.136	1.240 (.0004)	-1.838 (.0001)	1.80	.5451
25	16.763	1.109 (.1225)	-.851 (.0198)	cor.	.2283

Price Version

<u>Sec.</u>	<u>Constant</u>	<u>LPCI</u>	<u>LWCI</u>	<u>LR</u>	<u>DW</u>	<u>R²</u>
6 a	14.606	.455 (.0600)	.291 (.3122)	-.106 (.5906)	cor.	.8294
12	19.990	.175 (.4975)	-2.165 (.0003)	1.223 (.0129)	cor.	.7642
17	16.492	-6.610 (.0011)	-.328 (.8615)	.572 (.5859)	2.10	.6359
20	13.375	.658 (.0025)	-.094 (.7448)	.119 (.6618)	cor.	.4520
27	12.627	.498 (.5601)	.533 (.4965)	-.362 (.5073)	cor.	.2110
a:	16 observations					

TABLE 22
Cincinnati - Miscellaneous - OLS

		<u>LWCI</u>	<u>LUMPCI</u>	<u>DW</u>	<u>R²</u>
LFPRCI	.447	.000 (.2191)	.761 (.1166)	cor.	.1466
		<u>LWRCI</u>	<u>LERAT</u>		
MIGCI	-23698.	-68836. (.2242)	93159. (.7649)	cor.	.0627
		<u>SAVCI</u>	<u>YHHC1</u>		
HOUSCI	-54999.	-4.136 (.3601)	4.358 (.0383)		
		<u>RTB</u>	<u>DHHCI</u>		
		-1804.4 (.0010)	6.419 (.1251)	1.39	.5057
		<u>GMPCI10</u>	<u>RCB</u>		
KXCI10	-41.458	.078 (.0001)	-34.520 (.9403)	1.54	.8874
		<u>LPCI4</u>	<u>LHOUSCI</u>	<u>LHOUSCL</u>	<u>LHOUSCO</u>
LGMPCI4	-7.754	.065 (.9349)	.609 (.3057)	-.487 (.4004)	.884 (.0784)
		<u>LHOUSDA</u>	<u>LHOUSTO</u>	<u>LHOUSBL</u>	<u>LKXCI10</u>
		.314 (.6907)	-.420 (.5058)	-.256 (.7294)	.090 (.9288)

Cincinnati - Miscellaneous - OLS, continued

		<u>LKXCL10</u>	<u>LKXCO10</u>	<u>LKXDA10</u>	<u>LKXT010</u>
		.851 (.1805)	.678 (.2975)	.086 (.9177)	-.405 (.4733)
		<u>LKXBL10</u>		<u>DW</u>	<u>R²</u>
		-.214 (.6868)		cor.	.8125
		<u>PICI</u>		<u>DW</u>	<u>R²</u>
TCI	25486.	40827. (.0003)		2.11	.7377
		<u>WGOVCI</u>			
LGEMPCI	18214.	4.705 (.0001)		2.18	.7934

TABLE 23

Columbus - Demand - OLS - Part I

This table shows half of each equation. The rest of each equation is in the next table.

Dependent variable: LGMPCO__

<u>Sector</u>	<u>Constant</u>	<u>LPCO</u>	<u>LPICI</u>	<u>LPICL</u>	<u>LPICO</u>
2	-.665	.446 (.0095)	-.458 (.7817)	5.973 (.0316)	2.680 (.3132)
3	8.185	.845 (.0601)	-.814 (.8807)	-4.074 (.5882)	4.912 (.4704)
5	7.373	-.162 (.6042)	-1.099 (.4765)	.626 (.7671)	3.847 (.0517)
6	12.482	.309 (.2514)	-2.439 (.1792)	-3.162 (.2815)	6.778 (.0173)
7	4.364	-.339 (.0275)	-.332 (.7157)	.896 (.4732)	1.596 (.1605)
8	9.062	.648 (.0473)	-2.950 (.1007)	.599 (.8312)	8.808 (.0009)
		<u>LPCO</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>
10	.324	-.020 (.8812)	.487 (.2851)	-.703 (.0279)	
12	-10.765	-.104 (.8634)	-1.257 (.7993)	.933 (.7917)	1.643 (.4884)
15	-13.281	.517 (.1041)	-.693 (.6255)	3.136 (.0071)	2.109 (.0061)

Columbus - Demand - OLS - Part I, continued

16	-13.194	.445 (.3196)	.663 (.7929)	.825 (.6612)	.005 (.9970)
17	-2.413	.629 (.2390)	1.788 (.3915)	.419 (.7814)	-1.289 (.2126)
18	-1.709	-.049 (.7540)	-.576 (.4979)	-.572 (.3577)	.256 (.5376)
19	-2.441	-.095 (.5908)	.791 (.1932)	-1.190 (.0125)	.267 (.3638)
20	-1.660	.160 (.5516)	-2.089 (.2086)	.154 (.8967)	2.390 (.0065)
22	-7.815	-.663 (.0869)	3.888 (.0436)	-4.156 (.0052)	-1.067 (.2451)
23	-1.535	-.586 (.0525)	-.244 (.8732)	.580 (.6105)	.830 (.2810)
24	-.797	.795 (.0076)	-.976 (.3226)	.937 (.2043)	1.249 (.0152)
25	-6.220	.095 (.6196)	-1.562 (.1739)	.270 (.7483)	-1.011 (.0603)
26	-4.402	.251 (.1373)	-.145 (.8015)	1.753 (.0005)	.571 (.0537)
27	.340	.503 (.0565)	-.767 (.5044)	3.168 (.0012)	.047 (.9332)
28	-1.552	-.946 (.4672)	-.230 (.9422)	-5.364 (.0243)	3.221 (.0594)
29	3.302	-.364 (.1129)	-.993 (.2003)	.804 (.1427)	.280 (.4746)

Columbus - Demand - OLS - Part I, continued

30	-6.059	.784 (.1326)	.605 (.7174)	-.707 (.5668)	1.581 (.0662)
31	4.014	.997 (.1087)	.845 (.6047)	1.889 (.1095)	.032 (.9693)

TABLE 24

Columbus - Demand - OLS - Part II

Dependent variable: LGMPCO__

<u>Sector</u>	<u>LPIDA</u>	<u>LPITO</u>	<u>LPIBL</u>	<u>DW</u>	<u>R²</u>	
2	-.050 (.9461)	-5.292 (.1459)	-1.848 (.0828)	1.99	.9159	
3	1.346 (.5813)	-3.446 (.7068)	.877 (.7683)	2.03	.8742	
5	1.105 (.0807)	-3.868 (.1390)	-.444 (.5982)	1.33	.9593	
6	-.314 (.6824)	-2.095 (.5787)	-.084 (.9394)	1.98	.9649	
7	-.957 (.0167)	-1.142 (.4562)	.601 (.2299)	2.13	.9880	
8	.735 (.4265)	-7.877 (.0286)	-.703 (.5356)	1.78	.9607	
	<u>LGMPDA10</u>	<u>LGMPTO10</u>	<u>LGMPBL10</u>	<u>LGMPM</u>	<u>DW</u>	<u>R²</u>
10	.310 (.2094)	.235 (.1685)	.462 (.3456)	.053 (.8268)	1.44	.9852
12	-4.495 (.1014)	5.153 (.0099)	-.203 (.9683)	.336 (.8817)	1.96	.8355
15	-1.180 (.1384)	-1.546 (.0112)	.558 (.7141)	-.443 (.5276)	1.95	.9076
16	1.740 (.2243)	-.033 (.9733)	-1.186 (.6630)	.117 (.9305)	1.50	.8859

Columbus - Demand - OLS - Part II, continued

17	.363 (.7489)	.642 (.4171)	1.167 (.6018)	-1.708 (.1118)	1.41 .6988
18	.996 (.0411)	1.003 (.0048)	.347 (.6993)	-.426 (.3051)	1.92 .9668
19	-.291 (.3747)	.828 (.0014)	1.053 (.1104)	-.390 (.2177)	1.81 .9865
20	.953 (.2878)	-.967 (.1250)	1.784 (.3144)	-1.000 (.2233)	1.98 .9183
22	1.106 (.2762)	1.715 (.0212)	-.208 (.9150)	.393 (.6580)	1.82 .9588
23	-.166 (.8427)	.178 (.7769)	.221 (.8927)	-.553 (.4394)	1.94 .6204
24	-.873 (.1139)	.166 (.6515)	1.441 (.1733)	-.926 (.0712)	1.80 .9662
25	-.953 (.1244)	1.701 (.0003)	3.046 (.0373)	-.449 (.4366)	cor. .9769
26	-.353 (.2741)	-.302 (.1765)	-.318 (.6048)	-.023 (.9413)	2.35 .9625
27	-.376 (.5481)	.199 (.6470)	-.037 (.9761)	-1.162 (.0476)	1.49 .6673
28	1.719 (.2860)	.846 (.5075)	1585 (.5582)	-.272 (.8394)	cor. .8390
29	.340 (.3889)	.170 (.5709)	-.067 (.9213)	-.212 (.5514)	cor. .5900
30	.110 (.9044)	-.656 (.3120)	.538 (.7625)	-.111 (.8906)	1.37 .9516

Columbus - Demand - OLS - Part II, continued

31	-.603 (.4752)	.189 (.7719)	-.028 (.9849)	1.673 (.0481)	cor. .4547
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TABLE 25

Columbus - Price Elasticities of Demand - OLS

<u>Sector</u>	<u>Elasticity</u>	<u>Significant at 5%</u>
2	-.554	x
3	-.155	
4	-1.539	
5	-1.162	
6	-.691	
7	-1.339	x
8	-.352	x
10	-1.020	
12	-1.104	
15	-.483	
16	-.555	
17	-.371	
18	-1.049	
19	-1.095	
20	-.840	
22	-.663	
23	-1.586	
24	-.205	x
25	-.905	
26	-.749	
27	-.497	
28	-1.946	
29	-1.364	
30	-.216	
31	-.003	

TABLE 26
Columbus - Supply - OLS

<u>Sector</u>	<u>gQ</u>	<u>hL</u>	<u>hK</u>	<u>DW</u>	<u>R²</u>
2	4.808	.436	-.239 a	2.32	.8717
3	1.441 a	.320 a	.366 a	cor.	.6237
4	.979 a	1.017	.426 a	cor.	.8779
5	.726 a	.286 a	.947	cor.	.8009
6	.958 a	.147 a	.981	cor.	.7891
7	.556	1.303	-.126 a	1.53	.9366
8	.816 a	.387	.815	1.51	.9690
10	.703	1.119	.010 a	cor.	.9247
12	.825 a	1.249	-.020 a	cor.	.5104
15	1.185 a	.454	-.040 a	cor.	.6467
16	1.200 a	.213 a	.309 a	cor.	.5737
17	.890 a	.076 a	.540	cor.	.5794
18	1.019 a	.168 a	.515	cor.	.5186
19	.886 a	.786	.224 a	cor.	.8783
20	1.011 a	.673	.007 a	cor.	.5238
22	.845 a	-.006 a	.864	cor.	.4967
23	.750	.018 a	.703	cor.	.6712
24	.928 a	.806	.153 a	cor.	.8992
25	1.024 a	.519	.383 a	cor.	.7718
26	1.202 a	.095 a	.585	cor.	.7308
27	.996 a	1.153	-.167 a	cor.	.9039
28	.968 a	.353	.277	cor.	.7235
29	.732	.243	.388	cor.	.7771
30	1.212	.040 a	.177 a	cor.	.7128
31	1.065 a	.400	.351	cor.	.8085

gQ calculated. 28 observations for all sectors.

a: Not significant at 5%.

TABLE 27

Columbus - Labor Demand - Output Version - OLS

Dependent variable: LHRCO__

<u>Sector</u>	<u>Constant</u>	<u>LGMPCO</u>	<u>L (W/R)</u>	<u>DW</u>	<u>R²</u>
2	12.951	.627 (.0001)	-.319 (.0472)	1.65	.6617
3	17.627	.141 (.0792)	-.616 (.0016)	cor.	.3923
4	17.176	.129 (.0355)	.019 (.9336)	cor.	.1722
6	16.918	.218 (.0001)	-.056 (.5848)	1.11	.6176
7	16.134	.302 (.0490)	.035 (.9346)	1.91	.1666
10	21.527	-.064 (.0664)	-.178 (.1549)	1.61	.1927
26	31.954	-.053 (.5319)	-.261 (.0346)	1.45	.1679
27	19.287	.999 (.2978)	-.340 (.0918)	1.61	.1749

TABLE 28

Columbus - Labor Demand - Price Version - OLS

Dependent variable: LHRCO__

<u>Sec.</u>	<u>Constant</u>	<u>LPCO</u>	<u>LWCO</u>	<u>LR</u>	<u>DW</u>	<u>R²</u>
5	19.775	-.068 (.3330)	.101 (.1445)	.032 (.6272)	cor.	.1558
8	20.303	.581 (.0190)	-.208 (.0748)	.266 (.3098)	1.37	.9136
12	18.338	-.049 (.5547)	-.504 (.0185)	.224 (.1643)	2.10	.6566
15	30.094	.025 (.8734)	-.210 (.0710)	.0004 (.9955)	1.66	.4081
16	21.105	.589 (.0093)	-.594 (.0038)	-.406 (.0453)	2.13	.5445
18	31.730	-.645 (.0001)	-.176 (.1322)	.515 (.0001)	1.42	.7360
19	17.983	-.456 (.0380)	.008 (.9707)	.256 (.0383)	cor.	.3404
20	24.892	-.073 (.4584)	-.633 (.0002)	.357 (.0035)	1.95	.7478
22	33.608	-.044 (.9054)	-.102 (.6028)	1.016 (.0098)	cor.	.3308
24	16.631	-1.077 (.0001)	.509 (.0647)	.086 (.5986)	1.38	.6925
25	27.418	-.045 (.6918)	-.527 (.0001)	.181 (.0624)	1.66	.8282

Columbus - Labor Demand - Price Version - OLS, continued

28	28.353	-.161 (.4914)	-.437 (.0071)	.214 (.0145)	2.16 .5788
30	18.315	1.280 (.0038)	-.926 (.0001)	.068 (.7884)	cor. .8286

TABLE 29

Columbus - Labor Demand - Capital Version - OLS

<u>Sector</u>	<u>Constant</u>	<u>L (W/P)</u>	<u>LKCO</u>	<u>DW</u>	<u>R²</u>
17	23.785	-.619 (.0001)	-.377 (.5001)	cor.	.6052
23	25.297	-.148 (.3152)	.589 (.0020)	2.18	.3260
29	24.404	-.647 (.0001)	.217 (.4755)	cor.	.4974
31	19.542	-.752 (.0001)	.624 (.0042)	cor.	.6161

TABLE 30
Columbus - Miscellaneous - OLS

Dependent
Variable Constant

		<u>LWRCO</u>	<u>LURAT</u>	<u>DW</u>	<u>R²</u>
MIGCO	65028.	-39574. (.7048)	-22472. (.2745)	1.63	.0507
		<u>LW</u>	<u>LUMPCO</u>		
LFPRCO	0.	.00005 (.0001)	.509 (.0063)	cor.	.8447
		<u>SAVCO</u>	<u>YHHCO</u>		
HOUSCO	-44006.	-13.994 (.0002)	6.210 (.0001)		
		<u>RTB</u>	<u>DHHCO</u>		
		-155304. (.0024)	2.763 (.0041)	1.52	.6990
		<u>GMPCO10</u>	<u>RCB</u>		
KXCO10	-18.918	.055 (.0165)	627.844 (.1033)	cor.	.7094
		<u>LPCO4</u>	<u>LHOUSCI</u>	<u>LHOUSCL</u>	<u>LHOUSCO</u>
LGMPCO4	-4.205	-.539 (.1777)	.013 (.9727)	.170 (.6601)	.294 (.3153)

Columbus - Miscellaneous - OLS, continued

		<u>LHOUSDA</u>	<u>LHOUSTO</u>	<u>LHOUSBL</u>	<u>LKXCI10</u>
		-.284 (.5833)	.319 (.4083)	.038 (.9362)	.781 (.2547)
		<u>LKXBL10</u>		<u>DW</u>	<u>R²</u>
		-.374 (.2701)		1.59	.8834
		<u>PICO</u>		<u>DW</u>	<u>R²</u>
TCO	4314.82	45699.8 (.0001)		1.49	.9486
		<u>TCO</u>	<u>WGOVCO</u>		
LGEMPCO	18308.4	.131 (.0001)	-1.891 (.0001)	2.41	.9546

TABLE 31

Dayton - Demand - OLS - Part I

This table shows half of each equation. The rest of each equation is in the next table.

Dependent variable: LGMPDA__

<u>Sector</u>	<u>Constant</u>	<u>LPDA</u>	<u>LPICI</u>	<u>LPICL</u>	<u>LPICO</u>
2	.850	.699 (.0029)	-.912 (.6298)	3.709 (.2288)	-.366 (.8968)
3	1.877	1.688 (.0010)	-1.111 (.8324)	.135 (.9853)	8.067 (.2015)
5	3.448	.056 (.8473)	-.666 (.6509)	.699 (.7494)	4.462 (.0196)
6	6.952	.408 (.2178)	-1.022 (.5945)	-2.593 (.4276)	7.222 (.0095)
7	2.276	.066 (.8746)	-2.068 (.4579)	1.446 (.7225)	8.606 (.0150)
8	4.991	.545 (.0664)	-2.125 (.2742)	-.196 (.9501)	9.167 (.0026)
		<u>LPDA</u>	<u>LGMPCI10</u>	<u>LGMPCL10</u>	<u>LGMPCO10</u>
10	-1.477	-.032 (.8487)	-.529 (.1925)	.568 (.0694)	.260 (.1982)
12	7.481	.073 (.4967)	1.520 (.0563)	-1.446 (.0125)	-.464 (.2028)
16	-5.868	.384 (.3364)	.263 (.8754)	.390 (.7509)	.008 (.9919)

Dayton - Demand - OLS - Part I, continued

18	3.104	.054 (.8150)	1.674 (.0899)	-2.551 (.0014)	-.226 (.6251)
19	-1.079	-.347 (.0114)	.1744 (.0238)	-.497 (.0499)	.070 (.6465)
22	-7.460	-.345 (.0422)	1.119 (.0770)	-.487 (.2799)	.350 (.2467)
24	1.047	.250 (.4017)	.113 (.8750)	-.043 (.9417)	-.500 (.1712)
27	-13.186	-.565 (.0554)	.516 (.5915)	1.486 (.0552)	.040 (.9322)
29	-3.982	.388 (.3233)	.1771 (.5378)	1.119 (.2443)	.157 (.7996)
31	3.430	.950 (.2344)	-.006 (.9967)	2.365 (.0396)	.393 (.5908)

TABLE 32

Dayton - Demand - OLS - Part II

Dependent variable: LGMPDA__

<u>Sector</u>	<u>LPIDA</u>	<u>LPITO</u>	<u>LPIBL</u>	<u>DW</u>	<u>R²</u>
2	-.292 (.7386)	-.659 (.8663)	-.759 (.5186)	2.10	.9081
3	-3.003 (.1854)	-7.551 (.4050)	.886 (.7601)	1.89	.8391
5	.276 (.7016)	-3.870 (.1601)	-.438 (.6241)	1.46	.9829
6	-.957 (.2951)	-3.452 (.3679)	.044 (.9704)	1.75	.9790
7	-2.080 (.0822)	-6.356 (.1966)	-.081 (.9595)	1.54	.9207
8	-1.384 (.2277)	-6.074 (.1349)	-.371 (.7738)	1.79	.9762

<u>SEC.</u>	<u>LGMPDA10</u>	<u>LGMPITO10</u>	<u>LGMPBL10</u>	<u>LGMPM</u>	<u>DW</u>	<u>R²</u>
10		.012 (.9383)	.610 (.1483)	.069 (.7257)	1.87	.9847
12	1.796 (.0002)	-.078 (.7775)	-.200 (.7933)	-.881 (.0142)	1.69	.6720
16	.203 (.8285)	-.536 (.4209)	.954 (.5887)	-.302 (.7453)	1.47	.8518
18	1.486 (.0086)	.646 (.0814)	.656 (.5071)	-.884 (.0601)	1.58	.9592

Dayton - Demand - OLS - Part II, continued

19	.246 (.1528)	.243 (.2297)	.313 (.3341)	-.160 (.2803)	1.88 .9835
22	.520 (.1283)	.683 (.0073)	-.625 (.3303)	.179 (.5238)	2.43 .9894
24	.450 (.2618)	.557 (.0506)	.529 (.4801)	-.548 (.1275)	1.83 .9162
27	-.463 (.3795)	-.594 (.1129)	-.728 (.4700)	1.399 (.0048)	1.43 .9261
29	-.516 (.4494)	1.185 (.0193)	-.709 (.5852)	-.470 (.3806)	1.24 .9311
31	-.660 (.3989)	.021 (.9711)	-.643 (.6641)	-1.099 (.1501)	1.69 .4347

TABLE 33

Dayton - Price Elasticities of Demand - OLS

<u>Sector</u>	<u>Elasticity</u>	<u>Significant at 5%</u>
2	-.301	x
3	.688	x
4	-1.172	
5	-.944	
6	-.592	
7	-.934	
8	-.455	
10	-1.032	
12	-.927	
16	-.616	
18	-.946	
19	-1.347	x
22	-1.346	x
24	-.750	
27	-1.565	
29	-.612	
31	-.050	

TABLE 34

Dayton - Supply - OLS

<u>Sector</u>	<u>qQ</u>	<u>hL</u>	<u>hK</u>	<u>DW</u>	<u>R²</u>
2 a	22.727	.003 b	.033 b	1.94	.9576
3 a	2.703	.692	.347 b	1.91	.9228
4	1.134 b	1.130	.040 b	cor.	.8899
5	2.028	.104 b	.128 b	cor.	.8365
6 a	1.385 b	1.282	-.238 b	2.05	.9595
7	.947 b	.903	-.240 b	cor.	.8874
8 a	2.494	.399 b	.161 b	1.53	.9237
10	.857 b	1.009	-.105 b	1.36	.9658
12	1.091 b	1.237	-.405 b	cor.	.6333
16 a	1.653 b	1.270	-.699 b	1.58	.8492
18	.989 b	.970	-.095 b	cor.	.8414
19	.885 b	.622	.169 b	cor.	.8932
22 a	.983 b	.184 b	.467 b	cor.	.4836
24	.919 b	.785	.159 b	cor.	.9285
27	.849 b	1.257	.023 b	cor.	.9328
29	1.070 b	.704	-.062 b	cor.	.8510
31 a	.826 b	.033 b	.482 b	cor.	.6532

qQ is calculated.

a: 16 observations. Calculated wage rate from employment and payroll.

b: Not significant at 5%.

TABLE 35

Dayton - Labor Demand - Output Version - OLS

Dependent variable: LHRDA

<u>Sector</u>	<u>Constant</u>	<u>LGMPDA</u>	<u>L (W/R)</u>	<u>DW</u>	<u>R²</u>
2 a	11.354	.766 (.0509)	-.502 (.3351)	1.13	.3099
3 a	16.520	.190 (.1962)	-.913 (.0480)	cor.	.4290
4	11.525	.157 (.0495)	.731 (.0166)	cor.	.4545
5	14.005	.407 (.0001)	.293 (.0608)	cor.	.6751
6 a	10.051	.705 (.0001)	.634 (.0048)	1.23	.9359
7	13.072	.246 (.0001)	.264 (.1044)	cor.	.5043
8 a	11.282	.760 (.0001)	.725 (.0031)	1.72	.8701
18	14.732	.162 (.0941)	-.183 (.6265)	1.59	.1328
22 a	20.506	.899 (.0008)	-.470 (.2849)	2.04	.6067
24	4.987	1.532 (.0004)	.878 (.2278)	cor.	.4233
27	13.814	.347 (.0006)	.012 (.9656)	2.23	.4016

a: 16 observations

TABLE 36

Dayton - Labor Demand - Price and Capital Versions - OLS

Dependent variable: LHRDA__

Price Version

<u>Sec.</u>	<u>Constant</u>	<u>LPDA</u>	<u>LWDA</u>	<u>LR</u>	<u>DW</u>	<u>R²</u>
12	15.583	-.056	-.192	.074	1.66	.3904
8.2	.sp 2					
19	13.153	.165 (.7045)	.572 (.1868)	-.084 (.8225)	cor.	.5022
31 a	30.277	-.225 (.7358)	-.006 (.9846)	.716 (.3387)	1.21	.3186

Capital Version

<u>Sector</u>	<u>Constant</u>	<u>L (W/P)</u>	<u>LKDA</u>	<u>DW</u>	<u>R²</u>
10	13.638	.024 (.9255)	.597 (.0001)	1.87	.7379
16 a	23.387	-.198 (.4543)	1.138 (.0038)	1.53	.7253
29	12.403	.315 (.0863)	.460 (.0019)	2.22	.6532

a: 16 observations

TABLE 37

Dayton - Miscellaneous - OLS

		<u>LWRDA</u>	<u>LURAT</u>	<u>DW</u>	<u>R²</u>
MIGDA	102380.	-50862. (.2701)	-43856. (.0030)	1.19	.3528
LFPRDA	.365	<u>LWDA</u> .000005 (.0041)	<u>LUMPDA</u> .258 (.0266)	1.35	.4761
HOUSDA	-12455.	<u>SAVDA</u> -5.012 (.1097)	<u>YHHDA</u> 1.635 (.0092)		
		<u>RTB</u> -79841.6 (.0201)	<u>DHHDA</u> 1.759 (.0957)	cor.	.3431
KXDA10	-23.743	<u>GMPDA10</u> .086 (.0001)	<u>RCB</u> -4.937 (.9840)	1.55	.9147
LGMPDA4	-7.984	<u>LPDA4</u> -.172 (.6265)	<u>LHOUSCI</u> .516 (.1747)	<u>LHOUSCL</u> .070 (.8422)	<u>LHOUSCO</u> .400 (.1462)
		<u>LHOUSDA</u> -.207 (.6415)	<u>LHOUSTO</u> -.117 (.7315)	<u>LHOUSBL</u> -.133 (.7649)	<u>LKXCI10</u> .772 (.2440)

Dayton - Miscellaneous - OLS, continued

		<u>LKXCL10</u>	<u>LKXCO10</u>	<u>LKXDA10</u>	<u>LKXTO10</u>
		-.07 (.7825)	.345 (.3844)	.932 (.0764)	-.194 (.5420)
		<u>LKXBL10</u>		<u>DW</u>	<u>R²</u>
		-.303 (.3459)		1.91	.9522
		<u>PIDA</u>		<u>DW</u>	<u>R²</u>
TDA	-21996.	53465. (.0001)		1.76	.9688
		<u>WGOVDA</u>	<u>TDA</u>		
LGEMPDA	13860.	-.484 (.6302)	.093 (.0086)	cor.	.8944

TABLE 38

Toledo - Demand - OLS - Part I

This table shows half of each equation. The rest of each equation is in the next table.

Dependent variable: LGMPTO__

<u>Sector</u>	<u>Constant</u>	<u>LPTO</u>	<u>LPICI</u>	<u>LPICL</u>	<u>LPICO</u>
2	1.631	.509 (.0099)	1.544 (.2846)	1.820 (.4643)	1.204 (.5924)
3	11.147	1.433 (.0069)	-2.288 (.6503)	-6.829 (.3456)	2.265 (.7104)
5	6.400	.j402 (.2479)	-1.830 (.2067)	1.594 (.4966)	4.990 (.0123)
6	28.922	1.002 (.0003)	-1.138 (.4550)	1.511 (.5572)	7.328 (.0330)
7	4.464	-.222 (.4651)	-.572 (.6962)	.282 (.9068)	5.381 (.0062)
8	6.204	.946 (.0003)	-1.982 (.2122)	-2.260 (.3812)	7.508 (.0024)
		<u>LPTO</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>
10	-1.098	.333 (.0643)	.058 (.9162)	.744 (.0841)	.409 (.1208)
18	2.677	.242 (.6775)	-4.210 (.1052)	-1.369 (.4682)	1.211 (.3339)
19	-10.308	-.743 (.0504)	-1.118 (.2988)	2.069 (.0244)	.256 (.6251)

Toledo - Demand - OLS - Part I, continued

20	-6.594	-.145 (.2605)	1.894 (.0050)	-.441 (.3235)	.389 (.1983)
21	-10.302	.493 (.1086)	.373 (.8376)	1.762 (.1934)	-.754 (.4022)
24	-.128	.041 (.8934)	-1.691 (.0782)	-.426 (.5811)	.514 (.2566)
25	-6.183	.109 (.6669)	-.228 (.8339)	.930 (.2716)	-.890 (.1115)
26	-7.463	-.190 (.4201)	.390 (.53897)	1.492 (.0087)	-.160 (.6039)
27	-7.423	-.961 (.0058)	.913 (.4750)	.502 (.6162)	-.590 (.3527)
28	-.763	.395 (.0866)	3.481 (.0001)	-1.045 (.0867)	-.414 (.2560)
29	7.315	.885 (.0765)	-2.098 (.2487)	-1.740 (.2222)	.659 (.4565)
30	-2.543	-.143 (.6592)	-.642 (.4598)	-.343 (.6299)	.641 (.1393)
31	-12.446	-1.834 (.0850)	1.856 (.4377)	1.476 (.4366)	-.123 (.9148)

TABLE 39

Toledo - Demand - OLS - Part II

Dependent variable: LGMPTO__

<u>Sector</u>	<u>LPIDA</u>	<u>LPITO</u>	<u>LPIBL</u>	<u>DW</u>	<u>R²</u>
2	-.016 (.9804)	-2.984 (.3785)	-.821 (.3771)	1.75	.9312
3	2.641 (.3090)	-.086 (.9922)	1.890 (.5107)	2.23	.8496
5	.706 (.2822)	-4.814 (.0854)	-.605 (.5017)	1.73	.9864
6	.348 (.6018)	-5.378 (.0823)	-1.158 (.2266)	1.87	.9868
7	-1.394 (.0729)	-4.211 (.1324)	.611 (.4980)	1.26	.9772
8	.154 (.8378)	-7.686 (.0193)	-1.015 (.3203)	1.90	.9788

	<u>LGMPDA10</u>	<u>LGMPTO10</u>	<u>LGMPBL10</u>	<u>LG NPM</u>	<u>DW</u>	<u>R²</u>
10	-.034 (.9087)		.168 (.7694)	-.204 (.2445)	1.66	.9798
18	-.064 (.9625)	3.775 (.0011)	2.359 (.3725)	-.931 (.3278)	1.91	.9279
19	-1.400 (.0236)	1.056 (.0235)	.013 (.9907)	.504 (.1510)	1.64	.8700
20	-.329 (.3208)	.899 (.0011)	-1.318 (.0491)	.364 (.1498)	2.47	.9859

Toledo - Demand - OLS - Part II, continued

21	-.576 (.5627)	-.952 (.1838)	.430 (.8238)	.803 (.3559)	1.36 .8405
24	.216 (.6611)	2.146 (.0001)	.161 (.8644)	.004 (.9901)	2.10 .9769
25	-.122 (.8360)	1.322 (.0074)	.285 (.8017)	-.004 (.9925)	1.83 .9428
26	.187 (.5787)	-.017 (.9481)	-1.046 (.1165)	.484 (.0354)	2.09 .9380
27	.669 (.3406)	.684 (.1999)	-1.265 (.3452)	.548 (.2153)	1.51 .7012
28	.160 (.6892)	.201 (.5006)	-.212 (.7822)	-.880 (.7822)	2.06 .9631
29	.826 (.4008)	1.139 (.1280)	3.397 (.0809)	-1.667 (.0085)	1.35 .9390
30	-.442 (.3533)	-.383 (.2776)	1.842 (.0518)	-.558 (.3344)	1.82 .8966
31	-1.544 (.2362)	-.069 (.9414)	-1.216 (.6190)	.975 (.1974)	1.18 .3429

TABLE 40

Toledo - Price Elasticities of Demand - OLS

<u>Sector</u>	<u>Elasticity</u>	<u>Significant at 5%</u>
2	-.491	x
3	.143	x
4	-.618	
5	-.598	
6	.002	
7	-.778	
8	-.054	x
10	-.667	
18	-.758	
19	-1.743	
20	-1.145	
21	-.507	
24	-.959	
25	-.891	
26	-1.190	
27	-1.961	x
28	-.605	
29	-.115	
30	-1.143	
31	-2.834	

TABLE 41
Toledo - Supply - OLS

<u>Sector</u>	<u>qQ</u>	<u>hL</u>	<u>hK</u>	<u>DW</u>	<u>R²</u>
2 a	11.364	-.082 b	.184 b	1.67	.9032
3 a	5.952	.914	-.166 b	1.34	.8987
4	1.198	.734	.396 b	cor.	.9467
5	1.252 b	-.001 b	.550	1.20	.9619
6 a	2.141	.515	-.076 b	2.40	.9507
7	1.010 b	.586	-.040 b	cor.	.8198
8 a	1.905	.273 b	.362 b	2.08	.9383
10	1.512 b	.529	.088 b	cor.	.9088
18 a	.984 b	1.119	-.411	1.32	.9261
19 a	.987 b	.462	.129 b	1.79	.9153
20 a	.867 b	1.085	-.187 b	1.17	.8845
21 a	15.152	-.223 b	-.203 b	1.12	.7828
24	1.117 b	.383	.319	cor.	.9062
25	1.149 b	.662	.307 b	cor.	.8227
26	1.056 b	.459	.375	cor.	.9186
27	.899 b	.554	.321 b	cor.	.8764
29	1.012 b	.381	.217 b	cor.	.7559
30 a	1.013 b	.398	.058 b	1.38	.9149
31 a	.993 b	.302	.122 b	1.46	.9216

qQ is calculated.

a: 16 observations. Wages calculated from employment and payroll.

b: Not significant at 5%.

TABLE 42

Toledo - Labor Demand - Output Version - OLS

Dependent Variable: LHRTO__

<u>Sector</u>	<u>Constant</u>	<u>LGMP TO</u>	<u>L (W/R)</u>	<u>DW</u>	<u>R²</u>
3 a	18.682	.306 (.0401)	-1.222 (.0025)	cor.	.6789
7	14.034	.202 (.0013)	.619 (.0117)	2.14	.4672
8	11.037	.800 (.0001)	.777 (.0091)	1.55	.7727
18 a	37.694	.201 (.2337)	-1.450 (.0018)	1.35	.5561
19 a	34.746	.268 (.0638)	-.528 (.0393)	cor.	.4679
20 a	35.794	.123 (.3712)	-.831 (.0066)	1.54	.5066
24	16.083	.173 (.0184)	-.013 (.9649)	1.70	.3287
27	19.166	.286 (.0332)	-.527 (.0581)	1.95	.2835
30	30.893	1.492 (.0015)	-.407 (.3435)	1.67	.5813

a: 16 observations

TABLE 43

Toledo - Labor Demand - Price Version - OLS

Dependent variable: LHRTO__

<u>Sec.</u>	<u>Constant</u>	<u>LWTO</u>	<u>LR</u>	<u>LPTO</u>	<u>DW</u>	<u>R²</u>
2 a	14.435	.306 (.2649)	.083 (.7963)	.532 (.1008)	2.02	.8396
4	18.096	-.245 (.2001)		.426 (.0125)	1.68	.6559
5	19.153	.558 (.0012)	.131 (.4584)	-.097 (.6299)	cor.	.7890
6 a	18.198	.048 (.7863)	.121 (.4517)	.623 (.0036)	2.34	.9449
21 a	29.454	-.881 (.1074)	-.327 (.4932)	.987 (.0072)	1.60	.4658
25	16.671	.346 (.1348)	.227 (.1645)	-.500 (.0102)	2.14	.2602
26	17.063	.380 (.1159)	.049 (.8206)	-.209 (.4660)	cor.	.3101
29	18.175	-.392 (.1939)	.095 (.7648)	.279 (.4753)	1.83	.1716
31 a	34.985	-.952 (.1638)	.907 (.0739)	1.682 (.3246)	1.90	.5499

a: 16 observations

TABLE 44

Toledo - Miscellaneous - OLS

Dependent Variable		Constant				
		<u>LWTO</u>	<u>LUMPTO</u>			<u>R²</u>
LFPRT0	.348	2.005E-05 (.0001)	.273 (.1019)			.725
		<u>LWRT0</u>	<u>LERTO</u>			<u>R²</u>
MIGTO	-18054.	-1409. (.2606)	11132. (.0797)			.1880
		<u>YHHTO</u>	<u>DHHTO</u>			
HOUSTO	-8917.2	1927.9 (.0001)	-.386 (.0859)			
		<u>SAVTO</u>	<u>RTB</u>			<u>R²</u>
		-2.684 (.0611)	-93876. (.0001)			.738
		<u>GMPTO10</u>	<u>RCB</u>			<u>R²</u>
KXTO10	-24.571	.115 (.0001)	-332.9 (.4206)			.837
		<u>LHOUSCI</u>	<u>LHOUSCL</u>	<u>LHOUSCO</u>	<u>LHOUSDA</u>	
LGMPTO4	-3.707	.159 (.7208)	.303 (.4758)	.260 (.4589)	.420 (.4217)	

Toledo - Miscellaneous - OLS, continued

		<u>LHOUSTO</u>	<u>LHOUSBL</u>	<u>LKXCI10</u>	<u>LKXCL10</u>
		-.0 (.3302)	-.358 (.5161)	.805 (.3159)	-.076 (.8703)
		<u>LKXCO10</u>	<u>LKXDA10</u>	<u>LKXTO10</u>	<u>LKXBL10</u>
		-.094 (.8355)	.370 (.5334)	-.113 (.7535)	-.196 (.5991)
		<u>LPT04</u>			<u>R²</u>
		.382 (.4108)			.8962
		<u>PITO</u>			<u>R²</u>
TTO	-46630	62285. (.0010)			.856
		<u>WGOVTO</u>	<u>TTO</u>		<u>R²</u>
LGEMPTO	23236.	-3.434 (.0052)	.165 (.0018)		.9538

TABLE 45

Balance of State - Demand - OLS - Part I

This table shows half of each equation. The rest of each equation is in the next table.

Dependent variable: LGMPBL__

<u>Sector</u>	<u>Constant</u>	<u>LPBL</u>	<u>LPICI</u>	<u>LPICL</u>	<u>LPICO</u>
2	3.679	.482 (.0032)	1.800 (.2390)	.796 (.4679)	-.364 (.8649)
3	4.267	.420 (.2724)	4.913 (.1206)	-3.155 (.5501)	-1.134 (.7731)
5	4.772	.041 (.8800)	-.490 (.7623)	2.917 (.3231)	3.703 (.1006)
6	.118	-.237 (.2817)	-2.933 (.7847)	3.869 (.0456)	(.0025)
7	5.650	.610 (.2941)	-.364 (.8580)	.211 (.9565)	.574 (.8373)
8	6.217	.254 (.3527)	-1.045 (.6932)	1.722 (.6928)	8.110 (.0334)
		<u>LPCL</u>	<u>LGMPCL10</u>	<u>LGMPCL10</u>	<u>LGMPCL010</u>
10	-.428	-.092 (.3703)	.674 (.0003)	.208 (.1134)	.098 (.2726)
12	-4.224	.167 (.3464)	-.749 (.3902)	1.719 (.0093)	-.039 (.9302)
13	-14.982	-.584 (.8679)	-.536 (.9574)	6.705 (.3261)	2.115 (.6433)

Balance of State - Demand - OLS - Part I, continued

14	2.249	.834 (.0820)	-.881 (.5338)	.969 (.3793)	.478 (.4902)
15	-.497	.143 (.6387)	-.960 (.3099)	1.042 (.1600)	1.306 (.0091)
16	-3.435	-.076 (.7492)	-.093 (.9296)	.592 (.4641)	-.785 (.1413)
17	-.408	1.174 (.1006)	-1.393 (.3653)	1.714 (.1208)	.611 (.4177)
18	.699	.658 (.0183)	-2.234 (.0084)	1.437 (.0176)	.247 (.5286)
19	-.061	-.083 (.8680)	-.357 (.7404)	.537 (.4504)	-.134 (.7903)
20	-3.403	.995 (.0253)	-.048 (.9752)	1.556 (.1854)	.616 (.4282)
21	13.594	1.046 (.0012)	.580 (.7016)	-.557 (.6211)	.411 (.5850)
22	-4.136	.600 (.0348)	-.353 (.6789)	1.247 (.0530)	-.527 (.2412)
23	-.231	-.432 (.0898)	.469 (.5721)	.153 (.8060)	-.103 (.7976)
24	-5.481	.292 (.5344)	1.195 (.3354)	1.008 (.2279)	-.609 (.2771)
25	-.792	1.232 (.0004)	.280 (.7628)	1.087 (.1185)	-.047 (.9207)
26	3.217	-.337 (.5374)	-3.168 (.0443)	-.304 (.7583)	.001 (.9986)

Balance of State - Demand - OLS - Part I, continued

28	-2.149	3.357 (.0059)	-2.905 (.1958)	4.844 (.0030)	.201 (.8397)
30	-1.430	-1.524 (.0886)	.665 (.7042)	-2.213 (.0709)	-.853 (.2888)
31	-4.412	1.353 (.1640)	-.650 (.7852)	2.388 (.1501)	.073 (.9476)

TABLE 46

Balance of State - Demand - OLS - Part II

Dependent variable: LGMPBL__

<u>Sector</u>	<u>LPIDA</u>	<u>LPITO</u>	<u>LPIBL</u>	<u>DW</u>	<u>R²</u>	
2	-.266 (.7089)	-1.018 (.7388)	-.854 (.3866)	1.78	.9297	
3	.785 (.6105)	-1.524 (.7884)	1.026 (.5993)	1.31	.9094	
5	.692 (.3821)	-5.085 (.1359)	-.910 (.4099)	1.48	.9627	
6	-.050 (.9023)	-.916 (.5865)	.082 (.8822)	1.58	.9919	
7	-1.236 (.1983)	.459 (.9137)	.716 (.6161)	1.11	.9177	
8	.684 (.6033)	-8.242 (.1268)	-1.238 (.4723)	1.39	.9472	
	<u>LGMPDA10</u>	<u>LGMPTO10</u>	<u>LGMPBL10</u>	<u>LGMPM</u>	<u>DW</u>	<u>R²</u>
10	.050 (.6535)	.055 (.3855)		.163 (.0271)	cor.	.9986
12	.367 (.4082)	-.960 (.0098)	.745 (.3134)	.011 (.9752)	cor.	.8160
13	.573 (.9155)	-5.270 (.1400)	4.801 (.6215)	-4.411 (.2486)	2.24	.3026
14	-.635 (.4459)	-.170 (.7587)	1.433 (.3434)	-.529 (.3880)	1.98	.7610

Balance of State - Demand - OLS - Part II, continued

15	-.021 (.9687)	-.530 (.1586)	1.095 (.2759)	-.676 (.1047)	1.78	.9413
16	1.209 (.0658)	.092 (.8214)	-.273 (.8077)	.421 (.4125)	2.09	.9136
17	.463 (.6056)	.302 (.5886)	-.854 (.5844)	.188 (.7789)	1.42	.8665
18	.363 (.4249)	-.087 (.7667)	.529 (.5163)	.265 (.4946)	1.97	.9393
19	-.122 (.8335)	-.079 (.8279)	.683 (.4988)	.118 (.7732)	1.40	.8238
20	-.113 (.8984)	-2.215 (.0011)	1.818 (.2852)	-.536 (.5005)	1.30	.8132
21	-.450 (.6064)	1.031 (.0840)	1.159 (.4835)	-1.934 (.0285)	1.65	.7829
22	-.003 (.9952)	-.087 (.7830)	.048 (.9567)	.621 (.1045)	2.42	.9441
23	-.471 (.3170)	.300 (.3901)	.165 (.8487)	.246 (.4866)	128	.8651
24	.265 (.6928)	-.138 (.7400)	-1.743 (.1355)	1.131 (.0161)	2.12	.9053
25	.867 (.1266)	-.603 (.1059)	-.630 (.5153)	.016 (.9723)	2.31	.9637
26	-.033 (.9687)	.599 (.2469)	3.002 (.0429)	-.062 (.9117)	2.10	.8107
28	.028 (.9813)	.676 (.3674)	-2.427 (.2387)	.542 (.3717)	1.87	.6348

Balance of State - Demand - OLS - Part II, continued

30	-.128 (.8962)	2.324 (.0009)	-.433 (.7942)	.289 (.0373)	1.88	.9074
31	1.196 (.3677)	.147 (.8603)	-2.643 (.2614)	.846 (.2940)	1.55	.7659

TABLE 47

Balance of State - Price Elasticities of Demand - OLS

<u>Sector</u>	<u>Elasticity</u>	<u>Significant at 5%</u>
2	-.518	x
3	-.580	
4	-1.033	
5	-.959	
6	-.882	
7	-.390	
8	-.746	
10	-1.092	
12	-.833	
13	-1.584	
14	-.166	
15	-.857	
16	-1.076	
17	.174	
18	-.342	x
19	-1.083	
20	-.005	x
21	.046	x
22	-.400	x
23	-1.432	
24	-.708	
25	.232	x
26	-1.337	
28	2.357	x
30	-2.524	
31	.353	

TABLE 48

Balance of State - Supply - OLS

<u>Sector</u>	<u>gQ</u>	<u>hL</u>	<u>hK</u>	<u>DW</u>	<u>R²</u>
2	1000.	-.367 a	.199 a	1.56	.8288
3	1.032 a	1.450	-.302 a	cor.	.8150
4	1.326	.614	.341 a	cor.	.7744
5	1.340	.105 a	.251	cor.	.6690
6	1.701	.048 a	.273 a	cor.	.8247
7	1.065 a	.311	-.008 a	cor.	.6562
8	1.524	.052 a	.466	cor.	.8159
10	.955 a	.348	.177 a	cor.	.7511
12	.898 a	.931	-.474 a	cor.	.5352
13	1.006 a	.082 a	.519	cor.	.6913
14	1.030 a	.415	-.131 a	cor.	.3974
15	.990 a	.422	-.176 a	cor.	.3819
16	1.100 a	.879	-.261 a	cor.	.6035
17	.990 a	.296	.107 a	cor.	.5170
18	1.075 a	.366	.166 a	cor.	.6897
19	.912 a	.314	.234	cor.	.7757
20	1.020 a	.347 a	.070	cor.	.4706
21	1.178 a	.989	-.344 a	cor.	.7853
22	1.135 a	.264 a	.018 a	cor.	.4833
23	.686	1.299	-.247 a	1.37	.9118
24	.974 a	.378	.243	cor.	.7688
25	1.239	.222	.274	cor.	.8683
26	.970 a	.419	.242 a	cor.	.7399
28	1.045 a	.008 a	.170 a	cor.	.5460
30	.930 a	.319	.181 a	cor.	.8024
31	.997 a	.110	.258	cor.	.6640

gQ calculated

a: coefficient not significant at 5%

TABLE 49

Balance of State - Labor Demand - Output Version - OLS

Dependent variable: LHRBL__

<u>Sector</u>	<u>Constant</u>	<u>LGMPBL</u>	<u>L (W/R)</u>	<u>DW</u>	<u>R²</u>
2	12.865	.703 (.0015)	-.515 (.0593)	1.68	.4974
3	19.097	.141 (.1128)	-.534 (.0224)	1.86	.3851
4	17.039	.200 (.0011)	.028 (.9031)	1.54	.4927
5	15.676	.451 (.0001)	.254 (.2849)	2.30	.6011
6	10.765	.634 (.0001)	.828 (.0001)	cor.	.9137
7	17.888	.344 (.0080)	-.409 (.2112)	2.46	.3785
8	13.604	1.080 (.0001)	-.468 (.0294)	1.83	.8388
10	20.082	.182 (.0001)	-.169 (.2319)	1.34	.5888
12	18.027	.135 (.0550)	-.236 (.1836)	2.37	.2258
18	15.586	.370 (.0001)	-.141 (.1382)	2.13	.8025
19	13.563	.695 (.0001)	-.197 (.3566)	cor.	.6548

Balance of State - Labor Demand - Output Version - OLS, continued

22	17.511	.131 (.0707)	.086 (.5272)	2.08	.1630
28	22.655	.009 (.9400)	-1.066 (.0126)	cor.	.2633

TABLE 50

Balance of State - Labor Demand - Price Version - OLS

Dependent variable: LHRBL__

<u>Sec.</u>	<u>Constant</u>	<u>LPBL</u>	<u>LWBL</u>	<u>LR</u>	<u>DW</u>	<u>R²</u>
13	19.444	.199 (.7490)	-.651 (.0043)	-.579 (.1061)	cor.	.6221
14	14.645	-.137 (.7982)	.769 (.2476)	-.345 (.4696)	cor.	.1322
15	15.635	.326 (.5985)	.077 (.9298)	-.214 (.7711)	2.34	.0391
16	18.195	.746 (.0001)	-.446 (.0994)	.456 (.0188)	1.96	.8071
17	17.169	.495 (.3469)	-.137 (.7912)	.086 (.8257)	2.42	.0851
20	17.465	-.118 (.7922)	.161 (.6030)	.106 (.7051)	2.29	.2899
21	16.310	.942 (.1527)	-.405 (.5320)	.170 (.7424)	2.46	.1110
23	16.954	.621 (.1464)	-.787 (.3306)	.032 (.9507)	2.32	.2538
24	18.115	.041 (.8807)	-.170 (.4795)	-.094 (.6723)	1.95	.4060
25	18.897	.039 (.8644)	.039 (.7798)	-.154 (.3327)	2.30	.146
26	18.818	.416 (.1002)	.073 (.7603)	.053 (.8216)	1.60	.6547

Balance of State - Labor Demand - Price Version - OLS, continued

30	16.314	1.282 (.0777)	.406 (.5355)	.063 (.8888)	1.55	.7332
31	10.223	.329 (.6462)	-1.622 (.0001)	.983 (.0010)	1.27	.7944

TABLE 51

Balance of State - Miscellaneous - OLS

Dependent
Variable Constant

		<u>LWBL</u>	<u>LUMPBL</u>	<u>DW</u>	<u>R²</u>
LFPRBL	.385	.0 (.6135)	-.149 (.4941)	cor.	.0393
		<u>LWRBL</u>	<u>LURAT</u>		
MIGBL	-45630.	351008. (.4924)	44326. (.7448)	cor.	.0204
		<u>SAVBL</u>	<u>YHHBL</u>		
HOUSBL	-31074.	-3.091 (.0180)	18.281 (.0008)		
		<u>RTB</u>	<u>DHHBL</u>		
		-232505. (.0020)	.061 (.2812)	cor.	.5909
		<u>LPBL4</u>	<u>LHOUSCI</u>	<u>LHOUSCL</u>	<u>LHOUSCO</u>
LGMPBL4	-3.731	-.033 (.9339)	.289 (.4011)	.404 (.2697)	.037 (.8958)
		<u>LHOUSDA</u>	<u>LHOUSTO</u>	<u>LHOUSBL</u>	<u>LKXCI10</u>
		.109 (.8029)	-.022 (.9573)	-.193 (.6583)	.787 (.2255)

Balance of State - Miscellaneous - OLS, continued

<u>LKXCL10</u>	<u>LKXCO10</u>	<u>LKXDA10</u>	<u>LKXT010</u>
-.033 (.9308)	.200 (.5909)	.585 (.2001)	-.311 (.2986)
<u>LKXBL10</u>		<u>DW</u>	<u>R²</u>
-.190 (.5526)		1.79	.8984

TABLE 52

MAPEs and RMSEs for Major Variables

<u>Variable</u>	<u>MAPE</u>	<u>RMSE</u>
LGMPCL2	0.019	0.077
LGMPCL3	0.180	0.842
LGMPCL4	0.036	0.240
LGMPCL5	0.008	0.073
LGMPCL6	0.093	0.703
LGMPCL7	0.008	0.067
LGMPCL8	0.015	0.107
LGMPCL10	0.231	1.906
LHRCL2	0.008	0.130
LHRCL3	0.023	0.455
LHRCL5	0.026	0.490
LHRCL6	0.061	1.096
LHRCL7	0.122	2.168
LHRCL8	0.171	3.220
LHRCL10	0.051	1.004
LHRCL27	0.033	0.596
LHRCL28	0.026	0.448
LHRCL29	0.071	1.277
TCL	0.053	33959.
POPCL	0.010	23343.
UMPCL	0.000	0.413

TABLE 53
MAPEs and RMSEs

<u>Variable</u>		<u>MAPE</u>	<u>RMSE</u>
LGMPCL	1	0.043	0.405
	2	0.019	0.077
	3	0.180	0.842
	4	0.036	0.240
	5	0.008	0.073
	6	0.093	0.703
	7	0.008	0.067
	8	0.015	0.107
	10	0.231	1.906
	12	0.192	0.969
	14	1.558	4.786
	15	0.032	0.174
	16	0.493	0.889
	17	0.271	0.993
	18	0.075	0.313
	19	0.121	0.645
	20	0.162	0.908
	21	0.362	1.118
	22	0.421	1.831
	24	1.718	7.263
	25	0.356	2.257
	26	0.150	0.947
	27	0.389	2.523
	28	0.032	0.201
	29	0.586	3.706
	30	0.414	1.661
	31	0.360	1.364
LPCL	2	0.243	0.113
	3	0.835	0.516
	4	0.487	0.099
	5	0.194	0.099
	6	0.259	0.182
	7	0.271	0.088
	8	0.132	0.078
	10	0.547	0.171
	12	2.124	0.331
	14	0.267	0.087
	15	0.294	0.097
	16	0.429	0.159
	17	0.304	0.091
	18	0.456	0.146
	19	0.306	0.115
	20	0.504	0.184
	21	2.324	0.716

MAPES and RMSEs, continued

	22	0.782	0.201
	24	0.474	0.172
	25	0.882	0.273
	26	0.134	0.062
	27	0.442	0.130
	28	0.289	0.074
	29	1.080	.307
	30	1.080	0.044
	31	0.205	0.062
LHRCL	1	0.129	2.797
	2	0.008	0.130
	3	0.023	0.455
	4	0.725	12.557
	5	0.026	0.490
	6	0.061	1.096
	7	0.122	2.168
	8	0.171	3.220
	10	0.051	1.004
	12	0.055	0.960
	14	0.176	2.498
	15	0.018	0.319
	16	0.110	3.314
	17	0.978	15.407
	18	0.060	0.988
	19	0.071	1.202
	20	0.064	1.100
	21	0.413	12.711
	22	0.481	15.317
	24	0.003	0.115
	25	0.241	3.816
	26	0.285	4.884
	27	0.033	0.596
	28	0.026	0.448
	29	0.071	1.277
	30	0.463	14.305
	31	0.070	2.256
LGEMPCL		0.062	5591.488
TCL		0.053	33958.848
HOUSCL		0.191	2380.609
KXCL10		1.031	151.048
MIGCL		1.907	23295.504
LPPRCL		0.365	0.160
CLFCL		0.359	316612.500
POPCL		0.010	23342.574
URCL		0.263	0.013
UMPCL		0.000	0.413

MAPES and RMSEs, continued

LEMPCL	2	0.017	0.130
	3	0.048	0.455
	4	1.293	12.557
	5	0.042	0.490
	6	0.109	1.096
	7	0.21	2.168
	8	0.290	3.220
	10	0.083	1.004
	12	0.100	0.960
	14	0.382	2.498
	15	0.035	0.319
	16	0.512	3.314
	17	1.904	15.407
	18	0.115	0.988
	19	0.128	1.202
	20	0.118	1.100
	21	1.757	12.711
	22	1.851	15.317
	24	0.011	0.115
	25	0.470	3.816
	26	0.516	4.884
	27	0.059	0.596
	28	0.048	0.448
	29	0.126	1.277
	30	1.960	14.305
	31	0.266	2.256

TABLE 54
Impact Elasticities

<u>Variable</u>		<u>LR</u>	<u>LPICO</u>	<u>LGMPDA10</u>
LGMPCL	2	-0.000	0.002	0.0
	3	-0.004	-0.043	0.0
	4	0.000	0.0	0.0
	5	0.000	0.006	0.0
	6	-0.002	0.006	0.0
	7	-0.000	0.005	0.0
	8	0.000	0.009	0.0
	10	-0.000	0.0	0.002
	12	0.000	0.0	-0.002
	14	-0.000	0.0	0.001
	15	-0.001	0.0	0.001
	16	-0.003	0.0	-0.054
	17	-0.000	0.0	0.008
	18	0.001	0.0	0.003
	19	0.000	0.0	0.006
	20	-0.000	0.0	0.002
	21	-0.000	0.0	-0.008
	22	0.000	0.0	0.006
	24	-0.000	0.0	0.003
	25	0.000	0.0	0.001
	26	-0.000	0.0	0.006
	27	-0.001	0.0	0.007
	12	0.000	0.0	0.012
	29	0.000	0.0	0.000
	30	-0.001	0.0	-0.012
	31	0.002	0.0	0.007
LPCL	2	-0.022	0.011	0.0
	3	-0.024	-0.156	0.0
	4	0.641	0.0	0.0
	5	0.094	0.035	0.0
	6	0.188	0.068	0.0
	7	-0.007	0.003	0.0
	8	0.011	0.231	0.0
	10	0.014	0.0	0.006
	12	0.003	0.0	0.002
	14	-0.032	0.0	0.0
	15	-0.023	0.0	0.001
	16	-0.043	0.0	0.030
	17	0.022	0.0	-0.003
	18	0.042	0.0	0.002
	19	0.037	0.0	0.011
	20	-0.002	0.0	-0.017
	21	0.008	0.0	-0.053
	22	0.000	0.0	-0.003

Impact Elasticities, continued

	24	-0.031	0.0	-0.006
	25	0.021	0.0	0.003
	26	0.033	0.0	0.005
	27	-0.313	0.0	0.122
	28	0.033	0.0	0.061
	29	0.014	0.0	0.001
	30	-0.030	0.0	0.005
	31	-0.011	0.0	0.004
LHRCL	2	0.000	0.000	0.0
	3	0.001	-0.005	0.0
	4	0.001	0.0	0.0
	5	0.000	0.000	0.0
	6	-0.000	0.000	0.0
	7	0.000	-0.000	0.0
	8	0.000	0.002	0.0
	10	0.002	0.0	0.000
	12	0.000	0.0	-0.000
	14	-0.000	0.0	0.0
	15	0.000	0.0	0.0
	16	-0.000	0.0	0.000
	17	0.001	0.0	-0.000
	18	0.000	0.0	0.000
	19	0.000	0.0	-0.001
	20	0.000	0.0	0.000
	21	0.000	0.0	-0.000
	22	-0.002	0.0	0.000
	24	-0.000	0.0	-0.000
	25	0.000	0.0	0.000
	26	-0.001	0.0	0.000
	27	0.000	0.0	-0.000
	28	0.000	0.0	0.000
	29	0.000	0.0	0.000
	30	0.001	0.0	-0.001
	31	0.000	0.0	-0.000
LGEMPCL		0.0	0.0	0.0
TCL		0.0	0.0	0.0
HOUSCL		0.0	0.0	0.0
KXCL10		0.0	0.0	0.0
MIGCL		0.0	0.0	0.0
LPFRCL		0.0	0.0	0.0
CLFCL		0.0	0.0	0.0
POPCL		0.0	0.0	0.0
URCL		0.0	0.0	0.0
UMPCL		0.0	0.0	0.0

Impact Elasticities, continued

LEMPCL	2	0.000	0.000	0.0
	3	0.002	-0.011	0.0
	4	0.001	0.0	0.0
	5	0.000	0.001	0.0
	6	-0.000	0.001	0.0
	7	0.001	-0.000	0.0
	8	0.000	0.003	0.0
	10	0.003	0.0	0.001
	12	0.000	0.0	-0.000
	14	-0.000	0.0	0.0
	15	0.000	0.0	0.0
	16	-0.001	0.0	0.000
	17	0.001	0.0	-0.000
	18	0.000	0.0	0.000
	19	0.000	0.0	-0.001
	20	0.000	0.0	0.000
	21	-0.000	0.0	0.001
	22	0.004	0.0	-0.001
	24	-0.001	0.0	-0.000
	25	0.000	0.0	0.000
	26	-0.003	0.0	0.000
	27	0.000	0.0	-0.000
	28	0.000	0.0	0.000
	29	0.000	0.0	0.000
	30	-0.002	0.0	0.001
	31	0.000	0.0	-0.000

TABLE 55
Spatial Price Indexes, 1950-1977

(Ohio = 1.000)

<u>Year</u>	<u>Cin.</u>	<u>Cle.</u>	<u>Col.</u>	<u>Day.</u>	<u>Tol.</u>	<u>Bal.</u>
1950	1.229	1.152	0.938	0.744	0.726	0.984
	1.190	1.079	0.937	0.858	0.815	0.973
	1.226	1.100	0.860	0.876	0.790	0.975
	1.238	1.133	0.853	0.930	0.831	0.931
	1.210	1.107	0.827	0.880	0.858	0.966
1955	1.183	1.103	0.807	0.872	0.875	0.983
	1.131	1.113	0.792	0.833	0.895	1.009
	1.124	1.181	0.798	0.767	0.909	0.988
	1.167	1.212	0.830	0.876	0.951	0.912
	1.189	1.363	0.869	0.945	1.045	0.820
1960	1.131	1.305	0.880	0.898	0.993	0.874
	1.159	1.297	0.886	0.925	0.973	0.868
	1.148	1.310	0.868	0.952	0.983	0.866
	1.164	1.286	0.857	0.962	0.962	0.876
	1.129	1.285	0.847	0.972	0.982	0.884
1965	1.105	1.270	0.830	0.952	0.983	0.906
	1.128	1.269	0.858	0.941	1.015	0.893
	1.095	1.231	0.847	0.941	1.005	0.919
	1.094	1.217	0.838	0.971	1.005	0.923
	1.035	1.206	0.797	0.973	0.973	0.962
1970	1.009	1.138	0.810	0.959	0.907	1.012
	1.014	1.091	0.839	1.043	0.947	0.997
	1.002	1.103	0.867	1.021	0.972	0.987
	1.025	1.134	1.017	1.031	1.023	0.922
	1.080	1.202	1.085	1.061	1.008	0.874
1975	1.082	1.205	1.099	1.049	0.992	0.875
	1.038	1.261	1.089	1.141	0.924	0.868
1977	1.071	1.245	1.105	1.239	0.932	0.855

TABLE 56

Comparison of MAPE Statistics for SMSA Models

<u>Variable</u>	<u>Phil. I</u>	<u>Phil. IV</u>	<u>Milwaukee</u>	<u>Chicago</u>	<u>Cleveland</u>
Total GMP	4.32%	0.98%	3.49%	1.70%	4.30%
Total employment	1.56	0.66	1.58	1.28	12.90
Manu. employment	2.18	1.42	2.00	3.98	5.10
Population	1.02	1.27	2.05	N.A.	1.00

Sources: Philadelphia, Glickman (1974).
 Milwaukee, Rubin and Erickson (1980).
 Chicago, Duobinis (forthcoming).
 Cleveland (part of MREMO), calculated.

TABLE 57

Comparison of MAPE Statistics for Multiregional Models

	<u>Gross product</u>	<u>Total employment</u>	<u>Population</u>
Cleveland	4.30%	12.90%	1.00%
NRIES	0.73 to 4.11	.77 to 3.55	.27 to 2.49
Delaware Valley	1.4 to 6.8	1.7 to 5.1	1.3 to 6.0

Sources: Cleveland (part of MREMO), calculated;
 NRIES (states), Ballard and Wendling (1980).
 Delaware Valley (counties), Ballard and Glickman (1977).

TABLE 58

Reduced Form - Part I

D__ : constant from demand equation in SMSA __
 S__ : constant from supply equation in SMSA __
 For instance, DCI is the constant from the demand equation
 for Cincinnati.

Exeg.

<u>Variable</u>	<u>LGMPCI10</u>	<u>LGMPCL10</u>	<u>LGMPCO10</u>	<u>LGMPDA10</u>	<u>LGMPTO10</u>
DCI	-.148	.71	-.20	-1.68	-.91
DCL	2.22	-1.33	.168	1.77	-.63
DCO	.37	.23	-.10	-.04	-.69
DDA	1.62	-.48	.97	2.65	.01
DTO	-.19	.32	.31	-.73	1.38
DBL	.22	-.17	-.02	.36	.29
SCI	.12	-.06	.02	.14	.07
SCL	.48	-.29	.37	.39	-.14
SCO	.10	.06	-.03	-.01	-.19
SDA	-.22	.07	-.13	-.36	-.00
STO	-.02	.03	.03	-.08	.15
SBL	-1.03	.79	.10	-1.71	-1.40
LWCI 10	.08	-.04	.01	.09	.05
LWCL 10	.10	-.06	.08	.08	-.03
LWCO 10	.08	.05	-.02	-.01	-.15
LWDA 10	.09	-.03	.05	.14	.00
LWTO 10	-.01	.02	.02	-.05	.10
LWBL 10	.10	-.08	-.01	.16	.13
LR	-.05	.03	.02	-.11	-.03
LGMPM	.34	-.10	-.02	.37	.25

TABLE 59

Reduced Form - Part II

See previous table for explanation of D__ and S__.

Exog. <u>Variable</u>	<u>LGMPBL10</u>	<u>LPCI10</u>	<u>LPCL10</u>	<u>LPCO10</u>	<u>LPDA10</u>
DCI	.62	-.31	.23	-.10	.14
DCL	-1.53	.47	-.44	.86	-.15
DCO	-.36	.08	.08	-.05	.00
DDA	-.95	.34	-.16	.49	-.23
DTO	-.07	-.04	.11	.16	.06
DBL	-.17	.05	-.05	-.01	-.03
SCI	-.05	-.87	-.02	.01	-.01
SCL	-.33	.10	-2.78	.19	-.03
SCO	-.10	.02	.02	-1.76	.00
SDA	.13	-.05	.02	-.07	2.36
STO	-.01	-.00	.01	.02	.01
SBL	.81	-.22	.26	.05	.15
LWCI10	-.03	-.58	-.01	.01	-.01
LWCL10	-.07	.02	-.59	.04	-.01
LWCO10	-.08	.02	.02	-1.32	.00
LWDA10	-.05	.02	-.01	.03	-.92
LWTO10	-.00	-.00	.01	.01	.00
LWBL10	-.08	.02	-.02	-.01	-.01
LR	.03	.05	-.14	.09	.19
LGMPM	-.28	.07	-.03	-.01	-.03

TABLE 60

Reduced Form - Part III

See Part I for explanation of D__ and S__.

Exog. <u>Variable</u>	<u>LP TO 10</u>	<u>LP BL 10</u>
DCI	-.11	-.18
DCL	-.08	.45
DCO	-.09	.11
DDA	.00	.28
DTO	.17	.02
DBL	.04	.05
SCI	.01	.01
SCL	-.02	.10
SCO	-.02	.03
SDA	-.00	-.04
STO	-.79	.00
SBL	-.18	3.33
LWCI 10	.01	.01
LWCL 10	-.00	.02
LWCO 10	-.02	.02
LWDA 10	.00	.01
LWTO 10	-.53	.00
LWBL 10	.02	-.32
LR	-.19	.15
LGNPM	.03	.08

ACTUAL VS. PREDICTED UNEMPLOYMENT RATE - CLEVELAND

PLOT OF ACTUAL*T
PLOT OF PRED*T

SYMBOL USED IS +
SYMBOL USED IS *

Figure 1: Actual and Predicted Unemployment Rate

Appendix A
SECTORS

- 1 total
- 2 agriculture
- 3 mining and other
- 4 construction
- 5 wholesale and retail trade
- 6 finance, insurance, and real estate
- 7 transportation, communications, and utilities
- 8 services
- 9 government
- 10 total manufacturing

SIC

- 11 19 ordnance
- 12 20 food and kindred products
- 13 21 tobacco manufactures
- 14 22 textile mill products
- 15 23 apparel and related products
- 16 24 lumber and wood products
- 17 25 furniture and fixtures
- 18 26 paper and allied products
- 19 27 printing and publishing
- 20 28 chemicals and allied products
- 21 29 petroleum and coal products

22 30 rubber and plastics products, n.e.c.
23 31 leather and leather products
24 32 stone, clay, and glass products
25 33 primary metal industries
26 34 fabricated metal products
27 35 machinery except electrical
28 36 electrical equipment and supplies
29 37 transportation equipment
30 38 instruments and related products
31 39 miscellaneous manufacturing

Appendix B
VARIABLE NAMES

Suffixes

Some variables have two suffixes. The latter suffix is the sector number, found in Appendix A. The former is the SMSA suffix. This is the only suffix for variables which do not belong to a specific sector.

__CI__: Cincinnati

__CL__: Cleveland

__CO__: Columbus

__DA__: Dayton

__TO__: Toledo

__BL__: Balance of state

For instance, LGMPCI12 is the log of gross metropolitan product (LGMP__) in Cincinnati (__CI__) for sector 12 (__12).

Root variable names

Variables are nominal unless noted as real.

LGMP__: log of gross metropolitan product

LP__: log of price

LPI__: log of personal income

LHR__: log of annual labor hours
 LW__: log of hourly wage rate
 LK__: log of capital stock
 LGEMP__: local government employment
 WGOV__: average annual wage for local government employees
 T__: local government tax revenue
 MIG__: net migration
 LWR__: average wage in SMSA / average wage in U.S., lagged
 LER__: employment rate in SMSA / employment rate in U.S.,
 lagged
 LUR__: unemployment rate in SMSA / unemployment rate in
 U.S., lagged
 PI__: personal income
 KX__10: investment in manufacturing
 GMP__10: gross metropolitan product in manufacturing
 LFPR__: labor force participation rate
 LUMP__: lagged unemployment rate
 HOUS__: annual housing starts
 YHH__: real income per household
 DHH__: annual change in number of households
 SAV__: real savings at banks and savings and loans
 LHOUS__: log of housing starts
 LKX__10: log of manufacturing investment

Other variables

LGNPM: log of gross national product in manufacturing,

excluding Ohio

LR: log of corporate bond rate

RCB: corporate bond rate

RTB: real Treasury bond rate

Appendix C

DERIVATIONS OF SUPPLY

This appendix contains a derivation of the Cobb-Douglas supply curve and derivations of two forms of the translog supply curve. The following notation is used:

Q = output

$P(Q)$ = price of output

$X(i)$ = factor of production i

$S(i)$ = share of value of factor of production i

L = labor

K = capital

W = wage rate

R = price of capital

C = total cost

A. Cobb-Douglas Supply Curve

1. Cobb-Douglas cost function:

$$\ln C = \ln g(0) + g(Q) * \ln Q + \text{SUM (over } i) g(i) * \ln P(i)$$

Cobb-Douglas production function:

$$\ln Q = \ln h(0) + \text{SUM (over } i) h(i) * \ln X(i)$$

$$2. \quad d \ln C / d \ln Q = g(Q)$$

("d" means "partial derivative" in this appendix.)

$$3. \quad Q/C = [h(0) * \text{PROD}(\text{over } i) X(i) ** h(i)] / [g(0) * Q ** g(Q) * \text{PROD}(\text{over } i) P(i) ** g(i)]$$

$$4. \quad dC/dQ = (d \ln C / d \ln Q) * C/Q \\ = [g(Q) * g(0) * Q ** g(Q) * \text{PROD}(\text{over } i) P(i) ** g(i)] / [h(0) * \text{PROD}(\text{over } i) X(i) ** h(i)]$$

$$5. \quad \ln(dC/dQ) = \ln g(Q) + \ln g(0) + g(Q) * \ln Q + \\ \text{SUM}(\text{over } i) g(i) * \ln P(i) - \ln h(0) - \\ \text{SUM}(\text{over } i) h(i) * \ln X(i)$$

$$6. \quad \text{Since } \ln h(0) + \text{SUM}(\text{over } i) h(i) \ln X(i) = \ln Q, \\ \ln(dC/dQ) = \ln g(Q) + \ln g(0) + \text{SUM}(\text{over } i) g(i) * \ln P(i) \\ + (g(Q) - 1) \ln Q$$

$$7. \quad \text{If } dC/dQ = P(Q), \text{ the supply curve is} \\ \ln P(Q) = [\ln g(Q) - \ln g(0)] + \text{SUM}(\text{over } i) g(i) * \ln P(i) \\ - [1 - g(Q)] \ln Q$$

B. Translog Supply Curve: Shares (Translog A)

For simplicity, we use two factors of production.

1. Translog production function:

$$\ln Q = \ln a(0) + a(1) \cdot \ln L + a(2) \cdot \ln K + b(11) \cdot (\ln L)^2 + b(22) \cdot (\ln K)^2 + [b(12) + b(21)] \cdot \ln L \cdot \ln K$$

which is equivalent to

$$Q = a(0) \cdot L^{a(1) + b(11) \cdot \ln L + [b(12) + b(21)] \cdot \ln K} \cdot K^{a(2) + b(22) \cdot \ln K}$$

This can be written more simply as

$$Q = a(0) \cdot [L^{B(1)}] \cdot [K^{B(2)}], \text{ where}$$

$$B(1) = a(1) + b(11) \cdot \ln L + [b(12) + b(21)] \cdot \ln K \text{ and}$$

$$B(2) = a(2) + b(22) \cdot \ln K.$$

$$2. \quad dQ/dL = a(0) \cdot [B(1) \cdot L^{B(1)-1} + \ln L \cdot [L^{B(1)}] \cdot dB(1)/dL] \cdot K^{B(2)}$$

$$dB(1)/dL = b(11)/L, \text{ so}$$

$$\begin{aligned} dQ/dL &= a(0) \cdot [K^{B(2)}] \cdot [B(1) \cdot L^{B(1)-1} + \ln L \cdot [L^{B(1)}] \cdot b(11)/L] \\ &= (Q/L) \cdot [B(1) + b(11) \cdot \ln L] \\ &= (Q/L) \cdot [a(1) + 2 \cdot b(11) \cdot \ln L + [b(12) + b(21)] \cdot \ln K] \end{aligned}$$

3. The MVP of labor is $P(Q) \cdot dQ/dL$ in perfect competition.

In equilibrium, $W = MVP(L)$, so

$$W = (P \cdot Q / L) \cdot \{a(1) + 2 \cdot b(11) \cdot \ln L + [b(12) + b(21) \cdot \ln K]\}$$

Analogously,

$$R = (P \cdot Q / L) \cdot \{a(2) + 2 \cdot b(22) \cdot \ln K + [b(12) + b(21) \cdot \ln L]\}.$$

4. The supply curve is derived by substituting the factor demands from step 3 into the production function. First the factor demands must be rearranged.

$$\ln L = [1 / (2 \cdot b(11))] \cdot \{(WL/PQ) - a(1) - [b(12) + b(21) \cdot \ln K]\}$$

$$\ln K = [1 / (2 \cdot b(22))] \cdot \{(RK/PQ) - a(2) - [b(12) + b(21) \cdot \ln L]\}$$

Substitute $\ln K$ into L :

$$\begin{aligned} \ln L = & [4 \cdot b(11) \cdot b(22)] / \{8 \cdot b(11)^2 \cdot b(22) - [b(12) + b(21)]^2\} \\ & \cdot \{(WL/PQ) - [b(12) + b(21)] / (2 \cdot b(22))\} \cdot (RK/PQ) \\ & - a(1) + a(2) \cdot [b(12) + b(21)] / (2 \cdot b(22)) \} \end{aligned}$$

This can be written more simply as

$$\ln L = D + C \cdot [(WL/PQ) - B \cdot (RK/PQ)]$$

$$\text{where } D = [4 \cdot b(11) \cdot b(22)] / \{8 \cdot b(11)^2 \cdot b(22) - [b(12) + b(21)]^2\}$$

$$* \{-a(1) + a(2) * [b(11) + b(22)] / [2 * b(22)]\}$$

$$C = [4 * b(11) * b(22)] / \{8 * b(11) * b(22) - [b(12) + b(21)]^2\}$$

$$B = -[b(12) + b(21)] / [2 * b(22)]$$

$$\text{Likewise, } \ln K = D' + C' * [(RK/PQ) - B' * (WL/PQ)].$$

5. Substitute $\ln K$ and $\ln L$ into the production function, letting $S(L) = (WL/PQ)$ and $S(K) = (RK/PQ)$. Collecting terms, it becomes

$$\ln Q = A + F(1) * S(L) + F(2) * S(K) + F(11) * S(L)^2 + F(22) * S(K)^2 + F(12) * S(L) * S(K)$$

This generalizes to

$$\ln Q = A + \sum (\text{over } i) c(i) * S(i) + \sum (\text{over } i) \sum (\text{over } j) c(ij) * S(i) * S(j)$$

C. Translog Supply Curve: Factor Prices (Translog B)

(I am indebted to Francisco Bataller M. for this derivation.)

1. Translog cost curve:

$$\ln C = \ln f(0) + \sum (\text{over } i) f(i) * \ln P(i) +$$

$$\text{SUM}(\text{over } i) \text{SUM}(\text{over } j) d(ij) * \ln P(i) * \ln P(j) + \\ [d(Q) + d(QQ) * \ln Q + \text{SUM}(\text{over } i) d(Qi) * \ln P(i)] * \ln Q$$

$$2. \quad d \ln C / d \ln Q = f(Q) + 2 * f(QQ) * \ln Q + \text{SUM}(\text{over } i) f(Qi) * \ln P(i)$$

$$3. \quad dC/dQ = (d \ln C / d \ln Q) * (C/Q) \\ = [f(Q) + 2 * f(QQ) * \ln Q + \text{SUM}(\text{over } i) f(Qi) * \ln P(i) * \\ \text{PROD}(\text{over } i) P(i) * \text{PROD}(\text{over } i) \text{PROD}(\text{over } j) P(i) ** \\ [f(ij) * \ln P(j)] * Q ** \{f(Q) + f(QQ) * \ln Q + \\ \text{SUM}(\text{over } i) f(Qi) * \ln P(i) - 1\}$$

or, if $dC/dQ = P(Q)$,

$$\ln(dC/dQ) = \ln P(Q) \\ = \ln[f(Q) + 2 * f(QQ) * \ln Q + \text{SUM}(\text{over } i) f(Qi) * \ln P(i)] \\ + \ln f(0) + \text{SUM}(\text{over } i) \text{SUM}(\text{over } j) f(ij) * \ln P(i) * \\ \ln P(j) + \{f(Q) + f(QQ) * \ln Q * \text{SUM}(\text{over } i) [f(Qi) * \\ \ln P(i) - 1] * \ln Q$$

Appendix D

DERIVATION OF COST EQUATION FROM PRODUCTION FUNCTION

This appendix contains a derivation of the Cobb-Douglas cost function from the Cobb-Douglas production function.

Q = output

L = labor

K = capital

P = price of output

W = price of labor

R = price of capital

1. Minimize $WL + RK$ subject to $Q = h(0) * [L^{h(1)}] * [K^{h(2)}]$

$$L^0 = WL + RK - \lambda^0 * \{h(0) * [L^{h(1)}] * [K^{h(2)}] - Q\}$$

$$\begin{aligned} d^0 L^0 / dL &= W - \lambda^0 * h(0) * L^{h(1)-1} * [K^{h(2)}] * h(1) \\ &= W - \lambda^0 * h(1) * Q/L = 0 \end{aligned}$$

$$\begin{aligned} d^0 L^0 / dK &= R - \lambda^0 * h(0) * h(2) * [L^{h(1)}] * K^{h(2)-1} \\ &= R - \lambda^0 * h(2) * Q/K = 0 \end{aligned}$$

$$W/R = [h(1)/h(2)] / (K/L)$$

("d" means "partial derivative" in this appendix.

'L' is the Lagrangian. 'λ' is the Lagrangian multiplier.)

$$2. \quad K = L * (W/R) * [h(2)/h(1)] \text{ and } L = K * (R/W) * [h(1)/h(2)]$$

3a. Substitute for L in the production function.

$$\begin{aligned} K &= [Q/h(0)]^{**} \{1/[h(1) + h(2)]\} * \\ &\quad (W/R)^{**} \{h(1)/[h(1) + h(2)]\} * \\ &\quad [h(2)/h(1)]^{**} \{h(1)/[h(1) + h(2)]\} \end{aligned}$$

3b. Substitute for K in the production function.

$$\begin{aligned} L &= [Q/h(0)]^{**} \{1/[h(1) + h(2)]\} * \\ &\quad (R/W)^{**} \{h(2)/[h(1) + h(2)]\} * \\ &\quad [h(1)/h(2)]^{**} \{h(2)/[h(1) + h(2)]\} \end{aligned}$$

4. Substitute these expressions for K and L in $C = WL + RK$.

$$\begin{aligned} C &= \{[Q/h(0)]^{**} [W^{**}h(1)]^{**} [R^{**}h(2)]^{**} [1/h(1) + h(2)]^{**} \\ &\quad \{h(1)/h(2)\}^{**}h(2) + \\ &\quad [h(2)/h(1)]^{**}h(1)\}^{**} [1/[h(1) + h(2)]] \end{aligned}$$

5. In log form,

$$\begin{aligned} \ln C &= \{1/[h(1) + h(2)]\} * [\ln Q + h(1) * \ln W + h(2) * \ln R] \\ &\quad + \{1/[h(1) + h(2)]\} * \ln \{[h(1)/h(2)]^{**}h(2) * \end{aligned}$$

$$[h(2)/h(1)]^{h(1)} - \{1/[h(1)+h(2)]\} \ln h(0)$$

It is apparent that $h(1)/[h(1)+h(2)]$ and $h(2)/[h(1)+h(2)]$ are equivalent to $g(1)$ and $g(2)$ in the cost function in Appendix C, and that $1/[h(1)+h(2)] = g(0)$. The last two terms in the equation amount to $\ln g(0)$, a constant.

If the Cobb-Douglas production function is homogeneous of

- a) degree 1, then $h(1)+h(2)=1$ and $g(0) = 1$.
- b) degree less than 1, then $h(1)+h(2)$ is less than one and $g(0)$ is greater than one.
- c) degree greater than 1, then $h(1)+h(2)$ is greater than one and $g(0)$ is less than one.

Thus $g(0)$ indicates the returns to scale. $g(1)$ and $g(2)$ are the respective factor's share of value divided by the scale parameter.

Appendix E

DERIVATION OF LABOR DEMAND EQUATIONS

1. Derive "output form" of labor demand from Cobb-Douglas production function.

$$Q = h(0) * (L^{h_L}) * (K^{h_K})$$

$$dQ/dL = h_L * Q/L = W/P$$

$$dQ/dK = h_K * Q/K = R/P$$

("d" means partial derivative" in this appendix.)

So $K/L = (h_K/h_L) * (W/R)$. Solve for K and insert it into the production function:

$$Q = h(0) * (L^{h_L}) * [(h_K/h_L) * (W/R) * L]^{h_K}$$

Solve for L and take logs:

$$\ln L = \ln h(0) - [h_K / (h_L + h_K)] * \ln (W/R) + [1 / (h_L + h_K)] * \ln Q$$

2. Derive "price form" of labor demand from Cobb-Douglas production function.

From above, $P * h_L * Q = WL$ and $P * h_K * Q = RK$.

Also, $K/L = (h_K/h_L) * (W/R)$.

So $P * h_L * h(0) * (L^{h_L}) * (K^{h_K}) = WL$ and $K = L * (h_K/h_L) * (W/R)$.

Plug K into the expanded equation, solve for L,

and take logs:

$$\ln L = \ln h(0) - [h_L / (1 - h_L - h_K)] * \ln W + [h_K / (1 - h_L - h_K)] * \ln R \\ + [1 / (1 - h_L - h_K)] * \ln P$$

3. Derive "capital form" of labor demand from Cobb-Douglas production function.

$$\partial Q / \partial L = h_L * (Q/L) = W/P \text{ from above.}$$

$$h_L * [h(0) * (L^{h_L}) * (K^{h_K})] * [L^{-(1)}] = W/P$$

$$L = \{ (W/P) * [1 / (h_L * h(0) * K^{h_K})] \}^{1/(h_L - 1)}$$

Take logs:

$$\ln L = \ln h(0) - [1 / (1 - h_L)] * \ln (W/P) + [h_K / (1 - h_L)] * \ln K$$

Appendix F
DATA SOURCES

B (i): Vital Statistics of the United States, U.S. Dept. of Health and Human Services, National Center for Health Statistics

D (i): Vital Statistics

E (i): County Business Patterns, U.S. Bureau of the Census

E (N): Economic Report of the President

GMP (Mi): see Q (i) .

GNPM: Economic Report of the President

GSPM: see Q (i) .

HH (i): calculated from population in occupied housing and number of people in household, found in Census of Population and Housing and General Demographic Trends for Metropolitan Areas, U.S. Dept. of Commerce, Bureau of the Census.

HS (i): Construction Reports: Housing Authorized by Building Permits and Public Contracts (C40-65 to C40-77) and Housing Construction Statistics 1889-1964, Bureau of the Census, U.S. Dept. of Commerce.

IM (i): Annual Survey of Manufactures, Bureau of Economic Analysis, U.S. Dept. of Commerce.

L (i) , L (ij): calculated from E (i) and average weekly hours

from Employment and Earnings: States and Areas, Bureau of Labor Statistics, U.S. Dept. of Labor.

LFPR(i): calculated from civilian labor force and population. CLF is from Ohio Labor Force Estimates by County by Month and Ohio Labor Force Reports by County, Ohio Bureau of Employment Services. (Also see POP(i).)

LGEMP(i): "Local government finances in selected metropolitan areas and large counties" and "Local government in metropolitan areas", Census of Governments, U.S. Dept. of Commerce.

T(i): see LGEMP(i).

LS(i): see LFPR(i).

NM(i): calculated from B(i), D(i), and POP(i). See them.

P(ij): see Chapter 4 for method of calculation. Raw data came from Survey of Current Business, U.S. Dept. of Commerce; The Econometrics of Price Determination: Conference, edited by Otto Eckstein (1972), "Industry Price Equations" by O. Eckstein and D. Wyss. Retail sales developed from Bulletin of Business Research, The Ohio State University.

POP(i): Current Population Reports and Estimates, Series P25, U.S. Bureau of the Census; County and City Data Book, U.S. Bureau of the Census, U.S. Dept. of Commerce; and Personal Income in Ohio Counties, Milton Kafoglis and Madelyn Kafoglis, (Bulletin of Business Research, The Ohio State University, Research Monograph #102).

Q(ij): See Chapter 4 for method of calculation. Data are from

GSP, farm, 1950-1972: L'Esperance, Baird, Shumay.

GSP, farm, 1973-1977: Agricultural Statistics, U.S. Department of Agriculture; State Farm Income Statistics, U.S. Department of Agriculture (supplement to Farm Income Statistics).

Cash receipts from farm marketing, Ohio counties, 1950-1977: Ohio Farm Income, Ohio Agricultural Research and Development Center. Non-Ohio counties by phone (Michigan, Kentucky, Indiana). Income received, Ohio and U.S.: Survey of Current Business, U.S. Dept. of Commerce. Value added (U.S., Ohio, counties): County Business Patterns, U.S. Dept. of Commerce. Payroll (U.S., Ohio, counties): County Business Patterns, U.S. Dept. of Commerce. Employment in government (SMSA and Ohio): States and Areas: Employment, Hours, and Earnings 1939-1978, Bureau of Labor Statistics, U.S. Dept. of Labor.

RCB: Economic Report of the President

RTB: Economic Report of the President

S(i): Time deposits in banks from Assets, Liabilities, Reserves, and Capital Accounts: State and County Summaries, Commercial Banks, 4th District, Federal Reserve Bank of Cleveland. Time deposits in savings and loans from Summary of Savings Accounts by Geographic Area, Federal Home Loan Bank Board.

UMP(i) : See LFPR(i) .

W(ij) : See L(ij) .

Y(i) : Local Area Personal Income, U.S. Dept. of Commerce,
Bureau of Economic Analysis; Personal Income in Ohio
Counties (see POP(i)) ; County and City Data Book, (see
POP(i)) .

YHH(i) : constructed from Y(i) and HH(i) . See them.

Appendix G

NECESSARY CONDITIONS FOR IDENTIFICATION OF BEHAVIORAL EQUATIONS IN THE MULTIREGIONAL ECONOMETRIC MODEL OF OHIO

For each prototype equation, the number of predetermined variables (labeled "Pred") and the number of endogenous variables (labeled "End") are shown, along with the necessary condition for identification. GE is used to mean "greater than or equal to".

Nonmanufacturing Demand Except Construction

Pred: $\ln Y(1)$ through $\ln Y(6)$ (6)
End: $\ln Q(ij)$, $\ln P(ij)$ (2)
586 - 6 GE 2 - 1

Manufacturing Demand

Pred: $\ln GNPM$ (1)
End: $\ln Q(ij)$, $\ln QM(1)$ through $\ln QM(6)$, $\ln P(ij)$ (8)
586 - 1 GE 8 - 1

Supply

Pred: $\ln W(ij)$, $\ln R$ (2)
End: $\ln P(ij)$, $\ln Q(ij)$ (2)
586 - 2 GE 2 - 1

Labor Demand - Output Form

Pred: $\ln W(ij)$, $\ln R$ (2)
End: $\ln L(ij)$, $\ln Q(ij)$ (2)
586 - 2 GE 2 - 1

Labor Demand - Price Form

Pred: $\ln W(ij), \ln R$ (2)
 End: $\ln L(ij), \ln P(ij)$ (2)
 586 - 2 GE 2 - 1

Labor Demand - Capital Form

Pred: $\ln W(ij), \ln K(ij)$ (2)
 End: $\ln L(ij), \ln P(ij)$ (2)
 586 - 2 GE 2 - 1

Labor Force Participation Rate

Pred: $W(i, -1), UR(i, -1)$ (2)
 End: $LFPR(i)$ (1)
 586 - 2 GE 1 - 1

Net Migration

Pred: $[W(i)/W(N)](-1), [ER(i)/ER(N)](-1)$ (2)
 End: $NM(i)$ (1)
 586 - 2 GE 1 - 1

Housing Starts

Pred: $S(i), RTB, YHH(i), DHH(i)$ (4)
 End: $HS(i)$ (1)
 586 - 4 GE 1 - 1

Manufacturing Investment

Pred: RCB (1)
 End: $QM(i), KX(i)$ (2)
 586 - 1 GE 2 - 1

Construction Demand

Pred: None (0)
 End: $\ln Q(i4), \ln P(i4), \ln HS(1)$ through $\ln HS(6),$
 $\ln KX(1)$ through $\ln KX(6)$ (14)
 586 - 0 GE 14 - 1

Local Government Revenue

Pred: $Y(i)$ (1)
End: $T(i)$ (1)
586 - 1 GE 1 - 1

Local Government Employment

Pred: $WGOV(i)$ (1)
End: $T(i), LGEMP(i)$ (2)
586 - 1 GE 2 - 1

The necessary condition for identification holds for all equations.