DESCRIPTIVE AND CRITICAL REVIEW OF MULTIREGIONAL ECONOMETRIC MODELS OF THE UNITED STATES

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1. Introduction

Many methodological tools exist for use by regional planners and policy analysts concerned with the implications of federal and regional policies for regional economies. Regional and multiregional econometric models represent a class of such tools not widely available for public use outside their institutional settings. The purpose of such models is to provide economic forecasting and policy simulations with analytic flexibility. Accordingly, the methods employed in developing econometric models differ substantially from those of other national or regional analysis methods because they are not consistently subjected to theoretic or accounting restrictions. For example, instead of relying solely on export-base, input-output, or linear programming analysis, the emphasis in the development of econometric models is placed on their ability to model economic behavior empirically. While this may often involve the application of rigid theoretic constructs or accounting frameworks, the charm is that the constructs can be altered or combined to suit the economy as perceived by the modeler, thereby increasing the model's potential value and usability.

This paper presents a descriptive review and selective analysis of four multiregional econometric models for the United States. The four models were described in a symposium on multiregional econometric models in the May 1980 issue of the *Journal of Regional Science.* Section 2 of the paper presents an overview of the European experience and the intent in developing multiregional econometric models since Europe pioneered in this realm of activity. An introduction to the advantages and disadvantages of bottom-up versus top-down modeling structures in section 3 is then followed in section 4 by an exposition of the criteria used to assess the potential economic and planning applications of the models. The models are individually described in section 5 and then jointly critiqued in section 6 with respect to their responsiveness to the established criteria. The model reviews are technical in nature but limited in mathematical formulations to maximize comprehension and minimize confusion for the lay reader. Summary conclusions are presented in section 7.

2. History of Multiregional Econometric Models

The first burst of regional econometric modeling activity in the United States produced predominantly state or sub-state regional models often intimately tied to the national economy. The models concentrated on the linkages between sets of intra-regional activity and made much progress in systematizing regional activity. However, regional models tend to be dependent upon national models, with regions registering changes stemming from the national level but not vice versa, resulting in relatively limited analytic ability. Furthermore, single-region models cannot respond to interactions between one region and another in a recursive fashion. The development of multiregional econometric models (MRM) was therefore a logical progression, with MRMs representing in the aggregate either larger regional systems or more typically the nation. MRMs assume a variety of shapes, each predicated upon a different set of theories regarding regional growth, behavioral decisions and inter-regional linkages. It is with respect to the latter that MRMs differ most from single-region models, i.e., they incorporate inter- as well as intra-regional linkages. They are therefore potentially more powerful; they can forecast how a change in the economy of one region will effect all the others comprising the model as well as in some instances provide unique feedback to the nation.

The United States lagged slightly behind Europe in the construction of MRMs. European activity in this area began in the early 1970s. First among the European models was REGINA, a REGInal-NAtional model of the French economy. REGINA was advanced in 1971 by R. Courbis and J.C. Prager, and developed from 1972 to 1976 at the French Planning Office. The intention of the REGINA model was to redress previous deficiencies in the French national planning process, whereby the interdependence of regional and national problems and the effect of regional and spatial factors on national development were not taken into account. In an article about the evolution and preliminary structure of the REGINA model, Courbis (1972) discusses how it represents an overall time series model of the French economy, with most variables analyzed at the regional or sub-regional level. Courbis describes there and in later works the ability of the model to provide simultaneous urban, regional and national projections for the purpose of evaluating the usefulness of regional policies from these three perspectives.[1]

The next two MRMs constructed within a national framework were for Belgium and Italy. The RENA model for Belgium, developed by Thys-Clement, Van Rompuy and de Corel, was also intended for use by the national planning bureau.[2] The thrust of the RENA model was similar to REGINA's: to explicitly analyze the interaction between regional and national development (Courbis, 1980). In contrast, the Italian model was proposed in an effort to obtain national estimates within a consistent regional framework (Brown, di Palma, and Ferrara, 1972). Econometric models for several other countries (i.e., Canada, The Netherlands, Germany, Japan and another one for Belgium) preceded the development of such models for the United States.[3] U.S. modelers, however, did take up this activity in the mid- to late-1970s. As an outcome, the refinement of four MRMs for the United States were presented in the May 1980 issue of the *Journal of Regional Science.* The May 1980 presentation of the models addressed their applicability to analyzing the differential regional effects of federal policies in a vein similar to the focus of some of the European models. The four United States MRMs are introduced below.

3. Structure of Multiregional Econometric Models

Multiregional models generally assume one of two forms: bottom-up or top-down.[4] In a bottom-up model (BU), national variables are not exogenous to the model but are predicted as the summation of all the regions, i.e., the nation is defined by the regions. In contrast, a top-down model (TD) allocates portions of a predetermined national aggregate to regions on the basis of certain criteria (usually a share approach); the regions are forced to conform to an exogenously determined national total. Of the four United States models discussed here, only the National-Regional Impact Evaluation System (NRIES), developed at the Bureau of Economic Analysis and presented by Ballard and Wendling, is a BU model. The Multiregional Multi-Industry Forecasting Model (MRMI) developed by Harris and the extension of the Wharton Annual and Industry Model presented by Milne, Glickman and Adams are TD models. Treyz's presentation of a multiregional model design merges elements of BU and TD modeling.

Advantages and disadvantages to both the TD and BU modeling approaches exist. Klein speaks perhaps the strongest in defense of TD models when he says, "To go from the general to the particular is manageable and feasible. There are viable national models in existence . . . The national models have already proven themselves in repeated testing, and it is likely that much poorer results would be obtained by trying to build complete interregional systems from a much weaker data base (Klein, 1969, p. 112)." Klein's emphasis appears to be on feasibility, and here he is supported by Milne, Adams and Glickman (1980) who support TD models because of their lower development costs as well as greater manageablity, i.e., TD models provide for flexible spatial disaggregation. In another defense of the TD structure, Harris (1980) states his impression that the United States economy works largely from the top-down, with federal government and big business decisions affecting the entire nation rather than just one or a few regions. In general, however, TD advocates readily acknowledge the limitations of this approach. Klein indicates that TD models do not allow for feedback from the region to the nation or between regions, this being the main advantage of BU models. Lyall (1980) states this limitation in a more policy-relevant context by indicating that TD models cannot discriminate intervention from effect—similar results can be obtained from different types of interventions given the more black box approach of TD models. Milne et al. further indicate that TD approaches may not be able to handle local events and their consequent effects on the region and nation. Yet Brooking and Hake (1980) convincingly argue that highly spatially disaggregated MRMs may result in an inability to monitor and incorporate local events, implying a weakness of BU models.

Despite all the arguments for or against TD and BU modeling, the decision regarding which approach to assume rests upon the eventual use and expectations of the model. Courbis (1980) indicates TD models are sensible as long as (and only if) one is interested in either the effects of national intervention on regions minus feedback between regions and the nation, or the consistency of multiregional forecasts with national forecasts without reestimation. Adams and Glickman (1980) further state that a model's degree of disaggregation and level of spatial disaggregation is a function of the purpose of the model. The question for planners that emerges from the duel between the two factions asks which modeling structure provides a more policy-relevant framework for planning analysis, or even whether the issue matters.

4. Criteria for Assessing U.S. Models

As a means of structuring a discussion and assessment of the four models presented in the May 1980 *Journal of Regional Science,* seven categories in which econometric models or urban and regional analysis methods can bear improvement are drawn from the literature. To some degree these categories relate to how MRMs may overcome the limitations of single-region models. But the general intent of them is to define if and how MRMs of the United States enhance regional economic and planning analysis. The seven categories are:

1. Greater sectoral disaggregation of data;
2. Greater intra-regional disaggregation;
3. Sensitivity to spatial allocations and effects;
4. Integration with other forms of regional modeling;
5. Increased government sector modeling;
6. Consideration of people over place;
7. Tracing of secondary effects.

The first five of the above categories are generated from prescriptions identified in the main by Glickman (1971, 1977, 1980) for the future development of econometric models. The call for greater sectoral disaggregation of data requests the disaggregation of economic sectors, i.e., employment and sectoral output, to as low a level as possible. Greater intra-regional disaggregation relates to the ability to forecast the total regional economy while accommodating the unique attributes of the smaller locales comprising the region. Model sensitivity to spatial allocations and effects is particularly relevant to planning since this category concerns a model's ability to allocate resources and produce spatial effects of regional or federal policies. The fourth category of integrating other forms of regional modeling will be limited here to a discussion of MRMs' potential to overcome input-output analyses' inability to forecast the final demand sectors of input-output tables via the combination of econometric modeling and input-output analysis. The final category derived from Glickman concerns the further development of government sector modeling, with government endogenous to the regional economy as a reflection of its role in the shaping of regional economies. A counter to this desired development, however, is Markusen's (1980) question of whether the greater placement on the role of government will serve to downplay the often vital role of private sector activity in stimulating or redressing urban and regional problems.

The sixth and seventh above categories will be treated together in the critique of the models. The consideration of people over space category derives from Edel (1980) and Massey (1981). Both Edel and Massey indicate that the methodological investigation of the effects of economic change or policy implementation on social groups may become subjugated to the pursuit of spatial effects. For example, because MRMs simulate aggregate regional behavior, they can gloss over the distinctly different behavior of subpopulations and the ramifications of regional change on them. In short, regard for people over place brings to light a bias often built into econometric models; comprehensive representation of an economic body can obscure issues of interpersonal equity. The final category concerns the range of simulated forecasts of MRMs. This category is abstracted from Markusen (1980) and questions the ability of MRMs to identify secondary policy effects in light of econometric model projection tendencies to be strong in the short run but limited in the long run as their predictive power erodes.

5. Review of Multiregional Economic Models for the United States

5.1 The National-Regional Impact Evaluation System

Ballard and Wendling (henceforth BW) present a relatively simple formulation of a bottom-up MRM. Their purpose for developing this model is "to provide planners with information and analysis to determine the effects of public policy decisions and to forecast future conditions" (BW, 1980, p. 143). They are especially concerned with the model's ability to provide regional forecasts to be used in political and economic decision-making contexts in addition to the regional or spatial distribution of policy impacts. This latter emphasis is easily apparent in the title of their article, "The National-Regional Impact Evaluation System (NRIES): A Spatial Model of U.S. Economic and Demographic Activity."[5]

The NRIES constructs 51 independent state models (the 50 states plus the District of Columbia) and derives the national model from their sum, with each state serving as a region. The state models are linked by interaction variables representing distance deflated economic activity in all other states. These linkages are spatially proportioned and are built directly into the state equation estimates. The thrust of the model is provided by a gravity model, with an industry's output determined by its potential. The parameters of the model are derived from annual time series data from 1955-76, are non-linear and estimated by OLS. In total, the model uses 230 variables per region, 69 of which are behavioral.

The NRIES model estimates economic and demographic variables per region per time period using three types of explanatory variables: regional endogenous; regional and national exogenous; and national and interregional endogenous. Each of these explanatory variables is represented by a vector. The regional endogenous variables are specified by variables which determine intra-regional economic activity, e.g., local personal income, industrial output, employment, wage rates and retail sales. The regional and national exogenous variables are represented by a partitioned vector, with one half representing variables unique to each state, e.g., federal grants-in-aid payments to each state, and the other half containing national variables common to all the states, e.g., balance of payments and social security benefits. The vector of national and international endogenous variables is composed of three partitions and in toto represents activity exogenous to a particular region but endogenous to the entire model. The first partition contains interaction indices which measure distance-deflated demand outside a region and is represented by a distance scalar. The second partition contains national aggregates of all state activities across all variables and represents the basis of the NRIES BU modeling method. The final partition contains the national equations that are estimated stochastically and exhibit no regional variation, e.g., interest rates. Additional variables for which the authors were unable to collect regional data are also included in this vector, e.g., sector prices.

The individual regional models are specified using an export-base approach to identify regional and industrial activity as either export or import. The export industries are therefore related to local personal income and output levels in other states. Service sector activity is primarily considered for local use and is consequently modeled as a function of local level of personal income and population. Local government is modeled in much the same way. None of the NRIES variable specifications are a surprise. As BW state (1980), the specifications are relatively straightforward and formulated to conform with general export-based theoretical specifications.

BW used a dynamic simulation to test their model. They tested their predicted values against the actual values for 1976, the first year following their model specification. The resultant MAPE statistics were within acceptable ranges and proved to be higher for volatile economic sectors.

To demonstrate the model's simulation potential, BW simulated the regional impacts of a national policy to reduce unemployment. To achieve this the model was shocked (i.e., manipulated discontinuities to the model were introduced) by increasing federal government spending and decreasing personal income taxes. The goal was to decrease unemployment to 4.5 percent by 1982 (!). This simulation was chosen in response to the Humphrey-Hawkins bill which proposed increased public employment as an alternative means of reducing unemployment.

The first step in this simulation was to develop a base-line forecast, assuming no change in federal growth to 1985. This year was chosen because 1979-1982 were used as impact years and 1983-85 as post impact years. BW consider the NRIES model to be capable of reasonable forecasts within an eight year period, so the time period 1979-85 is well within the model's supposed forecasting range. Next, the baseline forecast was contrasted with the policy simulation forecast. To accomplish this the model was shocked by changing national spending and taxation policy for the years 1979-82. The period 1982-85 was then forecasted with previous spending and taxation levels, permitting the 1979-82 effects to resound through the economy. The national expenditures were designed to limit direct federal government involvement in the economy and to minimize the change in the spatial allocation of federal spending. Hence all regional revenues from the federal government were increased in proportion to previous shares.

In a series of tables the results of the policy simulation are presented in the article in contrast to the baseline forecasts.[6] The results indicate the above national policy toward unemployment would resound positively throughout the economy except for a slight reversal in 1983, the year the policy would be terminated. Four select economic variables (income, employment, disposable income and state and local government revenues) are presented to describe the differential growth patterns of all the regions. The results indicate that the Great Lakes, Mideast and Northeast regions would benefit most from the simulated national employment policy while the Southwest Rocky Mountain and Far West regions would benefit the least.

5.2 *The Multiregional Multi-Industry Forecasting Model*

In "New Developments and Extensions of the Multiregional Multi-Industry Forecasting Model (MRMI)," Harris (1980) presents a theoretically more complex model than the NRIES model.[7] As stated earlier, the MRMI is a top-down MRM. Harris therefore uses variables from the national econometric model INFORUM developed at the University of Maryland to drive (i.e., to introduce exogenous variables determined outside the model yet necessary to obtain values for the endogenous variables) his model. The regional variables are then determined as regional shares of the national totals. The purpose of this model is to investigate how location decisions by economic sectors respond to profit and how these decisions in turn effect the regional economy. Accordingly, the MRMI draws extensively on location equations that explain changes in output by region using individual variables representing components of profit. The model is recursive in nature because Harris postulates that industries will relocate in one period in response to profit levels in the previous period. The consequent relocation will then cause profits to change, and relocation will occur again in the next period.

Harris orients his model to the locational decisions made within relatively small economic areas, with output and investment the major variables of inquiry. There are four operational versions of this model, depending upon the geographic unit of interest: counties; Bureau of Economic Analysis Economic Areas (173); SMSA's; and DOT transportation zones. The last three geographic units are all aggregations of counties, and counties are Harris' preferred unit of analysis. Theoretically, he believes the smaller the geographic unit the better since industries and households tend to make locational decisions on the basis of information unique to relatively small geographic areas, i.e., counties and SMSA's (Harris, 1980, p. 165). However, since county-specific data is not as widespread as other aggregate data, the model relies heavily upon data estimates made within an unspecified accounting framework. The version of the MRMI presented in this paper uses county data for 1970-74. The equations are estimated using a combination of time-series and cross-sectional data. The model's parameters are set by using national variables and adjusting them slightly for each region on the basis of characteristics unique to that region, e.g., climate.

The major thrust of the MRMI model is as follows. Regional output (Q) is hypothesized to change in response to a set of explanatory variables. These explanatory variables include: location rent, as composed of the marginal transportation costs of shipping goods out of each region (supply shadow prices), the marginal transportation costs of obtaining inputs at the place of production (demand shadow prices) and wage rates (LR); the value of land (VL); gross equipment purchases (EQ); prior supply (S); total demand for all buyers in each industry (D); and input capacity to measure the amount of inputs that have to be imported into the region per dollar of output (IS). Hence the equation for regional change in output takes the form:

$$Q = f\,(LR, VL, D, S, IS, EQ)$$

The form of this equation indicates that firms respond to profits more than to individual cost components. Furthermore, location rent is consolidated into one variable to give the model a broad range of applicability. Once the model determines Q, investment, employment and earnings are estimated.

Locational decisions by individuals also have a major role to play in the MRMI. While little detail is provided, Harris postulates that locational decisions will be explained by wage rates, changes in employment and the amount of labor surplus or deficit (Harris, 1980, p. 133). After population location is forecasted, the model forecasts personal income and personal consumption expenditures. Total demand by industry sector is then derived using intermediate demand obtained by technical input-output coefficients and final demand consisting of personal consumption and government expenditures. Total supply by industry sector is also derived by the model.

How all these relate is as follows: 1) the change in industry output is forecasted; 2) all other variables are derived for the same forecast years and inserted into the explanatory variables in the output equations; 3) output is then forecasted for the next year. Hence the recursive nature of the model. The model's unique characteristic is its ability to take income spending rounds over several years and the consequent long-run multiplier effects resulting from changing cost into account.

The brief application of the MRMI model presented by Harris (1980) shows the results of highway improvement in Pitt County, North Carolina. Harris shows how simulated highway investment and job creation in Pitt County in 1976 and 1977 can cause GRP and number of jobs in the county to decline in 1981-90, relative to a baseline forecast. He concludes that the effect of highway construction on the other variables in the model explains the simulated long-run decline in Pitt County. Another simulation not explained in the article indicated that an increase of investment in communication industries in Pitt County resulted in large and positive long-run impacts on the economy.

5.3 *The Milne, Glickman and Adams Model*

Milne, Glickman and Adams (henceforth MGA) also present a top-down MRM in their article "A Framework for Analyzing Regional Growth and Decline: A Multi-Region Econometric Model of the U.S."[8] In this version of a MRM a macroeconomic model is developed with two sub-models: energy demand and population. The total model contains 571 endogenous and 149 exogenous variables. The model was developed in the hope it would allow for the viewing of differential regional growth under differing assumptions regarding national economic growth rates and national economic policy (MGA, 1980, p. 173). The geographic regions represented by the model are the nine regions defined by the U.S. Bureau of the Census.

The overall structure of the MGA model is as follows. National variables are derived from the Wharton Annual and Industry Model. National growth is then allocated to regions on the basis of their competitiveness and regional industrial structure. The national model is directly linked to the multiregional system via output and personal income, e.g., demand for manufacturing goods is assumed to be a national demand which is then allocated to each region per its share. Some of the variables estimated for each region include output, employment, personal income and population. Six industrial sectors are identified per region (farming, mining, manufacturing durables, manufacturing non-durables, other private nonmanufacturing and government). Personal income is composed of wage and five nonwage components. The model was estimated by Ordinary Least Squares (OLS) but MGA neglect to identify the length of a time series or the frequency of data used to develop the model.

In developing the output equations MGA assumed, as did BW, industries could be classified as either export or import (exposed or sheltered in their terminology). Therefore, they too conform to an economic base type organizational scheme. Furthermore, in using a shift-share approach to determine each region's share of produced goods they develop a logarithmic equation for manufacturing output which serves to restrict each region's share of output to between zero and one. Manufacturing output share is further considered to be a function of relative labor and energy costs in the region. The behavioral justification for this relationship is that firms will choose to locate in a region largely as a function of these two variables plus in some cases either a lagged dependent variable or a time trend. Nonmanufacturing industries' output is also estimated logarithmically but on a per capita basis as a function of per capita real personal income in the region.

The employment equations developed in MGA's model represent labor requirement relationships and are also logarithmic. Assuming profit maximizing conditions, the employment projection per sector per region is a function of output and wage rate per sector per region with the wage rate adjusted by a national industry deflator for each sector. Additional variables (e.g., unemployment rate, personal income, and wage rate) are estimated in the model, assuming fairly standard econometric forms with the exception of MGA's addition of a logarithmic transformation.

The purpose of the energy sub-model is to be able to examine the effects of government energy policy. This sub-model is linked back into the macroeconomic model through industrial fuel prices which enter the manufacturing output equations as explanatory variables in industrial location. The population sub-model serves to determine the age/sex composition and in and out-migration flows for each region. This sub-model is integral to the macroeconomic model because of its implications for regional economic output via the size of labor force, i.e., migration in response to wage differentials and regional quality of life. This sub-model is linked into the larger model primarily through the migration equations which are driven by regional attractiveness.

MGA tested their model and presented MAPE statistics for a multi-period simulation from 1963-74 for several variables. The MAPE's were within acceptable ranges although this was not the case for other "less important variables" (MGA, 1980, p. 181). MGA attribute the procedure by which the regional variables were forced to coincide with the national variables to be responsible for the larger than acceptable MAPE's.

To demonstrate the application of the model MGA presented a base-line long-term forecast for the multi-regional system in addition to three policy simulations, with the baseline forecast serving as a control for the policy simulations. The national forecast was for 1979-89 and was constrained by assumptions regarding reduced corporate and personal income taxes, gradual natural gas deregulation, less restrictive monetary policy and current population report demographics. The results revealed cyclical national growth with varying impacts on GNP, employment, consumption, etc. MGA then determined the implications of this national forecast for each of the nine regions. They state that the regional impact will depend primarily on the composition of demand and the structural characteristics (e.g., labor force growth, energy supply and prices) of the region. Briefly, their control forecast results indicate that with respect to GRP, the Northern portion of the U.S. will continue to grow slower than the nation, the South's previous strong growth will moderate during 1979-89 and the West will grow slower than in the previous decade.

Given this control situation MGA then determined the variable impact of several policy scenarios. One concerns the distribution of government activity and specifically addresses the discriminating effects of U.S. policy to locate military establishments primarily in the Sunbelt. Here, MGA simulated an increase in government output (government gross product originating, government employment and government wage bill) in the Northern portion of the U.S. and examined its impact on regional growth. They concluded that such a policy would tend to even out some of the regional differences in aggregate economic activity resulting from multiplier effects of the increased government spending in the service sector of the Northern U.S. economy (MGA, 1980, p. 188).

5.4 *The Treyz Model*

In "Design of a Multiregional Policy Analysis Model," Treyz describes a purely hypothetical MRM for policy analysis that strives for accuracy and comprehensiveness in an eclectic manner.[9] It is eclectic in that Treyz draws on a variety of modeling approaches including input-output, economic base, neoclassical general equilibrium, regional location analysis, segmented labor market analysis and last, but not least, econometric modeling (Treyz, 1980, p. 191). The purpose of Treyz' wide assortment of theoretical structural restrictions is to avoid the statistical estimation problems that result when large numbers of equations are estimated on the basis of short regional time series. Instead, Treyz' model formulation attempts to reveal the underlying relationships that such equations can only approximate. The Treyz model, however, is not operational and will therefore only be briefly described.

In the Treyz model every state is treated as a region and elements of BU and TD modeling are combined. Central to the BU portion of the model is the time-series of employment and personal income and the determination of the derived demand for labor. As hypothesized by Treyz, this derived demand will interact with labor supply by industry by state to determine the wage rates. These wage rates will then be aggregated to obtain the national average wage. Additional specifications of the model include: shifts in comparative advantage and the location of production as a function of relative cost calculations at points of delivery; and local consumer demands as a function of real income and regional spending patterns.

As a TD model, the supply of capital and energy is allocated on the basis of relative margins between desired and actual capital stock. Additionally, in-migration to an area is to be a function of trends in location preferences, labor market conditions, and real purchasing power of incomes.

The above represent the major elements of Treyz' model. Their interaction provides the driving force to the model, i.e., the constant interaction of labor demand and supply as a function of the above variables. Specifically, Treyz states that employment demand expansion will occur in markets where the comparative delivered costs to the market are improving. Labor supply, on the other hand, will be determined by personal calculations. The demand and supply interaction will occur in labor markets where wages rise faster in areas with excess labor demand than in areas with excess labor supply. Similarly, growing labor costs in the face of a labor shortage will slow down businesses and prompt emigration. Hence a circular process which drives the model.

Treyz further explains how he proposes to derive equations for employment, population, labor supply, wage determination, etc. all on the basis of different accounting schemes and with different underlying behavioral assumptions. He develops his equations with great intensity, but to describe one would mean describing all because of their interdependencies.[10]

Treyz illustrates how his model might work by positing a change in Massachusetts' electric power rates and traces how this change might reverberate through his model of the economy. In short, he suggests the imposition of a uniform rate per kilowatt hour would rock the economy by changing the relative cost of production. In turn, industrial production, employment and the demand for intermediate inputs would be reduced, possibly affecting other states or regions. Additional consequences are speculated yet Treyz indicates the long-range outcome would need to be left to the model to be determined.

6. Model Critique

6.1 *Greater Sectoral Disaggregation of Data*

Sectoral disaggregation of data at as low a level of disaggregation as possible is accomplished in three of the four models to varying degrees (Treyz does not review his formulation of sectoral output and will therefore be deleted from this discussion). Ballard and Wendling are perhaps the least attentive to this in their bottom-up NRIES model. The previous review of their model does not go into detail regarding their output specifications for two reasons. First, BW do not provide much detail and second, on the basis of what they do present, it is obvious they do not build in many behavioral relationships in the determination of output. Every economic sector is modeled the same, as a function of local personal income, output levels in other states, and sometimes regional wage rates in relation to national wage rates. In short, the output for different economic sectors is modeled on the same basic assumptions and only in a general manner.

Harris, on the other hand, incorporates more detailed behavioral assumptions into his model, requiring more detailed specifications of the determinants of sectoral output. This is accomplished through the inclusion of investment indicators, postulated by Harris to be the major explanatory variables of regional output. The nature of this specification is grounded in Harris' underlying location theory approach which lends theoretical guidance to his relationships, something distinctly lacking in BW's modeling of sectoral output. Like Harris, MGA also seek more disaggregation in their model with respect to output by building in behavioral assumptions requiring enough disaggregation of data to at least support these assumptions, i.e., manufacturing output as a function of relative labor and energy costs in a region. However, they do not break down this relationship as finely as does Harris.

The degree to which these three models incorporate the call for greater sectoral disaggregation appears to be dependent upon the extent to which their hypothesized output functions are or are not based upon a distinct theory. Hence Harris, who bases his model solidly on location theory, disaggregates his output functions more than the other two.

6.2 *Greater Intra-regional Disaggregation*

The greater intra-regional disaggregation category calls for the recognition of the unique attributes of smaller locales in econometric modeling. Of the five prescriptions identified by Glickman, this one may be the least applicable or appropriate for multi-regional econometric models, especially when they strive to represent the nation. Because of the models' comprehensiveness and the difficulty of obtaining time series data for relatively small economic units, only Harris' MRMI model fulfills this prescription. The MRMI model is developed for counties while all the others use either states or census regions as the basic economic unit. This choice of economic unit reveals the biases built into each of the models regarding the desired level of forecasting ability.

Harris' unique orientation toward counties, however, may limit his model's usefulness with respect to the others. This is illustrated by the simulation he presents: the impact of highway improvement in Pitt County, N.C. Here Harris concerns himself with the impact of change only on Pitt County, effectively ignoring the ramifications on other economic units near or far from this county. Such a presentation is deceptive, however, since elsewhere Harris (1973) provides a more large-scale simulation involving projections for all the counties within a national context. The other three models are also explicitly designed to forecast the effects of national changes on all the sub-regions, or regional changes on each other and the nation, but with less regional disaggregation. These latter models, however, continue to be potentially useful tools for large-scale policy analysis with definite economic implications. This is especially true if one places these models in the context of the Sunbelt-Frostbelt debate, a debate which appears to have inspired some of the models.

6.3 *Sensitivity to Spatial Allocation and Effects*

The four models appear best designed to address this prescription. In fact, each of the authors states the models were developed for this purpose. How well they accomplish this, however, is essentially a function of the above two categories. The greater the sectoral and intra-regional disaggregation, the greater the models' ability to forecast the spatial allocation of resources and the spatial effects of policies. The simulations presented in the models illustrate their potential with respect to this category.

BW's simulation of the NRIES model addresses the spatial effects of a change in national unemployment policy on selected economic variables. They use general indicators to reveal how this change in national policy would affect the individual states and their larger regions. Yet because the variable specifications are not very detailed, the model does not suggest what second-order state or regional changes might occur in response to this national shock. For example, the recursive nature of the model prohibits it from revealing how industrial structure or labor force composition may change as micro-economic manifestations of macro-economic change. This oversight is addressed in Harris' MRMI model which, however, leans in the other direction by placing more emphasis on micro-level rather than macro-level change. While Harris professes that the purpose of his model is to investigate how locational decisions by economic sectors respond to profit and how these decisions in turn affect the regional economy, it is questionable whether his model can actually accomplish this beyond the bounds of one county. Doubtless it can, but until he demonstrates this, the model's power in this respect is open to question.

MGA and Treyz both strike a medium in their models' abilities to deal with spatial considerations, with MGA more on the side of BW and Treyz more aligned with Harris. Because MGA's model was developed for the nine census regions it is necessarily restricted to relatively large-scale implications of national or regional change. Therefore, like BW, their forecasts are more attuned to macrooriented spatial effects, providing no room for small-scale private or individual decision-making in an intra-regional context. The strength of MGA's model lies in taking general regional or national economic indicators and forecasting the spatial effects of an exogenous change only with respect to the nine census regions. The discovery of more fine-tuned effects occurring within a region must therefore be relegated to a different analytic method.

Treyz takes yet a different approach to forecasting the spatial impacts of an exogenous change. Because his model is driven by the interaction of labor demand and supply per state he structures the model around private and individual responses to various economic conditions. The speculative simulation provided by Treyz reveals his emphasis on macro-level economic indicators. The wide range of theories incorporated by Treyz into his model and his fastidious variable specifications reveal his intention to get at the behavioral relationships underlying the linkages within and between regions. Because he postulates how a change originating in one region will resound throughout additional regions his model is seen as preferable to Harris'. However, until Treyz' model becomes operational this can only be a matter of conjecture.

The degree to which a model can forecast the spatial implications of change, especially at the micro-level, appears to be a function of variable specification; the more detailed the relationships are within and between the variables the greater will be the detail ascribed the spatial implications. The toss-up appears to be that when a model is oriented toward micro-level relationships (Harris, Treyz) its primary usefulness is in forecasting results for relatively circumscribed areas. In contrast, a model which incorporates more macro-level behavior (BW, MGA) appears more capable of forecasts in a national context.

6.4 *Integration with Input-Output Analysis*

Two of the four models score high with respect to this prescription. Harris uses technical input-output coefficients in his MRMI model to determine intermediate demand for industry sectors. He then couples this with an econometric method of determining final demand as a function of personal consumption and government expenditures. This use of both input-output coefficients and econometric modeling is integral to his determination of income spending rounds by industrial sector. Similarly, Treyz postulates using input-output coefficients in his model. Here, input-output coefficients are one of several elements in the employment equations, with industry employment per state partly a function of the proportion of one sector's output delivered to another sector. The coefficients represent the demand for intermediate outputs and are the only exogenous element of the private employment function. They are therefore a fundamental component of this variable.

It is interesting to note that the two models using input-output coefficients are the ones with a relatively more micro-level orientation. This circumstance leads to the tentative conclusion that these coefficients provide more detail than desired by modelers with a macro-level orientation. Instead, these modelers use general indicators such as personal income, and output levels in other states (BW) to determine final demand. The implication of this on the accuracy of the models is unknown at present, but would prove to be an interesting subject for future speculation.

6.5 *Increased Governmental Sector Modeling*

All four of the models endogenize government to some extent. Consequently, a more important question than how this is accomplished is whether or not this results in downplaying the role of the private sector in stimulating or redressing problems. As the reviews of the models indicate, this is indeed a valid concern and can again be demonstrated by comparing the Harris and Treyz models to BW's and MGA's. Because the former's variables are specified in greater detail than the latter's, and because their models have more involved theoretical underpinnings, they concentrate more on the consequences of private sector decision-making on the shape of their economic units of analysis. By building in behavioral assumptions about how industrial sectors and individuals will respond to exogenous changes they recognize it will be these actors rather than the public sector who ultimately determine the economic state of a region. The government can intervene only so much, while the private sector and individuals cope with the ramifications of this intervention. BW and MGA, however, do not seem to recognize this circumstance as clearly as do Harris and Treyz. By confining their variables to simple formulations and determining the effect of national change only on general economic indicators they gloss over the less conspicuous but potentially more important actions of the private sector, affirming Markusen's (1980) concern, as mentioned in section four.

6.6 *Consideration of People over Place/Tracing of Secondary Effects*

Earlier it was stated that one critique brought against urban and regional analysis methods is their tendency to emphasize place over people. This can well be a critique brought against these four multi-regional models as well. None of the models deals with how any government or private activity affects people except for non-specific indicators such as unemployment and labor migration. No model differentiates between races or sexes. Instead they are solely concerned with the general economic vitality of the regions. This is certainly an oversight of the models; they stress technique over knowledge-building with respect to the social implications of regional change. Yet this is not all that can be charged against these models. In accordance with Markusen's (1980) concern, they seldom probe the secondary effects of policy changes once the models traced the short-term effects. BW represent an exception to this negligence in their short and long-range forecasts, but some doubt about the accuracy of their long-range forecasts arises when one considers the limitations necessarily built into such modeling efforts. There comes a point where uncertainty rather than certainty must reign, and a modeler who could capture this uncertainty regarding the responses of economic actors would be a true marvel. Yet it can still be reasonable to require the models to be able to determine secondary effects resulting from a change to some degree. However, since this subject was basically untapped in the four models, we have to wait and see if they are indeed capable of forecasting the secondary in addition to first order effects of a simulated policy change.

7. Summary Conclusion

The four models presented in the May 1980 issue of the *Journal of Regional Science* represent a unique development in regional analysis in the United States. In developing multiregional econometric frameworks they are groundbreaking efforts toward stronger, more comprehensive tools for regional and national policy analysis. The models have merit in the degree to which they respond to the established criteria despite faults grounded in their limitations or inordinate complexity. It is therefore difficult and inappropriate to conclude which of the four models has the greatest potential to satisfy a planner's needs; such a determination rests upon the intentions of the user as well as the level of conformance between the theoretical beliefs of the user and the theoretical specifications of the model. Yet with respect to the criteria discussed here the cards appear to fall in favor of the Multiregional Multi-Industry Forecasting Model developed by Harris. Except for its lack of attention to the people over place and secondary effects categories, this model almost consistently satisfies the criteria more rigorously than the other operational models. The top-down structure of this model, however, may present an argument against it. Advocates for bottom-up or more hybrid models (merging elements of the two) would prefer applying the National-Regional Impact Evaluation System presented by Ballard and Wendling or the Treyz model to problems of regional planning analysis. The bottom-up nature of the former model, its ability to trace secondary effects, and its operational status could render it the most likely candidate for widespread policy application.

Current cost limitations inhibit multi-user and multi-purpose implementation of any of these models. Yet with continual refinement and examination of *ex ante* forecasts they clearly may gain credibility in the national and regional policy making process in the United States, as they have abroad. If so, they may help shape national or regional policies more sensitive to regional dynamics than presently exist.

NOTES

1 For an in depth discussion of the model, see Courbis (1972, 1975, and 1982). Additional publications about the model are available in French and are cited in Courbis (1982).

[2] All the publications about the model are in French. Mention of the model is made in Courbis (1982), with citations available in the bibliography of Adams and Glickman (1980).

[3] Multiregional models for the United States did exist concurrent with the development of the European multiregional economic models. However, these U.S. models were based almost solely on input-output analysis (the exception is Harris, 1973), and are therefore excluded from this review.

[4] Courbis (1980) indicates that multiregional econometric models are rarely pure top-down or bottom-up models, nor would such a distinction be realistic. Most multiregional econometric models, especially in Europe, tend to merge elements of both.

[5] One of several additional presentations of the NRIES model can be found in Ballard, Glickman, and Gustely (1980).

[6] To conserve space the tables or portions thereof are not reproduced here. See Ballard and Wendling (1980) for a full reporting of the simulation results.

[7] See Harris (1973) for earlier formulations and simulations of the MRMI model.

[8] A similar presentation can be found in Milne, Adams and Glickman (1980).

[9] See Treyz and Stevens (1980) for another theoretical discussion of this model.

[10] Due to the circularity of Treyz' equations it is difficult, if not impossible, to describe the relationships between the equations in few words. Refer to the original article (Treyz, 1980) for a description of this sequence of equations.

REFERENCES

Adams, F. Gerard and Glickman, Norman J. "Perspectives on Multiregional Modeling." In *Modeling the Multiregonal Economic System,* edited by Gerard F. Adams and Norman J. Glickman. Lexington, Mass.: Lexington Books, 1980.

Ballard, Kenneth P., Glickman, Norman J., and Gustely, Richard D. "A Bottom-Up Approach to Multiregional Modeling: NRIES." In *Modeling the Multiregional Economic System,* edited by Gerard F. Adams and Norman J. Glickman. Lexington, Mass.: Lexington Books, 1980.

Ballard, Kenneth P., and Wendling, Robert M. "The National-Regional Impact Evaluation System: A Spatial Model of U.S. Economic and Demographic Activity." *Journal of Regional Science,* 20 (May 1980), pp. 143-158.

Bolton, Roger. "Multiregional Models: Introduction to a Symposium." *Journal of Regional Science,* 20 (May 1980), pp. 131-142.

Brown, Murray; di Palma, Maurizio; and Ferrara, Bruno. "A Regional-National Econometric Model of Italy." *Papers of the Regional Science Association,* 29 (1972), pp. 25-44.

Brooking, Carl G., and Hake, David A. "The Impact of the Regional Econometric Model on the Policy Formation Decision Process." In *Modeling the Multiregional Economic System,* edited by Gerard F. Adams and Norman J. Glickman. Lexington, Mass.: Lexington Books, 1980.

Courbis, R. "The REGINA Model, A Regional-National Model of the

French Economy." *Economics of Planning,* 12 (1972), pp. 133-152.
Courbis, R. "Urban Analysis in the Regional-National Model REGINA of the French Economy." *Environment and Planning,* 7 (1975), pp. 863-878.
Courbis, R. "Multiregional Modeling and the Interaction Between Regional and National Development: A General Theoretical Framework." In *Modeling the Multiregional Economic System,* edited by Gerard F. Adams and Norman J. Glickman. Lexington, Mass.: Lexington Books, 1980.
Courbis, R. "Measuring Effects of French Regional Policy by Means of a Regional-National Model." *Regional Science and Urban Economics,* 12 (1982), pp. 59-79.
Edel, Matthew. "'People' versus 'Places' in Urban Impact Analysis." In *The Urban Impacts of Federal Policies,* edited by Norman J. Glickman. Baltimore: Johns Hopkins Press, 1980.
Glickman, N. J. "An Econometric Model of the Philadelphia Region." *Journal of Regional Science,* 11 (1971), pp 15-32.
Glickman, N. J. *Econometric Analysis of Regional Systems.* New York: Academic Press, 1977.
Glickman, N. J. "Methodological Issues and Prospects for Urban Impact Analysis." In *The Urban Impacts of Federal Policies,* edited by Norman J. Glickman. Baltimore: Johns Hopkins Press, 1980.
Harris, Curtis C., Jr. *The Urban Economies, 1985.* Lexington, Mass.: Lexington Books, 1973.
Harris, Curtis C., Jr. "New Development and Extensions of the Multiregional, Multi-Industry Forecasting Model." *Journal of Regional Science,* 20 (May 1980), pp. 159-171.
Klein, Lawrence R. "Specification of Regional Econometric Models." *Papers of the Regional Science Association,* 22 (1969), pp. 105-115.
Lyall, Katherine. "The Role of Regional Modeling in Federal Policymaking." In *Modeling the Multiregional Economic System,* edited by Gerard F. Adams and Norman J. Glickman. Lexington, Mass.: Lexington Books, 1980.
Markusen, Ann R. "Urban Impact Analysis: A Critical Forecast." In *The Urban Impacts of Federal Policies,* edited by Norman J. Glickman. Baltimore: Johns Hopkins Press, 1980.
Massey, Doreen. "Urban Impact Analysis: The Potential for its Application in the U.K." *Built Environment,* 6 (1981), pp. 131-135.
Milne, William J.; Adams, F. Gerard; and Glickman, Norman J. "A Top-Down Multiregional Model of the U.S. Economy." In *Modeling the Multiregional Economic System,* edited by F. Gerard Adams and Norman J. Glickman. Lexington, Mass.: Lexington Books, 1980.
Milne, William J.; Glickman, Norman J.; and Adams, F. Gerard. "A Framework for Analyzing Regional Growth and Decline." *Journal of Regional Science,* 20 (May 1980), pp. 173-189.
Treyz, George I. "Design of a Multiregional Policy Analysis Model." *Journal of Regional Science,* 20 (May 1980), pp. 191-207.
Treyz, George I. and Stevens, Benjamin, H. "Location Analysis for Multiregional Modeling." In *Modeling the Multiregional Economic System,* edited by Gerard F. Adams and Norman J. Glickman. Lexington, Mass.: Lexington Books, 1980.