A Survey of Static and Dynamic State-level Input-Output Models.

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I. INTRODUCTION

Input-output models have been applied to state and regional economies since the early 1950s. A quick glance through the literature reveals a continued interest in both the theoretical development and the application of I-O models at the regional level. The Kansas Long Term Modeling (KLTM) at the University of Kansas Institute for Public Policy and Business Research (IPPBR) recently conducted a survey of the use of regional input-output (I-O) models in the U.S., especially at the state level. The survey focused on state governments and university research institutes. We wanted to find out the extent to which I-O models are being used by state policy makers, and the types of models employed. We were particularly interested in the use of dynamic versus static models.

Several other surveys of input-output models and regional economic models have appeared recently; however, none of these have focused specifically on state-level I-O models or dynamic models. Brucker, Hastings, and Latham recently [1987] described five "ready made" or package, static I-O systems for bringing down existing U.S. models to the regional or local level. Halstead and Johnson [1986] examined 25 fiscal impact models at the local level; these models use either input-output or economic base approaches. Filip-Köhn and Stäglin [1985] reported on input-output policy applications by German government agencies, some at the regional level. Claude Farrell and William W. Hall at the University of North Carolina at Wilmington, in a study unpublished at the time of this writing, surveyed tracking and forecasting activities at the local level. Beaumont [1986] reviewed integrated I-O and econometric models, and devoted a chapter to models at the regional level. Briassoulis [1986] surveyed regional and multiregional I-O models integrated with environmental models. Bourque and Cox [1970] performed an early survey of regional I-O models.

The present survey finds that regional I-O models are in active use in most states. Most of the identified models are based on BEA data brought down to the state, rather than original surveys. There is a roughly equal split between package systems and individually designed models. State-wide models are about equally likely to operated by universities as by state government agencies; a few are operated by private firms or other agencies. Contrary to the authors' prior expectation that dynamic models are relatively scarce, there is a roughly equal split between dynamic and static models.

The extensive use of package models deserves further comment. Of the five models described by Brucker, Hastings, and Latham recently [1987], two systems (IMPLAN and RIMS II) are in substantial use by respondents to the present survey. No instances were reported from two other systems (ADOTMATR and RSRI). One application of the SCHAFFER system was reported. At the same time, REMI and IPASS, two dynamic package systems not discussed by Bruckner et al., were in equally wide use.

Does the surprisingly widespread use of dynamic models reflect preferences, or is it an accident of the market place? Most of the uses of dynamic models identified by the survey were instances of the two package systems, REMI and IPASS. It is possible that some users were attracted to these systems by features other than their dynamic capabilities. However, a new dynamic model or system is more costly to implement than a static model or system; it seems likely that dynamic models would be even more widespread if they were less expensive.

For whatever reason, dynamic I-O models have captured a large share of the regional I-O market. Moreover, since all of the identified dynamic models are of relatively recent vintage (post 1975), their market share may be growing. The technology of these models is still developing. For these and other reasons, dynamic modeling is a major main focus of this report.

Standard dynamic input-output models rely on a dynamic Leontief inverse, explained for example in Miller and Blair [1985, pp. 340-350]. Although our survey emphasized dynamic input-output models, we uncovered no active models which clearly fit the standard form of dynamic I-O models[1]. Some of the identified models have less structure than a dynamic Leontief inverse model: e.g., no depreciation matrix, no capital flows matrix, or no linkage between current investment and future output. Other identified models have more structure: capacity constraints, a distinction between expected and actual future

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1. A possible exception is the modified RIMS II model in Kentucky, for which no second round survey was received.

output, investment irreversibility.

Only recently has the use of dynamic input-output techniques in regional modeling become common. A literature search turned up only a few published examples of dynamic input-output models at the state or regional level prior to 1980 (Emerson [1974]; Miernyk et al. [1970]; Miernyk and Sears [1974]; Liew [1977]; L'Esperance st al. [1977]; Conway [1979]). Most of these models were of the strict dynamic Leontief type; however, the two most recent models were of the integrated I-O/econometric type. Only the last model was in use by survey respondents.

Models of the strict Leontief type have probably fallen into disuse for two interrelated reasons:

1. Practically speaking, they suffer from dynamic instability, which may causes predicted output to oscillate explosively or to become negative.

2. Theoretically speaking, they make implausible assumptions: intertemporal linearity, full capacity utilization in each period, investment reversibility, and perfect foresight. (For a mathematical demonstration that the unrealistic assumptions cause the dynamic instability, see Takayama [1985, pp. 503-517].)

At the same time, there are compelling reasons for preferring some form of dynamic model over a static one. All of the important issues that motivate I-O modeling have to do with the impacts of changes taking place over time: changes in final demands, changes in the export base, changes in industrial structure. It is deeply unsatisfying to try to explain these dynamic events using a static model.

Consequently, a major purpose of our survey was to discover what practical alternatives to the strict Leontief dynamic model exist in the market place.

The report of our survey is organized in the following manner. Section II gives a brief description of the survey methodology. Section III discusses the I-O models identified by a first round survey. Sections IV through X contain descriptions of several of the most common packages, together with descriptions of the dynamic models provided by second round survey respondents. Section XI compares the characteristics of the dynamic models. A summary of conclusions of the survey is given in section XII, together with some implications for scholarly research. Mailing addresses for contact persons knowledgeable about the identified models and systems are presented in Appendix I. Copies of the questionnaires are contained in Appendix II.

II. METHODOLOGY

Our survey sought to contact researchers or agencies involved in state level input-output modeling. As an initial contact group, we chose departments of commerce or economic development in 50 states, 32 full members of the Association for University Business and Economic Research (AUBER), and 24 additional agencies identified by early survey respondents. In July and August, 1987, we mailed 106 questionnaires; 73 were returned for a response rate of 69 percent.

Based on the initial responses we wrote a preliminary survey report. In November, 1987, we sent the preliminary report to those respondents who had requested a copy. In the same mailing, we sent second round questionnaires (also shown in Appendix 2) to 15 agencies, mainly those with identified dynamic I-O models. Ten of these were returned, for a 67 percent response rate. However, some replies were incomplete.

This report is based on three major sources of information. These are: the questionnaire responses, publications referred to by respondents, and follow-up telephone conversations with respondents, developers of package systems, and others knowledgeable about the models. It should be pointed out that this report is not intended to provide a comprehensive list of regional I-O models. In particular, the survey may underestimate the use of static I-O models based on the package systems RIMS II, IMPLAN, and perhaps also ADOTMATR, RSRI, and SCHAFFER. Developers of these static packages were not surveyed directly; however, when information about users of these systems was provided from other sources it was included in parts of the analysis.

The comprehensive sampling frame and the relatively high response rate of the survey support some analytic conclusions on the nature and extent of regional level input-output modeling. A client list provided by the developers of the REMI model, as well as other independent sources, provide some comparisons with the mail survey.

Table 1:
24 States with Regional Models (Identified by the First-Round Survey)

State	Agency Operating Model	Type of Agency	Name of Model or system	Number of Sectors	Regions covered	dynamic?	Package system?	comments/ref.
Arkansas	University of Arkansas College of Business	university	Arkansas Model	84	Arkansas	no	no	
Colorado	University of Colorado Center for Economic Analysis	university	REMI (note b)	52, 137	Colorado; 13 substate areas	yes	yes	water resources, tax impacts
Florida	Division of Economic and Demographic Research	state government	RIMS II (note c)	39, 500	Florida	no	yes	integrated with econometric model
Hawaii	Department of Business and Economic Development	state government	Hawaii I/O Model; SCHAFFER	20-50	Hawaii	no	no	1967, 1977, 1982 used SCHAFFER's pooled supply-demand. Earlier surveys.
	ibid.	ibid.	Hawaii Pop. Economic Projection and Simulation Model	ibid.	Hawaii	yes	no	Based on previous model
Idaho	University of Idaho Agricultural Economics	university	IMPLAN (note d)	528	Idaho	no	yes	
	University of Idaho Forest Resources Dept.	university	(NA)	(NA)	(NA)	(NA)	(NA)	indirect report

Table 1 (continued)

State	Agency Operating Model	Type of Agency	Name of Model or system	Number of Sectors	Regions covered	dynamic?	Package system?	comments/ref.
Kentucky	University of Kentucky Center for Business and Economic Research	university	RIMS II (note c) modified	556	Kentucky	yes	yes	modified for Kentucky
	Office of Tourism & Development	state government	REMI (note b)	492	Kentucky	yes	yes	tourism; auto plants
Kansas	University of Kansas Institute for Public Policy	university	KLTM (note e)	126	Kansas	yes	no	
	Jarvin Emerson Kansas State University	university	Kansas I-0 Model	69	Kansas	no	no	1965,1970,1985 surveys; Emerson [1969]
Maryland	Department of Economic and Employment Development	state government	IMPLAN (note d)	451	Maryland, also multiregional	no	yes	plus modified gravity model
Michigan	Department of Commerce Business Research	state government	REMI (note b)	461	Michigan	yes	yes	auto plants
Minnesota	Department of Revenue	state government	REMI (note b)	53	Minnesota	yes	yes	quarterly forecasting
	Wilbur Maki University of Minnesota	university	IPASS (note a)	528, 155, 75	multiregional	yes	yes	
	Richard Lichty University of Minnesota	university	IPASS (note a)	(NA)	Northeast Minnesota	yes	yes	indirect report
Missouri	Richard Multogh University of Missouri	university	(NA)	79	Missouri	no	no	

Table 1 (continued)

State	Agency Operating Model	Type of Agency	Name of Model or system	Number of Sectors	Regions covered	dynamic?	Package system?	comments/ref.
Nebraska	Department of Economic Development	state government	IMPLAN (note d)	489	Nebraska	no	yes	
	University of Nebraska-Lincoln Nebraska Forest Service	university	IMPLAN (note d)	528	Nebraska	no	yes	
	Department of Economic Development	state government	(NA)	(NA)	Nebraska	no	no	1970 model, not in use, indirect report
New Mexico	New Mexico Economic Development and Tourism	state government	(NA)	2	New Mexico	no	no	
	Los Alamos National Laboratory	federal government	Los Alamos I/O Technique	30-60	New Mexico	no	no	
	Agricultural Economics Dept. New Mexico State University Las Cruces	university	(NA)	(NA)	(NA)	(NA)	(NA)	indirect report
	University of New Mexico Bureau of Business and Economic Research	university	SWEEP	30	New Mexico	no	no	
Ohio	Department of Development	state government	RIMS II (note c)	39 x 531	Ohio	no	yes	
Oklahoma	Center for Economic and Management Research	university	Structure of the Oklahoma Economy	27	Oklahoma	no	no	

Table 1 (continued)

State	Agency Operating Model	Type of Agency	Name of Model or system	Number of Sectors	Regions covered	dynamic?	Package system?	comments/ref.
Oregon	Oregon Department of Forestry	state government	IPASS (note a)	74	Oregon, Western Oregon, Eastern Oregon	yes	yes	
	ibid.	ibid.	IMPLAN (note d)	varied	Oregon	no	yes	
	Thomas A. Johnson Virginia PI&SU	university/ US government	Dynamic Input-Output Model (note f)	19	Grant Co. OR, U.S.	yes	no	1977 Grant County survey
Pennsylvania	Office of the Budget	state government	(NA)	(NA)	(NA)	(NA)	(NA)	not in use
Texas	Texas Water Development Board	state government	Texas I/O Model 1979	183	Texas	(yes) (note g)	no	water resource emphasis; fixed investment rates
Utah	University of Utah Bureau of Economic and Business Research	university	Utah I/O Model	120	Utah	no	no	Weaver et al. [1980]
Virginia	Thomas Johnson Virginia PI&SU	university	Virginia I/O Model; VIP	500	Virginia	no	no	Johnson and Keeling [1986]
Washington	Dick Conway and Associates-funded by Washington State Department of Trade and Economic Development	private firm, state government	Washington Projection and Simulation Model (note h)	26	Washington	yes	no	
	University of Washington Philip J. Bourque	university	Washington I/O	(NA)	Washington	no	no	1963,1967,1972, 1982 surveys Bourque [1987]

Table 1 (continued)

State	Agency Operating Model	Type of Agency	Name of Model or system	Number of Sectors	Regions covered	dynamic?	Package system?	comments/ref.
West Virginia	West Virginia University Center for Economic Research	university	West Virginia I/O Model 1982	440	West Virginia and adjoining regions	no	no	state survey is planned
Wisconsin	Department of Development	state government	REMI (note b)	466	Wisconsin	yes	yes	
Wyoming	Department of Administration and Fiscal Control, Research Statistics	state government	Wyoming Inter-industry Modelling System	30	Wyoming	no	no	

NOTES:

a: See section VI for a description of the IPASS model.
b: See section VIII for a description of the REMI model.
c: See section IX for a description of the RIMS II model.
d: See section V for a description of the IMPLAN model.
e: See section VII for a description of KLTM.
f: See section IV for a description of Johnson's Dynamic I-0 model.
g: The Texas I-0 model is dynamic in the minimal sense of including columns of investment coefficients.
h: See section X for a description of the Washington Projection and Simulation Model.

SOURCE: survey by the Institute for Public Policy and Business Research.

Table 2:
Additional Results of the First-Round Survey

A. 14 states identified by (all) respondent(s) as having no input-output models.

State	Affiliation(s) of respondent(s)
Alabama	state government, university
Alaska	university
Georgia	state government
Illinois	university
Iowa	state government
Louisiana	university
North Carolina	state government
Nevada	university
New Hampshire	state government
New Jersey	state government
Rhode Island	state government
South Carolina	state government, university
South Dakota	state government, university
Tennessee	state government, university

B. 6 states with indirect, unconfirmed reports of input-output models.

State	Affiliation of respondent	Affiliation of reported modeler
Arizona	state government	university
California	state government	state government
Connecticut	state government	state government
Massachusetts	state government	state government
Montana	university	university
New York	state government	university

C. 6 states with no respondents.

State
Delaware
Indiana
Mississippi
Maine
North Dakota
Vermont

SOURCE: survey by the Institute for Public Policy and Business Research.

III. THE EXTENT OF STATE-LEVEL INPUT-OUTPUT MODELING.

Table 1 lists 24 states in which at least one input-output or intersectoral model was identified by the first-round IPPBR survey; we identified a total of 38 models. The models are classified as static or dynamic. Whenever possible, the regions covered by the model are named, as is the package system to which a model belongs. Also, the number of modeled economic sectors is given. As noted in the Table, subsequent sections describe some of these models in more detail. When available, citations are given to publications which describe the various models.

Table 2 examines the 26 states in which no input-output models were identified by the survey. In 14 states at least one agency responded to the IPPBR survey, and the respondent(s) was (were) not aware of an I-O model in that state. In 6 states no one responded to the IPPBR survey. In 6 states, a respondent identified another agency as possessing an I-O model, but we were unable to confirm this report by a direct survey response. If we assume that all survey correspondents are correct, then at least 30 states have functioning regional input-output models--the 24 states directly identified plus the 6 states with reported but unconfirmed models. On the basis of the survey responses, 14 states have no models. Hence, between 30 and 36 states possess functioning I-O models, depending on how non-respondents are allocated. However, as we shall see, that conclusion probably understates the extent of I-O modeling.[2]

Some improved evidence on the extent of I-O modeling can be extracted by comparing the first round survey with three other sources. First, all clients of the REMI package system were listed in a publication by the REMI developers [undated], partly summarized in Table 3. This table describes 15 REMI models which were owned and maintained by users, and which were not reported by respondents to the present survey. The majority of the clients listed in Table 3 do not belong to the target population of the present survey; the clients are local government units or private firms rather than state governments or universities. In our judgement, three REMI models not reported by our survey respondents do belong to the target population. Apparently a total of eight REMI models are in use by members of the survey population, five models identified directly by the survey and shown in Table 1, and three additional models identified in Table 3. We infer that the sampling success rate for REMI models was roughly 5/8. If the same success rate applies to all models in the population, then the population would consist of about 60 state and regional I-O models (of which 38 were successfully surveyed).

It is noteworthy that two of the three undetected REMI models were in states reported by respondents as having no models

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2. In fact, in some cases respondents were unaware of I-O models reported by other respondents in the same state (conversely, some indirect reports of I-O models were disconfirmed by a direct survey).

(Rhode Island and Illinois). The third was in a state with no respondents (Maine).

A second comparison employs second round survey information on IPASS.[3] IPASS models have been developed for at least three states, and 11 total regional groupings.[4] Two of the three state research efforts were identified by respondents to the first round survey, for a success rate of 2/3. The state and regional models for Alaska went unreported in the survey. Notably, Alaska was one of the states reported on the first round as having no I-O models.

A third comparison can be made to a literature search which turned up three examples of state-level I-O models using direct survey data (in Hawaii, Kansas, and Washington). All three of these models were reported by first round respondents, a success rate of 100%. Since these direct surveys are well-known, it is predictable that their reporting rate should be higher than that of other I-O models.

Taken together, these sources directly or indirectly identify 34 states as having state-level I-O models. It is likely that there are several additional, unreported models in the remaining states. Several states operate more than one

3. This information was provided by Doug Olson and Wilbur Maki at the University of Minnesota, who are developing versions of the IPASS system.

4. The regions are: Minnesota; North East Minnesota; Oregon; East Oregon; West Oregon; Douglas County, Oregon; Alaska; Northeast Alaska; Southeast Alaska; Fairbanks; Anchorage and Gulf Coast; Combined Fairbanks, Anchorage, and Gulf Coast.

model. In total, we found 42 instances of state-level I-O models, of which 21 were static, 18 dynamic, and 3 not classifiable from the survey results.

Nine of the 21 static models were instances of the RIMS II and IMPLAN packages, so that no more than 14 structurally distinct static models were identified. One model was a member of the SCHAFFER static system. However, several static I-O models were identified by respondents who provided relatively little specific detail. These models include those listed in Arkansas, Missouri, Oklahoma, Utah, and the three models in New Mexico. Based on the information collected, especially sectoral detail, it is believed that none of the above models are by IMPLAN or RIMS II; however, they might be members of other package systems.

Two package systems, REMI and IPASS, provided twelve of the state level dynamic models. In addition, the Washington Projection and Simulation Model and the Hawaii Population and Economic Projection and Simulation Model are similar enough in structure to be counted as two instances of the same model. In all, the survey identified seven structurally distinct dynamic I-O models. Our second round survey obtained information on five of these dynamic models, as presented in the next section.[5] The next section also provides information on the static packages IMPLAN and RIMS II. Appendix 1 lists contact persons for most of the

5. Detailed information is not available for the Texas and Kentucky models.

structurally distinct models identified in the survey.

Table 3:
15 Additional REMI Models Currently in Use

State	Agency Operating Model	Probable client	Regions covered	Belongs to survey population? (see text)
Connecticut	private firm	utility	Connecticut	no
Florida	University of South Florida Center for Economic and Management Research	county government	Tampa area; rest of Florida	no
Illinois	Department of Energy and Natural Resources	state governement	Illinois; also a seven area model (coverage NA)	yes
Maine	Maine Office of State Planning	state government	Maine	yes
Massachusetts	Boston Redevelopment Authority	local government	Boston	no
	Merrimack Valley Planning Commission	local government	Merrimack Valley	no
Michigan	Tri-County Regional Planning Commission, Lansing	local government	(NA)	no

Table 3 (continued)

State	Agency Operating Model	probable client	Regions covered	Belongs to survey population? (see text)
Michigan	W.E. Upjohn Institute for Employment Research	research institute	Western Michigan	no
Missouri	Mid-America Regional Council	local government	multi-region	no
Nevada	University of Nevada Center for Business and Economic Research	local government	Southern Nevada	no
New York	Clarkson University School of Management, for Development Authority of North County	local government	North county, two adjoining counties	no
	Erie and Niagra Counties Regional Board	local government	Erie and Niagra counties	no
Pennsylvania	Lehigh-Northhampton Counties Joint Planning Commission	local government	Lehigh and Northhampton counties	no
Rhode Island	Bryant College Business Economics	state government	Rhode Island	yes
Washington	consulting firm	local government	two ares in Washington	no

SOURCE: REMI Client list.

IV. DYNAMIC INPUT-OUTPUT MODEL (JOHNSON)

Thomas Johnson [1983, 1985, 1986] has developed a "Dynamic Input-Output Model" for Grant County, Oregon, as well as a national version. Among the interesting characteristics of the model are its treatment of investment, its source of data, and its solution method.

Most of the models discussed in this report adapt national data to a particular region through nonsurvey methods. In contrast, Johnson's Dynamic I-O Model uses an interindustry transactions matrix and investment matrix based on a 1977 survey of Grant County, Oregon.

The key to Johnson's model is the investment equation:

$I_t = \max \{0, B(\hat{d}x^c_t + \dot{x}^c_t)\}$, where the variables are:

I_t : investment in time t (all subscripts t refer to time).

B : capital coefficients matrix.

$\hat{d}$: diagonal matrix of capacity depreciation rates.

x^c_t : capacity.

$\dot{x}^c_t$: time derivative of x^c_t.

Capacity adjusts over time toward a desired capacity level, a level which depends both on output and on final demand. Output is constrained at all times so that it does not exceed capacity.

The solution technique for the Dynamic I-O Model relies on a computer simulation of continuous time. Use of the simulation language GASP IV allows continuous time simulation using a numerical integration technique. The solution technique for the

Dynamic I-O Model is unique among models identified by the survey.

The Dynamic I-O Model has been applied to Grant County, Oregon to simulate the effects of changes in timber harvests. A national version was produced for validation of the model.

V. IMPLAN

IMPLAN is a system for creating state, county group, and county static I-O models. It is produced by the U.S. Department of Agriculture, Forest Service [undated; b]. The most recent version of the model is based on 1982 national interindustry transactions data. A regional purchase coefficients technique is used to bring the model down to the regional level. An older version of IMPLAN used a supply-demand pool approach. An IMPLAN model may include a transactions table, a direct requirements table, and income and output multipliers.

Static IMPLAN models may be used by themselves or as the foundation of a dynamic IPASS data base.

VI. IPASS

Interactive Policy Analysis Simulation System (IPASS) is a dynamic model produced by the U.S. Department of Agriculture, Forest Service [undated; a]. (Additional references are Maki, Olson, and Schallau [1985]; Olson, Schallau, and Maki [1984, 1985].) Unlike IMPLAN, RIMSII, or REMI, IPASS does not include a general procedure to create a regional model from a national one.

Rather, IPASS models have been produced for a few specific regions. These include; Oregon, Alaska, Minnesota, and sub-state regions of Oregon, Alaska, and Minnesota. Typically an IMPLAN model is the basis of an IPASS data base. However, it is not necessary to use IMPLAN; another source of interindustry data could be used.

Olson, Schallau, and Maki [1984] describe the model as follows:

> The computations involved can be roughly separated into eight main groupings or "modules." These interrelated modules are investment, final demands, production, regional output, employment, labor force, population, and primary input. Socioeconomic projections derived from a particular module are inputs used for subsequent calculations. This is a basic characteristic of the model's dynamic nature: next year's projections are based on this and previous year's output.

A simplified description suggests the handling of investment in the model. The investment module of IPASS calculates investment by industry. Then purchases of regional output for capital stock are calculated using an investment coefficients matrix and are included as gross private capital formation within final demand. The investment module may be described as a four step process. The first step is calculation of a limit for the total investment by a sector. The investment limit is dependent on how much a sector may borrow in relation to its accumulated income, and how much of its income the sector prefers to invest. The second step is to calculate the amount of investment required to replace depreciated capital stocks. The third step is to calculate investment needed for expansion. Expansion investment occurs when capacity is exceeded by demand. The final step of the investment module is to update accumulated income. Accumulated income will effect investment behavior in future periods.

Among the models identified by the survey, IPASS appears to be the one with the most possibilities for the user to introduce constraints on investment activity. This is one of the distinguishing characteristics of the model.

In most versions of IPASS regional exports are dependent on the region's market share of U.S. output. The Minnesota Trade Model version links regional exports to the INFORUM (Interindustry Forecasting at the University of Maryland) model (described in Almon et al. [1974]). This U.S. interindustry model is itself linked into an international model, INFORUM-ERI. The IPASS model derives export shares from regressions using geographical area and relative costs as explanatory variables.

VII. KLTM

The Kansas Long Term Model (KLTM) is a dynamic model under development at the Institute for Public Policy and Business Research at the University of Kansas [Burress and El-Hodiri, 1987]. The model is intended to be used for both long term forecasting and policy analysis.

One of the distinguishing characteristics of KLTM is its handling of investment. Investment in a time period is dependent on expectations of the next period's capacities and demands. The model estimates expected output for next period and compares this with the depreciated value of this year's capacity. If expected output exceeds depreciated capacity, positve investment takes place. Declining industries with low expected output experience no gross investment and negative net investment. The basic investment equation for a given sector is:

$$I_t = \max \{0, k[bX^*_{t+1}(1+\hat{i}^*_{t+1})^{-1} - (1-d)Z_t]\}, \text{ where:}$$

I_t : gross investment by sector in period t.

k : capital to output ratio.

X^*_{t+1}: expected next period demand for output.

d : depreciation coefficient.

$\hat{i}^*$: expected price inflation rate by commodity.

Z_t : existing capacity, measured in value of output units

b : desired ratio of capacity to output.

Investment initiates changes in capacities and investment final demands. Gross investment calculated in the above equation is converted to changes in commodity final demands through an investment coefficients matrix. Various models of expected output (i.e. X^*_{t+1}) are being examined. The model can be solved using iterated matrix inversion.

A essential data source for the current version of the KLTM is a 1977 120 sector model of all 50 states produced by Jack Faucett Associates for the U.S. Department of Health and Human Services. This data set contains estimates of state imports and exports, a crucial element of any state model. The source of the investment coefficients matrix is the Bureau of Economic Analysis' 1977 U.S. capital flows table.

A major updating of KLTM is currently underway. In the updated model, technical coefficients will be based on the BEA 1982 input-output tables for the U.S., ultimately supplemented by survey based data in key sectors. Gross imports and exports will be estimated from a regression of net state exports with Kansas variables (final demand by type, relative prices) and U.S. variables (output, foreign exports) as explanatory factors.

VIII. REMI

Regional Economic Models, Inc. (REMI) produces a dynamic I-O model. REMI's use is widespread. A client list (partly reproduced in Table 3) identified 33 agencies as owning and maintaining or recently using the model. The model is based on estimated 1977, 1982, and projected 2000 national I-O tables. The model is specified to a particular region relying on the regional purchase coefficient approach. Regional purchase coefficients refer to the portion of a region's demand that is satisfied by that region's production. The REMI model estimates these coeffients from There are several different versions of the model. The model has been described in more detail in Treyz [1980], and Treyz and Stevens [1985].

IX. RIMS II

Regional Input-Output Modeling System (RIMS II) is a static I-O model produced by the U.S. Department of Commerce, Bureau of Economic Analysis. RIMS II models may be at the state, county group, or county level. A location quotient method is used to adjust the coefficients of a 1977 national I-O table to reflect conditions of the region under consideration. The Bureau of Economic Analysis has access to information that is not disclosed to other sources. This allows RIMS II to take into account more, and more detailed, information that other models. RIMS II models include direct input coefficients, total output multipliers, and earnings multipliers. The model is available as a 39 x 39 table, a 39 x 531 table, or a 531 x 531 table.

The Bureau of Economic Analysis was not sent a questionnaire as part of the IPPBR survey. There are probably many more users of RIMS II than have been identified by this survey. For additional information on RIMS II, see U.S. Department of Commerce, Bureau of Economic Analysis [1986].

X. WASHINGTON PROJECTION AND SIMULATION MODEL

The Washington Projection and Simulation Model (WPSM) is a dynamic model of the economy of the state of Washington, described in Conway [1979]. The model combines an I-O framework and time series analysis. The inter-industry transactions data source is the Washington I-O Study, 1982. The Washington I-O Study is a static model based on survey information produced by Philip Bourque. An earlier version of WPSM was based on the 1972 Washington I-O Study. Other static survey-based I-O tables for Washington have been produced for 1963 and 1967. Investment is incorporated by means of several econometric investment equations. As in IPASS, exports are based on a linkage to the INFORUM model of the U.S.

The Hawaii Population and Economic Projection and Simulation Model (HPSM) is similar in structure to the WPSM. Both models have been produced by Dick Conway. The HPSM uses the Hawaii I-O Model, a non-survey static model, as its base. As their names imply both the WPSM and the HPSM are used for impact analysis and for projections.

Table 4:
Characteristics of 6 Dynamic Input-Output Models or Systems

Characteristic	Dynamic Input-Output Model (Johnson)	IPASS	IPASS (Minnesota trade model)	KLTM	REMI (version FS-53)	Washington Projection and Simulation Model
matrix of import or regional purchase coefficients?	no	note a	yes	yes	yes	yes
endogenous household consumption?	no	yes	yes	yes	yes	yes
endogenous regional government consumption?	no	yes	yes	yes	yes	yes
endogenous exports?	no	yes (regional market share of U.S. output)	yes (linked to INFORUM model)	yes (satellite model of U.S.)	yes (note b)	yes (linked to INFORUM)
capacity variables?	yes	yes	yes	yes	no	no
capacity constraints on output?	yes	yes	yes	yes	no	no
depreciation matrix?	yes	yes	yes	yes	no	no
capital flows matrix?	yes	yes	yes	yes	no	no
capital/output ratios?	yes (fixed)	yes (fixed)	yes (fixed)	yes (fixed)	yes (fixed)	no
expected output variables?	yes	yes	yes	yes	yes	no
investment irreversibility?	yes	yes	yes	yes	no	no
capacity updating equation?	yes	yes	yes	yes	no	no

Table 4 (continued)

characteristic	Dynamic Input-Output Model (Johnson)	IPASS	IPASS (Minnesota trade model)	KLTM	REMI	Washington Projection and Simulation Model
gestation lag?	yes	yes	yes	yes	no	no
inventory adjustment equation?	yes	yes	yes	no	no	yes
interindustry transaction data source:	survey, BEA	IMPLAN (note a)	IMPLAN	Jack Faucett MRIO	BEA (national table brought-down)	survey
interindustry investment data source:	survey	IMPLAN	BEA	BEA	(NA)	(note c)
interindustry data base year:	1977	1982	1982	1977	1977, 1984, and projected 2000	1982
region(s) modelled:	Grant County, OR (and U.S.)	regions of Alaska, Oregon, Minnesota. (note f)	Minnesota	Kansas	many regions (note e)	Washington; Hawaii (note d)
Approximate number of instances of the model:	1	3	1	1	25	2
Solution algorithm	nonliner numeric	numerical integration	nonlinear numeric	iterated matrix inversion	nonlinear numeric	Gauss-Seidel

NOTES:

a: IPASS is generally based on an IMPLAN database. Such a database takes import coefficients into account. It is not necessary for IPASS to rely on IMPLAN. Any source of the appropriate information is usable. IMPLAN databases may be constructed for any state, county, or county group.

b: Endogenous exports in REMI depend on a satellite model of the U.S., an interregional model, and changes in regional relative production costs.

c: Interindustry investment data is based on plant and equipment expenditure information from the U.S. census.

d: The Hawaii Popupation and Economic Projection and Simulation Model is a simplified version of WPSM.

e: See Tables 1 and 3 for a list of active clients of REMI.

f: See footnote 4 for a list of regions modelled by IPASS.

SOURCE: Survey by the Institute for Public Policy and Business Research.

XI. A COMPARISON OF REGIONAL DYNAMIC INPUT-OUTPUT MODELS

Table 4 compares the characteristics of six dynamic I-O models, including two versions of the IPASS model. The sources for the information presented in the table are responses to the second round questionnaire and publications provided by respondents.

The KLTM and both versions of IPASS are quite similar in terms of their structural characteristics, which include endogenous imports, exports, domestic consumption, and investment. The major differences are in the handling of export demand, and the solution algorithms. These models have an extensive dynamic structure, with explicit capacity variables, capacity constraints, and with endogenous investment driven by depreciation and expected future output.

Johnson's Dynamic I-O Model has similar characteristics to KLTM and IPASS. However, the Dynamic I-O Model does not include exogenous demands for exports, imports, household consumption, and regional government consumption. Furthermore, its continuous time solution method distinguishes it from other models.

REMI and the Washington Projection and Simulation Model (WPSM) are rather similar to each other, and have less structure for modeling investment behavior than the other dynamic models. These two models omit the following features: capacity variables, capacity constraints on output, depreciation matrix, capital flows matrix, investment irreversibility, capacity updating equation, and gestation lags. REMI, unlike WPSM, does have variables for expected output and capital-to-output ratios, which drive investment. These two models both include exogenous demands for exports, imports, household consumption, and regional government consumption.

Four of the six models have inventory adjustment equations; the exceptions are KLTM and REMI.

Most of the dynamic models use numerical solution methods designed for non-linear simultaneous equations, a procedure adopted from econometric modeling. One exception is Johnson's Dynamic I-O Model, which uses a numerical integration technique based on a simulation language. Another is KLTM, which uses iterated matrix inversions.

KLTM's unique algorithm is possible because its behavioral equations are piece-wise linear (unlike the other dynamic models). This linearity follows from its design; KLTM is a dynamic Leontief inverse model, extended by a straight forward introduction of capacity constraints, explicit expectations, and investment irreversibility.[6]

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6. Technically speaking, the linearity properties of KLTM depend on the chosen expectational model. The model is piece-wise linear during each period, conditionally on any exogenous or predetermined values for expectations of future variables. It is also piece-wise linear under endogenous perfect foresight expectations. Its properties under more general endogenous stochastic expectational models are unknown.

XII. CONCLUSION

If one compares this survey to the earlier results of Bourque and Cox [1970], then three conclusions stand out: state-level I-O modeling has grown more wide-spread; the models are now routinely based on package systems, where previously they were home-made; the models are increasingly likely to be dynamic ones.

State-level I-O models are now at least as widespread as state-level econometric models were ten years ago. At present, the two types of models are complementary rather than competitive, because they typically have different uses. The I-O models are not effective for short term forecasting; the econometric models are not effective for impact studies and long-run projections. However, if an effective short-run dynamic method were to be developed for I-O models, then they might steal some market share which now belongs to econometric models.

The growth of state-level I-O models, like the earlier growth of econometric models, was made possible by commercial vendors. Several existing package systems can create a regional model from a national I-O table and some region specific economic data. This survey identified five package systems in use by its respondents. Four systems in wide use were: IMPLAN, IPASS (usually piggy-backed on IMPLAN), REMI, and RIMS II. An additional system with one identified example was William Schaffer's technique (Hawaii). Members of these 5 systems account for at least 21 models, or half of the 43 models identified by the survey. The non-survey techniques used by the systems include regional purchase coefficients, location quotients, and supply-demand pooling.

About half of the identified models were dynamic. We have described five distinct types of dynamic I-O models in detail. These are: Johnson's Dynamic I-O Model, IPASS, KLTM, REMI, and the Washington Projection and Simulation Model. (The Hawaii Population and Economic Projection and Simulation Model is a simplified version of the Washington Projection and Simulation Model. Two somewhat different versions of IPASS were described.) Most of these models rely on some econometric techniques to estimate some parameters of dynamic behavior, especially with respect to investment demand. An exception is KLTM, which in its current version is entirely restricted to cross-sectional data.

It is noteworthy that none of the reported state-level dynamic models belonged to two types which have received much attention: dynamic linear programming models, and dynamic computational general equilibrium models (as described for example in Dermis et al. [1982]).

The models reviewed here do not reflect any emerging consensus about how to incorporate dynamics into I-O modeling. However, it seems possible that dynamic modeling will soon come to replace static modeling as the standard of industrial practice in regional I-O modeling. But this goal must await some improvements in I-O technology. Theoretical improvements are needed so as to standardize the model of regional investment, and the role of expectations in particular; modeling improvements are needed which will provide efficient and convenient algorithms for decentralized markets with capacity constraints.

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Appendix I: Mailing Addresses of Contact Persons.

The list below gives addresses for contact people knowledgeable about each listed model. The primary sources are the questionnaires sent by IPPBR.

Model name	Contact address
ADOTMATR	F. Charles Lamphear 306 CBA Department of Economics University of Nebraska Lincoln, NE 68588 phone: (402) 472-3004
Arkansas I-O Model	Dennis G. Beckmann College of Business, BA402 University of Arkansas Fayetteville, AR 72701
Dynamic Input-Output Model	Thomas G. Johnson Dept. of Agricultural Economics 206-B Hutcheson Hall, VPI&SU Blacksburg, VA 24061 phone: (703) 961-6461
Hawaii I-O Model	Richard Y. P. Joun Department of Business and Economic Development Research and Economic Analysis P.O. Box 2359 Honolulu, HI 96804
Hawaii Population and Economic Projection and Simulation Model	Dick Conway, see address listed below for Washington Projection and Simulation Model.
IMPLAN	Eric Siverts or Greg Alward U.S. Forest Service Land Management Planning 3825 East Mulberry Ft. Collins, CO 80524 phone: (303) 224-1763

IPASS	Doug Olson PNW Research Station 3200 Jefferson Way Corvallis, OR 97331 Wilbur Maki University of Minnesota 248 Classroom-Office Building 1994 Buford Avenue St. Paul, MN 55108
Kansas I-O Model	Jarvin Emerson Department of Economics Kansas State University Manhattan, KS 66506
KLTM	Kansas Long Term Model IPPBR 607 Blake Hall Lawrence, KS 66045 phone: (913) 864-3701
Los Alamos I-O Modeling Technique	Larry D. Adcock Los Alamos National Laboratory P.O. Box 1663 MS F611 Los Alamos, NM 87545
Missouri I-O Model	Richard McHugh Department of Economics University of Missouri Columbia, MO 65211
REMI	George Treyz or Peg Larson REMI 306 Lincoln Avenue Amherst, MA 01002 phone: (413) 549-1169
RIMS II	Regional Economic Analysis Division/BE-61 U.S. Department of Commerce Washington, DC 20230
Structure of the Oklahoma Economy	Neil J. Dikeman, Jr. Center for Economic and Management Research 307 W. Brooks, No. 4 Norman, OK 73019

SWEEP--New Mexico	Brian McDonald Bureau of Business and Economic Research University of New Mexico 1920 Lomas NE Albuquerque, NM 87131
Texas I-O Model, 1979	Mickey L. Wright Texas Water Development Board 1700 N. Congress Avenue Austin, TX 78711
Utah I-O Model	Boyd Fjeldsted 401 KDGB University of Utah Salt Lake City, UT 84108
Washington I-O Study	Philip Bourque University Washington Graduate School of Business Administration Seattle, WA 98195
Washington Projection and Simulation Model	Dick Conway Dick Conway and Associates 2323 Eastlake Avenue E, suite 410 Seattle, WA 98102 phone: (206) 324-0700
West Virginia I-O Model	David Greenstreet Regional Research Institute 511 N. High Street Morgantown, WV 26506
Wyoming Inter-Industry Modeling System	Dean M. Rud Department of Administration and Fiscal Control 302 Emerson Building Cheyenne, WY 82002

Appendix II: Sample questionnaires

This appendix contains copies of the two questionnaires that were used in the IPPBR survey. For brevity, the page breaks are not accurately reproduced. See section II for a description of the sampling methodology.

First questionnaire:

1. Name of person completing this survey ____________________

   Name of agency ____________________

   Mailing address ____________________

   ____

   ____

   Phone number ____________________

2. Is your institution currently, or has it in the past 10 years, been involved in input-output, simulation, or computational general equilibrium (CGE) modeling of the economy (that is, any model using a matrix which describes the flows between industries of goods and services involved in the production of other goods)?

   Yes_____ No_____

(If the answer to question 2 is "no" go directly to question 3.)

A. Type of model (check all that apply).

   Input-output _____ Simulation _____ CGE _____

B. How many sectors of the economy are included in your model ?

   ____

C. Indicate what level of the economy is modeled.

   National _____ State/regional _____ Both _____

D. Does the model incorporate investment coefficients (that is, a matrix describing the inter-industry use of capital goods) ?

Yes_____ No_____

Briefly describe the investment equation used in your model.

E. Name of the model ______________________________

____

F. Name of person most knowledgeable about the model (if different from above)

Name ______________________________

Phone number ______________________________

3. Are you aware of any other institutions or agencies in your state that are engaged in input-output, simulation, or CGE modeling ?

Yes_____ No_____

If the answer to question 3 is "yes," please give the following information:

Name of agency ______________________________

Address ______________________________

____

Name of Contact Person ______________________________

4. Is your agency currently involved in state/regional econometric modeling ?

Yes_____ No_____

5. Do you wish to receive a copy of a report outlining the results of this survey ?

Yes_____ No_____

We would appreciate it if you could provide us with a copy of anything which you have written or published which describes your modeling efforts, or if you could provide a list of such publications.

Please use the enclosed envelope to return the completed survey form to IPPBR. If the enveloped has been misplaced, please mail the completed form to:

Pat Oslund
Institute for Public Policy and Business Research
607 Blake Hall
Lawrence, KS 66045

If you have any questions please contact Pat Oslund, at IPPBR (913) 864-3701.

Second questionnaire:

Please complete the following questions by checking the appropriate answer or filling in the requested information.

Name of person completing the questionnaire:

____

1. Name of Model ____

2. The model is (check one):
   static _________
   dynamic _________

3. Which of the following features does the model have ?

   Yes No
   ___ ___ matrix of import coefficients or regional purchase coefficients (i.e., endogenous imports).
   ___ ___ endogenous household consumption functions.
   ___ ___ endogenous regional government consumption functions.
   ___ ___ endogenous exports. If so, please explain briefly how exports are modeled:
      _____ inter-regional model.
      _____ the model uses a satellite model of the U.S. economy.
      _____ other (please describe); ______________
      ____
      ____
      ____

4. **If the model is dynamic**, which of the following features does the model include ?

   Yes No
   ___ ___ capacity variables (which are distinct from output variables).
   ___ ___ capacity constraints on output.
   ___ ___ depreciation matrix.

___ ___ capital flows matrix.
___ ___ capital to output ratios. Are these ratios:
_____ fixed, or
_____ dependent on interest rates ?
___ ___ variables for expected output next period (distinct from actual output).
___ ___ investment irreversibility (disinvestment can not exceed depreciation).
___ ___ capacity updating equation (e.g., capacity depends on previous capacity, current investment and depreciation).
___ ___ gestation lag (i.e., new investment does not increase capacity in the same period).
___ ___ inventory adjustment equation.

5. Source of the model's interindustry transactions data is:
regional survey__________
RIMSII* __________
IMPLAN* __________
REMI* __________
national table brought-down to region__________
other (please explain)________________________________

* RIMSII, IMPLAN, and REMI are completed models which may be purchased. For descriptions of these models see section II of the preliminary report.

6. If interindustry investment data is included in the model, the source of the investment data is:
BEA Capital Flows Table__________
other (please explain)________________________________

7. The base year for the interindustry data is:__________

8. The technique used to solve the model is:
matrix inversion__________
other numerical method________________________________

9. A contact person to be listed in the final report is:
name________________________________

agency or institution________________________________

address________________________________

phone________________________________

10. Please note any errors or omissions in the attached preliminary report ______________________________
____
____
____

11. Do you wish to receive a copy of the final report ?
yes__________ no__________

Please return this questionnaire to:

Institute for Public Policy and Business Research
607 Blake Hall
Lawrence, KS 66045-2960

Questions: contact Mike Eglinski at IPPBR (913) 864-3701.