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The Metropolitan And State Economic Regions (MASTER) Model—Overview

R. C. Adams
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May 1983

Prepared for the U.S. Department of Energy
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Pacific Northwest Laboratory
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THE METROPOLITAN AND STATE ECONOMIC
REGIONS (MASTER) MODEL - OVERVIEW

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Pacific Northwest Laboratory
Richland, Washington

SUMMARY

The Metropolitan and State Economic Regions (MASTER) model is a unique multi-regional economic model that was developed by researchers at Battelle, Pacific Northwest Laboratories. MASTER was designed to forecast regional economic activity and assess the regional economic impacts caused by national and regional economic changes (e.g., interest rate fluctuations, energy price changes, construction and operation of a nuclear waste storage facility, shutdown of major industrial operations). MASTER can be applied to any or all of the 268 Standard Metropolitan Statistical Areas (SMSAs) and 48 non-SMSA rest-of-state-areas (ROSAs) in the continental U.S. (see Figure 1). The model can also be applied to any or all of the continental U.S. counties and states.

MASTER CAPABILITIES

MASTER provides the capability to answer questions of relevance to regional planners, federal/local government, and industrial/commercial firms. This capability is provided by the historical data base and the ability to forecast regional economic activity.

The MASTER data base contains mid-1960s to late-1970s data on economic and demographic variables. County, SMSA/ROSA, and state-level data are all contained in the data base. Variables include employment, wage and salary income and wage rates for 12 standard industrial categories (SICs); personal income; commercial construction for 20 building types; residential construction for 5 building types; population; population density; births; deaths; net-migration; labor force size; unemployment; and energy prices (natural gas, electricity, petroleum, coal).

MASTER regional economic activity forecasts can be produced for counties, SMSA/ROSAs, and/or states in the continental U.S. For each geographical unit (region) the model forecasts:

- employment - 12 SICs
- wage rates - 12 SICs
- commercial construction - 20 building types

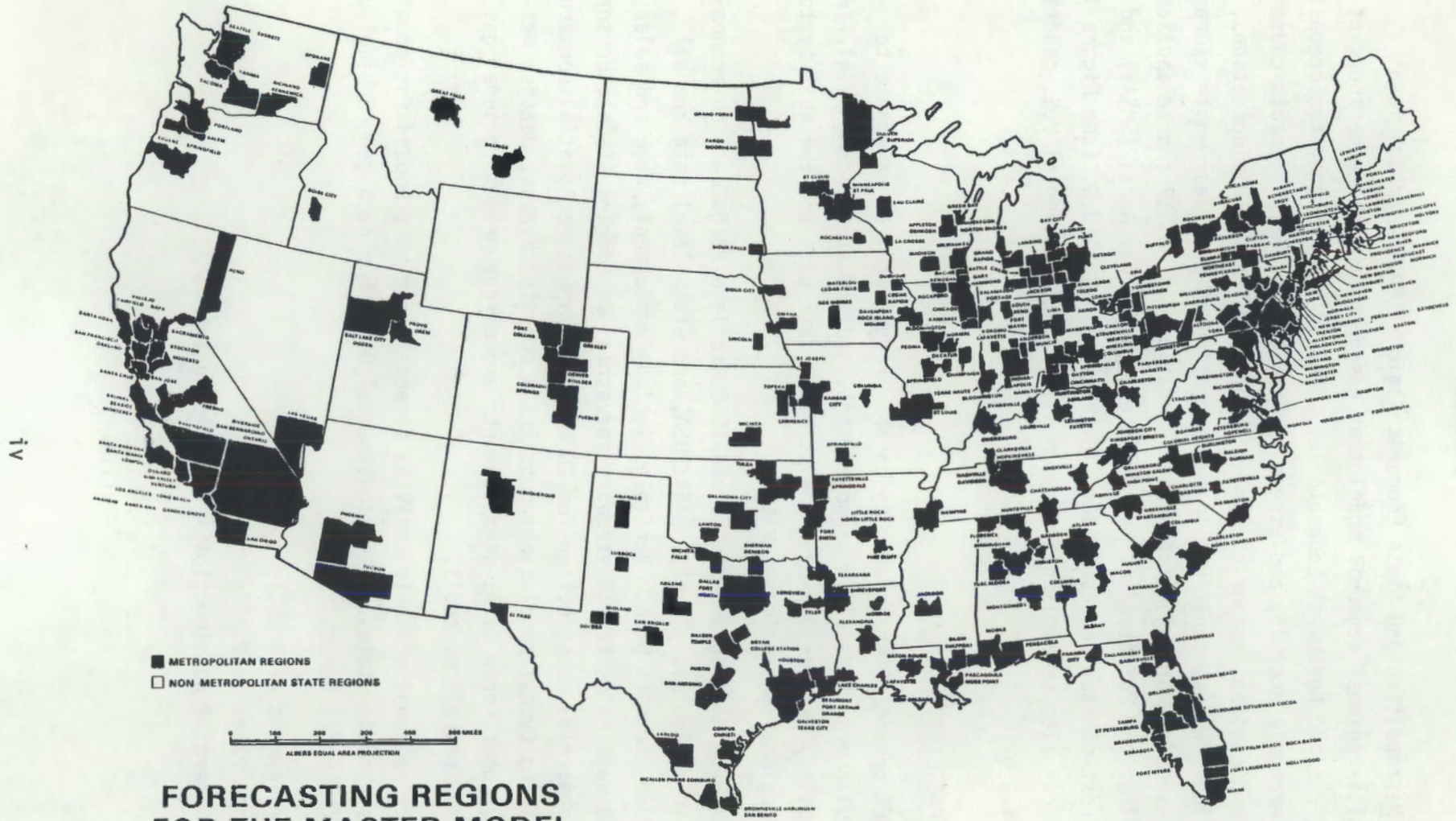


FIGURE 1. MASTER Economic Regions

- residential construction - 5 building types
- income - 5 categories
- population
- net-migration

An economic forecast can be produced for a single region or for all the regions in the continental U.S. in one computer run. Census division or national forecasts are derived by simply adding up the individual region forecasts.

MASTER can also be used to estimate the economic impact of various regional economic changes (such as shutting down a military base or large industrial facility, or constructing and operating a nuclear waste storage facility or energy-producing facility) and national economic changes (such as interest rate fluctuations or a general recession). An estimate of the change in each of the MASTER forecast variables identified above is estimated by generating two forecasts--a base case forecast and an alternative scenario forecast.

To date, MASTER has aided in the resolution of several policy issues. For example, population density information in the data base has been used as part of the nuclear waste repository siting process. In addition, construction forecasts to the year 2002 for the continental U.S. have been produced for input into energy demand models and analysis of appliance and building energy standards.

MASTER DEVELOPMENT

MASTER is a simultaneous equation econometric model. Development of the model involved specification of the equations, data collection, and estimation of the parameters. Economic theory was used to specify the model. Figure 2 illustrates the MASTER structure. The exogenous variables (ovals) include both region-specific and national variables. Endogenous variables (rectangles) are determined by both exogenous variables and other endogenous variables.

Annual county-level data (1967-1978) was collected from numerous sources. All the required data was available from secondary sources.

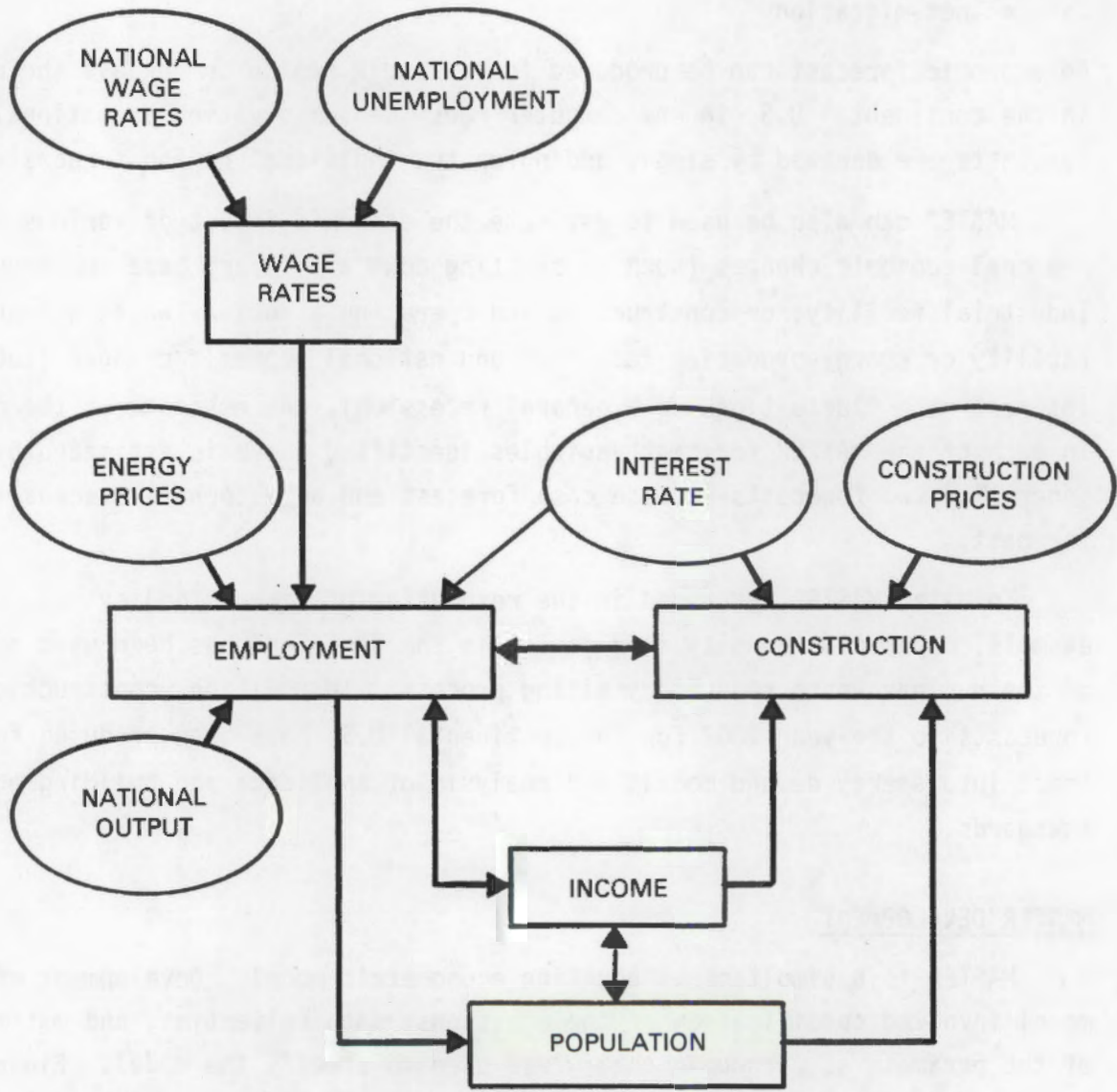


FIGURE 2. MASTER Model: Simple model schematic.

The MASTER data base and a time series/cross section regression procedure were then used to estimate the model parameters. The regression procedure used is designed to correct statistical problems typically encountered in time series/cross section estimation, such as unequal variance of error terms across cross sections (heteroscedasticity), correlation between the error terms of two cross sections for a given year (contemporaneous correlation), and correlation between successive error terms for a given cross section (autocorrelation).

MASTER SIMULATION

The MASTER simulation computer file can be set up for any county, SMSA/ROSA, or state in the continental U.S. The fully automated simulation procedure is divided into four steps. In the first, historical data for the relevant region(s) to be simulated are gathered from the computer files. In the second step, the intercepts of each stochastic equation are adjusted on an SMSA-by-SMSA basis to better reflect actual historical trends in each SMSA/ROSA. In the third step, residuals are calculated for each stochastic equation for use with the autoregressive parameters in the forecast step. The net result of the second and third steps is an improvement in the predictive power of the model. Finally, the modified equations are used to produce an economic forecast.

MASTER VALIDATION

The forecast capabilities of MASTER were tested in several ways. The model was subjected to backcast and forecast validation tests to discover how well the model could track history. In addition, numerous sensitivity tests were performed on the model.

Several summary statistics of the model's predictive ability were derived from the backcast validation tests, including a goodness-of-fit measure (R^2), Theil coefficients, and mean square error. These statistics were calculated from forecasts produced for four selected SMSAs (Albany, New York; Akron, Ohio; Portland, Oregon; Orlando, Florida) and for each of the nine census divisions in the U.S. In general, the results from these tests were encouraging. Typically, the error between historical (1967-1976) actual values and predicted

values (for both individual SMSAs and the census division totals) was in the 2 to 5 percent range.

Forecast validation tests were carried out for the same four selected SMSAs. Forecasts for these SMSAs were made for 1977-1980, and the forecasted values were compared with the actual values. The forecast error was not as small as in the backcast validation tests; yet, still typically within 5 to 15 percent error.

The sensitivity tests involved "shocking" the model by changing key exogenous inputs and observing the response. The MASTER response to exogenous changes was of correct sign and reasonable magnitude.

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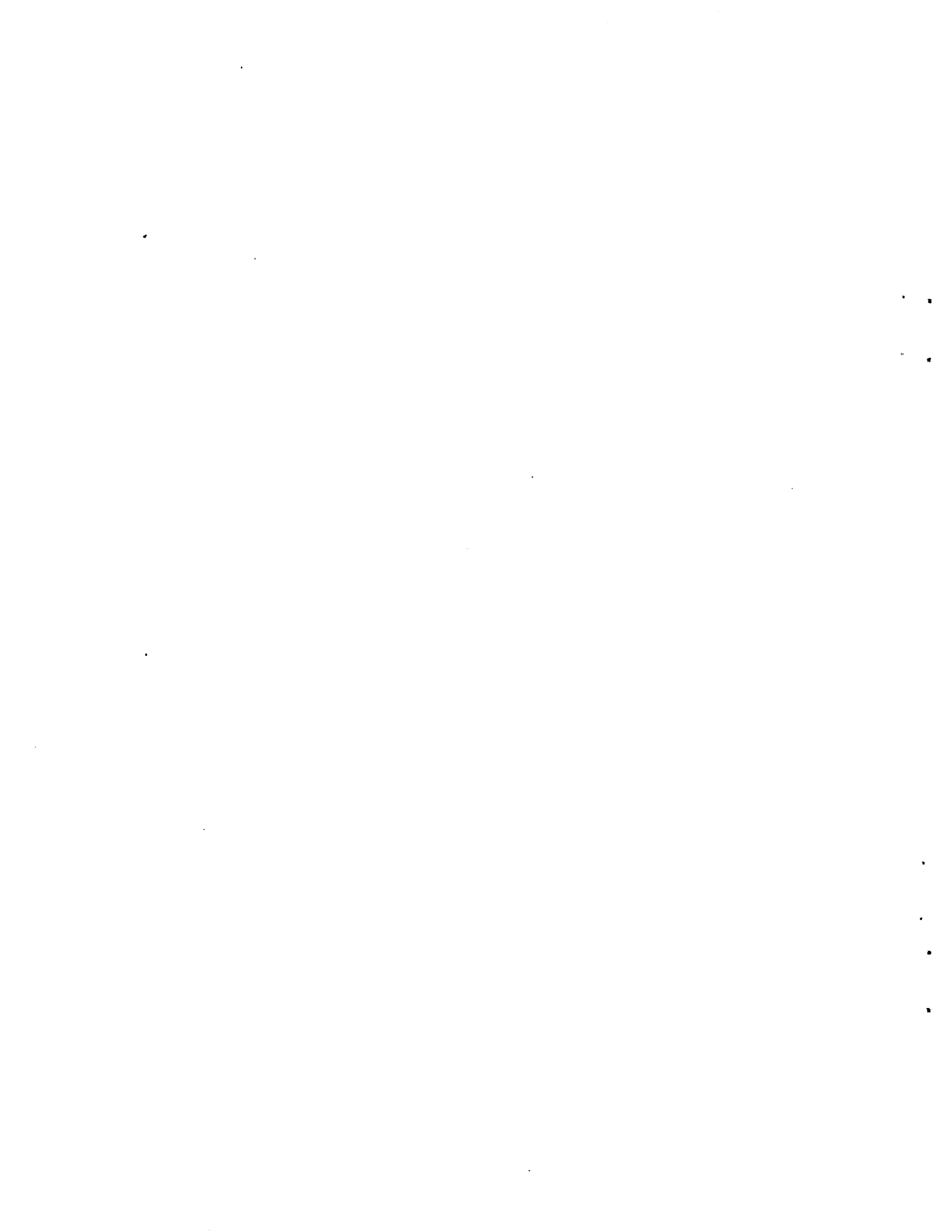
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1.0 INTRODUCTION

Pacific Northwest Laboratory has developed a unique multiregional economic model. The Metropolitan and State Economic Regions (MASTER) model was designed to forecast regional economic activity and assess the regional economic impacts caused by national and regional economic changes.

The remainder of this report is divided into four sections: capabilities and applications of the MASTER model, development of the model, model simulation, and validation testing. This report is intended to provide only an overview of MASTER. Detailed technical documentation on the model is also available.



2.0 MASTER CAPABILITIES

The capabilities of MASTER can be grouped into three areas. First, historical economic information is available in the MASTER data base. Second, MASTER will produce regional economic forecasts. Third, MASTER can be used to assess the regional economic impact of national and regional economic changes. Each of these areas is considered below.

2.1 MASTER DATA BASE

A large set of data was required to develop the MASTER model. This data file contains regional information on numerous economic and demographic variables. Table 2.1 lists the regional data in the MASTER data file, including source, time period, geographic disaggregation, and standard industrial classification (SIC) disaggregation. The regional data in MASTER could aid in the evaluation of numerous policy questions that are relevant to both the private and public sectors.

2.2 MASTER FORECASTING

MASTER can be used to produce regional economic forecasts for any county, Standard Metropolitan Statistical Area (SMSA), non-SMSA rest-of-state area (ROSA), or state in the continental United States. The model was specifically designed to produce forecasts for SMSAs/ROSAs (see Figure 2.1); however, with minor modifications the model can also forecast economic activity for county and state regions. MASTER forecasts can also be produced for groups of states and the continental U.S. These forecasts are derived by aggregating individual SMSA/ROSA forecasts. The time required to produce a MASTER forecast, whether it is for a single SMSA/ROSA or for the continental U.S., is typically less than a day.

The complete list of variables that MASTER forecasts for each region is shown in Table 2.2. There is a high level of disaggregation in the construction sector. The ten types of commercial floorspace shown in Table 2.2 are further subdivided into new and additions/alterations construction. Only total (new plus additions/alterations) residential construction is forecast.

TABLE 2.1. Regional Data in MASTER

Industrial Output

Sources: Annual Survey of Manufacturers
Statistical Abstract
Minerals Yearbook
Regional Detail: State
Time: 1965-1976
Disaggregation: 2 and selected 3 and 4 digit SIC

Construction

Source: F.W. Dodge Construction Potentials
Regional Detail: County
Time: 1965-1980
Disaggregation: More than 500 categories for commercial, industrial and residential construction

Employment

Source: Bureau of Economic Analysis
Regional Detail: County
Time: 1965-1978
Disaggregation: 1 and selected 2 digit SIC

Energy Prices

Source: DOE/EIA State Energy Price System
Regional Detail: State
Time: 1960-1980
Disaggregation: Commercial, residential and utility

Births, Deaths, Population

Source: Current Population Reports P-26 Series
Regional Detail: County
Time: 1965-1978
Disaggregation: No breakdown by age or sex

Climate

Source: NOAA
Regional Data: County
Time: 1965-1980
Disaggregation: Heating degree days, cooling degree days, temperature, precipitation

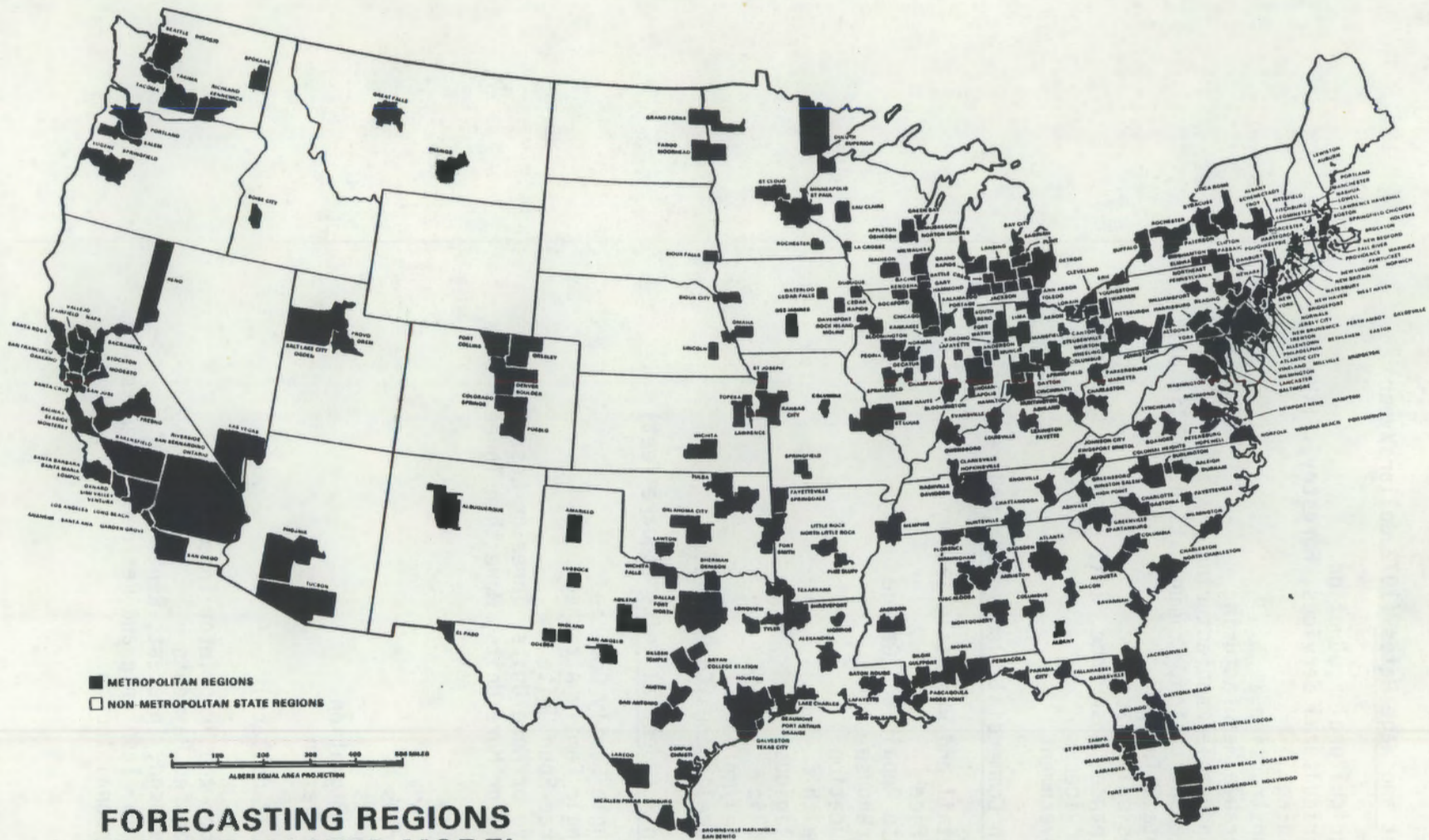


FIGURE 2.1. MASTER Economic Regions

TABLE 2.2. MASTER Forecast Variables

Employment and Wage Rates (1972 dollars/year)

Agricultural Production
Agricultural Services, Forestry, Fisheries, etc.
Mining
Construction
Durable Manufacturing
Nondurable Manufacturing
Transportation, Communication, Public Utilities
Retail Trade
Wholesale Trade
Finance, Insurance, Real Estate
Services
Government

Changes in Commercial Floorspace (square feet)

Retail and Wholesale Trade
Office
Auto Repair and Garage
Warehouse
Education
Health
Religious
Public
Hotel/Motel
Miscellaneous Commercial

Changes in Residential Units (square feet)

Single Family Detached
Single Family Attached
Three-Four Units
Five or More Units, Three or Less Floors
Five or More Units, More than Three Floors

Demographics

Births
Deaths
Net Migration
Population

Income (1972 dollars)

Labor and Proprietor Income
Transfer Payments
Dividend, Interest, Rent
Social Insurance and Residence Adjustments
Personal Income

Employment and wage rates are divided into 12 SIC categories, while income is divided into 5 categories.

MASTER requires exogenous variables (determined outside the model) to produce economic forecasts. Some of these are national variables, while most are region-specific variables. Exogenous variables include construction prices, energy prices, interest rate, national output by SIC, and national wage rates by SIC.

2.3 IMPACT ASSESSMENT

MASTER was designed to assess the regional economic impact caused by various national and regional changes. National changes that can be investigated include changes in output, wage rates, and the interest rate. Regional changes that can be investigated include changes in energy prices and construction prices. MASTER can also assess the regional economic impact caused by a large construction project or shutting down a major employer in a region. For example, MASTER can be used to assess the regional economic changes brought about by the construction and operation of a nuclear waste facility or the closure of a military base.

When MASTER is used for impact assessment, the first step is to select the region to be investigated (e.g., a group of counties or an SMSA), and then a base case economic forecast is derived. Modifications in the model inputs are then made to reflect the national or regional changes, and a second economic forecast is produced. The difference between economic activity in the base case and the alternative case reflects the impact of the change on the region.

Determining the MASTER input modifications that are required is usually a simple procedure. For example, assessing the impact of a 10% increase in the price of electricity simply involves increasing the electricity prices by 10% in the exogenous data set. However, to develop the input modifications required for assessing a large construction project, additional data is needed. Information is required on direct regional changes brought about by the project, including labor and capital requirements for building and operating the facility. This information is typically available from architectural and engineering plans and other sources. Information is also

required on the migration patterns of the construction and operation labor force. Migration patterns include: 1) whether the worker establishes a residence in the area, 2) the type of housing occupied, and 3) whether the entire family migrates. Reasonable assumptions regarding labor migration patterns can be generated from numerous surveys of nuclear power plant construction workers and other construction workers. PNL has direct computer access to the relevant surveys and other data required to develop the MASTER input modifications.

2.4 MASTER APPLICATIONS

To date, MASTER has been used in several ways. The MASTER data base has been used as part of the nuclear waste repository siting process. Population density information by county has been generated and automatically illustrated on a map.

Forecasts of annual national residential construction have been generated for input to a residential energy demand model. Also, national commercial construction forecasts have been generated for input to a commercial energy demand model. These national forecasts were generated by forecasting for each SMSA/ROSA and aggregating to a U.S. total.

Finally, the model has been used to assess the regional impact of Pacific Northwest economic changes. Scenarios that have been assessed include the loss of significant manufacturing activity in Washington and Oregon.

3.0 MASTER DEVELOPMENT

The MASTER model was developed by researchers at Battelle, Pacific Northwest Laboratories during fiscal year 1981 and fiscal year 1982. Development of the model involved three steps: specification, data collection, and estimation. Each of these is described below.

3.1 MODEL SPECIFICATION

Developing the specification of the MASTER model involved determining the types of variables to be forecast (i.e., the variables that would be endogenous or determined within the model). Five sets of variables were selected: 1) employment by SIC, 2) wage rates by SIC, 3) construction by building type, 4) population, and 5) income. The complete list of endogenous variables in the model is in Table 2.2.

Next, the explanatory variables (variables used to statistically explain changes in the endogenous variables) for each of the endogenous variables were identified. For example, regional wage rates, energy prices, and income were selected as explanatory variables for regional employment. Endogenous variables are statistically explained by other endogenous variables and exogenous variables (variables determined outside the model). A complete list of exogenous variables is provided in Table 3.1.

TABLE 3.1. Exogenous Inputs

- Total U.S. Output by SIC
- U.S. Wage Rates by SIC
- U.S. Unemployment Rate
- Prices for Nonlabor Production Inputs (e.g., energy prices)
- Consumer Price Index/GNP Deflator
- U.S. Interest Rate (90-day Treasury Bill)
- Population Age Distribution
- Construction Prices

Figure 3.1 is a relatively simple schematic of the MASTER model. It displays the endogenous sectors of the model (shown in rectangles) as well as the more important exogenous inputs to the model (shown in ovals).

Figure 3.1 illustrates the interactions among the model sectors.¹ Wage rates in the MASTER model are determined by the national unemployment rate and the national wage rate. National wages are used to capture national wage rate trends. The national unemployment rate is used as a proxy for the "tightness" of the local labor market.

Employment in the MASTER model is determined by the cost of labor, the cost of other production inputs (e.g., energy, materials), income and national output. Prices for inputs to production are used because as the price of one input changes relative to labor, the producer will respond by altering the quantity of labor used in the production process. Income reflects the local demand and national output reflects the national demand for products being produced in the region. Changes in demand for a product will cause corresponding changes in the quantity of labor used.

MASTER has a highly disaggregated construction sector. As a result, some detail will be provided on the specification of this particular sector. Construction in both the residential and commercial sectors is determined using a stock adjustment approach. That is, the level of construction is some fraction of the difference between the desired level of building stock in year t and the actual stock in the previous year ($t-1$). Construction is always some fraction of this difference because of the length of time required to plan and construct new buildings.

In residential construction, the construction level is determined by the price of housing (value per square foot), population between the ages of 18 and 64, and a proxy for the availability of mortgage money. Commercial construction is determined by the building price (value per square foot), interest rates, and a specific "driver" variable which is different for each type of commercial construction. (For example, the driver variable for retail and wholesale construction is retail and wholesale employment.)

¹ All variables in this discussion are regional unless otherwise indicated.

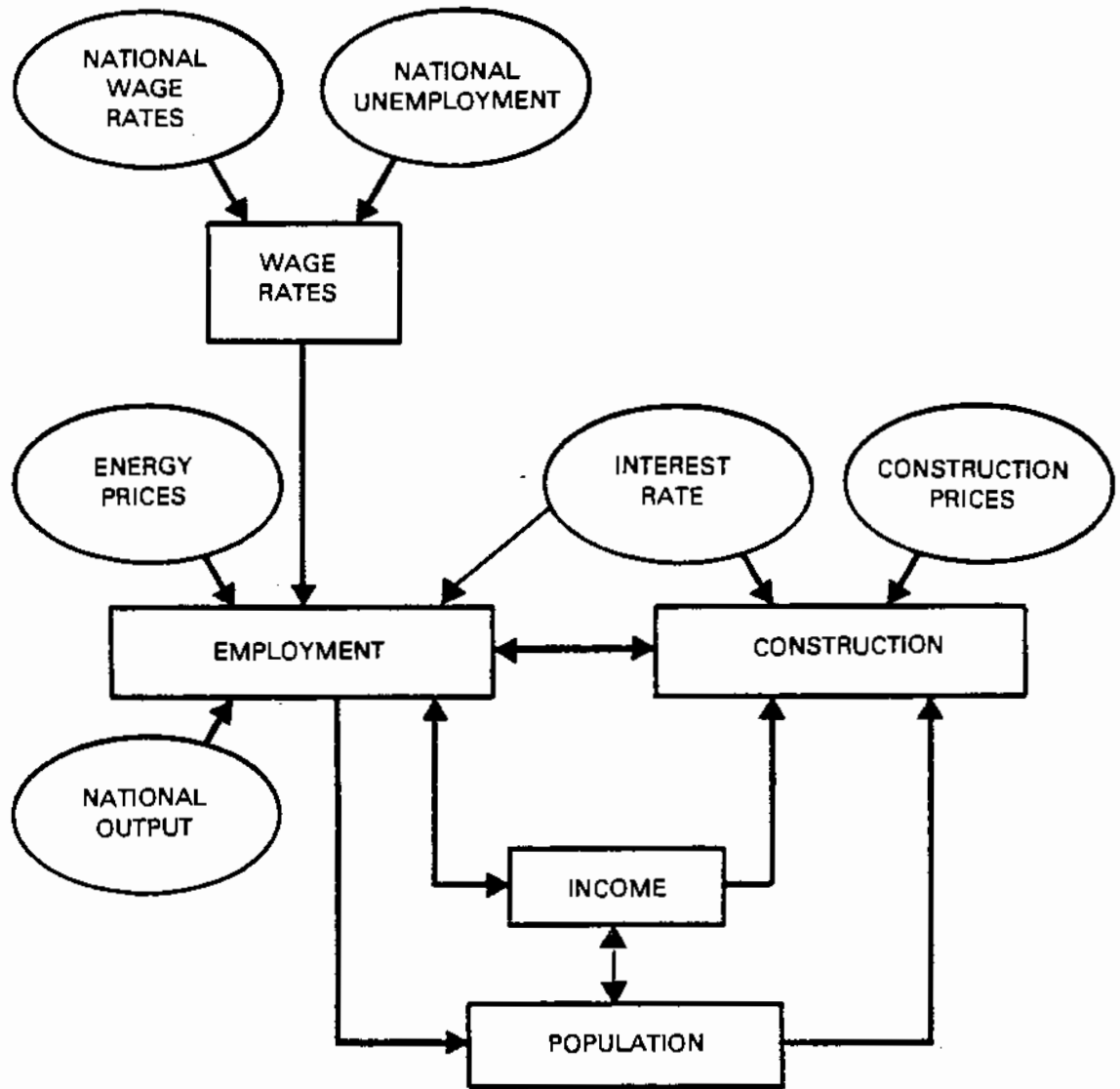


Figure 3.1. MASTER Model: Simple model schematic.

The population sector determines births, deaths, net migration and total population. Births and deaths are basically determined by population. Population is a scale variable; the greater the population, the higher the number of births and deaths.

Net migration is determined by lagged changes in employment. This specification is based on the theory that people migrate for economic reasons (real income potential). Total population is derived using an identity. Population in the previous year plus births, minus deaths, plus net migration equals population this year.

The income sector determines total wage and salary income, total proprietors income and personal income. These income measures are determined by the interest rate, unemployment rate (national), consumer price index, and employment. Increases in consumer prices and employment cause nominal income to increase.

3.2 DATA COLLECTION

Data was required to statistically estimate the parameters of the MASTER model. Annual data was collected covering, in general, the middle 60s to the late 70s. Much of the data that were collected are annual county level totals. Other data are annual SMSA, state, and national totals.

Table 2.1 describes all the regional data used in MASTER. The source, time period, geographic disaggregation, and standard industrial classification (SIC) disaggregation are listed for each regional variable in the model. All the required data was available from secondary sources.

3.3 MODEL ESTIMATION

The parameters of an econometric model describe the mathematical relationship between the explanatory variables and the dependent variable in an equation. The MASTER parameters were derived using statistical procedures, the model specification and the annual time series/cross sectional data. A time series/cross section regression procedure was used.

A MASTER specification was developed that is generic; i.e., it can be applied to all regions of the county. A generic specification is feasible because there are certain economic principles that apply to all regions. For example, no matter what region an industry is located in, if the cost of labor goes up, then that industry will use less labor as compared to the same situation without a labor cost increase.

The initial parameter estimates supported the notion that the same explanatory variables are important in all regions of the country, but tests of the model parameters showed that the way in which regional economies respond to changes varies significantly by region. In other words, the model parameters varied significantly by region. As a result, we estimated all the equations in the model separately for the four census regions (Northeast, North Central, West, South), thereby deriving different model parameters for different census regions.

To estimate the model parameters, county-level data was aggregated to the SMSA/non-SMSA state area level. This implies a cross section of 316 regions for each year of data, given the continental U.S. has 268 SMSAs and 48 ROSAs.

In general, the statistical results were highly significant. Most of the parameters were significantly different from zero and had the expected sign. Also, the parameters were determined to be of a reasonable magnitude. Tables 3.2 through 3.5 summarize the empirical results for the construction, employment and income equations in the model. The estimation procedure did not produce a goodness-of-fit measure; thus, none is included in these tables. Goodness-of-fit measures were derived, however, from the backcast validation tests. These results are discussed in Section 5.

The estimation procedure used is a time series/cross section regression procedure which is designed to correct statistical problems typically encountered in time series/cross section estimation, such as unequal variance of error terms across cross sections (heteroscedasticity), correlation between the error terms of two cross sections for a given year (contemporaneous correlation), and correlation between successive error terms for a given cross section (autocorrelation).

TABLE 3.2. Summary of Single Equation Test Results
New Commerical Construction

<u>Type of Building</u>	<u>No. of Variables</u>	<u>No. of Significant t Statistics</u>	<u>d.f.</u>
<u>Northeast Region:</u>			
1. Retail-Wholesale	7	7	424
2. Office	6	6	425
3. Auto Repair	6	5	425
4. Warehouses	7	6	424
5. Education	6	6	425
6. Health	6	3	425
7. Public	8	4	423
8. Religion	4	2	427
9. Hotel-Motel	6	5	425
10. Miscellaneous	8	6	423
<u>North Central Region:</u>			
1. Retail-Wholesale	9	9	694
2. Office	6	6	697
3. Auto Repair	5	5	698
4. Warehouses	8	7	695
5. Education	6	1	697
6. Health	5	3	698
7. Public	6	2	697
8. Religion	7	4	696
9. Hotel-Motel	7	5	696
10. Miscellaneous	4	4	699

TABLE 3.2. (contd)

<u>Type of Building</u>	<u>No. of Variables</u>	<u>No. of Significant t Statistics</u>	<u>d.f.</u>
<u>Western Region:</u>			
1. Retail-Wholesale	7	6	384
2. Office	8	8	383
3. Auto Repair	7	7	384
4. Warehouses	9	8	382
5. Education	5	1	386
6. Health	8	6	383
7. Public	8	6	383
8. Religion	5	4	386
9. Hotel-Motel	7	7	384
10. Miscellaneous	6	6	385
<u>Southern Region:</u>			
1. Retail-Wholesale	9	6	950
2. Office	9	9	950
3. Auto Repair	6	6	953
4. Warehouses	7	7	952
5. Education	5	1	954
6. Health	8	4	951
7. Public	5	5	954
8. Religion	5	4	954
9. Hotel-Motel	8	8	951
10. Miscellaneous	8	8	951

Notes: d.f. = degrees of freedom.

TABLE 3.3. Summary of Single Equation Test Results
Residential Construction

<u>Region and Type of Building</u>	<u>No. of Variables</u> ^(a)	<u>No. Significant</u> ^(b)	<u>d.f.</u> ^(c)
<u>Northeast Region:</u>			
1. Apts, 5+ units, 1-3 stories	7	5	424
2. Apts, 5+ units 4+ stories	7	5	424
3. Apts, 3-4 units	7	7	424
4. Single Family Detached	7	5	424
5. Single Family Attached	7	6	424
<u>North Central Region:</u>			
1. Apts, 5+ units, 1-3 stories	7	6	696
2. Apts, 5+ units, 4+ stories	5	4	698
3. Apts, 3-4 units	5	5	698
4. Single Family Detached	7	6	696
5. Single Family Attached	7	7	696
<u>Western Region:</u>			
1. Apts, 5+ units, 1-3 stories	7	7	384
2. Apts, 5+ units, 4+ stories	7	6	384
3. Apts, 3-4 units	7	6	384
4. Single Family Detached	6	5	385
5. Single Family Attached	6	5	385
<u>Southern Region:</u>			
1. Apts, 5+ units, 1-3 stories	6	4	953
2. Apts, 5+ units, 4+ stories	5	4	954
3. Apts, 3-4 units	4	4	955
4. Single Family Detached	7	6	952
5. Single Family Attached	7	4	952

Notes:

(a) Excluding intercept and dummy variables.

(b) 95 percent confidence, two tail test.

(c) d.f. = degrees of freedom.

TABLE 3.4. Summary of Static Tests, Employment Equations

Region and Sector	No. of Number of Variables (a)	Significant t-Statistics (b)	d.f. (c)
<u>Northeast Region</u>			
1. Agriculture	4	1	453
2. Ag Services, Forestry, Fisheries	4	4	453
3. Mining	4	4	453
4. Construction	2	1	456
5. Durables Mfg.	3	3	454
6. Nondurables Mfg.	4	3	454
7. Retail	6	6	452
8. Wholesale	5	5	453
9. FIRE	3	2	454
10. Services	4	4	453
<u>North Central Region</u>			
1. Agriculture	7	3	783
2. Ag Services, Forestry, Fisheries	5	5	785
3. Mining	5	3	786
4. Construction	2	1	789
5. Durable Mfg.	5	5	785
6. Nondurables Mfg.	2	2	788
7. Retail	4	4	786
8. Wholesale	4	4	787
9. FIRE	4	4	786
10. Services	2	2	788

Notes:

See end of table.

TABLE 3.4. (Con't)

Region and Sector	No. of Variables (a)	Significant t-Statistics (b)	d.f. (c)
<u>Western Region</u>			
1. Agriculture	2	2	455
2. Ag Services, Forestry, Fisheries	3	3	454
3. Mining	3	3	454
4. Construction	2	2	456
5. Durables Mfg.	3	3	454
6. Nondurables Mfg.	4	4	453
7. Retail	5	4	452
8. Wholesale	5	4	453
9. FIRE	6	4	452
10. Services	5	5	452
<u>Southern Region</u>			
1. Agriculture	4	3	1019
2. Ag Services, Forestry, Fisheries	6	5	1019
3. Mining	4	4	1020
4. Construction	2	1	1023
5. Durable Mfg.	4	3	1020
6. Nondurables Mfg.	4	3	1021
7. Retail	4	3	1019
8. Wholesale	4	4	1020
9. FIRE	4	2	1019
10. Services	3	3	1022

Notes:

- (a) Excluding intercept and dummy variables.
(b) 95 percent confidence, two-tail test.
(c) d.f. = degrees of freedom

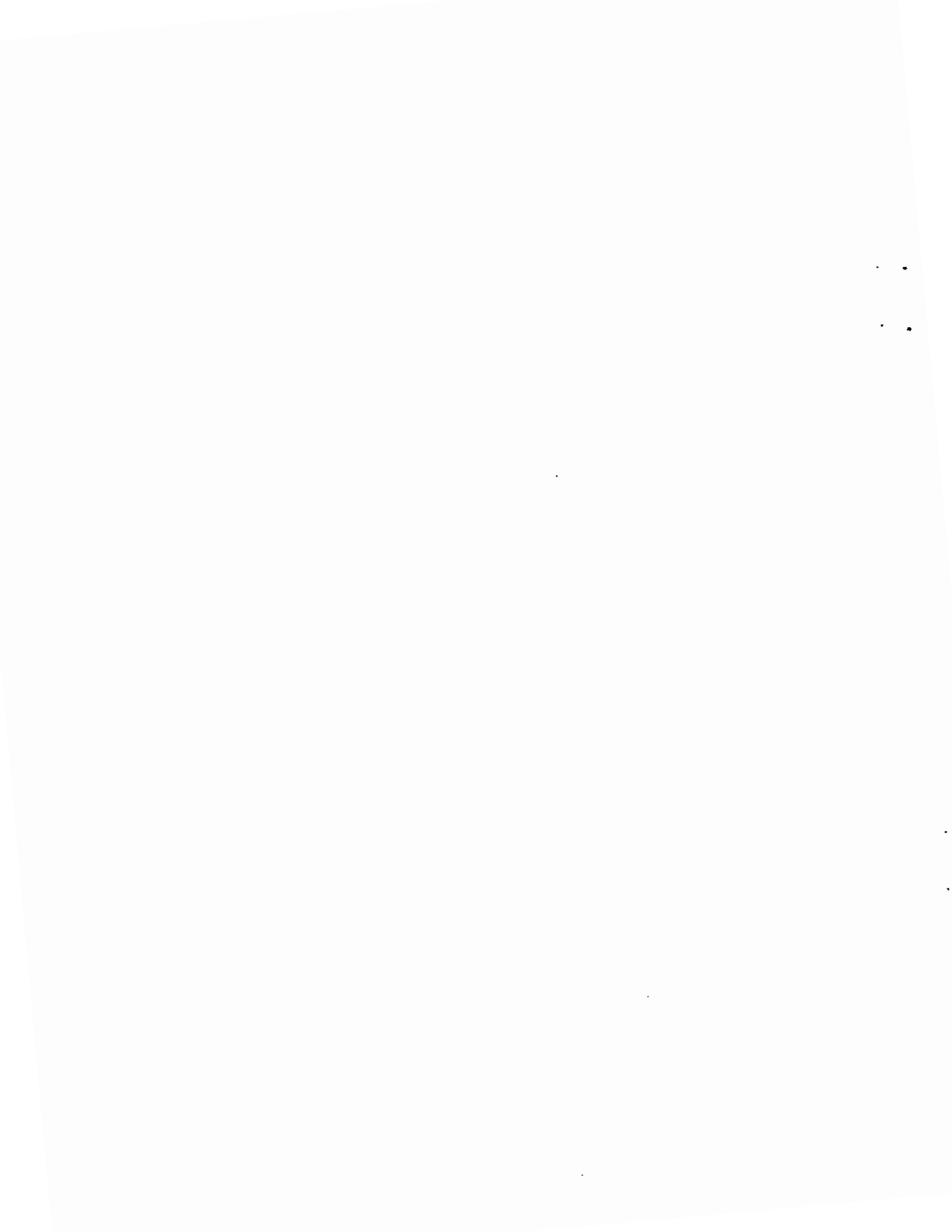
TABLE 3.5. Results of Static Tests, Income Equations

Region and Component	Number of Variables (a)	No. of Significant t-Statistics (b)	d.f. (c)
<u>Northeast Region:</u>			
1. Interest, Rent, Dividends	4	4	454
2. Transfers	5	4	452
3. Social Insurance	3	2	454
4. Residence Adjustment	3	3	454
<u>North Central Region:</u>			
1. Interest, Rent, Dividends	5	4	786
2. Transfers	5	5	785
3. Social Insurance	3	3	787
4. Residence Adjustment	3	3	787
<u>Western Region:</u>			
1. Interest, Rent, Dividends	3	2	455
2. Transfers	4	4	454
3. Social Insurance	3	3	454
4. Residence Adjustment	3	2	454
<u>Southern Region:</u>			
1. Interest, Rent, Dividends	3	3	1022
2. Transfers	3	2	1020
3. Social Insurance	3	3	1020
4. Residence Adjustment	3	3	1019

(a) Excluding constant and dummy variables.

(b) Two-tail test, 95 percent confidence.

(c) d.f. = degrees of freedom.



4.0 MASTER SIMULATION

MASTER currently has four simulation computer files corresponding to the four census regions. These files can be used to simulate economic activity in a county, group of counties, SMSA, ROSA, or state in the relevant census region.

The simulation procedure can be divided into four steps (see Figure 4.1). In the first step, historical data for the relevant region(s) are gathered from the MASTER data files. The file will contain 1967-1976 annual data.

In the next step, the equations in MASTER are modified to reflect the characteristics of each simulation region. The intercepts in each stochastic equation are adjusted separately for each simulation region to capture region-specific historical trends. This adjustment is equivalent to including a region-specific dummy variable for each SMSA/ROSA in each of the regression equations. In the third step, residuals for each stochastic equation are calculated for each simulation region. These residuals are combined with the region-specific autoregressive parameters (estimated along with the equation parameters in the model estimation process) in generating forecast values of each of the stochastic variables. Both of these steps are performed in order to improve the goodness-of-fit properties of the model and to make the model better reflect actual conditions in each simulation region.

In the final step, the historical data and modified model equations are used to produce an economic forecast. Table 4.1 shows the results of a forecast developed for Orlando, Florida. The forecast produces annual results; however, for brevity only 5-year intervals are shown in Table 4.1. The process of producing this forecast summary table for a region or for a group of regions is fully automated in the MASTER simulation program.

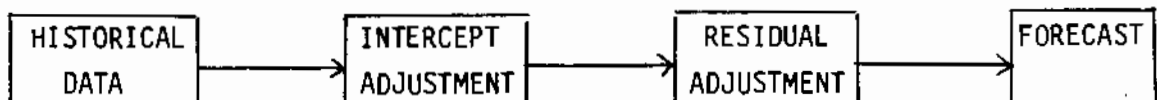


FIGURE 4.1 Simulation/Forecasting Procedure

TABLE 4.1. Orlando, Florida

MASTER FORECAST FOR ORLANDO, FLORIDA SMSA

	1980	1985	1990	1995	2000
EMPLOYMENT: (PERSONS)					
AGRICULTURAL	5484.04	4812.81	4223.54	3713.55	3303.66
AGRICULTURAL SERVICES	1466.92	626.54	709.18	462.59	519.08
MINING	388.63	1083.21	1324.53	1524.42	1687.37
CONSTRUCTION	7161.54	7552.19	7334.94	7031.78	7025.64
NONDURABLE MANUFACTURING	8370.95	6979.01	5842.02	4881.76	4183.90
DURABLE MANUFACTURING	14439.74	9993.45	6768.59	4480.73	3018.50
PUBLIC UTILITIES	11996.69	14386.50	17252.37	20689.15	24810.55
WHOLESALE TRADE	13832.29	11425.02	9284.47	7672.44	6463.42
RETAIL TRADE	43366.10	41087.44	39660.10	37766.58	37479.74
FINANCE-INSURANCE-REAL ESTATE	13305.36	11958.86	11001.33	10177.39	9816.01
SERVICES	71874.84	81374.04	90241.76	100524.10	114640.92
GOVERNMENT	59415.95	72288.58	87950.12	107004.76	130187.66
TOTAL	251104.06	263568.64	281593.95	305930.25	343137.45
NEW COMMERCIAL CONSTRUCTION (SQ. FT)					
RETAIL-WHOLESALE	1134176	1172411	1151154	1106093	1077862
OFFICE BUILDINGS	550492.43	816042.50	733738.12	673690.67	633675.94
AUTO REPAIR	47216.18	45470.02	27847.16	12869.41	9640.00
WAREHOUSES	740467.59	1782822	1718201	1832166	2028852
EDUCATION	220272.78	291087.95	270313.76	271616.40	277626.58
HEALTH	78881.43	106316.26	97962.35	94353.16	93031.45
PUBLIC	204219.41	241418.09	257641.29	289120.27	331736.26
RELIGIOUS	130730.29	136410.57	139357.25	143384.64	148996.06
HOTEL-MOTEL	1012044	1465228	1475096	1513429	1569694
MISCELLANEOUS	460086.03	571104.27	613329.04	670488.70	733253.91
TOTAL	4578586	6628311	6484840	6607211	6922368
COMMERCIAL CONSTRUCTION (SQ. FT)					
ADDITIONS AND ALTERATIONS					
RETAIL-WHOLESALE	144120.77	156861.76	141763.85	135008.33	130884.47
OFFICE BUILDINGS	44160.84	59082.21	56239.83	55464.70	54989.57
AUTO REPAIR	325.00	325.00	325.00	325.00	325.00
WAREHOUSES	53023.05	75773.79	77154.77	87394.04	99370.67
EDUCATION	81108.55	62536.28	78649.59	87361.71	99150.20
HEALTH	71284.96	89239.75	86052.65	87851.08	88112.47
PUBLIC	9949.31	16617.83	14840.89	15304.96	16056.57
RELIGIOUS	27593.91	29949.19	30808.24	32756.21	35532.35
HOTEL-MOTEL	91933.47	96831.85	100567.57	103174.95	107193.92
MISCELLANEOUS	45809.58	46169.44	52088.20	58047.98	65938.52
TOTAL	569309.45	633407.11	638490.59	662688.97	697559.75
RESIDENTIAL CONSTRUCTION (SQ. FT):					
APARTMENTS					
FIVE OR MORE UNITS					
1-3 STORIES	4183983	5075850	5177755	5254500	5339252
4 OR MORE STORIES	192455.19	258497.02	285456.82	308929.15	333243.37
THREE TO FOUR UNITS	534729.32	557217.11	565797.23	579136.32	594793.95
SINGLE FAMILY DETACHED					
DUPLEXES	5027921	6074547	6578717	7129926	7749695
TOTAL	151458.92	189129.53	198311.12	211355.98	226014.87
TOTAL	10090547	12155440	12806037	13483847	14242999
WAGES: (ANNUAL 000 1972 \$)					
AGRICULTURAL	10.78	10.49	10.38	10.33	10.33
AGRICULTURAL SERVICES	5.33	4.47	3.79	3.49	3.12
MINING	40.14	27.16	39.01	32.84	38.54
CONSTRUCTION	10.76	10.58	10.39	10.30	10.19
NONDURABLE MANUFACTURING	9.17	9.97	10.56	10.89	11.14
DURABLE MANUFACTURING	10.36	10.21	10.20	10.20	10.23
PUBLIC UTILITIES	11.64	12.81	13.89	14.40	15.51
WHOLESALE TRADE	10.79	11.22	11.49	11.61	11.76
RETAIL TRADE	5.86	5.40	5.27	5.21	5.14
FINANCE-INSURANCE-REAL ESTATE	9.37	10.17	10.76	11.01	11.55
SERVICES	7.14	7.54	7.88	8.05	8.23
GOVERNMENT	7.75	8.22	8.73	9.26	9.83
PERSONAL INCOME (000 1972 \$)					
WAGE BILL	2014638	2197970	2457549	2757322	3225320
PROPERTY INCOME	328287.31	382938.10	450822.72	524161.06	624406.76
TRANSFER PAYMENTS	471024.17	543531.89	621558.92	716747.52	830373.87
RESIDENCE ADJUSTMENT	19941.68	17784.90	19787.87	22199.37	23213.82
SOCIAL INSURANCE ADJUSTMENT	107349.23	123874.17	141657.00	163351.05	189247.17
PER CAPITA INCOME	4.25	4.29	4.45	4.59	4.88
TOTAL PERSONAL INCOME	2726542	3018350	3408061	3857079	4514067
DEMOGRAPHICS					
POPULATION	641472.90	704117.97	765928.05	840150.61	925369.76
BIRTHS	9114.75	9858.39	10335.83	10823.31	11067.05
DEATHS	5002.91	5285.28	5565.00	5857.32	6170.67
MIGRATION	4363.04	9913.76	7653.37	11344.20	13366.49

5.0 MASTER VALIDATION

Three types of MASTER validation tests were carried out: backcast tests, forecast tests, and sensitivity tests. The tests and corresponding results are described below.

5.1 BACKCAST VALIDATION TESTS

One necessary condition for a forecasting model to be deemed "reliable" or even "usable" is that it predict historical values reasonably well. If the model cannot predict year-to-year changes in variables of interest better than a naive no-change forecast model would during the historical period, then it cannot be expected to reliably forecast such changes in the future. After all, the equations in the model reflect the historical experience, or the "structure" of a region's economy during the historical period. Backcast statistics measure how well the actual structure is reflected in the model.

Given a set of data with both actual and predicted values of a variable or number of variables, a variety of statistics can be computed. Each statistic in some way summarizes the relationship between the actual and predicted values. The first summary statistic of a model's predictive ability over the historical period is R^2 . This statistic measures the percentage of variation in the actual values of a stochastic variable that is captured by an equation. R^2 permits validation of individual stochastic equations in a model, but not the model as a whole or the true variables of interest which are specified by identities. This statistic is usually calculated within an estimation program. However, the time-series/cross-section statistical package used to estimate the MASTER stochastic equations did not report such summary statistics. Thus, a backcast simulation was used to calculate the R^2 for each stochastic equation in the model for each Census Division.

R^2 measures the predictive capability of individual equations using actual values for right-hand-side variables. It is not useful, due to assumptions made in its calculation, for measuring goodness-of-fit in a full, dynamic simulation. In such a simulation the model is allowed to "forecast" over the historical period as if the actual values were truly unknown. A set

of statistics have been developed to measure the accuracy of such simulation experiments.² The measures, developed by Theil,³ focus on the year-to-year actual and predicted changes in a variable, not the actual and predicted values of the variable. The first statistic is the mean square error, defined as

$$MSE_1 = \frac{1}{n} \sum_{t=1}^n (p_t - a_t)^2$$

where $p_t = P_t - A_{t-1}$
 $a_t = A_t - A_{t-1}$
 P_t = predicted value of variable Y at time t
 A_t = actual value of variable Y at time t
n = number of periods

The mean square error is also frequently calculated in terms of relative changes, with $p_t = (P_t - A_{t-1})/A_{t-1}$ and $a_t = (A_t - A_{t-1})/A_{t-1}$. The mean square error using these definitions, MSE_2 , is smaller than MSE_1 if A_{t-1} on average is larger than 1. Mean square error measures how close, on average, the predicted change is to the actual change. $MSE_1=0$ implies a perfect forecast, but it has no upper bound, and no value of MSE other than zero has any particular meaning.

The Theil inequality coefficient, U_1 , overcomes the interpretation problem associated with non-zero $MSEs$. U_1 is defined as

$$U_1 = \frac{MSE_i}{MAC_i}$$

² The following discussion is taken primarily from G.S. Maddala, Econometrics, McGraw-Hill, New York, New York, 1977, pp. 343-347, and R.S. Pindyck and D.L. Rubinfeld, Econometric Models and Economic Forecasts, McGraw-Hill, New York, New York, 1981, pp. 360-367.

³ H. Theil, Applied Economic Forecasting, North-Holland, Amsterdam, 1971, Chapter 2.

where

$$MAC_1 = \frac{1}{n} \sum_{t=1}^n (A_t - A_{t-1})^2 \quad \text{and} \quad MAC_2 = \frac{1}{n} \sum_{t=1}^n \left(\frac{A_t - A_{t-1}}{A_{t-1}} \right)^2$$

$U_1=0$ for a perfect forecast and equals one if the model performs just as well as one in which $A_t - A_{t-1}$ was set equal to a constant. A value of U_1 greater than one indicates that such a "naive" model ($A_t - A_{t-1} = \text{constant}$) would predict the variable better than the model does. Theil also developed a decomposition of MSE into bias, regression, and disturbance proportions, called U_M , U_R , and U_D . They are defined by

$$U_M = \frac{(\bar{p} - \bar{a})^2}{MSE}$$

$$U_R = \frac{(S_p - rS_a)^2}{MSE}$$

$$U_D = \frac{(1-r^2)S_a^2}{MSE}$$

where S_p = standard deviation of predicted changes
 S_a = standard deviation of actual changes
 r = correlation between actual and predicted changes
 \bar{p} = mean predicted change
 \bar{a} = mean actual change

As U_M deviates from zero, the average predicted change deviates from the average actual change. This situation is obviously undesirable. As U_R deviates from zero, a one-unit change in p_t is associated with a change in a_t different than one unit. In this situation, the model over- or under-reacts. $U_R=0$ in the case where $\hat{\beta}=1$ in the regression, $a_t = \alpha + \beta p_t$; and $U_M=0$ if $\hat{\alpha}=0$. The Theil coefficient U_D is the part of the MSE due to noise; its desired value is one, since $U_M + U_R + U_D = 1$.

The Theil coefficients U_1 , U_M , U_R , and U_D , as well as MSE, provide useful summaries of how well a model performs in predicting particular variables. U_1 in particular is useful since it implicitly compares the model at hand with a "naive" model; U_M , U_R , and U_D provide information on the

source of prediction errors and whether anything can be done to reduce them. These statistics are presented in the following sections to evaluate MASTER's predictive ability.

In order to evaluate the predictive power of MASTER for individual SMSAs or ROSAs, one city from each Census Region was selected for in-depth study. Backcasts were generated and no special adjustments were made to the model to increase its apparent predictive power. The four SMSAs selected and the Census Regions in which they are contained are 1) Albany, New York (Northeast); 2) Akron, Ohio (North Central); 3) Portland, Oregon (West); and 4) Orlando, Florida (South). Each of these SMSAs is moderately sized and representative in size of a large number of SMSA/ROSAs within their respective regions. None experienced abnormally high or low growth during the historical period, which further makes them representative of typical SMSA/ROSAs in their respective regions. Table 5.1 shows the test results for the Portland, Oregon SMSA. These results are typical of the other three cities. Figures 5.1 through 5.6 graphically depict the relationship between historical actual and MASTER forecast variables for Portland.

Backcasts were also generated for each SMSA/ROSA in each of the nine Census Divisions. First, R^2 s were calculated for each stochastic equation for each Census Division. Actual values of right-hand-side variables were used, and intercept adjustments for each SMSA/ROSA in the Division were used. The R^2 statistics are presented in Table 5.2.

Backcasts were also generated for each of the SMSA/ROSAs in each of the nine Census Divisions. The backcast results for the individual SMSA/ROSAs were combined into nine divisional data sets. Their coefficients were then calculated for each Census Division by summing the prediction errors of all the SMSA/ROSAs in the Division for the years 1969-1976. Table 5.3 shows the results for the census division six (California, Oregon, Washington). These results are typical of the other eight regions. Figures 5.7 through 5.12 illustrate the difference between the historical actual and MASTER forecast for the census division six.

The tests presented in this chapter shed a positive light on the MASTER model. Backcasts for the four typical SMSAs showed that the model performs

TABLE 5.1. Theil Backcast Statistics of
Portland, Oregon SMSA

	Relative ¹ Change <u>M.S.E.</u>	<u>U₁</u>	<u>U_M</u>	<u>U_R</u>	<u>U_D</u>
Employment: (Persons) ²					
Agricultural	.01	A	.26	A	.74
Agricultural Services	.02	A	.54	.27	.19
Mining	.01	A	.29	.01	.70
Construction	.01	A	.27	.12	.61
Nondurable Manufacturing	A	A	.41	.02	.57
Durable Manufacturing	.01	A	.26	.28	.46
Public Utilities	A	A	.13	.04	.83
Wholesale Trade	.01	A	.44	.01	.54
Retail Trade	A	A	.46	.21	.33
Finance - Insurance - Real Estate Services	A .01	A A	.15 .20	.02 A	.83 .79
Government	A	A	.72	A	.28
New Commercial Construction (Sq.Ft)					
Retail - Wholesale	.17	A	.04	.14	.82
Office Buildings	10.98	A	.09	.84	.07
Auto Repair	4.21	A	.05	.49	.46
Warehouses	.23	A	.22	.40	.38
Education	.74	A	.04	.14	.82
Health	.39	A	.05	.41	.54
Public	1.03	A	.01	.21	.78
Religious	.12	A	.17	.27	.55
Hotel - Motel	7.27	A	.17	.77	.16
Miscellaneous	.13	A	.05	.12	.83
Commercial Construction (Sq.Ft) Additions and Alterations					
Retail - Wholesale	11.94	A	.14	.78	.08
Office Buildings	14.78	A	A	.01	.99
Auto Repair	.41	A	A	.54	.45
Warehouses	7.79	A	.09	.58	.34
Education	.98	A	.08	.26	.67
Health	4.30	A	.14	.09	.77
Public	1.11	A	.11	.34	.55
Religious	1.05	A	.22	.30	.48
Hotel - Motel	4.98	A	.43	.57	A
Miscellaneous	13.07	A	.05	.16	.79
Residential Construction (Sq.Ft):					
Apartments					
Five or More Units					
1-3 Stories	.40	A	.11	.42	.47
4 or More Stories	1.84	A	.01	.70	.29
Three to Four Units					
Single Family Detached	.19	A	A	.07	.92
Duplexes	.01	A	.06	.04	.91
	.08	A	A	.10	.90

TABLE 5.1. (cont.)

	Relative Change M.S.E.	<u>U</u> ₁	<u>U</u> _M	<u>U</u> _R	<u>U</u> _D
Wages: (Annual 000 1972 \$)					
Agricultural	.03	.02	.02	.11	.87
Agricultural Services	.01	.01	.17	A	.83
Mining	.07	.03	.63	.17	.20
Construction	A	A	.67	A	.33
Nondurable Manufacturing	A	A	.62	.06	.32
Durable Manufacturing	A	A	.64	.03	.33
Public Utilities	A	A	.10	.03	.87
Wholesale Trade	A	A	.27	.23	.50
Retail Trade	A	A	.04	.10	.87
Finance - Insurance - Real Estate Services	A	A	.19	.11	.70
Government	A	.01	.51	.18	.31
Personal Income (000 1972 \$)					
Wage Bill	A	A	.31	.09	.60
Property Income	A	A	A	.32	.68
Transfer Payments	A	A	.53	.04	.43
Residence Adjustment	4.94	A	.09	.02	.89
Social Insurance Adjustment	A	A	.07	.17	.76
Per Capita Income	A	A	.14	.31	.55
Total Personal Income	A	A	.11	.25	.64
Demographics					
Population	A	A	.68	.18	.14
Births	A	A	.03	.53	.44
Deaths	A	A	.05	.09	.86
Migration	.10	A	.30	.34	.36

1. Relative Change M.S.E. defined as

$$MSE_2 = \frac{1}{n} \sum_{t=1}^n (p_t - a_t)^2$$

with $p_t = (P_t - A_t)/A_t$, $a_t = (A_t - A_{t-1})/A_{t-1}$. U_1, U_M, U_R, U_D
as defined in text, using MSE_2 definitions.

2. "A" denotes a value less than 0.004.

FIGURE 5.1. Total Employment 1970-1976
PORTLAND, OREGON SMSA

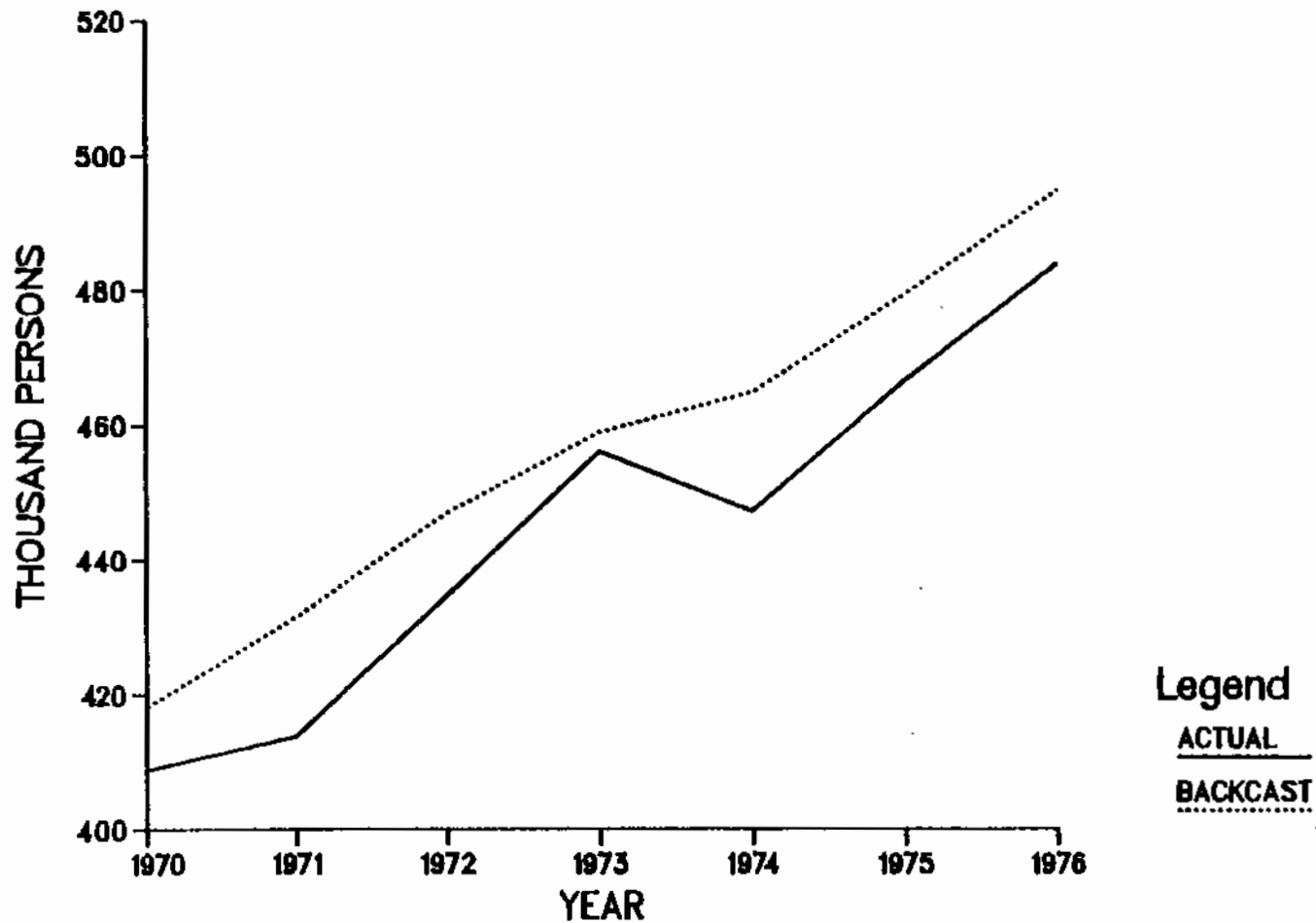
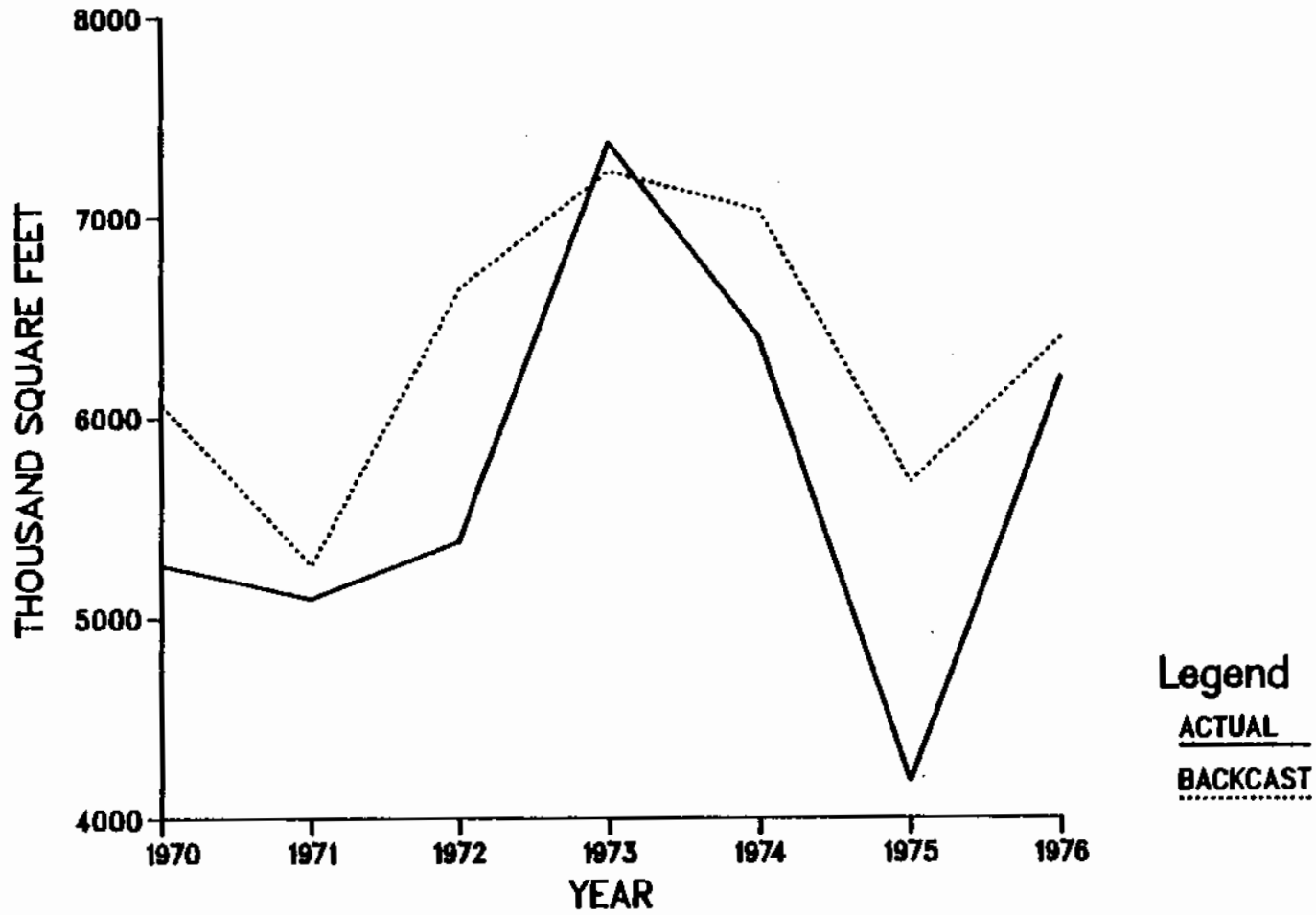


FIGURE 5.2. New Commercial Construction 1970-1976
PORTLAND, OREGON SMSA



Legend
ACTUAL
BACKCAST

FIGURE 5.3. Commercial Construction 1970-1976
Additions and Alterations
PORTLAND, OREGON SMSA

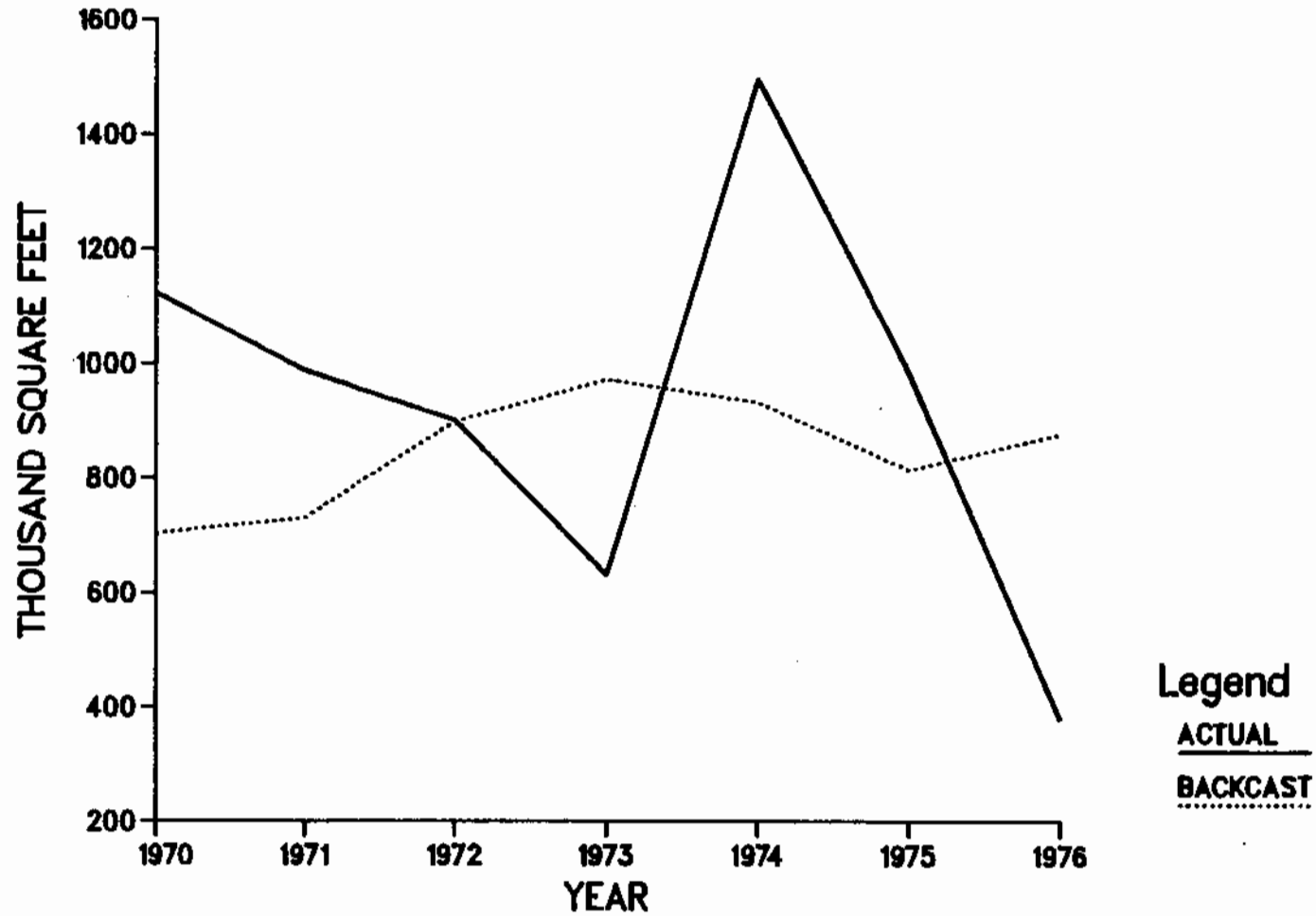


FIGURE 5.4. Residential Construction 1970-1976
PORTLAND, OREGON SMSA

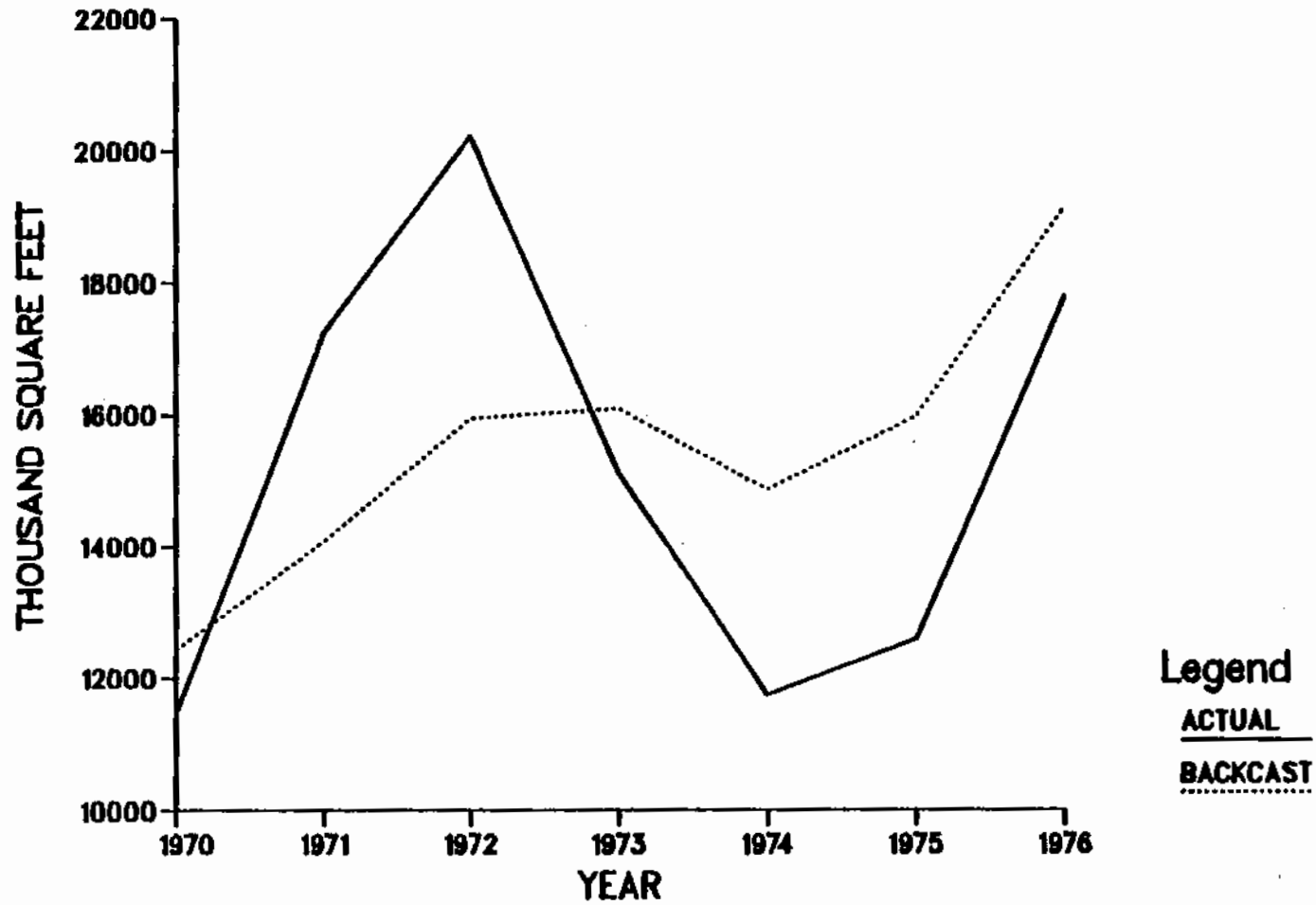


FIGURE 5.5.

Personal Income 1970-1976 PORTLAND, OREGON SMSA

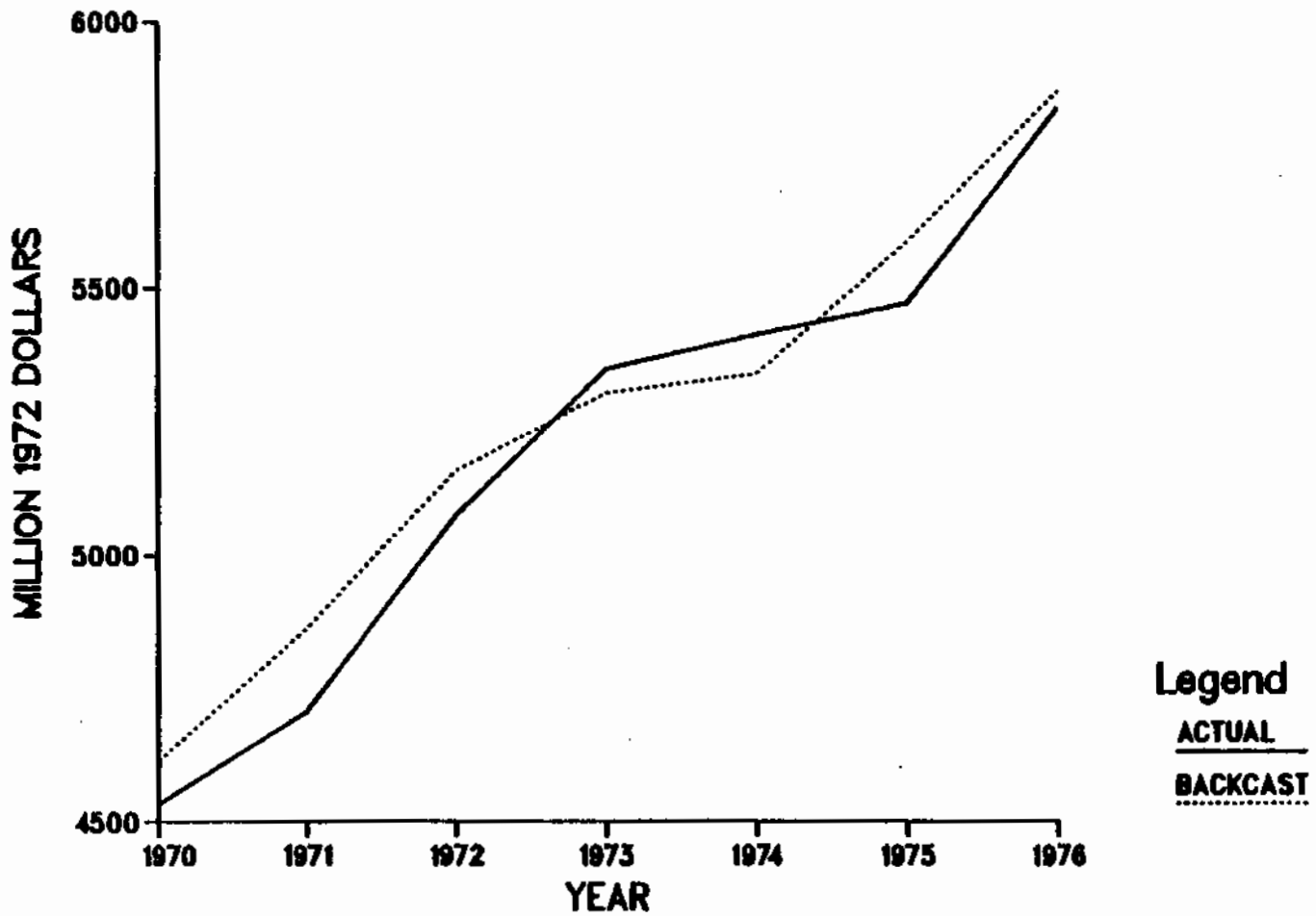


FIGURE 5.6.

Population 1970-1976 PORTLAND, OREGON SMSA

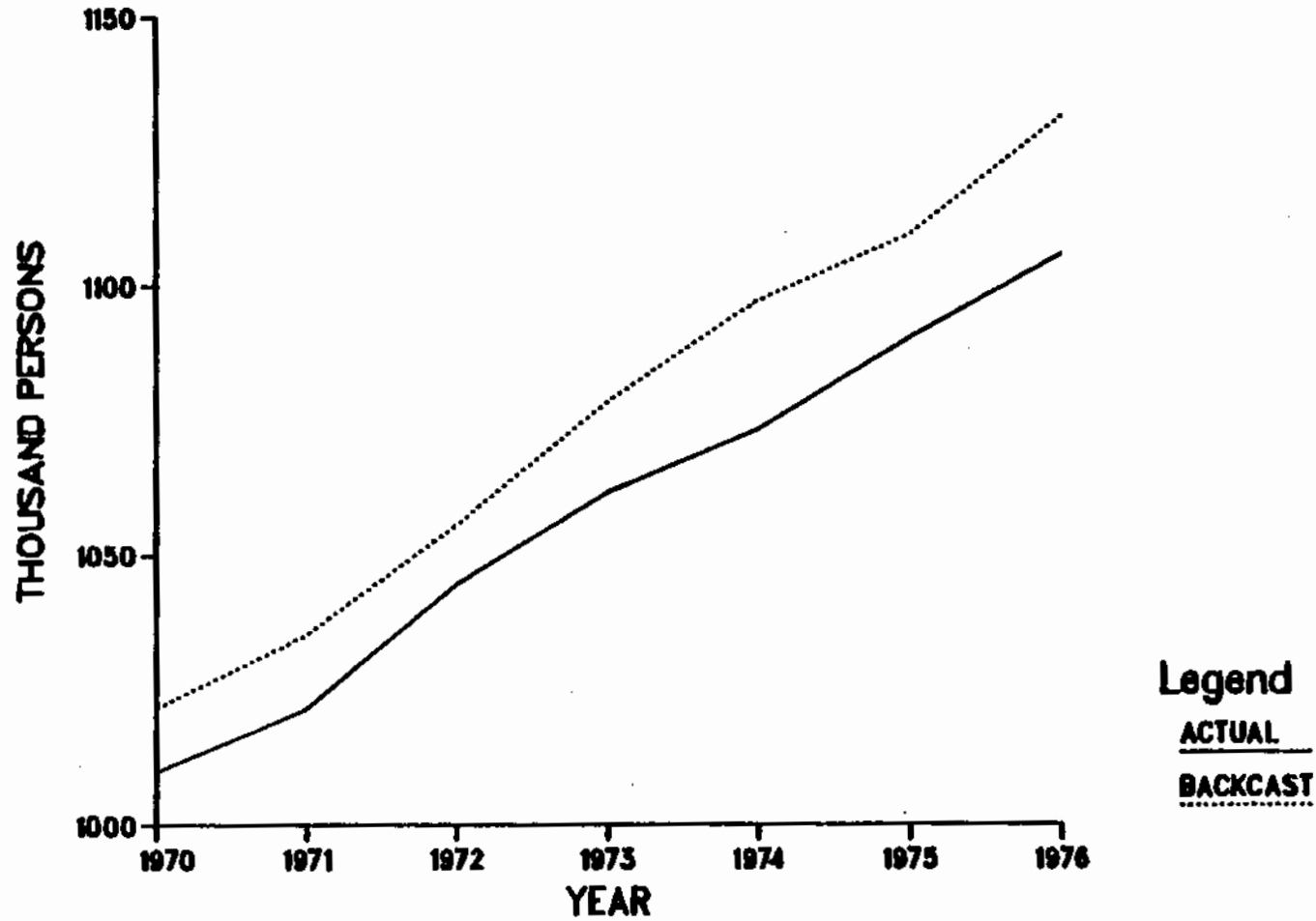


TABLE 5.2. Census Division Goodness-of-Fit (R^2) Statistics For Stochastic Equations

	Division								
	One	Two	Three	Four	Five	Six	Seven	Eight	Nine
Employment:(Persons)									
Agricultural	.10	.19	.23	.15	.08	.20	.21	.13	.09
Agricultural Services	.06	.22	.18	.14	.06	.12	.28	.09	.04
Mining	.01	.02	.05	.02	.03	.08	.09	.07	.01
Construction	.12	.11	.22	.01	.32	.38	.15	.25	.02
Non-durable Manufacturing	.43	.31	.31	.08	.21	.14	.12	.25	.01
Durable Manufacturing	.40	.37	.44	.06	.13	.37	.17	.36	.02
Wholesale Trade	.04	.11	.34	.39	.31	.31	.15	.26	.15
Retail Trade	.42	.62	.38	.21	.30	.36	.19	.53	.01
Finance - Insurance - Real Estate Services	.09	.15	.29	.11	.24	.20	.09	.18	.02
	.14	.09	.14	.12	.18	.12	.21	.28	.02
New Commercial Construction (Sq.Ft)									
Retail - Wholesale	.65	.69	.88	.47	.83	.84	.75	.43	.72
Office Buildings	.77	.84	.76	.63	.81	.72	.84	.43	.70
Auto Repair	.57	.55	.68	.38	.34	.77	.72	.30	.60
Warehouses	.68	.64	.85	.41	.75	.89	.90	.61	.76
Education	.63	.83	.40	.44	.66	.53	.76	.65	.75
Health	.34	.82	.18	.49	.29	.64	.57	.45	.60
Public	.46	.36	.14	.27	.40	.22	.42	.24	.55
Religious	.47	.70	.57	.67	.80	.75	.80	.53	.78
Hotel - Motel	.57	.62	.61	.45	.30	.60	.27	.36	.42
Miscellaneous	.81	.81	.88	.64	.76	.75	.58	.53	.80
Commercial Construction (Sq.Ft)									
Additions and Alterations									
Retail - Wholesale	.71	.48	.74	.29	.45	.74	.50	.28	.40
Office Buildings	.67	.48	.75	.34	.52	.71	.53	.35	.61
Auto Repair	.21	.80	.27	.38	.16	.63	.32	.28	.34
Warehouses	.60	.35	.78	.45	.44	.82	.72	.34	.61
Education	.57	.63	.46	.53	.53	.20	.76	.72	.69
Health	.51	.47	.06	.37	.10	.59	.32	.36	.52
Public	.25	.39	.09	.42	.18	.25	.22	.09	.28
Religious	.36	.35	.67	.60	.39	.51	.72	.59	.67
Hotel - Motel	.15	.68	.39	.38	.40	.22	.18	.19	.28
Miscellaneous	.44	.31	.68	.39	.58	.43	.40	.50	.56

TABLE 5.2. (cont.)

	<u>Division</u>								
	<u>One</u>	<u>Two</u>	<u>Three</u>	<u>Four</u>	<u>Five</u>	<u>Six</u>	<u>Seven</u>	<u>Eight</u>	<u>Nine</u>
Residential Construction (Sq.Ft):									
Apartments									
Five or More Units									
1-3 Stories	.81	.64	.86	.76	.75	.89	.83	.64	.71
4 or More Stories	.80	.84	.80	.45	.79	.70	.20	.28	.64
Three to Four Units	.40	.31	.72	.62	.65	.77	.35	.22	.53
Single Family Detached	.96	.95	.95	.95	.90	.90	.95	.95	.94
Duplexes	.62	.95	.67	.79	.54	.62	.64	.52	.63
Wages: (Annual 000 1972 \$)									
Agricultural	.15	.34	.08	.24	.14	.17	.20	.28	.13
Agricultural Services	.45	.24	.25	.16	.10	.21	.23	.24	.26
Mining	.33	.35	.27	.22	.13	.16	.43	.23	.27
Construction	.09	.09	.29	.19	.20	.42	.20	.25	.08
Nondurable Manufacturing	.54	.73	.47	.41	.43	.40	.64	.65	.38
Durable Manufacturing	.67	.59	.48	.45	.51	.48	.52	.63	.41
Public Utilities	.41	.58	.59	.49	.71	.72	.42	.68	.57
Wholesale Trade	.29	.41	.36	.40	.21	.29	.53	.42	.31
Retail Trade	.23	.34	.51	.29	.25	.40	.51	.48	.35
Finance - Insurance - Real Estate	.60	.73	.80	.70	.67	.83	.70	.78	.50
Services	.19	.14	.45	.51	.37	.52	.36	.49	.26
Personal Income (000 1972 \$)									
Property Income	.41	.24	.41	.24	.32	.62	.45	.39	.35
Transfer Payments	.84	.85	.76	.69	.72	.80	.58	.75	.63
Residence Adjustment	.01	.31	.36	.44	.11	.59	.60	.40	.14
Social Insurance Adjustment	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Demographics									
Births	.98	1.00	1.00	.99	.99	.99	.99	1.00	.98
Deaths	1.00	1.00	1.00	.99	.99	.99	1.00	1.00	1.00
Migration	.01	.43	.19	A	.67	.33	.56	.72	.34
Number of Cross-Sections	20	34	59	29	25	28	44	24	53

TABLE 5.3. Theil Backcast Statistics For Census Division Six

	\underline{U}_1^1	\underline{U}_M	\underline{U}_R	\underline{U}_D
Employment: (Persons) ²				
Agricultural	.72	.03	.02	.96
Agricultural Services	.55	.02	.15	.83
Mining	.91	A	.01	.99
Construction	1.32	.01	.24	.75
Nondurable Manufacturing	1.24	A	.21	.79
Durable Manufacturing	1.03	A	.04	.96
Wholesale Trade	.95	A	.18	.82
Retail Trade	.50	.03	.31	.67
Finance - Insurance - Real Estate	.40	A	.01	.99
Services	.51	.01	.10	.88
New Commercial Construction (Sq.Ft)				
Retail - Wholesale	1.83	.01	.45	.54
Office Buildings	1.27	.01	.23	.76
Auto Repair	.88	A	A	1.00
Warehouses	.75	A	.01	.99
Education	1.57	A	.51	.49
Health	1.60	A	.46	.54
Public	4.18	A	.76	.24
Religious	1.25	A	.21	.79
Hotel - Motel	.93	A	.01	.99
Miscellaneous	1.40	A	.35	.65
Commercial Construction (Sq.Ft)				
Additions and Alterations				
Retail - Wholesale	.90	A	A	1.00
Office Buildings	1.20	A	.17	.83
Auto Repair	1.10	.01	.11	.89
Warehouses	1.00	A	A	1.00
Education	1.97	A	.50	.50
Health	1.05	.01	.05	.94
Public	1.02	A	.03	.97
Religious	2.00	A	.50	.50
Hotel - Motel	.97	A	.01	.99
Miscellaneous	1.06	A	.10	.90
Residential Construction (Sq.Ft):				
Apartments				
Five or More Units				
1-3 Stories	.91	.01	A	.98
4 or More Stories	.99	.01	A	.99
Three to Four Units	.90	A	A	.99
Single Family Detached	.68	A	.02	.98
Duplexes	1.11	A	.11	.89

TABLE 5.3. (cont.)

	\underline{U}_1	\underline{U}_M	\underline{U}_R	\underline{U}_D
Wages: (Annual 000 1972 \$)				
Agricultural	1.03	A	.06	.94
Agricultural Services	.81	.01	A	.99
Mining	.73	.01	A	.99
Construction	.19	.01	A	.98
Nondurable Manufacturing	.19	A	A	1.00
Durable Manufacturing	.17	A	A	.99
Public Utilities	.04	A	.01	.99
Wholesale Trade	.30	.02	.11	.88
Retail Trade	.09	.14	.05	.81
Finance - Insurance - Real Estate	.14	A	.03	.97
Services	.10	.05	A	.95
Personal Income (000 1972 \$)				
Property Income	.02	A	.06	.94
Transfer Payments	.02	A	A	1.00
Residence Adjustment	.61	A	.09	.91
Social Insurance Adjustment	.38	A	.10	.90
Demographics				
Births	.99	A	A	.99
Deaths	.98	A	.01	.99
Migration	3.57	A	.72	.27
Number of Cross-Sections	28			

1. \underline{U}_1 , \underline{U}_M , \underline{U}_R , and \underline{U}_D based on MSE_1 definition of mean square error:

$$MSE = \frac{1}{q} \frac{1}{n} \sum_{j=1}^q \sum_{t=1}^n (p_{jt} - a_{jt})^2$$

with $p_{jt} = P_{jt} - A_{jt-1}$, $a_{jt} = A_{jt} - A_{jt-1}$, j denotes cross-section, t denotes time. \underline{U}_1 then is defined as

$$\underline{U}_1 = \frac{MSE}{MAC} \quad \text{with} \quad MAC = \frac{1}{q} \frac{1}{n} \sum_{j=1}^q \sum_{t=1}^n A_{jt}^2 - A_{jt-1}^2$$

2. "A" denotes value less than 0.004.

FIGURE 5.7. Total Employment 1970-1976
CENSUS DIVISION SIX

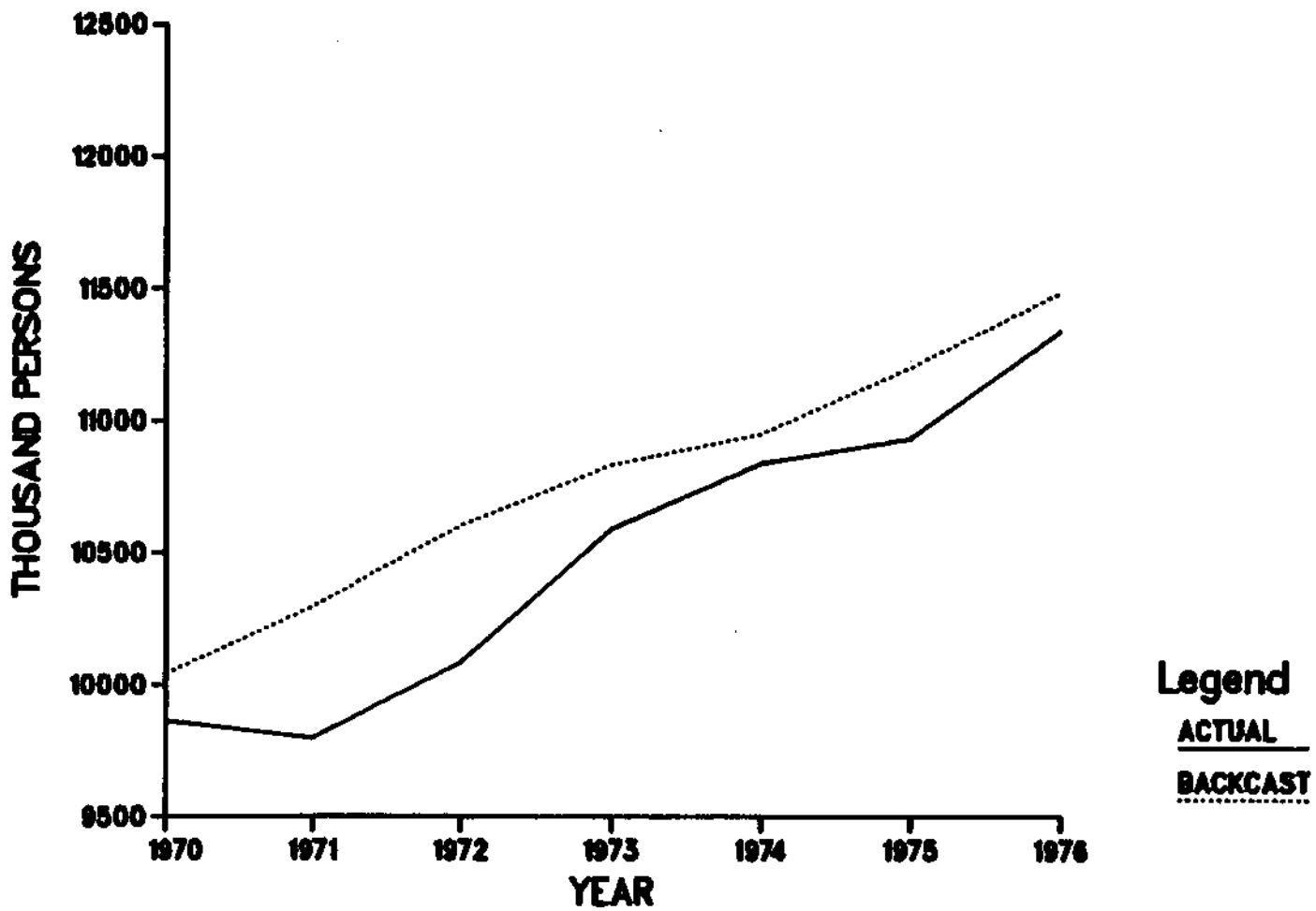
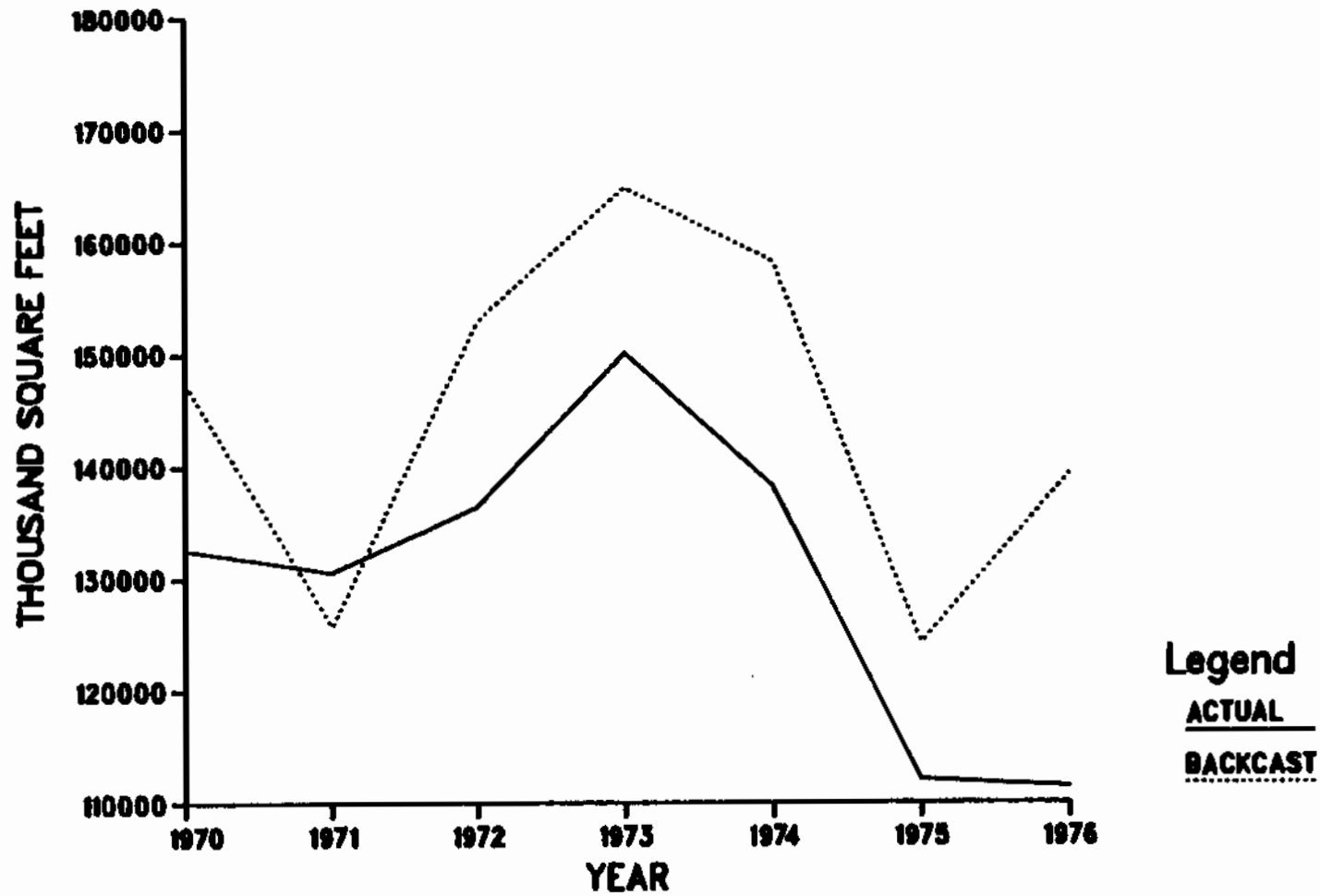


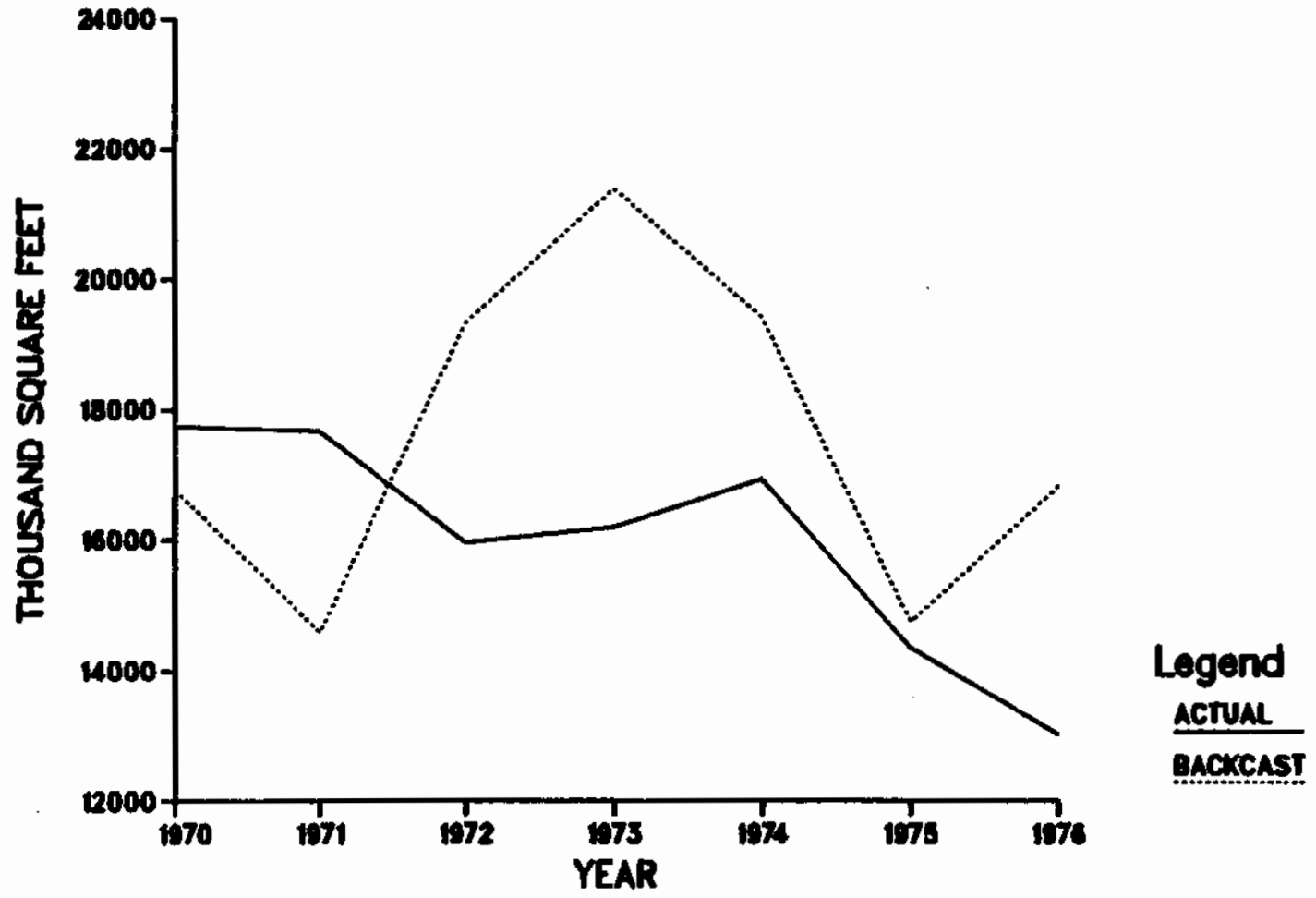
FIGURE 5.8. **New Commercial Construction 1970–1976**
CENSUS DIVISION SIX



5.18

FIGURE 5.9.

Commercial Construction 1970-1976 Additions and Alterations CENSUS DIVISION SIX



Legend
ACTUAL
BACKCAST

FIGURE 5.10.

Residential Construction 1970-1976 CENSUS DIVISION SIX

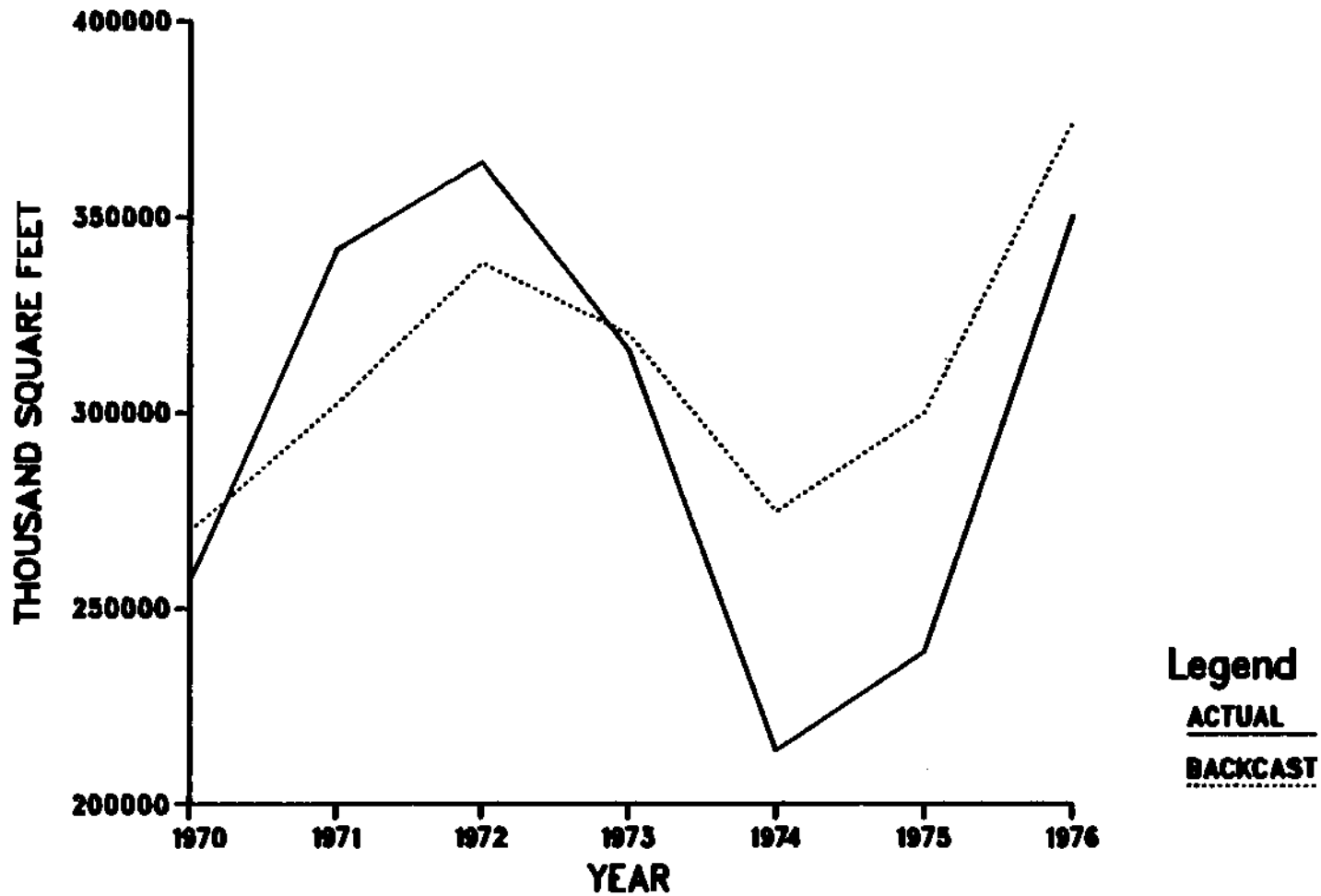


FIGURE 5.11.

Personal Income 1970-1976 CENSUS DIVISION SIX

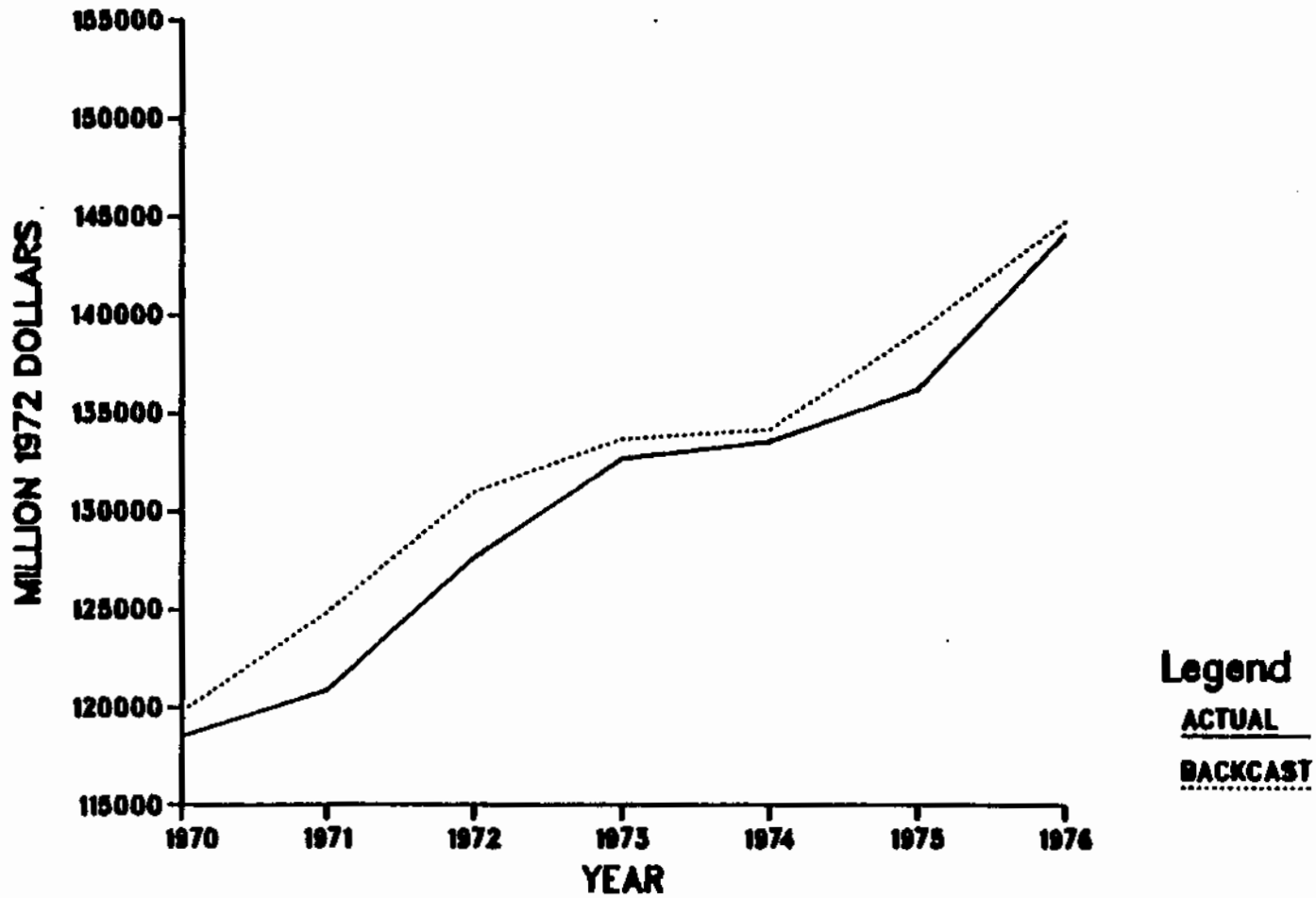
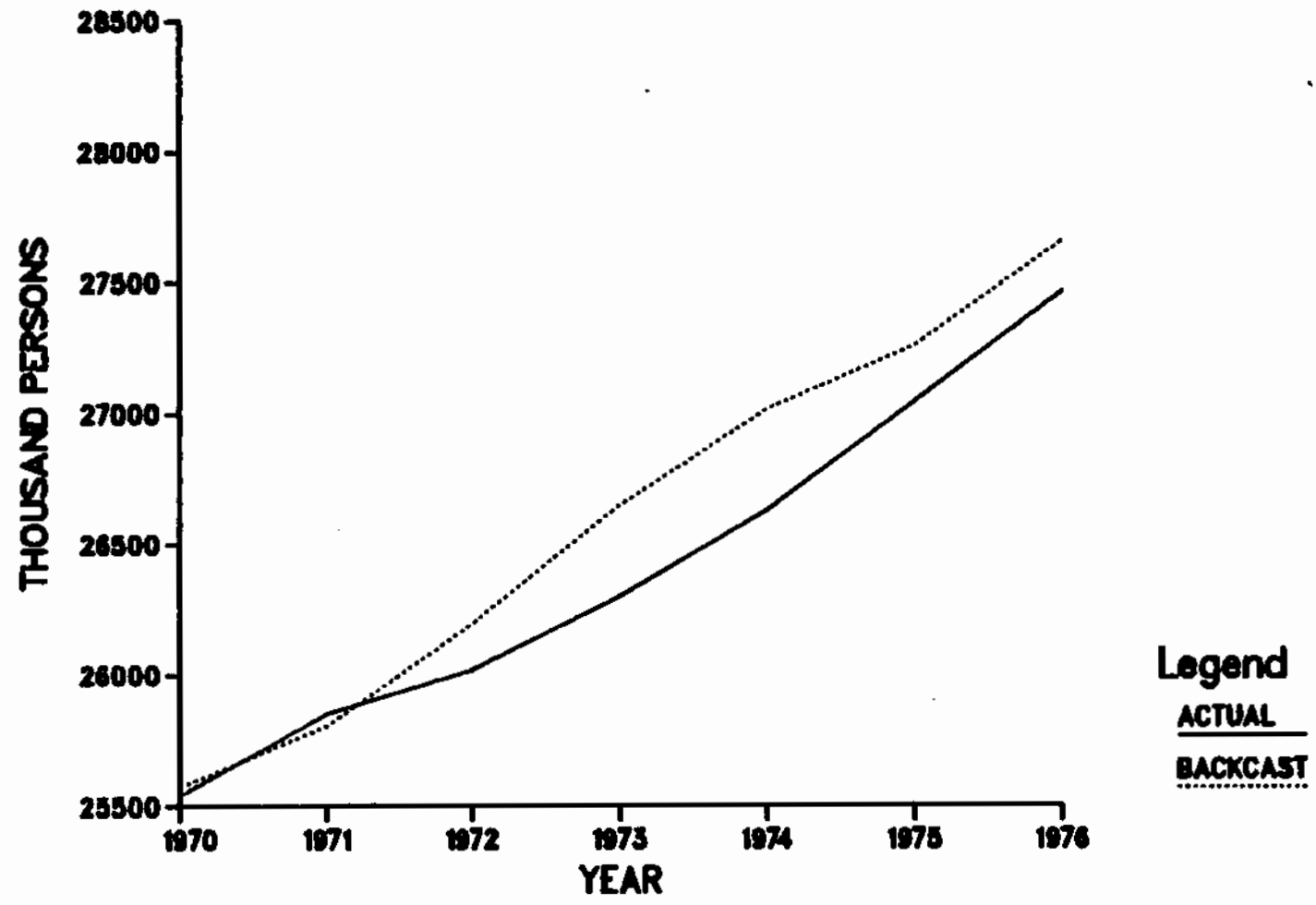


FIGURE 5.12. Population 1970-1976
CENSUS DIVISION SIX



quite well for SMSA/ROSAs which historically experienced "average" growth. Statistics and graphs for the Census Division backcasts would tend to support this view. First, the Census Division predicted totals did not deviate far from the Division actual totals. This indicates that the model predicts well for most large and medium-sized SMSA/ROSAs; if it did not, the predicted region totals would be quite different than the actual totals. Second, most of the Theil coefficients calculated for all of the SMSA/ROSAs in a Division lie significantly below 1.1; thus, it would appear that in most SMSA/ROSAs the model predicts significantly better than a naive model.

5.2 FORECAST VALIDATION TESTS

The forecast validation tests involved simulating the MASTER model for the years 1976 to 1980, a time period outside of the estimation period for which actual values of variables forecast by the model are known. A number of comparisons were done between forecasts and actual values of endogenous variables for this period. Forecasts were done for Albany, New York; Akron, Ohio; Portland, Oregon; and Orlando, Florida for the years 1976 to 1980. Because only five observations were reported for each variable in only four regions, Theil statistics would have been misleading and are not reported. The MAPE (mean absolute percent error) statistics are reported but must be used advisedly because of the very short time period involved in the historic forecast. Table 5.4 illustrates the forecast validation results for Akron, Ohio. These results are typical of the results for the other 3 SMSAs.

5.3 SENSITIVITY TESTS

Four types of sensitivity tests were carried out on Albany, New York; Akron, Ohio; Portland, Oregon; and Orlando, Florida. These tests involved producing a forecast base case for each SMSA and then changing an exogenous input to produce an alternative forecast. The sign and magnitude of the differences between the two forecasts were then checked for consistency. The four tests were: increased national output, increased regional government employment, higher energy prices, and lower interest rates.

TABLE 5.4. Comparison of MASTER Forecasts to Actual Data, 1976-1980

Akron, Ohio			
Variable and Sector	Mean Absolute Percent Error of Forecast (MAPE)	No. of Actual Turning Points	Correct Turning Points in Forecast
Total Employment	3.88	1	0
Wage Bill	4.51	1	1
Total Personal Income	3.27	1	1
Total Population	1.58	1	0
<u>Construction</u>			
Residential	25.10	1	1
New Commercial	28.58	1	1
Commercial Additions and Alterations	15.93	1	0

In general, the sensitivity tests results were of correct sign and reasonable magnitude. The tests did uncover some weaknesses in the model equations, which were corrected. Table 5.5 shows the results of the government employment increase sensitivity tests. In all cases, economic activity was significantly increased. Increased national output generally caused regional economic activity to increase significantly. Increased energy prices generally reduced regional economic activity as industries moved to lower production cost regions. Lower interest rates caused a rapid rise in construction activity.

TABLE 5.5. Impact of a One-Time Permanent
20% Increase in Government Activity
Starting in 1983
(Multiplier)^(a)

Area and Variable	1985	1990	1995	2000
1. Albany, New York:				
Total Employment	1.501	1.364	1.345	1.332
Total Income ^(b)	2.109	1.811	1.740	1.688
Residential Construction ^(c)	47.74	2.894	1.426	1.241
Commercial Construction ^(c)	17.82	4.281	4.426	4.622
2. Akron, Ohio:				
Total Employment	1.416	1.362	1.345	1.336
Total Income ^(b)	1.736	1.603	1.537	1.482
Residential Construction ^(c)	72.158	25.833	20.057	18.784
Commercial Construction ^(c)	62.990	9.657	9.904	10.195
3. Portland, Oregon:				
Total Employment	1.699	1.585	1.551	1.538
Total Income ^(b)	2.267	2.018	1.918	1.858
Residential Construction ^(c)	139.501	43.476	28.711	25.753
Commercial Construction ^(c)	64.965	24.834	22.280	23.123
4. Orlando, Florida:				
Total Employment	2.165	1.953	1.807	1.716
Total Income ^(b)	2.781	2.438	2.213	2.058
Residential Construction ^(c)	35.916	38.488	34.968	31.461
Commercial Construction ^(c)	15.444	27.362	25.343	23.125

(a) For employment, this is an employment impact multiplier in 1981 and a transitory multiplier for other years.

In both cases, it is computed

$$M_{jt} = \frac{L_{jt} \text{ (impact_case)} - L_{jt} \text{ (base case)}}{L_{gt} \text{ impact case)} - L_{gt} \text{ (base case)}}$$

Where

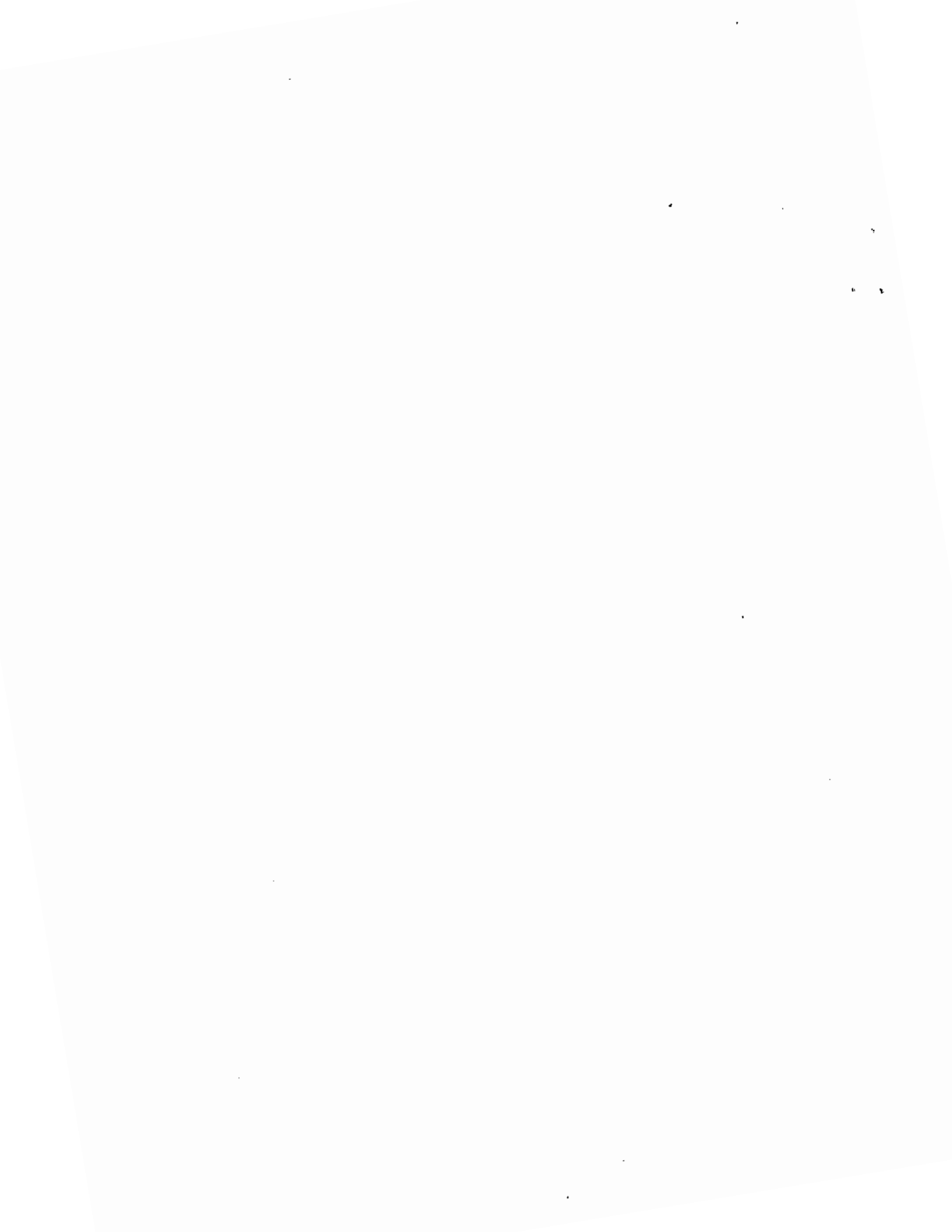
j = sector (g = government)

t = year

L = employment

(b) For income, the definition is similar, but government employment is multiplied times government wage to estimate an income multiplier.

(c) For construction, the difference between impact and base cases for construction is measured in square feet, divided by the government employment change.



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