DYNAMIC INTERACTIONS BETWEEN ELECTRICITY PRICES AND THE REGIONAL ECONOMY

A Thesis

by

DANIEL NAVEEN BETHAPUDI

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

May 2005

Major Subject: Agricultural Economics

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Approved as to style and content by:

David Bessler (Chair of Committee)	Dennis U. Fisher (Member)
Michael Pustay (Member)	John P. Nichols (Interim Head of Department)

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ABSTRACT

Dynamic Interactions between Electricity Prices and the Regional Economy.

(May 2005)

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In this thesis we study characterize the dynamic relationships among two electricity price variables (residential and commercial) and six regional economic variables in order to examine each individual variable's role in regional economic activity. We also answer the question "Do electricity prices have impact on regional economic variables?"
We use two statistical techniques as engines of analysis. First, we use directed acyclic graphs to discover how surprises (innovations) in prices from each variable are communicated to other variables in contemporaneous time. Second, we use time series methods to capture regularities in time lags among the series.

Yearly time series data on two electricity prices and six regional economic variables for Montgomery County (Texas) are studied using time series methods. Directed Acyclic Graphs (DAGs) are used to impose restrictions on the Vector Auto Regression model (VAR). Using Innovation Accounting Analysis of the estimated Vector Auto Regression (VAR) model we unravel the dynamic relationships between the eight variables. We conclude that rising electricity prices have a negative impact on all

regional economic variables. The commercial average electricity prices lead residential average electricity prices in the time frame we studied (1969-2000). Rising residential electricity prices also have a positive impact on income derived from transfer payments.

Dedicated to my parents who have always been there for me.

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Above all I would like to thank the Almighty God for being ever so graceful to me.

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CHAPTER I

INTRODUCTION

1.1 Problem Statement and Justification

In the history of economic thought there have been several cases where basic commodity prices have been found as fundamental or bedrock upon which economy-wide economic development depends. Rostow (1978) argues that nineteenth century economic development of the North American Continent depended on the new and highly productive agricultural land opened up in the Great Plains. Higher wheat production, in particular, led to lower wheat prices, which in turn spurred or supported greater economic development over the entire continent. More recently Hamilton (1985) shows that oil price shocks had a negative effect on the US economy in the 1970s. Price shocks following the first and second oil embargos lead to a slow-down in economic activity in the US.

1.2 Objectives

In the light of these earlier studies, in this thesis we try to see if the electricity prices have an impact on the regional economic activity. The argument considered here is that electricity and its price are fundamental to growth in local economies. Just how shocks in electricity prices affect various regional economic variables will be sorted out using modern econometric methods.

This thesis follows the style and format of the *American Journal of Agricultural Economics.*

The objective of this study is to characterize the dynamic relationships among two electricity price variables (residential and commercial) and six regional economic variables in order to examine each individual variable's role in regional economic activity. The above objective is inspired by the study done by the Committee on Electricity and Economic Growth, National Research Council (1986). As part of their study they found that the historic trends in the electricity use- GNP relationship include the effects of a host of factor like prices of electricity and competing energy forms, the composition of national output, regional economic activity, technical change etc. The committee also found out that only when there are major perturbations in the trends of the above factors the basic electricity – GNP relationship changes. The figure 1.1, developed by the Committee, identifies the relationship between electricity and economy.

The following are the conclusions of the Committee on Electricity and Economic Growth, National Research Council (1986), which are relevant to this study:

1. Electricity use and gross national product have been and probably will continue to be strongly correlated.
2. Electricity prices and alternative fuel prices affect electricity consumption in two ways: first they directly affect the use of electricity and non electric fuels as input factors of production; second, they indirectly affect productivity growth and thereby economic growth.

The committee recommends further research in order to identify and quantify the forces affecting the relationships between electricity and economic growth in view of their critical importance, complexity and regional diversity. With the recent advances in the field of econometrics it is possible to study the energy price – economic activity relationship on a contemporaneous scale. Such a study will not only offer better insights into the relationship but also provides a better understanding of how price innovations in one variable affect other variables and their interactions. This study makes an effort to answer the following question:

Do electricity prices have impact on regional economic variables?

To this end this study presents empirical findings on the contemporaneous and short run interdependencies using a vector auto regression model, causal flow based on directed acyclic graph method and innovation accounting analysis.

1.3 Organization of the Thesis

This thesis is organized as follows: A critical review of selected previous studies in the fields of regional economic modeling and energy- economy linkages in presented in chapter II. Methodology, model specification, data and results are presented in chapter III. A discussion of results and suggestions for their applications are given in chapter IV.

CHAPTER II

LITERATURE REVIEW

In this chapter earlier studies which have dealt with concepts and issues relevant to our study are presented. This chapter is divided into four sections. In the first section economic activity issues are discussed. In the second section the regional economic modeling issues are discussed. In the third section the energy-economy link is discussed and in the fourth section the link between electricity and economy is discussed.

2.1 Economic Activity

In this section literature exploring measures of economic activity, factors affecting the economic activity are discussed. First we start with measures of income and try to identify the measure of income that is more relevant to our study. Next we look at theories /models that explain how different factors affect economic activity. This is followed by models that focus on measuring the economic activity.

Measures of Income

At the national level Gross Domestic Product (GDP) is often considered the best measure of how well the economy is performing. GDP measures the total income of everyone in the economy and the total expenditure on the economy’s output of goods and service. These two items should be equal as every transaction has two sides – a buyer and seller (Mankiw, 1986).

Gross National Product (GNP) is total income earned by nationals. It includes the income that nationals earn abroad but does not include the income earned within a country by foreigners (Mankiw, 1986).

Net National Product (NNP) = GNP – Depreciation.

National Income = NNP – Indirect Business Taxes.

The national income accounts divide national income into five categories depending on the way the income is earned. The five categories are:

1. Compensation of employees: the wages and fringe benefits earned by workers
2. Proprietor's Income: The income of non corporate businesses such as small firms, mom and pop stores etc.
3. Rental Income: The income that land owners receive including the imputed rent that homeowners pay to themselves, less expenses such as depreciation.
4. Corporate Profits: The income of corporations such after payments to their workers and creditors.
5. Net Interest: The interest domestic businesses pay minus the interest they receive plus interest earned from foreigners.

A series of adjustments takes from national income to personal income. It is the amount of income that households and non corporate businesses receive.

Personal Income = National Income – (Corporate Profits + Social Insurance Contributions + Net Interest) + Dividends + Personal Interest Income + Government transfers to individuals (Mankiw, 1986).

Since the focus of our study is regional economic activity, we are trying to focus on that component of measures of income that stems from a regional level and that is personal income.

Now we look at theories /models that explain as to how different factors affect economic activity.

Solow Growth Model

The Solow growth model, which is based on the Neo-classical growth model, shows how savings, population growth and technological progress affect the growth of output over time. It shows that the saving rate is a key determinant of the steady state capital stock. If the saving rate is high the economy will have a large capital stock and a high level of output. However it also shows that capital accumulation by itself cannot explain sustained economic growth. High rates of saving leads to high growth temporarily but the economy eventually approaches a steady state in which capital and output are constant. To explain sustained economic growth the Solow model incorporates two more sources of economic growth: population and technological progress. Population growth results in an additional increase in the number of workers. This growth in the number of workers causes capital per worker to fall. However the overall impact of population growth on economic growth depends on the positive effects of investment on capital stock per worker and the negative effects of depreciation. The Solow model shows that only technological progress can have a positive impact on economic growth by affecting the rate of growth of output per worker (Mankiw 1986).

Total Factor Productivity and Economic Activity

According to the Neo-classical model economic growth occurs because the supply of labor and capital expands and the productivity of these factors increases over time. This relatively simple production function view of the economy has provided an extraordinarily rich basis for theoretical analyses and empirical investigation of the determinants of economic growth (Mankiw 1986).

The traditional production function in which labor and capital are the major factors of production when applied to actual data describing changes over time or differences among countries it is discovered that only part of the changed quantity of output can be accounted for by changes in the weighted sum of the inputs. The change in the output that is not explained by the change in inputs is productivity improvement in the combination of production factor inputs. Since this measure does not distinguish labor productivity from capital productivity it has come to be called Total Factor Productivity.

The determinants of total factor productivity can be grouped into two sets of characters:

1. The technical characters of the production process
2. The movement of the relative prices for the factors of production.

The technical characters refer to a number of issues (Mankiw 1986):

- Whether the application of better production techniques will reduce the cost of all factors of production.
- Whether new techniques will lead to a greater saving in one input than another.
- The difficulties or ease of exchanging factors of production in the course of the production process.

- The economies or diseconomies that arise in the course of changes in the scale of economy's operation.
- Whether the returns of scale are evenly distributed among all factors of production.

The relative price movements influence factor productivity through their effects between capital and labor. For example if there is a relative increase in wage rates there would be a substitution of capital for labor and technological innovations would seek to concentrate on labor saving devices. The impact of relative price changes will depend on the possibilities of substitution between capital and labor. If the substitution possibilities are good the changes in relative prices will have substantial effects on the factor productivity but if there are few substitution possibilities between labor and capital even major relative price changes will have little effect (Mankiw 1986).

Using the aggregate production function economic growth can be quantitatively related to changes in the quantity of the factors of production, changes in the quality of these factors, exogenously determined technical progress, technical characters of the production process and relative price movements among the production factors (Mankiw 1986).

Growth Accounting

The concepts of growth accounting and the related discussion presented in this section are drawn heavily from *Energy Connections: Between Energy and the Economy* by Sidney Sonenblum (1978).

Another approach to quantifying the various sources of economic growth is Growth Accounting. In growth accounting the observed rate of growth in output between two dates is separated into component growth rates indicating the contribution to overall growth made by specific determinants (Sonenblum, 1978).

As per Sonenblum the estimating procedure in growth accounting depends on measuring the growth trends in total output and in each of the determinants of output. Comparing growth rates over a particular time span quantifies how much the change in each determinant contributed to the change in total output.

The many specific determinants of growth are consolidated by Sonenblum (1978) into two broad groups:

1. The total factor input group. The quantity and quality of labor inputs, capital inputs and natural resources together account for the total factor input group.
2. The total factor productivity group. The state of technology and the way it changes, the scale of the economy and the resource allocation efficiency of markets including legal and psychological attributes of economic life.

Edward Denison (1974), the inventor of growth accounting examined the economic growth of the US between 1948 and 1969. He found that about half of this growth could be attributed to increases in total factor input while the other half comes from improved total factor productivity. The increases in total factor input were (Denison, 1974):

1. More labor

2. More capital
3. More natural resources

The raised factor productivity according to (Denison, 1974):

1. Advancing state of technology
2. Increasing scale economies
3. Improving resource allocation.

More Labor: The standard model says that population affects economic growth through its impact on changes in the quantity and quality of the labor input. Over the long run the size of the labor force is determined primarily by the changes in the size and composition of the population, which in turn are the result of demographic and not economic factors. Also the quality of the labor force is theoretically determined by the extent of investment in human capital primarily through education and health investments but also improved efficiency through reduced discrimination and other job barriers. Potentially economic growth can alter the size of the labor force through its effect on fertility, mortality and labor participation rates. Long run effects of economic growth on labor participation are uncertain because there are two opposing forces at work. On the one hand economic growth furnishes opportunities to engage in work that wouldn't otherwise be available. On the other hand economic growth provides rising incomes which lowers the propensity to engage in remunerative activities. (Denison, 1974; Sonenblum, 1978).

More Capital Stock: For long term issues of economic growth the amounts society decides to invest and consume are of critical importance. There are two views on the share of investment in total output. The optimistic view is that with more investment now next year the economy will be able to produce more output. The pessimistic view is that if an economy is unable to employ its people and resources fully now then high investment merely means that next year will bring still more unemployment. Both these views may be correct depending on circumstances (Denison, 1974; Sonenblum, 1978). The rate of investment is a key indicator as it highly correlates with the rapid post war growth in output. The high rates of investment lead to increases in the capital stock which in turn produced growth in potential output. Added capital stock affects output by (Denison, 1974; Sonenblum, 1978):

Capital widening - which provides new workers with the same amount of tools on the average as those already at work.

Capital deepening - which increases the amount of tools available to workers on average.

Capital quickening - which improves the quality of tools available to workers.

While capital widening increases capacity output without affecting productivity per worker, capital deepening increases labor productivity not by changing technology but by giving workers more tools to work with. Capital quickening improves labor productivity by providing better tools made available through invention. In this view capital stock is the “causeway” for achieving growth in economic output. It emphasizes the close relationship between capital investment, technical progress and productivity improvement. Investment is perceived as a necessary condition for growth not only because it can substitute for other inputs but also because it “embodies” the improvements in technology and productivity. This view should be contrasted with the "source of growth" view in which it is not assumed that more capital stock is a necessary condition for growth; Growth can occur even if net capital formation is zero. As per this view in order to stimulate growth significantly through capital accumulation we should increase our investment quotas enormously. In causeway view we could merely maintain the rate of potential improvement opened up by the advance of knowledge, the economies of scale, the extension of education and whatever else contributes to potential efficiency of resources. A fairly modest increase in rates of capital formation would provide large increases in our rate of growth (Denison, 1974; Sonenblum, 1978).

The distinction between investment as a causeway for productivity growth as against an independent source of growth helps us to clarify the question of whether energy and economy are linked. If energy is perceived as a source of growth then growth in national output can continue without massive investments in energy facilities. Furthermore such massive investments taken by them could increase national output only by very modest amounts. This reflects the beta connection whose protagonists believe that energy can be decoupled from economic growth. If energy is perceived as the causeway through which productivity improvements are implemented, then continued expansion in energy supplies would be needed if the rate of output growth is to be sustained. Furthermore such investment would be socially beneficial since without it the potential improvements in productivity wouldn't be achieved. Advocates of the alpha connection who believe that energy and economic growth can not be decoupled would agree with this proposition (Denison, 1974; Sonenblum, 1978).

<u>Advances in Knowledge:</u> Advances in knowledge are assumed to be of special importance in spurring economic development. When economic and technical developments are linked, as they have tended to be in modern times, then advances in knowledge become the source of progress in technology which in turn is the means for growth in production. Advancing technical knowledge is supposed to contribute to economic growth in several ways- it enables a greater quantity of output to be produced from given quantities of inputs. It facilitates the production of goods better suited to specific wants, it creates new and better ways to meet human needs and it enables new wants to be developed that could never be met before (Denison, 1974; Sonenblum, 1978).

<u>Scale Economies:</u> In an economy operating under constant returns to scale an increased input will augment the output by some amount. If the observed increase is greater than this amount the economy is operating under increased returns to scale. Kaldor (1940) has claimed that as resources shift from agriculture to manufacturing efficiency improves because manufacturing industries enjoy the advantages of economies of scale. Two conditions are associated with scale economies. One occurs when the national market expands in size. The second happens when the nation's population and production become more concentrated in particular regional markets (Denison, 1974; Sonenblum, 1978).

<u>Reducing Inefficiencies:</u> Increases in total factor productivity (and total output) are affected by the extent to which there are "inefficiencies" in the economic system. In general it is assumed that market economies are reasonably efficient primarily as a result

of competition. If there is such efficiency then economic growth can be promoted only by more resource inputs and advances in knowledge or scale. But if the efficiency assumption is called into question then an important additional avenue for output growth opens up. Assuming that any economic system has some level optimal efficiency at any point in time there are always such hazards as market failure, market interventions, inadequate knowledge, uncertainties, poor planning and inappropriate intervention that prevent the optimal from being reached. So the economy will fall short of the optimal by some amount and the extent to which it falls short could be considered a measure of inefficiency. Reducing these inefficiencies can be a potential source of growth (Denison, 1974; Sonenblum, 1978).

Legal and Social Factors: The structure and enforcement of property rights significantly influence efficiency because they define the scope of benefits and costs that can be included under contractual arrangements. Not only the particular content of the law but also its certainty and it continuity are of vital importance in reducing inefficiencies. For without a reasonable certainty about legal decisions and their enforcement there would be substantial additions to the costs of engaging in market transactions (Denison, 1974; Sonenblum, 1978).

Social Mobility: This enhances the opportunities for reducing inefficiencies for such mobility encourages people to move between jobs, industries and regions as they seek superior opportunities. The mobility of workers and entrepreneurship interacts with the mobility of capital to make it more likely that resources will be allocated to the most socially productive sectors (Denison, 1974; Sonenblum, 1978).

Government Factors: Government can be considered as a fourth factor determining economic growth. We may be certain that government activities will affect performance in the economy, but whether they raise efficiency is a different question. Many economists seeking to promote growth believe that government interference with operation of the market place will only lower efficiency. Other observes do not agree with it. In general sense government contributes to efficiency by resolving and preventing conflicts among private interests and by guaranteeing sufficient social justice to prevent civil disturbance. Beyond this general role of being in charge of rules of the game, government also is involved with fiscal and monetary policies that seek to raise efficiency through the control of inflation and reduction in unemployment (Denison, 1974; Sonenblum, 1978).

Internal and External Determinants of Regional Economic Growth

Horst Siebert (1969) in his book *Regional Economic Growth: Theory and Policy* identifies the internal and external determinants of regional economic growth. His work differs from the earlier works in the same domain in the sense that he uses the concept of "region" in the theoretical analysis. The following discussion is drawn heavily from his book.

Internal Determinants: As per Siebert (1969) the factors influencing the rise in potential output inside the region alone are called internal determinants of growth. The potential volume of regional output is a function of the inputs available in the area.

$O = f(K, L, Q, T_r, T, S_o)$

O = Potential Regional Output; K = Available Resources of Capital;

L = labor; Q = Land; T_r = Transport Services; T = Technical Knowledge;

S_o = Social Systems.

Transport inputs (T_r) are the quantity of resources used for the movement of commodities and persons (labor) over space. They are a derived factor of production. Technical Knowledge and Social system factors of production that are vague and are not operationally defined. The last two determinants influence the combination of the preceding four growth factors. The inputs are more or less arbitrarily built constructs and represent complex aggregates which are supposed to be the most important determinants of regional output and its variations (Siebert 1969).

Variations in Capital Stock: The variation in the capital stock of a closed region depends on the supply and the demand for investment funds "J". On the supply side the volume of investment in a period is identical to the amount of savings in the same period. The total amount of regional savings "S" depends on regional income "Y". More realistic than an aggregated savings function is a disaggregated relation which contains different groups of savers characterized by differing saving behaviors. Neglecting other factor returns total savings are split up into savings out of profits "P" and savings out of wages "W" since Y = P + W. Savings of wage earners depend on the regional wage sum "W". Savings of profit earners are by analogy a function of profits P. Profits and savings depend on the level of regional income Y and its distribution. Thus regional income determines the sources of investment in the next period via savings function (Siebert 1969).

Variations in the Labor Supply: Another internal determinant of a change in regional output, as per Siebert (1969) is a variation of the labor supply. With a given wage and a given proportion of the work force to total population the change in the labor supply depends on the increase in the population. Besides the change in population, the wage is another factor influencing variations in the labor supply. Wage increases can represent incentives for the non working population to join the labor force and for those employed to increase their labor supply. (Hauser and Duncan, 1963)

External Determinants: As per Siebert (1969) growth factors relating to an open era and not originating within a region are called – external determinants. The two basic forms of external determinants exist identified by him are: Movement of factors of production and the exchange of commodities (interregional interactions) (Siebert 1969).

Mobility of Labor: Siebert (1969) defines the mobility of labor as a function of distance. The mobility of labor is affected by distance as follows:

- The greater the distance the greater the difference in the social systems and the stronger the obstacles to mobility.
- The greater the distance the less intense are the formal and informal information effects
- The greater the distance the higher the search costs
- The greater the distance the higher the transportation costs.
- The greater the distance the more the intervening opportunities are likely to exist- the number of people going a given distance "s" from a point is not a function of distance directly but rather a function of the spatial

distribution of opportunities. Also the number of persons who migrate a distance is directly proportional to the number of opportunities on the periphery and inversely proportional to the number of opportunities in the circle.

Also Siebert (1969) identified the following relationships between labor mobility and distance: Measuring labor mobility as the proportion of migrating workers to total work force, the mobility of labor decreases with distance. The mobility between adjacent regions will be greater than between non adjacent regions. The interregional mobility of labor may be considered as a function of the distribution of opportunities between regions. The difference in opportunities can be expressed in terms of variables such as income, rate and stability of employment, cost of living, availability of a cultural infrastructure such as educational facilities, social position and amenity factor of a location. For purposes of simplification we assume that the number of workers migrating to an area depends on the wage rates in the two regions- the greater the difference in wages the stronger the information effect , the higher the possible attainment level at the new location and shorter is the period needed to earn the cost of transportation.

The mobility of labor between regions has a direct impact on the wages in the regions involved in the mobility.

Mobility of Capital: Siebert (1969) states that accumulation in an open region consists of internal and external increase. As per his book the external variation of the capital stock may become negative if the capital moves from region-1 to region 2. If the existing stock of capital is immobile the outflow is limited by internal increase because the existing capital stock may be reduced by an outflow of old capital units. The external variation in the capital stock can be regarded as a function of rates of return in the two regions. If the rate of return is higher in region 2 than in region 1 the capital will flow from 1 to 2 and vice versa.

The mobility of capital is restricted by the following factors (Siebert 1969):

1. The existing stock of capital tends to be largely immobile in a physical interpretation.
2. A part of the addition to the capital stock is also immobile.
3. As sources for investment originate mainly within firms, it can be expected that entrepreneurs tend to invest in their own firms and that it requires sizeable differences in the rate of return to invest in another region.
4. Information obstacles may reduce the mobility of capital.

Seibert (1969) makes a subtle distinction between regional income and regional product. The difference is due to the mobility of capital. Regional income is normally defined according to the residents of an area while regional product which represents the output produced by all factors of production available to an area. As some factors may be owned by residents of another region income produced is not identical to income received. Also part of the income produced may leave the area in the form of interest payments. On the other hand the residents of an area may receive interest payments from another region (Siebert 1969). He reasons that since output produced is a decisive variable of supply and income received the basic determinant of demand, a regional growth model should include output produced and income received. As per him the increase in the capital stock of region1 is the sum of internal increase and the external increase flowing into the region. The internal increase in capital depends on the demand for investment funds and is a function of the rate of return and the savings depend on regional income. Total savings are once again split into savings out of profits and savings out of wages. So wages not only have an impact on the capital stock of a region but also on the labor supply and hence have a big impact on the region's economy (Siebert 1969).

2.2 Regional Economic Modeling

The early contributions in the field of regional economic modeling consisted primarily of economic sub models usually exogenous to the larger systems and it is only in the recent past that there have been meaningful advances. The most frequently used techniques for modeling regional economies are economic base models, Input Output models and econometric models. Each of the above models is discussed in detail below. The discussion presented below is drawn heavily from *Econometric Analysis of Regional Systems- Explorations in Model Building and Policy Analysis* by Norman J Glickman (1977).

Economic Base Models

In its simple form, the regional economy is divided into two producing sectors according to the location for the market for goods:

Goods sold outside the region-"Basic "

Goods sold within the region-"Non Basic" or "Service"

Also in this model the following assumptions are made:

Regional economic growth is intimately tied to the growth of basic sector. Expansion of the basic sector is said to result in an increase of production in the service sector which is viewed as supportive in function to the basic sector. Also a stable relationship is assumed to exist between the basic and the service sectors. (Leven, 1956).

Following Richardson (1969) for region "i" the model can be summarized as follows:

$Y_i = (E_i - M_i) + X_i$ 2.1

where Y_i = Total income in region i

E_i = Local Spending (including consumption, investment and local government activity)

M_i = the imports in region i

X_i = the exports in region i

As per this model the regional income is determined by exogenously determined exports and marginal propensity to spend.

In the following models of the economic base models the assumption of exports as a sole source of economic growth is dropped and replaced by a model which allows for exogenously determined investment (I_i), Government spending (G_i) as well as consumption (Ci). Furthermore exports are then determined via interaction with the activity of the other regions. Thus the regional income identity (1) becomes:

$Yi = C_i + I_i + G_i + X_i - M_i$ 2.2

In this interregional model, regional income can change due to four sources (Glickman, 1977):

1. Exports as in the earlier model
2. Any of the components of autonomous expenditure
3. Income in the other regions which will have repercussions on the exports of the region i.
4. Any of the parameters in the model.

Based on this model two variants of the economic base model have been developed. The first one relates changes in total employment to changes in basic employment and the second relates total employment to basic employment in absolute terms. The multiplier for variant 1 is $1 + dE_s/dE_b$ and the multiplier for variant 2 is $1 + E_s/E_b$. Using either formulation in conjunction with location analysis can be used to forecast future levels of basic employment and total employment (Glickman, 1977).

The assumption of constancy in the basic/service ratio as assumed by in the economic base model does not hold good and is the major deficiency of these models. The Basic/Service ratio is not constant for the following reasons (Glickman, 1977):

1. Productivity increases in the service sector may allow more the service industry to be supported with a given amount of basic industry.
2. The ratio also ignores the feedback effects of economic development. Growth tends to produce further growth as Thompson (1965) argues and concomitantly the demand for more industry to serve local needs. This group of firms may

export part of its output and yet its primary function is internally oriented (Yeates and Garner 1971).

3. Location factors that affect a region may change thus making the region more specialized or independent in the long run.

Regional and Interregional Input Output Models

According to the I/O theory each producing sector in the economy is said to be dependent on every other sector. This analytic system allows from tracing of multiplier effects emanating from exogenous shocks to the economy in a more detailed manner than economic base models. (Glickman, 1977)

The assumptions made under these models are:

1. Each commodity group is produced by a unique producing industry.
2. There are no external economies or diseconomies possible.
3. There is a unique observable production process which does not allow for substitution of inputs.

In an open static economy the following accounting balance (Glickman, 1977) holds in each of the economy's "m" industries:

$$X_i = \sum_{k=1}^{m} X_{ik} + Y_i; \quad i, k = 1, 2, 3 \ldots\ldots m \qquad 2.3$$

X_i = Total output of industry "i"

X_{ik} = Amount of industry i's output absorbed in the production of industry k's output.

Y_i = Amount of industry i's output absorbed by final demand.

Following assumption 3; $X_{ik} = a_{ik} X_k$ 2.4

where a_{ik} is the production coefficient specifying the amount of "i" needed to produce one unit of "K" and X_k is the output of industry "k".

2.3 in 2.4 gives $X_i = \sum_{k=1}^{m} a_{ik} X_k + Y_i$; i, k = 1, 2, 3……m 2.5

Equation 2.5 is a system of linear equations and may be solved for X_i if the distribution and level of final demand are known.

In the I/O model for a single region, each industry in the region "r" is related to the other industries in "r" and to the final demand components. For region "r":

$$ {}_rX_i = \sum_{k=1}^{m} {}_rX_{ik} + {}_rY_I \qquad 2.6 $$

$$ {}_rX_{ik} = r\, a_i k_r\, X_k \qquad 2.7 $$

$$ {}_rX_i = \sum_{k=1}^{m} {}_r a_i k_r\, X_k + {}_rY_i \qquad 2.8 $$

Regional models have two forms. The "square" version consists of a highly disaggregated final demand sector, one column each for consumption, investment, government, imports and exports. The second form of regional I/O models is the "dog leg" which has a more aggregated final demand sector (Glickman, 1977).

<u>Conceptual and Technical Problems with I/O Models (Glickman, 1977)</u>

1. The assumption of constant coefficients implies economies of scale are effectively ruled out. This problem becomes more pronounced when technological change takes place. Innovations will call forth changes in

production techniques and trading patterns. The assumption of fixed coefficients does not recognize these events.

2. The assumption of a unique observable production process which does not allow for substitution of inputs is very restrictive as the factors of production are substitutable to some extent.
3. Many of the simplifying assumptions were made because of the difficulty in obtaining data. Some of the data required for building these I/O models have not been collected for regions smaller than SMAs and hence make the use of I/O models restricted.
4. Since the data requirements are so stringent the studies involving I/O models can be very expensive and time consuming.
5. Since I/O modeling is essentially a technology oriented system of analysis, pricing and trading considerations, crucial elements in regional analysis are of secondary importance.

In spite of the problems mentioned above there have been a number of regional input-output studies that have been extensively used. Some of these are the Philadelphia region input-output study (Isard et al, 1967). Similar models have been constructed for Utah (Moore and Peterson (1955)), St Louis (Hirsch (1959a, b) and many other regions.

Econometric Models

In contrast to economic base and I/O models econometric models are not necessarily based upon a specific theory of urban structure. Econometric models therefore offer a more flexible approach to regional analysis than other approaches. In the absence of any constraints, econometricians are free to work with relationships between variables that are shown to hold for a given region. In terms of research design econometric models offer a good compromise between economic base and I/O in terms of using more data than the former and lesser than the later but offering better insights. (Glickman, 1977) There are two classes of regional econometric models, simple and simultaneous (Glickman, 1977).

Simple Econometric Models: These consist of a series of regression equations in which national variables are related to regional variables. Individual equations are unrelated to each other. Each of the equations in the simple model is of the general form (Glickman, 1977):

$Y_{it} = f\ (Z_{kt}, u_t)$ --- 1

Y_{it} = i^{th} endogenous variable in period t.

Z_{kt} = K^{th} exogenous variable in period t

u_t = Error in period t

The major conceptual problems of this model include its lack of simultaneous construction and its total dependence upon national variables. That is none of the regional variables are influenced by other endogenous variables but only by (exogenous) national variables. A more realistic model would relate them to more regional variables. Also in order to construct time series for some of the variables at the regional level assumptions are made which “build in” a high degree of correlation between regional and national variables (Glickman, 1977).

<u>Simultaneous Models:</u> These models express causal relationships among the various equations and the endogenous variables in the model. They are determined simultaneously with the solution of the entire system. (Glickman, 1977)

Each equation in a simultaneous model can be represented as (Glickman, 1977):

$Y_{it} = f\ (Y_{jt}, Z_{kt}, U_t)$ --- 1

Y_{it} = the ith endogenous variable in period t

Z_{kt} = the kth exogenous variable in period t

Y_{jt} = the jth endogenous variable in period t

U_t = the error in period t

The addition of Y_{jt} as an explanatory variable is the essence of simultaneity. Endogenous variables such as variable "j "in 1 are used to explain other endogenous variables such as "i". Thus the analyst is concerned with the entire system of simultaneous equations rather than individual equations. (Glickman, 1977)

Simultaneous equation models have been built for a number of regions like Puerto Rico (Dutta and Su, 1969), Philadelphia (Glickman, 1969, 1971, 1974), Massachusetts (Bell 1967), North East Corridor (Crow, 1969) and Hawaii (Norman, Russell and Hambor, 1974).

Some of the issues encountered with the above mentioned studies are discussed below (Glickman, 1977).

In the Puerto Rico model (Dutta and Su, 1969) six categories of consumption, three types of output and several foreign trade components were estimated. One of the problems with the model was the lack of endogenously determined employment and demographic variables. Population and employment are key variables for purposes of public policy and are important right hand side variables within the model, yet they are taken are exogenous.

In the Massachusetts model Bell (1967) incorporated elements of Economic Base model. The growth of GNP determines the growth of export income which in turn determines the local income. In addition Bell estimates manufacturing and non manufacturing investment, total production and other variables mostly as bi-variate relationships. In all, the model contains 8 stochastic equations. There is no simultaneity among the endogenous variables. Even though it implies that the model is logically simple it does not explain important interactions and local variables.

The North East Corridor model(Crow,1969) contains 50 stochastic equations and is quite comprehensive estimating Gross Product Originating (GPO), employment and wages for nine sectors of the economy as well as consumption, investment, state and local government expenditure, non wage income and net migration. The major problem with this model is the construction of some time series. The ratio between total wage bill and GPO for the US is formed for each sector and equated to the same ratio for the corridor. A solution to these equations yields GPO for the corridor by sector. This method of construction not only builds in a high correlation between corridor and US GPO but also between corridor GPO and corridor wages and employment.

The Pennsylvania model contains 92 equations of which sixty are stochastic. The equations were estimated for the following types of economic activity: output, employment, agriculture, wage and non wage income, consumption, government revenues, labor force, demography, retail sales, banking and investment. The model is simultaneous over the sample period and MAPE statistics were calculated. For most of the important variables the results were satisfactory.

In addition to the problems that have been discussed above the following are the problems that are encountered while using econometric models for regional studies identified by Glickman (1977):

1. Many of the important problems in the development of regional econometric models have revolved around the availability of data. One of the data constraints has been the lack of data on a basis more frequent than annual. Because of the use of annual data there are relatively few observations.
2. The fact that there are very few variables for which there are lengthy time series constitutes another main data constraint. The combination of annual data and few variables with long time series has not only produced small models but ones which are relatively simple often consisting of sets of bivariate relationships.
3. The models are relatively static. With so few observations there is little room for accurately specifying the lag relationships that may be relevant many of which hold for period of less than one year.
4. The models are heavily linked with the national economy. There are relatively large numbers of exogenous variables in these models; most are national variables. The presence of large number of national exogenous variables and the highly recursive nature of many regional models means that they are structurally

dependent on national movements and they do not constitute to any considerable degree internally generated systems. This may lead to relatively weak regional analysis.

5. As in other kinds of empirical research the availability of data often influences the direction of research. In the case of regional models the variables such as industry output, personal income and employment are extensively used since such variables are readily available. However there are a large number of variables of great interest to regional analysis and public policy makers that are missing including exports, imports, migration and various land use variables.
6. Due to the data in availability very few models have been estimated for small areas like counties. Most have been constructed for states or larger areas.
7. There are also significant problems relating to the use of constructed data: most researchers use the Kendrick – Jay Cox method (Kendrick and Jay Cox, 1965) which tends to mask differences in regional production function as well as wage versus non wage industrial income. Thus interesting differences in employment productivity and wages are lost in this data construction process.

In sum as per Glickman (1977) the regional econometric models are rather simple being constructed on annual data with static and largely recursive frameworks. They are structurally linked to national economies often through the mechanism of a companion econometric model. Nearly all look at regional economy as a point in space thus ignoring important intra regional phenomena and policy issues. Yet these models are relatively inexpensive to build than I/O models and yield more information than economic base models.

Multi-region Econometric Models

The following discussion is based on the paper "A framework for analyzing regional growth and decline: A multi-region econometric model of the US" by Glickman et al (1980).

In their paper Glickman et al (1980) present a preliminary view of a multi-region econometric model of the US. The model is a broad one containing most elements of the macro economy, the demographic sector and the energy sector of the regional economies. It draws on the work on single-region economies, multi region econometric models of other countries and on multi regional I/O analysis for the US. This model includes six industrial sectors for each region: farming, mining, manufacturing durables, manufacturing non durables, other private non manufacturing and government. For each of these sectors, equations for output, employment and wage rates have been developed. In addition five categories of the non wage components of personal income are estimated: other labor income, property income, proprietor's income, transfer payments and personal contributions to social insurance.

In their study Glickman et al (1980) estimated the output equations under the hypothesis that the industries within a region could be classified as being either exposed or sheltered. As per them an exposed industry is one that markets its products outside the region or internally under strong competition from other regions. Sheltered industries are those that serve primarily the local market such as service industries. Employment equations are labor requirement relationships. The equations are estimated following a specification derived from the profit maximizing conditions of a generalized CES function. Personal Income has two parts, the wage rate equations (these when combined with employment lead to estimates of the wage bill by region) and the non-wage components of personal income.

As per Glickman et al (1980), in each region the manufacturing and non manufacturing sectors must compete for the regional labor supply. As a result, if the manufacturing wage rate increases, so must the wage rate in the other non manufacturing sector. Hence the specifications for the other non manufacturing wage rates change. The behavioral non wage components of personal income are determined by Glickman et al (1980) as follows: other labor income is a supplement to wages and salaries and hence is related to the average rate in the region. Non farm proprietor's income in each region is related to national non farm proprietor's income and time trend. Regional property income is related to Gross Regional Product in current dollars. Transfer payments are estimated on a per capita basis. These per capita payments are related to the total wage rate in the region and the regional unemployment rate. Finally personal contributions to social insurance respond to the wage bill in the region and the regional unemployment rate. Farm proprietor's income is treated exogenously as is the residence adjustment made to account for people who work in one region while they reside in another.

Energy Demand Model (Glickman et al, 1980): The regional energy demand model is an attempt to examine the effects of government energy policy via its impact on prices and supplies on regional economic development. This sub model of the multi region system estimates regional energy consumption by consuming sector and by fuel type. The major explanatory variable here is the price of the fuel relative to the total energy price for the sector in the region. Regional economic activity is the driving force behind regional energy consumption and this provides the major link between the macroeconomic model and the energy demand model. The link from the energy model back to the macroeconomic model is through industrial fuel prices. These prices enter the manufacturing output equations as an aid in determining industrial location.

Population Model (Glickman et al, 1980): In this sub model of the multi region system the age/sex composition of the resident population for each of the census regions is determined together with in and out migration flows for each region. In determining the potential output of a regional economy the size of the population and hence the labor force is an important component. The labor force further indicates the number of jobs that are required if the output potential is to be achieved. In and out migration is estimated for each region by a sub model in which people move in response to significant wage differentials between regions or significant differences in the labor market conditions as evidenced by relative employment rates or employment growth differences. The major link from the macro economic model to the population model is in the migration equations which are driven by attractiveness of locating in particular regions.

2.3 Energy and Economy Link

The energy economy link is widely discussed by Sidney Sonenblum in his 1978 book

The Energy Connections: Between Energy and the Economy. As per the analysis laid out by Sonenblum Output growth depends on energy, labor, capital and technical inputs. Energy changes not only affect output directly but also indirectly through their impacts on the demand for labor as well as on the demand and supply of capital. If energy affected only output then a reduction in the availability or use of energy would proportionately lower the output. However in actuality labor to some degree can be substituted for energy. Therefore added demand for labor would replace some of the energy reduction so that a position of the lost output is restored. The end result would still be reduced output but less than proportionate to the energy reduction.

As per Sonenblum's analysis reduced energy availability will affect the demand for capital. In his book he also notes that most observers believe that capital and energy are complements rather than substitutes for each other. That is reduced energy availability will be accompanied by a reduced demand for capital input which needs energy to function. The impact of reducing capital input would be to lower output. Thus the result of including the capital input effect is to remove some of the output restored by the labor substitution effect.

Putting all the three forces together the effect of reduced energy usage resulting perhaps from an energy price increase would be to lower output by proportionately less than the reduction in energy but proportionately more than the substitute labor employed (Sonenblum 1978).

The effects of rising energy costs as discussed by Sonenblum in his book are as follows.

Energy Effects on Labor Supply: Rising energy costs can conceivably affect the labor supply through their impact on population growth and on the labor participation rate. For example rising energy costs may lower living standards and there by slow population expansion. Also effects on labor participation as a result of higher energy prices can be expected. For example energy induced changes in the product mix of consumption are likely to make some skills obsolete which could result in early retirements, higher unemployment and increased worker training all of which would mean a reduction in the effective work force although not necessarily a permanent one.

Energy Effects on Labor Demand: The empirical studies indicate that labor is a substitute for energy, although the extent of substitutability probably varies among different producing sectors in the economy. Whether we conclude that because of substitution unfavorable conditions of energy supply will significantly expand the demand for labor depends on which energy consuming sectors we believe will be most affected. If the cut in energy consumption occurs through the reduction in direct energy use by households there may not be a significant increase in labor demand. If the cut affects industrial energy consumption a rise in labor demand will serve as a partial offset. However raising demands for labor by expanding labor intensive production processes may not bode well for long run growth in output. It is true that given the need to reduce energy use a substitution of labor for energy would permit output to grow faster than if the substitution did not take place. However this output growth would still be slower than actual growth in the past. Diminished levels of productivity and output could reduce opportunities for business expansion which over the long run would lower labor demand.

Energy Effects on Supply of Capital: Rising energy costs and increased investment needs by the energy sector may permanently slowdown growth of the nation's plant and equipment in other sectors. This possibility is of great concern because continued productivity improvement is assumed to be tied to plant and equipment growth. In addition to the overall decline in available investment funds growing energy demands for investment are likely to result in an important diversion of capital funds. More funds will be required to be spent on exploration, research and development and capacity increase in the energy sector itself which could mean less investment in other business sectors lowering their opportunities for productivity improvement and output growth. Such diversion could also stimulate inflation, constrain residential investment and reduce government expenditures.

Energy Effects on Demand for Capital: There are two different arguments as far as the relationship between energy consumption and capital stocks are concerned. One argument is that they complement each other as the stock of energy using business plant and equipment grows not only does quantity of energy consumption rises but also labor productivity ultimately expands resulting in increases of overall output. Therefore if the conditions of energy supply become more unfavorable the growth in capital stock will slow down followed by a slowdown of growth in output. Another argument is that capital stock and energy are substitutes. Therefore unfavorable conditions in energy supply will induce growth in capital stock leading to improvements in labor productivity which will prevent a slowdown in expansion of economic development. If energy and capital are perfect complements then the capital intensity should be constant. But the data shows that neither industrial nor total capital intensity remain constant over time. Rather they fluctuate widely declining as often as they increase. The diversity occurs partly because of the changes in product mix and in the efficiency with which capital stock uses energy. The best conclusion to draw from the data is that capital and energy have been complementary inputs particularly in the manufacturing sector. However the degree of complementarity has varied from one period to the next and it is even likely that capital and energy have been substitutes in some periods.

The ease or difficulty the economy has in substituting capital or labor for energy input depends on elasticity of substitution. If it is high unfavorable conditions of energy supply may produce adjustments that do not seriously lower national output or increase unemployment. If it is low (numerically) then adverse conditions of energy supply will not be adequately compensated by the use of labor and capital and hence resulting in reduced output and increased unemployment.

Some of the above changes in the economy as a result of rising energy prices were showcased in the analysis of the effects on rising energy prices between 1972-76 by Hudson and Jorgenson in their 1978 paper. Their analysis was based on a dynamic equilibrium model of the US economy which was developed for the energy policy project of the Ford foundation.

The model was used to simulate two economic growth patterns over the 1972-1976 period. In the 1st simulation actual values of the exogenous variables including world oil prices were employed as the basis for model solution. This simulation provides an estimate of the actual development of the US economy between 1972 and 1976. In the second simulation 1972 energy prices were employed over the whole 1972-1976 period. As world prices are the only set of exogenous variables to change between the two simulations the differences in the simulated economic activity were attributed by Hudson and Jorgenson to the impact of the oil price increase.

The higher energy prices have significant impacts on both the quantity and the price aspects of overall economic activity. The rise in energy prices leads to a reduction in real GNP as per Hudson and Jorgenson. According to the authors, there are two broad sets of reasons for this decline. They are discussed below.

Input Productivity: In their study Hudson and Jorgenson (1978) found out that producers can economize on energy by substituting other inputs for energy. This substitution is not perfect so that productivity is adversely affected. In addition any additional input used as a substitute for energy must be taken from some other use, further detracting from overall productive potential. The result is that a given set of primary inputs can sustain a lower real GNP than would be possible without the restructuring of production patterns caused by energy price increase. At reduced GNP levels under higher energy prices and with reduced rate of return, savings and investment account for a smaller fraction of income. The resulting slowdown in the rate of capacity expansion works to reduce the rate of economic growth (Hudson and Jorgenson, 1978).

Capital: The second result of the energy induced changes found out by Hudson and Jorgenson (1978) is a reduction in the demand for capital services. As per their study the rise in energy prices leads to a decline in the rate of return on capital. This reduces the incentive for saving and investment, slowing the rate of capital formation. In addition there is less saving and a change in the allocation of income between consumption and savings and investment. This further slows the rate of capital formation. There is then a slowing of the rate of growth of productive capacity with the result that the level of potential GNP is lower than would have been the case at lower energy prices. The demand for capital services also changes as a result of adjustments in the pattern of inputs to each producing sector. Specifically the energy changes are accompanied by shifts in the capital input output coefficients. In some sectors production becomes more capital intensive and in other sectors it becomes less intensive. The overall change depends on the size of the shift in each sector and the magnitude of each sector (Hudson and Jorgenson, 1978).

In addition to the above two effects Hudson and Jorgenson(1978) conclude that inflation will be accelerated by the higher energy prices since the direct impact of higher energy prices is to raise the level of output prices as the energy prices as passed through the whole cost structure. In addition the pattern of relative prices is changed with the more energy intensive goods experiencing the largest price increases. These prices changes induce a shift in the pattern of final demand spending away from the now more expensive energy intensive products. Producers respond to higher energy prices in a way analogous to final demand. The motivation is to minimize unit costs in the face of the new price structure. The direction of adjustment is to economize on energy input and given time to adjust significant reductions in energy use is cost effective under a regime of high energy prices. This reduction in energy use is not costless. It is achieved by increases in the use of labor services, capital services and other intermediate inputs. What is involved, as per Hudson and Jorgenson (1978), is a redirection of input patterns away from energy and not a net reduction in input levels.

Changes in Employment: The adjustments in spending and production patterns that reduce energy utilization relative to GNP also affect capital, labor and other factors of production. The changes in employment as laid out Jorgenson and Hudson (1978) as follows:

Demand for labor and employment is affected by the energy induced adjustments through a restructuring of final demand spending, a restructuring of the pattern of inputs into production and a reduction in overall level of economic activity. A restructuring of input patterns occurs in the producing sectors of the economy. In each sector increased labor input per unit of output results from the higher energy prices so that the labor input for any given set of production outputs is increased. In each sector the labor input coefficient increases leading to additional labor demand. Between 1972-1976, Hudson and Jorgenson found that the largest increases in labor demand occurred in services and in manufacturing, although there was also a significant increase in agriculture and construction. The increase in labor input is beneficial for employment, reducing the loss of jobs in the face of GNP reduction, but it has an adverse effect on productivity. These adjustments lead to a reduction in the average gross productivity of labor. This decline implies that the rate of growth in real wages will not be as rapid as would otherwise have occurred. To the extent that real wages outstrip the slower growth of productivity, unit labor costs will increase and inflation will be accelerated. Lower productivity leads to slower real growth, slower growth of real wages, and more rapid inflation. It should be noted that these are one time effects rather than permanent trends. Once the economy has adjusted to the new labor and productivity, there will be no further energy induced pressures.

2.4 Electricity and Economy

The special significance of energy in economic growth was first established in the study*, Energy and the American Economy 1850-1875: Its History and Prospects* (Schurr et al., 1960). In this study Schurr and his colleagues noted that, between 1920 and 1955, the energy intensity of production (defined as energy consumed per unit of GNP) fell in the US, while both labor productivity and total factor productivity were rising. The simultaneous decline in energy and labor intensities of production ruled out explaining the growth of productivity solely by substitution of cheap energy for expensive labor. To explain the growth of output given declining energy and labor intensities required examining the character of productivity growth, engendered largely by technical change. The two most important features of technical change as noted by Schurr and his associates concerning electricity during this time were, the thermal efficiency of conversion of fuels into electricity increased by a factor of three and second that "the unusual characteristics of electricity had made it possible to perform tasks in altogether different ways than if those fuels had to be used directly" (Schurr, 1983, p.205). The importance of electrification in productivity growth was also documented by Rosenberg (1983): "Increasingly, the spreading use of electric power in the 20th century has been associated with the introduction of new techniques and new arrangements which reduce total costs through their saving of labor and capital. Perhaps the most distinctive features of these new techniques are (1) that they take so many forms as to defy easy categorization, and (2) that they occur in so many industries that they defy a simple summary." Baughman and others (1986) of the committee on electricity in economic growth in their book *Electricity in Economic Growth* felt the need to do more than merely describe the trends in energy use and productivity and for this purpose they developed an econometric model that determines sectoral productivity growth rates as a function of relative prices of production inputs. Using this model and its results they test the hypothesis advanced by Schurr and Rosenberg about the importance of electricity in productivity growth. Each industry in this model is based on sectoral price function that encompasses possibilities for substitution among inputs as well as patterns of technical change. Each price function gives the price of output for an industrial sector as a function of the prices of capital, labor electricity, non-electrical energy and material inputs and in time. The unknown parameters of econometric model are the biases of productivity growth, which indicate the effects of change in the level of technology on the value shares of each of the five inputs. The bias of productivity growth for each of the five inputs appears as the coefficients of time representing the level of technology. In assessing the role of electricity in productivity growth, the critical parameter in the econometric model is the bias of productivity growth for electricity. This bias gives the change in the value share of electricity in response to changes in the level of technology (technical change). Productivity growth (technical change) is electricity using if the bias of productivity growth is positive. Similarly the productivity growth is said to be electricity saving if the bias of productivity growth for electricity input is negative. In order to test the hypothesis the production biases were calculated for the US economy across 35 industries. The first and foremost conclusion was that electricity plays a very important role in productivity growth. A decline in the price of electricity stimulates productivity growth in 23 of the 35 industries and dampens productivity growth in only 12. Alternatively it is also shown that technical change results in an increase in the share of electricity input in the value of the output, holding the relative prices of all inputs constant, in 23 of the 35 industries. These empirical results provide strong confirmation of the hypothesis about the relationship of electrification and productivity growth in a wide range of industries (Baughman et al, 1986).

The effects of changing electricity prices are discussed in the book *Electricity in Economic Growth* (Baughman et al, 1986). The electricity prices for the 40 year period before 1973 declined through out the entire period. The rapid price decline for electricity has been attributed to the increasing economies of scale in electricity generation and distribution over this period and to improvements in the efficiency of generation. The prices were also favorably affected by the stability of primary energy input costs over the period. Since 1973 a number of forces have combined to reverse the historical trend of declining electricity prices. First, there was the great increase in oil prices starting in 1973 due to the oil embargos in 1973 and 1979, second the exhaustion of the economies of scale and improvements that led to lower per unit costs of generation over the longer period.

Electricity prices affect electricity consumption in two ways:

1. They directly affect the use of electricity and non electric fuels as input factors of production.
2. They indirectly affect productivity growth and thereby economic growth.

If electricity prices alone rise, electricity use decreases in accordance with elasticity of demand with respect to its own price. This result will occur through removing the efficiency of electricity use and through substituting other inputs for electricity. If the price of the fuels that compete with electricity rise without a corresponding increase in the price of electricity, then the consumption of electricity rises. If electricity prices rise because of a rise in primary fuel prices a reduction in electricity use through own price elasticity will occur and will be offset to some degree by an increase in the use of electricity as a substitute for primary fuels through cross price elasticity. Any real increase in the real price of electricity will indirectly further decrease electricity use because it will lower productivity growth rates in many industries and in turn leading to a lower rate of economic growth (Baughman et al, 1986).

Opposing Views on Electricity Prices and Employment

A review of the different works reveal two major opposing views on the nature of relationship between electricity prices and employment growth of an area.

Inverse Relationship between Electricity Prices and Employment: Miernyk (1978) segregated the US into energy consuming and energy producing states using state's consumption and production patterns of coal, natural gas, petroleum and electricity. Indications from the examination revealed that the energy producing states gained in economic well being at the expense of energy consuming states. The relations between fluctuations in electricity prices and variations in the ratio of manufacturing employment to population were examined by means of simple regression analysis between energy surplus and energy deficit states. Employment in each region was classified on the basis of sensitivity to changes in energy prices during the 1970-1980 period. On the basis of this classification approximately 21% of the US employment in the 1970 was directly vulnerable .Less than 5% was indirectly vulnerable and almost 75% was considered sheltered from the direct effects of differential changes in electricity prices. There was a decline in employment in both directly and indirectly vulnerable employment in the North Mid Atlantic – an energy deficient region. A pronounced drop was noted in sheltered employment during the same period. In contrast employment in all three categories expanded in the south west – the region with the largest energy surplus. Miernyk speculated that much of the decline in employment in New York and New Jersey generated by rapid overall increases in energy prices in that region. Some of the increase in employment in south west was precipitated by favorable prices in that area.

Direct Relationship between Electricity Prices and Employment: Nordlund and Robson (1980) promoted the theory that as price of electricity increased so would the percentage of employment in an area. This direct relationship resulted due to "spill over effects" and the substitutability factor between electricity and labor.

The spill over effects would take the form of increased interest and employment in other non electric energy production. In addition research and development in alternate forms of energy production to counter rising electricity prices would increase employment in these areas. Nordlund and Robson (1980) maintain that energy prices have determined how firms substitute labor or capital for expensive or unavailable energy. Because of its typically low price energy, prior to 1970, had traditionally been included as a miscellaneous variable factor. Labor in contrast constituted the principal variable factor of production. The prices of these two factors determined their relative usage and degree of substitutability. Firms typically attempted to find the combination of factor inputs that minimized the per unit cost of production. Although labor cost rose significantly in the 1970s energy prices climbed at a faster rate. Nordlund and Robson (1980) argued that when feasible firms would substitute the lower priced labor resource for the relatively higher priced energy resource.

Bruce Hannon (1977) supported the contention that higher energy prices created jobs in all sectors of the economy. He argued that under conditions of zero economic growth the US could have accomplished full employment in the 1935-1970 period by raising the price of energy relative to wages. He noted that in the past the price of labor rose much faster than the price of electricity. As a consequence electricity was substituted for labor. Hannon (1977) further argued that the rapid drop in wage/electricity price ratio between 1970-1975 supports the hypothesis that energy and labor are substitutable.

In this chapter we have reviewed studies that have dealt with issues relevant to our study. In the first part of this chapter we looked at the measures of economic growth. Some of the possible measures are income levels (including wages, rents, profits etc), population etc. We also looked at the determinants of economic growth. Some of the determinants of economic growth as identified in the earlier studies are – more labor, more capital, and more natural resources, factor inputs such as – state of technology, scale of economies and improved resource allocation. The internal determinants are regional savings, regional wages and profits, population. The external determinants are mobility of labor and capital. The second part of this chapter was dedicated to review the existing regional economic modeling techniques. The economic base models are by far the earliest and the easiest modeling techniques. But these models are not all that useful as they make some assumptions which make their results flawed and misleading. The input/output models have been used successfully in a number of regional studies but they can get very demanding with regards to their data requirements. Also some of the assumptions made, like – constant coefficients, observable production processes pose some problems to the general acceptance of the results of these studies. The econometric models offer a good compromise between the economic base models and the Input/Output models in terms of data requirements. Even though some of the earlier econometric studies lacked in terms of simultaneity the later models took care of these shortcomings. The earlier econometric models were also depending more heavily on the national variables. That is none of the regional variables are influenced by other endogenous variables but only by exogenous (national) variables. In order to overcome these problems we use Vector Auto Regressions (VAR) in this study. VAR models account for effects of other endogenous variables. Also econometric models can be used in conjunction with economic base models in order to develop the theoretical construct required for an econometric study.

In the third part of this chapter the literature dealing with the energy economy link was reviewed. The studies by Sidney Sonenblum (1978) and Jorgenson and Hudson (1978) showcased the relationship. As per their studies energy and energy prices do have an impact on the supply and demand of labor and capital. The study by Schurr et al (1986) emphasizes the important role electricity played in the economic growth of the US. As per their finding a decline in the price of the electricity stimulates the productivity growth in a majority of the industries. However, the effect of rising energy prices on employment is debatable. We in our study use econometric modeling techniques to throw light on kind of relationship between electricity prices and their impact on regional economic activity.

CHAPTER III

METHODOLOGY, MODEL AND RESULTS

This chapter is organized as follows. In section 3.1 methodology used in this study is discussed. In section 3.2 the model and the variables used and the rationale behind using them are discussed. In section 3.3 the results are presented.

3.1 Methodology

The objective of this study is to characterize the dynamic relationships among electricity prices and regional economic indicators using Vector Auto Regressions (VARs). A VAR model differs from the structural econometric modeling techniques as it does not impose restrictions on which variables enter specific equations in the analysis of multi-variate systems. In this approach identification is achieved by estimating reduced form relationships in which every variable in the multi-variate system is allowed to influence every other variable in the system with lags. The other advantages that a research effort might have when compared to one using other approaches are:

1. The research effort falls outside the logical analysis of Popper (1968, section1.1) (Bessler, 1984). In other words the research effort is not aimed at proving a theory right or wrong, but it helps the researcher make explicit some of the operations that were obscure from earlier studies or even better allows the researcher to use a set of variables that are not necessarily governed by a predefined structure. The empirical regularities uncovered by this method may follow conventional wisdom (already existing theories) or raise new questions

and view points which were assumed to have never existed and thereby fuel further research /studies.

2. The study of dynamic economic system gets much easier as the empirical regularities are uncovered without using a priori theory that is static.

Even though VARs presents a unique advantage to the researcher by not imposing structural restrictions on the variables that can be used in the model, theory is still used rather weakly to suggest alternative variables. One must not think of VAR as an approach that is devoid of any theoretical backing as the choice of variables to be studies is based on theory. Unless theory explicitly prevents it, every variable in the system is allowed to affect every other variable with lags.

<u>Vector Auto Regression Model</u>

A VAR model is:

$$Q_t = \alpha + \sum_{i=1}^{k} \beta_i Q_{t-1} + \gamma Z_t + e_t \qquad 3.1$$

where α is a (m x 1) vector of intercept terms, m is the number of series, Q_t is a (m x 1) vector of electricity prices and the regional economic indicators, e_t is a (m x 1) vector of the residual terms (innovations), Z_t is a (q x 1) vector of strictly exogenous variables, β_i and γ are appropriately dimensioned matrices of coefficients , k represents the number of lags and t is a specific observation from a sample of T observations. The innovation term, e_t, is assumed to be white noise with a mean of zero and a positive definite covariance matrix. Further the innovations e_t and e_s are assumed to be independent for $s \neq t$. Although serially uncorrelated, contemporaneous correlations among the elements of e_t are possible, implying the contemporaneous correlation matrix may not be an orthogonal matrix. If no contemporaneous correlation exists among the elements of $e_{t,}$ then innovation accounting procedures (impulse response functions and forecast error variance decompositions) can be conducted using the moving average representation of the estimated VAR (Hamilton 1994). Innovation accounting procedures encompass the analysis of the dynamic model in terms of shocks to the model. There are two technical operations that are performed on the estimated vector auto regression as part of the innovation accounting analysis which will make the study of the dynamic system more insightful. The impulse response function simulates over time the effect of a shock in one series on itself and on the other series of the system. By viewing these responses the researcher may gain insights into the dynamic system in study. The second technical operation is the forecast error variance decomposition. Forecast error variance decompositions indicate whether the forecast error (the error between the VAR model prediction and actually observed) variance for each series at any horizon is due to its own innovations or other variables' innovations (Doan, 1995).This gives the researcher the additional ability to measure the relative strength of the relationships at various lag length. Also it allows the researcher to infer about the strength and timing of similar relationships (Bessler, 1984).

Contemporaneous correlation among price series is the norm when using economic data. If innovations are contemporaneously correlated it is misleading to examine a shock to a single variable in isolation (Doan, 1995). To address the contemporaneous correlation issue, the VAR model must be transformed such that the innovations are orthogonal. A recursive ordering procedure suggested by Bernanke (1986) is used to obtain the transformed VAR.

Following Bernanke(1986) the innovations are written as a function of more fundamental driving sources of variation , ϵ_t , which are independent (orthogonal) of other sources of variation:

$$e_t = A\,\epsilon_t \qquad 3.2$$

where A is a matrix representing how each non –orthogonal innovation is caused by the orthogonal variation in each question. Innovation accounting procedures are carried out on the moving average representation of the transformed VAR:

$$AQ_t = A\,\alpha + \sum_{i=1}^{k} A\beta i_{Qt-1} + A\,\gamma\,Z_t + A\,\epsilon_t \qquad 3.3$$

because VAR model has the same right hand side variables in each equation, the model is estimated using Ordinary Least Squares equation by equation. There is no gain in efficiency using seemingly unrelated regression (Baltagi et al, 2002). Directed Acyclic graphs are used to provide identifying restrictions on the matrix A.

<u>Directed Acyclic Graphs</u>

A directed graph is a picture representing the causal flow among a set of variables. Lines with arrowheads are used to represent such flows, so that the picture A->B indicates that variable A causes variable B. A line connecting two variables, say C-D indicates that C and D are connected by information flow but we cannot tell if C causes D or vice versa (Pearl 2000).

Directed acyclic graphs represent conditional independent relationship as implied by the recursive product decomposition:

$$Pr(x_1, x_2, x_3 \ldots x_n) = \prod_{i=1}^{n} Pr\,(x_i/pa_i) \qquad 3.4$$

where Pr is the joint probability of variables $x_1, x_2, x_3 \ldots x_n$ and pa_i is a set of variables representing the minimal set of predecessors (the variables that come before in causal sense) of x_i that x_i renders independent of all its other predecessors (Pearl 2000, p.14). It has been shown that there is a one-to-one correspondence between the set of conditional independencies among variables implied by equation (4) and the graphical expression of variables in directed graph (See Pearl 2000 for further details).

PC Algorithm, which finds causal flows from correlation relationships among the variables, is used in this study (Sprites, Glymour and Scheines, 2000). PC algorithm begins with a general unrestricted set of relationships among the variables and proceeds stepwise to remove edges between the variables depending on correlation relationships. Finally PC algorithm directs causal flow using conditional independent relationship. PC Algorithm makes three assumptions. First, causally sufficient sets of variables are included in the observational data set. This implies there are no omitted variables that cause any two of the included variables. Second the causal Markov condition is assumed to be satisfied. This implies that if x_1 causes x_2 and x_2 causes x_3 then the underlying probability distribution on x_1,x_2 and x_3 , $Pr(x_1,x_2,x_3)$ can be expressed as $Pr(x_1)Pr(x_2/x_1)Pr(x_3/x_2)$. In other words this assumption means that one need only to condition on variables of direct cause to capture the probability distribution generating any variable. Finally the faithfulness condition is assumed. The probabilities Pr(.) are said to be faithful to the corresponding directed graph in case that x_1 and x_2 are dependent if and only if there is an edge between x_1 and x_2 (Bessler and Lee ,2002).

3.2 Model Specification

Based on the review of earlier studies in the fields of regional economies, regional modeling ,energy-economy link the following are the conclusions which have had a direct bearing on our selection of variables that are in the VAR model:

Employment

Demand for labor and employment is affected by the energy induced adjustments through a restructuring of final demand spending, a restructuring of the pattern of inputs into production and a reduction in overall level of economic activity. (Hudson and Jorgenson in their paper "Energy prices and the US economy, 1972-1976"). The empirical studies indicate that labor is a substitute for energy, although the extent of substitutability probably varies among different producing sectors in the economy (Sonenblum, 1978).Between 1972- 1976 Hudson and Jorgenson found that the largest increases in labor demand occur in services and in manufacturing although there is also a significant increase in agriculture and construction. In addition to demand shocks, rising energy costs affect the labor supply through their impact on population growth and on the labor participation rate (Sonenblum, 1978).

Since the relationship between energy prices and employment are well documented (even though there exists some confusion as to the kind of relationship) it was decided to include Employment as one of the variables in the study. Since the rising energy costs are supposed to have varying impacts on employment in the different sectors, in our study the employment in the regional economy under study has been classified into two broad categories: Employment in Goods Sector (GP) and Employment in Services Sector (SER).

Employment in Goods Sector (GP) includes the following sectors: farming, agricultural services, mining, construction and manufacturing. Employment in Services Sector (SER) includes the following sectors: services, wholesale and retail trade, finance, insurance and real estate; transportation and public utilities and government.

Population

When studying an economy and economic activity population comes into play in more than one ways. At a macro level population affects economic activity through its impact on changes in the quantity and quality of the labor input. Over the long run the size of the labor force is determined primarily by the changes in the size and composition of the population (Denison, Growth Accounting and Solow Growth Model). Also in determining the potential output of a regional economy the size of the population and hence the labor force is an important component. (William J. Milne, Norman J Glickman and F.Gerard Adams, 1980).The impacts of energy costs on the employment levels are to some extent influenced by population. Rising energy costs affect the labor supply through their impact on population growth and on the labor participation rate (Sonenblum, 1978).Population (POP) is included as one of the variables in our study.

<u>Interregional Mobility</u>

The mobility of factors of production, especially labor, has been cited as one the determinants of economic growth. Factor mobility enhances the opportunities for reducing inefficiencies, for such mobility encourages people to move between jobs, industries, and regions as they seek superior opportunities. The mobility of workers and entrepreneurship interacts with the mobility of capital to make it more likely that resources will be allocated to the most socially productive sectors. (Denison, Growth Accounting). The mobility between adjacent regions will be greater than between non adjacent regions. The interregional mobility of labor may be considered as a function of the distribution of opportunities between regions (Horst Siebert, 1969). Also Meirnyk concluded from his studies that as a result of rising energy costs one region (which is energy producing) will benefit at the expense of another region which is energy consuming mainly due to the migration of factors of production (Meirnyk,1978).

In our study Montgomery County is situated right next to Houston, which is one of the most economically vibrant cities in the world, a sizeable population of Montgomery works in Houston and lives in Montgomery County. In order to account for this condition and also the mobility of factors of production we have used Adjustment for Residence (RAD) as one of the variables in our study.

<u>Adjustment for Residence (RAD)</u>

RAD is the net inflow of the net labor earnings of inters regional commuters. The county estimates of personal income are presented by the state and county of residence of the income recipients. However, the source data for most of the components of wage and salary disbursements, supplements to wages and salaries, and contributions for government social insurance are on a place-of-work basis. Consequently, a residence adjustment is made to convert the estimates based these source data to a place-of-residence basis.

Dividends, Interests and Rent (DIR) and Transfer Payments (TRF)

These are also used in our study as a way to account for non –wage sources of income.

Electricity Prices

The electricity prices as charged to the residential customer and the commercial customers are used in this study. Residential Average Price (RAP) is the price that the residential customers living in Montgomery county pay. Commercial Average Price (COM) is the price paid by the services and manufacturing sectors.

The variables Employment in Goods Sector (GP), Employment in Service Sector (SER), Dividends, Interest and Rent (DIR), Transfer payments (TRF), and Adjustment for Residence (RAD) are computed on a per capita basis and have been adjusted for inflation.

The variables, Residential Average Price (RAP) and Commercial Average Price (COM) have been adjusted for inflation. All the data (except electricity prices) for this study are from the Regional Economic Information System data set of the Bureau of Economic Analysis, for the Montgomery County. The electricity price data is provided by Mid-South Synergy, an electric utility company providing electricity to areas Montgomery County. All data is from 1969 to 2000. The data set used for this study is provided in Appendix D. Plots of the series for each variable are provided in Fig.3.1.

3.3 Results

Stationarity and Optimal Lag Length

Two tests, Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) are used to examine the stationarity of the 8 series. As shown in Fig.3.1, each series is volatile and potentially heteroscedastic. Schwarz loss measure is used to determine the optimal lag length. The Schwarz loss measure used is based on the following formula:

$$SL = \log (|\Gamma| + (8k) (\log T))/T \qquad 3.5$$

where Γ is the error variance covariance matrix estimated with 8k regressors in each equation, T is the total number of observations on each series, the symbol '| |' denotes the determinant operator and log is the natural logarithm. We select that order of lag that minimizes the loss metric.

Table 3.1 gives both Dickey-Fuller (DF) and Augmented Dickey-Fuller (ADF) tests on the null hypothesis that all the 8 series are non-stationary against the alternative that the series are stationary. Schwarz loss measures are computed and are presented in the same table. Both the sets of tests (DF and ADF) indicate that all series are non – stationary as the calculated t-statistics are greater than the 5% critical value (-2.89) in all cases.

In order to account for non stationarity and non-constant variance all the eight series are logged and first differenced. DF and ADF test results are given in Table 3.2. The DF tests indicate the Population (POP), and Employment in Service Sector (SER) series are stationary. Using the ADF test once again Population (POP) and Service Sector Employment (SER) are stationary. Although these tests are not conclusive, the tests indicate at least two series among the 8 series are stationary using both the DF and ADF tests. Since we do not have considerable number of observations we use two lags 9 (the maximum allowable) for the model. A two lag VAR model is used in this study.

Identifying Contemporaneous Structure

Innovation accounting analysis is conducted to identify the contemporaneous structure among the eight variables in our study. Using the innovations from the VAR model, the lower triangular of the contemporaneous innovation covariance matrix, Σ is presented in the table 3.3.

The covariance matrix Σ presented in the table 3.3 is used in the directed acyclic graph analysis to identify the Bernanke ordering structure. The resulting causal flows between contemporaneous innovations from each of the 8 variables are assigned using TETRAD II, a computer software implementing PC Algorithm (Scheines et al., 2000) in Fig.3.2. In the directed acyclic graph at $\alpha = 0.2$, there are bi-directed edges between Residential Average Prices (RAP) and Transfer Payments (TRF). These bi-directed edges indicate there are potentially omitted variables between these variables. The edges among four variables Employment in Goods Sector (GP),Employment in Service Sector (SER), Dividends Interest and Rents(DIR) and Adjustment for Residence (RAD) are not determined at $\alpha = 0.2$.

In order to account for these bi-directed edges and un-directed edges we have come with two different models. The models differ in the direction of the edges between the bi-directed and undirected variables.

Model 1

The directed acyclic graph shown in figure 3.2 is modified by directing the bi-directed edge from Transfer Payments (TRF) to Residential Average Prices (RAP). Also the undirected edge between Employment in Goods Sector (GP), Employment in Service Sector (SER), Dividends Interest and Rents (DIR) and Adjustment for Residence (RAD) as follows:

GP → SER

GP → DIR

RAD → SER

The modified directed acyclic graph that will be used in model 1 is shown in figure 3.3. The dashed edges (---->) in figure 3.3 indicate the edges that have been modified from the original directed acyclic graph. The direction of these edges will be reversed in model 2.

The directed acyclic graph (fig 3.3) shows that Population (POP) and Commercial Average Price (COM) are exogenous, as there are no variables that cause these variables in contemporaneous time. The information flow is Employment in Goods Sector (GP) causes Employment in Service Sector (SER) and Dividends Interest and Rents (DIR). Employment in Service Sector (SER) causes Transfer Payments (TRF). Transfer Payments (TRF) cause Residential Average Prices (RAP). Adjustment for Residence (RAD) causes Employment in Service Sector (SER). Commercial Average Price (COM) causes Residential Average Prices (RAP). Dividends Interest and Rents (DIR) and Residential Average Prices (RAP) appear to be information sinks as they do not cause Any Other Variable.

Forecast Error Variance Decomposition: Forecast error variance decompositions for model 1 are given in table 3.4. Listed are the decompositions for the horizons of zero (contemporaneous time) one, two, three and five years.

In the contemporaneous time the variation in Population (POP) is explained by innovations from itself (POP, 100%). The variations in the first year are explained by itself (60.5%), Employment in Goods Sector(GP) (15.778%).The variations in second year are explained by innovations from Population (POP) (27%), Employment in Goods Sector (GP) (28.8%), Transfer Payments (TRF) (14%) and Commercial Average Price(COM) (8.7%).In the third year the variations are explained by Employment in Goods Sector (GP)(21.9%), Transfer Payments (TRF)(15.9%), Population (POP)(16.2%), Adjustment for Residence (RAD)(12.4%) and Commercial Average Prices(COM)(12.5%). In the fifth year the variations are explained mainly by innovations from Commercial Average Price (COM) (21.4%), Adjustment for Residence (RAD) (16.6%), Employment in Goods Sector (GP) (14.2%), Dividends Interests Rents (DIR) (12.9%) and Transfer Payments (TRF) (12.5%). In the contemporaneous time and in the first year Population appears to be exogenous. In the intermediate time horizon the variations are explained by innovations from Population (POP), Employment in the goods sector (GP) and Transfer Payments (TRF). In the long run the variations in the Population are explained by innovations from Commercial Average Price (COM), Adjustment for Residence (RAD) and Employment in Goods Sector (GP).

In the contemporaneous time the variation in Employment in Goods Sector (GP) is explained by innovations from itself (100%). The variations in the first year are explained by itself (54.6%), Commercial Average Price (COM) (13.2%) and Employment in Service Sector(SER) (11.3%).The variations in second year are explained by innovations from Employment in Goods Sector (GP) (45.2%), Commercial Average Price (COM) (14.9%), Employment in Service Sector(SER) (13.5%), and Transfer Payments (TRF) (11.7%) . In the third year the variations are explained by Employment in Goods Sector (GP) (40%), Commercial Average Price (COM) (14.9%), Employment in Service Sector (SER) (11.6%), and Transfer Payments (TRF) (10.9%). In the fifth year the variations are explained mainly by innovations from Employment in Goods Sector (GP) (33.5%), Commercial Average Price (COM) (17.9%), and Adjustment for Residence (RAD) (10.9%), Dividends Interests Rents (DIR) (10.5%) and Transfer Payments (TRF) (10.3%). Both in the contemporaneous time horizon and in the long run Employment in Goods Sector (GP) appears to be exogenous. In the intermediate time horizon the variations are explained by innovations from Commercial Average Price (COM), Employment in Service Sector (SER), and Transfer Payments (TRF) in addition to Employment in Goods Sector (GP).In the long run the variations are explained by innovations from Commercial Average Price (COM), Adjustment for Residence (RAD), Dividends Interests Rents (DIR) and Transfer Payments (TRF) in addition to Employment in Goods Sector (GP).

In the contemporaneous time the variation in Employment in service sector (SER) is explained by innovations from itself (58.9%), Employment in Goods Sector

(GP) (26.8%) and Adjustment for Residence (RAD) (14.1%). The variations in the first year are explained by itself (26.7%), Employment in the goods sector (GP) (41.4%), Transfer Payments (TRF) (9.6%) and Adjustment for Residence (RAD) (6.4%). The variations in second year are explained by innovations from Employment in Goods Sector (GP) (33.2%), Employment in Service Sector (SER) (23.7%), Transfer Payments (23.3%) and Commercial Average Price (COM) (6.1%). In the third year the variations are explained by Employment in Goods Sector (GP) (32.2%), Employment in service sector (17.9%), Transfer Payments (19.6%) and Commercial Average Price (COM) (8.9%). In the fifth year the variations are explained mainly by innovations from Employment in Goods Sector (GP) (29.7%), Commercial Average Price(COM) (20.2%), Employment in service sector (SER) (14.5%), and Transfer Payments (TRF) (18.7%). In the contemporaneous time horizon Employment in Service Sector (SER) appears to be exogenous. In the intermediate time horizon the variations are explained by innovations from Employment in Goods Sector (GP), Employment in Service Sector (SER), Transfer Payments (TRF) and Commercial Average Price (COM). In the long run the variations are explained by innovations from Employment in Goods Sector (GP), Commercial Average Price (COM), and Transfer Payments (TRF) in addition to Employment in service sector (SER).

In the contemporaneous time the variation in Dividends Interest Rent (DIR) is explained by innovations from itself (77.2%) and Employment in Goods Sector (GP) (22.7%). The variations in the first year are explained by itself (37.4%), Employment in the goods sector (GP) (25%), Transfer Payments (TRF) (15.4%), Commercial Average

Price (9.8%) and Residential Average Prices (9.1%). The variations in second year are explained by innovations from itself (33.1%), Employment in Goods Sector (GP) (24.8%), Residential Average Price (RAP) (14.3%) and Transfer Payments (13.4%). In the third year the variations are explained by itself (29.8%), Employment in Goods Sector (GP) (27.2%), Residential Average Prices (RAP) (14.7%) and Transfer Payments (TRF) (12.1%). In the fifth year the variations are explained mainly by innovations from Employment in Goods Sector (GP) (27.9%), from itself (27.6%), Transfer Payments (TRF) (13.9%) and Residential Average Prices (RAP) (11.9%). In the contemporaneous time horizon Dividends Interest Rent (DIR) appears to be exogenous. Even in the intermediate horizon it appears to be exogenous. In the intermediate time horizon the variations are explained by innovations from Employment in Goods Sector (GP), Transfer Payments (TRF) and Residential Average Prices (RAP). In the long run the variations are explained by innovations from itself, Employment in Goods Sector (GP), Transfer Payments (TRF) and Residential Average Price (RAP).

In the contemporaneous time the variation in Transfer Payments (TRF) is explained by innovations from itself (72.2%) and Employment in service sector (SER) (16.3%) and Employment in Goods Sector (GP) (7.4%). In the first year the variations are explained by innovations from Transfer Payments (TRF) (65%), Employment in service sector (SER) (11.2%) and Adjustment for Residence (RAD) (6.5%). In the second year the variations are explained by innovations from Transfer Payments (TRF) (59.4%), Adjustment for Residence (RAD) (9.8%) and Residential Average Price (RAP) (7.9%). In the third year the variations are explained by innovations from Transfer

Payments (TRF) (50.2%), Adjustment for Residence (RAD) (12.4%), Employment in Goods Sector (GP) (9.9%) and Commercial Average Price (COM) (9.1%). In the fifth year the variations are explained by innovations from Transfer Payments (TRF) (34.4%), Employment in Goods Sector (GP) (25.8%), Adjustment for Residence (RAD) (12.8%) and Commercial Average Price (COM) (8.5%). In the contemporaneous and the intermediate time horizons Transfer Payments (TRF) is exogenous. In the intermediate time horizons the variations are explained by innovations from Adjustment for Residence (RAD), Residential Average Price (RAP), Commercial Average Price (COM) and Employment in Goods Sector (GP). In the long run the variations are explained by innovations from Transfer Payments (TRF), Employment in Goods Sector (GP), Adjustment for Residence (RAD) and Commercial Average Price (COM).

In the contemporaneous time the variation in Adjustment for Residence (RAD) is explained by innovations from itself (100%). In the first year the variations are explained by innovations from Adjustment for Residence (RAD) (67.3%), Dividends Interests Rents (DIR) (16.9%) and Transfer Payments (TRF) (9.1%). In the second year the variations are explained by innovations from Adjustment for Residence (RAD) (51%), Employment in Goods Sector (GP) (15.6%), Dividends Interests Rents (DIR) (12.6%) and Transfer Payments (TRF) (11.7%). In the third year the variations are explained by innovations from Adjustment for Residence (RAD) (40.8%), Employment in Goods Sector (GP) (25.6%) and Transfer Payments (TRF) (14.5%). In the fifth year the variations are explained by innovations from Adjustment for Residence (RAD) (35.1%), Employment in Goods Sector (GP) (35%), Transfer Payments (TRF) (12.6%)

and Dividends Interests Rents (DIR) (8.3%). In the contemporaneous and the intermediate time horizons Adjustment for Residence (RAD) is exogenous. In the intermediate time horizons the variations are explained by innovations from Employment in Goods Sector (GP), Dividends Interests Rents (DIR) and Transfer Payments (TRF). In the long run the variations are explained by innovations from itself, Employment in Goods Sector (GP), Transfer Payments (TRF) and Dividends Interests Rents (DIR).

In the contemporaneous time the variation in Residential Average Price (RAP) is explained by innovations from Commercial Average Price (COM) (81.9%) and itself (12.4%). In the first year the variations are once again explained by innovations from Commercial Average Price (COM) (83.7%) and itself (10.1%). In the second year the variations are explained by innovations from the same variables as in the contemporaneous and first year horizons. The innovations from Commercial Average Price (COM) (76.8%) and itself (11.8%). In the third year the variations are explained by innovations from Commercial Average Price (COM) (67.6%) and Residential Average Price (RAP) (10.8%), Adjustment for Residence (RAD) (6.2%) and Population (POP) (5.7%). In the fifth year the variations are explained by innovations from Commercial Average Price (COM) (53.8%) and Residential Average Price (RAP) (9.4%), Transfer Payments (TRF) (12.5%) and Adjustment for Residence (RAD) (8.3%). In the contemporaneous, the intermediate and even in the long run time horizons the variations in Residential Average Price (RAP) are explained by innovations from Commercial Average Price (COM) and itself. In the long run in addition to the above two mentioned above the innovations from Transfer Payments (TRF) also explain the variations in Residential Average Prices (RAP).

In the contemporaneous time the variation in Commercial Average Price (COM) is explained by innovations from itself (100%). In the first year the variations are once again explained by innovations from Commercial Average Price (COM) (89.7%) and Residential Average Prices (RAP) (2.8%). In the second year the variations are explained by innovations from the same variables as in the contemporaneous and first year horizons. The innovations from Commercial Average Price (COM) (78.4%) and Residential Average Prices (RAP) (8.2%). In the third year the variations are explained by innovations from Commercial Average Price (COM) (67.1%), Residential Average Price (RAP) (7.2%), Population (POP) (8.2%) and Employment in Goods Sector (GP) (5.8%). In the fifth year the variations are explained by innovations from commercial average price(COM) (58.3%), Population (POP) (8.9%) and Employment in Goods Sector (GP) (8.3%), Adjustment for Residence (RAD)(6.3%)and Residential Average Price (RAP) (6.3%).In the contemporaneous, and the intermediate time horizons we can conclude that Commercial average price(COM) is exogenous. In the intermediate time horizon in addition to itself, Residential Average Price (RAP) and Population (POP) explain the variations in Commercial Average Price (COM). In the long run in addition to itself, Population (POP), Employment in Goods Sector (GP), Adjustment for Residence (RAD) and Residential Average Price (RAP) explain the variations in Commercial Average Price (COM).

Impulse Response Functions: Impulse response functions are presented as a matrix of graphs with each element of the matrix corresponding to the response of one series to a one time only shock in another series. The impulse response functions for model 1 are presented in Fig.3.4. Horizontal axes on the sub-graphs represent the horizon or number of years after shock, here 32 years. Vertical axes indicate the standardized response to the one time shock in the each variable labeled at the top of each column of graphs. Normalization allows for comparisons of relative responses across variables.

The responses of Employment in Goods Sector (GP), Adjustment for Residence (RAD) and Residential Average Prices (RAP) to shocks in Population (POP) are immediate and positive and dampen to zero quickly. The responses of Commercial Average Price (COM) are immediate, very small and negative followed by a positive response before it dampens to zero. The responses of Employment in service sector (SER), Dividends Interest and Rents (DIR) and Transfer Payments (TRF) are immediate, small and negative and also these responses dampen to zero quickly.

The responses of Population (POP) and Transfer Payments (TRF) to shocks in Employment in Goods Sector (GP) are immediate, strong and positive. However, the responses in Population (POP) do not dampen to zero immediately. In Transfer Payments (TRF) the strong positive impulse dampens to zero followed by a small negative response and finally another relatively smaller positive response. The Adjustment for Residence (RAD) responses can be termed as opposite to those of Transfer Payments (TRF). There is an immediate, strong negative response followed by a quick dampening to zero followed by a strong positive impulse. The responses in

Employment in service sector (SER) are strong and positive and these seem to be long lasting. Dividends Interest and Rents (DIR) responses are immediate, small and positive and dampen to zero quickly. The Residential Average Prices (RAP) and Commercial Average Price (COM) have responses which are immediate, small and negative and dampen to zero in the short run.

The responses of Population (POP) and Employment in Goods Sector (GP) to a shock in Employment in Service Sector (SER) are similar. Both have immediate, small and negative responses which dampen to zero almost immediately. The responses of Dividends Interest and Rents (DIR) are small, positive followed by small negative responses before it dampens to zero. Transfer payment's (TRF) response is negative which dampens to zero immediately. Adjustment for Residence's (RAD) response is positive which dampens to zero. The responses in Residential Average Prices (RAP) and Commercial Average Price (COM) are lagged and positive and dampen to zero thereafter.

Shocks in Dividends Interest and Rents (DIR) result in responses in Population (POP) which are immediate, small and positive followed by strong negative responses before dampening to zero. Employment in Goods Sector (GP) and Adjustment for Residence (RAD) responses are immediate and negative and dampen to zero thereafter. Employment in service sector (SER) responses are immediate, positive and seems to be long-lasting. Transfer Payments (TRF) responses start with an almost negligible negative response followed by a relatively stronger positive response. Dividends Interest and Rents (DIR) shocks seem to have no big responses from Residential Average Prices

(RAP) and Commercial Average Price (COM) even though, there seem to be small, negative responses in about the second or third time periods.

Shocks in Transfer Payments (TRF) result in responses in Population (POP) and Employment in Service Sector (SER) which are similar. In both the cases the responses are immediate and positive and they do no dampen to zero implying the responses are fairly long-lasting. Employment in Goods Sector (GP) responds to the shocks by immediate, small and positive responses. These responses also take some time before they dampen to zero. Dividends Interest and Rents (DIR) and Adjustment for Residence (RAD) responses are similar in the sense that both have immediate, small and negative responses followed by small positive responses which eventually dampen to zero. Residential Average Prices (RAP) and Commercial Average Price (COM) respond by lagged, small and negative responses.

Adjustment for Residence (RAD) shocks seems to have significant responses from Population (POP) when compared to those of the other variables in the system. The responses are immediate, strong and positive followed by a negative response which is followed by a positive response. The responses of Employment in Goods Sector (GP) are similar but relatively weaker to those of Population (POP). Employment in Service Sector (SER), Residential Average Prices (RAP) and Commercial Average Price (COM) respond in a similar fashion with immediate, weak and positive responses before dampening to zero. Dividends Interest and Rents (DIR) responds with an immediate, weak and negative response followed by a relatively stronger positive response. Responses of Transfer Payments (TRF) are relatively similar to those of Dividends

Interest and Rents (DIR), but for the strength of the responses.

Populations (POP), Employment in Goods Sector (GP), Dividends Interest and Rents (DIR) and Adjustment for Residence (RAD) have similar responses to Residential Average Prices (RAP) shocks. All of them respond with immediate, weak and negative responses which dampen to zero almost immediately. The difference that Employment In Service Sector (SER) responses have when to compared to those of the above mentioned variables are that the responses of Employment in Service Sector (SER) take a longer time to dampen to zero. Transfer Payments (TRF) and Commercial Average Price (COM) respond with immediate, small and positive responses before they dampen to zero.

Population (POP) and Employment in Service Sector (SER) have strong and negative responses that increase in magnitude after passage of time and do not dampen to zero even though, the magnitude decreases. Employment in Goods Sector (GP) and Transfer Payments (TRF) respond with immediate, negative and strong responses. Dividends Interest and Rents (DIR) and Adjustment for Residence (RAD) respond with immediate, weak and negative responses followed by weak, positive responses before dampening to zero. Residential Average Prices (RAP) have an immediate and strong positive response and dampens to zero thereafter.

Model 2

The directed acyclic graph shown in figure 3.2 is modified by directing the bi-directed edge from Residential Average Prices (RAP) to Transfer Payments (TRF). Also the undirected edge between Employment in Goods Sector (GP), Employment in Service Sector (SER), Dividends Interest and Rents (DIR) and Adjustment for Residence (RAD) as follows:

SER → GP

DIR → GP

SER → RAD

The directed acyclic graph that will be used in model 2 is presented in figure 3.5. The dashed edges (---->) in figure 3.5, indicate the edges that have been modified from the original directed acyclic graph.

The directed acyclic graph in figure 3.5 shows that Population (POP) is exogenous; Employment in Service Sector (SER), Dividends Interest and Rents (DIR) and Commercial Average Price (COM) appear to be exogenous as there are no variables that cause these variables in contemporaneous time. The information flow is Employment in Service Sector (SER) cause Employment in Goods Sector (GP), Transfer Payments (TRF) And Adjustment for Residence (RAD). Dividends Interest and Rents (DIR) cause Employment in Goods Sector (GP). Residential Average Prices (RAP) causes Transfer Payments (TRF). Commercial Average Price (COM) causes Residential Average Prices (RAP). Employments in Goods Sector (GP) and Transfer Payments (TRF) appear to be information sinks as they do not cause any other variable.

<u>Forecast Error Variance Decomposition:</u> Forecast error variance decompositions for model 2 are given in table 3.4. Listed are the decompositions for the horizons of zero (contemporaneous time) one, two, three and five years.

In the contemporaneous time the variation in Population (POP) is explained by innovations from itself (POP, 100%). The variations in the first year are explained by itself (61%), Dividends Interests Rents (DIR) (15.1%) and Transfer Payments (TRF) (11.2%). The variations in second year are explained by innovations from Population (POP) (26.5%), Employment in Goods Sector (GP) (26.4%), Transfer Payments (TRF) (17.9%) and Adjustment for Residence (RAD) (11.7%). In the third year the variations are explained by Employment in Goods Sector (GP) (27.3%), Transfer Payments (TRF) (22.4%), Adjustment for Residence (RAD) (17.2%) and Population (POP) (15.6%). In the fifth year the variations are explained mainly by innovations from Employment in Goods Sector (GP) (19.3%), Transfer Payments (TRF) (19%), Adjustment for Residence (RAD) (17.1%), Commercial Average Price (COM) (11.8%) and Dividends Interests Rents (DIR) (10.9%).In the contemporaneous time Population appears to be exogenous. In the intermediate time horizon the variations are explained by innovations from Population (POP), Employment in the Goods sector (GP), Transfer Payments (SER) and Adjustment for Residence (RAD). In the long run the variations in the Population (POP) are explained by innovations from itself, Employment in Goods Sector (GP), Transfer Payments (TRF), Adjustment for Residence (RAD) and Commercial Average Price (COM).

In the contemporaneous time the variation in Employment in Goods Sector (GP) is explained by innovations from itself (59.1%), Employment in Service Sector (SER) (28.7%) and Dividends Interest and Rents (DIR) (12.1%). The variations in the first year are explained by itself (46.2%), Transfer Payments (TRF) (19.5%) and Employment in Service Sector (SER) (12.1%). The variations in second year are explained by innovations from Employment in Goods Sector (GP) (43.9%), Transfer Payments (TRF) (21.2%) and Employment in Service Sector (SER) (9.7%). In the third year the variations are explained by Employment in Goods Sector (GP) (39.3%), Transfer Payments (TRF) (18.6%) and Employment in Service Sector (SER) (13.2%). In the fifth year the variations are explained mainly by innovations from Employment in Goods Sector (GP) (32.9%), Transfer Payments (TRF) (17.9%), Employment in Service Sector (12.4%) and Adjustment for Residence (RAD) (11.9%). In the contemporaneous time variations in Employment in the Goods Sector (GP) are explained by innovations from itself, Employment in service sector (SER) and Dividends Interests and Rents (DIR). In the intermediate and in the long run time horizons the variations are explained by innovations from itself (GP), Transfer Payments (TRF) and Employment in Service Sector (SER).

In the contemporaneous time the variation in Employment in service sector (SER) is explained by innovations from itself (100%). The variations in the first year are explained by itself (52.8%), Transfer Payments (TRF) (15.9%), Transfer Payments (TRF) (15.9%) and Employment in the Goods Sector (GP) (12.4%). The variations in second year are explained by innovations from Transfer Payments (30.7%), Employment in Service Sector (SER) (25.2%), Employment in Goods Sector (GP) (18.4%), and Dividends Interest and Rents (DIR) (16.2%). In the third year the variations are explained by innovations from Transfer Payments (TRF) (26.7%), Employment in Goods Sector (GP) (23.8%), Employment in Service Sector (22.3%), Transfer Payments (19.6%) and Dividends Interest and Rents (DIR) (12.7%). In the fifth year the variations are explained mainly by innovations from Transfer Payments (TRF) (29.5%), Employment in Goods Sector (GP) (21.9%), and Employment in Service Sector (SER) (18.6%), And Dividends Interest and Rents (DIR) (9.6%). In the contemporaneous time horizon Employment in Service Sector (SER) appears to be exogenous. In The Intermediate and the long run time horizons the variations are explained by innovations from Transfer Payments (TRF), Employment in Goods Sector (GP), Employment in Service Sector (SER), And Dividends Interest and Rents (DIR).

In the contemporaneous time the variation in Dividends Interest Rents (DIR) is explained by innovations from itself (100%). The variations in the first year are explained by itself (47.1%), Commercial Average Price(21.1%) and Residential Average Prices (15.8%). The variations in second year are explained by innovations from itself (42.5%), Residential Average Price (RAP) (21.9%) and Commercial Average Price (19%). In the third year the variations are explained by innovations from itself (39.9%), Residential Average Price (RAP) (22.1%) and Commercial Average Price (17.7%). In the fifth year the variations are explained mainly by innovations from innovations from itself (33.6%), Residential Average Price (RAP) (17.9%), Employment in Goods Sector (GP) (17.5%) and Commercial Average Price (17%). In the contemporaneous time horizon Dividends Interest Rents (DIR) is exogenous. In the intermediate time horizon the variations are explained by innovations from Residential Average Prices (RAP), Commercial Average Price (COM) and from itself. In the long run the variations are explained by innovations from Residential Average Prices (RAP), Commercial Average Price (COM), from itself and from Employment in Goods Sector (GP).

In the contemporaneous time the variation in Transfer Payments (TRF) is explained by innovations from itself (64.9%), Employment in service sector (SER) (21.8%) and Commercial Average Price (COM)(11%). In the first year the variations are explained by innovations from innovations from itself (52.6%), Employment in service sector (SER) (15.4%), Residential Average Price (RAP) (11.6%) and Commercial average price (COM) (9.7%). In the second year the variations are explained by innovations from innovations from innovations from itself (45.6%), Residential Average Price (RAP) (19.8%) and Employment in service sector (SER) (10.9%).In the third year the variations are explained by innovations from innovations from itself (41.8%), Residential Average Price (RAP) (15.2%) and Dividends Interest and Rents(DIR) (13.7%).In the fifth year the variations are explained by innovations from Transfer Payments (TRF) (31.9%), Dividends interest and rents (DIR) (23.6%), Employment in Goods Sector (GP) (10.7%) and Adjustment for Residence (RAD) (9.8%). In the contemporaneous time horizon variations in Transfer Payments (TRF) are explained by innovations from itself, Employment in service sector (SER) and Commercial Average Price (COM). In the intermediate time horizons the variations are explained by innovations from itself (TRF), Residential Average Price (RAP), Employment in service sector (SER) and Adjustment for Residence (RAD). In the long run the variations are explained by innovations from Transfer Payments (TRF), Dividends interest and rents (DIR), Employment in Goods Sector (GP), Adjustment for Residence (RAD) and Residential Average Price (RAP).

In the contemporaneous time the variation in Adjustment for Residence (RAD) is explained by innovations from itself (73.5%) and Employment in service sector (SER) (26.4%). In the first year the variations are explained by innovations from Adjustment for Residence (RAD) (46%), Dividends Interest and Rents (DIR) (21.6%) and Employment in service sector (SER) (18.7%). In the second year the variations are explained by innovations from Adjustment for Residence (RAD) (34.5%), Dividends Interest and Rents (DIR) (24.8%) and Employment in service sector (SER) (12.4%) and Employment in Goods Sector (GP).In the third year the variations are explained by innovations from Adjustment for Residence (RAD) (27%), Dividends Interest and Rents (DIR) (25.3%) ,Employment in Goods Sector (GP)(17.5%) and Employment in service sector (SER) (9.1%).In the fifth year the variations are explained by innovations from Dividends Interest and Rents (DIR) (24.7%) ,Employment in Goods Sector (GP)(24.4%) and Adjustment for Residence (RAD) (23.6%). In the contemporaneous time horizon variations in Adjustment for Residence (RAD) are explained by Employment in service sector (SER). In the intermediate time horizons the variations are explained by innovations from itself (RAD), Dividends Interest and Rents (DIR), and Employment in service sector (SER). In the long run the variations are explained by innovations from itself, Employment in Goods Sector (GP) and Dividends Interest and Rents (DIR).

In the contemporaneous time the variation in Residential Average Price (RAP) is explained by innovations from Commercial Average Price (COM) (84.3%) and itself (15.6%). In the first year the variations are once again explained by innovations from Commercial Average Price (COM) (81.4%) and itself (12.3%). In the second year the variations are explained by innovations from the same variables as in the contemporaneous and first year horizons. The innovations from commercial average price (COM) (74%) and itself (RAP) (13.6%). In the third year the variations are explained by innovations from Commercial Average Price (COM) (66.6%) and Residential Average Price (RAP) (12.5%), Transfer Payments (TRF) (5.2%) and Population (POP) (5.2%). In the fifth year the variations are explained by innovations from commercial average price(COM) (57.1%) and Residential Average Price (RAP) (12.4%), Transfer Payments (TRF) (9.6%) and Population (POP) (5.7%). In the contemporaneous, the intermediate and even in the long run time horizons the variations in Residential Average Price (RAP) are explained by innovations from Commercial Average Price (COM) and itself. In the long run in addition to the above two mentioned above the innovations from Transfer Payments (TRF) also explain the variations in Residential Average Prices (RAP).

In the contemporaneous time the variation in Commercial Average Price (COM) is explained by innovations from itself (100%). In the first year the variations are once again explained by innovations from Commercial Average Price (COM) (87.7%) and Residential Average Prices (RAP) (3%). In the second year the variations are explained by innovations from the same variables as in the contemporaneous and first year horizons. The innovations from Commercial Average Price (COM) (75.6%) and Residential Average Prices (RAP) (9.7%). In the third year the variations are explained by innovations from Commercial Average Price (COM) (65.5%), Residential Average Price (RAP) (8.3%) and Population (POP) (8.2%). In the fifth year the variations are explained by innovations from Commercial Average Price (COM) (59%), Population (POP) (9%), Residential Average Price (RAP) (7.7%) and Transfer Payments (TRF) (7.1%). In the contemporaneous, and the intermediate time horizons we can conclude that Commercial Average Price (COM) is exogenous. In the intermediate time horizon in addition to itself, Residential Average Price (RAP) and Population (POP) explain the variations in Commercial Average Price (COM). In the long run in addition to itself, Population (POP), Employment in Goods Sector (GP), Transfer Payments (TRF) and Residential Average Price (RAP) explain the variations in Commercial Average Price (COM).

Impulse Response Functions: The impulse response functions for model 2 are presented in figure 3.6.The responses of the variables to one time shocks in the one variable are very similar to those in model.1. The differences are discussed below. Shocks to the Employment in service sector (SER) in model 2 result in responses that are different from those from model 1. While in model 1 the Population (POP) responds with a strong and negative response in model 2 it responds with a strong, negative response which increases slightly in magnitude before it dampens to zero. These differences are not significantly different findings from Model 1 which shows that the model and the methodology are robust. The results of these models are discussed in the next chapter.

CHAPTER IV

DISCUSSION, CONCLUSIONS AND APPLICATIONS

In this chapter the results from the two models that we have developed in chapter III will be discussed in section 4.1 followed by some applications of this study in section 4.2.

4.1 Discussion

The directed acyclic graphs, the forecast error variance decompositions and impulse response functions resulting from this study uncover interactions between the variables used in this study that confirm the findings of earlier studies that dealt with regional economies and energy-economy linkages. However there were some interactions that were unexpected, at least at the beginning of this study.

In contemporaneous time, causal flows among the variables used in this study as given by directed acyclic graphs reflect that there are significant interactions among income related variables (DIR, TRF and RAD) and between income related variables and employment variables (GP and SER). These interactions were expected and they support some of the findings of earlier studies that dealt with economic activity and the energy-economic linkages. The result that is arrived at by the directed acyclic graphs, the causal flows from Employment in Goods Sector (GP) to employment in service sector (SER), is in line with the concept of basic and service sector employment as laid out by Economic base models used in Economic Base models (Leven, 1956). Another observation that is in line with existing body of knowledge is the causal flows from Adjustment for Residence (RAD) to Employment in service sector (SER). This observation supports one of the drawbacks of economic base models of regional economy which suggests that service employment exists only to support the basic industry. (Econometric Analysis of Regional Analysis, Glickman. pp.26). With the causal flows from both Adjustment for Residence (RAD) and Employment in goods employment to Employment in service employment (SER) we know that Employment in service employment does not depend entirely Employment in Goods Sector (analogous to Basic employment used in Economic base models).

The forecast error variance decomposition and the impulse response functions resulting from the VAR models allow us to analyze dynamic information flows overtime. Employment in the goods sector (GP) is an exogenous variable in the short term but in the intermediate and long run the variations are explained by Employment in service sector (SER), Transfer Payments (TRF) and Commercial Average Price (COM). The Commercial Average Price (COM) having an influence on Employment in Goods Sector (GP) as showed by forecast error variance decomposition confirms the early studies focusing on energy prices and economy. This result is also confirmed by impulse response functions. The shocks in Commercial Average Price (COM) result in a negative and immediate response. However the unexpected result once again is the effect of Transfer Payments (TRF) on Employment in Goods Sector (GP). This result is consistent in both forecast error variance decomposition and impulse response functions. While Transfer Payments (TRF) explain the variations in the Employment in Goods Sector (GP) the vice versa is not the case. Also the Employment in Service Sector (SER) changes are explained by Employment in Goods Sector (GP) in the contemporaneous and in the long run. In the short and intermediate time frames the changes in employment in service sector (SER) are explained by Transfer Payments (TRF) along with Employment in Goods Sector (GP) and by itself. In the long run however, other than itself, Commercial Average Price (COM) explains a good portion of changes in employment in service employment (SER).

Changes in Dividends, Interests and Rent (DIR) are also explained to a large extent, in the short run and in the long run by Employment in Goods Sector (GP) and Transfer Payments (TRF). Employment in the goods sector (GP) also explains changes in Transfer Payments (TRF) in the long run. Employment in the goods sector (GP) and Commercial Average Price (COM) account for changes in the population in the intermediate and long-term time horizons (Miernyk, 1978). The changes in adjustment for residents (RAD) in the long run are once again explained by Employment in Goods Sector (GP) and Transfer Payments (TRF). Commercial Average Price(COM) seem to be exogenous to the system, while it accounts significantly for changes in Residential Average Prices (RAP). Both these findings about the electricity prices (COM & RAP) are consistent with the findings of the directed acyclic graphs. Going by the forecast error variance decomposition and impulse response functions obtained from the VAR model used in this study, it appears that the changes in the economic variables are caused by employment in the goods sector (GP), employment in service sector (SER) and Transfer Payments (TRF). The changes in employment in service sector (SER), in turn can be attributed to Employment in Goods Sector (GP) and Commercial Average Price (COM). The changes in Employment in Goods Sector (GP) in turn are determined by itself and Commercial Average Price (COM) in the medium and long run time horizons.

From the above discussion we might tentatively say that employment in the goods sector (GP), Commercial Average Price (COM) and Transfer Payments (TRF) account for changes in the other variables used in the study. We might also say that Commercial Average Price (COM) transmits its impacts into the system (VAR Model) through Employment in Goods Sector (GP) and Transfer Payments (TRF). Using the impulse response functions of the Commercial Average Price (COM) we see that a one-time shock to the Commercial Average Price (COM) results in negative responses from all the other variables in the system except Residential Average Prices (RAP) which have a strong positive response. One interesting observation is the difference in the time horizons in which the negative responses of Employment in Goods Sector (GP) and Employment in Service Sector (SER); while the former reaches its maximum in a time horizon ‘t’ (say) the latter reaches its maximum in ‘t*’. Where‘t*’>‘t’. These findings are in line with those of the earlier studies in the field of energy-economy linkage (Hudson & Jorgenson, 1978 and Miernyk, 1978). This shows that this methodology of using VAR is robust and the results are reliable. However, the role of Transfer Payments (TRF) in the above discussed interactions unraveled by the VAR Model come as a surprise and might make an interesting subject for future studies in the field energy economy linkage.

4.2 Conclusions

From the reviewing the existing body of knowledge relevant to this study we found out that there are some issues that were not properly addressed in the earlier studies, the same were addressed in this study. The first issue that was identified in the earlier studies was the effect of rising energy prices would have on employment levels. The second notable issue that was identified from the earlier studies was the over dependence on national level variables in regional economic models. The third issue that was identified in the earlier studies was the inability to model the contemporaneous causal flows between the participating variables of the study. All the above issues have been addressed in the present study. As far as the effect of rising electricity prices on employment levels is concerned, based on the results of our study we can conclude that a one-time shock to the Commercial Average Price (COM) results in negative responses from all the other variables in the system except Residential Average Prices (RAP) which have a strong positive response. The negative impacts on the employment in service sector can be seen in a time horizon different than the one in which the commercial electricity prices changed. We can also conclude from the results of our study that employment in the goods sector (GP), Commercial Average Price (COM) and Transfer Payments (TRF) account for changes in the other variables used in the study. We might also say that Commercial Average Price (COM) transmits its impacts into the system (VAR Model) through Employment in Goods Sector (GP) and Transfer Payments (TRF). The second and third issues are taken care of the VAR model that we used in this study. The biggest gain from this study is the versatility and flexibility that a

VAR Model can bring to the regional economic studies that have variables which are determined at a macro level but might transmit their impacts at a micro level. This study shows that this methodology can be used to address policy issues at a regional level.

4.3 Applications

Uses to Utilities, Coops and Municipalities

- Use the findings about TRF and RAP in planning for better cash flow management.
- New Opportunities exist where there is good population growth. Especially useful when operating in dual certified territories.
- Operating in territories with more labor mobility might help in good price hikes for the utility.
- Since the effects of rising electricity prices vary between service and goods sector depending on the composition of the consumer base the utility might go about the price rises in a judicious manner so that the effects are not adverse.

Uses to the Consumer

- The regulatory body which oversees the electricity price hikes can use this study to determine how adversely the price rise might affect the consumers of the energy provider.
- The findings of this study can be used as starting points for much more focused efforts.

REFERENCES

Baltagi, B., B. Georges, P. Alain. "Comparison of Forecast Performance for Homogeneous, Heterogeneous and Shrinkage Estimators." *Economics Letters* 76 (August 2002):375-382.

Bernanke, B.S. "Alternative Explanations of the Money-Income Correlation." *Carnegie-Rochester Conference on Public Policy* 25(1986):49-99.

Bell, F.W. "An Econometric Forecasting Model for a Region." *Journal of Regional Science* 7(1967):109-127.

Bessler, D.A. "An Analysis of Dynamic Economic Relationships: An Application to the US Hog Market." *Canadian Journal of Agricultural Economics* 32(March 1984):109-124.

Bessler, D.A., and A. Kergna. "Price Discovery: The Case of Millet in Bamako, Mali." *Journal of African Economics* 11(December 2003):472-502.

Bessler, D. A., and S.Lee. "Money and Prices: US Data 1869-1914, A Study with Directed Graphs." *Empirical Economics* 27(2002):427-446.

Baughman, M. *Electricity and Economic Growth* Committee on Electricity and Economic Growth, National Research Council. Washington D.C National Academy Press, (1986).

Crow, R.T. "A Nationally Linked Regional Econometric Model," *Journal of Regional Science* 13(1973):187-204.

Denison, E. *Why Growth Rates Differ: Postwar Experience in Nine Western Countries*. Washington DC: Brookings Institution, 1974.

Doan, T. A. *Regression Analysis for Time Series (RATS)*, Version 4. Evanston, IL : Esima, 1996.

Dutta, M., and V. Su "An Econometric Model of Puerto Rico."*Review of Economic Studies* 36(1969):319-333.

Glickman, N. J. *Econometric Analysis of Regional Systems- Explorations in Model Building and Policy Analysis*. New York: Academic Press, 1977.

__________. "An Econometric Model of the Philadelphia Region." Ph.D. dissertation: University of Pennsylvania, 1969.

__________. “An Econometric Model of the Philadelphia Region.” *Journal of Regional Science* 11(1971):15-32.

__________. “Econometric Analysis of a Regional System I: A Forecasting Model.” Discussion Paper No.290, Department of Economics: University of Pennsylvania, Philadelphia, 1974.

__________, F. G Adams, and W. Milne. “A Framework for Analyzing Regional Growth and Decline: A Multi-region Econometric Model of the United States," *Journal of Regional Science (*May, 1980): 173-190

Hamilton, J.D. *Time Series Analysis.* Princeton, NJ: Princeton University Press, 1994.

Hannon, B. “Energy, Labor and the Consumer Society.” *Technology Review* (March/April 1977):1-6.

Hamilton, J.D. *Time Series Analysis.* Princeton, NJ: Princeton University Press, 1994.

Hauser, P.M., and O.D. Duncan. “Population and Development, a General Model.” *Quarterly Journal of Economics* 77(1963):55-70.

Hirsch, W.Z. “An Application of Area Input – Output Analysis.” *Papers and Proceedings of the Regional Science Association* 5, (1959a): 79-94

________ “Interindustry Relations of a Metropolitan Area.” *Review of Economics and Statistics* 41(1959b):360-369.

Hudson, E. A., and D.W. Jorgenson. “Energy Prices and the US Economy: 1972-1976.” *Natural Resources Journal* 18, 4(October 1978):877-897.

Isard, W. T., W. Langford, and E. Romanoff. *The Philadelphia Region Input-Output Study.* Philadelphia: Regional Science Research Institute, 1967.

Jorgenson, D., and H. S. Houthakker. “Energy Resources and Economic Growth.” A Draft Report to the Energy Policy Project, New York, 1973.

Kaldor, N. “A Model of the Trade Cycle.” *Economic Journal* 50(1940):78-92.

Kendrick, J.W., and M.C. Jaycox. “The Concept and Estimation of Gross State Product.” *Southern Economic Journal* 32(1965):153-168.

Leven, C.L. “Measuring the Economic Base.” *Papers of the Regional Science Association* 2(1956):250-258.

Mankiw, G.N. *Macroeconomics* New York: Worth Publishers, 1986.

Miernyk, W. H. *The Differential Effects of Rising Prices on Regional Income and Employment*. Baltimore, MD: Johns Hopkins University Press. 1982, pp. 297-330.

Miernyk, W.H., F. Giarrantani, and C.F. Socher. *Regional Impacts of Rising Energy Prices*. Boston: Ballinger Publishing Company, 1970, pg. 44.

Milne, W.J., N.J. Glickman, and F.G. Adams. "A Framework for Analyzing Regional Growth and Decline: A Multi-Region Econometric Model of the US." *Journal of Regional Science* 20, 2(1980):173-189.

Moore, F., and J.Peterson, "Regional Analysis: An Interindustry Model of Utah." *Review of Economics and Statistics* 37 (1955): 368-380

Nordlund, W.J., and T.R. Robson. *Energy and Employment*. New York: Praeger Publishers, 1980.

Norman, M., R. Russell., and J. Hambor "A Tax Revenue Forecasting Model for the State of Hawaii." *Public Finance Quarterly* 2 (1974): 432-450.

Pearl, J. *Causality*. Cambridge: Cambridge University Press, 2000.

Popper, K.R. *The Logic of Scientific Discovery*. New York: Harper and Row, 1968.

Richardson, H.W. *Elements of Regional Economics,* Baltimore, MD: Penguin 1969.

Rosenberg, N. "The Effects of Energy Supply Characteristics on Technology and Economic Growth." *Energy, Productivity and Economic Growth* (1983):279-305.

Rostow, W.W *The World Economy: History And Prospect* Austin: University of Texas Press, 1978

Scheines, R., P. Spirtes, C. Glymour, and C. Meek. *Tetrad II: Tools for Causal Modeling: Users Manual*. Pittsburgh: Carnegie Mellon University, 1993.

Schurr, S., B.C. Netschert, V.E. Eliasberg, J. Lerner, and H.H Landsberg. *Energy in American Economy, 1850-1975: Its History and Prospects* Baltimore, MD: Johns Hopkins University Press for Resources for Future, 1960.

Siebert, Horst. "*Regional Economic Growth: Theory and Policy*." Scranton, Pennsylvania: International Textbook Company, 1969.

Spirtes, P., C. Glymour, and R. Schenies. *Causation, Prediction and Search.* Cambridge, MA: MIT Press, 2000.

Sonenblum, S. *Energy Connections: Between Energy and the Economy.* Cambridge, MA: Ballinger Publishing Company, 1978.

Stouffer, S.A. "Intervening Opportunities: A Theory Relating Mobility and Distance." *American Sociological Review* 5(1940):845-867.

Thompson, W. *A Preface to Urban Economics*. Baltimore, MD: Johns Hopkins University Press, 1965.

Yeates, M.H., and B. J. Garner. *The North American City*. New York: Harper and Row, 1971.

APPENDIX A

FIGURES

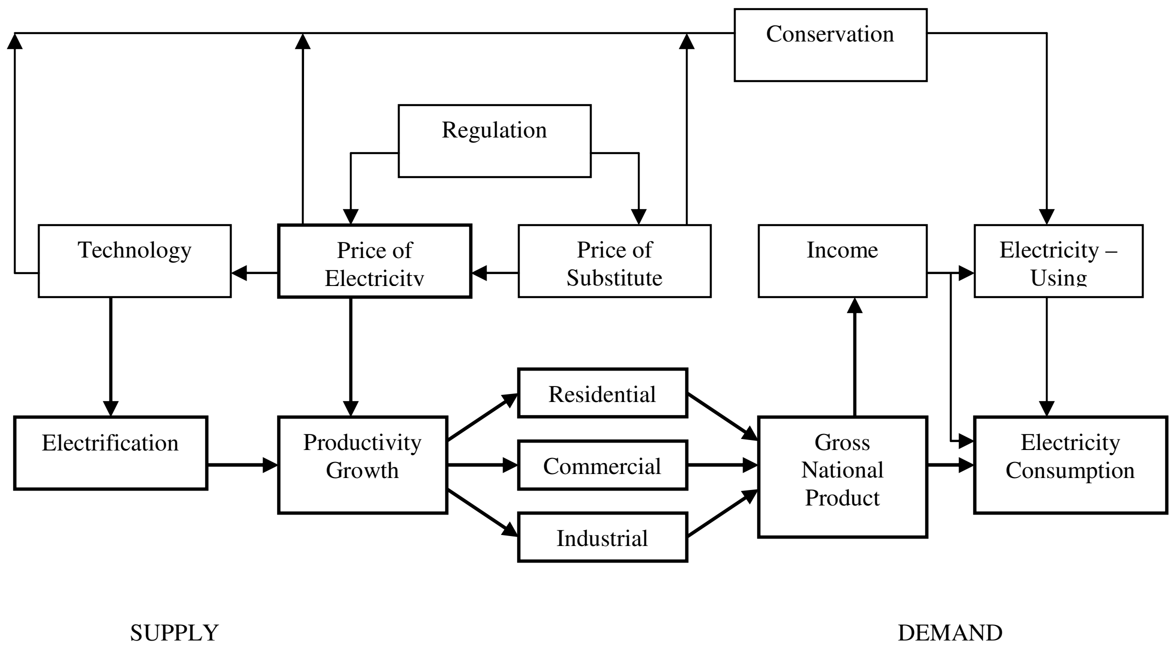

Figure 1.1 Relationship Affecting Electricity and Economic Growth
(Source: Committee on Electricity and Economic Growth, 1986, Pg 6)

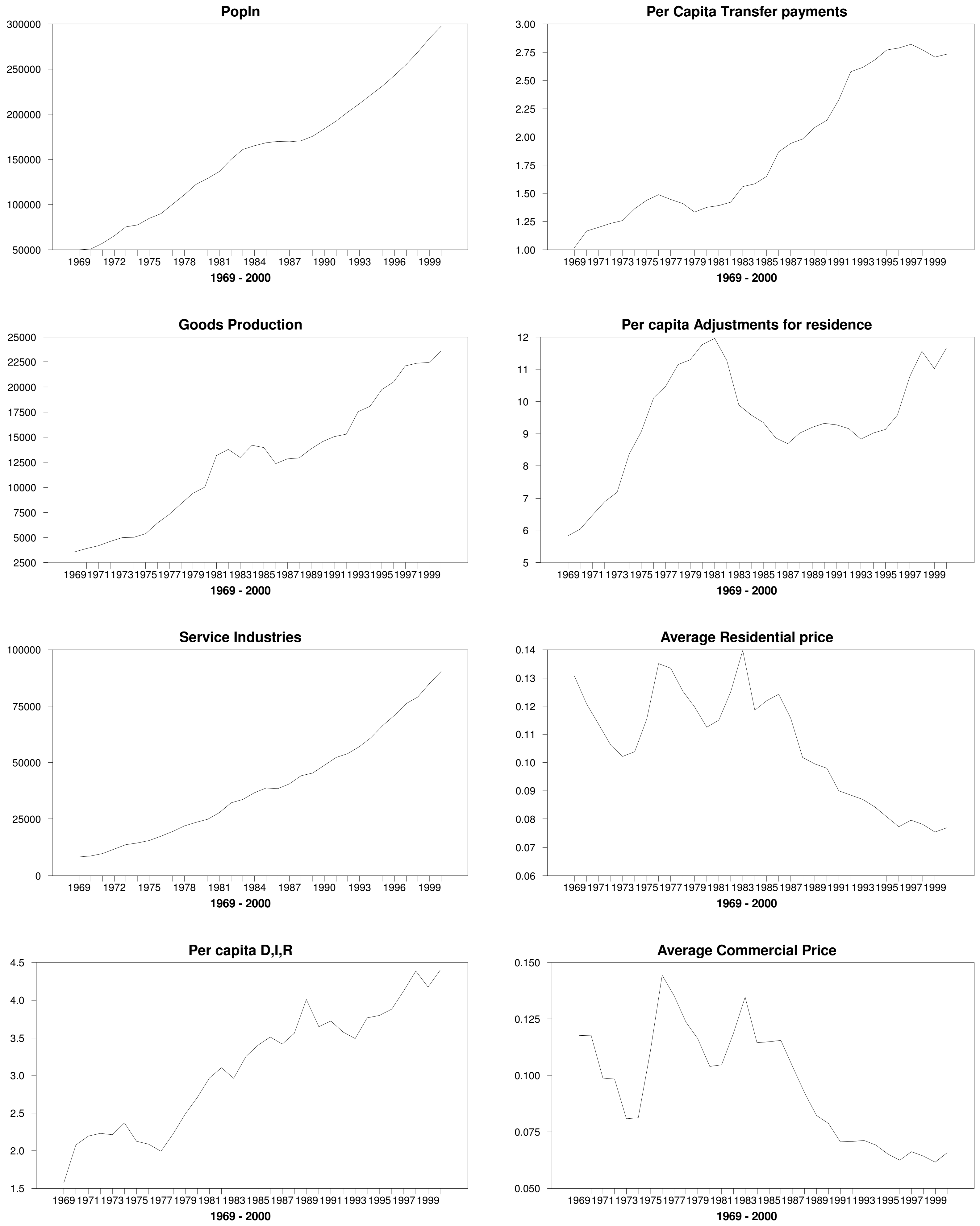

Figure 3.1 Data Plots for All Eight Series [1]

- All the variables except employment levels are adjusted for inflation.
- All the variables except electricity prices are computed on a per capita basis.
- All the data (except electricity prices) for this study is from the Regional Economic Information System data set of the Bureau of Economic Analysis, for the Montgomery County, Texas. All data is from 1969 to 2000.
- The electricity price data is provided by Mid-South Synergy, an electric utility company providing electricity to areas of Montgomery County, Texas.

[1] Table 3.6 gives the full form of the variable acronyms used in this study

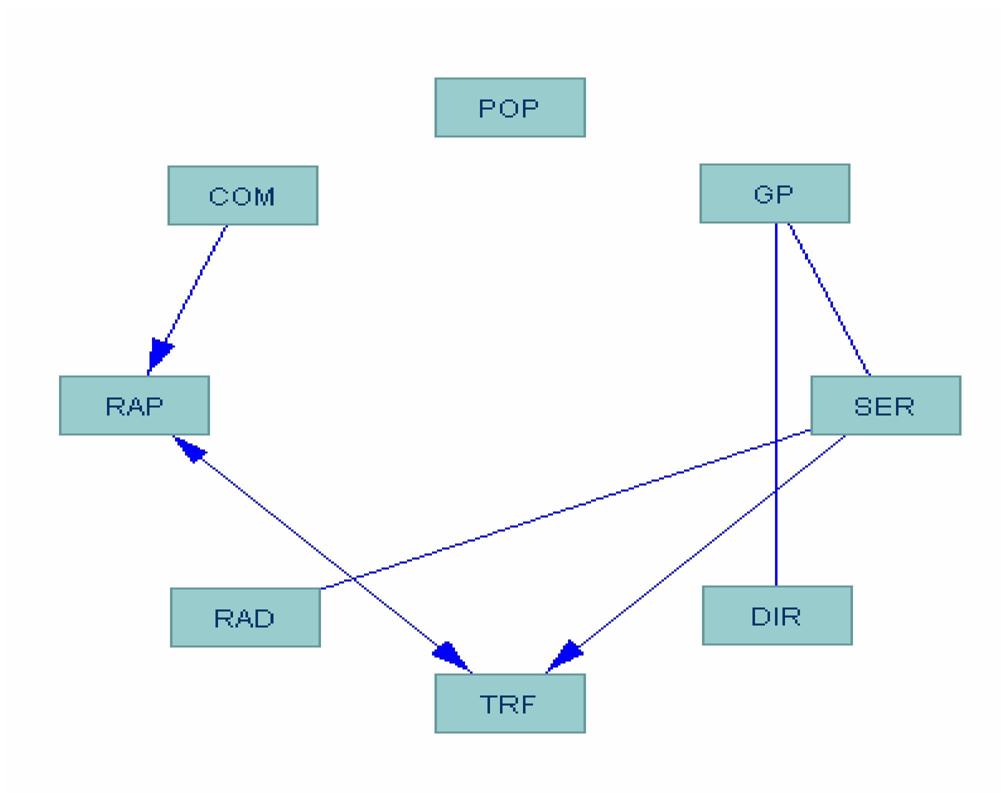

Figure 3.2 Directed Acyclic Graphs at 20% Significance Level [2]

[2]Table 3.6 gives the full form of the variable acronyms used in this study

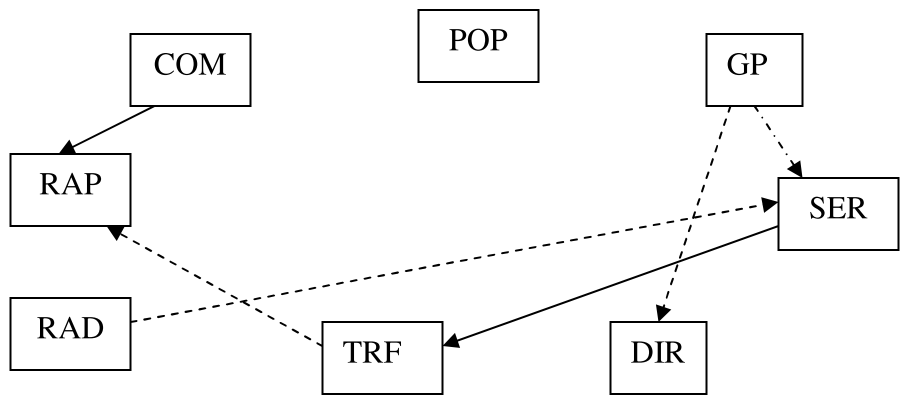

Figure 3.3 Directed Acyclic Graphs for Model 1 [3]
Here the undirected and bi directed edges have been assigned a direction.

[3] Table 3.6 gives the full form of the variable acronyms used in this study

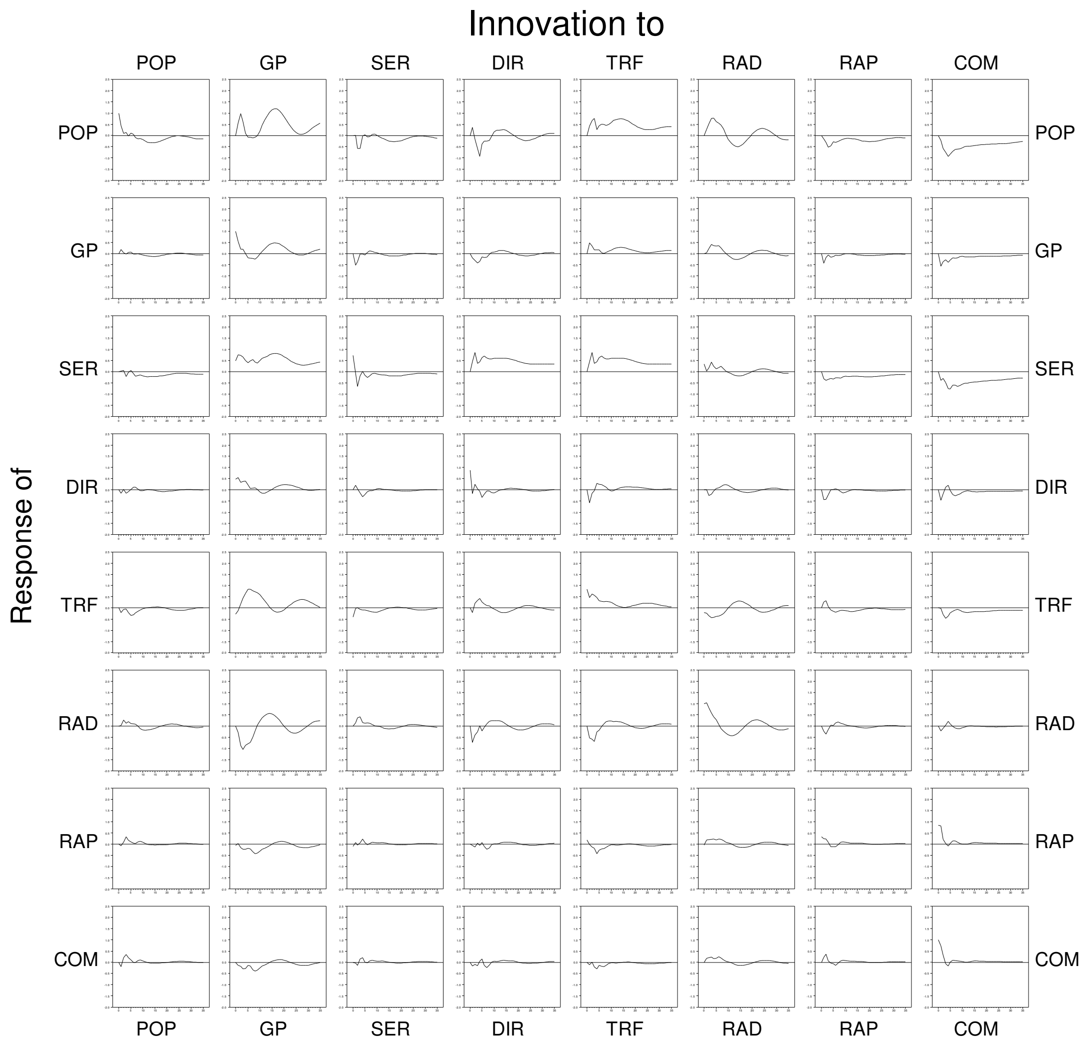

Figure 3.4 Impulse Response Functions for Model 1 [4]

[4] Table 3.6 gives the full form of the variable acronyms used in this study

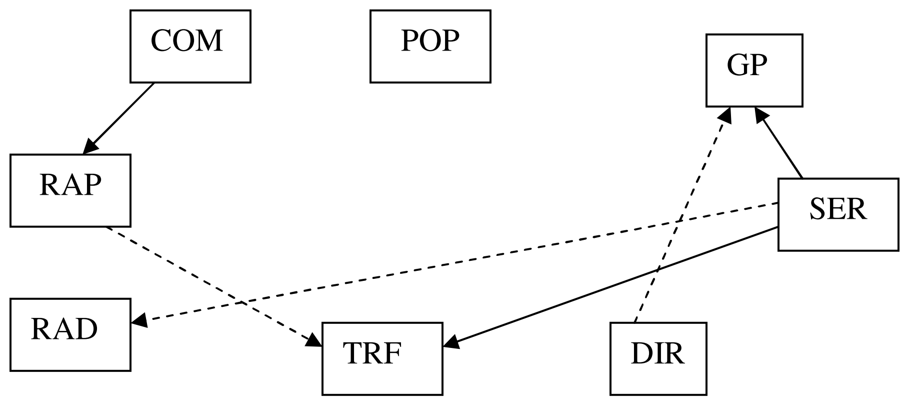

Figure 3.5 Directed Acyclic Graphs for Model 2 [5]
Here the undirected and bi directed edges have been assigned a direction.

[5] Table 3.6 gives the full form of the variable acronyms used in this study

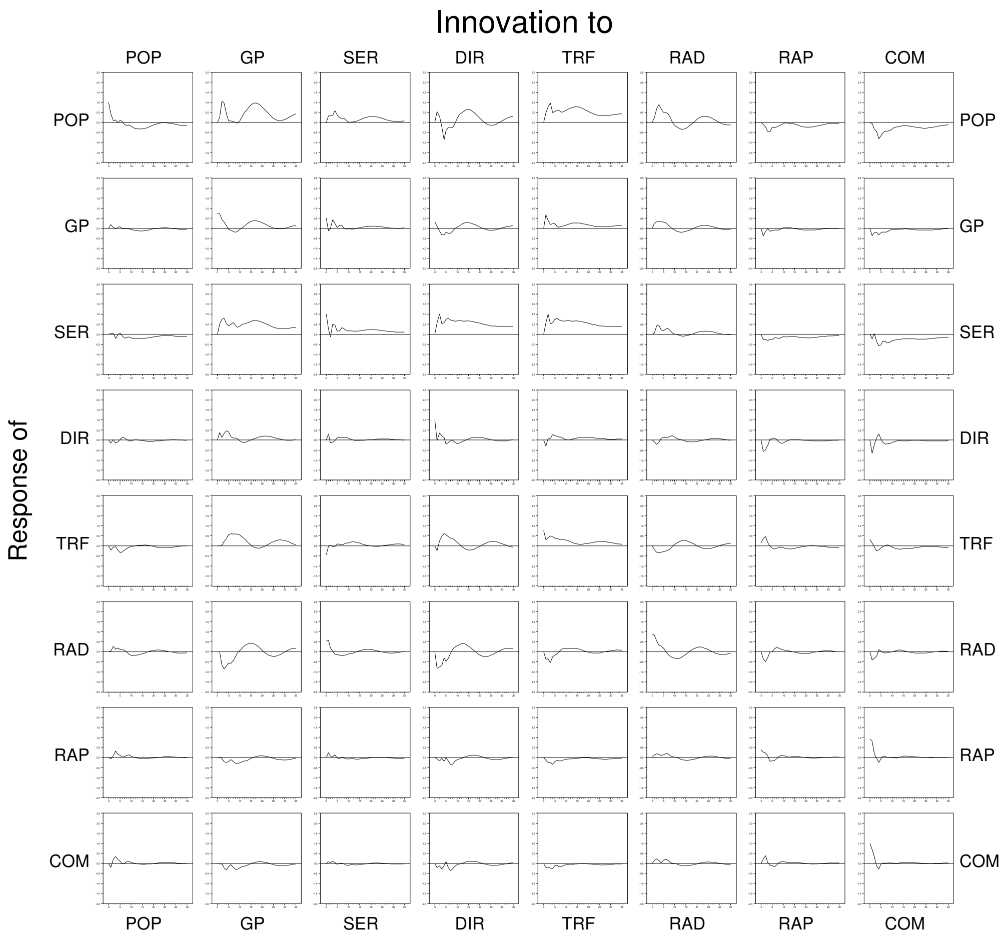

Figure 3.6 Impulse Response Functions for Model 2 [6]

[6] Table 3.6 gives the full form of the variable acronyms used in this study

APPENDIX B

TABLES

Table 3.1 Tests for Stationarity, First Differences [7]

	Dickey –Fuller		Augmented DF	
Variable	t-stat	SL	t-stat	SL
POP	2.13109	16.6545	0.61701	16.296
GP	0.20834	13.7057	0.17626	13.834
SER	5.34623	14.1962	3.83346	14.322
DIR	-0.41921	-3.1432	-0.40279	-3.033
TRF	-0.05959	-4.9866	-0.23257	-5.013
RAD	-1.97697	-1.0658	-2.20443	-1.239
RAP	-0.79026	-9.4546	-1.08811	-9.377
COM	-1.25237	-8.6497	-1.79532	-8.641

[7] Table 3.6 gives the full form of the variable acronyms used in this study

Table 3.2 Tests for Stationarity, First Differences and Logged [8]

	Dickey – Fuller		Augmented DF	
Variable	t-stat	SL	t-stat	SL
POP	-4.67484	-6.9913	-3.43070	-6.974
GP	-1.97556	-5.1891	-1.75958	-5.072
SER	-3.96777	-6.6736	-3.22139	-6.554
DIR	-0.75589	-5.4192	-0.73659	-5.290
TRF	-0.60941	-6.2723	-0.48537	-6.245
RAD	-2.60787	-5.6763	-2.53042	-5.870
RAP	-0.49025	-5.1856	-0.85285	-5.121
COM	-1.02131	-4.1699	-1.56223	-4.164

[8] Table 3.6 gives the full form of the variable acronyms used in this study

Table 3.3. Variance –Covariance Matrix (∑) [9]

	POP	GP	SER	DIR	TRF	RAD	RAP	COM
POP	9.4320E-05							
GP	7.1616E-05	1.3812E-03						
SER	5.2443E-05	3.0898E-04	1.8935E-04					
Σ=DIR	-3.6334E-05	5.4442E-04	1.2076E-04	9.4189E-04				
TRF	-7.9288E-05	-1.8367E-04	-1.5706E-04	-2.3371E-04	4.3059E-04			
RAD	-3.7196E-05	2.9754E-04	1.7299E-04	2.1207E-04	-1.5634E-04	5.9684E-04		
RAP	-1.2536E-04	-3.6475E-04	-1.7447E-04	-5.8933E-04	4.1662E-04	-5.8601E-05	1.7496E-03	
COM	-1.2710E-04	-6.3021E-04	-1.8526E-04	-8.5563E-04	4.0374E-04	1.4097E-04	2.5148E-03	4.2879E-03

[9] Table 3.6 gives the full form of the variable acronyms used in this study

Table 3.4 Forecast Error Variance Decomposition for Model 1 [10]

Decomposition of Variance for Population (POP)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.00971	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.01362	60.500	15.778	0.00	7.129	9.281	3.929	1.063	2.319
2	0.02043	27.061	28.371	7.667	3.771	14.060	7.808	2.548	8.714
3	0.02655	16.281	21.957	8.991	6.692	15.976	12.469	5.131	12.502
5	0.03314	10.555	14.230	5.785	12.948	12.545	16.612	5.863	21.462

Decomposition of Variance for Goods Employment (GP)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.03716	0.00	100.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.05703	1.355	54.630	11.434	1.603	9.907	0.059	7.722	13.290
2	0.06352	1.148	45.286	13.531	4.425	11.741	1.656	7.280	14.932
3	0.06853	0.999	40.078	11.630	8.843	10.921	6.247	6.337	14.944
5	0.07592	1.050	33.565	9.556	10.516	10.330	10.968	6.113	17.904

Decomposition of Variance for Services Employment (SER)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.01295	0.00	26.856	58.956	0.00	0.00	14.189	0.00	0.00
1	0.01934	0.066	41.489	26.727	2.809	9.604	6.439	4.969	7.897
2	0.02766	0.125	33.216	23.732	3.553	23.358	3.942	5.910	6.163
3	0.03237	0.930	32.328	17.959	7.727	19.647	6.062	6.393	8.954
5	0.03926	0.680	27.026	12.490	7.106	20.502	5.079	6.816	20.299

Decomposition of Variance for Dividends, Interests, Rent (DIR)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.03069	0.00	22.783	0.00	77.217	0.00	0.00	0.00	0.00
1	0.04486	1.083	25.079	1.956	37.443	15.446	0.00	9.143	9.850
2	0.04986	0.902	24.897	1.678	33.134	13.460	2.309	14.342	9.277
3	0.05231	1.595	27.289	2.147	29.890	12.149	3.364	14.707	8.859
5	0.05803	1.507	27.969	5.676	27.604	13.980	2.916	11.964	8.384

[10] Table 3.6 gives the full form of the variable acronyms used in this study

Table 3.4 Continued [11]

Decomposition of Variance for Transfer Payments (TRF)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.02039	0.00	7.460	16.377	0.00	72.222	3.941	0.00	0.00
1	0.02468	3.218	6.255	11.216	2.940	65.014	6.568	4.767	0.020
2	0.03079	2.272	5.536	7.223	3.888	59.479	9.861	7.933	3.808
3	0.03735	1.635	9.903	5.018	6.102	50.220	12.491	5.512	9.119
5	0.04933	3.765	25.862	3.124	7.780	34.420	12.827	3.679	8.544

Decomposition of Variance for Adjustment for Residence (RAD)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.02443	0.00	0.00	0.00	0.00	0.00	100.00	0.00	0.00
1	0.04299	0.033	2.635	0.655	16.935	9.156	67.390	1.761	1.435
2	0.05666	1.354	15.691	2.909	12.696	11.767	51.079	3.503	1.002
3	0.06711	1.193	25.689	4.288	9.921	14.540	40.825	2.814	0.731
5	0.07517	1.496	35.001	3.833	8.369	12.654	35.176	2.270	1.202

Decomposition of Variance for Residential Average Price (RAP)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.03931	0.00	0.421	0.925	0.00	4.077	0.223	12.442	81.912
1	0.05405	0.263	0.287	0.734	0.238	2.158	2.433	10.155	83.732
2	0.05735	0.659	1.542	0.739	1.144	2.808	4.413	11.870	76.826
3	0.06112	5.715	3.569	0.773	1.102	4.011	6.263	10.868	67.697
5	0.06869	6.013	5.759	2.848	1.210	12.513	8.382	9.401	53.874

Decomposition of Variance for Commercial Average Price (COM)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.06548	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
1	0.08577	2.214	1.286	0.040	1.576	0.592	1.719	2.816	89.757
2	0.09469	3.858	2.717	0.998	1.738	0.487	3.432	8.290	78.479
3	0.10246	8.200	5.814	1.676	2.507	2.229	5.114	7.264	67.196
5	0.11092	8.962	8.343	2.935	2.898	5.710	6.384	6.393	58.375

[11] Table 3.6 gives the full form of the variable acronyms used in this study

Table 3.5 Forecast Error Variance Decomposition for Model 2 [12]

Decomposition of Variance for Population (POP)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.00971	100	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.01355	61.042	3.403	5.720	15.127	11.276	2.897	0.409	0.126
2	0.02063	26.535	26.492	5.017	8.473	17.975	11.774	1.302	2.432
3	0.02710	15.623	27.360	4.496	5.524	22.470	17.204	3.347	3.975
5	0.03373	10.189	19.371	6.950	10.937	19.077	17.175	4.480	11.822

Decomposition of Variance for Goods Employment (GP)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.0353	0.00	59.107	28.716	12.177	0.00	0.00	0.00	0.00
1	0.0562	1.395	46.256	12.104	5.313	19.527	2.737	6.669	5.999
2	0.0626	1.181	43.935	9.753	5.041	21.283	6.163	6.057	6.587
3	0.0687	0.993	39.359	13.238	7.318	18.626	8.740	5.051	6.675
5	0.0757	1.054	32.974	12.412	9.459	17.948	11.962	4.937	9.254

Decomposition of Variance for Services Employment (SER)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.0137	0.00	0.00	100.00	0.00	0.00	0.00	0.00	0.00
1	0.0194	0.065	12.485	52.805	12.229	15.936	0.204	3.738	2.537
2	0.0284	0.118	18.490	25.289	16.290	30.704	4.421	3.476	1.212
3	0.0335	0.866	23.830	22.398	12.734	26.723	6.407	4.129	2.913
5	0.0397	0.663	21.995	18.683	9.678	29.502	5.437	4.582	9.460

Decomposition of Variance for Dividends, Interests, Rent (DIR)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.0306	0.00	0.00	0.00	100.00	0.00	0.00	0.00	0.00
1	0.0447	1.090	6.495	3.783	47.102	4.113	0.343	15.889	21.185
2	0.0498	0.895	5.816	3.764	42.594	3.607	2.282	21.963	19.080
3	0.0523	1.592	8.873	3.758	39.910	3.546	2.470	22.149	17.702
5	0.0584	1.484	17.588	3.404	33.669	6.156	2.753	17.919	17.027

[12] Table 3.6 gives the full form of the variable acronyms used in this study

Table 3.5 Continued [13]

Decomposition of Variance for Transfer Payments (TRF)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.0197	0.00	0.00	21.885	0.00	64.992	0.00	2.060	11.063
1	0.0235	3.536	0.00	15.413	4.195	52.602	2.819	11.699	9.737
2	0.0281	2.723	0.096	10.919	6.558	45.658	7.182	19.860	7.003
3	0.0332	2.065	2.001	7.896	13.752	41.850	9.811	15.233	7.391
5	0.0439	4.747	10.752	4.709	23.644	31.992	9.853	9.015	5.289

Decomposition of Variance for Adjustment for Residence (RAD)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.0244	0.00	0.00	26.478	0.00	0.00	73.522	0.00	0.00
1	0.0430	0.033	0.002	18.793	21.635	4.322	46.008	3.813	5.394
2	0.0545	1.459	8.786	12.424	24.863	5.161	34.556	7.382	5.369
3	0.0634	1.333	17.555	9.190	25.306	8.211	27.082	6.632	4.690
5	0.0700	1.721	24.431	7.925	24.788	7.971	23.679	5.445	4.040

Decomposition of Variance for Residential Average Price (RAP)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.0418	0.00	0.00	0.00	0.00	0.00	0.00	15.699	84.301
1	0.0569	0.237	0.016	3.640	0.220	0.955	1.083	12.362	81.487
2	0.0602	0.597	0.096	3.607	1.580	3.648	2.770	13.672	74.029
3	0.0635	5.279	1.851	3.304	1.488	5.296	3.761	12.509	66.512
5	0.0700	5.784	5.097	3.355	2.427	9.699	4.129	12.403	57.105

Decomposition of Variance for Commercial Average Price (COM)

Step	Std.Error	POP	GP	SER	D,I,R	TRF	RAD	RAP	COM
0	0.0654	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100.00
1	0.0850	2.250	0.055	0.504	2.392	2.571	1.483	3.015	87.732
2	0.0946	3.863	0.081	0.464	2.651	3.646	3.867	9.736	75.691
3	0.1023	8.214	2.066	0.981	5.481	5.259	4.089	8.382	65.528
5	0.1106	9.011	6.308	0.981	5.353	7.146	4.417	7.761	59.022

[13] Table 3.6 gives the full form of the variable acronyms used in this study

Table 3.6 List of Variables Used in This Study

Variable Acronym	Full form
POP	Population
GP	Employment in Goods Sector
SER	Employment in Service Sector
DIR	Dividends, Interests and Rents
RAD	Adjustment for Residence
TRF	Transfer Payments
RAP	Residential Average Prices
COM	Commercial Average Prices

APPENDIX C

REGRESSION ANALYSIS FOR TIME SERIES (RATS)

INPUT PROGRAMS USED IN THE THESIS

1. **Plots of the series for each variable.**

```
*************** RATS Input Program for plots of the series ****************
************************for eight variables************************

calendar 1969 1 1
allocate 40 2001
eqv 1 to 8
X1 X2 X3 X4 X5 X6 X7 X8 $
DX1 DX2 DX3 Dx4 DX5 DX6 DX7 DX8
**** data are in files listed in the following two lines
open data a:mont.txt
data(format=free,org=obs) 1969:1 2000:1  1 to 8
**********************************************
open plot a:\plot1.rgf
spgraph(vfields=4,hfields=2)

graph(patterns,header="Popln",max=300000,min=50000,$
HLABEL='1969 - 2000',VLABEL=' ') 1
# x1 1969:1  2000:1 1
****

graph(patterns,header="Goods Production",max=25000,min=3500, $
HLABEL='1969 - 2000',VLABEL=' ') 1
# x2 1969:1 2000:1 1
****


graph(patterns,header="Service Industries",max=95000,min=8000,$
HLABEL='1969 - 2000',VLABEL=' ') 1
# x3 1969:1 2000:1 1

***



graph(patterns,header="Per capita D,I,R", max=4.5,min=1.5,$
HLABEL='1969 - 2000',VLABEL=' ') 1
```

```
# x4 1969:1 2000:1 1

****


graph(patterns,header="Per Capita Transfer payments", max=3,min=1.0,$
HLABEL='1969 - 2000',VLABEL=' ') 1
# x5 1969:1 2000:1 1
**

graph(patterns,header="Per capita Adjustments for residence", max=12,min=5.5,$
HLABEL='1969 - 2000',VLABEL=' ') 1
# x6 1969:1 2000:1 1

****

graph(patterns,header="Average Residential price", max=0.14,min=0.06,$
HLABEL='1969 - 2000',VLABEL=' ') 1
# x7 1969:1 2000:1 1

graph(patterns,header="Average Commercial Price", max=0.15,min=0.05,$
HLABEL='1969 - 2000',VLABEL=' ') 1
# x8 1969:1 2000:1 1



spgraph(done)
end
```

2. Dickey-fuller & Augmented Dickey –Fuller Test results; first differences

```
*****RATS input program for dickey-fuller test*****
************and augmented dickey fuller ******
calendar 1969 1 1
allocate 30 2001
eqv 1 to 16
X1 X2 X3 X4 X5 X6 X7 X8  $
DX1 DX2 DX3 Dx4 DX5 DX6 DX7 DX8
**** data are in files listed in the following two lines
open data a:mont.txt
data(format=free,org=obs) 1969 2000  1 to 8
******************************************************
declare symmetric v
do i=1,8
diff i 1970 2000 i+8 1970
end do i
*** Next are Dickey-Fuller regressions******
**first diff regressed on levels lagged one period****
do i=9,16
linreg i 1971 2001
# constant (i-8){1}
**************************************
compute schwarz = log((%seesq)) + ((%nreg))*log(%nobs)/%nobs
compute phi = log(%seesq) + ((%nreg))*(2.01)*log(log(%nobs))/%nobs
display @10 ##### %nreg schwarz @+10 ####.#### phi @+10 #####.####
**************************************
end do i

**** Next is the Augmented Dickey-Fuller Test
***  One lag of first differences on the rhs
do i=9,16
linreg i 1971 2001
# constant (i-8){1} i{1}
**************************************************************
 compute schwarz = log(%seesq) + ((%nreg))*log(%nobs)/%nobs
 compute phi =  log(%seesq) + ((%nreg))*2.1*log(log(%nobs))/%nobs
 display @10  ### %nreg schwarz @+10 ####.### phi @+10 ####.###
end do i




End
```

3. Dickey-fuller & Augmented Dickey –Fuller Test results; first differences; series logged

```
*****RATS input program for dickey-fuller test*****
************and augmented dickey fuller ******
calendar 1969 1 1
allocate 30 2001
eqv 1 to 16
X1 X2 X3 X4 X5 X6 X7 X8  $
DX1 DX2 DX3 Dx4 DX5 DX6 DX7 DX8
**** data are in files listed in the following two lines
open data a:mont.txt
data(format=free,org=obs) 1969 2000  1 to 8
************************************************
declare symmetric v
do i= 1,8
log i
end do i
do i= 1,8
diff i 1970 2000 i+8 1970
end do i
*** Next are Dickey-Fuller regressions******
**first diff regressed on levels lagged one period****
do i=9,16
linreg i 1971 2001
# constant (i-8){1}
************************************
compute schwarz = log((%seesq)) + ((%nreg))*log(%nobs)/%nobs
compute phi = log(%seesq) + ((%nreg))*(2.01)*log(log(%nobs))/%nobs
display @10 ##### %nreg schwarz @+10 ####.#### phi @+10 #####.####
************************************
end do i
**** Next is the Augmented Dickey-Fuller Test
***  One lag of first differences on the rhs
do i=9,16
linreg i 1971 2001
# constant (i-8){1} i{1}
******************************************************
 compute schwarz = log(%seesq) + ((%nreg))*log(%nobs)/%nobs
 compute phi =  log(%seesq) + ((%nreg))*2.1*log(log(%nobs))/%nobs
 display @10  ### %nreg schwarz @+10 ####.### phi @+10 ####.###
end do i
```

4. VAR in First Differences and Covariance/Correlation Matrix

```
*****************VAR in first differences *****************
******************eight variables***************
***************and variance/correlation matrix******
calendar 1969 1 1
allocate 40 2001
eqv 1 to 16
X1 X2 X3 X4 X5 X6 X7 X8 $
DX1 DX2 DX3 Dx4 DX5 DX6 DX7 DX8
**** data are in files listed in the following two lines
open data a:mont.txt
data(format=free,org=obs) 1969:1 2000:1  1 to 8
**************************************************
source C:\PROGRA~1\Estima\WINRAT~1.0\bernanke.src
do i=1,8
log i     1969:1 2000:1 i 1969:1
end do i
do i= 1,8
diff i 1970 2000 i+8 1970
end do i
system 1 to 8
variables  1 to 8
det constant
lags 1 to 2
end(system)
estimate(print,outsigma=vsigma) 1971:1 2000:1
write vsigma

DECLARE RECT PATTERN(8,8)

*@BERNANKE(PRINT,TEST) VSIGMA PATTERN FACTOR
*

*INPUT PATTERN
* 1 0 0 0 0 0 0 0
* 0 1 0 0 0 0 0 0
* 0 0 1 0 0 0 0 0
* 0 0 0 1 0 0 0 0
* 0 0 0 0 1 0 0 0
* 0 0 0 0 0 1 0 0
* 0 0 0 0 0 0 1 0
* 0 0 0 0 0 0 0 1
*
ERRORS(impulses) 8 14 vsigma
```

1
2
3
4
5
6
7
8

END

5. Programs for Impulse Responses and Error Decompositions – Model 1

```
******************VAR in first differences ***********
******************for eight variables*********
***************to get impulse responses and**********************
***************forecast error decompositions in levels************
***************20% DAG significance level***********************
calendar 1969 1 1
allocate 40 2001
eqv 1 to 16
X1 X2 X3 X4 X5 X6 X7 X8 $
DX1 DX2 DX3 Dx4 DX5 DX6 DX7 DX8
**** data are in files listed in the following two lines
open data a:mont.txt
data(format=free,org=obs) 1969:1 2000:1  1 to 8
**************************************************
source C:\PROGRA~1\Estima\WINRAT~1.0\bernanke.src
do i=1,8
log i    1969:1 2000:1 i 1969:1
end do i
do i= 1,8
diff i 1970 2000 i+8 1970
end do i
system 1 to 8
variables  1 to 8
det constant
lags 1 to 2
end(system)
estimate(print,outsigma=V) 1971:1 2000:1
write v

DECLARE RECT PATTERN(8,8)

WRITE V
DECLARE RECT PATTERN(8,8)
INPUT PATTERN

1 0 0 0 0 0 0 0
0 1 0 0 0 0 0 0
0 1 1 0 0 1 0 0
0 1 0 1 0 0 0 0
0 0 1 0 1 0 0 0
0 0 0 0 0 1 0 0
0 0 0 0 1 0 1 1
0 0 0 0 0 0 0 1
```

```
nonlin A32 A36 A42
nonlin A53 A75 A78
declare rect A
compute A32=-.1,A36=-.1, A42=-.1
compute A53=-.1,A75=-.1, A78=-.1

compute A=%Identity(8)
find min -2*log(%det(A))+%sum(%log(%mqformdiag(v,TR(A)))) {
compute A(3,2)=A32,A(3,6)=A36,A(4,2)=A42, $
A(5,3)=A53, A(7,5)=A75, A(7,8)=A78
 }
 end find
@BERNANKE(initial=A,TEST,PRINT) V PATTERN FACTOR
ERRORS(DECOMP=FACTOR,Impulses) 8 36
# 1
# 2
# 3
# 4
# 5
# 6
# 7
# 8

compute neqn = 8
declare rect[series] impblk(8,8)
declare vect[series] scaled(8)
declare vect[labels] implabel(8)
compute implabel=||'POP','GP','SER','DIR','TRF','RAD','RAP','COM'||
list ieqn = 1 to 8
*declare vect[strings] mplabel(8)
compute mplabel=||'POP','GP','SER','DIR','TRF','RAD','RAP','COM'||


 impluse(noprint,decomp=factor) 8 36 1
 card ieqn impblk(ieqn,1) 1 ieqn

  set scaled(1) = (impblk(1,1))/sqrt(v(1,1))
  set g11 = scaled(1)
  labels scaled(1)
  #implabel(1)


  set scaled(2) = (impblk(2,1))/sqrt(v(2,2))
  set g21 = scaled(2)
```

```
labels scaled(2)
#implabel(2)


set scaled(3) = (impblk(3,1))/sqrt(v(3,3))
set g31 = scaled(3)
labels scaled(3)
#implabel(3)

set scaled(4) = (impblk(4,1))/sqrt(v(4,4))
set g41 = scaled(4)
labels scaled(4)
#implabel(4)


set scaled(5) = (impblk(5,1))/sqrt(v(5,5))
set g51 = scaled(5)
labels scaled(5)
#implabel(5)

set scaled(6) = (impblk(6,1))/sqrt(v(6,6))
set g61 = scaled(6)
labels scaled(6)
#implabel(6)

set scaled(7) = (impblk(7,1))/sqrt(v(7,7))
set g71 = scaled(7)
labels scaled(7)
#implabel(7)


set scaled(8) = (impblk(8,1))/sqrt(v(8,8))
set g81 = scaled(8)
labels scaled(8)
#implabel(8)


impluse(noprint,decomp=factor) 8 36 2
card ieqn impblk(ieqn,2) 1 ieqn

set scaled(1) = (impblk(1,2))/sqrt(v(1,1))
set g12 = scaled(1)
labels scaled(1)
#implabel(1)
```

```
set scaled(2) = (impblk(2,2))/sqrt(v(2,2))
set g22 = scaled(2)
labels scaled(2)
#implabel(2)


set scaled(3) = (impblk(3,2))/sqrt(v(3,3))
set g32 = scaled(3)
labels scaled(3)
#implabel(3)


set scaled(4) = (impblk(4,2))/sqrt(v(4,4))
set g42 = scaled(4)
labels scaled(4)
#implabel(4)

set scaled(5) = (impblk(5,2))/sqrt(v(5,5))
set g52 = scaled(5)
labels scaled(5)
#implabel(5)

set scaled(6) = (impblk(6,2))/sqrt(v(6,6))
set g62 = scaled(6)
labels scaled(6)
#implabel(6)

set scaled(7) = (impblk(7,2))/sqrt(v(7,7))
set g72 = scaled(7)
labels scaled(7)
#implabel(7)


set scaled(8) = (impblk(8,2))/sqrt(v(8,8))
set g82 = scaled(8)
labels scaled(8)
#implabel(8)



impluse(noprint,decomp=factor) 8 36 3
card ieqn impblk(ieqn,3) 1 ieqn

set scaled(1) = (impblk(1,3))/sqrt(v(1,1))
```

```
set g13 = scaled(1)
labels scaled(1)
#implabel(1)

set scaled(2) = (impblk(2,3))/sqrt(v(2,2))
set g23 = scaled(2)
labels scaled(2)
#implabel(2)


set scaled(3) = (impblk(3,3))/sqrt(v(3,3))
set g33 = scaled(3)
labels scaled(3)
#implabel(3)


set scaled(4) = (impblk(4,3))/sqrt(v(4,4))
set g43 = scaled(4)
labels scaled(4)
#implabel(4)


set scaled(5) = (impblk(5,3))/sqrt(v(5,5))
set g53 = scaled(5)
labels scaled(5)
#implabel(5)

set scaled(6) = (impblk(6,3))/sqrt(v(6,6))
set g63 = scaled(6)
labels scaled(6)
#implabel(6)

set scaled(7) = (impblk(7,3))/sqrt(v(7,7))
set g73 = scaled(7)
labels scaled(7)
#implabel(7)

set scaled(8) = (impblk(8,3))/sqrt(v(8,8))
set g83 = scaled(8)
labels scaled(8)
#implabel(8)
impluse(noprint,decomp=factor) 8 36 4
card ieqn impblk(ieqn,4) 1 ieqn
```

```
 set scaled(1) = (impblk(1,4))/sqrt(v(1,1))
 set g14 = scaled(1)
 labels scaled(1)
 #implabel(1)

 set scaled(2) = (impblk(2,4))/sqrt(v(2,2))
 set g24 = scaled(2)
 labels scaled(2)
 #implabel(2)

 set scaled(3) = (impblk(3,4))/sqrt(v(3,3))
 set g34 = scaled(3)
 labels scaled(3)
 #implabel(3)


 set scaled(4) = (impblk(4,4))/sqrt(v(4,4))
 set g44 = scaled(4)
 labels scaled(4)
 #implabel(4)


 set scaled(5) = (impblk(5,4))/sqrt(v(5,5))
 set g54 = scaled(5)
 labels scaled(5)
 #implabel(5)

set scaled(6) = (impblk(6,4))/sqrt(v(6,6))
 set g64 = scaled(6)
 labels scaled(6)
 #implabel(6)

set scaled(7) = (impblk(7,4))/sqrt(v(7,7))
 set g74 = scaled(7)
 labels scaled(7)
 #implabel(7)

set scaled(8) = (impblk(8,4))/sqrt(v(8,8))
 set g84 = scaled(8)
 labels scaled(8)
 #implabel(8)
impluse(noprint,decomp=factor) 8 36 5
card ieqn impblk(ieqn,5) 1 ieqn
```

```
set scaled(1) = (impblk(1,5))/sqrt(v(1,1))
set g15 = scaled(1)
labels scaled(1)
#implabel(1)


set scaled(2) = (impblk(2,5))/sqrt(v(2,2))
set g25 = scaled(2)
labels scaled(2)
#implabel(2)


set scaled(3) = (impblk(3,5))/sqrt(v(3,3))
set g35 = scaled(3)
labels scaled(3)
#implabel(3)

set scaled(4) = (impblk(4,5))/sqrt(v(4,4))
set g45 = scaled(4)
labels scaled(4)
#implabel(4)


set scaled(5) = (impblk(5,5))/sqrt(v(5,5))
set g55 = scaled(5)
labels scaled(5)
#implabel(5)

set scaled(6) = (impblk(6,5))/sqrt(v(6,6))
set g65 = scaled(6)
labels scaled(6)
#implabel(6)

set scaled(7) = (impblk(7,5))/sqrt(v(7,7))
set g75 = scaled(7)
labels scaled(7)
#implabel(7)

set scaled(8) = (impblk(8,5))/sqrt(v(8,8))
set g85 = scaled(8)
labels scaled(8)
#implabel(8)
```

```
impluse(noprint,decomp=factor) 8 36 6
 card ieqn impblk(ieqn,6) 1 ieqn

  set scaled(1) = (impblk(1,6))/sqrt(v(1,1))
  set g16 = scaled(1)
  labels scaled(1)
  #implabel(1)


  set scaled(2) = (impblk(2,6))/sqrt(v(2,2))
  set g26 = scaled(2)
  labels scaled(2)
  #implabel(2)


  set scaled(3) = (impblk(3,6))/sqrt(v(3,3))
  set g36 = scaled(3)
  labels scaled(3)
  #implabel(3)

  set scaled(4) = (impblk(4,6))/sqrt(v(4,4))
  set g46 = scaled(4)
  labels scaled(4)
  #implabel(4)


  set scaled(5) = (impblk(5,6))/sqrt(v(5,5))
  set g56 = scaled(5)
  labels scaled(5)
  #implabel(5)

 set scaled(6) = (impblk(6,6))/sqrt(v(6,6))
  set g66 = scaled(6)
  labels scaled(6)
  #implabel(6)

set scaled(7) = (impblk(7,6))/sqrt(v(7,7))
  set g76 = scaled(7)
  labels scaled(7)
  #implabel(7)

set scaled(8) = (impblk(8,6))/sqrt(v(8,8))
  set g86 = scaled(8)
  labels scaled(8)
```

```
 #implabel(8)


impluse(noprint,decomp=factor) 8 36 7
 card ieqn impblk(ieqn,7) 1 ieqn

  set scaled(1) = (impblk(1,7))/sqrt(v(1,1))
  set g17 = scaled(1)
  labels scaled(1)
  #implabel(1)


  set scaled(2) = (impblk(2,7))/sqrt(v(2,2))
  set g27 = scaled(2)
  labels scaled(2)
  #implabel(2)


  set scaled(3) = (impblk(3,7))/sqrt(v(3,3))
  set g37 = scaled(3)
  labels scaled(3)
  #implabel(3)

  set scaled(4) = (impblk(4,7))/sqrt(v(4,4))
  set g47 = scaled(4)
  labels scaled(4)
  #implabel(4)


  set scaled(5) = (impblk(5,7))/sqrt(v(5,5))
  set g57 = scaled(5)
  labels scaled(5)
  #implabel(5)

 set scaled(6) = (impblk(6,7))/sqrt(v(6,6))
  set g67 = scaled(6)
  labels scaled(6)
  #implabel(6)

set scaled(7) = (impblk(7,7))/sqrt(v(7,7))
  set g77 = scaled(7)
  labels scaled(7)
  #implabel(7)
```

```
set scaled(8) = (impblk(8,7))/sqrt(v(8,8))
  set g87 = scaled(8)
  labels scaled(8)
  #implabel(8)


impluse(noprint,decomp=factor) 8 36 8
 card ieqn impblk(ieqn,8) 1 ieqn

  set scaled(1) = (impblk(1,8))/sqrt(v(1,1))
  set g18 = scaled(1)
  labels scaled(1)
  #implabel(1)


  set scaled(2) = (impblk(2,8))/sqrt(v(2,2))
  set g28 = scaled(2)
  labels scaled(2)
  #implabel(2)


  set scaled(3) = (impblk(3,8))/sqrt(v(3,3))
  set g38 = scaled(3)
  labels scaled(3)
  #implabel(3)

  set scaled(4) = (impblk(4,8))/sqrt(v(4,4))
  set g48 = scaled(4)
  labels scaled(4)
  #implabel(4)


  set scaled(5) = (impblk(5,8))/sqrt(v(5,5))
  set g58 = scaled(5)
  labels scaled(5)
  #implabel(5)

 set scaled(6) = (impblk(6,8))/sqrt(v(6,6))
  set g68 = scaled(6)
  labels scaled(6)
  #implabel(6)

set scaled(7) = (impblk(7,8))/sqrt(v(7,7))
  set g78 = scaled(7)
```

```
  labels scaled(7)
  #implabel(7)

set scaled(8) = (impblk(8,8))/sqrt(v(8,8))
  set g88 = scaled(8)
  labels scaled(8)
  #implabel(8)





grparm(nobold,font='time new roman') hlabel 8 matrixlabels 14 $
                                     header * vlabel *
spgraph(vfields=8,hfields=8,header='Innovation to',$
        xlabels=mplabel,ylabels=mplabel,vlabel='Response of',$
        xpos=both,ypos=both)


dofor i = g11 g21 g31 g41 g51 g61 g71 g81  $
          g12 g22 g32 g42 g52 g62 g72 g82   $
          g13 g23 g33 g43 g53 g63 g73 g83   $
          g14 g24 g35 g44 g54 g64 g74 g84   $
          g15 g25 g35 g45 g55 g65 g75 g85   $
          g16 g26 g36 g46 g56 g66 g76 g86   $
          g17 g27 g37 g47 g57 g67 g77 g87   $
          g18 g28 g38 g48 g58 g68 g78 g88

   open plot a:\grf4.rgf

   graph(number=0,min=-2.0,max=2.5) 1
   # i

end dofor
spgraph(done)


END
```

6. Programs for Impulse Responses and Error Decompositions – Model 2

```
******************VAR in first differences ***********
******************for eight variables*********
***************to get impulse responses and**********************
***************forecast error decompositions in levels************
***************20% DAG significance level***********************

calendar 1969 1 1
allocate 40 2001
eqv 1 to 16
X1 X2 X3 X4 X5 X6 X7 X8 $
DX1 DX2 DX3 Dx4 DX5 DX6 DX7 DX8
**** data are in files listed in the following two lines
open data a:mont.txt
data(format=free,org=obs) 1969:1 2000:1  1 to 8
*************************************************
source C:\PROGRA~1\Estima\WINRAT~1.0\bernanke.src
do i=1,8
log i    1969:1 2000:1 i 1969:1
end do i
do i= 1,8
diff i 1970 2000 i+8 1970
end do i
system 1 to 8
variables  1 to 8
det constant
lags 1 to 2
end(system)
estimate(print,outsigma=V) 1971:1 2000:1
write v

DECLARE RECT PATTERN(8,8)

WRITE V
DECLARE RECT PATTERN(8,8)
INPUT PATTERN

1 0 0 0 0 0 0 0
0 1 1 1 0 0 0 0
0 0 1 0 0 0 0 0
0 0 0 1 0 0 0 0
0 0 1 0 1 0 1 0
0 0 1 0 0 1 0 0
0 0 0 0 0 0 1 1
```

```
0 0 0 0 0 0 0 1

nonlin A23 A24
nonlin A53 A57 A63 A78
declare rect A
compute A23=-.1,A24=-.1, A53=-.1
compute A57=-.1,A63=-.1, A78=-.1

compute A=%Identity(8)
find min -2*log(%det(A))+%sum(%log(%mqformdiag(v,TR(A)))) {
compute A(2,3)=A23,A(2,4)=A24,A(5,3)=A53, $
A(5,7)=A57, A(6,3)=A63, A(7,8)=A78
 }
 end find
@BERNANKE(initial=A,TEST,PRINT) V PATTERN FACTOR
ERRORS(DECOMP=FACTOR,Impulses) 8 36
# 1
# 2
# 3
# 4
# 5
# 6
# 7
# 8

compute neqn = 8
declare rect[series] impblk(8,8)
declare vect[series] scaled(8)
declare vect[labels] implabel(8)
compute implabel=||'POP','GP','SER','DIR','TRF','RAD','RAP','COM'||
list ieqn = 1 to 8
*declare vect[strings] mplabel(8)
compute mplabel=||'POP','GP','SER','DIR','TRF','RAD','RAP','COM'||


 impluse(noprint,decomp=factor) 8 36 1
 card ieqn impblk(ieqn,1) 1 ieqn

  set scaled(1) = (impblk(1,1))/sqrt(v(1,1))
  set g11 = scaled(1)
  labels scaled(1)
  #implabel(1)
```

```
set scaled(2) = (impblk(2,1))/sqrt(v(2,2))
set g21 = scaled(2)
labels scaled(2)
#implabel(2)


set scaled(3) = (impblk(3,1))/sqrt(v(3,3))
set g31 = scaled(3)
labels scaled(3)
#implabel(3)

set scaled(4) = (impblk(4,1))/sqrt(v(4,4))
set g41 = scaled(4)
labels scaled(4)
#implabel(4)


set scaled(5) = (impblk(5,1))/sqrt(v(5,5))
set g51 = scaled(5)
labels scaled(5)
#implabel(5)

set scaled(6) = (impblk(6,1))/sqrt(v(6,6))
set g61 = scaled(6)
labels scaled(6)
#implabel(6)

set scaled(7) = (impblk(7,1))/sqrt(v(7,7))
set g71 = scaled(7)
labels scaled(7)
#implabel(7)


set scaled(8) = (impblk(8,1))/sqrt(v(8,8))
set g81 = scaled(8)
labels scaled(8)
#implabel(8)



impluse(noprint,decomp=factor) 8 36 2
card ieqn impblk(ieqn,2) 1 ieqn

set scaled(1) = (impblk(1,2))/sqrt(v(1,1))
```

```
set g12 = scaled(1)
labels scaled(1)
#implabel(1)


set scaled(2) = (impblk(2,2))/sqrt(v(2,2))
set g22 = scaled(2)
labels scaled(2)
#implabel(2)


set scaled(3) = (impblk(3,2))/sqrt(v(3,3))
set g32 = scaled(3)
labels scaled(3)
#implabel(3)


set scaled(4) = (impblk(4,2))/sqrt(v(4,4))
set g42 = scaled(4)
labels scaled(4)
#implabel(4)

set scaled(5) = (impblk(5,2))/sqrt(v(5,5))
set g52 = scaled(5)
labels scaled(5)
#implabel(5)

set scaled(6) = (impblk(6,2))/sqrt(v(6,6))
set g62 = scaled(6)
labels scaled(6)
#implabel(6)

set scaled(7) = (impblk(7,2))/sqrt(v(7,7))
set g72 = scaled(7)
labels scaled(7)
#implabel(7)


set scaled(8) = (impblk(8,2))/sqrt(v(8,8))
set g82 = scaled(8)
labels scaled(8)
#implabel(8)

impluse(noprint,decomp=factor) 8 36 3
```

```
card ieqn impblk(ieqn,3) 1 ieqn

 set scaled(1) = (impblk(1,3))/sqrt(v(1,1))
 set g13 = scaled(1)
 labels scaled(1)
 #implabel(1)

 set scaled(2) = (impblk(2,3))/sqrt(v(2,2))
 set g23 = scaled(2)
 labels scaled(2)
 #implabel(2)


 set scaled(3) = (impblk(3,3))/sqrt(v(3,3))
 set g33 = scaled(3)
 labels scaled(3)
 #implabel(3)


 set scaled(4) = (impblk(4,3))/sqrt(v(4,4))
 set g43 = scaled(4)
 labels scaled(4)
 #implabel(4)


 set scaled(5) = (impblk(5,3))/sqrt(v(5,5))
 set g53 = scaled(5)
 labels scaled(5)
 #implabel(5)

set scaled(6) = (impblk(6,3))/sqrt(v(6,6))
 set g63 = scaled(6)
 labels scaled(6)
 #implabel(6)

set scaled(7) = (impblk(7,3))/sqrt(v(7,7))
 set g73 = scaled(7)
 labels scaled(7)
 #implabel(7)

set scaled(8) = (impblk(8,3))/sqrt(v(8,8))
 set g83 = scaled(8)
 labels scaled(8)
 #implabel(8)
```

```
impluse(noprint,decomp=factor) 8 36 4
card ieqn impblk(ieqn,4) 1 ieqn

 set scaled(1) = (impblk(1,4))/sqrt(v(1,1))
 set g14 = scaled(1)
 labels scaled(1)
 #implabel(1)

 set scaled(2) = (impblk(2,4))/sqrt(v(2,2))
 set g24 = scaled(2)
 labels scaled(2)
 #implabel(2)

 set scaled(3) = (impblk(3,4))/sqrt(v(3,3))
 set g34 = scaled(3)
 labels scaled(3)
 #implabel(3)


 set scaled(4) = (impblk(4,4))/sqrt(v(4,4))
 set g44 = scaled(4)
 labels scaled(4)
 #implabel(4)


 set scaled(5) = (impblk(5,4))/sqrt(v(5,5))
 set g54 = scaled(5)
 labels scaled(5)
 #implabel(5)

set scaled(6) = (impblk(6,4))/sqrt(v(6,6))
 set g64 = scaled(6)
 labels scaled(6)
 #implabel(6)

set scaled(7) = (impblk(7,4))/sqrt(v(7,7))
 set g74 = scaled(7)
 labels scaled(7)
 #implabel(7)

set scaled(8) = (impblk(8,4))/sqrt(v(8,8))
 set g84 = scaled(8)
 labels scaled(8)
 #implabel(8)
```

```
impluse(noprint,decomp=factor) 8 36 5
card ieqn impblk(ieqn,5) 1 ieqn

 set scaled(1) = (impblk(1,5))/sqrt(v(1,1))
 set g15 = scaled(1)
 labels scaled(1)
 #implabel(1)


 set scaled(2) = (impblk(2,5))/sqrt(v(2,2))
 set g25 = scaled(2)
 labels scaled(2)
 #implabel(2)


 set scaled(3) = (impblk(3,5))/sqrt(v(3,3))
 set g35 = scaled(3)
 labels scaled(3)
 #implabel(3)

 set scaled(4) = (impblk(4,5))/sqrt(v(4,4))
 set g45 = scaled(4)
 labels scaled(4)
 #implabel(4)


 set scaled(5) = (impblk(5,5))/sqrt(v(5,5))
 set g55 = scaled(5)
 labels scaled(5)
 #implabel(5)

set scaled(6) = (impblk(6,5))/sqrt(v(6,6))
 set g65 = scaled(6)
 labels scaled(6)
 #implabel(6)

set scaled(7) = (impblk(7,5))/sqrt(v(7,7))
 set g75 = scaled(7)
 labels scaled(7)
 #implabel(7)

set scaled(8) = (impblk(8,5))/sqrt(v(8,8))
 set g85 = scaled(8)
 labels scaled(8)
```

```
  #implabel(8)



impluse(noprint,decomp=factor) 8 36 6
 card ieqn impblk(ieqn,6) 1 ieqn

  set scaled(1) = (impblk(1,6))/sqrt(v(1,1))
  set g16 = scaled(1)
  labels scaled(1)
  #implabel(1)


  set scaled(2) = (impblk(2,6))/sqrt(v(2,2))
  set g26 = scaled(2)
  labels scaled(2)
  #implabel(2)


  set scaled(3) = (impblk(3,6))/sqrt(v(3,3))
  set g36 = scaled(3)
  labels scaled(3)
  #implabel(3)

  set scaled(4) = (impblk(4,6))/sqrt(v(4,4))
  set g46 = scaled(4)
  labels scaled(4)
  #implabel(4)


  set scaled(5) = (impblk(5,6))/sqrt(v(5,5))
  set g56 = scaled(5)
  labels scaled(5)
  #implabel(5)

 set scaled(6) = (impblk(6,6))/sqrt(v(6,6))
  set g66 = scaled(6)
  labels scaled(6)
  #implabel(6)

set scaled(7) = (impblk(7,6))/sqrt(v(7,7))
  set g76 = scaled(7)
  labels scaled(7)
```

```
  #implabel(7)

set scaled(8) = (impblk(8,6))/sqrt(v(8,8))
  set g86 = scaled(8)
  labels scaled(8)
  #implabel(8)



impluse(noprint,decomp=factor) 8 36 7
 card ieqn impblk(ieqn,7) 1 ieqn

  set scaled(1) = (impblk(1,7))/sqrt(v(1,1))
  set g17 = scaled(1)
  labels scaled(1)
  #implabel(1)


  set scaled(2) = (impblk(2,7))/sqrt(v(2,2))
  set g27 = scaled(2)
  labels scaled(2)
  #implabel(2)


  set scaled(3) = (impblk(3,7))/sqrt(v(3,3))
  set g37 = scaled(3)
  labels scaled(3)
  #implabel(3)

  set scaled(4) = (impblk(4,7))/sqrt(v(4,4))
  set g47 = scaled(4)
  labels scaled(4)
  #implabel(4)


  set scaled(5) = (impblk(5,7))/sqrt(v(5,5))
  set g57 = scaled(5)
  labels scaled(5)
  #implabel(5)

 set scaled(6) = (impblk(6,7))/sqrt(v(6,6))
  set g67 = scaled(6)
  labels scaled(6)
  #implabel(6)
```

```
set scaled(7) = (impblk(7,7))/sqrt(v(7,7))
  set g77 = scaled(7)
  labels scaled(7)
  #implabel(7)

set scaled(8) = (impblk(8,7))/sqrt(v(8,8))
  set g87 = scaled(8)
  labels scaled(8)
  #implabel(8)



impluse(noprint,decomp=factor) 8 36 8
 card ieqn impblk(ieqn,8) 1 ieqn

  set scaled(1) = (impblk(1,8))/sqrt(v(1,1))
  set g18 = scaled(1)
  labels scaled(1)
  #implabel(1)


  set scaled(2) = (impblk(2,8))/sqrt(v(2,2))
  set g28 = scaled(2)
  labels scaled(2)
  #implabel(2)


  set scaled(3) = (impblk(3,8))/sqrt(v(3,3))
  set g38 = scaled(3)
  labels scaled(3)
  #implabel(3)

  set scaled(4) = (impblk(4,8))/sqrt(v(4,4))
  set g48 = scaled(4)
  labels scaled(4)
  #implabel(4)


  set scaled(5) = (impblk(5,8))/sqrt(v(5,5))
  set g58 = scaled(5)
  labels scaled(5)
  #implabel(5)

 set scaled(6) = (impblk(6,8))/sqrt(v(6,6))
```

```
  set g68 = scaled(6)
  labels scaled(6)
  #implabel(6)



set scaled(7) = (impblk(7,8))/sqrt(v(7,7))
  set g78 = scaled(7)
  labels scaled(7)
  #implabel(7)



set scaled(8) = (impblk(8,8))/sqrt(v(8,8))
  set g88 = scaled(8)
  labels scaled(8)
  #implabel(8)





grparm(nobold,font='time new roman') hlabel 8 matrixlabels 14 $
                                header * vlabel *
spgraph(vfields=8,hfields=8,header='Innovation to',$
        xlabels=mplabel,ylabels=mplabel,vlabel='Response of',$
        xpos=both,ypos=both)


dofor i = g11 g21 g31 g41 g51 g61 g71 g81  $
          g12 g22 g32 g42 g52 g62 g72 g82   $
          g13 g23 g33 g43 g53 g63 g73 g83   $
          g14 g24 g35 g44 g54 g64 g74 g84   $
          g15 g25 g35 g45 g55 g65 g75 g85   $
          g16 g26 g36 g46 g56 g66 g76 g86   $
          g17 g27 g37 g47 g57 g67 g77 g87   $
          g18 g28 g38 g48 g58 g68 g78 g88



   open plot a:\grf4.rgf

   graph(number=0,min=-2.0,max=2.5) 1
   # i
```

```
end dofor
spgraph(done)


END
```

APPENDIX D

DATA USED IN THIS STUDY [14]

YEAR	POP	GP	SER	DIR	TRF	RAD	RAP	COM
1969	50004	3568	8216	1.5691	1.01923	5.834533	0.130615	0.11764
1970	50907	3906	8645	2.07701	1.165441	6.033651	0.120773	0.117781
1971	57242	4164	9703	2.193594	1.200787	6.4759	0.113538	0.098803
1972	65521	4619	11704	2.228344	1.235363	6.894343	0.106145	0.098396
1973	75478	4977	13572	2.210395	1.258554	7.180637	0.102246	0.080816
1974	77625	5024	14433	2.369413	1.363862	8.367257	0.103841	0.081235
1975	84767	5382	15427	2.125056	1.439347	9.060384	0.115384	0.110517
1976	89978	6440	17455	2.08722	1.487821	10.10961	0.135054	0.144494
1977	100541	7327	19435	1.989315	1.445141	10.46424	0.133465	0.13539
1978	110899	8377	21928	2.223549	1.408895	11.14489	0.125305	0.123604
1979	122203	9413	23621	2.488513	1.334792	11.28857	0.119743	0.116372
1980	129154	10036	24911	2.70778	1.377935	11.76763	0.112551	0.103975
1981	136500	13170	27722	2.966989	1.392605	11.95215	0.115115	0.104712
1982	150025	13792	32129	3.101272	1.421641	11.27231	0.125046	0.11866
1983	160975	12973	33706	2.95959	1.559359	9.894478	0.139716	0.134618
1984	165147	14188	36571	3.249624	1.583249	9.576209	0.118609	0.114469
1985	168585	13946	38771	3.401491	1.649422	9.343822	0.121936	0.114979
1986	169898	12372	38431	3.512059	1.868371	8.866328	0.124221	0.115556
1987	169534	12826	40630	3.418918	1.941234	8.687421	0.115706	0.1038
1988	170791	12955	44100	3.563341	1.982067	9.022123	0.101881	0.092221
1989	175584	13864	45368	4.009134	2.082653	9.195559	0.099496	0.082298
1990	184066	14578	48784	3.646428	2.148178	9.323029	0.097925	0.078771
1991	192732	15085	52325	3.721487	2.326358	9.268707	0.090059	0.070551
1992	202374	15312	53891	3.57384	2.577656	9.148562	0.088451	0.070731
1993	211878	17542	57092	3.487266	2.617851	8.830059	0.08685	0.0711
1994	221428	18077	61003	3.765632	2.682007	9.018741	0.084314	0.069278
1995	231816	19758	66484	3.796956	2.769739	9.130523	0.080755	0.065166
1996	243221	20533	70929	3.88274	2.786994	9.569873	0.077259	0.062462
1997	255557	22101	76196	4.123058	2.822358	10.77961	0.079618	0.066149
1998	269043	22367	79014	4.387506	2.770808	11.55851	0.07809	0.064263
1999	284271	22464	85042	4.174926	2.706995	11.01287	0.075321	0.061562
2000	297572	23576	90354	4.394758	2.732539	11.64537	0.076913	0.065802

- All the variables except employment levels are adjusted for inflation (1969-2000)
- All the variables except electricity prices are computed on a per capita basis.
- All the data (except electricity prices) for this study is from the REIS data set of the Bureau of Economic Analysis, for the Montgomery County.
- The electricity price data is provided by Mid-South Synergy, Navasota, TX.

[14] Table 3.6 gives the full form of the variable acronyms used in this study

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