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SIMULATION OF AGGREGATE DEMAND IMPACTS ON THE SECTORAL VALUE ADDED IN THE IRANIAN ECONOMY

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ABSTRACT The purpose of this study is to measure the impact of final demand aggregates on the sectoral value added in the Iranian economy by employing input-output analysis and econometric modelling. This paper presents a model in which the sectoral value added for major aggregate sectors is linked with final demand deliveries. The policy implications of this study highlight the outcome of a sustained percentage shock in each component of aggregate demand, other components remaining unchanged, on the growth of the sectoral value added in four counterfactual simulation experiments. These policy implications can provide insights for decision makers and planners in Iran.

1. INTRODUCTION

The linking of the demand and production sides of the economy is relevant for effective coordination of stabilisation policies and development strategies which are of paramount importance for policy makers. In macroeconometric modelling there are several ways to deal with the production block by using various types of production functions. In the context of the Iranian economy some models, such as ECAFE (1968) and UNCTAD (1968), have employed the Harrod-Domar production function while others, Vakil (1973), Shahshahani (1978), Hoda (1983), Heiat (1986), the Plan and Budget Organisation (1990), and Noferesti and Arabmazar (1994), have separately estimated a production function for each sector. However, these models do not consider production interdependencies between interrelated sectors.

In this study, using a base year input-output table, a "conversion matrix" is computed which translates final demand aggregates into sectoral value added. This link is important particularly in a developing country, such as Iran, where intermediate demands among various sectors are significant. One should

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recognise that, by using an input-output table in a macroeconometric model (MEM), the supply side has not been neglected since both intermediate and final demand encompass demand for capital goods and other factors of production (Klein, 1965, p. 323).

This paper has two objectives. The first is to show that the updated 1991 input-output table can fairly represent production interdependencies in the Iranian economy, and the second is to evaluate the responsiveness of the sectoral value added growth to a 10 per cent change in aggregate final demand components by running four counterfactual simulations.

The organisation of the rest of the paper is as follows: Section 2 specifies the theoretical and analytical framework of the model. Section 3 presents the empirical results and an assessment in relation to the reliability of the model. Section 4 discusses the policy implications of the study which aims to measure the impact of a sustained 10 per cent increase in each component of the aggregate demand on the growth of sectoral value added. Section 5 consists of some concluding remarks.

2. THEORETICAL FRAMEWORK

The incorporation and implementation of a demand-side input-output model in macroeconometric modelling have been examined by many applied economists. The main objective of the integration of an input-output system to a MEM is to obtain a "conversion (transition) matrix" by using a base year input-output table.[2] According to Klein (1983), the conversion matrix is the vehicle of transformation and has two important applications. First, by multiplying the aggregate demand components in each row of the conversion matrix, the model-builder can compute sectoral value added. Second, by multiplying the sectoral value added price deflators by each column of this matrix, the aggregate final demand price deflators can be estimated. See Bodkin (1976) and Klein (1983) for a detailed discussion of these applications. In this study only the first application has been utilised.

To obtain the conversion matrix one may begin with the following Leontief relation:

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{F} \tag{1}$$

where $\mathbf{I}$ is an identity matrix, $\mathbf{X}$ is a (n x 1) vector of total gross output, $\mathbf{F}$ indicates the (n x 1) vector of sectoral final demand, and $\mathbf{A}$ is the (n x n) square

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[2] Using various versions of the Brookings model, Fisher, Klein and Shinkai (1965) and Kresge (1969) pioneered the use of the conversion matrix to link a national income determination model and an input-output system. Some other economists who have also discussed input-output analysis in a MEM framework are Klein (1965, 1978, 1983, 1989), Behrman and Klein (1970), Morishima *et al.* (1972), Preston (1972), Chalmers (1972), Bodkin (1976), Marzouk (1975), Seguy and Ramirez (1975), Sapir (1976), Hebden (1983), Chowdhury (1984), Oshikoya (1990) and Bon and Bing (1993).

matrix of the Leontief domestic direct coefficients.[3] Given annual sectoral final demand data, the sectoral output time series can be obtained by using equation (1). However, because of some data limitations, as is common for many other less developed countries (LDCs), equation (1) cannot be immediately utilised unless some assumptions are invoked.

First, while time series data for sectoral gross output are not usually available, sectoral value added data are. With regard to this problem, one has to transform output into value added. To this end, using a base year input-output table, it is assumed that the ratio of value added to output remains unchanged in each sector over the period of study. This calls for the following relation:

$$\mathbf{CV}_j = [1 - \sum_{i=1}^{n} a_{ij}]\,\mathbf{X}_j \tag{2}$$

where **CV** is the vector of computed sectoral value added.
Now if

$$\mathbf{B} = 1 - \sum_{i=1}^{n} a_{ij} \tag{3}$$

where **B** is a diagonal matrix which shows the sectoral value added ratios to the sectoral output, then in matrix notation

$$\mathbf{CV} = \mathbf{B\,X} \tag{4}$$

Second, time series observations on sectoral final demand deliveries are also unavailable. In other words, only aggregate final demand components such as private consumption (NPC_t), government consumption (NGC_t), gross capital formation ($NTIN_t$), changes in capital inventory (NDK_t), and exports (NTX_t) are reported annually in statistical yearbooks. If these aggregates, i.e. NPC_t, NGC_t, $NTIN_t$, NDK_t and NTX_t, shape the **E** vector and also if one accepts proportionality and constancy of the (n x m) matrix of the sectoral distribution of final demand components (**D**), (where n and m denote the number of sectors and aggregate final demand components, respectively) the column vector of sectoral final demand can be written as

$$\mathbf{F} = \mathbf{D\,E} \tag{5}$$

By substituting (5) into (1), it is clear that

$$\mathbf{X} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{D\,E} \tag{6}$$

Then if equation (6) is substituted into equation (4), the following equation is obtained:

[3] This implies imports are non-competitive and completely exogenous to the input-output system and will be determined in the demand side of the MEM.

$$\mathbf{CV} = \mathbf{H}\,\mathbf{E} \tag{7}$$

where $\mathbf{H} = \mathbf{B}\,(\mathbf{I}\text{-}\mathbf{A})^{-1}\,\mathbf{D}$.

Since all elements of **B**, $(\mathbf{I}\text{-}\mathbf{A})^{-1}$ and **D** in equation (7) are given by the base year input-output table, **H** the conversion matrix, can be computed.[4]

Regarding the first application of the conversion matrix (**H**) in equation (7), given the *ex ante* or *ex post* time series data of aggregate final demand components for any given time period, a time series of sectoral value added can be accordingly obtained in factor prices.[5] Equation (7) can also be written as

$$\begin{bmatrix} CV_{1t} \\ CV_{2t} \\ . \\ . \\ CV_{nt} \end{bmatrix} = \begin{bmatrix} h_{11} & h_{12} & . & . & h_{1m} \\ h_{21} & h_{22} & . & . & h_{2m} \\ . & . & . & . & . \\ . & . & . & . & . \\ h_{n1} & h_{n2} & . & . & h_{nm} \end{bmatrix} \begin{bmatrix} e_{1t} \\ e_{2t} \\ . \\ . \\ e_{mt} \end{bmatrix} \tag{8}$$

Further, the **H** matrix can be regarded as a comprehensive sectoral value added multiplier matrix. For example, h_{ij} shows, if the j^{th} component of aggregate demand changes by one unit, how much value added in sector i will be changed, i.e. $h_{ij} = \partial CV_i / \partial e_j$.

Attention is now directed to the assumptions which have been made for capturing the conversion matrix. The question is: can **B**, **D** and $(\mathbf{I}\text{-}\mathbf{A})^{-1}$ be relatively stable over a period of time? Put otherwise, are the following constant: relative productivity in the various sectors (**B**), consumers' taste patterns (the **D** matrix or sectoral distribution of final demand deliveries), and sectoral interdependencies, i.e. $(\mathbf{I}\text{-}\mathbf{A})^{-1}$?[6]

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4 Preston (1972) and Sapir (1976) proved that the column sum of the **H** matrix is less than unity.

5 In this respect, one should note that there is no constraint on these computed sectoral value added. Therefore, it is necessary for the modeller to bear in mind the extent to which an increase in each component of final demand can be converted to value added in various sectors. In other words, an infinite increase in each component of aggregate demand does not imply an infinite increase in value added in various sectors. In this study a limited increase in each component of final demand over the period of study is assumed not to be restrictive.

6 There are two major methods to accommodate changes in the $(\mathbf{I}-\mathbf{A})^{-1}$ and **D** matrices, when input-output tables are not available on an annual basis. They are the RAS method used by Preston (1975) in the Wharton annual model, and modelling the residuals as implemented by, *inter alia*, Arrow and Hoffenberg (1959), Klein (1983) and Chowdhury (1984).

To answer this question and evaluate the reliability of the above-mentioned assumptions, first one should compute sectoral value added by substituting actual historical time series data of the **E** vector into equation (7) or equation (8) for a given period of time. Once these computed value added (CV_{it}) for different sectors have been derived, then they can be compared with actual data (V_{it}). Depending on the resulting sectoral residuals, i.e. $R_{it} = V_{it} - CV_{it}$, the reliability of the above assumptions can be assessed. If the residuals are small, equation (8) is taken as given in the model. However, if the residuals are relatively large, it means one or more of the components of the **H** matrix, i.e. **B**, **D** and/or $(\mathbf{I-A})^{-1}$, have undergone major changes over the period under study.[7]

A characteristic of this approach is that the differences between computed value added and actual value added are discerning of further analysis. One method proposed by Klein (1983) to take the impact of the sectoral residuals into account is to model them in terms of the residuals in other sectors (by employing the method of principal components), the ARMA process and other possible determinants (such as relative prices, sectoral investment, etc). However, it is relevant to recognise that an important issue in the modelling of the residuals is related to the equality of the sum of sectoral value added (including net indirect taxes) and gross domestic expenditure (*GDE*). This means the national accounting identity must be maintained. Such a constraint has been met in this study.

3. EMPIRICAL RESULTS AND RELIABILITY OF THE MODEL

In this paper, first the 1984 input-output table, comprising 92 sectors as compiled by Iran's Plan and Budget Organisation (1989), has been aggregated to ten major sectors according to the ISIC (International Standard Industry Classification). These ten sectors are as follows:

1. Agriculture (including agricultural products, livestock, hunting, forestry and fishing),
2. Petroleum (including natural gas),
3. Manufacturing (including mining activities),
4. Water, electricity and city gas,
5. Construction,
6. Trade (including hotels and restaurants),
7. Transport (including communication and warehousing),
8. Financial and real estate services (including insurance and monetary institutions),
9. Public sector services, and
10. Personal and domestic services.

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[7] The question "which components of the **H** matrix have changed?" cannot be answered unless a time series of input-output tables is available which is impossible especially for the $(\mathbf{I-A})^{-1}$ and **D** matrices. Therefore, only the overall changes are reflected in the sectoral residuals.

Second, the aggregated table has been updated by the RAS method for the year 1990 by Central Bank (1992) data on sectoral value added, output and aggregate demand components. Before undertaking the updating procedure, the table was expressed in terms of 1990 prices to capture sectoral price changes by the method proposed by Tofigh (1992). In this method the transaction matrix is multiplied by the price vector (**P**) to express the base year (1984) inter-industry flows in terms of the destination year (1990) prices as follows:

$$\dot{\mathbf{P}} = \dot{\mathbf{W}}\,\mathbf{B}(\mathbf{I}-\mathbf{A})^{-1} \tag{9}$$

where **W** is a vector of the 1990 price deflators for the sectoral value added (1984=100), and **B** is a diagonal matrix which represents the ratio of value added to gross output in various sectors.

The first step in the empirical work is related to the computation of the conversion matrix. Using the updated 1990 input-output table and equation (8), the **H** matrix is presented in Table 1.

One should note that the column sums of the conversion matrix are less than unity which satisfy Preston's (1972) criterion. As discussed earlier, each element of this matrix can be regarded as a multiplier. For instance, the impact of a 100 rial increase in total exports involves an increase of 70 rials in petroleum value added (second row and fifth column) and only an increase of 7.2 rials in the manufacturing sector (third row and fifth column).

Table 1. Conversion Matrix for the Iranian Economy, 1990 (10 Sectors and 5 Aggregate Final Demand Components)

		NPC (1)	*NGC* (2)	*NTIN* (3)	*NDK* (4)	*NTX* (5)	Row sum
Agriculture	(1)	0.1917	0.0225	0.0642	0.6287	0.0667	0.97
Petroleum	(2)	0.0001	0.0000	0.0001	-0.0006	0.7071	0.71
Manufacturing	(3)	0.1173	0.0307	0.1193	0.1253	0.0715	0.46
Water, gas and electricity	(4)	0.0129	0.0116	0.0035	0.0021	0.0017	0.03
Construction	(5)	0.0052	0.0012	0.2316	0.0006	0.0004	0.24
Trade	(6)	0.2003	0.0332	0.1667	0.0812	0.0529	0.53
Transport	(7)	0.0837	0.0332	0.0509	0.0167	0.0273	0.21
Financial and real estate services	(8)	0.1723	0.0119	0.0125	0.0054	0.0049	0.21
Public services	(9)	0.0261	0.5904	0.0002	0.0002	0.0155	0.63
Personal and domestic services	(10)	0.0233	0.0093	0.0139	0.0063	0.0211	0.07
Column sum		0.83	0.74	0.66	0.87	0.97	4.07

Source: Calculated by the author from updated input-output table for 1990.

Notes: *NPC*: private consumption, *NGC*: government consumption, *NTIN*: gross capital formation, *NDK*: changes in capital inventory, *NTX*: exports.

To determine the reliability of this matrix, first one should substitute final demand aggregates into equation (8) to obtain computed sectoral value added (CV_{it}). This has been undertaken for the period 1966 to 1992. CV_{it} can then be compared to the actual value added (V_{it}) and the residuals in each sector can be determined by $R_{it} = V_{it} - CV_{it}$. Figures 1 to 10 in the appendix show, *inter alia*, these comparisons for the above-mentioned 10 major sectors for the period 1966-1992. These figures also demonstrate time series data on simulated sectoral value added (SV_{it}). The definition and characteristics of SV_{it} will be discussed below.

As seen from Figures 1 to 10 in the appendix, the residuals for the agriculture sector, the financial and real estate sector, the public services sector, and the personal and domestic services sector are small. On the other hand, the residuals in all other sectors, particularly in the construction sector and the petroleum sector, are somewhat large. These differences become quite large in the period 1989-1992, which coincides with the post Iran-Iraq war period. However, the computed sectoral value added (CV_{it}) for almost all ten sectors over the period 1966-1992 can explain the turning points and the general patterns of the actual sectoral value added data. In other words, one can conclude that in most sectors the data for computed sectoral value added are very close to the actual values. However, by modelling the sectoral residuals this reliability can be further enhanced, by the process now described.

In order to obtain more efficient results especially in those sectors in which the residuals are large, the residuals in each sector are modelled as a function of several factors whenever these factors are statistically significant.[8] First, overall technological progress has been captured by a time trend when significant. Second, an intercept dummy variable has been entered in each equation to capture a few outlier observations due to the Iraq-Iran war (1980-1988), the Islamic revolution, volatile oil markets in terms of prices or quantities, recent exchange rate devaluation policies, and frequent data revisions by official statistical centres. There are eleven intercept dummy variables in the ten estimated equations for the sectoral residuals. Seven out of the eleven dummy variables are equal to unity only in one or two (different) years, and zero otherwise. The other alternative was to exclude these few observations from the sample period. However, this would lead to loss of continuity of the time series data. However continuity is essential in the use of ARMA (autoregressive and moving average) error process. Therefore, the use of dummy variables for these few observations is preferred. Third, the residuals in other sectors have been tested as explanatory variables as proposed by Klein (1983). If the residuals in one sector move with the residuals in another sector then those residuals are taken as an explanatory variable in the equation. Fourth, the ARMA error processes have also been utilised in the

[8] In this study other methods, such as testing the residuals in each sector as a function of sectoral investment and/or the residuals in the other sectors by using the method of principal components, have also been tried. However, the results were poor since the tracking performance of the whole model, as a system, was not satisfactory.

Table 2. Econometric Results for Residuals in the Agriculture Sector (R_{1t}), 1966-1992

Variable	Identifier	Coefficient	t statistic	Order of integration
Dependent variable	ΔR_{1t}	1		I(0)
Constant	C	-92.349	-2.920*	
Dummy variable	D1	408.167	5.733*	
Residual in sector 8	ΔR_{8t}	1.477	5.157*	I(0)
First order Moving Average	MA(1)	0.823	6.561*	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.71 $F(3,23)$=22.64*
Diagnostic tests: DW=2.55 Ramsey RESET (specification) $F(2,21)$=1.22
Jarque-Bera (normality) $Chi^2(2)$=2.04 LM (serial correlation) $Chi^2(2)$=6.30*
ARCH (Heteroscedasticity) $Chi^2(2)$=4.54 Ljung-Box (serial correlation) $Chi^2(2)$=10.41*
Box-Pierce (serial correlation) $Chi^2(2)$=8.86*
Chow (stability) forecast test (1987-1992) $F(6,17)$=1.12
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

Table 3. Econometric Results For Residuals in the Petroleum Sector (R_{2t}), 1966-1992

Variable	Identifier	Coefficient	t statistic	Order of integration
Dependent variable	ΔR_{2t}	1		I(0)
Constant	C	-202.754	-4.604*	
Dummy variable	D2	563.949	4.872*	
Residual in sector 7	ΔR_{7t}	-1.262	-6.316*	I(0)
Time trend	T	-12.536	-4.122*	
First order Autoregressive	AR(1)	-0.293	-1.435	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.74 $F(4,22)$=19.81*
Diagnostic tests: DW=1.83 Ramsey RESET (specification) $F(2,20)$=3.13
Jarque-Bera (normality) $Chi^2(2)$=0.50 LM (serial correlation) $Chi^2(2)$=7.17*
ARCH (Heteroscedasticity) $Chi^2(2)$=1.27 Ljung-Box (serial correlation) $Chi^2(2)$=6.98*
Box-Pierce (serial correlation) $Chi^2(2)$=5.95
Chow (stability) forecast test (1987-1992) $F(6,16)$=3.96*
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

estimation of the sectoral residuals to improve the tracking performance of the model.

As will be shown below stationary data have been used in the estimation of most equations to avoid spurious regressions. In those few cases in which non-stationary data have been used the estimated coefficients of the AR and the MA processes are less than unity, which indicates the reliability of the estimated equations. The Plan and Budget Organisation (1994) database has been used for the estimated equations.

Table 4. Econometric Results for Residuals in the Manufacturing Sector (R_{3t}), 1966-1992

Variable	Identifier	Coefficient	*t* statistic	Order of integration
Dependent variable	ΔR_{3t}	1		I(0)
Constant	C	34.622	1.046	
Lagged dependent variable	ΔR_{3t-1}	0.311	3.688*	I(0)
Dummy variable	D3.1	672.595	10.098*	
Dummy variable	D3.2	-272.751	-4.241*	
Time trend	T	2.361	1.296	
First order Moving Average	MA(1)	-0.942	-6.349*	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.86 $F(5,21)$=33.76*
Diagnostic tests: Durbin *h* test=-0.60 Ramsey RESET (specification) $F(2,19)$=0.84
Jarque-Bera (normality) $Chi^2(2)$=0.53 LM (serial correlation) $Chi^2(2)$=6.32*
ARCH (Heteroscedasticity) $Chi^2(2)$=3.34 Ljung-Box (serial correlation) $Chi^2(2)$=2.50
Box-Pierce (serial correlation) $Chi^2(2)$=2.17
Chow (stability) forecast test (1987-1992) $F(6,15)$=not calculable
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

Table 5. Econometric Results for Value Added in the Water, Gas and Electricity Sector (V_{4t}), 1966-1992

Variable	Identifier	Coefficient	*t* statistic	Order of integration
Dependent variable	ΔR_{4t}	1		I(1)
Constant	C	6.504	2.038*	
Dummy variable	D4.1	111.453	12.090*	
Dummy variable	D4.2	-27.714	-4.195*	
Time trend	T	0.338	1.501	
First order Moving Average	MA(1)	-0.828	-6.013*	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.89 $F(4,22)$=53.05*
Diagnostic tests: DW=1.68 Ramsey RESET (specification) $F(2,20)$=0.29
Jarque-Bera (normality) $Chi^2(2)$=0.18 LM (serial correlation) $Chi^2(2)$=1.84
ARCH (Heteroscedasticity) $Chi^2(2)$=1.84 Ljung-Box (serial correlation) $Chi^2(2)$=0.77
Box-Pierce (serial correlation) $Chi^2(2)$=0.69
Chow (stability) forecast test (1987-1992) $F(6,16)$=Not calculable
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

An important step before the modelling of the sectoral residuals (R_{it}) is to determine the time series properties of the data. This is an important issue since the use of non-stationary data can result in spurious regression results. To this end, the Augmented Dickey-Fuller (ADF) test has been used to examine the

Table 6. Econometric Results for Residuals in the Construction Sector (R_{5t}), 1966-1992

Variable	Identifier	Coefficient	*t* statistic	Order of integration
Dependent variable	ΔR_{5t}	1		I(2)
Constant	C	12.349	1.243	
Residuals in sector 3	ΔR_{3t}	-0.661	-9.454*	I(1)
Dummy variable	D5	-198.804	-6.140*	
Second order Moving Average	MA(2)	0.422	1.662	
stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.92 $F(3,23)$=99.08*
Diagnostic tests: DW=2.03 Ramsey RESET (specification) $F(2,21)$=2.43
Jarque-Bera (normality) $Chi^2(2)$=2.08 LM (serial correlation) $Chi^2(2)$=2.43
ARCH (Heteroscedasticity) $Chi^2(2)$=0.96 Ljung-Box (serial correlation) $Chi^2(2)$=2.16
Box-Pierce (serial correlation) $Chi^2(2)$=1.85
Chow (stability) forecast test (1987-1992) $F(6,17)$=Not calculable
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

Table 7. Econometric Results for Residuals in the Trade Sector (R_{6t}), 1966-1992

Variable	Identifier	Coefficient	*t* statistic	Order of integration
Dependent variable	R_{6t}	1		I(0)
Constant	C	-412.397	-7.725*	
Lagged dependent variable	R_{6t-1}	0.7671	12.640*	I(0)
Dummy variable	D6	566.034	8.893*	
Time trend	T	-19.361	-5.762*	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.92 $F(3,23)$=95.42*
Diagnostic tests: Durbin *h* test=-0.09 Ramsey RESET (specification) $F(1,21)$=3.06
Jarque-Bera (normality) $Chi^2(2)$=0.94 LM (serial correlation) $Chi^2(2)$=1.84
ARCH (Heteroscedasticity) $Chi^2(2)$=3.03 Ljung-Box (serial correlation) $Chi^2(2)$=3.50
Box-Pierce (serial correlation) $Chi^2(2)$=2.67
Chow (stability) forecast test (1987-1992) $F(6,17)$=3.85*
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

stationarity, or otherwise, of the time series data.[9] In this paper the lowest value of the Akaike Information Criterion (AIC) has been used as a guide to determine the optimal lag length in the ADF regression. These lags are added to the ADF regression to ensure that the error term is white noise. The upper limit for these lags is assumed to be two, since the data are annual. Because of space limitations, the ADF test results are not reported here but they are available from the author upon request.

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[9] For more detailed information see Fuller (1976) and Dickey and Fuller (1979, 1981).

Table 8. Econometric Results for Residuals in the Transport Sector (R_{7t}), 1966-1992

Variable	Identifier	Coefficient	*t* statistic	Order of integration
Dependent variable	ΔR_{7t}	1		I(0)
Constant	C	-3.770	-0.594	
Dummy variable	D7	598.296	9.881*	
First order Moving Average	MA(1)	0.478	2.405*	
Second order Moving Average	MA(2)	-0.429	-1.903	
Second order Autoregressive	AR(2)	-0.645	-2.619*	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.88 $F(4,22)$=50.57*
Diagnostic tests: DW=1.48 Ramsey RESET (specification) $F(2,20)$=2.71
Jarque-Bera (normality) $Chi^2(2)$=1.72 LM (serial correlation) $Chi^2(2)$=2.72
ARCH (Heteroscedasticity) $Chi^2(2)$=3.41 Ljung-Box (serial correlation) $Chi^2(2)$=2.72
Box-Pierce (serial correlation) $Chi^2(2)$=2.32
Chow (stability) forecast test (1989-1992) $F(6,16)$=not calculable
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

Table 9. Econometric Results for Residuals in the Financial and Real Estate Sector (R_{8t}), 1966-1992

Variable	Identifier	Coefficient	*t* statistic	Order of integration
Dependent variable	ΔR_{8t}	1		I(0)
Constant	C	29.030	2.876*	
Dummy variable	D8	-259.698	-6.895*	
Lagged dependant variable	ΔR_{8t-1}	-0.558	-5.530*	I(0)
First order Moving Average	MA(1)	0.652	3.935*	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.75 $F(3,23)$=26.83*
Diagnostic tests: Durbin *h* test=0.45 Ramsey RESET (specification) $F(2,21)$=2.69
Jarque-Bera (normality) $Chi^2(2)$=0.08 LM (serial correlation) $Chi^2(2)$=2.18
ARCH (Heteroscedasticity) $Chi^2(2)$=0.19 Ljung-Box (serial correlation) Chi (2)=0.24
Box-Pierce (serial correlation) $Chi^2(2)$=0.21
Chow (stability) forecast test (1989-1992) $F(6,17)$=2.08
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

However, the order of integration of each and every dependent and independent variable (as well as each set of stochastic residuals) was determined at 10 per cent significance level and is shown, *inter alia*, in Tables 2 to 11. The ADF test results (including constant and/or both constant and trend) reveal that seven out of the ten estimated equations for the sectoral residuals, *i.e.* for sectors 1, 2, 3, 6, 7, 8, and 9, use stationary data as determined. The residuals in sector 6 are stationary in level form so the equation is estimated in levels. All the

Table 10. Econometric Results for Residuals in the Public Services Sector (R_{9t}), 1966-1992

Variable	Identifier	Coefficient	*t* statistic	Order of integration
Dependent variable	ΔR_{9t}	1		I(0)
Constant	C	73.777	2.439*	
Time trend	T	4.149	1.962	
Dummy variable	D9	-250.098	-4.780*	
First order Moving Average	MA(1)	0.300	1.467	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.46 $F(3,23)$=8.27*
Diagnostic tests: DW=1.94 Ramsey RESET (specification) $F(2,21)$=1.99
Jarque-Bera (normality) Chi^2(2)=34.90* LM (serial correlation) Chi^2(2)=0.41
ARCH (Heteroscedasticity) Chi^2(2)=0.74 Ljung-Box (serial correlation) Chi^2(2)=1.0
Box-Pierce (serial correlation) Chi^2(2)=0.83
Chow forecast (stability) test (1989-1992) $F(4,19)$=0.85
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

Table 11. Econometric Results for Residuals in the Personal and Domestic Services Sector (R_{10t}), 1966-1992

Variable	Identifier	Coefficient	*t* statistic	Order of integration
Dependent variable	ΔR_{10t}	1		I(1)
Constant	C	-4.551	-1.50	
Residuals in sector 5	ΔR_{5t}	0.131	5.330*	I(1)
Dummy variable	D10	66.832	5.454*	
Lagged dependent variable	ΔR_{10t-1}	-0.609	-3.081*	I(1)
First order Moving Average	MA(1)	0.547	1.802	
Stochastic residuals				I(0)

Estimation method: OLS Adj R^2=0.73 $F(4,22)$=18.87*
Diagnostic tests: Durbin *h* test=0.56 Ramsey RESET (specification) $F(2,20)$=0.47
Jarque-Bera normality Chi^2(2)=6.02* LM (serial correlation) Chi^2(2)=0.80
ARCH (Heteroscedasticity) Chi^2(2)=0.22 Ljung-Box (serial correlation) Chi^2(2)=2.94
Box-Pierce (serial correlation) Chi^2(2)=2.47
Chow (stability) forecast test (1987-1992) $F(6,16)$=2.39
Note: * indicates the relevant null hypothesis is rejected at the 5% level of significance.

dependent and explanatory variables in the equations capturing the residuals in sectors 1, 2, 3, 7, 8 and 9 are stationary after first differencing. As a result, the first difference form has been utilised in the estimation of these equations. Therefore, most of the estimated equations use stationary data. It should be emphasised that stationary data in this context can be time series data in levels, or first differences. However, in a few cases the sectoral residuals are I(2), which means they are stationary after second differencing. In these cases (sectors 4, 5, and 10) the first difference forms have been employed since the second differencing did not provide satisfactory results in terms of R^2 and t statistics. It should be mentioned that despite the use of non-stationary data in these few cases, the estimated coefficients for AR and MA in the equations are less than unity. However, the important point is that the stochastic error terms resulting from all the estimated equations for the sectoral residuals have also been tested and the results indicate they are all stationary. See Tables 2 to 11.

The OLS method is used for estimation since the equations are not simultaneous. Note that in some cases these equations are recursive. More specifically, the equations for sectors 1 and 8, 2 and 7, 5 and 3, and 10 and 5 are recursive. Thus, the OLS method is legitimate (Gujarati, 1995). Each estimated equation has a reasonable goodness of fit.

In order to provide some insights into the reliability of the estimated equations for the sectoral residuals a number of important diagnostic tests has been presented for each equation. The diagnostic tests used are as follows: first, the Durbin Watson test for autocorrelation; second, the Ramsey RESET test for functional form and specification of the equation; third, the Jarque-Bera test for normality of the stochastic residuals; fourth, the Breusch-Godfrey Lagrange Multiplier (LM) test for first and second order serial correlation; fifth, the Autoregressive Conditional Heteroscedasticity (ARCH) test for heteroscedasticity in the disturbances; sixth, the Box-Pierce and Ljung-Box Q statistics for testing first to third order autocorrelations; and seventh, the forecast version of the Chow test.[10] Examination of the diagnostic tests for most of the estimated equations indicates that there are a few econometric "pathologies". See Tables 2 to 11.

Having estimated the sectoral residuals, they can then be added to the corresponding computed sectoral value added to improve the tracking performance of the model. This can be done by the Gauss-Seidel solution technique. In this regard, a small convergence value of 0.02 is chosen to provide more sensitive and accurate results. By implementing this procedure, a new time series will be obtained which will henceforth be referred to as "simulated value added" (SV_{it}) in this paper. The tracking performance of simulated value added for all ten sectors is also presented in Figures 1 to 10 in the appendix. See the simulated values with the notation SV_{it} in these figures.

As indicated in these Figures, the simulated series (SV_{it}) tracks the actual sectoral value added quite well. Therefore, the conversion matrix, together with the modelled residuals, are capable of explaining the prevailing structure of the Iranian economy.

4. POLICY IMPLICATIONS OF THE STUDY

Using the conversion matrix and the modelled sectoral residuals, this section of the paper is concerned with an evaluation of the impact of changes in final demand deliveries on the growth of sectoral value added. To this end, first a

[10] For a concise explanation of these diagnostic tests see Cuthbertson, Hall and Taylor (1992, pp. 106-18).

control (baseline) solution is obtained. This control solution is nothing but the historical simulation presented in Figures 1 to 10 in the appendix. The next step is to investigate how sectoral value added would have changed if one of the final demand components had increased by a sustained 10 per cent. This task has been fulfilled using the index of *PDCS* (Percentage Deviation from the Control Solution) as follows:

$$PDCS_{it} = \frac{PV_{it} - SV_{it}}{SV_{it}}.100 \qquad (10)$$

where PV_{it} is the "perturbed" or "shocked" value added for the i^{th} sector after a (sustained) 10 per cent increase in one of the final demand aggregates over the simulation period 1983-1992.

This index is reported in Tables 12 to 15 for four specific scenarios of 10 per cent annual increases in private consumption, government consumption, gross domestic investment and total export. The sensitivity and responsiveness of each sector to these hypothetical simulations can be measured for the period 1983-1992. All the sectors are ranked in terms of average values of *PDCS* over the period of simulation. This information is useful for measuring the various demand impacts on the sectoral value added in economic planning. Furthermore, in macroeconometric modelling, the aggregate demand components can also be modelled and linked to the monetary and financial sectors in such a way that the impact of fiscal and monetary policies etc., on sectoral value added can be determined. Such an analysis is the subject matter of further research. Having made some general comments about policy analysis, it is now pertinent to discuss the four scenarios.

4.1 Private Consumption

The results of the simulation experiment of a (sustained) 10 per cent increase in private consumption are presented in Table 12. This shock can significantly stimulate the growth in sectoral value added in all sectors, except in the petroleum and construction sectors where the average impact is lower than 1 per cent per annum.

The sectors which can benefit from this stimulus, in order of importance, are as follows: the financial and real estate sector; the water, gas and electricity sector; the trade sector; the manufacturing sector; the transport sector; the personal and domestic services sector; the agriculture sector; and finally the public services sector. See the "Rank" row of Table 12. Generally speaking, the impact of this shock is on expanding both the goods and the services sectors. However, according to the simulation results, over time, these impacts are not the same for each year but they vary in a narrow range. For instance, the impact of this 10 per cent increase in private consumption on value added in the agriculture sector varies from a minimum of 4.90 per cent in 1987 to a maximum of 6.44 per cent in 1985.

Table 12. Percentage Deviation from Control Solution for the Sectoral Value Added as a Result of a 10 per cent Increase in Private Consumption

Year	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
1983	6.06	0.00	7.47	7.48	0.36	9.12	6.32	8.26	1.18	6.03
1984	6.08	0.00	7.81	9.06	0.37	8.78	6.75	8.26	1.28	6.49
1985	6.44	0.01	8.19	8.73	0.42	7.79	7.19	8.35	1.23	5.68
1986	5.49	0.01	8.24	8.63	0.48	7.33	7.44	8.38	1.32	6.90
1987	4.90	0.01	7.37	8.20	0.54	6.90	7.39	8.48	1.35	6.54
1988	5.70	0.01	7.74	8.07	0.62	7.09	7.67	8.63	1.52	6.19
1989	5.23	0.01	6.97	7.95	0.79	6.95	7.67	8.76	1.72	6.82
1990	5.17	0.00	6.28	7.71	0.84	7.35	7.42	9.40	1.93	6.47
1991	5.21	0.01	5.28	7.48	0.80	7.25	6.12	9.12	1.91	6.81
1992	5.04	0.01	5.10	6.41	0.81	7.26	6.29	9.27	2.00	6.63
Average	5.53	0.01	7.04	7.97	0.60	7.90	7.03	8.69	1.54	6.46
Rank	7	10	4	2	9	3	5	1	8	6

Table 13. Percentage Deviation from Control Solution for the Sectoral Value Added as a Result of a 10 per cent Increase in Government Expenditure

Year	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
1983	0.20	0.00	0.54	1.86	0.02	0.56	0.69	0.16	7.36	0.67
1984	0.18	0.00	0.50	2.00	0.02	0.36	0.66	0.14	7.09	0.63
1985	0.19	0.00	0.54	1.99	0.02	0.33	0.72	0.15	7.07	0.57
1986	0.15	0.00	0.49	1.76	0.02	0.28	0.67	0.13	6.78	0.62
1987	0.13	0.00	0.43	1.63	0.03	0.25	0.65	0.13	6.73	0.58
1988	0.14	0.00	0.44	1.56	0.03	0.25	0.65	0.13	7.37	0.53
1989	0.11	0.00	0.33	1.27	0.03	0.21	0.54	0.11	6.95	0.49
1990	0.10	0.00	0.28	1.17	0.03	0.20	0.50	0.11	7.34	0.43
1991	0.10	0.00	0.23	1.14	0.03	0.20	0.41	0.11	7.29	0.46
1992	0.10	0.00	0.22	0.97	0.03	0.20	0.42	0.11	7.59	0.44
Average	0.14	0.00	0.40	1.53	0.03	0.28	0.59	0.13	7.16	0.54
Rank	7	10	5	2	9	6	3	8	1	4

Notes: V_1: Agriculture sector; V_2: Petroleum sector; V_3: Manufacturing sector; V_4: Water, gas and electricity sector; V_5: Construction sector; V_6: Trade Sector; V_7: Transport sector; V_8: Financial, monetary and real estate sector; V_9: Public services sector; V_{10}: Personal and domestic services sector.

As a general pattern, it is relevant to note that over time the increasing impact occurs mainly in the services sectors, rather than the goods sectors. Such a differential expansion between sectors, like compound interest, has a cumulative effect. This trend is important because the growing sectors are those in which rent-seeking behaviour is rampant.[11] It is worth noting that Karshenas and Pesaran

[11] There is growing evidence that directly unproductive profit-seeking (*DUP*) activities in developing countries are inimical to long-run growth prospects. See Bhagwati (1987).

(1995) and Pesaran (1995) have also argued that rent-seeking is endemic in many services sectors in Iran.

4.2 Government Expenditure

As seen from Table 13, a 10 per cent increase in government consumption results in a considerable increase (more than one per cent) in the average value of the PDCS index over the simulation period for only two sectors. These two are the public services and Water, electricity and city gas sectors whose average annual *PDCS* are 7.16 per cent and 1.53 per cent respectively. The average annual response in other sectors associated with this simulation are less than one per cent. This is a manifestation of the exclusive government role in providing public goods and services such as public health, education, defence, etc.

Given the economic structure and sectoral interdependencies, it is highly likely that government expenditure does not have a high potential to expand productive economic activities which can supply goods for curbing inflation, or exporting goods in order to obtain foreign currency. Although the need for public goods and services produced by the government sector is irrefutable, government fiscal policies (as manifested by current expenditure) can have little influence on expanding the goods-producing sectors for long-run economic growth.

Table 13 also reveals that during the simulation period the impact of such an increase in government consumption in expanding value added in the goods sectors is not only negligible but is decreasing.

4.3 Gross Domestic Investment

First of all it is necessary to clarify what it is meant by a 10 per cent increase in gross domestic investment, because gross domestic investment, as described by various statistical sources, embodies two components, *viz.* changes in capital inventory and gross fixed investment. In this simulation experiment, it is assumed that there is an equal 10 per cent (sustained) increase in both gross fixed investment and changes in capital inventory for each year for the period 1983-1992.

The impact of this change is measured in terms of the *PDCS* and is presented in Table 14. As can be seen from this table, this increase in total investment leads to a considerable expansion (an average of more than 2 per cent) of value added in the following sectors: construction (7.41 per cent), manufacturing (2.89 per cent), agriculture (2.76 per cent), and trade (2.27 per cent). Therefore, it can be concluded that the impact of investment is directed more towards the goods-producing sectors.

As a general conclusion, investment has a positive or constructive, and in the latter half of the simulation, a growing impact on sectoral value added, particularly for the goods-producing sectors. Since the Iranian economy has a pressing need for goods, rather than services, this is a promising positive

Table 14. Percentage Deviation from Control Solution for the Sectoral Value Added as a Result of a 10 per cent Increase in Gross Domestic Investment

Year	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
1983	1.33	0.00	3.04	0.78	5.90	3.92	1.46	0.23	0.00	1.37
1984	1.84	0.00	3.23	0.93	5.71	2.74	1.50	0.22	0.00	1.44
1985	1.85	0.00	2.90	0.76	5.37	2.04	1.34	0.19	0.00	1.06
1986	2.33	-0.01	2.93	0.71	5.12	1.77	1.24	0.17	0.00	1.18
1987	3.53	-0.02	3.19	0.75	5.30	1.80	1.27	0.19	0.00	1.20
1988	2.00	-0.01	2.28	0.55	5.55	1.42	1.06	0.15	0.00	0.88
1989	3.04	-0.01	2.59	0.64	7.10	1.60	1.18	0.17	0.00	1.10
1990	3.80	-0.01	2.85	0.74	8.89	2.04	1.36	0.22	0.01	1.26
1991	3.73	-0.01	2.87	0.92	12.24	2.61	1.50	0.28	0.01	1.72
1992	4.16	-0.01	3.01	0.84	12.93	2.78	1.63	0.30	0.01	1.79
Average	2.76	-0.01	2.89	0.76	7.41	2.27	1.35	0.21	0.00	1.30
Rank	3	10	2	7	1	4	5	8	9	6

Table 15. Percentage Deviation from Control Solution for the Sectoral Value Added as a Result of a 10 per cent Increase in Total Exports

Year	V_1	V_2	V_3	V_4	V_5	V_6	V_7	V_8	V_9	V_{10}
1983	0.51	6.93	1.10	0.24	0.01	0.78	0.50	0.06	0.17	1.32
1984	0.37	6.95	0.84	0.21	0.01	0.41	0.39	0.04	0.13	1.03
1985	0.29	6.96	0.65	0.15	0.00	0.27	0.31	0.03	0.09	0.67
1986	0.10	6.41	0.27	0.06	0.00	0.10	0.13	0.01	0.04	0.33
1987	0.12	9.41	0.31	0.07	0.00	0.12	0.17	0.02	0.05	0.40
1988	0.20	11.29	0.48	0.11	0.00	0.19	0.25	0.02	0.09	0.57
1989	0.27	11.77	0.64	0.16	0.01	0.28	0.38	0.04	0.15	0.93
1990	0.40	9.84	0.86	0.23	0.01	0.44	0.54	0.06	0.26	1.31
1991	0.43	12.10	0.76	0.23	0.01	0.45	0.47	0.06	0.26	1.45
1992	0.42	11.93	0.74	0.20	0.02	0.46	0.49	0.06	0.28	1.44
Average	0.31	9.36	0.66	0.17	0.01	0.35	0.36	0.04	0.15	0.94
Rank	6	1	3	7	10	5	4	9	8	2

Notes: V_1: Agriculture sector; V_2: Petroleum sector; V_3: Manufacturing sector; V_4: Water, gas and electricity sector; V_5: Construction sector; V_6: Trade Sector; V_7: Transport sector; V_8: Financial, monetary and real estate sector; V_9: Public services sector; V_{10}: Personal and domestic services sector.

indication which should be considered by the government by allocating more funds to capital formation rather than current expenditure.

4.4 Total Exports

The purpose of the final simulation is to measure the consequence of a 10 per cent increase in total exports on value added in various sectors. According to Table 15, the most impressive feature of this change pertains to the petroleum sector. On average, value added in the petroleum sector is increased by 9.36 per cent for the period 1983-1992.

In examining the effect of a sustained increase in total exports there are two distinct periods to be considered. During the Iraq-Iran war on average the *PDCS* for the petroleum sector was 8.5 per cent, whereas after the end of the war the average *PDCS* was 11.41 per cent. In this context it is important to note that the analysis reported here has captured an important difference in economic behaviour associated with exports and the petroleum sector during and after the Iraq-Iran war.

Table 15 also shows how reliant the Iranian economy is on the petroleum sector. The impact of such a perturbation on value added in the other sectors is not very large. In other words, a sustained 10 per cent increase in total exports only gives rise to an average growth of less than one per cent in value added of all the other sectors. During the period 1983-1988 the *PDCSs* are decreasing for almost all the sectors due to the adverse consequences of the Iraq-Iran war. However, in the years after 1988 most of the sectors showed an increasing response to an increase in total exports.

This indicates that value added in non-oil exporting sectors has increased after the war, albeit those increases are not of a large magnitude. These results seem quite legitimate since they are in line with the current economic circumstances in Iran. As seen from Table 15, the five important sectors which responded to such a change in total exports are personal and domestic services, manufacturing, transport, trade and agriculture sectors. More specifically, according to the simulation results, if total exports had increased by 100 rials in 1992, with the petroleum sector expanding by 119 rials, the above five non-oil sectors would grow by only 35.5 rials (14.4+7.4+4.9+4.6+4.2). This result indicates how heavily the Iranian economy relies upon petrodollars.

5. CONCLUDING REMARKS

This paper has linked the sectoral value added to the final demand deliveries for ten major sectors. Input-output analysis and econometric modelling have been utilised to formulate four types of policy analyses to understand, in part, the working mechanism of the Iranian economy. That is, the policy implications of this study highlight the impact of (sustained) 10 per cent increases in each of the components of final demand, other elements remaining unchanged, on the growth of value added in various sectors.

The simulation results over the period 1983-1992 show that the model can represent production interdependencies of the Iranian economy. This indicates the acceptability of the assumptions made in the computation of the conversion matrix and the modelled sectoral residuals.

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APPENDIX

This Appendix presents ten Figures in order to demonstrate actual and various computations of value added in different sectors. The notation *Vi*, *CVi*, *SVi* and *Ri* in these Figures corresponds to V_i, CV_i, SV_i and R_i in the text.

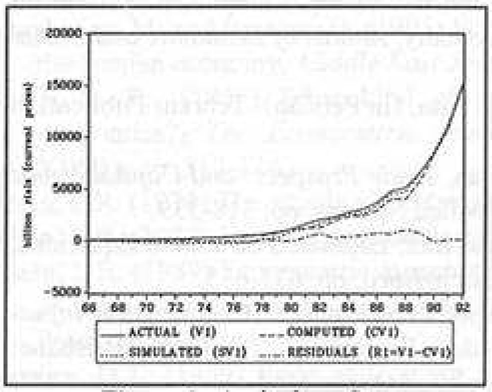

Figure 1. Agriculture Sector

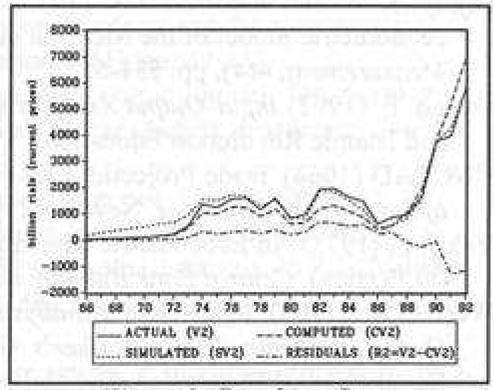

Figure 2. Petroleum Sector

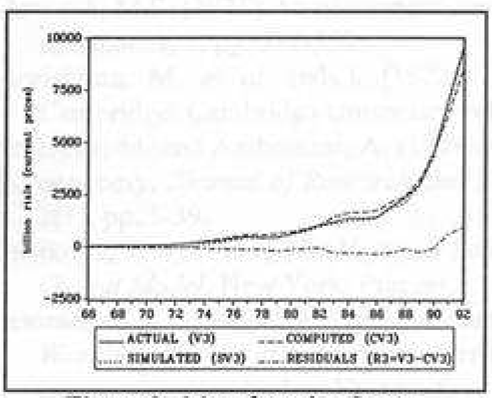

Figure 3. Manufacturing Sector

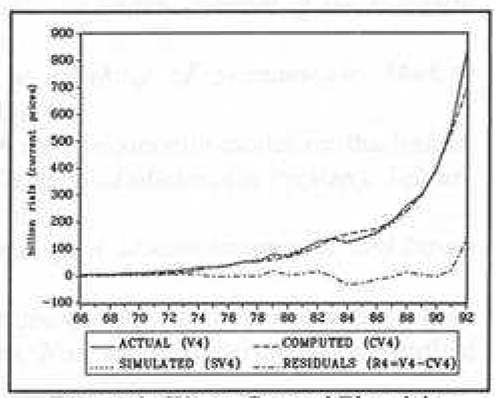

Figure 4. Water, Gas and Electricity

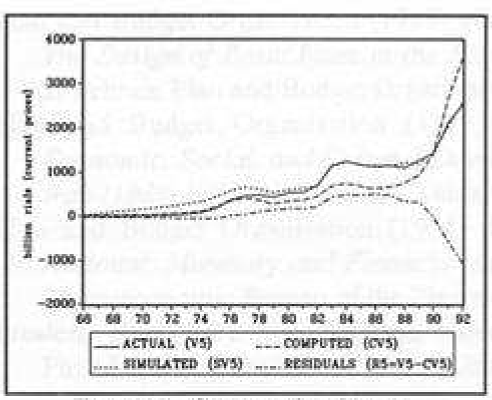

Figure 5. Construction Sector

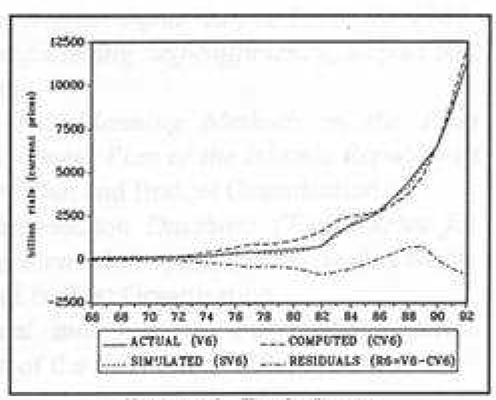

Figure 6. Trade Sector

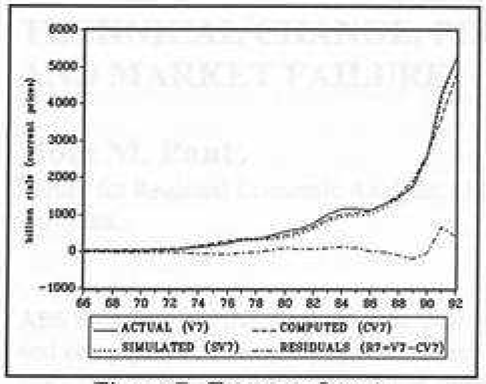

Figure 7. Transport Sector

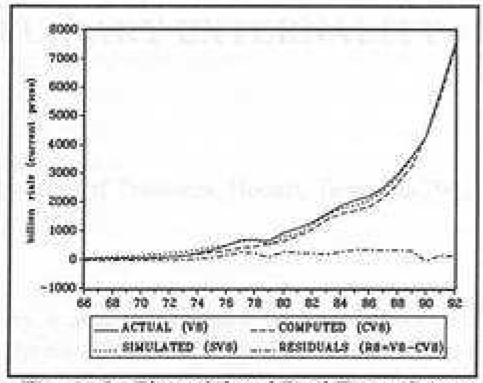

Figure 8. Financial and Real Estate Sector

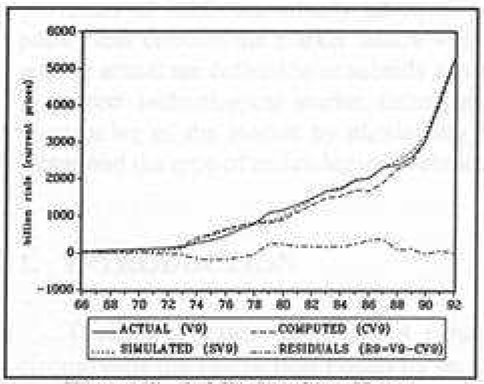

Figure 9. Public Services Sector

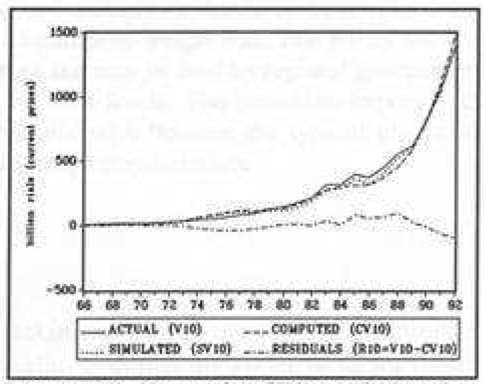

Figure 10. Personal and Domestic Services