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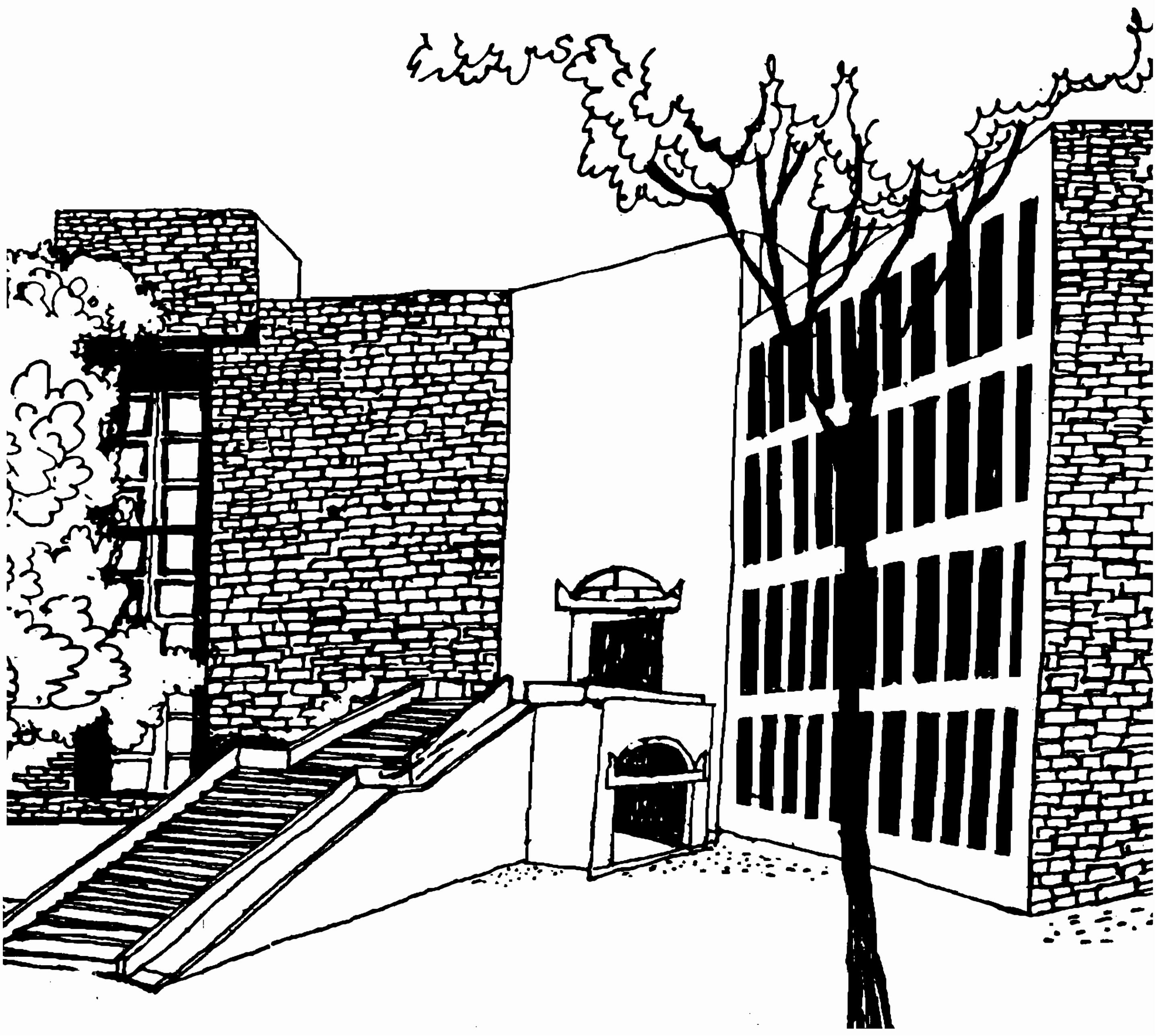

Modelling of Industrial Sector in Macroeconometric Models of Indian Economy

By

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ABSTRACT

Modelling of the industrial sectors has been ad-hoc in macro models. The proportion of industrial sector out in nation output has steadily increased but modellers have ignored the link between industrial sector output and employment. There are various reasons for that. The scenario of industrial sector is changing rapidly and far-reaching changes are taking place in the economy. It has become imperative for the modellers to model industrial sector with its links with employment generation in the economy and policy variables which affect the industrial sector production. As service sector is gaining importance in the economy, it would be ideal to explore links between service sector and industrial sector output and services sector's potential to generate employment in the economy.

Modelling of Industrial Sector in Macroeconometric models of Indian economy

by
Anupam B. Rastogi[1]

1. Introduction

The output of industrial sector has been increasing since independence. Industrial output as a proportion of GDP has been on a secular upward trend. However, growth of industrial sector has not been the same in the last four decades or so. In the fifties, large public sector investments gave a boost to the industrial sector, the sixties and the seventies saw a stagnation. But the eighties, again, had been quite good as far as industrial growth was concerned. Various aspects of industrial stagnation etc. have been well documented showing as to how industrial sector at aggregated and disaggregated level has performed [Ahluwalia(1989, 1991)]. Figure 1 gives a bird's eye view of the proportion of agricultural, industrial and services sector in India's GDP and the growth rates in different sectors have been tabulated in Table 1.

Table-1: Sectoral Growth Rates in Indian Economy

	51-60	61-70	71-80	81-90	51-90
1. Agriculture	3.11	2.54	1.83	3.76	2.81
2. Industry	6.99	4.12	5.30	6.69	5.77
(a) Manufacturing	6.80	3.81	4.86	6.18	5.41
(i) Registered	7.97	4.86	4.78	7.13	6.19
(ii)Unregistered	5.79	2.59	5.00	4.88	4.56
(b) Electricity	13.21	10.53	8.34	8.35	10.11
(c) Mining etc.	7.52	3.90	8.60	11.43	7.86
3. Construction	8.91	5.36	3.92	7.17	6.34
4. Railways	5.86	1.04	-0.96	10.38	4.08
5. Services	3.46	5.74	3.97	6.61	4.95

Source: National Accounts Statistics 1989 & 1991

1. I am thankful to Ms. Anjana Ghosh for her research assistance in writing this paper. Helpful comments from Professors J.C. Sandesara, K. Krishnamurty and Dr. S. Bhide are gratefully acknowledged. This is essentially a survey article, presented at the workshop on macro-modelling organised by NCAER from September 1-3, 1993.

Figure 1: Share of Agriculture, Industry and Services in GDP

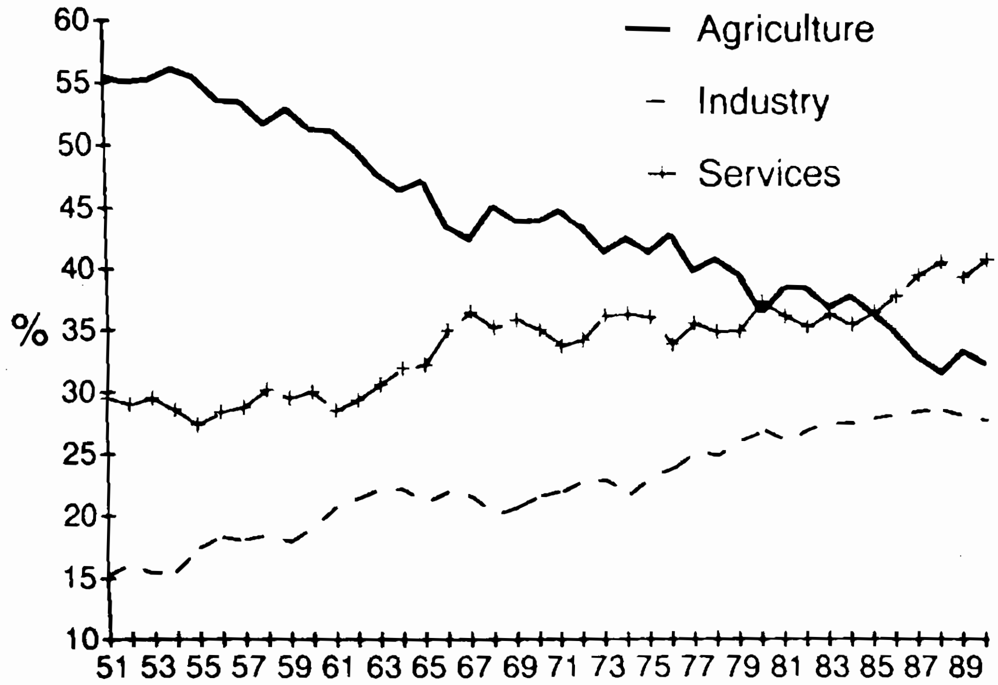
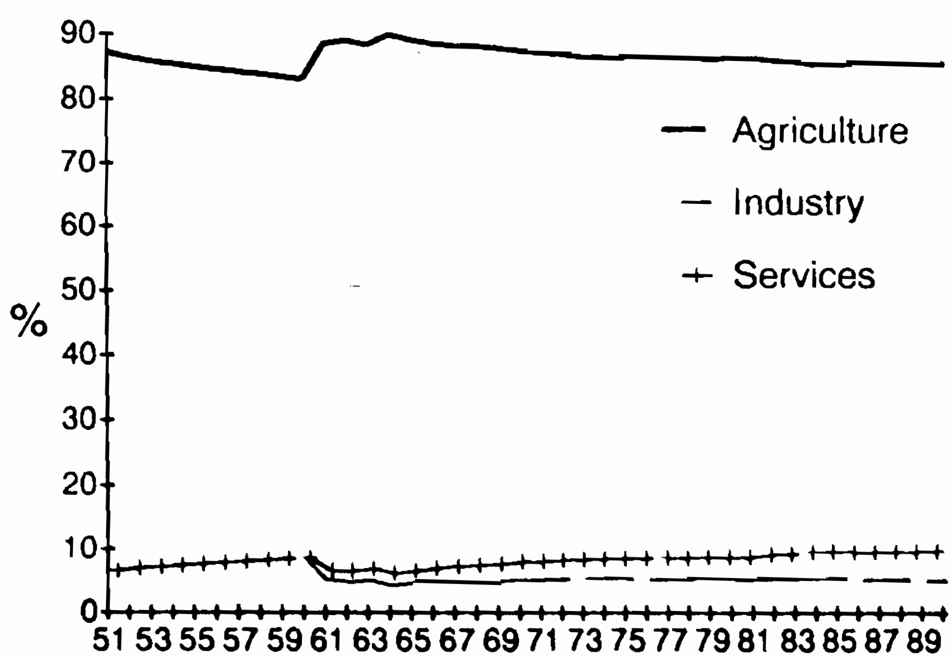


Fig 2 - Share of employment in Agriculture, industrial and services sector



As early as mid-seventies, attention of the policy-makers had turned to promotion of employment generating industries - registered or unregistered, the reason being that the 'temples of modern India' could not provide employment to growing working population. Table 2 and Figure 2 present a grim view of growth rates of employment and proportion of employment in different sectors.

Table-2: Employment Growth Rates in Different Sectors of Indian Economy

	51-60	61-70	71-80	81-90	51-90
1. Agriculture	0.86	2.56	2.07	0.76	1.56
2. Industry	-0.24	2.79	2.44	0.42	1.35
3. Services	1.38	4.70	2.98	2.03	2.77

Source: Economic Survey (various issues); 1951-1960 from World Tables (UN) Social Database

This paper seeks to examine how the industrial sector is modelled and determined in macro-econometric models of the economy. After critical examination of the sector, a suggested line of analysis is put forward for modelling.

A framework for analysis is set out in section 2, which is sufficiently general to encompass not only a number of specific models which have been discussed, but also all but one of the theoretical structures that underpin the treatment in the empirical models. Some specific theoretical issues, such as the Cobb-Douglas production function and the constant elasticity supply function are discussed in Section 2. Section 3 deals with the empirical models of industrial sectors as embedded in the macro models. The relationship between employment and industrial output is not a recurring theme, as is the dynamic behaviour of the industrial sector output and the agricultural sector output. Even though there are similarities initially the actual models differ quite sharply.

2. Theoretical Framework

Neo-classical models of industrial sector output are based on the production function of a firm, where output is a function of factors of production namely, stock of capital and labour. Inputs are assumed to be continuously substitutable at the levels of production. It should be noted that in the production function Q = Q(K,L) where K is stock of capital and L is labour: Q defines the maximum possible level of output. The technical problem of how to achieve the greatest output from given inputs is assumed to be solved. There are some serious conceptual problems involved with the idea of a macro production function. First, the aggregation is performed over firms all within the same industry. Second, the marginal productivity condition across the firms is assumed to be same. Hence, the concept of an aggregated production function is a nebulous one. But, the attraction of the proposition to attempt to find a simple relationship which sums up the whole technology under which an economy operated has led the modellers to sweep all the conceptual problems under the carpet and utilize either Cobb-Douglas production function or constant elasticity of substitution (CES) production function to estimate industrial sector output.

The Cobb-Douglas Production Function:

The most frequently employed production function in empirical work is:

$$Q=AK^{\alpha}L^{\beta}$$

This function has a number of convenient properties. The parameters α and β measure the elasticities (assumed constant and between zero and unity) of output with respect to capital and labour respectively. The parameter A is regarded as an efficiency parameter, since for fixed input of K and L, the larger the A is, the greater the maximum output Q is obtainable from such inputs. In line with economic theory, the marginal product of capital ($\delta Q/\delta K$) and labour ($\delta Q/\delta L$) diminishes as the relevant factor input increases since both ($\alpha-1$) and ($\beta-1$) are negative quantities. As Cobb-Douglas function is homogeneous of degree ($\alpha+\beta$), in empirical work it is assumed that data shows a constant return to scale or very near to it. Lastly, the function implies a constant elasticity of substitution of unity.

The Constant Elasticity of Substitution Production Function:
As noted earlier the Cobb Douglas production function has a constant elasticity of substitution of unity, which is restrictive, if the analysis is to be done to examine the extent to which factor substitution is possible. Under CES production function, though elasticity of substitution is constant, it can take values other than unity. The CES production function is of the form:

$$Q = \chi[\delta K^{-\theta} + (1-\delta)L^{-\theta}]^{-\upsilon/\theta}$$

where, χ is efficiency parameter akin to A in Cobb-Douglas production function, δ is known as the distribution parameter, θ is known as the substitution parameter and υ is returns to scale parameter. This function was first introduced by Arrow, Chenary, Minhas and Solow in 1961. It is also known as SMAC function sometimes. However, as it is non-linear in the parameter θ, one cannot take logarithms of both sides and proceed. But what the CES production function lacks in simplicity it makes up for its generality.

The links between industrial sector and rest of the economy can be broadly defined as production linkages, demand linkages and savings and investment linkages. The industrial sector is linked to agriculture and services sector through the input-output relationship. The input of many industries like sugar, cotton textiles, tobacco come from agriculture sector. On the other hand, farm equipments, pesticides etc. are products of industrial sector. Demand for industrial goods, especially industrial consumption goods is demanded by rural and urban population. Agricultural output and term of trade between agriculture and industry have positive influence on the demand of consumption goods [Rangarajan (1982)]. As cited earlier, the government has been a key player in the industrial sector of the economy. Industrial sector output has greatly depended on government expenditure, which is directly related to government savings. Government savings in turn is a function of industrial sector output and agricultural sector output. Household savings are largely influenced by income which affects the demand for industrial consumption goods. Thus the industrial sector in a macroeconometric model can be linked to rest of the economy by any of the three links outlined above.

3. Existing Models

Agarwala (1970) model divides the economy into two sectors, namely, agricultural and non-agricultural sector. The estimated equation for the non-agricultural sector is as follows:

$$\text{Log}\ \frac{Y_i}{L_i} = -0.4407 + 0.5599\ \text{Log}\ \frac{K_i}{L_i}$$

(s.e.) (0.0734) (0.0628)

R^2 = 0.8675 Method of estimation = OLS
Sample size= 14 (1948-49 to 1961-62)
where Y_i = output in non-agricultural sector
K_i = stock of capital in non-agricultural sector
L_i = employment in the non-agricultural sector.

The estimated equation in the log-linear form is derived from the Cobb-Douglas production function with an implicit assumption of constant returns to scale. The estimated equation has a further restriction and that is the coefficient on the capital variable and the labour variable should add up to one. The estimated coefficient for capital is 0.5599 and that for labour is 0.4401. The non-agricultural employment is an endogenous variable in the model and it is a function of domestic foodgrains production and net imports of foodgrains.

GDP deflator is a weighted average of agricultural prices and non-agricultural prices and weights are given by the proportion of output of the two sectors in the economy. Price index of manufactured goods is estimated as a function of marginal labour cost to output ratio $[W/(\partial Y_i/\partial L_i)]$ where W is nominal wage. Net private investment in non-agriculture sector. Investment is a function of government control, disposable income of the non-agriculture sector and relative prices of non-agriculture sector to general price index. Interestingly, government control is measured in terms of percentage of the applications for capital issues for which consent was given by the Controller of Capital Issues. Capital stock in non-agriculture sector is updated by total net investment in non-agriculture sector which includes government investment as well as private investment in non-agriculture sector.

Marwah (1972) model has a few elaborate equations for manufacturing and semi-manufacturing production indices but there is no equation for industrial sector as such. The relevant equations for some sub-sectors of industrial sector are as follows:

(i) $X_m = -21.2881 + \underset{(0.1399)}{0.5021X} + \underset{(0.097)}{0.7523X_{m-1}}$ (s.e.)

$R^2 = 0.97$ Mean = 107.26 SEE = 4.13
Method of estimation = TSLS Sample size = 27 (1939-1965)

(ii) $\frac{X_m}{XC_m} = -0.0475 + \underset{(0.277)}{0.4875\frac{L}{Y}} \underset{(0.049)}{-0.127\left(\frac{S_m}{X_m}\right)_{-1}} + \underset{(0.259)}{0.9934\frac{X}{XC}}$ (s.e.)

$R^2 = 0.69$ Mean = 0.903 SEE = 0.045
Method of estimation = OLS Sample size= 19 (1947-1965)

(iii) $\frac{S_m}{X_m} = 0.522 - \underset{(0.016)}{0.025\frac{H}{P}} + \underset{(0.238)}{0.4806\left(\frac{S_m}{X_m}\right)_{-1}}$ (s.e.)

$R^2 = 0.45$ Mean = 0.60 SEE = 0.16
Method of estimation = OLS Sample = 1951-65

(iv) $X_{sm} = -120.223 + \underset{(0.165)}{2.2408X}$ (s.e.)

$R^2 = 0.93$ Mean = 127.71 SEE = 7.38
Method of estimation = TSLS Sample size = 25 (1951-1965)

where - X_m = Index of manufactured goods production
X = Net national product at factor cost
C_m = Consumption of manufactured goods
L = Currency + demand deposit + savings deposits
Y = Net national product at factor cost
S_m = Stock of manufactured goods
C = Aggregate private consumption
H = Sum of government expenditure, investment in inventories and net foreign income from services
P = Index of general price level
X_{sm} = Index of semi-manufactured goods
XC_m= Capacity output of manufactured goods

Manufactured goods and semi-manufactured goods are dependent on net national product. Stocks (inventory) of manufactured and semi-manufactured goods in turn depend on the output of manufacturing and semi-manufactured goods respectively. Although modelling is elaborate, it is more like a bivariate time-series models. There is no direct linkage between manufacturing and semi-manufacturing output and employment.

The functional form of price indices of manufactured and semi-manufactured goods is a linear approximation of other price indices and cost of inputs. Price index of manufactured goods is a function of wage cost, capacity utilisation, foodgrain price index and unit value index of imports. Semi-manufactured price index is a function of stock of semi-manufactured goods and general price level. Real aggregate investment and real government investment is specified as a function of output only and aggregate capital stock is updated by aggregate investment expenditure. The national output is driven by past aggregate capital stock.

Ahluwalia (1979) model divides the economy into two sectors - agriculture and non-agriculture. Non-agricultural sector is further divided into the manufacturing and other sectors. Her model emphasises supply constraints arising from the agricultural sector and the foreign sector on total output and prices. The estimated equations of the non-agricultural sector output are as follows -

(i) $\log Y'_m = -0.257 + 0.318 \log (U'_m . S) + 0.0307$

Method of estimation = OLS Sample size = 22 (1952-1973)

(2) $Y' = -11.005 + 1.401 Y'_a + 2.939 Y'_m$

Method of estimation = OLS Sample size = 22 (1952-1973)

(3) $Y'_n = Y' - Y'_a$

where, Y'_m = GDP in manufacturing
Y' = GDP at factor cost
Y'_n = GDP in sectors other than agriculture
Y'_a = GDP in agriculture
U'_m = Value added in manufacturing per reporting establishment
S = No. of reporting establishments
T = Time trend

As emphasis of the model was to explain the price and output behaviour in the economy, the linkage of the manufacturing sector output to the rest of the model is through relative prices of commercial crops to manufactured goods and the relative prices of foodgrains to manufactured goods. There is no direct link between manufacturing sector output and employment.

Wholesale price index of manufactured goods is a linear function of WPI of non-agriculture price index. These price indices are used to calculate relative prices but general price index is calculated from the monetary sector of the economy. Private corporate sector investment is a log linear function of returns on industrial securities, government expenditure, capital stock in the manufacturing sector, imports of capital goods and unit value index for commercial crops. Private non-corporate sector investment is a function of lagged GDP only. Investment in the manufacturing sector is taken as a weighted average of private corporate sector investment and government investment. Net capital stock in manufacturing per establishment is updated by net investment in manufacturing per establishment. Manufacturing prices do not have any impact effect on manufacturing output and the manufacturing sector output affect investments with a lag of one year. In this model investment in the manufacturing sector depends on the past output but manufacturing prices are affected by current output.

Rangarajan (1982) model emphasises the link between agricultural sector and industrial sector growth as such. However, it has two equations which explain the behaviour of output of industrial consumption good and total output of industrial production as follows:

(i) $ICI = 4.868 + 0.612\, IQI_{-1} + 0.447 AQI_{-1} - 0.094 FGTT_{-1}$
(s.e.) (0.0632) (0.1135) (0.0588)

$R^2 = 0.97$ DW = 1.94
Method of estimation = OLS Sample size = 12 (1961-72)

(ii) $IQI = 10.189 + 0.508 IBKI + 0.37 ICI$
(s.e.) (0.0415) (0.0784)

$R^2 = 0.99$ DW = 1.17
Method of estimation = OLS Sample size = 12 (1961-72)

where, ICI = Industrial consumption goods output index
IQI = Industrial production index
AQI = Agricultural output index
FGTT = Foodgrains terms of trade
IBKI = Capital goods output index

Equation for industrial consumption goods (ICI) suggests that the output of this sector is demand determined and it is dependent on lagged values of agricultural output index, industrial production index and the ratio of food prices to that of manufactured consumption goods. Industrial production index (IQI) on the other hand is a function of contemporary values of the index of industrial consumption goods output and the index of capital goods output. Both, the output index and the production index are used to determine relative prices of food prices and manufactured goods prices. Employment in the industrial sector of the economy has not been explained in this model.

This model is estimated in 1960 prices and TOT between agricultural commodities and manufactured finished products is estimated but it does not explain the price behaviour of the economy. The gross capital formation of the economy is divided into three sectors, namely, private corporate sector, household sector and government sector. Public sectors' capital formation is a linear function of their savings and capital inflows. Other two sectors' capital function is predetermined by previous year's income and TOT between price of agriculture commodity and price of manufactured finished products. The linkage of gross capital formation to industrial production runs through capital goods output index which is a function of gross capital formation and imports of capital goods.

Pani (1984) model is a disaggregated model. This divides the economy into two sectors, namely, agriculture and non-agriculture sector. The non-agriculture sector is further divided into four sub-sectors, namely mining & manufacturing (registered), unregistered manufacturing, transport & communications and other services. All the equations have a sample size of 13 observations only from 1969-70 to 1981-82. The estimated equations are:

(i) Mining & manufacturing (registered)

$$YMR = 89.82352 + 0.10838\ (GDER-IR) + 255.04152\ \frac{QNF_{-1}}{KMR} + 1.0012 KMR + 25.57410\ \left(\frac{GE-CGN}{PCF}\right)$$

(s.e.) (0.06) (1.91) (1.06) (0.85) (1.66)

R^2 = 0.93 DW = 2.38 SEE = 204.13 Mean = 6572.92

(ii) Unregistered manufacturing

$$YUR = 789.33691 + 0.15934\ YMR + 1.25948\ KUR$$

(s.e.) (3.95) (3.61) (3.93)

R^2 = 0.99 DW = 1.12 SEE = 41.52 Mean = 2209

(iii) Transport & Communications

$$YTR = 902.85335 + 0.01799\,(YAR+YMR) + 2.56448\,KTR$$
$$(s.e.)\quad (2.50)\qquad (1.01)\qquad (9.75)$$
$$R^2 = 0.98 \qquad DW = 1.25 \qquad SEE = 66.15 \qquad Mean = 2173$$

(iv) Other Services

$$YOR = 2798.85 + 0.22134 \left(\frac{(YAR+YTR+YMR)+(YAR+YMR+YTR)_{-1}}{2}\right)$$
$$(s.e.)\quad (1.08)\qquad (1.83)$$

$$+\ 10.67252\,KOR_{-1}$$
$$(4.45)$$
$$R^2 = 0.98 \qquad DW = 0.55 \qquad SEE = 314.25$$

where, YMR = Net Domestic Product of manufacturing industries
YUR = Net Domestic Product of unregistered manufacturing industries
YTR = Net Domestic Product of Transport & Communication industries
YOR = Net Domestic Product of other services
GDER= Gross domestic expenditure
IR = Gross domestic capital formation
QNF = Non-foodgrains production index
KMR = Gross capital stock in manufacturing industry
GE = Government expenditure
CGN = Government consumption expenditure
PCF = Price deflator for gross domestic capital formation
KUR = Gross capital stock in unregistered manufacturing industry
KTR = Gross capital stock in transport & communications industry
KOR = Gross capital stock in other services

Registered mining & manufacturing output is a function of capital stock, capital expenditure of government, consumption expenditure (demand variable) and availability of raw materials. Functional form of the specified equation is an imputed form of production function in the sense that output is a function of capital stock and another factor of production, namely, labour which is assumed to be infinitely elastic at the given wage rate. Unregistered manufacturing sector output is a function of capital stock in the unregistered sector and the output in the registered manufacturing sector. The latter acts as a proxy for both demand and supply factors. The functional form for the output of transport and communications sector is same as that of unregistered manufacturing sector except that the income from the agricultural and manufacturing sector together acts as a proxy for demand factor. The output of other services is mainly demand determined from agriculture, manufacturing, transport and communications sector and also capital stock available in the sector.

The wholesale price of manufactured products is formulated as a function of food prices, prices of agricultural raw materials and import price. National income deflator is a function of real output, money and price of foodgrains. Investment in private manufacturing, transport and other services is related to output of the sector or total output, government investment and lagged capital stock. Government investment is taken as exogenous in the model. Gross capital stock in different sectors is calculated using investment in that sector which affects the output of the sector. Being a disaggregated model prices do not impinge output in that sector immediately.

Krishnamurty (1984) model has a well defined industrial sector which comprises of mining and manufacturing only. Output in this sector is a function of labour and capital. Other quality variables which affect the demand of industrial output, for example, public sector infrastructure, public investment etc. and supply of industrial output like agricultural raw materials, imported raw materials etc. are included. The estimated equation is as follows:

$$\frac{XGDPIND}{XKIND} = \underset{(0.0175)}{0.0342} + \underset{(13.2)}{43.6975}\frac{LABIND}{XKIND_{-1}} + \underset{(0.5989)}{1.0602}\frac{XGDPINFPU}{XKIND_{-1}} + \underset{(0.2739)}{0.2137}\frac{XMRM}{XKIND_{-1}} + \underset{(5.295)}{6.4602}\frac{NFDGPI}{XKIND_{-1}}$$

(s.e.) in parentheses

$R^2 = 0.99$ DW = 1.20,

Method of Estimation = OLS Sample size = 19 (1962-1980)

where, XGDPIND = GDP in industry
XKIND = Capital stock in industry
LABIND = Employment in mining and manufacturing
XGDPINFPU= GdP in public sector infrastructure
XMRM = Imports of raw materials, fuels & intermediaries
NFDGPI = Non-foodgrains production index

As noted earlier the functional form of the model is well specified in the tradition of Keynesian type models and the model does not have a theoretical production function underpining.

Furthermore, as industrial sector output is estimated as a proportion of capital stock in the industrial sector it is not easy to disentangle capital and labour elasticities. The labour employment in the industrial sector is determined by industrial sector output.

Prices in each of the sectors are determined by incorporating supply, demand, cost, monetary factors and import prices. Industrial sector and public sector infrastructure are supply constrained as their output depends primarily on the stock of capital. Private investment in industry depends on internal funds (i.e. non-wage income in the economy) and public investment.

Pandit (1984) model emphasises output and prices. Conceptually the total output is divided into four sectors, namely, agriculture, manufacturing, services and mining, forestry & fisheries. Output of fisheries and forestry being small is taken as exogenous variable. In the model it is assumed that manufacturing absorbs the slack in the system i.e. manufacturing output is demand determined and it is the difference between the total output of the economy and output of agriculture, forestry & fisheries and services sector. Services sector output is assumed to be a function of agriculture and manufacturing sector (including mining, forestry and fisheries). The estimated equation is:

$$X_s = -9.708 + 0.211\, X_a + 1.053\, (X_m + X_{mf})$$
(s.e.) (5.54) (0.0643) (0.0593)

$R^2 = 0.993$

Sample size= 28 (1951 to 1978) Method of estimation= OLS

where, X_s = Services sector output
X_a = Agricultural sector output
X_m = Manufacturing sector output
X_{mf}= Output of mining and forestry

As manufacturing sector output is taken as slack variable there is no link between employment and output in the economy. In fact, labour market has been ignored altogether in this model.

In this model prices of different sectors of the economy are estimated. Rate of change of price of manufactures is a function of raw materials price inflation, energy price inflation, bank credit, wage cost and unit indirect tax. Investment in the economy is modelled along the line of funds of flow framework. Hence, household investment and corporate sector investment is modelled. Corporate investment is split into fixed capital formation and changes in stocks. The latter is a function of speculative demand and demand arising from productive activity. Fixed investment is related to changes in the level of non-agricultural output, the lagged rate of profit. At the first glance, the relationship between investment and non-agriculture output does not get highlighted but with some manipulation one can see that non-agriculture output has an impact effect on corporate investment. However, the effect of inflation is indefinite.

Krishnamurty et.al. (1989) emphasise economic growth in their model and focus on output-capital ratios, rates of savings and import intensity. They have estimated output-capital ratio of manufacturing & construction, infrastructure and services sector. Capital-output ratio, in different sectors is a function of the capital stock available in the sector and other variables which are able to capture capacity utilisation. For example, manufacturing & construction output depends on imports of raw materials and fuel. Infrastructure sector output depends on the output of the rest of the economy. The estimated equations are:

(i) Output-capital Ratio : Manufacturing & Construction

$$\log\left(\frac{ZX_{mc}}{ZK_{mc-1}}\right)=2.220 - 0.336 \log ZK_{mc-1} + 0.651 \log\left(\frac{ZX_{in}}{ZK_{mc-1}}\right)$$

(s.e.) (0.192) (0.0573) (0.0186)

$$+ 0.047 \log\left(\frac{ZIMM_{rm}+ZIMM_{fl}}{ZK_{mc-1}}\right)$$

(0.0456)

Method of estimation = AR1(RHO=0.498) Sample Size=23 (1960-82)

R2=0.969 DW=1.354

(ii) Output-capital Ratio : Infrastructure

$$\log\left(\frac{ZX_{in}}{ZK_{in-1}}\right) = -0.8175 - 0.142 \log ZK_{in-1} + 0.113 \log\left(\frac{ZIMM_{fl}}{ZK_{in-1}}\right)$$

(s.e.) (0.1675)(0.0478) (0.0585)

$$- 0.09 \log\left(\frac{ZIMM_{fl}}{ZK_{in-1}}\right)*D(62\text{-}76) - 0.091 \log ZK_{in-1}*D(62\text{-}76)$$

(0.0456) (0.0474)

Method of estimation = OLS(RHO=0.300) Sample Size=23 (1960-82)

R2=0.879 DW=1.300

(iii) Output-capital Ratio : Services

$$\log\left(\frac{ZX_{sr}}{ZK_{sr-1}}\right) = 1.256 - 0.082 \log ZK_{sr-1} + 0.897 \log\left(\frac{ZX_{in}}{ZK_{sr-1}}\right)$$

(s.e.) (0.318) (0.1025) (0.1073)

$$+ 0.177 \log\left(\frac{ZX_{ag}+ZX_{mc}+ZX_{in}}{ZK_{sr-1}}\right) .$$

(0.0855)

Method of estimation = AR1(RHO=0.385) Sample Size=23 (1960-82)

R2=0.988 DW=1.551

where, subscripts $_{ag}$, $_{mc}$, $_{in}$ and $_{sr}$ refer to agriculture, manufacturing & construction, infrastructure and services sector

and ZX = real output

ZK = real capital stock

ZIMM = real imports

According to the authors, it is assumed that the technology is simple Cobb-Douglas type wherein output-capital ratio is posited to depend on the stock of capital and other explanatory variables. However, labour employed in these sectors is not one of the explanatory variables. The link with the rest of the model is weak as the authors have constructed a sub-model of output-capital ratios of different industrial sectors in the economy. The impact of public sector investment is weak on manufacturing investment and the TOT between agriculture price index and general price index has a negative effect on manufacturing investment.

Rastogi (1991) is a rational expectations model of the Indian economy and there is a strong emphasis on the supply side and total output capacity of the economy. The model divides the economy into two sectors, namely, agricultural and non-agricultural sector. The theoretical underpining for the non-agricultural sector is taken from Landon (1990) where techniques of non-agricultural sector production is assumed to be fixed in the short run due to prohibitive adjustment costs and hence short-run production function is Leontief production function type in the short run but in the long run it takes Cobb Douglas form. The estimated equation of the non-agricultural sector is:

$$\underset{(s.e.)}{\text{Log } Y_{na}} = \underset{(0.0032)}{0.47275} \log K_{na} + \log \left(\frac{K-K_a L}{K_{na}-K_a}\right)$$

$$- \underset{(0.61)}{0.43480} \log fuelpi + \underset{(0.0012)}{0.047576} \ trend$$

$R^2 = 0.991$ Mean = 10.7097 RSS = 0.085
Sample size = 36 (1952-1987)
Method of estimation = Instrumental variable

where, Y_{na} = Output of non-agricultural sector
K_{na} = Stock of capital in non-agricultural sector
K = Total stock of capital
K_a = Stock of capital in agricultural sector
L = Working population
fuelpi = Fuel price index
trend = time trend

The non-agricultural sector is linked to the rest of the model through the stock of capital which is an endogenous variable. The long-run value of the non-agricultural sector gives the total non-agricultural output capacity of the economy, which along with the other equations defines the total supply side of the economy.

There is only one price deflator in the model and that is determined according to the quantity theory of money i.e. inflation is the difference between the rate of money supply and the rate of demand of money. Non-agriculture capital stock is estimated as a function of private sector wealth, financial wealth, trend and expected capacity utilization. The non-agriculture capital stock directly affects the non-agriculture sector output. Total output in turn is positively related to the demand of money equation.

NCAER (1993) model is an extension of the Sarkar and Subbarao (1983) model based on Social Accounting Matrix (SAM). Theoretically, this model is different from other models as all other models are based on investment-expenditure framework and use national accounts identity. This model, on the other hand, uses input-output matrix of the economy and it is a structuralist model. It is a highly disaggregated model and the industrial sector has been sub-divided into four sectors namely consumer goods industries, intermediate goods industries, capital goods industries and infrastructure (railways, electricity, mining and quarrying). Services are taken as a separate production sector.

These sectors are demand determined and a variable mark up rate on prime cost is used to determine prices in each sector. Production coefficients are from SAM (I-O table) but the variable mark up rate and the wage rate which goes into prime cost are estimated coefficients. These sectors are linked with the rest of the model through income/wages which people working in these sectors get and form three income levels. Each sector's commodity supply is equal to output and imports. The total supply of the sector is equated to the sum of intermediate and final demand. Final demand in this model for each sector consists of private consumption, private investment and non-competitive imports.

The price specification followed in the non-agriculture sector is the "cost plus mark up" principle. The main costs in a production process consist of cost of intermediates, wage cost and the cost of imports. But, there is no direct link between prices and output of particular sector. Private investment is a function of total output and bank credit to commercial sector.

One of the problems in macro modelling using time-series data is that it does not take into account technology changes. One way to resolve this dilemma for the modellers is to assume that the technological changes are embodied in higher productivity. Some modellers on the other hand use a time trend to capture 'residual' factors left out in the model specification. One of the residual factors is technological changes. None of the models described above has specified technological changes explicitly in the models. Krishnamurty (1984), however, has used a dummy variable to account for the effect of new technology while specifying productivity per unit of land in agricultural sector. He found that the coefficient on the dummy to be significant.

As existing models specification do not take care of duties like import duty and excise duty as part of the production cost, the direct impact of changes in these duties on industrial sector cannot be predicted from the existing models. In some models these duties, as part of direct and indirect taxes, form part of the functional form of other equations and an indirect effect can be simulated.

Except the NCAER model, all other models have used time series data to estimate their models. As all of them are annual models, one would expect that these specifications are meant for long run analysis (i.e. over a period of 2-3 years). Only the NCAER model is a structuralist model which is based on the premises that structural parameters do not change in long-term. Hence, the prediction may hold for very long period. On the other hand, input-output matrix coefficients do not support structuralist contention. Especially when structural changes in the economy are taking place, model specification based on input-output matrix may not predict future accurately.

In general, it seems that in both, aggregated and disaggregated models the modelling of industrial sector can be improved. Very few models have estimated industrial output as a function of capital and labour - the basic economic tenet. Most of the studies have used some approximation of a production process. One of the reasons for this could be a small sample size over which the models have been estimated and reliable employment data may not have been available. Second, given a rigid labour market, no reliable estimates for the industrial sector employment could be found. Third, macroeconometric models in general have tried to explain a particular linkage or relationship, for example, output and prices, relationship between agricultural and non-agricultural sector output and hence, have ignored other linkages in the economy. For example, link between output and prices has been explored by many modellers. Some have tried to discover the linkage between agriculture and rest of the economy. Fourth, the missing labour market in many of the models is conspicuous by its absence.

4. Future Research

Past functional specification of industrial sector in macro models is of a limited use now because investment had been largely independent of demand pattern of the economy as substantial portion of investment in the industrial sector was made by the government. A large modification of the existing models may not be useful to predict future because so far underlying assumption in macro-modelling had been that of a closed economy and government playing a leading part in the industrial sector of the economy. As the economy was protected, it was a sellers market. With the opening up of the economy to internal and external competition, it would develop into a buyers' market. Hence, both quality and quantity of output, have to be taken care of. The link between industrial sector and real economy would be from demand side and how investment in industrial sector can meet those demand patterns.

As mentioned earlier it was quantum of investment which was important - though it is still important as one of the major demand component in the economy - but the cost of capital is equally important in the present environment. As it would provide the estimates of investment at the given price (i.e. interest rate) an entrepreneur would be ready to invest. But, at present, within sample we may not find a significant coefficient on interest rate and therefore, a re-calibration may be required initially.

There is some encouraging news for macro modellers. A consistent long series on many of the macroeconomic variables is available. To make the economy internally and externally competitive, far reaching changes in the labour laws are on the anvil. Hence, a link between industrial sector output and employment is going to become important in times to come. Modellers have to spend more time to model the structure of industrial sector and its link with employment, import content, tax variables etc. Future research on building aggregated or disaggregated models has to try to discover the links between industrial output and employment generation, import contents and tax variables. The empirical relationship between industrial output and import contents may throw some light on its importance on industrial performance. From policy point of view a quantified relationship between industrial output and tax variables is important. The last topic is vital at the time of industrial restructuring as it can give a quantitative analysis of many far reaching changes taking place in the tax structure of our economy.

A word of caution here is appropriate. The main thrust of public sector reform is to make public sector competitive, but quantification of improved efficiency at macroeconomic level is very difficult to measure in a couple of years time. First of all, the reforms in this sector would be implemented over a period of time and their effect would get reflected in macroeconomic time series data after some time. It should be noted that these reforms are essentially enterprise level reforms and impact of these reforms is likely to affect government budget constraint and tax variables rather than output from public sector enterprises.

It is time to disaggregate non-agriculture sector into industrial and services sector as services are providing higher employment opportunities and also as a proportion of GDP, they are increasing. In fact, they increased from 36% GDP in 1980-81 to 40% in 1990-91.

Furthermore, in the changing economic environment, the predictability of industrial sector output can be improved if modellers reconsider the dynamic profile of industrial sector and identify the role of forward-looking expectations, particularly with respect to output, and incorporate the effects of relative factor prices and other financial variables [Minford, Hughes-Hallet and Rastogi (1992), Minford and Rastogi (1990), Haque and Montiel(1990)]

5. Summary and Conclusion

The share of industrial sector has improved steadily over the period of last forty years. Modelling of the industrial sectors has been done in some models using Cobb-Douglas production function. However, many modellers have ignored the link between industrial sector output and employment. There are various reasons for that. For example, lacuna in data, pre-dominance of government and rigid labour system are a few which come to mind readily. The scenario of industrial sector is changing rapidly and far-reaching changes are taking place in the economy. It has become imperative for the modellers to model industrial sector with its links with employment generation in the economy and policy variables which affect the industrial sector production. As service sector is gaining importance in the economy, it would be ideal to explore links between service sector and industrial sector output and services sector's potential to generate employment in the economy. The predictability of the models could be improved if the new research in applied macroeconomics could be incorporated in the models.

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