Micro Foundations of Macro Economics: An Empirical Evidence of Sectoral Phillips Curve

by

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The embodied technical change should reduce the cost of production of the commodity. However, price structure, wages and interest rates also will change over time. Thus if a commodity is following a fixed price regime, the adjustment of a historical input-output table to current price wage level will leaves less and less profit per unit of output. The extent of this reductions will indicate the extent of technological change. There are two separate approaches to the prediction of changes in input-output coefficients. The first approach, attributable to leontief (1941), Stone(1962), assumes that input-output matrices change over time in a “biproportional” way. The another approach is to estimate trends in individual coefficients using statistical data. A number of experts Former is used by a number of experts, e.g., Fontela, et.al. (1970), Almon, et al. (1974) and Carter(1970). Arrow and Hoffenberg (1959), Henry (1974), Savaldson (1970, 1976), Ozaki (1976) , Aujac (1972) and Buzunov (1970) are examples of the application of the quantitative approach for forecasting input-output coefficients. Another approach which could not get much attention for forecasting input-output coefficients, is constructing the marginal input-output coefficients (Tilanus 1967, Middelhoek 1970).Marginal coefficients for forecasting, are constructed by Tilanus and Middelehoek are based on average input-output tables, which seems that still new approach (marginal) is based on the old(average) one.

However, Professor Mathur (1977, 1986a, 1986b, 1989, 1990) was interested in both types of firms, i.e., best-practice and least efficient. According to him, in translating the extra final demand of macro-models, the best-practice coefficients will more useful than the average ones, while in assessing the incidence of obsolescence, unemployment, etc., the least coefficients will be the more appropriate ones. In the following sections the discussion will be more on the Professor Mathur’s work. His approach was also later on discussed theoretically and empirically by Azid (1993), Law and Azid(1993), Azid and Law(1994, 1995), Azid and Ghosh(1998) and Azid and Noor(2000), Azid (2002).

When a new technical advance is embodied in the capital equipment of the old technique also remains producing for a certain time, though by the nature of things it is likely to be earning lesser returns. The very fact that the new technology requires an accumulation of the corresponding capital will allow for the old technology to be in use for some time, that is until the time that the accumulated new capital becomes sufficient to meet with the total demand of the product. Subsequently, investment of various techniques will work with different efficiencies, and hence with different requirements in puts, labor and working stocks to produce a unit of output.

The afore-mentioned make clear that it is not necessary to assume, as Shumpeter (1934) and Galbraith (1952) do, that there must be monopoly power with the firm to prevent its capital equipment embodying old technology from becoming obsolete due to new innovations. Up until the time that sufficient equipment of new technology is not accumulated, the equipment of old technology will go on producing. Once sufficient new capital is accumulated, no amount of monopoly power can prevent the old capital equipment from being pushed out to the scrap heap, as the demand will be met cheaply by the processes employing the new capital equipment.

If the industry is under monopolistic control, the monopolist will not find it to his advantage to go on using the old capital which produces at a higher cost. As a matter of fact, new capacity will be installed when the cost advantage outweighs the loss of abandoning some old working capacity; or there is sufficient extra demand to justify it, and the extra revenues generated by increasing prices to equate this extra demand with supply are expected to be less than those achieved by increasing the capacity. Nevertheless, the monopolist may delay, purposely, the process of new capital accumulation thereby giving more time for the old capital goods to survive economically than would have been otherwise possible.

If the industry is working in a competitive environment, the firms possessing the technologically advanced outfit, which leads to the reduction of the production cost, would have to see that others with old capital equipment stop producing so that it can use its modern capital to the fullest capacity. This can be achieved by reducing the price of the product in such a way that production from the capital of old technology becomes loss making. The monopolist, however, needs not reduce the price to achieve this objective. The can switch off the machines of old techniques without reducing the price to such an extent as to make its use unprofitable.

The next section make a quick review of the work done in this field. Then we set up a mathematical model generalizing the input-output analysis to take account of the situation, and examine how this model with the layers of techniques can be constructed. For the empirical analysis the data of US 3-digit chemical industry will be used.

1. Layers of Techniques

The fixed capital embodies the technology of the time technology when it was installed. The embodying technology remains almost the same up to the time the equipment embodying it is scrapped. Moreover, at a particular time, capital equipment installed at different past dates will be working simultaneously having, of course, different productivities and profits. Thus in a state of technical change, the economy has got in situ various amounts of fixed capital equipment belonging to different layers of techniques.

The fixed capital embodies the technology of the time when it was newly installed. This embodied technology remains almost the same up to the time the equipment embodying it is scrapped. He technological progress come about by the installation of new equipment, embodying more profitable techniques at the current price structure. At a particular time equipment installed at different past dates will be simultaneously working, having, of course, different productivities and profits. In understanding the working of the economy, we can neglect this embodiment of technological change in the equipment only at the cost of relevance. Thus in a growing economy there will be a layers of techniques of different technologies working simultaneously.

Let C^K_j represents the capacity of the fixed capital equipment of the kth technique for producing the jth commodity. Similarly, A^k_j and L^k_j stand for the column vectors of the commodity and labor inputs per unit of production of the jth commodity by the kth technique. Furthermore, let ${}^fB^k_j$ and ${}^wB^k_j$ give the column vectors of the fixed and working capital stock requirements respectively per unit of production of the jth commodity by the kth techniques. And finally, let there may be m_j techniques working to produce the jth commodity.

If all the capital equipments are working to the full capacity, then the total output of the jth commodity will be

$$X_j = \sum_{K=1}^{m_j} C_j^K \qquad \text{where } j = 1,2,3,\ldots.n \qquad (1)$$

the average input-output coefficients will be given by

$$a_{ij} = \left(\frac{\sum_{K=1}^{m_j} C_j^K a_{ij}^K}{X_j} \right) \quad i = 1,2,\ldots,n \qquad (2)$$

whereas the price structure will be such that

$$\begin{aligned} P_j &= P_1 a_{1j}^K + P_1 a_{2j}^K + \ldots\ldots\ldots + P_i a_{ij}^K + \ldots\ldots + P_n a_{nj}^K + \\ &w\left(l_{1j}^K + l_{2j}^K + \ldots\ldots\ldots + l_{nj}^K\right) + r P_1^w b_{1j}^K + r P_2^w b_{2j}^K + \ldots\ldots\ldots + \qquad (3) \\ &r P_i^w b_{ij}^K + \ldots\ldots\ldots + r P_n^w b_{nj}^K + S_j^K \end{aligned}$$

for all k

and in matrix algebra notation

$$P_j = PA_j^K + wL_j^K + r P^w B_j^K + S_j^K \qquad (4)$$

It is noted as while the row vector of prices (p), the wage rate (w) and the interest rate (r) are the same for all the techniques, the residual S^K_j is different for each one, which emphasizes that the technical change comes about by the installation of new equipment embodying more profitable techniques at the current price structure. In fact it is on the value of this residual that the actions of units depend. When an investment is being done in an equipment pertaining to a new technology, the expected residual should be so large as not only to cover the interest and depreciation charges of the fixed capital but, also, the risk as well as the profit expectations of the entrepreneur. It may be recalled that this residual is not like a fixed annuity over the physical life time of the equipment, as it is the case if there is no technical progress and, hence, no obsolescence. In the age of advancing technology, the value of this residual should be gradually declining, and an investor should take this into account while making his investment.

However, the returns on the fixed capital are not essential for the firm to remain in production. Once the fixed capital is installed and if it is not economically worthwhile to produce with it, it can only fetch its scrap value. So its opportunity cost is almost zero. This, of course, does not imply that there must not be expectation of sufficient returns before it is installed at all. Therefore, in taking decisions whether to continue the production process, the unit will not take into consideration any returns on the fixed capital by continuing production. It should go on producing until it can cover the variable cost of production. In other words, a unit will remain in production until its residual is not negative. Thus the price of the jth commodity p_j will determine which techniques should be used in the production and which should not.

Let m_j be the least efficient technique required to be in production to meet with the demand. For that

$$P_j = PA_j^{mj} + wL_j^{mj} + r\,P^w B_j^{mj} + S_j^{mj} \qquad (5)$$

The above equation will be valid for one technique of each of the industries, namely for the marginal technique which is on the verge of obsolescence. The condition that the total output of each industry should be just sufficient to meet with the demand of its product will uniquely determine the number of techniques in use. Consequently the price structure will be such that all those techniques required to produce will be economically feasible. An increase in the demand might induce some obsolete techniques to be brought back into production by suitably adjusting the price structure and vice versa.

Collecting equation (5) for each industry, viz. The marginal or zero residual units, we derive the price determining equation for the system as

$$P = P\overline{A} + w\overline{L} + rP^{w}\overline{B} \qquad (6)$$

where $\overline{A}$, $\overline{L}$ and ${}^{w}\overline{B}$ denote the sets of input, labor and working capital stock requirements respectively for the marginal techniques which are on the verge of obsolescence.

As seen the current price structure is related to the current wage and interest rates as well as to the least efficient technique and not to the average or the best practice technique. Besides, the profit rate and the value of fixed capital do not play any role in the determination of price structure.

If the production of the marginal technique units is represented by the vector X, then the net output available for use is given by

$$P\left(I-\overline{A}\right)\overline{X} \qquad (7)$$

out of this, $rP^{w}\overline{B}\overline{X}$ is the income of the interest receivers, and the rest the wage incomes of those working with the marginal units. Hence the wage rate is given by

$$P(I-\overline{A}-r^{w}\overline{B})\overline{X}\big/\overline{L}\overline{X} \qquad (8)$$

which implies that given the interest rate, the marginal technique determines both the price structure and the real wage rate. Similarly given the real wage rate, the marginal technique determines the price structure as well as the interest rate. There is one degree of freedom. Either the interest rate or the wage rate can be determined.

The marginal technique itself will be determined in such a way the total savings in the economy are equal to the total investment and other autonomous demand. As less and less efficient techniques, in the sense of having lesser values of residual, are brought into production, both employment and savings will increase. The saving rate is likely to be higher from the residual income than that from the income from wages or interest. Therefore, such a redistribution of income in favor of the residual income earners will increase the total savings even from the old techniques. Over and above there will be some savings by the income receivers from the increased production. Thus bringing more and more marginal techniques into production will increase the total savings in the economy. In the opposite case of taking more and more marginal firms out of production will decrease the total savings. Therefore, the number of firms in operation depends on the savings out of their production matching the investment and other autonomous demand.

2. Fix Price System and Phillips Curve

As indicating by the preceding analysis, there is a spectrum of techniques in the economy working simultaneously and having different productivities and profits. Out of these, the least efficient technique is the one determining the price structure. This marginal technique is in operation because the at that price structure exceeds the total capacities of all the more efficient techniques.

When the new investment is made it is used the best practice technique available at that time for producing the commodity. But if the demand does not increase proportionally to the newly created capacity, the firm has to poach someoneelse’s market. Being a competitive firm, or a fix price firm according to Hicks(1965), it will resort to market mechanism. It can use either of the two strategies or combination of the two. It may reduce the selling price of the commodity in such an extent as to derive the nonprofit firm out of the market. And/or it may increase the wages of its employees. Thus, it may not only be able to poach better workers from the other firms, but also to induce such an increase in the wage rate that the zero residual firm is forced to close down. However, in a period of inflationary climate it is more likely to select the latter strategy rather than the former one. On the other hand, the firm on the verge of obsolescence will try to recoup the higher wage bill by increasing the commodity price. If at the same time there is a compensating increase in the demand, the marginal firm will be able to survive. If not, its attempt to increase the price will not avert the closure.

Furthermore, as the new firms will be using less labor per unit of output than the old firms, which will be closing down, there will be a generation of unemployment if the demand will not increase *pari pasu*; as it is the case with the replacement of old capital and/or the undertaking of new investment in order to take advantage of the higher profitability opened up by the technical change. At the other extreme there will be price rises as the increases in the wage rates instigated by the new firms will be absorbed by the old firms. As a matter of fact, the result in the real world will be associated with lesser inflation and vice versa. Thus Phillips curve does not determine the trade-off between inflation and unemployment but is the resultant of the introduction of labor saving technological progress and the struggle of firms becoming economically obsolete to remain in business.

The above is only a part of the total Schumpetarian cycle of the adoption of new technique. He envisaged an innovation ushering new technology resulting in creation of exogenous demand on the economy for instance by being financed by bank credit. As the demand of capital goods increase in the short run they will be produced by less and less efficient equipment. This increase in the 'marginal' increase in the cost of production will imply higher prices. Not only higher income will be generated by the original program, but the profitability of all the existing working firms will increase. The consequent increased demand will spill over to almost all industries and thus opening their sub-marginal firms for production. This will imply a rise in the prices of all commodities. This will not only lead o decrease in unemployment, but also increase in money wages, which tend to increase with inflation. For this to happen the existence of full employment or trade union pressure is not necessary. As. Hicks(1976) puts it "A firm will surely seek to maintain a regular relation with the workers whom it employs. It cannot expect to do that unless it pays them what they regard as fair wages." In time of rising prices some compensation in wages in necessary to consider them fair. Thus during the days when innovations are being translated into new investment we cannot expect a rise in prices and money wages coupled with a decline in unemployment.

When the burst of activity resulting from innovations is over, unemployment will be generated from two sources. The extra activity generated in the capital goods sector will taper off and together with it a lot of secondary production activity generated as a consequence. This will of course, throw out labor working on those sub-marginal firms that go activated during this period. Further the new capacity created will make some old technology redundant and obsolete. As pointed out above, the new techniques of production are likely to employ less labor for producing the same amount of goods as the one on its way out.

This will indicate not only a slowing down of price rises but even its reversal. However, the wage of those remaining in employment may still increase. That may be the market's signal to less efficient firms to close down when their extra output is not required. So the phenomenon of the coexistence of rising real wages and raising unemployment is to be expected.

3. <u>High Nominal Interest Rates and Cost Push Inflation</u>

From equation 6 we have seen that price structure or fix price system is given by

$$P = P\overline{A} + w\overline{L} + rP^{w}\overline{B}$$

Let W be represented in terms of commodity or as a vector of commodities C then

$$P = PC\overline{L} + P\overline{A} + rP^{w}\overline{B} \qquad (9)$$

It nmay be noted that as C is a column vectr and $\overline{L}$ a row vector $C\overline{L}$ is a (n x n) matrix. So

$$P(I - \overline{A} + C\overline{L} + r^{w}\overline{B} = 0 \qquad (10)$$

As shown elsewhere Mathur (1963) there will be only one value of r which will be associated with positive P vector and it will be given by the reciprocal of the largest eigen value of the matrix ${}^{w}\overline{B}(I - \overline{A} - C\overline{L})^{-1}$. This shows that for every real wage, the equilibrium rate of interest is determined by the technology on the verge of obsolescence (no profit technology). It is bvious that as we move to more and more efficient technologies, the equilibrium rate of interest will be progressively higher and higher for a given wagerate. Alternatively, for a given interest rate real wage rate will be greater.

If nominal interest rate ρ is greater than equilibrium interest rate r, equation (9) becomes

$$P = P(C\overline{L} + \overline{A}) + \rho P^{w}\overline{B}$$

$$P = P(C\overline{L} + \overline{A}) + rP^{w}\overline{B} + (\rho - r)P^{w}\overline{B}$$

$$P = P + (\rho - r)\rho P^{w}\overline{B}$$

This is impossible since (ρ -r); p; as well as ${}^{w}\overline{B}$ are positive. The only way to have a feasible solution is for input prices to be different form output prices viz.

$$P^{t} = P^{t-1}(C\overline{L} + \overline{A}) + rP^{t-1\,w}\overline{B} + (\rho - r)P^{t-1\,w}\overline{B} \qquad (11)$$

If we assume that in period t-1 the equilbrium interest rate prevails then

$$P^{t} = P^{t-1} + (\rho - r)P^{t-1\,w}\overline{B} \qquad (12)$$

from the above equation it is clear that with fix price system a higher nimonal interst rate than the equilibrium one will lead ti increases in prices. Not only that the increases will be different conmmodities depending on their working capital requirements per unit of output. Thus we have a cost push inflation and inflation is not neutral.

In a flex price monopolistic case also, the higher nominal interst rate will lead to higher marginal cost, and as marginal revenue would tend to be equal to this, the price of the commodity will increase. T may be noted that in this case the capital at change will be total capital rather than working capital only.

4. Adjustment to High Nominal Interest Rates

There are several was in which an economy can adjust to these high nominal interest rates. It may have a differential inflation as given by equation (11) or (12) above. This will be the case if the exogenous demand remains unchanged both in quantity and structure, and further if the economy is closed. We have seen from equation (11) and 12) that the relative prices will change in the situation where nominal interest rate is different from the equilibrium interest rate. The prices of the goods using more capital per unit of output are likely to increase more. In an open economy it will indicate higher import penetration in that economy's domestic market (Mathur 1977).

If as a consequences of high nominal interest rates, or through the fiscal policies of the state, the autonomous demand is reduced, he techniques on the verge of obslescence will be abandoned anyway, as they will not be necessary to produce the demand output. This of course will create unemployment, but now a more efficient technique will become 'no profit' technique. Onsequently with given wage rate the equilibrium interest rtae will become higher than before. Thus (ρ -r) the difference between nominal and equilibrium interest rate will be reduced, reducing in its turn he necessity of price rises. In such cases, we expect the high nominal interst rates to produce less inflation than they would otherwise but that inflation will be accompanied with unemployment. This phenomenon will tend to shift Phillips Curve to north–east.

4. Unemployment and Obsolescence

Let in matrix algebra notation, $\underline{A}$, $\underline{L}$, ${}^{f}\underline{B}$ and ${}^{w}\underline{B}$ stand for the input, labor, fixed and working capital stock requirements respectively per unit of production of the best practice technique in the economy, which is formed by collecting the technique with the largest residual for each industry, and let $\underline{F}$ denote the column vector of the extra final demand to be satisfied by the best practice technique, then the balanced capacity creation will be given by (13) becomes

$$\underline{C} = (I - \underline{A})^{-1}\underline{F} \qquad (13)$$

the requirements of the extra capital goods and the extra working capital stocks to achieve $\underline{C}$ by

$${}^{f}\underline{B}\underline{C} = {}^{f}\underline{B}(I - \underline{A})^{-1}\underline{F} \qquad (14)$$

and

$${}^{w}\underline{B}\underline{C} = {}^{w}\underline{B}(I - \underline{A})^{-1}\underline{F} \qquad (15)$$

whereas the extra employment will be

$$\underline{L}\underline{C} = \underline{L}(I - \underline{A})^{-1}\underline{F} \qquad (16)$$

If the increase in the final demand is lesser than the extra demand to be satisfied by the best practice technique, $\Delta F < \underline{F}$, then capacity of the least efficient technique will be unutilized. Using the notation of equation (6), the unutilized capacity of the least efficient technique will be equal to

$$U = (I - \underline{A})^{-1}(\underline{F} - \Delta F) \qquad (17)$$

and the newly created unemployment equal to

$$\bar{L}U = \bar{L}(I - \underline{A})^{-1}(\underline{F} - \Delta F) \qquad (18)$$

Hence, the net employment will be given by the subtraction of equation (16) from equation (18)

$$\bar{L}U - \underline{L}\underline{C} = \bar{L}(I - \underline{A})^{-1}(\underline{F} - \Delta F) - \underline{L}(I - \underline{A})^{-1}\underline{F} \qquad (19)$$

or

$$\bar{L}U - \underline{L}\underline{C} = [\bar{L}(I - \underline{A})^{-1} - \underline{L}(I - \underline{A})^{-1}]\underline{F} - \bar{L}(I - \underline{A})^{-1}\bar{F} \qquad (20)$$

where the first term of the right hand side is positive, since the productivity of the best practice technique is greater than that of the least efficient technique.

Therefore, it is evident that in translating the extra final demand of macro-models, the best practice coefficients will be more useful than the average ones, while in assessing the incidence of obsolescence, unemployment, etc. the least efficient coefficients will be the more appropriate ones. Moreover, if the extra final demand to be satisfied by the best practice technique is larger than the change in the final demand of the economy, there will be a rise in the unemployment. The net employment will take its highest value when there is no change in the final demand of the economy. Thus the present level of employment will be maintained when the change in the final demand of the economy is such that equation (20) will become equal to zero.

5 Data Requirement

The preceding analysis points out that the knowledge of both best practice and least efficient coefficient is more essential than the knowledge of average coefficients for disaggregating planning and forecasting as well as for exercising a suitable economic policy. Therefore, the analysis underlines the need for compiling input-out tables referring to the best practice and the least efficient techniques, rather than to the average technique, in order to improve the reliability of input-output estimates.

The data were tabulated by the US Census Bureau from its Longitudinal Research Database (LRD). This research is based on data from the 1982[1] Census of Manufacturers. Individual establishment data in the LRD file were sorted at three digit level according to the following scheme. First the cost per unit of output for every establishment in every industry was computed. Output was defined as shipment plus the changes in the finished goods and half of goods – in – progress inventories between 1981 and 1982. Total variable cost was defined as the sum of the purchased materials, fuels, electricity, communication services, and building and machinery repairs plus worker payroll and supplementary labor cost. Thus the information gathered in this stage pertained to the average variable cost (AVC) of each establishment. Disclosure rules prevent the Census of Bureau from releasing information on any single establishment. Therefore, the unit of observation had to be changed from an establishment to a group of establishments. This was done by first arranging all establishments in order of rising unit variable cost within each three digit industry as a whole. Then groups of establishments were formed in such a way that unit cost of each establishment within a group was less than that of any establishment s in the subsequent group. The number of establishments that fell within a group was determined in such a way that this number be equal for all groups within an industry.

Once these groups were formed information was collected for variables like output, employment, material and energy inputs, wages, etc. In fact most of the data available on the short file of the Census were collected. We did not collect the data regarding individual material input as that would have led to tabulating data from the comprehensive files themselves. This would have been not only very time-consuming but also quite costly in term of resources. Further, it would have been much beyond our aim to have a preliminary understanding of the dimensions and hence practical importance of the problem of layers of techniques in US manufacturing industry.

For empirical testing we select the following eight US three digit chemical industries to measure the effects of technological change under the state of flux. These three digit industries areas: Industrial inorganic Chemicals (SIC 281), Plastics Materials and Synthetics (SIC 282), Drugs (SIC 283), Soap, Cleaners and Toilet Goods (SIC 284), Paints and Allied Products (SIC 285), Industrial Organic Chemicals (SIC 286), Agricultural Chemicals (SIC 287) and Miscellaneous Chemicals (SIC 289). Among the eight US three-digit chemical industries, Industrial Chemicals (SIC 281), Drugs (SIC 283), and Agricultural Chemicals (SIC 287) have 25 groups of establishments and the other five industries consist of 50 groups. List of variables used in this analysis is as below:

Variable	Description
AVC	Variable Cost Per Dollar Worth of Output
TE	Total Number of Employees
PW	Number of Production Workers
PH	Production Workers' Hours
SW	Pay Roll-all Employees Per Dollar Worth of Output
WW	Pay Roll of Production Workers Per Dollar Worth of Output
LC	Supplementary Labor Cost Per Dollar Worth of Output
Labor	Total Labor Cost Per Dollar Worth of Output
EF	Fuel Cost Per Dollar Worth of Output

EE	Electricity Purchased Per Dollar Worth of Output
Energy	Total Energy Cost Per Dollar Worth of Output
CPC	Communication Cost Per Dollar Worth of Output

6 Marginal Input-Output Coefficients of US 3-digit Chemical Industry

For the empirical analysis the required data (as mentioned above) for the US 3-digit chemical industry is available and also fulfill the requirement for the construction of best-practice and least efficient coefficients.

Table 1 shows the marginal input-output coefficients at different level of capacity of 3-digit US chemical industry. Five levels of capacity are assumed, i.e., 10%, 25%, 50%, 75% and 90%, which implies that five layers of techniques are working simultaneously experiencing different cost per unit of output. It is further assumed that 50% is the level for average techniques. The next step is to conversion these coefficients to percentages of the average technique, finally an index of coefficients for alternative capacity level can be achieved.

Table 1

Index of Marginal Input-output Coefficients for 3-digit U.S. Chemical Industries (Base = 50%)

Industrial Inorganic Chemicals (SIC 281)

Level of Capacity → Variables ↓	10%	25%	50%	75%	90%
AVC	**89.84**	**94.83**	**100.00**	**111.45**	**114.44**
TE	**85.65**	**92.69**	**100.00**	**116.17**	**123.23**
PW	**84.77**	**92.23**	**100.00**	**117.22**	**124.67**
PH	**88.42**	**94.10**	**100.00**	**113.04**	**118.75**
SW	**84.71**	**92.21**	**100.00**	**117.24**	**124.74**
WW	**83.69**	**91.69**	**100.00**	**118.39**	**126.40**
LC	**83.43**	**91.67**	**100.00**	**118.49**	**126.54**
CF	**78.13**	**88.87**	**100.00**	**124.63**	**135.37**
EE	**75.89**	**87.73**	**100.00**	**127.18**	**139.02**
CPC	**73.39**	**86.47**	**100.00**	**129.94**	**1434.04**
Labor	**84.49**	**92.11**	**100.00**	**117.49**	**125.10**
Energy	**76.65**	**88.11**	**100.00**	**126.34**	**137.80**
Plastics Materials and Synthetics (SIC 282)					
AVC	**89.30**	**93.35**	**100.00**	**106.84**	**110.88**
TE	**60.96**	**75.72**	**100.00**	**124.95**	**139.71**
PW	**56.57**	**73.01**	**100.00**	**127.75**	**144.16**
PH	**59.18**	**74.61**	**100.00**	**126.08**	**141.51**
SW	**60.00**	**75.12**	**100.00**	**125.55**	**140.68**
WW	**56.49**	**72.94**	**100.00**	**127.79**	**144.24**
LC	**55.13**	**72.10**	**100.00**	**128.66**	**145.64**
CF	**60.07**	**75.16**	**100.00**	**125.55**	**140.65**
EE	**81.15**	**88.29**	**100.00**	**112.07**	**119.21**
CPC	**75.63**	**84.97**	**100.00**	**115.64**	**124.81**
Labor	**59.02**	**74.52**	**100.00**	**126.18**	**141.68**
Energy	**69.15**	**80.81**	**100.00**	**119.70**	**132.37**
Drugs (SIC 283)					
AVC	**75.29**	**84.76**	**100.00**	**116.38**	**125.85**
TE	**59.32**	**74.92**	**100.00**	**126.94**	**142.55**
PW	**83.11**	**89.58**	**100.00**	**111.23**	**117.68**
PH	**81.01**	**88.30**	**100.00**	**112.57**	**119.85**
SW	**44.88**	**66.03**	**100.00**	**136.51**	**157.65**
WW	**73.31**	**83.55**	**100.00**	**117.68**	**127.92**
LC	**35.30**	**60.12**	**100.00**	**142.85**	**167.64**
CF	**31.73**	**57.91**	**100.00**	**145.18**	**171.36**
EE	**50.64**	**69.57**	**100.00**	**132.65**	**151.58**
CPC	**38.82**	**62.28**	**100.00**	**140.48**	**163.94**
Labor	**43.19**	**64.98**	**100.00**	**137.63**	**159.42**
Energy	**41.51**	**63.95**	**100.00**	**138.78**	**161.22**
Soap, Cleaners and Toilet Goods (SIC 284)					

AVC	**87.86**	**92.67**	**100.00**	**108.72**	**113.53**
TE	**56.38**	**73.67**	**100.00**	**131.32**	**148.60**
PW	**64.32**	**78.47**	**100.00**	**125.62**	**139.76**
PH	**65.87**	**79.40**	**100.00**	**124.50**	**138.02**
SW	**60.48**	**76.15**	**100.00**	**128.37**	**144.04**
WW	**71.38**	**82.72**	**100.00**	**120.54**	**131.87**
LC	**60.28**	**76.04**	**100.00**	**128.52**	**144.26**
CF	**95.45**	**97.23**	**100.00**	**103.16**	**105.04**
EE	**81.86**	**89.06**	**100.00**	**113.03**	**120.22**
CPC	**01.20**	**40.34**	**100.00**	**170.94**	**210.12**
Labor	**60.45**	**76.13**	**100.00**	**128.40**	**144.00**
Energy	**89.81**	**93.84**	**100.00**	**107.31**	**111.40**
Paints and Allied Products (SIC 283)					
AVC	**93.42**	**96.05**	**100.00**	**104.82**	**107.46**
TE	**78.27**	**86.96**	**100.00**	**115.94**	**124.63**
PW	**85.56**	**91.34**	**100.00**	**110.62**	**116.40**
PH	**87.53**	**92.52**	**100.00**	**109.14**	**114.13**
SW	**72.69**	**83.61**	**100.00**	**120.02**	**130.94**
WW	**81.83**	**89.09**	**100.00**	**113.31**	**120.58**
LC	**72.01**	**83.19**	**100.00**	**120.50**	**131.71**
CF	**89.24**	**93.54**	**100.00**	**107.87**	**112.17**
EE	**82.20**	**89.31**	**100.00**	**113.06**	**120.19**
CPC	**59.55**	**75.73**	**100.00**	**129.69**	**145.45**
Labor	**72.57**	**83.54**	**100.00**	**120.11**	**131.08**
Energy	**85.44**	**91.26**	**100.00**	**110.68**	**116.50**
Industrial Organic Chemicals (SIC 286)					
AVC	**86.75**	**91.87**	**100.00**	**108.92**	**114.03**
TE	**74.40**	**84.27**	**100.00**	**117.23**	**127.13**
PW	**78.29**	**86.67**	**100.00**	**114.62**	**123.00**
PH	**78.54**	**86.23**	**100.00**	**114.42**	**122.71**
SW	**67.61**	**80.11**	**100.00**	**121.80**	**134.31**
WW	**73.08**	**83.48**	**100.00**	**118.12**	**128.50**
LC	**68.85**	**80.88**	**100.00**	**120.96**	**132.99**
CF	**53.83**	**71.66**	**100.00**	**131.06**	**148.88**
EE	**44.58**	**65.99**	**100.00**	**137.32**	**158.50**
CPC	**65.27**	**78.73**	**100.00**	**123.45**	**136.83**
Labor	**67.86**	**80.26**	**100.00**	**121.63**	**134.04**
Energy	**50.65**	**69.71**	**100.00**	**133.21**	**152.25**
Agricultural Chemicals (SIC 287)					
AVC	**91.12**	**94.53**	**100.00**	**105.91**	**109.33**
TE	**88.95**	**93.20**	**100.00**	**107.38**	**111.63**
PW	**90.56**	**94.17**	**100.00**	**106.27**	**109.89**
PH	**89.95**	**93.82**	**100.00**	**106.68**	**110.54**

SW	**80.27**	**87.85**	**100.00**	**113.15**	**120.74**
WW	**82.72**	**89.37**	**100.00**	**111.50**	**118.15**
LC	**77.51**	**86.18**	**100.00**	**114.98**	**123.69**
CF	**37.53**	**61.55**	**100.00**	**141.60**	**165.61**
EE	**75.57**	**84.97**	**100.00**	**116.29**	**125.66**
CPC	**51.54**	**70.14**	**100.00**	**132.20**	**150.80**
Labor	**79.76**	**87.54**	**100.00**	**113.47**	**121.25**
Energy	**49.83**	**69.12**	**100.00**	**133.41**	**152.71**
Miscellaneous Chemicals (SIC 287)					
Level of Capacity → Variables ↓	**10%**	**25%**	**50%**	**75%**	**90%**
AVC	**91.05**	**94.57**	**100.00**	**106.31**	**109.84**
TE	**89.37**	**93.56**	**100.00**	**107.51**	**111.71**
PW	**77.59**	**86.41**	**100.00**	**115.81**	**124.63**
PH	**77.81**	**86.55**	**100.00**	**115.64**	**124.37**
SW	**72.23**	**83.14**	**100.00**	**119.58**	**130.51**
WW	**71.62**	**82.79**	**100.00**	**120.00**	**131.16**
LC	**57.36**	**74.11**	**100.00**	**130.02**	**146.83**
CF	**52.34**	**70.20**	**100.00**	**129.80**	**147.72**
EE	**67.81**	**80.47**	**100.00**	**122.70**	**135.36**
CPC	**49.09**	**69.11**	**100.00**	**135.98**	**155.99**
Labor	**71.91**	**82.96**	**100.00**	**119.81**	**130.86**
Energy	**61.42**	**76.58**	**100.00**	**127.20**	**142.39**

6.1 Marginal Input-Output coefficients of variable cost, communication cost and material cost per dollar worth of output

The chemical industry modernized existing facilities by retro-fitting with updated, largely computerized equipment and instrumentation. Computers, programmable controls, computerized sensors for temperature, pressure, flow rate liquid levels, material analyzers, and other process equipments have been increasingly diffused. Pneumatic controls have been more and more replaced by electronic signals and apparatus (except in the processing of flammable materials)[2]. This throws light on the idea that the chemical industry is in the process of change. Analysis of this section is based on the marginal coefficients of the above mentioned variables of different sectors of US 3-digit chemical industry. At a particular time, there is an economy, where simultaneously layers of techniques are working. After the construction of marginal coefficients for variable cost pre dollar worth of output, forecast can be made on the basis of given information, of how much variable cost can be saved after a particular elapse of time. Assuming that the middle value is the average value, how much will be the divergence from both sides of the practices, i.e., worst- and best-practice?

Looking at the marginal coefficients of variable cost per dollar worth of output, in all sectors of the US 3-digit chemical industry, a gradual shift of the coefficient is observed, reflecting the continuous introduction of new-practice technologies. The difference describes the ability to produce output with different technologies.

Further, it is assumed that the replacement of all chemical sector is 5% per annum, then our calculations at the 10% level of capacity describes the marginal marginal coefficients of the previous two years. At the 25% level of capacity level, it means the coefficients of five years, and so on. 50% of capacity represents the average technology. The ratio between the best practice and least efficient will be clarified by examining Table 2.

It is clear that the ratio between the best- and worst-practice 90% and 10% of capacity (in terms of percentage) is maximum(1.67) in Drugs(SIC 283) and minimum(1.15) in Paints and Allied Products(SIC 285). If there is continuous change in technology, establishments can save more. On the basis of these information, forecasts can be made of much variable cost can be saved in the future. When large ratios are observed, it means that the rate of obsolescence is very fast, but where the ratio is small it means that rate of obsolescence is not very fast.

Table 2

Ratio of Marginal Coefficients (Best Practice to Least Efficient Techniques) for Variable Cost Per Dollar Worth of Output

Name of Industry	90% / 10%	75% / 25%
Industrial Inorganic Chemicals (SIC 281)	1.30	1.18
Plastics Materials & Synthetics (SIC 282)	1.24	1.14
Drugs (SIC 283)	1.67	1.37
Soap, Cleaners and Toilet Goods (SIC 284)	1.29	1.17
Paints and Allied Products (SIC 285)	1.15	1.09
Industrial Organic Chemicals (SIC 286)	1.31	1.19
Agricultural Chemicals (SIC 286)	1.20	1.12
Miscellaneous Chemicals (SIC 287)	1.21	1.12

6.2 Marginal Coefficients of Communications Cost

Technological changes forced further cuts in communication cost per dollar worth of output. Over the past two decades, expansion and competition in the communication industry reduced the communication cost of other industries. This is reflected in the communication cost pattern in the US chemical industry. Except Plastic Materials(SIC 282), every sector is saving communication cost per dollar worth of output to a remarkable extent. In Soap, Cleaners and Toilet Goods(SIC 284) the ratio is very high and this is (174.4). Owing to the technological progress the new vintages are saving communications costs and enjoying the surplus. Table 3 illustrates in detail.

Table 3

Ratio of Marginal Coefficients (Best Practice to Least Efficient Techniques) for Communication Cost Per Dollar Worth of Output

Name of Industry	90% / 10%	75% / 25%
Industrial Inorganic Chemicals (SIC 281)	1.95	1.50
Plastics Materials & Synthetics (SIC 282)	1.65	1.36
Drugs (SIC 283)	4.22	2.26
Soap, Cleaners and Toilet Goods (SIC 284)	4.40	4.24
Paints and Allied Products (SIC 285)	2.54	1.71
Industrial Organic Chemicals (SIC 286)	2.20	1.57
Agricultural Chemicals (SIC 286)	2.93	1.88
Miscellaneous Chemicals (SIC 287)	3.18	1.97

6.3 Marginal Coefficients for labor

This sub-section will analyze the marginal coefficients of the different sectors of the US 3-digit chemical industry relating to labor.

6.3.1 Requirement of labor

This section analyses changes in input-output coefficients in terms of labor requirement with the help of marginal input-output coefficients, which describe the impact of observed structural changes on the efficiency of the economy as a whole.

Such an analysis will fit nicely into our main discussion on technological progress in the chemicals industry of USA.

The marginal input-output model enable us to evaluate the performance of industry in terms of the amount of input required for different vintages to produce a given level of output. A new vintage capable of producing a given level of output with less input than old vintages, or producing more with the given level of input, may be judged technological superior to the old one.

In the eight sector of the chemical industry, the marginal coefficients of variables related to labor are constructed:

Table 4 illustrates these variables in terms of marginal coefficients.

As indicated by the previous analysis, there is a spectrum of techniques in the economy working simultaneously and having different productivities and profits. Out of these, the least efficient technique is the one determining the price structure. This marginal technique is the operation because the demand at that price structure exceeds the total capacities of all the more efficient techniques.

When the new investment is made it uses the best-practice technique available in the time for producing the commodity. But if the demand does not increase proportionally to the newly created capacity, the firm has to poach someone else's market. Being a competitive firm, or a fix-price firm according to Hicks (1965), it will resort to market mechanism. It can either of the two strategies or a combination of two. The market may reduce the selling price of the commodity to such an extent as to derive the non-profit out of the market. And/or it may increase the wages of its employees. Thus, it may not only be able to poach better workers from other firms, but also to induce such an increase in the wage are that the zero-surplus firm is forced to close down. However, in an inflationary climate it is more likely to select the latter strategy rather than the former. On the other hand, the firm on the verge of obsolescence will try to recoup the higher wage bill by increasing the commodity price. If at the same time there is a compensating increase in demand, the marginal firm will be able to survive. If not, its attempt to increase the price will not avert closure.

As a matter of fact, new investment is undertaken not only to meet increasing demand but also to replace old capital and/or to reap the high profits opened up by technical advance. In such a case, however, it will be at the cost of closing down some other firms. In a competitive industry this can be achieved through the change in the price-wage-interest structure so as to convert the least efficient firms into loss making ones.

Therefore, if the extra final demand to be satisfied by the best practice technique is not counterbalanced by the appropriate rise in final demand, there will be a net increase in unemployment. The net unemployment obviously takes its largest value when final demand remains unaltered.

The above phenomenon can be analyzed in the Table 4 which describes the ratio between the capacity level of 90% to 10%. The analysis about the results is as below.

i) Total employees and production workers: It is likely that, beyond cyclical swings, there will be improvement in the productivity of the chemical industry over the long-term. Such long-term may well be associated with continued small overall increases in output being accompanied by losses in employment. Among technological and organizational factors likely to spur productivity are more centralized technical controls of plant complexes, facilitated by comparatively low-cost computer networks.

In Plastic Materials and synthetics (SIC 282), it is found that the ratio in total employees is 3.29 and in production workers it is 2.55, which shows either that there is a revolutionary change or very fast changes occurred, so the old techniques are not very old. Only in Industrial organic chemicals(SIC 281) and Miscellaneous Chemicals (SIC 289) is the ratio of coefficients for total employees less than the ratio of best-practice and least efficient of production workers. In the other sectors, the ratio is higher in production workers than total employees. Agricultural Chemicals (SIC 287) is saving less of these two variables compared to other sectors (1.26 and 1.21 respectively). The ratio in total employees varies from 1.25 (Miscellaneous Chemicals) to 3.29 (Plastics Materials and Synthetics), and in production workers it varies from 1.21 (Agricultural Chemicals) to 2.55 (Plastics Materials and Synthetics).

ii) Production hours: The ratio of marginal coefficients between the production hours of least efficient and best-practice workers. The ratio varies from 1.23 (Agricultural Chemicals) to 2.39 (Plastics Materials and Synthetics). It is observed that Plastics and Synthetics Materials and Synthetics (SIC 282) is saving more production hours per dollar worth of output than other sectors of the US 3-digit industries.

iii) Supplementary Labour Cost: Generally, chemicals are manufactured by means of continuous processes, operated around the clock and worked by employees on either over time or additional shifts. Due to this reason, consistently high over time in the industry is linked to a large extent to the highly seasonal pattern of industry output (e.g., Agricultural Chemicals), combined with the difficulty in hiring and training additional workers on seasonal basis. Chemical manufacturers prefer to hold on to experienced workers to oversee and maintain instruments and equipment that are highly sensitive to small changes in variables such as temperature and pressure, and to provide the ceaseless attention that is required to forestall breakdowns and costly downtime. Another important factor is changing technology; new innovations require less labor per unit of output, so in those industries where this coefficient is low, it seems that industry is spending more on research and development (e.g., Drugs).

iv) Labour Cost: The maximum labor cost is saved by Drugs(SIC 283) and the minimum by Industrial Organic Chemicals(SIC 281), Whereas the minimum production workers cost is saved by Agricultural Chemicals(SIC 287) and maximum by Plastics Materials and Synthetics(SIC 282).

Table 4

Ratio of Marginal Coefficients of Labor: Best to Worst Practice

Industrial Inorganic Chemicals (SIC 281)		
Name of Variables	**90% / 10%**	**75% / 25%**
TE	**1.44**	**1.25**
PW	**1.47**	**1.27**
PE	**1.34**	**1.20**
SW	**1.47**	**1.27**
WW	**1.51**	**1.29**
LC	**1.51**	**1.29**
Total Labor Cost	**1.48**	**1.28**
Plastics Materials and Synthetics (SIC 282)		
TE	**3.29**	**1.65**
PW	**2.55**	**1.75**
PE	**2.39**	**1.69**
SW	**2.34**	**1.67**
WW	**2.55**	**1.75**
LC	**2.64**	**1.78**
Total Labor Cost	**2.40**	**1.69**
Drugs (SIC 283)		
TE	**2.40**	**1.69**
PW	**1.42**	**1.24**
PE	**1.48**	**1.27**
SW	**3.51**	**2.07**
WW	**1.74**	**1.41**
LC	**4.74**	**2.38**
Total Labor Cost	**3.69**	**2.12**
TE	**2.64**	**1.88**
PW	**2.08**	**1.60**
PE	**2.10**	**1.57**
SW	**2.38**	**1.69**

WW	**1.84**	**1.46**
LC	**2.39**	**1.69**
Total Labor Cost	**1.80**	**1.44**
Paints and Allied Products (SIC 285)		
TE	**1.59**	**1.33**
PW	**1.36**	**1.21**
PE	**1.30**	**1.18**
SW	**1.80**	**1.44**
WW	**1.47**	**1.27**
LC	**1.83**	**1.45**
Total Labor Cost	**1.80**	**1.44**
Organic Chemicals (SIC 286)		
TE	**1.71**	**1.39**
PW	**1.57**	**1.32**
PE	**1.56**	**1.32**
SW	**1.99**	**1.52**
WW	**1.76**	**1.20**
LC	**1.93**	**1.50**
Total Labor Cost	**1.98**	**1.52**
Agricultural Chemicals (SIC 287)		
TE	**1.26**	**1.15**
PW	**1.21**	**1.13**
PE	**1.23**	**1.14**
SW	**1.50**	**1.29**
WW	**1.43**	**1.25**
LC	**1.60**	**1.33**
Total Labor Cost	**1.52**	**1.30**
Miscellaneous Chemicals (SIC 289)		
TE	**1.25**	**1.15**
PW	**1.61**	**1.34**
PE	**1.60**	**1.34**
SW	**1.81**	**1.44**
WW	**1.83**	**1.45**
LC	**1.88**	**1.47**
Total Labor Cost	**1.82**	**1.44**

6.4 Marginal Coefficients for Energy

Information on the quantities of energy required per unit of output is interesting for two reasons. First, such information will indicate how the industrial demand for energy changes with the mix of output. Second, it will indicate how the pattern of commodity prices will, initially, respond to change in energy prices.

Since the early 1970's when it was realized that energy prices might be below their true scarcity value, various methods of analyzing energy use and energy substitution possibilities have been developed and refined. Among them methods for determining levels of energy content used in producing products is energy input-output analysis which recognizes the interdependence of all sectors of the economy and their contribution to the energy embodied in specific goods and services.

All the work on these lines is based on average input-output analysis, which is based on the average technique, so it is not very helpful in forecasting of demand. For accurate forecasting it is better to construct the marginal input-output coefficients, which are based on the different layers of techniques.

Table 5 indicates the ratio of marginal coefficients for energy of best and least efficient practices. We construct the marginal coefficients for three energy variables of US 3-digit chemical industry.

Drugs(SIC 283), Industrial Organic Chemicals(SIC 286) and Agricultural Chemicals(SIC 287) are saving more energy than other sectors due to technology. Soap, Cleaners and Toilet Goods(SIC 284) and Paints and Allied Products(SIC 285) the lowest savers of energy among the eight sectors US chemical industry. Fuel is saved more by Drugs(SIC 283) and more electricity is saved by Industrial Organic Chemicals(SIC 286). The variation in ratios is from 1.14 (Soap, Cleaners and Toilet Goods) to 2.16 (Drugs). Whereas the variations in fuel is from 1.10 (Soap, Cleaners and Toilet Goods) to 5.40 (Drugs) and in electricity is from 1.46 (Paints and Allied Products) to 3.56 (Industrial Organic Chemicals). For electricity three groups can be distinguished, one is 1.46 to 1.65 (Plastics Materials and Synthetics; Soap, Cleaners and Toilet Goods; and Paints and Allied Products), another is from 1.65 to 2.00 (Agricultural Chemicals, Industrial Inorganic Chemicals, and Miscellaneous Chemicals) and the third is above 2.00 (Drugs, and Industrial Organic Chemicals), but under the column of fuel(EF), more variations can be observed than in the case of electricity; this effect is also reflected under the column of energy.

Table 5

Marginal Coefficients for Energy: Ratio of Best to Worst Practice

Name of Industry	EF		EE		Energy	
Industrial Inorganic Chemicals (SIC 281)	1.73	1.40	1.83	1.45	1.80	1.43
Plastics Materials & Synthetics (SIC 282)	2.34	1.67	1.47	1.27	1.90	1.40
Drugs (SIC 283)	5.40	2.51	2.99	1.91	3.88	2.16
Soap, Cleaners & Toilet Goods (SIC 285)	1.10	1.06	1.47	1.27	1.24	1.14
Paints & Allied Products (SIC 285)	1.26	1.15	1.46	1.27	1.36	1.21
Industrial Organic Chemicals (SIC 286)	2.77	1.83	3.56	2.08	3.01	1.91
Agricultural Chemicals (SIC 287)	4.41	230	1.66	1.37	3.06	1.93
Miscellaneous Chemicals (SIC 289)	2.54	1.75	2.00	1.52	2.32	1.66

Note: For every variable, the left column is the ratio 90% to 10% , and the right is ratio 75% to 25%.

7. Forecasting in an Economy with Several Layers of Techniques

As already discussed in previous sections, new techniques are producing with less variable cost, labor cost, and energy cost per dollar worth of output. At the same time if demand is not increasing *pari passu*, the old vintage will fetch its scrap value. These are the marginal input-output coefficients, *de facto* which explain the real situation of the economy, when the economy is working under a spectrum of techniques, having different productive efficiencies.

If it is assumed that new capacity is increasing 5% by the installation of new technology, then 5% of old capacity which is on the verge of obsolescence, will no longer be working. Table 6 shows how many groups of old vintages close down in each sector if *ceteris paribus*, new capacity is created(5%) by the new techniques. The same methodology can be used for the forecasting of energy cost and labor cost per dollar worth of output in each sector of US chemical industry. Table 7 analyses the effect on energy cost per dollar worth of output in the US 3-digit chemical industry when 5% new capacity is created, demand assumed to be constant.

Assuming that autonomous demand is increased by 5%, in the short run it is impossible for the producers to fill the gap between demand and supply by installing new technology. The establishments will try to use unutilized capacity. The minimum condition for restarting the capacity is that the prevailing price must not be less than their average variable cost. There are two possibilities, either variable cost go down or price will go up to cover their average variable cost. The first is unlikely, so normally price will go up, which is cost push inflation; price is fix-price, is determined by cost instead of the market mechanism. Table 8 shows the highest level of variable cost and energy cost per dollar worth of output, if 5% new autonomous demand is fulfilled in the short run by using the old vintage.

Table 8 shows that when demand increases the utilization of resources will increase, but without increase in the price levels, the supply will not increase. The same phenomenon will occurs in the labor market and that the relationship between cost-push inflation and unemployment can be seen. New capacity increases the rate of obsolescence, and non-profit firms on the verge of obsolescence cannot bear the burden of a cut in prices due to increase in supply. Without an increase in demand, they are not able to survive, just disappear, creating unemployment and the Phillips curve will be pushed horizontally eastward. Section 7.1 discussing this relationship in detail.

Table 6

Forecasting the obsolescence of the groups

Name of Industry	**Variable cost per dollar worth of output of new created capacity (5%)**	**Variable cost per dollar worth of output of group, after new created capacity (5%) (on the verge of obsolescence)**	**Number of groups closing down, after new created capacity (5%)**

Industrial inorganic Chemicals (SIC 281)	**0.572**	**0.973**	**1**
Plastics Materials & Synthetics (SIC 282)	**0.727**	**0.929**	**2**
Drugs (SIC 283)	**0.432**	**0.778**	**2**
Soap, Cleaners & Toilet Goods (SIC 284)	**0.610**	**0.820**	**6**
Paints & Allied Products (SIC 285)	**0.715**	**0.841**	**2**
Industrial Organic Chemicals (SIC 286)	**0.683**	**0.933**	**2**
Agricultural Chemicals (SIC 287)	**0.782**	**0.963**	**3**
Miscellaneous Chemicals (SIC 289)	**0.690**	**0.857**	**3**

Table 7

Forecasting of the Energy Cost Per Dollar Worth of Output After Created 5% Capacity by New Technology

Name of Industry	**Energy cost per dollar worth of output of new created capacity (5%)**	**Energy cost per dollar worth of output of the group, which is on the verge of obsolescence after created (5%) capacity**
Industrial inorganic Chemicals (SIC 281)	**0.010**	**0.061**
Plastics Materials & Synthetics (SIC 282)	**0.040**	**0.088**
Drugs (SIC 283)	**0.010**	**0.038**
Soap, Cleaners & Toilet Goods (SIC 284)	**0.015**	**0.019**
Paints & Allied Products (SIC 285)	**0.010**	**0.014**
Industrial Organic Chemicals (SIC 286)	**0.038**	**0.140**
Agricultural Chemicals (SIC 287)	**0.040**	**0.152**
Miscellaneous Chemicals (SIC 289)	**0.018**	**0.048**

Table 8

Variable Cost and Energy Cost Per Dollar Worth of Output of That Group, Which is on the Verge of Obsolescence, After Generating the Autonomous Demand (5%)

Name of Industry	Variable cost per dollar worth of output	Energy cost per dollar worth of output
Industrial inorganic Chemicals (SIC 281)	0.805	0.062
Plastics Materials & Synthetics (SIC 282)	0.940	0.090
Drugs (SIC 283)	0.797	0.041
Soap, Cleaners & Toilet Goods (SIC 284)	0.832	0.020
Paints & Allied Products (SIC 285)	0.848	0.014
Industrial Organic Chemicals (SIC 286)	0.947	0.143
Agricultural Chemicals (SIC 287)	0.973	0.159
Miscellaneous Chemicals (SIC 289)	0.866	0.050

7.1 Phillips Curve in an Economy with Several Layers of Techniques

As discussed above the economy has a spectrum of techniques working simultaneously, with different average variable cost of production, i.e., technological surplus. It is the technique with almost zero surplus that determines the price structure.

All techniques which are better than these marginal ones would be working at full capacity. New establishments will be using less labor per dollar worth of output than the old establishments which will be closing down, so there will be generation of unemployment if demand does not increase *pari passu*. If the strategy of a new establishment is to increase the wages of its employees, the establishments on the verge of obsolescence would try to recoup the higher wage-bill by increasing prices. If simultaneously demand also increases, it will be able to save itself. If not, its attempt to increase the price will be abortive and it will have no alternative but to close down. This will create unemployment with price rises. At the other extreme there will be a rise in prices as the increased wage rates instigated by new establishments could only be thus absorbed by the old establishments. In the real world, the result will be somewhere in between. Thus Phillips curve does not determine the trade-off between inflation and unemployment but is the resultant of the introduction of labor-saving technological progress and the struggle of firms becoming obsolete to remain in business.

Thus when innovations are being translated into new investment a rise in prices and money wages can be expected, coupled with a decline in unemployment.

When the burst of activity resulting from innovation is over, unemployment will be generated from the sources:

i) The extra activity generated in the capital goods sector will taper off and together with it a lot of secondary production activity generated as a consequence. This will of course, throw out labor working in sub-marginal establishments that activated during this period.

ii) The newly created capacity will make some old technology redundant and obsolete, i.e., the new techniques of production are likely to employ less labor to produce the same amount of goods as the one on its way out.

This will indicate not only a slowing down of price rises but even its reversal. However, the wages of those remaining in employment may still increase. That may be the market signal to less efficient firms to close down when their extra output is not required. So the phenomenon of the co-existence of rising real wages and rising unemployment is to expected.

After explaining the basic theory of this phenomenon, it is easy to understand Table 9, which assume that 5% of output is produced by new capacity, implying that the price level will fall, and old vintages which are on the verge of obsolescence are closing down, creating unemployment. When autonomous demand rises, the price level will increase due to increasing costs; however, employment level will increase.

From Table 9 it is clear that when autonomous demand increases, prices will also increase due to the cost-push phenomenon, and more resources will be employed. The increase is likely to be different in different sectors depending upon their input requirement per unit of output. Once an increase in autonomous demand is accompanied with newly created capacity, we can expect the Phillips curve to move northeast, which shows the trade-off between inflation and unemployment.

The above approach gives the empirical evidence for the analysis of Phillips curve on the basis of the structural requirement for the labor in the different sectors in an economy with several existing layers of techniques with different productive efficiencies.

Table 9

Coefficients of Labor After Creating the New Capacity and Autonomous Demand in US 3-digit Chemical Industry

	TE	PW	PH	SW	WW	LC	Labor Cost
Industrial Inorganic Chemicals (SIC 281)							
Coefficients of new created capacity (5%)	0.044	0.003	0.006	0.100	0.056	0.025	0.125
Coefficients of that group which is on the verge of obsolescence (after created new capacity , 5%)	0.006	0.004	0.008	0.164	0.095	0.042	0.206
Coefficients of that group which is on the verge of obsolescence, after created autonomous demand (5%)	0.007	0.004	0.008	0.168	0.097	0.043	0.211
Plastics Materials and Synthetics (SIC 282)							
Coefficients of new created capacity (5%)	0.003	0.002	0.004	0.067	0.037	0.015	0.082
Coefficients of that group which is on the verge of obsolescence (after created new capacity , 5%)	0.007	0.005	0.010	0.178	0.109	0.047	0.224
Coefficients of that group which is on the verge of obsolescence, after created autonomous demand (5%)	0.008	0.005	0.010	0.184	0.113	0.048	0.232
Drugs (SIC 283)							
Coefficients of new created capacity (5%)	0.005	0.004	0.007	0.069	0.054	0.010	0.079
Coefficients of that group which is on the verge of obsolescence (after created new capacity , 5%)	0.013	0.006	0.011	0.235	0.097	0.054	0.289
Coefficients of that group which is on the verge of obsolescence, after created autonomous demand (5%)	0.014	0.007	0.011	0.323	0.104	0.075	0.398
Soap, Cleaners & Toilet Goods (SIC 284)							
Coefficients of new created capacity (5%)	0.004	0.003	0.005	0.084	0.047	0.019	0.103
Coefficients of that group which is on the verge of obsolescence (after created new capacity , 5%)	0.012	0.007	0.013	0.235	0.097	0.054	0.289
Coefficients of that group which is on the verge of obsolescence, after created autonomous demand (5%)	0.013	0.007	0.014	0.244	0.100	0.019	0.299
Paints & Allied Products (SIC 285)							
Coefficients of new created capacity (5%)	0.005	0.003	0.006	0.099	0.047	0.021	0.120
Coefficients of that group which is on the verge of obsolescence (after created new capacity , 5%)	0.009	0.004	0.008	0.197	0.073	0.043	0.240
Coefficients of that group which is on the verge of	0.010	0.004	0.009	0.203	0.075	0.044	0.247

obsolescence, after created autonomous demand (5%)							
Industrial Organic Chemicals (SIC 286)							
Coefficients of new created capacity (5%)	**0.003**	**0.002**	**0.004**	**0.069**	**0.041**	**0.081**	**0.191**
Coefficients of that group which is on the verge of obsolescence (after created new capacity , 5%)	**0.005**	**0.003**	**0.006**	**0.153**	**0.079**	**0.038**	**0.191**
Coefficients of that group which is on the verge of obsolescence, after created autonomous demand (5%)	**0.006**	**0.003**	**0.007**	**0.158**	**0.081**	**0.039**	**0.197**
Agricultural Chemicals (SIC 287)							
Coefficients of new created capacity (5%)	**0.004**	**0.002**	**0.005**	**0.077**	**0.044**	**0.016**	**0.093**
Coefficients of that group which is on the verge of obsolescence (after created new capacity , 5%)	**0.005**	**0.003**	**0.007**	**0.122**	**0.066**	**0.027**	**0.150**
Coefficients of that group which is on the verge of obsolescence, after created autonomous demand (5%)	**0.006**	**0.004**	**0.008**	**0.125**	**0.067**	**0.028**	**0.153**
Miscellaneous Chemicals (SIC 289)							
Coefficients of new created capacity (5%)	**0.179**	**0.003**	**0.006**	**0.101**	**0.050**	**0.021**	**0.122**
Coefficients of that group which is on the verge of obsolescence (after created new capacity , 5%)	**0.231**	**0.005**	**0.010**	**0.201**	**0.101**	**0.044**	**0.245**
Coefficients of that group which is on the verge of obsolescence, after created autonomous demand (5%)	**0.234**	**0.005**	**0.011**	**0.206**	**0.103**	**0.046**	**0.252**

Is there any theoretical explanation of the above drastic shifting Phillips Curve? Quite a few explanations in terms f inflationary expectations have poured in. The most well known of them are those given by the Friedman (1967) with his theory of inflationary expectation theorists. We shall not to go into its details. We shall merely note that fact that volatile expectations have been a part of economic climate over the whole of the last century. It requires a bit of straining of the credulity o imagine that something significant has changed in terms of psychology within the last three decades, so unique as to change the Phillips Curve which described the situation so well for more than a century. We can formulate a general hypothesis from observations about the shifting of Phillips Curve. The higher the nominal interest rate, more and more Phillips Curve shifts to the north-east corner. Similarly larger cost of the imported inputs also tend to shift the Phillips Curve in the same direction. But why?

High nominal interest rates effect the economy in two ways. Firstly it increases the rate of obsolescence. No profit firms on the verge of obsolescence cannot bear the burden of extra nominal interest rates at current prices. There is only one way to escape. That is to be able to do so survive creating inflation and those which are not able to do so, just disappear creating unemployment. If all such firms are able to increase the prices of their output as much as it required to meet their cost of production, it will push up the Phillips Curve vertically. If they are not able to increase the prices of their output at all and thus go out of business, the Phillips Curve will pushed horizontally eastward. In practice some firms more or less succeed in pushing up prices and others do not, we can expect the north-east in Phillips Curve with the nominal interest rates being high compared to the equilibrium rates. And that is what we observe.

Similarly, if the cost of imports become high for the whole economy, the no profit manufacturer can recover it either by raising the price of his output or closing own. Therefore, its effect will be similar to the one higher nominal than equilibrium rate of interest is displacing the Phillips Curve north-east. These two factors completely explain the movement of Phillips Curve during the last three decades. And to explain that we do not require any hypothesis about the volatile unobservable expectations etc.

Recapitulation

Since the early days of Input-Output analysis, input-output forecasts of total based on a given final bill of goods have been made. Thus far, however, it seems that all studies have made use of what we call “Average” input-output coefficients, i.e., those shown in published input-output tables. Do these represent the real situation of the economy? In fact an economy consists of several layers of techniques, and these average coefficients are simply a weighted average of them, and are therefore not suitable for many aspects of analysis and policy.

An economy having continuous technical advance will embody a portion of improving know-how in the new investment being undertaken. Investment of different vintages will work with different productive efficiencies, and as may require different amounts of various inputs to produce a unit of output. At a particular time, fixed capital equipment of several vintages may be expected to be in situ for production. When investment involves equipment of the latest technique, the older equipment may also continue in production, though by the very nature of things it is likely to be earning lesser returns. The old equipment will go on producing until enough capital of the newer vintages is accumulated to satisfy total demand for that commodity.

However, after installation of fixed capital equipment, when it eventually becomes not economically worthwhile to produce with it, it may only fetch its scrap value. Thus its opportunity cost is almost zero. Therefore, in taking the decision whether to continue in production, the unit will not consider whether it can get any return on fixed capital by continuing production. It should continue production as long as it can cover the average variable cost of production. In other words, a unit will remain in production until its technological surplus is not negative.

So, looking at the economy as consisting of several layers of techniques gives a way to spell out the implications of macro economic situations, to micro levels. For instance, if macro economic consideration point to reducing total employment, a map of the layers of the techniques of the economy should be able to pinpoint of the different regions or industries that are likely to be affected. In such cases, to be able to delineate the effects of extra demand or of new investment on the production or utilization of the resources in the economy, we require marginal input-output coefficients instead of the weighted average that are at present computed worldwide. Similarly, for capacities going out of production either because of lack of demand, or obsolescence, knowledge of the least efficient techniques of production is essential.

It is observed from the previous analysis that every best- practice in US 3-digit chemical sector saves both labor and energy per dollar worth of output. There is saving of production as well as non-production workers per unit of output. A very interesting phenomenon is observed, that wth the help of marginal input-output coefficients, a Phillips Curve can be drawn, which will be on a disaggregated basis and for policy formation it indicates the relationship between inflation and unemployment in the different sectors, i.e., the Phillips Curve for different sectors could be same or different dependent on the structural requirement of that sector. Not only does this curve explain the sectoral requirement of resources it also differentiate the demand of production workers and non-production workers per dollar worth of output separately. In this case any adjustment of supply and demand is achieved by changes in production rather than by changes in prices. So extra demand increases production, hence employment rather than prices. Prices are determined on the basis of what has been variously called the "full cost", "cost-plus" or "cost mark-up" principle, and increase with the increase in cost.

Interestingly, it is observed that it is the marginal coefficients, which allow input-output analysis to meet the challenge of precision for the fast-developing forecasting industry. And the technique developed by P. N. Mathur, allows analysis of the effect monetary and fiscal policy down to the level of establishments, providing the detailed effects of the policy or any economic activity, and giving a way to spell out the implications of macro economic situation to micro economic phenomena.

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Footnotes

1. However, it is not a recent data, but for the understanding of the problem ,detailed data of any other year is not available. We are also thankful to US National Science Foundation for the provision of this data.
2. For the advancement of the chemical industry see the various issues of Chemical Engineering News, Chemical Engineering, Chemical and Engineering News.