Impact of Technology on Production in Indian Economy

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Abstract. The input output model of this paper evaluates output effect of change in technology independent of other factors. It also examines output effect of change economic in factors, indexed by final demand, independent of technology. Besides, joint output and technology effects are also analyzed.

Keywords: Technology, Final Demand, Change, Output Effect, Input Output Model

1. Introduction

Modern economic growth revolves around technology. Change in technology is associated with the shift in production function (Prakash-Balakrishnan, 2006). Macro production function relates to the economy as a whole, while micro function relates to companies, firms and group of companies. But Leontief model lies between these two ends of the spectrum as it deals with the economy and its constituent sectors individually and jointly. Technology is a function of innovation/ invention its commercial exploitation. There are two sources of technological change: Indigenously developed technology and imported technology. Indigenous technology does not involve transformation of institutional structure, organizational base and social system. Mostly advance countries develop their own technology. Technological change for such countries is marginal. In advance countries, new technology is developed to replace the old. Imported technology involves far reaching changes. The imported technology may be a radical jump from the least to most efficient technology, for example, manually drawn cycle rickshaw and fly by wire aero bus technology operates together in India. In developing countries, several technologies of different vintages exist together (Mathur 1963, Bhatia 1965).

2. Research Approach

This study evaluates the impact of change in technology on output in Indian economy in relation to economic factors which influence final demand. Development requires technological changes across the sectors. All such changes are captured by technology matrix of Leontief model. Each pair of rows and columns of technology matrices relates to one sector. Rows depict the pattern and structure of supplies of output of one industry/sector to the rest of the economy (B to B Business). Output is also supplied to meet the final demand, which comprises these: Private final consumption, Government final consumption, Investments and Exports – Imports. This matrix is based on inter sector transactions in the economy. The number of sectors into which the economy is classified is a matter of data availability and the refinement of the change in technology matrix. The change in the structure of the economy and hence, the structure of each sector has a direct effect on the growth of output. On analyzing demand vector with relation to technology matrix gives us total output within given technology in an economy.

3. Models

The growth/output effect of technological change can be measured and analyzed by the changes in input coefficients matrix, A in Input-Output Model. IO model is used for examining growth effect of change in technology as reflected by change in matrix, A. The following is the model:

$$X_t = (I-A_t)^{-1} * f_t \qquad (1)$$

Where X_t = Gross output vector; A_t = Technology matrix; f_t = Final demand vector; t= Time,

$(I-A)^{-1}$ = Leontief inverse, and A is the technology matrix: 113 * 113

I-O tables of Indian economy for 1998-99 and 2003-04 are used. Equation has 1 degree of freedom which is used to fix either f or A. Solution vector Xt is derived from equation 1 in terms of f. Isolation of pure technology effect from the influence of other factors is needed. ft is the index of influence of all factors on Xt other than technology. The model allows either technology to change with constant final demand, or to change with final demand with the constant technology. The equation 1 is modified as follows in order to apply the above procedure:

$$X_0^1 = (I-A_0)^{-1} * f_0 \qquad (2)$$

$$X_1^1 = (I-A_1)^{-1} * f_1 \qquad (3)$$

$$X_0^2 = (I-A_1)^{-1} * f_0 \qquad (4)$$

$$X_1^2 = (I-A_0)^{-1} * f_1 \qquad (5)$$

Subscript 0 stands for base year 1998-99 and 1 refers to 2003-04, t= o or 1. X, A and f are three variables of the matrix equation, giving us one degree of freedom. In an I-O model, A is a set of technological parameters, which are given exogenously. X is determined in terms of A and f. Above specification treats A as variables rather than as parameters. A and f are allowed to change turn by turn from one to another time period. In equations 2 and 5, technology of 1998-99 is kept constant, while final demand is allowed to change from 1998-99 to 2003-04. The difference between solution vector $X_1^2 - X_0^1$ (equations 5 and 2) depicts the change in output that is accounted by the change in final demand, when the influence of techno logical change is neutralized. Similarly, difference of $X_1^1 - X_1^2$ (equations 5 and 3) shows the output effect of a change in technology, when final demand of 2003 -04 is kept constant. Further the difference between $X_1^1 - X_0^2$ (equations 3 and 4) reflects the influence of change in demand with constant technology of 2003-04 in use. Difference between $X_0^1 - X_0^2$ and $X_0^2 - X_0^1$ reflect the impact of technological change on output, when final demand of 1998-99 is kept constant. Constancy of the final demand means that the influence of all factors on output other than technology is neutralized.

4. Empirical Analysis

4.1 Effect of Technological Change

In the first part, results of application of above four I-O models are analyzed. This part evaluates the differences of four output vectors as explained above. Significance of the differences of the means of comparable output vectors is evaluated by t- test, while differences of their variance are examined by f test.

4.2 Output Effect of Technology with Constant Final Demand

Since the values of t is 1.85 which indicate that it is statistically significant at .3 degree of probability, means that change in technology exercises significant influence on output. However the change in technology with constant demand of 2004 influences output more the change in constant demand of 1998-99. However, the factors economic factors exercise greater influence than technology. These results suggests that the technological changes in Indian economy during the period of 5 yrs has been low and slow, though the fast growing sectors have registered greater than average change in technology. The variances are also statistically significant; it suggests that the technological change and its influence on output vary

significantly temporally among the sectors. This thesis is tested further by 2 factors ANOVA. ANOVA of differences of output vectors $X_0^1 - X_1^2$, and $X_1^1 - X_0^2$ is reported below:

Table 1

ANOVA 1						
Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows	1.59636E+16	112	1.42533E+14	6.736971658	1.95697E-21	1.366389
Columns	7.26574E+13	1	7.26574E+13	3.434238156	0.066490165	3.925834
Error	2.36956E+15	112	2.11568E+13			
Total	1.84059E+16	225				

The results in table1 are derived from column one of ANOVA table which relates to final demand of 2004 with the differentials of technology of 1999 and 2004. Similarly, second column relates to final demand of 1999 but the differentials of technology of 1999 and 2004. Thus between column variance depicts the change in final demand on output, whereas between rows variance reflects change in technology. The table shows that both columns and rows variance are statistically significant. However the effect of change in final demand is more that effect in change in technology on output.

ANOVA table for the pair of output vector of $X_0^1 - X_1^2$ and $X_1^1 - X_0^2$ is reported below:

Table 2

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F critical*
Rows	7.51892E+15	112	6.71332E+13	3.173132278	1.43199E-09	1.366389225
Columns	7.26574E+13	1	7.26574E+13	3.434238156	0.066490165	3.925834021
Error	2.36956E+15	112	2.11568E+13			
Total	9.96113E+15	225				

The first column of the table depicts the output effect base on the technology of 1999 used to produce final demand of 1999 as well as 2004. Similarly second column shows output of different sectors produced by technology of 2004 to produce output for satisfying demand of 1999 and 2004. The result of ANOVA shows that the change in final demand that is variation between rows is statistically significant, whereas change in technology is not significant. These results also lend support to the inference drawn from the previous table. Further growth of output based on change in final demand with the same technology is regressed on sector wise changed technology. The results are reported below:

$Y_1 = 834668.7 + 0.432X_1$, $R^2 = 0.7409$, F=317.49 > F* = 2.42, t= 3.56 Where ,

Y_1 represents growth rate of output derived from $(I-A_0)^{-1} * f_0$ and $(I-A_1) * f_0$

X_1 represents output derived from $(I-A_0)^{-1} * f_0$

This regression result shows the effect of technological change. The result shows that corresponding to one unit change in technology represented by the input coefficient, leads to an increase of .432 crores on output. As represented by total intermediate goods required leads to an increase in output of 0.432Rs.

Regression result for effect of technological change on different sectors

$Y_2 = 1.54 + 0.18X_2$, $R^2 = .0059$ F=.655 <F*= .419, t= 5.18 Where,

Y_2 represents growth rate of output derived from $(I-A_0)^{-1} * f_0$ and $(I-A_0)^{-1} * f_1$.

X_1 represents growth rate of column total of $(I-A_0)^{-1}$ and $(I-A_1)^{-1}$.

These regression result shows index of sector specific technology, which displays intermediate inputs per unit of final demand. The result shows corresponding to a unit change in X, Y changes by 0.18. The results are in consonance with ANOVA results. Incidentally the results are in consonance with the finds of Prakash-Balakrishnan(2008) that the growth of Indian economy is dominant by productivity and productivity have been dominated by human capital rather than technology.

5. Analysis of effect of change in demand and change in technology on sectors

To analyse the above result in detail we further extended our research to sectors and sector wise analysis is done using following set of equations:-

$$C = X_1^1 - X_0^1 \tag{6}$$

$$D = X_0^2 - X_0^1 \tag{7}$$

$$E = X_1^1 - X_1^2 \tag{8}$$

Where,

C= Joint effect of change in demand and change in technology; D= Change in technology effect with demand of 1998-99; E= Change in technology effect with demand of 2003-4.

6. Joint effect of change in demand and change in technology

We have classified the sectors into five categories according to the change in the output due to change in final demand. For analyzing joint effect of change in demand and change in technology categories are made on the basis of result derived from equation 6 .Table is given below

Table 3

Output derived from eq.6 (Figures in 100000 INR)	Category	No of sectors	% of sectors	Major sectors
Less than and equal to 0	Negative growth	21	19	Jowar, Cotton, Rubber, Coconut, Mineral, silk textile, woolen textile Garments, Tobacco products, Leather products and footwear etc
Greater than 0 and less than 25	Very Low growth	55	49	Heavy chemicals, Fertilizers, Tractors, Industrial machinery, Ships and Rail equipment, Transport equipment, Medical and Health etc
Greater than 25 and less than 50	Low growth	20	18	Paddy, Wheat, Milk and animal products, Coal & lignite, Railway Transport services, Insurance Education and Research etc
Greater than 50 and less than 75	Moderate Growth	6	5	Jute, Plastic products, Hand tools, hardware, Motor vehicles, electricity and gas
Greater than 75 and less than 100	High Growth	2	2	Communication , Hotels and restaurants
Greater than 100	Very High Growth	9	8	Banking, Trade, Crude petroleum, Petroleum Products, other transport services, Other services etc

Slightly less than 1/5th of the total sectors display negative change in response to change in both, technology and change in final demand. Among these 19 sectors 12 relates to either agriculture(4 sectors) or agro based industries like silk, cotton, khadi textile, Garments, Tobacco products etc which were traditionally foreign exchange earner as they are strong in international market as well as domestic markets. Substitution of these organic products by synthetic products have reduced the demand and thus affecting

final growth of demand. Besides this, these sectors also show stagnation in technology. So this result is not surprising even though these sectors are key and leading sectors (Mathur 1963, Bhatia 1965). Nearly half of the total sectors fall in low growth category showing output falling in the range of 0-25. The largest proportion is accounted by agriculture and agro linked industries like Fertilizer, Tractor and agri. Implements. Health care and Transport equipment also fall in this category. This is an interesting part which shows that technological growth in agro and agro linked sectors is very low in India. 18% sectors are in average growth category which comprises of sectors like Paddy, Wheat, Milk and animal products, Coal & lignite, Railway Transport services, Insurance Education and Research etc. 10% of total sectors account for high and very high growth. These are leading sectors of the economy. The above results are in accordance with theory as well as public policy persuaded so far in India. The theory predicts that a developing country moves away from primary to secondary production in the process of development, but at the maturity it becomes tertiary dominated. Economic policy of India has also promoted tertiary sectors. They have got greater ascendency under new economic policy also.

7. Change in Technology with Constant Final Demand

To study the impact of change in technology with constant demand output derived from equation 7 and 8 are used which are classified in five categories. Results are tabulated below:-

Table 4

Output derived from eq.7 (Figures in 100000 INR)	Category	No of sectors	% of sectors	Major sectors
Less than and equal to 0	Negative growth	39	35	Bajra, Cotton, Rubber, Cconut, Bsic metaic Mineral, silk textile, Garments, milk & Milk products, Leather products and footwear, electricity and gas etc
Greater than 0 and less than 25	Very Low growth	61	54	Heavy chemicals, Fertilizers, Tractors, Industrial machinery, Ships and Rail equipment, Transport equipment, Medical and Health, Hotels and restaurants, Paddy, Coal & lignite, , Insurance Education and Research
Greater than 25 and less than 50	Low growth	6	5	Banking ,Communication, Construction, Hand Tools and hardware, Plastic products, Wheat
Greater than 50 and less than 75	Moderate Growth	1	1	Trade
Greater than 75 and less than 100	High Growth	2	2	Crude petroleum, Petroleum Products,
Greater than 100	Very High Growth	4	4	Banking, other transport services, Other crops,Other services

Table 5

Output derived from eq. 8 (Figures in 100000	Category	No of sectors	% of sectors	Major sectors

INR)				
Less than and equal to 0	Negative growth	35	31	Ground nut, Cotton, Rubber, Coconut, Non metallic minerals, silk textile, Garments, milk & Milk products, Leather products and footwear, electricity and gas , rubber products etc
Greater than 0 and less than 25	Very Low growth	56	50	Jawar, Bajara, Tea, ,sugar cane , Heavy chemicals, Fertilizers, Tractors, Industrial machinery, Ships and Rail equipment, Transport equipment, Medical and Health, Paddy, Coal & lignite, Railway Education
Greater than 25 and less than 50	Low growth	12	11	Wheat, Paddy, Jute, Hand Tools and hardware, Plastic products, Paint, Iron and steel foundries etc
Greater than 50 and less than 75	Moderate Growth	2	2	Communication, Construction
Greater than 75 and less than 100	High Growth	1	1	Banking
Greater than 100	Very High Growth	7	6	Trade, Crude petroleum, Petroleum Products, other transport services, Other services, miscellaneous manufacturing etc

The results are put into two distinct set of equations which are equation 7 and 8. Table 3 and 4 contains compressive analysis of data for change in technology with constant final demand of (i) 1998-99 and (ii) 2003-04. As per the data tabulated above we can draw inference that slightly more than $1/3^{rd}$ of the total sectors depict negative effect of technological change on output. Majority of the negative growth sectors present in table3 are also present in table 4 and 5 but nearly 10 sectors have not moved from negative growth to very low growth category. This implies that these 10 sectors in this category are technologically stagnant. The numbers of low growth sectors have increased from 55 to 61 these sectors accord for 54% of the total sectors. It implies that more than half the economy is awaiting the technological change. Incidentally numbers of high growth sectors have been reduced from 11 to 7 or 10% to 6 %. It means that these high growth sectors like Trade, Hotels and Restaurants are technologically stagnant. This was the state in 1998-99, on examining the data further for 2003-04 we found that, the number of sectors in low growth have been reduced by four. These four sectors have gained in growth through expansion of final demand for their products. Also the moderate growth sector has increased marginally by 1%. We may infer that neither the growth of final demand nor change in technology have effected this category. Number of sectors which fall in the category of high and very high growth changed from 6 to 8. This shows that these sectors have shown greater influence to change in technology.

8. Conclusion

Results of this paper highlight the impact of technology and final demand on output. The results have clearly shown that output does grow with change in technology. But change in final demand, reflecting the influence of a host of economic factors, affects output much more than the change in technology. One unit change in sector specific final demand, keeping technology constant, raises sector specific output by 0.43 units. However, change in output corresponding to unit change in sectors' technology index is only 0.18. Thus, output effect of technological change is only 42% of output effect of change in final demand. Thus we can say that the limited role of technological change indicates that growth of output is mainly accounted by growth of productivity(Prakash-Balakrishnan, 2006). In Indian economy it is accounted by human power

rather than physical power. The results furnish by different methods of analysis are in conformity with each other.

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