INPUT OUTPUT MODELING OF UTILIZATION OF ENERGY RESOURCES AS BASE OF GROWTH OF EMERGING MARKET ECONOMY OF INDIA

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Energy resources are the pivot of modern developed, emerging market and developing economies. Both consumption and production revolves round the use of energy resources. Whereas consumption expenditure on energy resources operationalizes consumption multiplier process of growth, energy resources used in production activates investment accelerator process and backward and forward linkage effect on growth of output on the other. Use of energy resources in general and electricity in particular is considered an indicator of stage of growth and standard of living of a country. Quality of life and living styles, in fact, depend largely on the use of electricity and oil/gas products.

Energy resources in India comprise coal, mineral oil and oil products, gas and electricity. Availability of oil and oil products, inclusive of domestic output and imports, and coal are adequate to meet demand, but gas and electricity are short in supply relative to demand in India. Both these energy resources are a bottleneck and constraint to growth. Shortfalls in domestic output of oil and oil products and gas relative to demand are met largely by imports. But coal is abundantly produced in the country, while electricity is produced largely domestically and imported partially from adjoining countries. Supply of electricity is, however, perennially short relative to demand/requirement, which leads to almost regular power cuts; during the period of power cuts alternative sources of in-house supplies both by households and business/commercial enterprises are used. The alternative sources of electricity supply are costlier than the public supplies. This not only enhances cost of production, and hence, prices of goods but it also disrupts the continuity of production process and comfortable living of the households. Households' budgets are adversely affected by the use of alternative sources of electricity supply. Consequently, it affects the expenses on other items of consumption. As against this, prices of petroleum and diesel are raised almost every month, which not only squeezes household budgets directly but it also results in periodic hikes in fares and freights. These price hikes, in turn, raise transportation costs of both men and materials. Consequently, inflationary pressures are intensified in the economy. This is the backdrop of this study.

Focus of Study

The paper focuses on (i) Current level of utilization of energy resources and its inter-temporal and inter-sector variation; (ii) Output/growth effect of utilization of energy resources and its inter-temporal and inter-sector variation; (iii) Determination of inter-relation between inter-sector and inter-temporal linkages, final demand for energy resources and output; and (iv)

Energy resource use intensity and its inter-temporal and inter-sector differentials. The study attempts to capture the outcome of activation of both consumption multiplier and investment accelerator, embodied in final demand for energy resources.

Methods and Models

An Input Output model with energy resources alone constituting non-zero final demand has been formulated for the determination of output effect of utilization of energy resources; output effect so derived is net of influence of final demand for all other goods which are kept at zero level in calculations.

Model of Output Effect

$X\hat{}_t = (I-A_t)^{-1} f_t$………………(1)

$X\hat{}_t$ is estimated output vector for time period t, $(I-A_t)^{-1}$ is Leontief Inverse and f_t is specially constructed final demand vector ,all elements of which, except 5 sectors relating to energy resources are zero and t refers to time/year. Final demand for output of Coal & Lignite, Natural Gas, Crude Petroleum, Petroleum products and Electricity sectors is considered under energy resources. For netting out the effect of final demand of all sectors other than energy on output, Leontief inverse is multiplied by specially constructed final demand vector in which all elements except the energy resources are zero.

Energy Intensity

Energy intensity of individual sectors is estimated by the following I-O Model:

$E = (I-A_e)^{-1} \varepsilon$………………….(2)

E is the vector of total energy requirement, $(I-A_e)^{-1}$ is the Leontief type inverse of energy resource required per unit of final demand, and ε is unit vector of final demand.

The above I-O model is supplemented by the tools of descriptive statistics, ANOVA and regression model.

Sources of Data

CSO's Commodity x Commodity technology matrix Input Output tables of 1993-94, 1998-99, 2003-04, and 2007-08 are used as data base of I-O model. Output estimates derived from the applications of model 1 are subjected to the application of tools of descriptive statistics, ANOVA and regression model in order to explain the basic facets underlying the results of I-O model. The results of analysis will identify highly, moderately and low energy intensive sectors of the economy. This may be helpful in the choice of sectors for rapid growth according to their energy intensity nature. Less priority may be assigned to highly energy intensive but low growth sectors to mitigate energy resource as constraint to growth.

Results of Empirical Analysis

Results of application of methods and models to data are presented sequentially. Rather than reporting sector-wise output effect for each of the four years, results of application of tools of descriptive statistics to the output effect of utilization of energy resources for all the four years are presented first. The table 1, given below, shows the basic results relating to output effect of utilization of energy resources on 115 sectors of the economy for 1993-94,1998-99 and 130 sectors for 2003-04 and 2007-08:

Table-1: Year-wise Output Effect of Utilization of Energy Resources

Output Summary Stats				
	1993-94	**1998-99**	**2003-04**	**2007-08**
Mean	26055.38	67153.05	115145.5	2002499
Standard Error	11389.93	26882.16	53366.85	958672.4
Median	720.0408	2061.405	2870.64	349420.9
Mode	0	0	0	0
Standard Deviation	122143.4	288279.1	608475.7	10930547
Sample Variance	1.49E+10	8.31E+10	3.7E+11	1.19E+14
Kurtosis	36.42659	26.3935	60.31753	113.1752
Skewness	6.026168	5.1985	7.513815	10.36226
Range	895957.6	1760807	5617804	1.22E+08
Minimum	0	0	0	0
Maximum	895957.6	1760807	5617804	1.22E+08
Sum	2996369	7722601	14968909	2.6E+08
Count	115	115	130	130

A perusal of the above table reveals that (i) average output effect of energy resources use is significantly greater than the median output effect. It implies that the output effect, as expected is not uniformly or symmetrically distributed among the sectors; (ii) Consequent to the uneven distribution of output effect among the sectors, the pattern of distribution is highly skewed and concentrated; (iii) Degree of skewness and concentration on the whole tends to rise from first to third and third to fourth year of observation; (iv) Range of variation of output effect of use of energy resources shows a highly increasing trend. It implies increasing degree of uneven distribution of output effect among the sectors. This may probably be accounted by the level of technology and nature of the industry.

Significance of Paired Differences of Mean Output Effect and their Variances

Significance of inter-year differences of paired mean output effects on sectors and corresponding variances are evaluated by t and F tests; results are reported in table 2 given below.

Table-2: Test Statistics of Significance of differences of Paired Means and Variances

	93-94 & 98-99	**93-94 & 2003-04**	**93-94 & 2007-08**	**98-99 & 2003-04**	**98-99 & 2007-08**	**2003-04 & 2007-08**
F value	5.570398	24.81684	8008.363	4.455128	1437.664	322.69879
t value	2.147657	2.751529	4.074879	1.196087	3.927425	3.7298026
Av Standard Error	19136.05	32378.39	485031.2	40124.51	492777.3	506019.62

Means and variances of output effect of individual years are paired for the evaluation of statistical significance of paired means and variances of 4 years of observations. Incidentally, successive I-O table involve a time lag of 5 years. The following inferences flow from the values of t and F statistics reported in table 2: (i) Differences of all paired variances are highly significant statistically; and (ii) Degree of differences between paired variances seem to rise for each successive year. It implies high degree of differentials of use of energy resources over the years.

Test of Composite Data of Output Effect of Energy Resources

It is possible that the paired differences of individual year's means and variables are significant but the differences taken for all four years together may not differ significantly. For evaluating this possibility, sector wise output effect of energy resources is subjected to two factor ANOVA without replication. Results are reported in table-3 given below:

Table-3: Inter-Sector and Inter-Temporal Variation of Output Effect of Energy Resources

ANOVA

Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows	4.11E+15	114	3.6E+13	1.088798	0.279289	1.275316
Columns	3.89E+14	3	1.3E+14	3.913629	0.00905	2.63102
Error	1.13E+16	342	3.31E+13			
Total	1.58E+16	459				

This table reveals that output effect of energy resources for all four years taken together does not differ significantly between sectors. This runs counter to the inference drawn from the test of paired differences of two years taken at a time. It may mean that there exists the tendency towards convergence of energy resources between sectors over the years. This is not surprising as these four tables cover a period of 20 years and during this period concerted efforts have been made to mitigate shortages of energy resources, especially electricity. This is substantiated by the fact that output effect of energy resources between the years has varied significantly.

Determinants of Differentials of Inter- Sector Output Effect of Energy Resources

A relevant research question is why does output effect of energy resources differ between sectors and years? It is postulated that (i) magnitude of final demand for energy resources, which differ greatly among sectors and over years, and (ii) backward and forward linkages of sectors are main determinants of differential of inter-sector and inter-temporal differentials of output effect (See, Shri Prakash and Rekha Sharma, 2010, Shri Prakash and Ritisnigdha Panigrahi, 2012). In view of the hypothesis, step-wise regression model is estimated. Results are given hereunder.

Table-4: Regression of Output on Average Linkage Index

	Intercept	**Slope**	**t of intercept**	**t of slope**	**R^2**	**F value**
1993-94	-86898	55894.04	-3.53	5.06	0.19	25.57
2007-08	-1013657	9462239.5	-0.81	3.56	.09	12.7

The OLS estimates of the linear regression model of output effect on linkage index show that the function fits the data well as the coefficients of determination and the slope coefficients for both these years are statistically significant, though explained proportion of variation is quite low. Intercept for both the years is negative but significant only for the base year. It implies that factor(s)/variable (s) excluded from the above regression exercise significant influence on output effect of energy resources.

Table-5: Regression of Output Effect on Final Demand

	Intercept	Slope	t of intercept	t of slope	R^2	F value
1993-94	12564.26	1.12	2.0	16.38	0.7	268.39
2007-08	1818496	1.16	1.90	1.89	.02	3.58

OLS estimate of regression of output effect on final demand for energy resources practically depict the results similar to the regression of output effect on final demand. Positive and significant intercept in this case also points towards the need for incorporation of some important determinant of output effect as an additional determinant in the function. This moves the study to multiple regression of output effect both on linkages and final demand.

Table-6: Regression results of Output on Average Linkage and final Demand

	Intercept	Slope of Linkage	Slope of FD	t of intercept	t of linkage	t of FD	R^2	F value
1993-94	-42505	27721.33	1.04	-3.0	4.29	15.71	0.74	164.13
2007-08	-984096	892573.1	0.89	-0.79	3.34	1.50	0.1	7.54

The fit of this function is much better for both the years than the fit of earlier regression equations which is highlighted by considerable improvement in the explanatory power of the model. In both the years, the slope coefficients are statistically significant. But the output effect is much more responsive to the degree of linkage index than the magnitude of final demand for energy resources. This is partly explained by the nature and structure of the specially constructed final demand vector for energy resources used in the study.

Energy Intensity and Its Inter-Sector and Inter-Temporal Variations

Model 2 is used for determining the total amount of energy resources required per unit of final demand of different goods produced in the economy.

Table 7: Energy Intensity of Final Demand

	1993-94	1998-99	2003-04	2007-08
Mean	0.203191	0.161285	0.256549	0.294644
Standard Error	0.024162	0.019862	0.024923	0.088255
Median	0.175374	0.111596	0.2198	0.066053
Standard Deviation	0.259103	0.213	0.267264	0.946434

Sample Variance	0.067135	0.045369	0.07143	0.895737
Kurtosis	21.87335	25.25987	16.60898	62.86536
Skewness	4.360985	4.54783	3.766132	7.33371
Range	1.801144	1.631713	1.7846	8.94328
Minimum	0	0	0.0212	2.63E-05
Maximum	1.801144	1.631713	1.8058	8.943306
Sum	23.36697	18.54782	29.5031	33.88407

A perusal of the table in which total energy used in production to satisfy one unit of final demand for different goods in Indian economy shows that (i) energy intensity of each sector varies over the years though there exist no definite pattern of change for most of the sectors; (ii) energy intensity varies greatly between the sectors. For rigorous evaluation of the above inferences, two factor ANOVA without replication is used and the results are reported in table 8.

Table-8: Energy Intensity and Its Inter-Sector and Inter-Temporal Variations

	ANOVA						
	Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
	Rows	42.96217	114	0.376861	1.608661	0.000587	1.275316
	Columns	1.186734	3	0.395578	1.688556	0.169191	2.63102
	Error	80.12034	342	0.23427			
	Total	124.2692	459				

The results in the above table support the hypothesis that energy intensity varies greatly and significantly between the sectors for all the years taken together. Energy intensity of all sectors taken together differs significantly between the years only if a relatively low confidence interval of 83% is accepted. In view of frequent power cuts and less than prominent year on year differentials within the sectors, this level of confidence interval may be accepted. Otherwise it may be surmised that the debilitating power shortages and rising energy cost over the years have prevented the Indian economy to move away from low to high energy intensity production processes which revolve around advanced technologies.

Energy inputs as a proportion of total of all inputs used in production is also employed to assess the energy intensity of sectors. This is an alternative measure of energy intensity. Results of calculations are contained in a table 9.

Table 9: Proportion of Energy Resources in Total Inputs per unit of FD

	1993-94	**1998-99**	**2003-04**	**2007-08**
Mean	0.097224	0.0793146	0.1191061	0.0653057
Standard Error	0.012461	0.0112302	0.0132187	0.0128055
Median	0.074806	0.0519097	0.0905603	0.0312431

Standard Deviation	0.133631	0.1204302	0.1417553	0.1373233
Sample Variance	0.017857	0.0145034	0.0200946	0.0188577
Kurtosis	21.08951	27.27699	15.579903	19.686913
Skewness	4.523963	5.0292827	3.9577939	4.3702221
Range	0.830403	0.8413618	0.7903138	0.8921194
Minimum	0	0	0.0179759	2.632E-05
Maximum	0.830403	0.8413618	0.8082897	0.8921458
Sum	11.18075	9.1211779	13.697204	7.5101509

Results of this measure of energy intensity differ quite a bit from those derived from the earlier measure. Results of two factor ANOVA without replication are reported in table 10, given hereunder.

Table- 10: ANOVA of Inputs of Total Energy Resources as Proportion of All Inputs

ANOVA						
Source of Variation	*SS*	*Df*	*MS*	*F*	*P-value*	*F crit*
Rows	3.85354	114	0.033803	2.703523	1.54E-12	1.275316
Columns	0.186658	3	0.062219	4.976233	0.002158	2.63102
Error	4.276131	342	0.012503			

The table shows that both between rows and column variations are statistically significant. Therefore, it is inferred that energy intensity differs significantly between sectors for all years taken together as well between the years for all sectors taken together. This highlights the ever rising energy resource requirement of Indian economy.

Findings and Conclusions

Following are the main findings of the study:

i. Energy resource utilization has high growth/output effect on Indian economy though the output effect of energy use differs both between sectors and years;

ii. Output effect of energy utilization depends on magnitude of final demand for energy resources and linkages of the sectors;

iii. Linkages affect output effect much more than the magnitude of final demand;

iv. Energy intensity of Indian economy differs both between sectors and years; and

v. Energy requirements of Indian economy are increasing year by year.

References

Central Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India, “Input – Output Transactions Table, 1993-94”

Central Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India, "Input – Output Transactions Table, 1998-99"

Central Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India, "Input – Output Transactions Table, 2003-04"

Central Statistical Organization, Ministry of Statistics and Programme Implementation, Government of India, "Input – Output Transactions Table, 2007-08"

Chakraborty, D. (2007). "A Structural Decomposition Analysis of Energy Consumption in India". Paper submitted for the 16th International Input Output Conference, 2-6 July, Istanbul, Turkey

Chenery, H.B. and Watanabe, T.(1958). "International Comparisons of the Structure of Production". *Econometrica*, 26(4), pp.487-521

Jain, S. (2012). "An Input Output Analysis to Estimate Embodied Energy of Goods". *International Journal of Scientific and Research Publications*, 2(11), pp.3-12

Leonteif,W.W.(1936), "Quantitative Input Output Relations in the Economic system of the United States",*Review of Economics and Statistics*,Vol.XVII.

Prakash, Shri and Singh, Inderjeet (1984) "Energy Intensity in Indian Economy- A study in Input Output framework" *proceedings of twentieth anniversary international conference IORA*, NEHU, Shillong

Prakash,S and Sharma,R.(2010), "Output Effect of Exchange Rate Fluctuation in Indian Economy" presented 19th International Input Output Conference, Sao Polo

Prakash,S and Panigrahi,R (2012), "Growth Effect of Mutual Funds on Indian Economy", *Bulletin of Political Economy*, Athens, Greece

Ray, B.K. and Reddy, B.S. (2007). "Decomposition of Energy consumption and Energy Intensity in Indian Manufacturing Industries". Indira Gandhi Institute of Development Research, Mumbai, India available online at http://www.igidr.ac.in/pdf/publication/WP-2007-020.pdf

Singh, M.K, Pal, S.K Thakur, R and Verma, U.N.(1997). "Energy Input Output Relationship of Cropping Systems", *Indian Journal of Agriculture Science*, 67(6), pp. 262-266