Changing Gross Output Elasticity in the Energy Sector: A Comparative Study in the Economies of India and Pakistan in the I-O Framework

Prof Dipti Prakas Pal*
& Swati Pal**

Energy is an important input of production of every economy. Its use has been day by day increasing and every economy has been becoming more and more dependent on it. From the demand side it is used by different industries as inputs in their production (called interindustry demand) and by different final agents like individual consumers, government and export (called final demand) while from the supply side it uses as inputs the outputs of other industries (both endogenous and exogenous).The former corresponds to the output-distribution structure of the energy sector while the latter corresponds to its input-structure. With development both the input and output-distribution structures of energy have been changing.

Energy has different components. Coal energy, gas energy, electricity energy and oil energy are distinguished. The energy sector has different sub-sectors like coal, oil, gas and electricity. These energy sub-sectors have different structures of input and output-distribution. Over time energy structures change, causing changes in the overall economic structure in general and the structures of different industries in particular.

In this paper an attempt has been made to quantitatively examine the nature and the extent of changes in the structures of energy in the economies of India (1993-2003) and Pakistan (1984-90).

The technique of structural decomposition in the I-O framework is used in analysis to isolate the effects of different sources responsible for changes in energy demand and in turn the prime sources are identified. In addition to the decomposition of absolute changes, gross output elasticity with respect to the explanatory factors is estimated for different types of energy output and thereby demand laws are verified. Changes in output elasticity are also analyzed using a scheme of additive decomposition formulated by us. The prime factors influencing the output elasticity are thereby identified.

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*Prof of Economics, University of Kalyani, West Bengal, India. Email-id : **diptiprakas@yahoo.co.in**

** Lecturer in Economics, Kidderpore College, Kolkata & University Research Fellow, University of Kalyani, West Bengal, India. Email-id : **swatipal24@gmail.com**

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Production is dependent upon the local situation prevailing in the economy on the one hand and the external situation outside the economy on the other. So whenever changes take place either in the local situation and/or in the external situation , the economy's gross outputs change. In the framework of I-O analysis, demand for gross output of a sector has two main components: (a) interindustry demand (demand for output by different sectors as inputs) and (b) final demand (demand by final consumers like domestic consumers and foreign consumers). On the supply side , gross output has also two components : (a)inter-industry input supply and (b) value added . With changes in different components of demand for output, gross output changes . Also changes in value added and inter-industry input supply cause variations in gross output. The nature of changes in gross output is measured by gross output elasticity which is defined as the ratio between the percentage changes in gross output and final demand/value added.

Time changes and variation also takes place in output elasticity. However, changes in elasticity differ from sector to sector and from economy to economy. Whenever demand patterns change, sectors do not respond equally. Some sectors may change more while some sectors may display little changes .This is reflected in the value of output elasticity. Sectors will have different elasticity values. Obviously, changes in elasticity across sectors will not be uniform in both magnitude and sign. While in some sectors change in elasticity is positive and massive, for some other sectors changes are negative, either massive or small.

Since changes in output elasticity are dependent upon the changes in the components of final demand on the one hand and changes in gross output consequent

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*Prof of Economics, University of Kalyani, West Bengal, India. E-mail:diptiprakas@yahoo.co.in

** Lecturer in Economics, Kidderpore College, Kolkata & University Research Fellow, University of Kalyani, West Bengal, India. E-mail: swatipal24@gmail.com.

upon the changes in production technology on the other, it is of interest to isolate the contributions of the factors generating changes in output elasticity. This necessitates the Structural Decomposition Analysis(SDA) which was first performed by Chennery and Watanabe(1958). Subsequently, SDA is reformulated in alternative directions by researchers like Pal(1981,1986), Cella (1984), Forssell(1988a,1988b), Skolka(1989), Barker (1990), Rose and Casler (1996), Dietzenbacher and Los (1998), Chakraborty and Mukhopadhyay (2005), Chakraborty(2007) etc. **Those studies mainly concentrate on the decomposition of changes in gross outputs of the sectors during a specified period. But decomposition of changes in gross output elasticity has not so far been performed.**

Energy is viewed to-day as an important input for production. It has different types depending upon the sources from which it is generated. Energy outputs of different energy sectors change differently depending upon the different mode of changes in their final demand[1] .

In this paper we have attempted to examine structurally the nature and the extent of changes in the output elasticity of energy sectors during the period 1993-2004 for India and during the period 1984-1990 for Pakistan. The period of study is not same for the two countries because of non-availability of data, inter country comparison is hence to be considered with care and caution. **SDA analysis has been performed for the energy sector in India by researchers like Chakraborty & Mukhopadhyay (2005), Chakraborty(2007) . But the issue of decomposition of output elasticity has not been discussed . The comparative study in the economies of India and Pakistan has also not yet been performed.** These issues have been dealt with in this paper.

1. Demand side SDA is performed in this paper. Supply side SDA estimates are not presented.

We have considered four (4) types of energy output generated by four energy sectors like coal, crude petroleum & natural gas, electricity & water works and gas supply. Five non-energy sectors are considered. These are agriculture, industrial, transport, commercial and construction. The interrelationships of the energy sectors(4) with these non- energy sectors are also accounted for towards measuring the changes in output elasticity. A scheme of structural decomposition is formulated by means of which the contributions of the stipulated factors to the changes in output-elasticity are measured

In the **first section**, the methodology is described and the estimates are analysed in the **second section**. The **third section** describes scheme of the decomposition of changes in output elasticity .The concluding remarks are presented in the **fourth section.**

Section 1. Methodology

The Leontief Input-Output model can be written as

$x = Ax + c$ …….. (1) where x: n-element gross output vector(column)

$A = (a_{ij})$: input coefficient matrix; i,j =1,2 .....n;

c: n-element final demand vector(column)

Equation (1) gives the solution

$x = B^{-1}c$ ……(2) where $B = (I-A)$: Leontief matrix,

$B^{-1}=(b_{ij})$: Leontief inverse matrix,

and c : final demand vector.

Clearly , $A \geq 0$, $B^{-1} > 0$ and $c>0$.

Given the final demand (c), the model determines the amounts of gross -output the different industries will produce. Thus it is a demand driven model. Given the production technology, final demand determines the gross output level x. Gross output is determined by final demand.

The degree of responsiveness of gross outputs of different industries to changes in final demand for different output or how gross output responds to changes in final demand can be explained by the concept of elasticity of gross output. Define

$E_{ij} = (dx_i/dc_j).(c_j/x_i)$

$= b_{ij} (c_j/x_i)$; i,j = 1, 2 ,……,n ; since $dx_i/dc_j = b_{ij}$.

This is elasticity of gross output of the i^{th} sector with respect to the final demand for the output of the j^{th} sector.

The elasticity matrix of gross output with respect to final demand is

$$E=(x^{\wedge})^{-1} B^{-1}\hat{c} \quad \ldots\ldots\ldots\ldots\ldots(1)$$

where $x^{\wedge}= \text{diag}(x_1, x_2, \ldots\ldots\ldots\ldots x_n)$,

B^{-1} is Leontief inverse

and $\hat{c} = \text{diag}(c_1, c_2, \ldots\ldots\ldots\ldots c_n)$.

$E \geq 0$ since $B^{-1} > 0$, $x > 0$ and $c \geq 0$.

E has three components: $(x^{\wedge})^{-1}$, B^{-1} and $\hat{c}$. Changes in any of these components will cause changes in E. These changes can be measured using continuous analysis or comparative static analysis.

The (i,j) element of E is $E_{ij} = (b_{ij}c_j)/x_i$ …….(2)

Case 1. In continuous analysis, we differentiate E_{ij} with respect to t and get

$dE_{ij}/dt = d(b_{ij}c_j/x_i)/dt$

$=[x_i d (b_{ij}c_j) /dt - (b_{ij} c_j) d (x_i) /dt]/ x_i^2$

$=[x_i\{ c_j d (b_{ij}) /dt + b_{ij} dc_j/dt\} - b_{ij} c_j dx_i/dt]/x_i^2$

$= [x_i c_j db_{ij}/dt + x_i b_{ij} dc_j/dt - b_{ij}c_j dx_i/dt]/x_i^2$

$= (c_j/x_i) db_{ij}/dt + (b_{ij}/x_i)dc_j/dt - ((b_{ij}c_j/x_i) (dx_i/dt)/x_i$ ……(2a)

Changes in E will be determined by changes in (a)Leontief inverse matrix, (b)changes in final demand and above all (c) changes in gross output with respect to time. (2a) is a 3-component decomposition

Technology change is reflected by the Leontief inverse matrix. Whenever technology changes, it would have an impact on the economy's output. Change in technology brings about changes in the production process. More is the improved technology, higher is the output of the economy. It may also affect the cost of production or it may change the duration of time taken for production. As a whole, the output of the economy changes due to change in technology. The effect of change in technology on the output elasticity can be termed as the technology effect. Normally, the technology effect becomes positive.

Again, when final demand for output changes in any direction (upward/downward),to maintain the equilibrium in the economy supply must

change. So changes take place in the production side of the economy. The effect of final demand on the output elasticity may be termed as the demand effect. Normally, the demand effect is positive.

Finally irrespective of technology change and demand change the volume of the output may change (either increase or decrease) within a time horizon. Volume of production changes due to change in scale. This effect of volume change on output elasticity can be termed as gross output effect or volume effect. Time changes and all these effect bring about changes in elasticity.

Case 2. In comparative static analysis for two time points t and t+1 we get

$E_t=(x\hat{}_t)^{-1} B_t^{-1}\hat{c}_t$

and $E_{t+1}=(x\hat{}_{t+1})^{-1} B_{t+1}^{-1}\hat{c}_{t+1}$

so that we get

$\Delta E = E_{t+1} - E_t$

$= (x\hat{}_{t+1})^{-1} B_{t+1}^{-1}\hat{c}_{t+1} - (x\hat{}_t)^{-1} B_t^{-1} \hat{c}_t$

$= (x\hat{}_{t+1})^{-1} B_{t+1}^{-1} \hat{c}_{t+1} - (x\hat{}_{t+1})^{-1} B_{t+1}^{-1} \hat{c}_t + (x\hat{}_{t+1})^{-1} B_{t+1}^{-1} \hat{c}_t - (x\hat{}_t)^{-1} B_{t+1}^{-1} \hat{c}_t +$
$(x\hat{}_t)^{-1} B_{t+1}^{-1} \hat{c}_t - (x\hat{}_t)^{-1} B_t^{-1} \hat{c}_t$

$=(x\hat{}_{t+1})^{-1} B_{t+1}^{-1} \Delta\hat{c}_t + \Delta x\hat{}_t^{-1} B_{t+1}^{-1} \hat{c}_t + (x\hat{}_t)^{-1} \Delta B_t^{-1} \hat{c}_t$ …….. (3)

(3) is also a 3-component decomposition scheme in discrete terms. As before the first component $(x\hat{}_{t+1})^{-1} B_{t+1}^{-1} \Delta\hat{c}_t$ measures the demand effect, the second component $\Delta x\hat{}_t^{-1} B_{t+1}^{-1} \hat{c}_t$ measures the output effect and the last component $(x\hat{}_t)^{-1} \Delta B_t^{-1} \hat{c}_t$ measures the technology effect. Equation (3) is derived using some scheme of aggregation.

Using alternative modes of manipulations we can arrive at the alternative schemes of decomposition. We describe below four such schemes.

$\Delta E_t = E_{t+1} - E_t$

$= (x\hat{}_{t+1})^{-1} B_{t+1}^{-1} \hat{c}_{t+1} - (x\hat{}_t)^{-1} B_t^{-1} \hat{c}_t$

$= (x\hat{}_{t+1})^{-1} B_{t+1}^{-1} \hat{c}_{t+1} - (x\hat{}_{t+1})^{-1} B_t^{-1} \hat{c}_{t+1} +(x\hat{}_{t+1})^{-1} B_t^{-1} \hat{c}_{t+1} -(x\hat{}_{t+1})^{-1} B_t^{-1} \hat{c}_t +$
$(x\hat{}_{t+1})^{-1} B_t^{-1} \hat{c}_t - (x\hat{}_t)^{-1} B_t^{-1} \hat{c}_t$

$= (x\hat{}_{t+1})^{-1} \Delta B_t^{-1} \hat{c}_{t+1} + (x\hat{}_{t+1})^{-1} B_t^{-1}\Delta \hat{c}_t + \Delta x\hat{}_t^{-1} B_t^{-1} \hat{c}_t$

$= (x^{\wedge}_{t+1})^{-1} B_t^{-1} \Delta \hat{c}_t + \Delta x^{\wedge}_t{}^{-1} B_t^{-1} \hat{c}_t + (x^{\wedge}_{t+1})^{-1} \Delta B_t^{-1} \hat{c}_{t+1}$ ……(4)

$\Delta E_t = E_{t+1} - E_t = (x^{\wedge}_{t+1})^{-1} B_{t+1}^{-1} \hat{c}_{t+1} - (x^{\wedge}_t)^{-1} B_t^{-1} \hat{c}_t$

$= (x^{\wedge}_{t+1})^{-1} B_{t+1}^{-1} \hat{c}_{t+1} - (x^{\wedge}_t)^{-1} B_{t+1}^{-1} \hat{c}_{t+1} + (x^{\wedge}_t)^{-1} B_{t+1}^{-1} \hat{c}_{t+1} - (x^{\wedge}_t)^{-1} B_{t+1}^{-1} \hat{c}_t +$
$(x^{\wedge}_t)^{-1} B_{t+1}^{-1} \hat{c}_t - (x^{\wedge}_t)^{-1} B_t^{-1} \hat{c}_t$

$= \Delta x^{\wedge}_t{}^{-1} B_{t+1}^{-1} \hat{c}_{t+1} + x^{\wedge}_t{}^{-1} B_{t+1}^{-1} \Delta \hat{c}_t + (x^{\wedge}_t)^{-1} \Delta B_t^{-1} \hat{c}_t$

$= x^{\wedge}_t{}^{-1} B_{t+1}^{-1} \Delta \hat{c}_t + \Delta x^{\wedge}_t{}^{-1} B_{t+1}^{-1} \hat{c}_{t+1} + (x^{\wedge}_t)^{-1} \Delta B_t^{-1} \hat{c}_t$ ……(5)

$\Delta E_t = x^{\wedge}_t{}^{-1} B_t^{-1} \Delta \hat{c}_t + \Delta x^{\wedge}_t{}^{-1} B_t^{-1} \hat{c}_{t+1} + (x^{\wedge}_{t+1})^{-1} \Delta B_t^{-1} \hat{c}_{t+1}$ ……(6)

and

$\Delta E_t = (x^{\wedge}_{t+1})^{-1} B_{t+1}^{-1} \Delta \hat{c}_t + \Delta x^{\wedge}_t{}^{-1} B_t^{-1} \hat{c}_t + (x^{\wedge}_{t+1})^{-1} \Delta B_t^{-1} \hat{c}_t$ ……(7)

All of these five schemes (3) to (7) follow the same basic identity(2) and have only pure components but no interaction components on the assumption that the component variables are all independent and hence the decomposition schemes are three – component schemes involving Δc, ΔB and Δx. These schemes are different only in weights i.e., the equations vary in terms of weights. Base year weights and current year weights are interchangeably used in those equations, resulting in index number bias (in estimates). Furthermore, the variables included in the equations are assumed to be independent and consequently no interactive terms incorporating simultaneous variations in the variables are used. To avoid these problems (problem of bias as well as problems of simultaneity), let us now combine the equations together to arrive at new decomposition schemes which would account for the effect of interaction of different variables through the insertion of interactive terms on the one hand and minimize the index number bias through the use of average weights on the other hand.

Combination of equations (3) and (4) yields

$2\Delta E = (x^{\wedge}_{t+1})^{-1} B_{t+1}^{-1} \Delta\hat{c}_t + \Delta x^{\wedge}_t{}^{-1} B_{t+1}^{-1} \hat{c}_t + (x^{\wedge}_t)^{-1} \Delta B_t^{-1} \hat{c}_t + (x^{\wedge}_{t+1})^{-1} B_t^{-1} \Delta \hat{c}_t +$
$\Delta x^{\wedge}_t{}^{-1} B_t^{-1} \hat{c}_t + (x^{\wedge}_{t+1})^{-1} \Delta B_t^{-1} \hat{c}_{t+1}$

$= (x^{\wedge}_{t+1})^{-1} (B_{t+1}^{-1} + B_t^{-1}) \Delta\hat{c}_t + \Delta x^{\wedge}_t{}^{-1}(B_{t+1}^{-1} + B_t^{-1}) \hat{c}_t + (x^{\wedge}_t)^{-1} \Delta B_t^{-1} \hat{c}_t$
$+(x^{\wedge}_{t+1})^{-1} \Delta B_t^{-1} \hat{c}_{t+1} + (x^{\wedge}_{t+1})^{-1} \Delta B_t^{-1} \hat{c}_t - (x^{\wedge}_{t+1})^{-1} \Delta B_t^{-1} \hat{c}_t$

$= (x\hat{}_{t+1})^{-1} (B_{t+1}^{-1} + B_t^{-1}) \Delta\hat{c}_t + \Delta x\hat{}_t^{-1}(B_{t+1}^{-1} + B_t^{-1}) \hat{c}_t +(x\hat{}_t^{-1}+ x\hat{}_{t+1}^{-1}) \Delta B_t^{-1} \hat{c}_t$

$+(x\hat{}_{t+1})^{-1} \Delta B_t^{-1} (\hat{c}_{t+1} -\hat{c}_t)$

so that

$\Delta E = ½ (x\hat{}_{t+1})^{-1} (B_{t+1}^{-1} + B_t^{-1}) \Delta\hat{c}_t + ½\Delta x\hat{}_t^{-1}(B_{t+1}^{-1} + B_t^{-1}) \hat{c}_t + ½(x\hat{}_t^{-1}+ x\hat{}_{t+1}^{-1})$

$\Delta B_t^{-1} \hat{c}_t + ½ (x\hat{}_{t+1}^{-1}) \Delta B_t^{-1} \Delta\hat{c}_t$ …… ……………………(8)

Similarly , combination of equations(3) and (5) gives

$2 \Delta E = (x\hat{}_{t+1})^{-1} B_{t+1}^{-1} \Delta\hat{c}_t + \Delta x\hat{}_t^{-1}B_{t+1}^{-1} \hat{c}_t + (x\hat{}_t)^{-1} \Delta B_t^{-1} \hat{c}_t + x\hat{}_t^{-1} B_{t+1}^{-1}\Delta \hat{c}_t +$

$\Delta x\hat{}_t^{-1} B_{t+1}^{-1} \hat{c}_{t+1}+ (x\hat{}_t)^{-1}\Delta B_t^{-1} \hat{c}_t$

$= (x\hat{}_{t+1}^{-1} + x\hat{}_t^{-1}) B_{t+1}^{-1} \Delta\hat{c}_t + \Delta x\hat{}_t^{-1} B_{t+1}^{-1}(\hat{c}_t+ \hat{c}_{t+1}) + (x\hat{}_t)^{-1}\Delta B_t^{-1} \hat{c}_t +(x\hat{}_{t+1})^{-1}\Delta$

$B_t^{-1} \hat{c}_t -(x\hat{}_{t+1})^{-1}\Delta B_t^{-1} \hat{c}_t -(x\hat{}_t)^{-1}\Delta B_t^{-1} \hat{c}_t$

$= (x\hat{}_{t+1}^{-1} + x\hat{}_t^{-1}) B_{t+1}^{-1} \Delta\hat{c}_t + \Delta x\hat{}_t^{-1} B_{t+1}^{-1}(\hat{c}_t+ \hat{c}_{t+1}) +(x\hat{}_{t+1}^{-1} + x\hat{}_t^{-1}) \Delta B_t^{-1} \hat{c}_t$

$- \Delta x\hat{}_t^{-1} \Delta B_t^{-1} \hat{c}_t$

so that

$\Delta E = ½[(x\hat{}_{t+1}^{-1} + x\hat{}_t^{-1}) B_{t+1}^{-1} \Delta\hat{c}_t + \Delta x\hat{}_t^{-1} B_{t+1}^{-1}(\hat{c}_t+ \hat{c}_{t+1}) +(x\hat{}_{t+1}^{-1} + x\hat{}_t^{-1}) \Delta B_t^{-1} \hat{c}_t$

$- \Delta x\hat{}_t^{-1} \Delta B_t^{-1} \hat{c}_t]$

$\Delta E = ½ \Delta x\hat{}_t^{-1} B_{t+1}^{-1}(\hat{c}_t+ \hat{c}_{t+1}) + ½[(x\hat{}_{t+1}^{-1} + x\hat{}_t^{-1}) B_{t+1}^{-1} \Delta\hat{c}_t + ½ (x\hat{}_{t+1}^{-1} + x\hat{}_t^{-1})$

$\Delta B_t^{-1} \hat{c}_t - ½ \Delta x\hat{}_t^{-1} \Delta B_t^{-1} \hat{c}_t$ ……………………………………..(9)

One can make pair wise combinations of equations (3) to (7) in ${}^5c_2 = 10$ ways and get 10 such schemes of decomposition. But there is no unique method of selection of the schemes. Selection becomes purely arbitrary to a large extent.

Since we have three variables gross output(x), production technology (B) and final demand(c), so we can get different interactive terms.

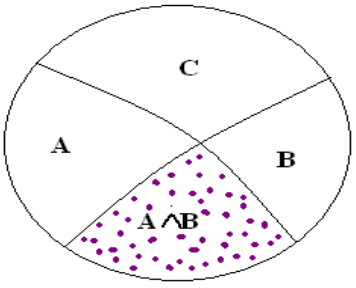
Theoretically, there should be relatively more pronounced interaction between production technology and gross output compared to production technology and final demand. The impact of change in production technology is more pronounced on gross output. **So we take the decomposition scheme (9). We admit that our selection is arbitrary and the results are to be taken accordingly.**

The first term of equation (9) includes $\Delta \hat{x}_t^{-1}$. It measures the elasticity changes caused by changes in gross output, other variables remaining constant during the period. Here the change in elasticity takes place because of the change in volume of gross output. This may be called the volume effect. However we call it the growth effect (g- effect).

The second term in the equation includes $\Delta \hat{c}_t$ and it reflects the elasticity changes due to change in the final demand for the outputs of different industries, when the other variables are kept constant during the period under study. This may be termed as the final demand effect (d-effect).

The third term in equation (9) contains ΔB_t^{-1} , which reflects changes due to the direct and indirect changes in the producing technology keeping other variables constant during the period. This may be called the technology effect (t-effect).

The fourth term consists of both $\Delta \hat{x}_t^{-1}$ and ΔB_t^{-1}. This is the interaction term. It can be termed as the interactive effect (i-effect). It thus emerges that the change in elasticity takes place due to change in B change in x or change in c or in all. Again a change in B brings about a change in x. So if we include both change in B and change in x to estimate the total change in elasticity, then the problem of double counting appear. So to avoid this problem the interactive effect is subtracted from the total effect. This can also be explained with the Venn diagramme.



A : Technology effect

B: Growth effect

C: demand effect

The pink dotted area in the diagram reflects A∩B which is the intersection of Technology Effect and Growth Effect. In other words, it is the interactive effect ,which we have to subtract from the total effect of elasticity change.

Thus the total change in elasticity (total effect) can be decomposed into four effects. The total change in E can be positive or negative or zero. The strength of positive or negative changes may be massive or small. The four effects determine the nature and the magnitude of the total effect. We can get several cases. For simplicity equation (9) can be written as

ΔE = g-eff(d) + d-eff(g) + t-eff(t) – i-eff(i)

where g-eff= $\frac{1}{2} \Delta x^{\wedge}_t{}^{-1} B_{t+1}{}^{-1}(\hat{c}_t + \hat{c}_{t+1})$

d-eff= $\frac{1}{2}[(x^{\wedge}_{t+1}{}^{-1} + x^{\wedge}_t{}^{-1}) B_{t+1}{}^{-1} \Delta\hat{c}_t$

t-eff=$\frac{1}{2} (x^{\wedge}_{t+1}{}^{-1} + x^{\wedge}_t{}^{-1}) \Delta B_t{}^{-1} \hat{c}_t$

and i-eff= $\frac{1}{2} \Delta x^{\wedge}_t{}^{-1} \Delta B_t{}^{-1} \hat{c}_t$

The following cases are distinguished with respect to the E_{ij} element of the matrix E:

case 1. g-eff>0, d-eff>0 , t-eff>0 and i-eff>0

& g-eff + d-eff+ t-eff >| i-eff |

so that $\Delta E_{ij}>0$.

case 2. g-eff>0, d-eff>0 , t-eff>0 but i-eff<0

so that $\Delta E_{ij} >0$.

case 3. g-eff>0, d-eff>0 , t-eff<0, i-eff<0

& g-eff+ d-eff - i-eff >| t-eff|

so that $\Delta E_{ij} >0$.

case 4. g-eff>0, d-eff<0, t-eff <0, i-eff<0

& g-eff - i-eff >| d-eff |+ |t-eff|

so that $\Delta E_{ij} >0$.

case 5. g-eff>0, d-eff>0 , t-eff>0 and i-eff>0

& g-eff + d-eff+ t-eff < |i-eff|

so that $\Delta E_{ij} < 0$.

case 6. g-eff <0, d-eff<0, t-eff<0 and i-eff<0

& |g-eff| + |d-eff|+ |t-eff| > |i-eff|
so that $\Delta E_{ij} < 0$.

In the similar way several other cases can be interpreted. Our objective is to identify the results to see effect which is strong in determining the total change in output elasticity in different sectors.

Section 2. Estimates

In estimation the I-O tables of India and China are used. For India three I-O tables - 1993-94,1998-99 and 2003-04 are used and for Pakistan two I-O tables 1984-85 and 1990-91 are used. Tables1.2- 1.4 present the estimates of change in overall output elasticity of different sectors in both the economies during the respective period of study.

2.1. Own Elasticity

Pakistan : The diagonal elements of Table 1.1 are changes in own elasticity of different sectors in Pakistan during 1984-90. There are nine sectors in our study. Out of these, five sectors (agriculture, commercial, coal, crude petroleum and natural gas and gas supply) have positive changes in own-elasticity and the remaining four have negative changes. And out of those five sectors, there are three energy sectors –sector 6(coal), sector 7(crude oil and natural gas), sector 9(gas supply) which have displayed positive changes in own output elasticity.

Notably, among the four energy sectors, only sector 8(electricity and water works) has the negative change in own elasticity. That is to say, in those above mentioned three energy sectors own elasticity has increased, indicating the fact the gross outputs have turned out to be relatively more own-demand-elastic. Contrary to this, own elasticity of sector 8(electricity and water works) has decreased indicating the fact that its gross output has become relatively more own- demand-inelastic. **Among the other energy sectors, sector 7 (crude oil and natural gas) has displayed the maximum increase of 1.149** during the period: the sector has become more than unitary elastic during the period.

India: The diagonal elements of Table 1.2 present the estimates of changes in own elasticity of different sectors of India for the period 1993 to 2003 and Tables 1.3 and 1.4 present the same for the two sub-periods: 1993- 1998(sub-period I) and 1998-2003 (sub-period II). In India we have eight sectors including 3 energy sectors. (Sector 9 (gas) is omitted due to non availability of data for the year 2003-04).

1993-2003: Among the eight sectors, three sectors have exhibited positive changes in own elasticity and the remaining five sectors have exhibited negative changes during the overall period. Among these five sectors three are non energy sectors and two are energy sectors. Three non energy sectors are agriculture, industry, commercial and two energy sectors are coal (sector 6) and crude oil & natural gas(sector 7). **Energy sector 7(crude oil and natural gas) has displayed a substantial negative change.** The other energy sector, i.e, sector 8(electricity and water works) has, however positive change. That is, for **the energy sectors 6 and 7 own elasticity has decreased which indicates that gross outputs of these sectors has become relatively more own demand inelastic**. On the other hand, for energy sector 8 gross output has become relatively more own demand elastic. **That is, a completely opposite scenario is observed in India and Pakistan.**

Sub-periods: However, the results are not same in both the sub-periods. In sub period 1, four sectors has exhibited positive change in own elasticity and in sub-period II only one sector has positive change in own elasticity (Tables 1.3 and 1.4).

Among the energy sectors, only in 'electricity and water works' elasticity has increased in sub period I and decreased in sub period II. Negative changes in elasticity are observed in other energy sectors.

2.2 Cross elasticity: Let us now turn to analyse the impact of change in final demand for a particular sector's output on the energy sectors as well as the impact of changes in energy sector's final demand on other sectors. We can compare the cross output elasticity among the sectors considering elements of ΔE either row-wise or column- wise. Elements of row i give us the changes in output elasticity of sector i due to changes in demand for outputs of different sectors. Elements of column j give us the effect of change in demand for output of sector j on elasticity of output of different sectors.

Pakistan: The first row (off-diagonal) of Table 1.1 gives changes in agriculture sector's output elasticity consequent upon changes in demand for output of other sectors. It is observed that the agriculture sector like other sectors responds differently to changes in final demand for outputs of different sectors. Changes in final demand for the three energy sectors (6 ,8 and 9) bring about either a negative or negligible impact on output elasticity of the agriculture sector. The elasticity change is positive with respect to final demand for sector 7 (crude petroleum and natural gas).

Change in output elasticity of the industrial sector (sector 2) is positive with respect to crude petroleum &natural gas (sector 7) sector. For other three non energy sectors the impact of final demand change on energy sector are either negligible or very little.

The cross elasticity of four energy sectors are either negative, positive or very negligible indicating the fact that change in final demand of each energy sector affects the other energy sectors differently.

Coming to the impact of other sectors on energy sector it is observed that elasticity change of four energy-sectors are negative due to changes in final demand of sector 3(Transport sector)'s demand. Agriculture sector has negative impact on sector 6(coal) and sector 7(crude oil& natural gas sector) and positive impact on sector 8(electricity and water works) and sector 9(gas supply). Industrial sector has positive impact on all four energy sectors. Among them change in output elasticity of sector 7 is more than 1, which indicates that a change in demand for output of industrial sector has turned the output elasticity of sector 7 relatively more demand elastic.

Sector 4 (commercial sector) has negative impact on sector 7(crude oil & natural gas) and sector 8(electricity & water works) and positive impact on sector 6 and sector 9 i.e., In sector 7 and sector 8 output elasticity has decreased due to change in demand for output of commercial sector, whereas in sector 6 and sector 9 output elasticity has decreased for the same reason.

Thus we observe that sectoral effects are divergent in respect of cross-output elasticity, which is caused by the divergence in interrelationships among the sectors..

India: The estimates of first row of Table 1.2 reveals that if the final demand of all sectors changes, then sector 1 responds positively to all sectors except sector 7 i.e., agriculture output elasticity has increased due to change in demand for outputs of all other sectors including the energy sectors except energy sector 7. In the same way first column indicates that c change in final demand for output of sector 1 creates a negative impact on all sectors other than sector 7.

The change in cross elasticity of three energy sectors(Table 1.2) with respect to final demand change for sector 2 is positive i.e., the output elasticity of three energy sectors has increased while the demand for output of industrial sector has increased. Notably change in cross elasticity of energy sector 7 with respect to final demand changes for all non energy sectors are positive indicating that output elasticity of sector 7 has increased due to change in demand for non energy sectors but with respect to all energy sectors . Output elasticity change is negative in sector 7.

Comparison :

(1) Changes in own-output elasticity of two energy sectors (sector 6(coal) and sector 7(crude petroleum & natural gas)) are positive in Pakistan, whereas those of sectors 6 and 7 are negative in India; That is to say, own elasticity of these two energy sectors has increased in Pakistan whereas the reverse has happened in India. It indicates that gross outputs of energy sectors 6 and 7 have turned out to own demand elastic in Pakistan, whereas it turned to be own demand inelastic in India.

(2) Own output elasticity of gas sector has risen for both the countries.

(3) In case of Pakistan, the impact of final demand change in energy sectors 6 and 8 on non energy sectors are either negative or negligible, whereas the final demand change for sector 7 has a positive impact on all non energy sectors except sector 5 (construction). Contrary to this, a change in final demand for sector 7 brings about a negative impact on other five non energy sectors of India. Also sector 8 has positive impact on all non energy sectors except sector 3(Transport).

(4) Change in final demand for energy sector 6(coal) causes negative change in output elasticity of energy sector 7 in both the countries but change in final demand for energy sector 7, causes positive changes in energy sectors 6 and 8 in Pakistan and negative changes in India.

Section 3. Decomposition of Total Effects

Tables 2.1 to 2.4 and Tables 3.1 to 3.4 present the estimates of different effects as illustrated by equation (9) for Pakistan and India respectively. Expectedly, the magnitude and the sign of these effects are divergent among the sectors. In some cases, the effects are relatively strong and more pronounced while in some other cases effects are weak and less pronounced.

Pakistan: If we concentrate only on own elasticity of energy sectors, (Table 2.1 to 2.4) then it is observed that for sector 6 (coal) demand effect is weak and negative, technology effect is negative and interactive effect is negligible, growth effect is strong and positive but the total effect is positive. That is, the positive growth effect is so strong that it has more than offset the negative effects and makes the total effect positive.

However, for sector 7 (crude petroleum and natural gas) growth effect and demand effect are positive, technology effect is also positive but weak. It is also observed that interactive effect is very weak and the total effect is positive. Here all the positive effects together make the total effect strongly positive.

For sector 8((electricity and water works) demand effect and technology effect are positive and interactive effect is negative but weak. However, growth effect is negative and so strong that it makes the total effect negative.

India: In India (1993-2003), for some sectors demand effect and growth effect are strong , whereas for some others they are weak(Tables 3.1 to 3.4).

For sector 6(coal), demand effect is negative but strong, growth effect is positive but weak, technology effect is negative and less pronounced , interactive

effect is negative. So negative effects dominate the positive effects and total effect has become negative.

For sector 7(crude petroleum and natural gas), demand effect is strongly negative, growth effect is also strongly positive, technology effect is negative but weak, interactive effect is positive but weak. However demand effect is more pronounced than other effects and in turn, other effects are more than offset by it making the total effect negative.

For sector 8 demand effect is positive, growth effect is negative, technology effect is positive and interactive effect is negative but weak. Here positive effects dominate the negative effects and thus the total effect has become positive.

Comparison:

(1) For both India and Pakistan, demand effect is negative and growth effect is positive for sector 6. However for sector 7, demand effect is positive in Pakistan but negative in India. And for sector 8 demand effect is positive and growth effect is negative in both the countries.

(2) In Pakistan technology effect is positive for sector 7, whereas it is negative in India. Technology effect is negative but weak for sector 6 and is positive for sector 8 in both the countries.

(3) Interactive effect is weak on both sides (positive or negative) for all the sectors in both the countries.

Section 4. Concluding Remarks

Changes in own output elasticity of two energy sectors- 6(coal) and 7(crude petroleum and natural gas) reveal a completely opposite scenario in Pakistan and India. In Pakistan these two sectors are own- demand elastic whereas in India they are own -demand inelastic.

Cross elasticity of energy sectors reveals that a change in demand for sector 6 causes a negative change in output elasticity of sector 7 in both India and Pakistan but

a change in final demand for energy sector 7 causes positive changes in energy sectors (6 and 8) in Pakistan and negative changes in India.

When total effects are decomposed into the component effects, it is observed that the magnitude and the sign of these effects are divergent among the sectors in both the countries.

Table 1.1. Change in Output Elasticity: Pakistan,1984-1990

sectors	1	2	3	4	5	6	7	8	9
1	0.046	-0.024	-0.019	0.006	-0.014	ng	0.003	-0.001	ng
2	0.007	-0.014	-0.036	0.058	-0.032	ng	0.008	-0.001	ng
3	0.029	0.037	-0.158	0.078	-0.009	0	0.023	ng	ng
4	0.049	0.025	-0.012	0.021	-0.006	-0.001	0.004	0	0
5	0.026	0.074	0.008	0.168	-0.274	0	-0.002	0	0
6	-0.003	0.145	-0.074	0.079	-0.066	0.188	0.013	-0.008	ng
7	-0.078	1.016	-0.148	-0.010	-0.197	0	1.497	-0.027	-0.031
8	0.055	0.224	-0.028	-0.091	0.016	-0.001	0.005	-0.135	ng
9	0.021	0.056	-0.026	0.020	-0.011	0	0.006	-0.052	0.019

Data Source: Federal Bureau of Statistics, Statistics Division, Government of Pakistan

Note. Sectors are 1. Agriculture; 2. Industry; 3.Transport; 4.Commercial; 5.Construction; 6.Coal; 7.Crude Oil and natural gas; 8.Electricity and water works; 9.Gas supply.

Table 1.2. Change in Output Elasticity: India ,1993-2003

sectors	1	2	3	4	5	6	7	8
1	-0.080	0.040	0.011	0.018	0.014	0	-0.0037	0.001
2	-0.016	-0.023	0.032	-0.010	0.026	-0.001	-0.010	0.002
3	-0.038	-0.035	0.087	0.002	-0.008	-0.001	-0.007	-0.001
4	-0.008	0.003	0.008	-0.008	0.010	0	-0.005	0.0001
5	-0.009	0.019	0.001	-0.017	0.015	0	-0.009	0.001
6	-0.021	0.127	0	-0.018	0.058	-0.137	-0.016	0.014
7	0.002	0.892	0.150	0.018	0.253	-0.003	-1.288	-0.024
8	-0.041	0.011	-0.023	-0.013	0.052	-0.002	-0.019	0.035

Data Source: Central Statistical Organisations, Government of India, New Delhi

Note.. Sectors are :1. Agriculture; 2. Industry; 3.Transport; 4.Commercial; 5.Construction; 6.Coal; 7.Crude Oil and natural gas; 8.Electricity and water works;

Table 1.3 Change in Output Elasticity: India , 1993-1998

sectors	1	2	3	4	5	6	7	8	9
1	-0.053	0.029	-0.001	0.018	0.005	ng	ng	0	0
2	-0.005	-0.017	0.001	0.028	-0.002	0	0	0.001	ng
3	0.007	-0.034	0.070	0.021	-0.013	0	0.001	0.003	0
4	-0.008	-0.004	0.003	0.016	-0.005	ng	0	0.001	0
5	-0.009	-0.005	-0.002	-0.012	0.028	ng	0.001	0.001	Ng
6	-0.027	0.003	-0.003	0.027	0.002	-0.026	0.001	0.026	0
7	-0.029	0.153	-0.017	0.096	0.010	-0.001	-0.143	-0.052	0
8	-0.058	-0.012	0.023	0.011	0	0	0.001	0.038	0
9	0.023	0.112	0.047	0.065	0.039	ng	-0.001	0.061	-0.345

Data Source: Central Statistical Organisations, Government of India, New Delhi

Note. Sectors are: 1. Agriculture; 2. Industry; 3.Transport; 4.Commercial; 5.Construction; 6.Coal; 7.Crude Oil and natural gas; 8.Electricity and water works; 9.Gas supply.

Table1.4. Change in Output Elasticity: India ,1998-2003

sectors	1	2	3	4	5	6	7	8
1	-0.027	0.011	0.011	0	0.009	0	-0.003	0
2	-0.011	-0.006	0.030	-0.038	0.029	-0.001	-0.011	0.001
3	-0.045	0	0.016	-0.019	0.005	-0.001	-0.007	-0.003
4	0	0.008	0.005	-0.025	0.015	-0.003	-0.005	0
5	0	0.023	0.003	-0.005	-0.012	ng	-0.010	0
6	0.006	0.119	0.002	-0.046	0.056	-0.111	-0.017	-0.013
7	0.031	0.740	0.167	-0.078	0.243	-0.002	-1.145	0.027
8	0.016	0.023	-0.044	-0.024	0.052	-0.002	-0.020	-0.003

Data Source: Central Statistical Organisations, Government of India, New Delhi

Note. Sectors are : 1.Agriculture; 2. Industry; 3.Transport; 4.Commercial; 5.Construction; 6.Coal; 7.Crude Oil and natural gas; 8.Electricity and water works;

Table 2.1. Demand Effect for Change in Output -Elasticity: Pakistan ,1984-90

sectors	1	2	3	4	5	6	7	8	9
1	0.64483	0.21639	0.00255	0.03966	0.01749	-0.00016	0.00098	0.00033	0.00011
2	0.07212	0.68604	0.00796	0.10197	0.05541	-0.00016	0.00300	0.00105	0.00034
3	0.09502	0.21133	0.06378	0.09439	0.02077	-0.00035	0.01116	0.00084	0.00067
4	0.10293	0.22918	0.00406	0.68465	0.01945	-0.00042	0.00312	0.00063	0.00031
5	0.02861	0.06875	0.00191	0.17540	0.44393	-0.00014	0.00316	0.00024	0.00025
6	0.09373	0.87086	0.01014	0.14719	0.07036	-0.22369	0.00481	0.00136	0.00048
7	0.12542	0.94184	0.01129	0.18523	0.07617	-0.00033	0.60955	0.01478	0.03130
8	0.20240	0.52289	0.00719	0.22341	0.04261	-0.00071	0.00355	0.08607	0.00037
9	0.07569	0.37036	0.00514	0.15548	0.03012	-0.00023	0.00245	0.01532	0.10389

Table 2.2.Growth Effect for Change in Output- Elasticity : Pakistan,1984-90

sectors	1	2	3	4	5	6	7	8	9
1	-0.63316	-0.22248	-0.0155	-0.03327	-0.0293	0.000328	0.001071	-0.00067	-0.00012
2	-0.07641	-0.76105	-0.05219	-0.0923	-0.10017	0.000359	0.003554	-0.00226	-0.00041
3	-0.05014	-0.11677	-0.20837	-0.04256	-0.01871	0.000392	0.006582	-0.0009	-0.0004
4	-0.11008	-0.25665	-0.02691	-0.62563	-0.0355	0.000946	0.003733	-0.00137	-0.00038
5	-0.0276	-0.06945	-0.01143	-0.14459	-0.73087	0.000285	0.003405	-0.00046	-0.00027
6	-0.08177	-0.79547	-0.05476	-0.1097	-0.10474	0.411783	0.004691	-0.00241	-0.00048
7	-0.16129	-1.26818	-0.08992	-0.20351	-0.16714	0.000883	0.876395	-0.03864	-0.04534
8	-0.26196	-0.7086	-0.05762	-0.24705	-0.0941	0.001941	0.00513	-0.22653	-0.00054
9	-0.05478	-0.28069	-0.02305	-0.09615	-0.0372	0.000356	0.001979	-0.02255	-0.08469

Table2.3.Technology Effect for Change in Output- Elasticity: Pakistan , 1984-90

sectors	1	2	3	4	5	6	7	8	9
1	0.02496	-0.01275	-0.00421	-0.00062	-0.00145	-0.00014	0.00078	-0.00015	-0.0000
2	0.00758	0.04250	0.00568	0.03421	0.00886	-0.00010	0.00079	-0.0001	0.0001
3	-0.01322	-0.04745	-0.01095	0.02156	-0.00930	0.00028	0.00404	-0.0000	-0.000
4	0.03961	0.03644	0.00773	-0.02679	0.00706	-0.00077	-0.00171	0.0003	0.0001
5	0.01786	0.05353	0.01256	0.09900	0.00918	-0.00030	-0.00589	0.0004	0.0002
6	-0.01136	-0.16313	-0.02153	0.03097	-0.02347	-0.00002	0.00229	-0.0052	-0.0000
7	-0.02773	-0.45525	-0.04602	0.00567	-0.06974	-0.00008	0.00756	-0.0022	-0.0115
8	0.07534	0.26985	0.01489	-0.04464	0.04425	-0.00126	-0.00214	0.0038	0.0005
9	0.00013	-0.02623	-0.00635	-0.03049	-0.00322	-0.00026	0.00110	-0.0350	0.0000

Table 2.4.Interactive Effect for Change in Output- Elasticity: Pakistan , 1984-90

sectors	1	2	3	4	5	6	7	8	9
1	-0.0098	0.0050	0.0017	0.0002	0.0006	0.0001	-0.0003	0.0001	0.0000
2	-0.0032	-0.0180	-0.0024	-0.0145	-0.0038	0.0000	-0.0003	0.0000	0.0000
3	0.0028	0.0100	0.0023	-0.0046	0.0020	-0.0001	-0.0009	0.0000	0.0001
4	-0.0170	-0.0156	-0.0033	0.0115	-0.0030	0.0003	0.0007	-0.0001	0.0000
5	-0.0069	-0.0207	-0.0049	-0.0383	-0.0035	0.0001	0.0023	-0.0002	-0.0001
6	0.0040	0.0570	0.0075	-0.0108	0.0082	0.0000	-0.0008	0.0018	0.0000
7	0.0143	0.2346	0.0237	-0.0029	0.0359	0.0000	-0.0039	0.0011	0.0059
8	-0.0391	-0.1399	-0.0077	0.0231	-0.0229	0.0007	0.0011	-0.0019	-0.0001
9	0.0000	0.0076	0.0018	0.0088	0.0009	0.0001	-0.0003	0.0101	0.0000

Data Source: Federal Bureau of Statistics, Statistics Division, Government of Pakistan

Table 3.1.Demand Effect for Change in Output- Elasticity: India ,1993-2003

sectors	1	2	3	4	5	6	7	8
1	0.628807	0.17975	0.03142	0.06630	0.05634	-0.00028	-0.005	0.00186
2	0.057334	1.11447	0.14499	0.13401	0.26684	-0.00162	-0.02786	0.00928
3	0.05569	0.28165	1.03022	0.14869	0.16910	-0.00139	-0.01819	0.00955
4	0.037868	0.20913	0.07435	1.25	0.12026	-0.00069	-0.01322	0.00644
5	0.015914	0.08134	0.03276	0.06887	1.73743	-0.00026	-0.02593	0.00326
6	0.061021	0.74562	0.12746	0.14503	0.22757	-0.22285	-0.02985	0.09897
7	0.221035	4.13585	0.54841	0.52043	1.00781	-0.00643	-5.75446	0.06748
8	0.084883	0.49267	0.14024	0.19657	0.24648	-0.00382	-0.03946	0.25142

Table 3.2.Growth Effect for Change in Output- Elasticity: India, 1993-2003

sectors	1	2	3	4	5	6	7	8
1	-0.76062	-0.13377	-0.02116	-0.04782	-0.03808	0.00010	0.00267	-0.00140
2	-0.09816	-1.17391	-0.13824	-0.13681	-0.25531	0.00086	0.02105	-0.00986
3	-0.09225	-0.28703	-0.95039	-0.14687	-0.15653	0.00071	0.01330	-0.00981
4	-0.06389	-0.21710	-0.06987	-1.25767	-0.11340	0.00035	0.00984	-0.00674
5	-0.02853	-0.08974	-0.03272	-0.07363	-1.74104	0.00014	0.02052	-0.00362
6	-0.07585	-0.57022	-0.08824	-0.10750	-0.15808	0.08583	0.01638	-0.07628
7	-0.39029	-4.49296	-0.53929	-0.54796	-0.99447	0.00352	4.48530	-0.07389
8	-0.12168	-0.43451	-0.11196	-0.16803	-0.19746	0.00169	0.02496	-0.22349

Table 3.3.Technology Effect for Change in Output -Elasticity: India ,1993-2003

sectors	1	2	3	4	5	6	7	8
1	0.036567	-0.00422	0.000174	-0.0004	-0.00281	-5.2E-06	-0.00031	0.000294
2	0.01559	0.022826	0.015662	-0.0045	0.009311	-1.8E-05	-0.00198	0.001888
3	-0.00061	-0.01866	0.004302	0.000222	-0.01307	-1.5E-05	-0.00124	-0.00046
4	0.01126	0.007244	0.001927	-0.00035	0.002055	-1.2E-05	-0.00094	0.000798
5	0.002461	0.016717	0.000534	-0.00763	0.011805	-2.2E-06	-0.00252	0.000557
6	-0.00457	-0.03768	-0.02769	-0.03937	-0.00807	-0.00013	-0.0019	-0.00642
7	0.107224	0.780946	0.087969	0.028664	0.149917	1.35E-05	-0.01197	-0.01131
8	-0.00259	-0.03176	-0.03424	-0.02796	0.001932	-0.00011	-0.00307	0.004711

Table3.4. Interactive Effect for Change in Output- Elasticity: India ,1993-2003

sectors	1	2	3	4	5	6	7	8
1	-0.01502	0.001733	-7.1E-05	0.000166	0.001154	2.12E-06	0.000128	-0.00012
2	-0.00906	-0.01327	-0.00911	0.002617	-0.00541	1.05E-05	0.001153	-0.0011
3	0.000342	0.010498	-0.00242	-0.00013	0.007352	8.42E-06	0.000698	0.000261
4	-0.00645	-0.00415	-0.0011	0.0002	-0.00118	6.87E-06	0.000539	-0.00046
5	-0.0015	-0.01018	-0.00033	0.004646	-0.00719	1.34E-06	0.001536	-0.00034
6	0.001931	0.015903	0.01169	0.01662	0.003405	5.28E-05	0.000803	0.00271
7	-0.06429	-0.46825	-0.05275	-0.01719	-0.08989	-8.1E-06	0.007177	0.006783
8	0.001259	0.015461	0.016669	0.013612	-0.00094	5.16E-05	0.001492	-0.00229

Data Source: Central Statistical Organisations, Government of India, New Delhi

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