SPCRD GLOBAL PUBLISHING Sustainable Solutions
READS Review of Economics and Development Studies
Journal homepage: http://reads.spcrd.org ISSN (Print): 2519-9692 ISSN (Online): 2519-9706

Energy Substitution Effect in Major Energy Consumption Sectors of Pakistan: Translog Cost Function

Sidra Nazir [a], Nasir Mahmood [b], Gulnaz Hmaeed [c]

[a] PhD Scholar, Pir Mehr Ali shah University of Arid agriculture, Rawalpindi, Pakistan
Email: sidranazir.shah@gmail.com
[b] Lecturer, Pir Mehr Ali shah University of Arid agriculture, Rawalpindi, Pakistan
Email: nasir@uaar.edu.pk
[c] Assistant Professor, Pir Mehr Ali shah University of Arid agriculture, Rawalpindi, Pakistan
Email: gulnaz.hameed@uaar.edu.pk

ARTICLE DETAILS

History:
Accepted 25 May 2022
Available Online June 2022

Keywords:
Elasticities, Energy-Inputs, Translog Cost Function, LMDI Model, Rebound Effect

JEL Classification:
Q4, Q11, Q21

DOI: 10.47067/reads.v8i2.448

ABSTRACT

There is inadequate works available in case of Pakistan that tested rebound effect (RE) having energy use and its impacts on environment, this study, comparative analysis of energy substitution effect on Pakistan' three major energy consumption sectors industrial, transport and electricity sector has done, by using translog cost function in time series data framework. From analysis, it has been concluded to have diseconomies of scale in each sector of economy of Pakistan, as elasticity of cost concerning output is greater than one. All energy and non-energy-inputs are substitutes for each or but labor is needed more than any or input sectoral wise as it is cheaper and easily available in Pakistan. From results, in industrial sector capital intensive production has preferred to increase use of energy. RE in Pakistan is negative, which means super conservation or have less use of energy. This could be having high price of energy-inputs and underdevelopment, disinvestment so less profit and income generation, and technological progress leads to less use of resources.

Corresponding author's email address: sidranazir.shah@gmail.com

1. Introduction

Since occurrence of oil price tremors in 1973, world has placed its struggles to improve energy competent machinery to decrease energy use and reducing dependence on costly resources of energy, explicitly, petroleum products. It causes a destructive impact on macroeconomic condition of oil trading nations. Globally this phenomenon has recognized, having inexpensive, trustworthy, sustained and up-to-date energy for everyone should be one of Sustainable Development Goals which approved in such conditions. Though reduction in per-unit cost of energy-inputs, resulting from improvement in energy-inputs which are being more efficient, energy demand is not decreasing having an increase in energy use day by day. This phenomenon was first discussed by William Jevons during nineteenth century. To improvement in energy-inputs, it leads to change in respective prices causing affect income of consumers and also leads to use of energy substitutes. Though, having income and substitution effect does not cause to decrease in energy use with an appropriate proportion. This phenomenon leads to a RE in making energy policies re is also a need to keep in consideration rebound effect.

Energy has a very strong impact on economic growth of Pakistan as discussed by (Siddiqui, 2004; Nazir, S., and Qayyum, 2014). In Pakistan, energy components like oil and gas have high use in commercial and industrial sectors. Oil is largely imported and extensively used as a source of energy in industrial, transport, and power generation sectors (Nazir, S., and Qayyum, 2014). therefore, prices of both oil and gas vary considerably and result in changes in consumer behavior over time with substituting effects on each or. For example, declining trend is observed in use of Compressed Natural Gas (CNG) use for transport sector from 2012 to 2017 having its shortage and increased load shedding over time in contrast to a rising trend in share of petrol use from 8 % in 2008 to 57 % in 2017 in electricity production (CEIC, 2008a; 2017b) followed by 14 % decrease in March 2019. Similarly, industrial sector is also a major user of various forms of energy including a 27 % share of electricity and 648 mmcfd (million cubic feet per day) of natural gas during last fiscal year 2018 to July 2019 (Yearbook, 2018). Power plants Output contribution and total production cost share of se plants about 12 % and 32 % respectively. Similarly, industrial sector is also a major user of various forms of energy but oil use has declined to 31 % during 2018, there was use of 10 % of CNG in industrial sector of Pakistan with an approximate contribution of 1.40 % growth during fiscal year 2019 in economy of Pakistan (Economic Survey of Pakistan, 2018-19).

There is a need to analyze substitution, own, and output elasticities at sectoral as well as aggregate level with more advanced methodology and updated data and different energy-inputs, also need to check rebound effect at sectoral and aggregate level. Followings are main objectives of study:

1. Comparative analysis of energy substitution effect in three major energy consumption sectors of Pakistan, including industrial, transport, and electricity production sector using translog cost function in time series data framework.
2. Give Policy suggestion for idea 2030 through forecasting, related to use of energy and non-energy-inputs in production process and ire impact on environment, at aggregate level.

2. Literature Review

According to (Lin & Ahmad, 2016b) Energy use is very important in every sector of economy of Pakistan like transport, industrial sector, and also power sector. One of reasons for having different results regarding substitutes and complement of inputs and outputs primarily depends on country-specific data and sample size (Stern, 2011), but se studies are too old criticized by (Smyth, Narayan, & Shi, 2011). In case of Pakistan, none of studies or than this study has estimated inter fuel and factor analysis. In Pakistan's perspective, very few studies have estimated Elasticity of Substitution (EOS) at aggregate or dis-aggregate level for manufacturing sector (Kazi, et al., 1976; Kemal, 1982; Ahmed, 1982; Battese and Malik, 1986; Mahmood, 1989; Kalim, 2001; Chishti and Mahmood, 1991; Zahid et al., 1992; S. F. Mahmud, 2000; Zafar and Ahmed, 2005; Batool and Zulfiqar, 2011), except (Lin and Ahmad, 2016).

Alvi et al (2018) have investigated direct RE in case of household electricity sector. Alivelu (2007) has explained relationship between Indian railways' cot function, by estimating translog cost function and found elasticity between fuel - capital, capital - labor, and labor - fuel. Before this study, few studies have done on this issue, like Borts (1952), Koshal (1970), Meyer, et al (1964), and Verma

(1988), after big gap, in 2007 this is only study which has estimated model for Railway sector, provided very useful results.

Krishnapillai & Thompson (2012), have added in literature of United States (US) economy after 1989, (Thompson, 2006) has explained translog production and cost function to estimate relationship. Allen (1938) has given concept of relative substitution elasticity, which has also been used in this study. A detailed theoretical background of energy substitution has been discussed in which Cobb Douglas production function and energy substitution have explained. Literature has discussed RSE of Thompson and Tylor (1995). Energy cross-price substitution elasticity methodology has discussed could be calculated through Shephard lemma. study has also explained concept of translog production function originally generated by Christensen et al (1973), which has been used by many studies followed by translog cost function.

Thompson (2006) has criticized on production function should not only comprise upon labor and capital but various natural factors should also be included like energy, raw material, etc., Lachaal et al. (2005) have used variable translog cost function to find out neoclassical duality theory EOS between inputs and price elasticity. Ayadi & Hammami (2015) have also used translog cost model in their study to analyze cost structure in transport sector of Tunisia using panel data of transport companies from 2000-2010. Berndt et al. (1975) studied this issue primarily as among foundational literature available related energy-inputs and using cost models. In example of US electricity producing enterprises, Christensen and Greene (1976) employed cross-sectional data for 1955 and 1970 using a translog cost function. Efficiencies of scale has observed. Moshiri & Aliyev (2017) have analyzed transport sector of Canada to check RE of gasoline price efficiency to fuel use.

For both energy and non-energy-inputs, Stern (2011) has described various test used to measure EOS and complementary. Kinugasa (1997) has also used flexible translog cost function to analyze economies of scale and technological transformation for Gas Company of Australia and found increasing return to scale and have Hicks neutral and non-neutral technological progress in gas sector.

3. Materials and Methods

3.1 Oretical Framework

In all-economic process energy is needed under macroeconomic framework. EOS (between capital/labor or energy-inputs like oil, gas, electricity, and coal) indicates how much one input increased; there is lowered to get same level of production. Demand elasticity of substitutes indicates, energy-inputs may have an elasticity between 0 and 1 (Stern, 2004).

3.2 Economic Linkage between Energy and Output

Translog Cost Function (TCF) which is modification of Neo-Classical Production Function (NCPF) given by Charles Cobb and Paul Douglas in 1928. This function states, output (Y) is obtained by utilizing input likes labor, capital, and for intermediary inputs like energy. So, output function can be derived as:

$$Y = f(K, L, E) \tag{1}$$

From Cobb-Douglas production function, cost function has derived in which cost has minimized.

3.3 Empirical Framework

In analysis, it has proposed to use three inputs labor, capital, and energy, with input prices like p_L, p_K, and p_E.

3.1 Translog Cost Function

As microeconomic assumption is; firm will minimize its cost subject to given output (y) determined by inputs $f(x)$. So function has formulated as below, used by like (Adetutu, 2015; Mahmood, 1989; Thompson, 2006).

$$C(y, pL, pK, pE) = K, L, E^{min} (p_l L, p_k K, p_E E) \quad (2)$$

Subject to: Y = f(x)
Where; C = cost of production
$Y = output$
$p_L = price\ of\ labour$
$p_K = price\ of\ capital$
$p_E = price\ of\ energy$
$K = Capital$
$L = Labour$
$E = Energy$

TCF formulated by (Christensen et al. 1973) is more flexible and free from restrictions, TCF for three inputs and prices shall be as under m = 3 inputs

$$lnCost = \beta_0 + \sum_{i=1}^{m} \beta i\ lnP_{it} + 0.5\sum_{i=1}^{m}\sum_{j=1}^{m} \beta ij\ lnP_{it}\ lnP_{jt} + \beta_t T + 0.5\beta_{tt}T^2 + \sum_{i=1}^{m} \beta itT\ lnP_{it} + \beta_y\ lnY_t + 0.5\beta_{yy}\ (lnY_t)^2 + \sum_{i=1}^{m} \beta iy\ lnP_{it}\ lnY_t + \beta_{yt}T\ lnY_t \quad (3)$$

where cost is equls; Cost = $p_L L + p_K K + p_E E$.
For duality property re are some restrictions of symmetry and homogeneity as below:

$$\sum_{i=1}^{m} \beta i = 1 \text{ and } \sum_{i=1}^{m} \beta ij = 0 \text{ for all m}$$

By applying Shephard's Lemma on translog cost equation after applying restrictions input demand function can be obtained in terms of cost-shares (S) by differentiating concerning each input price as below:

$$S_i = \beta_i + \sum_{j=1}^{3} \beta ij\ lnP_j + \beta_{it}\ T + \beta_{iy}\ lnY \quad (4)$$

Where β_i *and* β_{ij} are distribution and substitution parameters, S is cost of shares. Equation can be estimated individually for capital and energy cost of shares by using seemingly unrelated regression (SUR) knows as GLS method that converges to maximum likelihood (MLE).

3.2 Decomposition of Energy Demand Equation and Calculation of Rebound Effect

Utilizing Slutsky model, which equates Marshallian input equation given cost with Hicksian input demand provided productivity, one may determine breakdown of energy demand at disaggregate level (Sub-industries of Pakistan) (Hicks, 1932). It has split into substitution & output impact. Our primary focus is on energy's own price impact, which is relevant for rebound inquiry. Using Wang et al (2018).'s work, direct RE has been computed using formulas below.

In accordance with (Ang, 2004; Wang and Zhou, 2008), Equation defines direct energy rebound impact (5).

$$Rebound\ Effect\ (RE) = {}^{\Delta TE_2}/_{\Delta TE_1}$$

$$= \frac{EI_t\{y_t - y_{t-1}\}\lambda}{y_t\{EI_{t-1} - EI_t\}\varphi} \quad (5)$$

Where ΔTE1 denotes energy savings brought on by technological advancement and ΔTE2 denotes an increase in energy intake. RE stands for direct electrical RE, for λ technical advancement rate predicted by Cobb-Douglas production system, ϕ technological advancement rate calculated using LMDI decomposition technique, which is explained in following section.

In Equation (5), while RE lies between 0 and 100%, direct energy RE resulting from economic development is small and general energy intake demonstrated a descending inclination; when direct energy RE is greater than 100%, direct energy rebound resulting from economic development of progress is extensively better than energy savings resulting from technological development and total energy intake suggests a rising inclination. except, bigger RE shows energy usage indicates a noticeable upward inclination.

3.3.3 Cobb-Douglas Production Function for Technological Rate

In this study, a better Cobb-Douglas production function has indeed been built to relate economic output, energy supply, and technical advancement to Gross Domestic Product (GDP), as shown in Equation. (6)

$$Y_t = A_t F_t(L, K, E) = A_t L^{\alpha} K^{\beta} E^{\gamma} \quad (6)$$

In equation (6) A represents technical advancement during t-th year, L represents labour input during t-th year, and β represents output elasticity of labour capital. K represents capital input during t-th year, and γ represents output elasticity of energy. Let's say; at = A_0e^{a}, where A_0 denotes base year's technical stage. Calculate growth rates of all variables by taking logarithms of each side of aforementioned equations. Equation (7) below describes technological advancement λ:

$$\lambda = {}^{A_g}/_{y_g} = \frac{y_g - \alpha L_g - \beta K_g - \gamma E_g}{y_g} \quad (7)$$

3.3.4 LMDI Decomposition Energy Demand Model

This direct energy conversion RE can be broken down into three categories: energy technology effect, energy substitution impact, and industrial structural impact. To examine direct power paradoxical effect over all three areas of essential industries, LMDI decomposition model is employed.

So, total effect will be calculated as,

$$\Delta EI = \Delta EI_N + \Delta EI_T + \Delta EI_S$$

ΔEI stands for variability of overall energy intensity. LMDI decomposition method has been used to separate ΔEI into ΔEI_N, ΔEI_T, and ΔEI_S, illustrating change in energy intensity brought on by an influence on energy substitution, an impact on energy technology, and an impact on structure of energy industry, separately. construction approach proposed by (Wang and Zhou, 2008), as stated by Equation, may be used to describe technological development/progress effect ϕ (8).

$$\varphi = \{-1\}^n \left[{\Delta EI_T}/{\Delta EI}\right]$$

$$\varphi = \{-1\}^n \left[{\Delta EI_T}/{\Delta EI_N + \Delta EI_T + \Delta EI_S}\right] \quad (8)$$

3.3.5 Data Sources and Variables

Data Information has been geared from a number of sources, including Federal Bureau of Statistics of Pakistan (FBS), International Monetary Fund (IMF), World Bank Indicators (WDI), publication of an economic survey of Pakistan (since 1989-2018), labour force survey, and energy yearbook, which are all accessible for Pakistan, time - series data. Deals with measurement by (Berlemann & Wesselhöft, 2016) utilised by (Kamps et al., 2006; Lin & Ahmad, 2016b), capital stock dataset has calculated indicator capital used in industrial, transport, and electricity sectors as shown in formula (9) below:

$$K_t = k_{t-1}(1-\delta_t) + I_t \quad (9)$$

Where Kt is capital stock, t represents investment's rate of depreciation, which is an investment. Data on Capital (K), Labor (L), Output (Y), and Overall Energy Usage are needed for regression analysis (E), and material utilized (M), which was collected for Pakistan between 1990 and 2019 in order to calculate direct rebound impact from their translog minimization problem. Overall cost as well as all costs of production are computed based on (Adetutu, 2015), Labor costs are computed by dividing labour reimbursement by number of people employed, while capital costs are measured by dividing capital reimbursement by fixed capital stock. Energy costs are computed by dividing primary input energy costs at existing selling prices by gross energy use. combination of industry's capital, labour, and energy expenditures is overall cost. For average correction, logarithmic form will be applied to all observations.

4. Results and Discussions

4.1 Sectoral Analysis of Energy Substitution Under Translog Cost Function

Three major economic sectors of Pakistan such as industrial, transport and power sector which have a greater % of energy-inputs use has been used. Translog cost function estimations have indeed been made for Pakistan's 3 sectors of economy, however by imposing modelling limitations, restricted cost model has estimated first. By using SUR technique, output parameter for each of three areas are higher than zero and statistically meaningful, so in cost model, all coefficients are statistically significant at 1% threshold. These has been estimated through SUR approach also, after normalizing by input prices to apply homogeneity and by differentiating cost function by Shephard lemma concerning input prices and derived cost shares estimated for all three sectors through cost equation.

Next, Scale elasticity tests are shown in Table 1, for three areas, where elasticity of output was deduced from their cost model, industrial sector's elasticity of cost to outcome, or scale elasticity, is larger than one and considerable, showed lose to industrial sector cause low production having high cost. Since coefficients of input and output elasticity of demand are statistically significant and positive, however, projected cost function is non-decreasing in output and price of input. Monotonicity situation for cost model has been evaluated, given in Table 1. Done for all three areas (industrial, transport, and power sector).

EOS has indeed been determined for each of three areas listed in Table 2. According to Allen and Uzawa technique, EOS for industry is measured in first column. Coefficient for k-L is a little less than one and statistical significance, inelastic and substitutable in industrial sector. Findings are comparable with (Chishti & Mahmood, 1991; Mahmood, 1989), in which elastic demand of substitution for labour and capital in manufacturing sector is Column 1's substitution elasticity for capital and oil, which is larger than one and noteworthy, displays a strong substitutability in an industrial factor of Pakistan but labor and oil are limited to substitute in this sector, Labour is vital for industrial sector and unreplaceable.

EOS for transportation sector is discussed in second column of Table 2. All of parameters are significant. Oil and capital are inelastic and capable of being substituted. However, elasticities of capital-gas and oil-gas are elastic in nature, so substitutable in transport sector. EOS coefficients for Allen's elasticity for power are in column three, elasticity of labour with respect to oil, gas, coal, and oil gas was more than one, indicating elastic nature, can be substituted for gas, coal, and oil. Oil and Gas are also substitutable each sector of Pakistan based upon price of inputs and methods of producing electricity. Coefficients of Oil-Coal and Gas-Coal are less than one, shows oil and gas are limited substitute with coal and inelastic change with coal. Capital in industrial sector is greater than one consistent with (Kazi et al., 1976), and in transport sector, all inputs are substitute consistent with (Lin & Ahmad, 2016a).

In Table 3, own-price elasticity for capital, labor, and oil has been calculated in case of industrial sector of Pakistan; all estimates of elasticity are significant and have expected negative signs consistent with microeconomic theory. Coefficient of all inputs shows highly elastic demand in all three sectors industrial, power, and transport sector of Pakistan. Own elasticity of demand for capital, labor, oil, gas, and coal for all three sectors is elastic but among all labor and oil in power, sectors are more elastic prices than other sectors.

Table 1: Properties of Monotonicity Cost Function (Non-Decreasing in Input Prices and Output)

Economic properties	Industrial	Transport	Power
Scale elasticity (output)	4.120646***	.8161446***	30.03694***
capital	2.599022***	4.055864***	-
labor	4.646246***	-	200.9239***
Oil	7.312061***	.1266402***	67.29036***
Gas	-	.8191019***	1.941521***
Coal	-	-	22.3616***

Note: Delta method SE (standard errors), ***donated significantat1% level

Table 2: Allen's Elasticity of Substitution between Inputs

Variables	Industrial	Transport	Power
K-K	-4.44854***	-1.748346***	-
L-L	-5.80525***	-	-19.7811***
O-O	-11.65124***	-3.767429***	-17.17665***
G-G	-	-7.008045***	-11.62145***
C-C	-	-	-8.148812***

Note: Delta method SE (standard errors), ***donated significantat1% level

Table 3: Own Elasticity of Demand of Inputs

Variables	Industrial	Transport	Power
Capital-labour	.8780108***	-	-
Capital-oil		.9991169***	-
Capital-gas	1.019719***		1.00052***
Capital-Coal		-	-
Labour-oil	-	.9375715***	1.000733***
Labour-gas	-	-	1.000889***
Labour-coal	-	-	1.002751***
Oil-gas	-	1.037864***	1.000001***
Oil-coal	-	-	.9988231***
Gas-coal	-	-	.9985498***

Note: Delta method SE (standard errors), ***donated significantat1% level

4.1.1 Substitution Effect

Given methodology previously, energy substitution effect has been calculated as demand for energy input changes with change in price of energy-inputs. Value of substitution effect for industrial, transport, and power sectors have been calculated for energy-inputs; like oil and gas for each sector. Since 1991-2018 it can be examined in figure 1, substitution effect of gas for transport factor shows less change and for industrial sector of Pakistan but substitution effect for oil in transport sector shows very high change synchronized with total substitution effect in transport sector.

In 2016 transport sector, gasoline use was 55 % having a shortage of CNG. Petrol use increases between 18-57 % in 2017 having over burden of gas sector and its reduction. therefore, an upsurge in usage of FO and high-speed diesel (HSD) because of rise in power sector requirements, sale of petrol increased since 2012 having CNG curtailment, and CNG use for transport sector shows decreasing trend after 2012-2017, use of petrol increases and reaches at 57 % in 2017 as it was 8 % in 2008. As Pakistan's major import is petroleum or petroleum product from which major part is consumed by transport sector of Pakistan.

Although in whole era since 1991 to 2018 substitution effect for oil for transport sector shows higher change having high change in price of petrol and petroleum product in world and Pakistan but in 2005 it shows sudden decrease and in 2007 shows spikes again followed by again increasing trend since 2008 up to 2015 and abrupt decline in 2017 in transport sector of Pakistan substitution effect of oil in gas for power factor also showed some change in 2008, Price control is needed to control change in substitution effect having change in price. According to report of Economist, on August 6, 2018, oil use will decrease in 2030 having coal, hydro or renewable resource use will be increased. Demand for costly inputs is being substituted with inputs having effect of price. In case of Pakistan for development, energy-inputs are needed but non-energy-inputs like labor and capital are more appropriate options and available at cheaper prices than energy-inputs. Only a need to have efficient labor knowing advanced technologies.

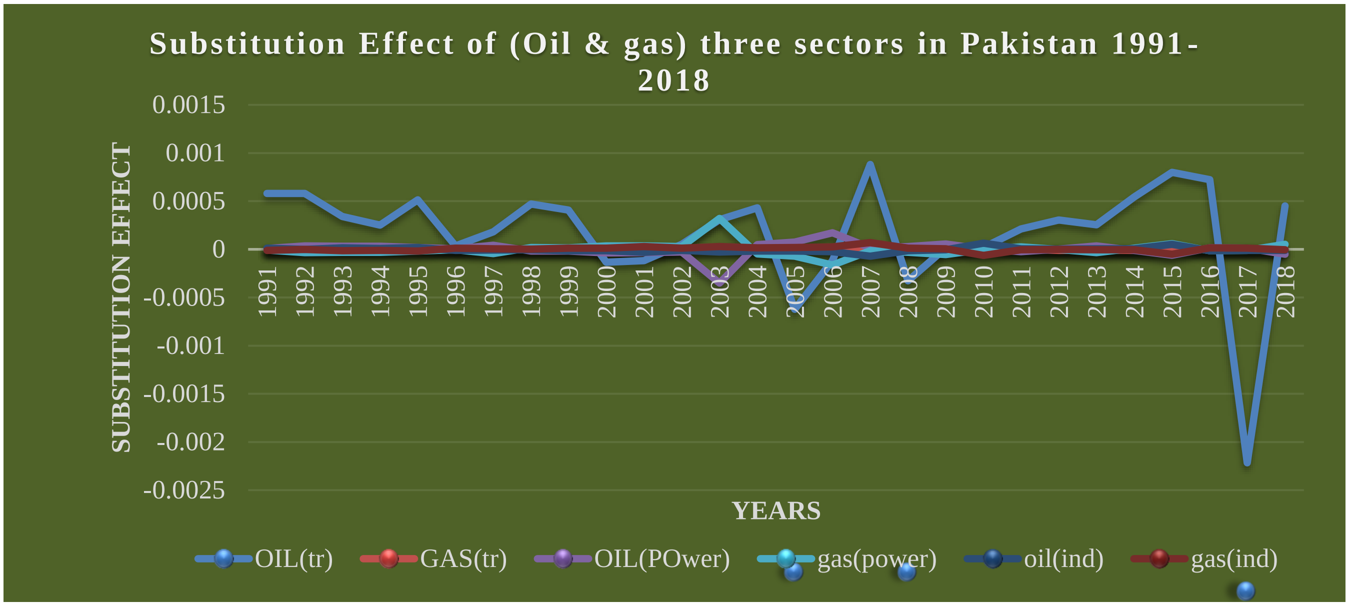

Figure 1: Substitution Effect in Three sectors (Transport, Industrial, Power) Source: author's self-calculated

4.1.2 Structural Effect

Structural outcome refers to variation in effect of energy use intensity as structural effect has been calculated through GDP of each sector so it's affected by change in GDP of sector and by GDP of whole nation. It can be seen in Figure 2 structural effect of oil in power sector followed by total structural effect in power sector shows very high change. According to government of Pakistan in 2015 and 2016 industrial sector has accelerated its production by about 4.8 % and 6.8 % respectively and is expected to increase in 2017. Structural effect of oil in transport sector also shows two high spikes but less than other sectors. However, structure of production in any sector can influence need for energy and economic growth.

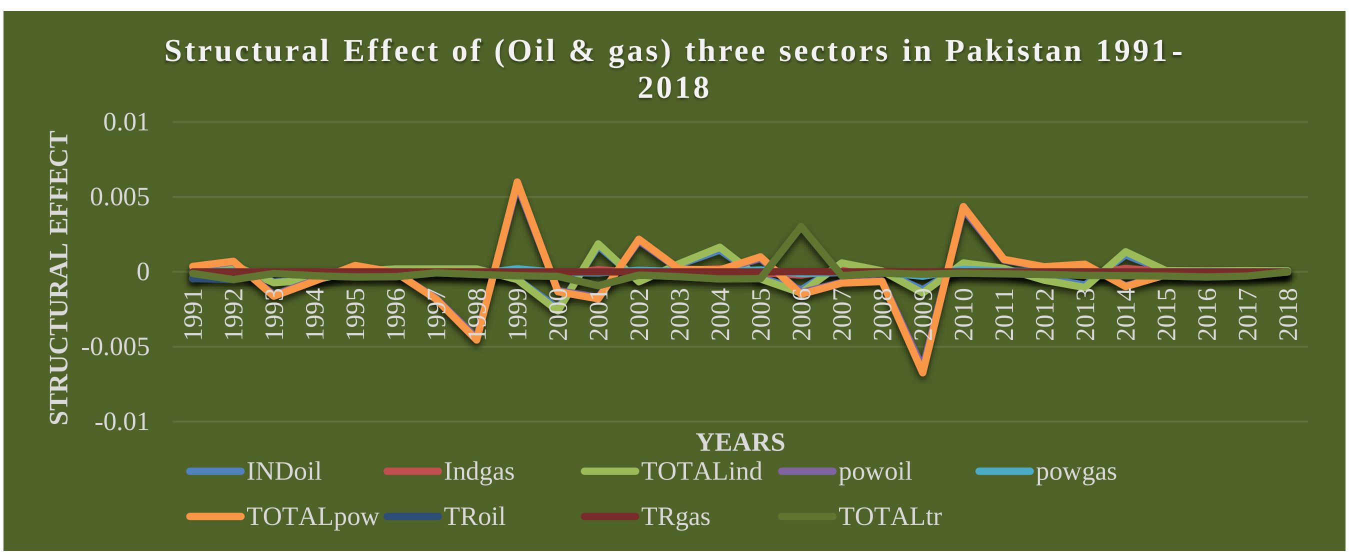

Figure 2: Structural Effect in three sectors of Pakistan (Transport, Industrial, Power) Source: author's self-calculated.

4.1.3 Technological Effect

In Technological effect, use of advanced technology that affects use of energy leads to a technological effect in Figure 3. But power sector has shown a higher technological effect synchronized with total technological effect in power sector. Oil use has increased in power sector having electricity is being highly produced by oil and oil products, it shows high technological effect in industrial sector, oil in transport sector also shows significant spikes in 2006 and 2017 that is in line with total technological effect in transport sector of Pakistan having increase of energy use having technological progress has increased, energy use has increased. Economic progress needs to use energy-saving technology and products, bad effects of energy emission in industrial and power sector can be removed.

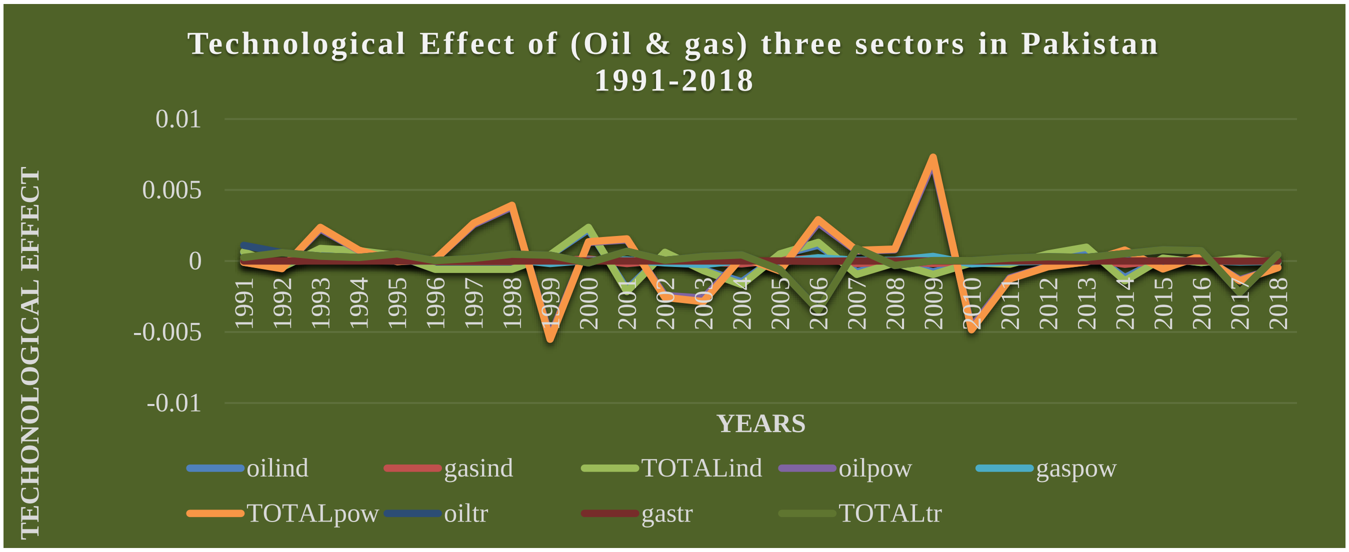

Figure 3: Technological Effect in three sectors of Pakistan (Transport, Industrial, Power)
Source: author's self-calculated

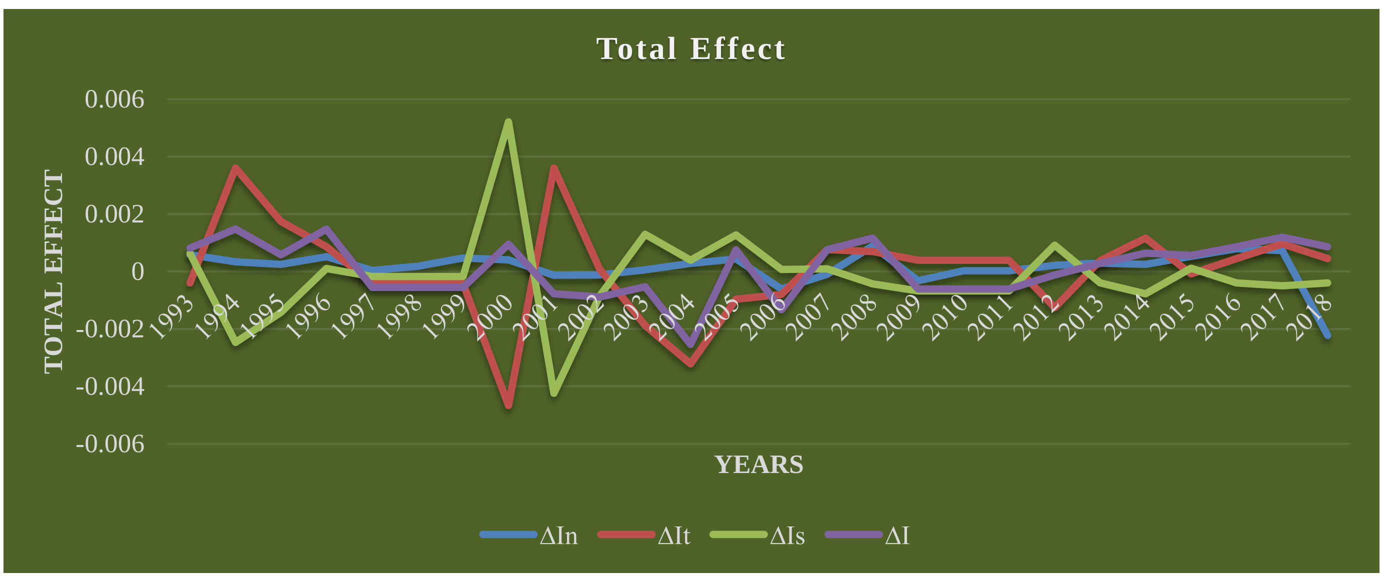

Figure 4: Total Effect in three sectors of Pakistan (Transport, Industrial, Power)
Source: author's self-calculated

4.1.4 Total Effects

Figure 4 of total effect of all three sectors for oil and gas has calculated, where total structural effect has shown higher change in 1992 and 1991 to 2000, followed by total technological effect in same era but when structure effect Shows increasing trend, technological effect shows a declining trend. In figure 5, it can be examined that total substitution effect has less change than change in structural and technological effects. Overall total effect has mitigated to less change but still change between 1990 to 2007 and some increasing trend seen in 2010 to 2018, it can be having a higher increase in energy prices, less use of energy. Changing technology and structural advancement leads to an increase in energy demand, which leads to higher change.

4.1.5 Direct Rebound Effect in Case of Three Sectors

RE is given in Table 6, value of direct rebound affected by energy-inputs used in Pakistan from 1991 to 2018; has been given. Surprisingly, Figure 6 in case of Pakistan in three sectors indicates a pretty negative trend for overall rebound impact. This is because Pakistan has underdeveloped technology. Super conservation is name given to this situation since it increases efficiency, which lowers value of materials being conserved. When RE exceeds one for a few years, as it did between 2007 and 2009, it is referred to as RE occurs "backfire effect."; demonstrates energy conservation has decreased, resulting in a RE positive, called Jevons paradox, arise from rise in energy, greater efficiency; having decrease in price of energy in both oil and gas specifically oil in power and industrial sectors. Substitution impact, which was earlier computed and showed increased energy input use as a result of a price decline, also contributes to RE.

As it can be seen in graph value lies below 100% in case of Pakistani industries since 1990 up to 2007, after this a clear spike which is above 100% shows technological progress accompanied with high energy use, as in case of Pakistan, calculations showed direct Energy conversion RE from economic development is larger than 100 hundred %, it is substantially better to direct energy RE from technological progress, and overall pattern in is rising. Additionally, larger RE denotes energy use and supports a more obvious upward trend.

According to economic survey of Pakistan 2007-08, fiscal year was year of a structural shift, and real per capita GDP of Pakistan has shown an increase of almost 5% as compared to last five years. energy demand has also increased with an increase in per capita income and strong economic growth. Having a high value of RE in 2008 is also having use of energy products like petroleum, coal, gas, and electricity has showed increased use up to 10.1%, 11.9%, 2.8%, and 5.7% respectively.

Useful resource crisis can be aggravated through impending wear change, whose effect and potential to de-stabilize geographical unfold and area of human habitats is most effective just starting to be unstated. Pakistan has to be prepared to evolve to approaching changes and mitigate terrible effects.

Table 6: Direct Rebound effect of Three sectors (Industrial, Transport and Power) of Pakistan using K, L, Oil and gas as input

λ	φ	EI	RE%
0.28404	-0.45	5.460129	-1.04474
0.392382	-0.48259	5.329131	-8.4138
0.11519	2.437305	5.270224	1.63232
0.019902	3.017142	5.442345	-0.32548
0.733708	0.584228	5.461819	20.94765
-0.07541	0.750633	5.434872	-0.213
-2.51823	0.667431	5.455328	-92.2042
-0.43021	0.709032	5.544133	-32.3761
0.443356	-4.90812	5.523275	0.491225
-0.27461	-4.63816	5.625939	0.182481
-0.78944	-0.59354	5.540251	-47.9554
-0.17647	3.520527	5.521179	-0.31621
-0.13474	1.266447	5.408805	-4.0395

0.479461	-1.28092	5.392914	-28.2919
-0.08314	0.599302	5.384773	-0.0488
-0.35695	1.003383	5.185952	1.515653
0.472726	0.600908	5.088105	14.54617
-1.36152	-0.64558	5.113627	-38.9303
-0.34317	-0.02234	4.943676	91.60498
2.563449	-0.33396	4.879832	123.483
0.184227	10.49077	4.872116	0.125169
-0.29648	1.396879	4.777466	-0.674
-0.02751	1.825415	4.668988	-0.05465
0.189661	-0.14963	4.582162	-2.51128
-0.31022	0.528582	4.536275	-0.09277
-0.12506	0.809027	4.422163	0.574905
0.3463	0.668804	4.479219	0.826617
-0.03995	0.738916	4.450691	-1.34558
0.153173	0.70386	4.464955	-12.6147

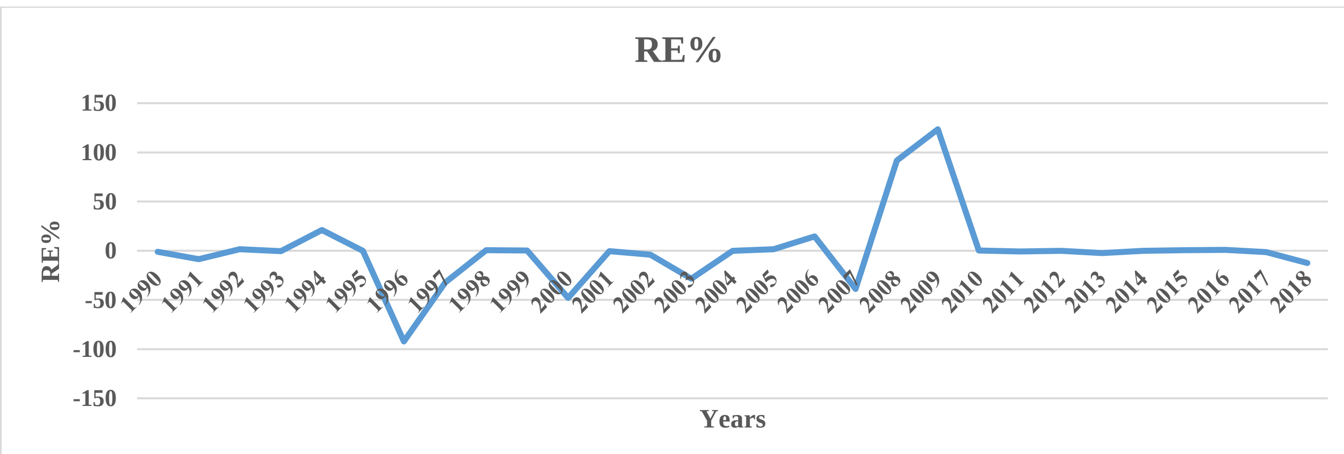

Figure 5: Direct Rebound Effect in case of three sectors of Pakistan
Source: Author's self-calculated

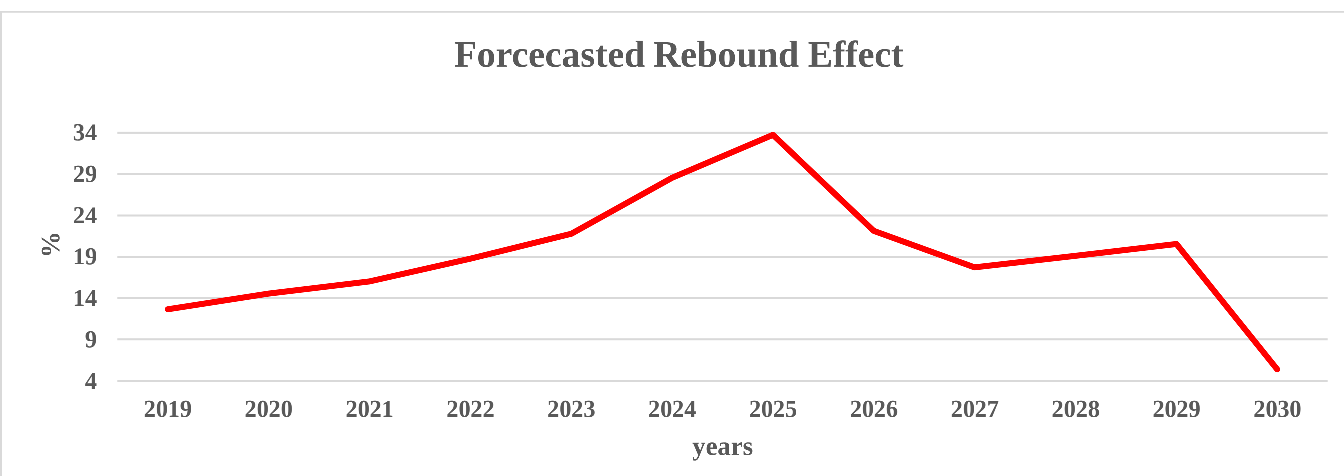

Figure 6: forecasted Direct RE in case of three sectors of Pakistan
Source: Author's self-calculated

In figure 6, forecasted RE has been displayed from 2019 to 2030, RE values will remain below 34 % but positive in next decade, showed backfire RE, in all three main sectors. In future, globally the demand will increase for energy cause shortage of supply in whole world, causing a dilemma for supplier to meet demands and maintain sustainable development goals (SDG). Pakistan requisite a combined strategy that links energy, climate, sustained economic and progressive goals organized. For occasion, Pakistan is a participant in Paris Climate Change Agreement and United Nation's SGDs in accumulation to have implemented, on state intensities, Vision 2030 and progressive accomplishments similar to China Pakistan Economic Corridor (CPEC).

5. Conclusion

Having diseconomies of scale at sectoral level (industrial, transport, and power sector) and aggregate level, Having positive output elasticity shows inputs used at a sectoral and aggregate level have a positive impact on economies of scale, consistent with (Lin & Liu, 2017). According to results, labor and capital inputs show more substitution with or inputs like energy (oil, gas, and coal). High substitutability has been found between capitals (K) with or inputs. All energy and non-energy-inputs are substitutes to each or and positive, as labor-energy has greater elasticity consistent with (Berndt et al., 1975; Mahmood, 1992). In case of Pakistan's RE in three energy use sectors (Industrial, Transport, and Power), a negative RE has been calculated which shows super conservation, consistent with (Saunders, 2000; Turner, 2009).

According to results, there are following policy implications. Having diseconomies of scale at sectoral level (industrial, transport, and power sector) and aggregate level, re is needed to split large industries into small as diseconomies of scale is problem of large-scale industries. According to results labor and capital inputs shows more substitution with or inputs like energy (oil, gas, and coal), so government needs to take clear actions and policies for labor efficiency improvement by an increase of wages, providing information and communication technologies (ICTs), training and skills for new methods of production in industries, electricity generation and fast and efficient transportation using cheaper resources including renewable energy-inputs. Negative RE is having low investment and fall in use of advanced technologies leads to a low level of profit. Need to have such productive policies with technological progress, with implication of energy-saving policies are than no energy use policies.

References

Adetutu, M. O. (2015). Three Essays on Rebound Effects.

Ahmed, M. (1982). Substitution Elasticities in Large-Scale Manufacturing Industries of Pakistan: A Comment. Pakistan Development Review, 21(1), 73–82. https://doi.org/10.30541/v21i1pp.73-82

Allen, R. G. D. (1938) Mamatical Analysis for Economists (London, Macmillan).

Alivelu, G. (2007). Estimation of Indian Railway Cost Function. Zagreb International Review of Economics & Business, 10(1), 11–32.

Alvi, S., Mahmood, Z., & Nawaz, S. M. N. (2018). Dilemma of direct rebound effect and climate change on residential electricity consumption in Pakistan. Energy Reports, 4, 323–327. https://doi.org/10.1016/j.egyr.2018.04.002

Ang, B. W. (2004). Decomposition analysis for policymaking in energy: which is preferred method? Energy policy, 32(9), 1131-1139.

Ayadi, A., & Hammami, S. (2015). Analysis of technological features of regional public transport companies: Tunisian case. Public Transport, 7(3), 429–455. https://doi.org/10.1007/s12469-015-0109-4

Batool, S., & Zulfiqar, S. (2011). Performance and Structure of Small & Medium Enterprises: An Empirical Evidence from Pakistan. In Pakistan Journal of Social Sciences (PJSS) (Vol. 31).

Battese, G. E., & Malik, S. J. (1986). Estimation of elasticities of substitution for CES production functions using aggregative data on selected manufacturing industries in Pakistan. University of New England, Dept. of Econometrics.

Berlemann, M., & Wesselhöft, J.-E. (2016). Estimating Aggregate Capital Stocks Using Perpetual Inventory Method. Review of Economics, 65(1), 1–34. https://doi.org/10.1515/roe-2014-0102

Berndt, E. R., Wood, D. O., Lvii August, V., & Wood, D. o. (1975). Technology, Prices, and Derived Demand for Energy. Review of Economics and Statistics (Vol. 57).

Chishti, S., & Mahmood, F. (1991). energy demand in industrial sector of Pakistan. Pakistan Development Review.

Christensen, L., Jorgenson, D., Lau, L. (1973) Transcendental logarithmic production frontiers. Review of Economics & Statistics, vol. 55, no. 1, pp. 28-45.

Christensen, L.R. & Greene, W.H., (1976) Economies of scale in US electric power generation. Journal of political Economy, 84(4, Part 1), pp.655-676.

Hicks, J. R. (1932) ory of wages (New York St. Martin Press)

Kalim, R. (2001). A Measure of Elasticity of Substitution in Manufacturing Sector of Pakistan *. Lahore Journal of Economics, 6(2).

Kamps, C., Boss, A., Carstensen, K., Doepke, J., Scheide, J., Sturm, J.-E., & Timmer, M. (2006). New Estimates of Government Net Capital Stocks for 22 OECD Countries, 1960-2001 IMF Staff Papers (Vol. 53). Retrieved from www.ifw-kiel.de/forschung/netcap/netcap.htm.

Kazi, S., Khan, Z. S., & Khan, S. A. (1976). Production Relationships in Pakistan's Manufacturing Industries. Pakistan Development Review. https://doi.org/10.30541/v15i4pp.406-423

Kemal, A. R. (1982). Substitution Elasticities in Large-Scale Manufacturing Industries of Pakistan - A Rejoinder. Pakistan Development Review, 21(2), 159–168. https://doi.org/10.30541/v21i2pp.159-168

Khan, M.U.H., & Burki, A. A. (1999). Technological change and substitution possibilities in pakistan's large-scale manufacturing: some new evidence. Pakistan Economic and Social Review (Vol. 37).

Kinugasa, T. (1997). Flexible cost function estimates for a gas and fuel corporation in australia. Review of Urban & Regional Development Studies, 9(2), pp.103-114.

Krishnapillai, S., & Thompson, H. (2012). Cross section translog production and elasticity of substitution in U.S. manufacturing industry. International Journal of Energy Economics and Policy, 2(2), 50–54.

Lachaal, L., Chebil, A., & Dhehibi, B. (n.d.). Measuring factor substitution and technological change in Tunisian agricultural sector, 1971-2000.

Lin, B., & Ahmad, I. (2016a). Technical change, inter-factor and inter-fuel substitution possibilities in Pakistan: A trans-log production function approach. Journal of Cleaner Production, 126, 537–549. https://doi.org/10.1016/j.jclepro.2016.03.065

Lin, B., & Ahmad, I. (2016b, April 1). Energy substitution effect on transport sector of Pakistan based on trans-log production function. Renewable and Sustainable Energy Reviews, Vol. 56, pp. 1182–1193. https://doi.org/10.1016/j.rser.2015.12.012

Lin, B., & Liu, K. (2017). Energy substitution effect on China's heavy industry: Perspectives of a translog production function and ridge regression. Sustainability (Switzerland), 9(11). https://doi.org/10.3390/su9111892

Mahmood, Z. (1989). 731-742. Pakistan Development Review, 28(4), 243–262. Retrieved from http://www.pide.org.pk/pdf/PDR/1989/Volume4/731-742.pdf

Mahmood, Z. (1992). Factor Price Shocks, Factor Substitution and ir Implications for Policy. International Economic Journal, 6(4), 63–73. https://doi.org/10.1080/10168739200080027

Mahmud, F., & Chishti, S. (1990). demand for energy in large-scale manufacturing sector of Pakistan. Energy Economics. https://doi.org/10.1016/0140-9883(90)90015-8

Mahmud, S. F. (2000). energy demand in manufacturing sector of Pakistan: some furr results. In Energy Economics (Vol. 22).

Moshiri, S., & Aliyev, K. (2017). Rebound effect of efficiency improvement in passenger cars on gasoline consumption in Canada. Ecological Economics, 131, 330–341. https://doi.org/10.1016/j.ecolecon.2016.09.018

Nazir, S., & Qayyum, A. (2014). Impact of Oil Price and Shocks on Economic Growth of Pakistan: Multivariate Analysis. In Munich Personal RePec Archive. https://doi.org/10.4172/2151-6219.1000182

Series, P. (2009). Working Paper Series. In Accounting & Finance.Vol. 24. https://doi.org/10.1111/j.1467-629x.1984.tb00054.x

Saunders, H. D. (2000). A view from macro side: rebound, back"re, and Khazzoom} Brookes. In Energy Policy (Vol. 28).

Siddiqui, R. (2004). Energy and economic growth in Pakistan. Pakistan Development Review.

Smyth, R., Narayan, P. K., & Shi, H. (2011). Substitution between energy and classical factor inputs in Chinese steel sector. Applied Energy, 88(1), 361–367. https://doi.org/10.1016/j.apenergy.2010.07.019

Stern, D. I. (2004). Economic Growth and Energy. In Encyclopedia of Energy. https://doi.org/10.1016/b0-12-176480-x/00147-9

Stern, D. I. (2011). Elasticities of substitution and complementarity. Journal of Productivity Analysis, 36(1), 79–89. https://doi.org/10.1007/s11123-010-0203-1

Thompson, P., Taylor, T.G. (1995). capital energy substitutability debate: a newlook. Review of Economics and Statistics. (Vol.77, 565-569).

Thompson, H. (2006). applied ory of energy substitution in production. E./nergy Economics, 28(4), 410–425. https://doi.org/10.1016/j.eneco.2005.01.005

Turner, K. (2009). Negative rebound and disinvestment effects in response to an improvement in energy efficiency in UK economy. Energy Economics, 31(5), 648–666. https://doi.org/10.1016/j.eneco.2009.01.008

Uzawa, H. (1962) Production Functions with Constant Elasticities of Substitution, Review of Economic Studies, October, 29, 291--299.

Wang, Q. W., & Zhou, D. Q. (2008). Improved model for evaluating rebound effect of energy resource and its empirical research. Chinese Journal of Management, 5(5), 688-691.

Wang, Q., Gao, Z., Tang, H., Yuan, X., & Zuo, J. (2018). Exploring direct rebound effect of energy consumption: A case study. Sustainability (Switzerland), 10(1). https://doi.org/10.3390/su10010259

Wang, X., Wen, X., & Xie, C. (2018). An evaluation of technical progress and energy rebound effects in China’s iron & steel industry. Energy Policy, 123, 259–265. https://doi.org/10.1016/j.enpol.2018.08.016

World Bank. (2003). Pakistan Oil and Gas Sector Review (Report no. 26072-PK).

Yearbook, P. E. (2018). Pakistan energy yearbook. Hydrocarbon Development Institute of Pakistan, Ministry of Petroleum and Natural Resources, Government of Pakistan, Karachi.

Zafar, S., & Ahmed, E. (2005). Evidence on Allocative Efficiency and Elasticities of Substitution in Manufacturing Sector of Pakistan. In Pakistan Development Review (Vol. 44).

Zahid, S. N., Akbar, M., & Jaffry, S. A. (1992). Technical change, efficiency, and capital-labour substitution in Pakistan’s large-scale manufacturing sector. Pakistan Development Review.