Gauging Energy Rebound Effect in Selected Energy Intensive Industries of Pakistan

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Gauging Energy Rebound Effect in Selected Energy Intensive Industries of Pakistan

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AUTHOR'S DECLARATION FORM

I Hafiz Muhammad Zahid S/o Rahi Sahib Yar hereby declare that the thesis titled "**Gauging Energy Rebound Effect in Selected Energy Intensive Industries of Pakistan**" submitted at National University of Modern Language for the award of degree of Master of philosophy (M.Phil) in Economics is the result of research work carried out by me under the supervision of Mr. Shafqut Ullah, department of Economics, National University of Modern Languages, Islamabad, Pakistan. I further declare that the results presented in this thesis have not been submitted for the award of any other degree or fellowship. I am aware of the terms, copyright and plagiarism and I shall be responsible for any copyright violation found in this work.

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"In the Name of Allah, the most Beneficent, the most Merciful"

DEDICATION

I DEDICATE THIS HUMBLE EFFORT TO MY PARENTS, RAHI SAHIB YAR & KULSOOM BIBI, WHO TAUGHT ME THAT IT'S NEVER TOO LATE TO TRY FOR ACHIEVING YOUR GOALS.

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H.M Zahid

Abstract

Availability of energy at affordable prices plays a vital role in beautification of any economy and sector. Over the passage of time, energy consumption substitutes with efficient-energy

consumption because it is desirable for the sustainable industrial growth. Energy efficiency is the supply side and energy consumption is demand side phenomenon. One main source of energy efficiency is technological advancement and it is expected that it lowers the energy demand or a factor of energy saving. But in many cases expected energy saving targets are not achieved due to energy rebound effect. The present study investigates the effect of the technological efficiency gain on energy consumption in three (Steel, Fertilizer, Cement) selected energy intensive industries of Pakistan. Moreover, study also drives a general expression of the energy rebound effect. For this purpose, Cobb Douglas production function is used and empirically analyzed with the help of time series data from 1978-2015. In three models output of each industry is a dependent variable, while gross fixed capital formation, labor and total energy consumption of each selected industry are independent variables. The confirmation of unit root level is a pre-request for efficient and consistent outcomes especially when we analyze time series data. On average the energy rebound effect of selected industries is about two hundred and sixteen percent. At disaggregate level the range of energy rebound effect is about 186% in fertilizer industry, 337% in cement and 127% in steel industry. In comparison with other international studies, the energy rebound effect of Pakistani industries is significant. It mean our industrial sector positively responds to energy efficiency by consuming more energy. Such a size of energy rebound is meaningful as well alarming for future generations in terms of environmental degradation. Without planning, energy efficiency may be proven counterproductive. So, policy makers should incorporate the energy rebound effect for better implications.

Keywords: Energy efficiency, Energy rebound effect, ARDL, ECM, Environment and efficiency

CHAPTER 1

01 Introduction

Throughout history, energy is considered as an integral component for social and economic wellbeing of a society. As other branches of science and art, types of energy also pass through an evolutionary process. Old sources of energy elevated with some modern efficient types, according to the availability of technology at that time. Having historical background, contemporary energy sources are still related to modern usages. In early days, the invention of fire and its uses for melting metals shifted energy paradigm. It was coal (energy) that brought the Industrial Revolution. It brought massive technological advancement in every sphere of life. Hereafter, fossil fuels were extracted with technological tools (Lin, & Liu, 2013). Nuanced fossil fuels are still used to facilitate economic activities (Binswanger, 2001).

Energy is equally important for the developing, and developed world. Developed nations almost achieve and keep their steady-state goals stable because of their richness in sectors of energy. While developing nations, grind in energy poverty because they don't have access to energy at affordable prices. Being a developing country, Pakistan has made a few moderate achievements. However, due to the developing stature of economy, total energy consumption is continuously soaring (Khalil & Zaidi, 2014). Quadrupling energy consumption causes carbon emission and high import bill. These two main issues place environmental and economic constraints on Pakistan's economy to achieve sustainable growth. Given this situation, the government of Pakistan set specific goals for energy saving (Kugelman, 2013). In this direction, the government planned to reduce energy uses per unit of GDP near twelve percent in 11th five year plans (2013–2018) (Khalil & Zaidi, 2014). To overcome these two issues (efficient energy or energy efficiency) will gradually replace the inefficient energy valleys. In the following section, study categorically define various definitions of energy efficiency and different interlinked as well as interrelated concepts of energy advancement.

1.1 Energy Efficiency

In simple words energy efficiency (technological change) is energy saving(Gillingham, Rapson, & Wagner, 2015). According to Gillingham et al., (2015) diminishing trend of energy consumption, without lowering the living standards on households side and decrease in production quality on firms side, is called energy efficiency.

Schurr, (1982) defined energy efficiency as produce more with the same or produce same with less inputs is called energy efficiency.

1.2 Types of Efficiency

There are different types of energy efficiency, some are discussed here. First type of energy efficiency is productive efficiency. It concerns the optimal level of inputs for producing goods at lowest cost (Schurr, 1982). Second, type of energy efficiency is allocative efficiency. It concerns with optimal distribution of goods and services where social welfare is at maximum level (Christopoulos & Tsionas, 2002).

Third type is dynamic efficiency in which the pace of innovations, improvements in the range of choice for consumers, reliability, performance, and quality of goods and services improve over time (Mankiw, 1986).

The most desirable efficiency for future generations is community efficiency. This is the best supply of capitals among economic agents, considering all outside and inside expenses and welfares. Social efficiency exists where marginal social advantage also equals marginal social price (Lefeber & Vietorisz, 2007). In recent years air pollution global warming, and similar environmental issues have forced the government to implement the sustainability tasks seriously in the industrial sector (Freire-González, 2017). Government of Pakistan motivate the industrial sector to follow energy efficiency programs (Javed & Rizwan., 2016). Such programs are established to reduce energy consumption of primary resources like; natural gas, oil, coal, and electricity. Furthermore, policies such as subsidy schemes or energy taxes are used to control energy consumption in Pakistan (Khalil & Zaidi, 2014).

Sometimes governments bring energy efficiency by imposing taxes on energy. By doing so, prices of energy increase but it might halt or lower the production process in the short-run and development path in the long-run (Dasgupta & Roy, 2017). Fiscal authorities bring social efficiency forcefully in such cases. Last type of efficiency is non-price induced efficiency. It is also called technological efficiency. A firm is said to be efficient if she gains maximum output with minimum inputs (Birol & Keppler, 2000). In our case, study are going to analyze the impact of technological efficiency or non-price efficiency of energy on energy consumption and output in selected energy intensive industries.

1.3 Energy Efficiency and Energy Rebound

It is a myth that energy efficiency is the prime source of energy savings. But efficiency improvements don't achieve expected energy savings goals. It is because advancement of energy efficiency lowers the prices of energy which further enhance energy consumption. The more consumption of energy due to energy efficiency is called the energy rebound effect. This incremental energy consumption comes through two channels a) output effect and b) substitution effect. In literature, output effect also called growth effect and substitution effect is basically energy intensity (Saunders, 2008). In narrow perspective output effect is supply side while substitution effect is demand side phenomenon. Form these two channels the expected energy savings is offset by extra energy use (Dasgupta & Roy, 2017). Technical advancement is measured as a cause of energy efficiency. Energy efficiency comes through the improvements of technology and it is helpful to control industrial energy consumption (Javed et al., 2016).

The energy efficiency (technological change) has a significant effect on the suspension of particular problems like as energy safety, high rate of dependency, climate change and technology (Gillingham et al., 2015). This goal achieved some stages such as, normalizing the electrical appliances used at household and in manufacturing, house designing, improving buyer attentiveness, and duty and encouragement programs.

1.4 Size of Rebound Effect

Consumption of energy services increases due to energy efficiency is called energy rebound in literature. Technological efficiency lowers the price of that energy service and this low price motivate for more demand (Saunders, 2008). The size of this increasing demand must be obtained a value that we are going discussed in following lines. Value of energy rebound depends upon nature of energy and it varies from society to society. First time in history, the concept of energy rebound effect was given by Stanley Jevons in 1865 (Economics, pp.126 (2017). Jevons found that the new efficient steam engine required low quantity of coal for same work and this reduction of coal quantity lower the prices of coal (Ficano & Thompson, 2014). This nothing means people easy to coal, but in this situation coal also cheap for new uses therefore, the coal consumption rise. Energy rebound effect is linked with buyers' tendency to use more energy due to economic gains of efficiency improvements (Dasgupta & Roy, 2017). For example, whenever the cost of passenger

kilometer PK reduced with fuel-effective cars, travel more in term of PK (Ficano & Thompson, 2014). In simple term, cost reductions motivate the individual to increase consumption. According to Flues, RRbbelke, & VVgele, 2013 rise in energy consumption due to low prices and people harm the expected energy saving path. Ficano & Thompson, (2014) discuss that energy efficiency lower the marginal cost of energy and it leads to raise the energy consumption. For example, when the cost of traveling is low then, passenger travel extra and drive long. An increase in the uses of energy services can offset the predictable or expected decrease in energy uses or savings. Now in general those certain degrees of energy rebound are discussed. Let, a five percent improvement occurred in energy efficiency but energy savings are only three percent, than remaining two percent is energy rebound.

RE> 1	Backfire (i.e., greater than 100%)
RE=1	Full rebound (i.e. hundred per-cent)
$0 < RE < 1$	Partial rebound (less than hundred per-cents but greater one percent)
RE=0	Zero rebound (zero per-cent)
$RE < 0$	Super conservation (energy saving gain) (Saunders, 2008).

Furthermore, if zero percent energy rebound effect then hundred percent achievement of energy saving, while the hundred percent of energy rebound means zero achieve in energy saving goals. In case of backfire the magnitude of energy rebound effect is greater than hundred percent (van den Bergh, 2011).

1.5 The Direct Rebound Effect

Basically, direct rebound effect is extra consumption of energy when price of energy lowers after positive technological change. From microeconomics perspective, it is also called price effect. Generally, price effect is varying from fuel type and from society to society.

The effect of decrease price of energy on its consumption is also own price elasticity. Price elasticity differ by product to product, depending on the customers response to price change, replacement of substitutes or technical change (Z. Wang & Lu, 2014). For example, after the oil shock of 1970s, automobile industry moves (via research and development) towards oil

efficient cars. As oil prices fell down in 1980s car industry offered powerful and better cars (luxury 4 wheels or sports cars) with the same passenger kilometer cost (Ficano & Thompson, 2014).

1.6 Indirect Rebound Effect

The second effect of energy efficiency is indirect effect. When price of energy decreases it means cost of energy also move downward at micro level so it enhance the demand of other energy related appliances which further increase the demand of energy (Wu, Wu, Huang, Fu, & Chen, 2016). Additional energy may use by a consumer in such ways: drive quicker, buy energy intensive products, enjoy fast food and may prefer private transport instead of public transport. Or consumer may also enjoy foreign trips after savings through low energy price and it again increase the fuel consumption (Freire-González, 2017).

In simple word we can say that the lower energy price, more income is available to spend on other products and services such as holidays which involve consuming energy. Indirect rebound effect come from two different source (Stapleton, Sorrell, & Schwanen, 2016) (1) energy content: this is the required energy to produce and implement the measures that improve energy efficiency. (2) Secondary effect: this is indirect energy consumption from energy efficiency improvement and they arise after the implementation of the measure, and as a consequence of it. Energy efficiency improvements may also change the quantity demanded of other goods and services. These changes in consumption patterns will impact energy use and emissions at each stage of the relevant supply chains. From a global perspective, these changes may either offset or add to the energy and emission savings from the energy efficiency improvement depending on whether the quantity demanded of the relevant goods or service has increased or fallen.

1.7 Economy wide effects

Economy wide effect due to long term changes in the economy caused by technological innovation, change in consumer preferences or social institutions bought about by the substitution of energy for other factors of productions (Barker, Dagoumas, & Rubin, 2009). Most probably the greatest effect (in the long term) of lower cost of energy services is on the direction and pace of technological innovation and consumption in the economy (Broberg et al., 2014). New product and services will be created or purchased to exploit

markets opened up by lower cost thus creating an overall increase in energy consumption. For instance the range of uses for electric lighting has expanded greatly. For example, to sell much electricity at a low cost margin than this result is a growing market for electricity and the continual development of new electrical and electronic products and services: some historical energy consumption trend as, electric lighting in 1900s, domestic refrigeration in the 1930s, TV in the 1950s, microwaves and videos in the 1980s computer and internet in the 1990s, digital TV and home cinema in the early 21st Century resulting in an overall historical increase in energy consumption (van den Bergh, 2011). In an economy, even if direct rebound effect is zero in particular energy services, there are other factors that are in the direction to be lower than the expected value obtained from simple calculations of economy-wide reduction in energy consumption. For example, money savings provided from engine fuel consumption may lead to other goods and services which have energy requirements. This effect is called indirect rebound effect as this study discuss in early section 1.6. It will be useful to classify the indirect rebound effect as "process energy" and "secondary effect". In simple word we can say the aggregate of direct and indirect rebound effect is named the economy-wide rebound effect.

At disaggregate level, relatively industrial sector is consuming more energy as compare to other sectors of Pakistan (Khalil & Zaidi, 2014). Due to Pakistan's developing stature and the features of industries energy uses, particular vital factors would be taken into account while we reviewing the energy rebound effect from the industrial viewpoint in Pakistan.

The growth level and economic organizations differ from region to region because of the huge land of Pakistan. Therefore, local difference can't be ignoring. And other things, energy are used in a primary and in a secondary way by industries. Energy consumption in electricity, natural gas, fuels and coal of industries can be described as primary energy use. Secondary energy use of household discusses to the energy use in the transport and discarding of goods and services. Energy effectiveness (EE) is key to certifying a safe, dependable, inexpensive and supportable energy system for the future (Su, 2019).

Economies of scale are distinguished into the real economies and strictly pecuniary economies of scale. Pecuniary economies are the economies realized from paying the lower the price from the factor used in the process of productions and the product distributions, due to Bulk-Buying by the firm as its size increased. Such strictly monetary economies do not imply an actual decrease in the quantity of inputs used but accrues to the firm from lower

prices paid for raw materials, lower interest rate as the size of the firm increases, or lower the wage and salaries of labor (Becker, 2014). Pecuniary economies scale can be beneficial to society when they reflect economies of scale in the supply of input. For the example, if the firm grows larger and increases its order from supplier, the supplier may now be able to enjoy lower the cost through the economies of scale. Any subsequent lowering of price by supplier to the purchasing firm will create the pecuniary economies for that buyer. The purchasing does not achieved economies in production itself, but now they enjoy the pecuniary economies because the larger orders allow supplier to be more efficient and lower their cost,

The focus of current study is on the direct energy rebound effect, which is the additional energy use attributable to raise energy services demand when the implicit price of the services decreases as a result of an energy efficiency (technological advancement) improvement, and the indirect energy rebound effect which is increase in consumption of energy from change in the consumption of the others services and goods due to improvement energy efficiency (technological advancement) in the product of interest. Much of the literature discussing the microeconomics of the energy rebound effect is focused solely on estimating direct energy rebound effect. This study follows the traditional literature by conceptualizing energy rebound as a change in consumer energy consumption while energy efficiency (technological advancement) exists.

1.8 Statement of problem

In literature energy efficiency is considered as a source of blessing for sustainability of environment, and lowering the energy demand. But in reality, toward energy rebound effect, energy efficiency does not provide targeted or expected results. Energy efficiency is almost supply side phenomenon while rebound effect of energy efficiency is totally demand side problem. In this study we are going to analyze the naive behavior of demand side that restrains the supply side to achieve its targets goals via energy efficiency. To check the energy rebound effect, this select three main energy intensive industries of Pakistan. These industries are main contributors in terms of industrial output as well in terms of energy consumption.

1.9 Research Objectives

1. The main objective of this study is to measure energy rebound effects separately for each industry.

1.10 Locale

Researcher investigates the impact of energy efficiency on its demand in industrial sector of Pakistan. For this study take three representative industries steel, cement and fertilizer. Because these selected industries are energy intensive industries and consuming large share of energy of industrial sector.

1.11 Significance of Study

Study will help to formulate the future energy and environment related policies to achieve desirable or sustainable goals. Moreover, study open the new avenues of research related to energy-economy-environmental (3E) issues specifically in case of Pakistan.

1.12 Organization of Study

The rest of study is planned as follow. Chapter two is the literature review of existing literature related to energy efficiency and energy rebound effect. Chapter three explains the theoretical justification of energy rebound effect. While chapter four presents the model, methodology, and data related to our study. Moreover, in same chapter we also derive mathematically that, how technological efficiency brings output and rebound effect for short run and long run separately. The results and discussion are present in chapter five. In last chapter of this study, we provide conclusion and relevant policy suggestions for better policy making.

CHAPTER 2

Literature Review

2.1 Introduction

Many quality empirical studies have been conducted on the theme of energy rebound effect at aggregate and disaggregate level. Consequently, this segment is dedicated to go through the previous studies at international level. At national level, the empirical literature on the same topic is missing or not available on sources. Remaining section starts from latest studies to oldest one.

Literature of Developing Economies

According to Du & Li, (2019), energy efficiency is one of the source of reducing energy use. It can helpful to resolve the major challenges related to fossil fuels like; limiting carbon dioxide emissions to mitigate climate change, lowering local air pollution to yield health benefits, and enhancing the security of energy supply. The rebound effect has drawn considerable attention in recent years from energy economists and policymakers. However, the measurement issues related to energy rebound effect are quite controversial because of the differences in the definitions and methods used. This study developed an improved approach of energy rebound effect by incorporating energy efficiency. The advantages of the proposed approach are in two directions. This approach is easy to estimate in terms of demand elasticity of energy with respect to energy price. Second, through this approach they decompose direct rebound effect into substitution and output effects. By doing so, study enables us to better understand the energy rebound effect. Applying this method, study assesses the direct energy rebound effect in China's industrial sectors. They find that the direct rebound effect for the industry is 37.0 percent.

Wei, Zhou, & Zhang, (2019) suggested that improvements in energy efficiency (technological advancement) are suitable technique to reduce the reliance on energy. Whenever advancement in energy efficiency will not reduce the energy consumption than overall reduction in economic activity is called for energy rebound effect. This study statistically finds the direct energy rebound effect in case of China. Study use the Cobb

Douglas production function to find out the rebound effects of energy for forty provinces. Study taken the time series data form 1996 to 2009 for different provinces of China. These studies indicate that the energy rebound effect highly affected by these forty provinces at industrial level. Furthermore its range varies low to high over time. Wei et al conclude that China energy rebound effect significant and its magnitude reached to 84% in the short-run while 146% in the long-run.

Chan & Gillingham, (2018) investigated energy rebound effect and its circumstances on welfare in terms of environment. This study also discussed and explores the theoretical behavior of demand side that plays a key role to determining the energy efficiency that cause energy rebound effect. Study employed a generalized model with the help of microeconomics theory to highlight the economic implications of energy rebound effect. Study taken time series data set from 1995 to 2015 and find out the energy rebound effect. Gillingham formally estimate short run energy rebound effect and conclude the energy efficiency cause for energy rebound effect. Study result indicates that energy rebound effect varies low to high range and its magnitude was more than 20%.

J. Zhang, Lin Lawell, & Lin, (2018) considering the crucial role of industrial sectors in energy conservation, this study investigates the impact of energy consumption on output growth in China's industrial sectors with the index decomposition model and find out the energy rebound effect in the industrial sectors with the use of annual panel data from 1994–2012. This study result shows that the industrial output growth is proved to be the major factor in promoting industrial energy consumption, while energy intensity reduction and structure shifts across industrial sub-sectors play the dominant roles in slowing down industrial energy consumption. Second, there are exist energy rebound effect in China's aggregate Industries. In particular, the energy rebound effect in manufacturing is relatively lower during the sample period. Finally, the energy rebound effect between China's aggregate Industry and manufacturing exhibit an overall decreasing trend over time.

The energy rebound in road transportation in China studied by (Hymel et al., 2018). Now the transportation’s policies are linked by various common effects. First one is effect is rebound

effect of energy in which technological advancement that increase oil efficiency may reduce the per kilometer oil price of the driving and therefore a rise in cars usage. Second effect is induced demand effect for traveling. Now the rise in highway ability traffic, maybe people ore traveling because there journey are faster. The reason is the rebound effect of energy; oil efficiency advancement saves the smaller amount oil than in the situation of unchanged traveling demand. So, the both reaction effects are example of extra universal phenomena offsetting performances. This research work directly captures the rebound effect of energy and induces demand for different ways. Study collects the data randomly and employed the vehicle mile travel model to find out the energy rebound effect in transportation. Study outcome indicates that the oil consumption is greater in urban areas as compare to backward areas the reason is in urban areas road infrastructure is better than the backward areas. So, rebound effect in urban areas is high as compare to backward areas. Now transportation system need much intention regarding energy rebound effect. According to Hymel government need to make some different policies where people consume less energy but output are not effects.

Rebound effect of energy indicates the idea that the few of the expected energy saving cause by the energy efficiency advancement (technological change) are leave. This reason is energy services demand highly increased as the prices of these service decreasing after the energy advancement (technological advancement) progresses. In 2018 Greene measure the energy rebound effect in construction sector of China. Government of China later 1980 has become one of the priorities building energy efficiency. The fresh created housing constructions to attain energy efficiency advancement in thirty percent phase by phase grounded on the construction energy consumption circumstances in 1980 to 1981. Energy efficiency design standard of China has continuously preserved as the base of countrywide conservations of energy industrial investment and planning. This study find out the rebound effect of energy in case of China city and villages housing areas, and further find out the housing energy consumption through the primary data analysis, measuring the exact impacts of rebound effect of energy on housing energy consumption and the conforming housing energy conservations in China. When author regress the data than this outcome shows that the rebound effect of energy was exist.

Peng, & Su, 2018) investigated rebound effect of energy in passenger road transportation in case for China. Now the China is biggest emerging nation in the world has knowledgeable a successful economy for the last nineteen years wherever the consumption of energy have risen histrionically, under position extra burden on China's reserve that denote to China primary controlled consumption of energy in near to 4.8B. The transportation sector of China looks a major energy consumer and shows a positive role in energy conservations. Reduction of transportations sector energy also linked to the energy efficiency improvement. This study estimation the energy rebound effect in case of direct rebound in road transportation sector in the all-state respectively on the data for thirty states from 2003-2012. Study statistical results indicate the energy rebound effect in case of direct are exists in the roads transportations sector. Furthermore, its range in short run and long run near to 28% and 32%. Study indicate direct energy rebound effect vary low to high trend. Lastly they argue the strategies of energy efficiency in road transportation sectors are not too good, government need much intention for rebound effect of energy to awareness for give the people to use effective commodity.

According to Su, (2018) whenever the energy rebound effect exist then people are offset the expected energy saving. This study main objective was to discover the domestic energy rebound effect in case of China. They randomly collected the local energy input and output data set of China. Formerly, they examining the econometrics technique, both output and input investigation and take the Cobb Douglas production function. This study outcome indicates that energy rebound effect exists and its magnitude was varying for different provinces of China. Qinghai is also the supreme susceptible region and here energy rebound effect are sixty nine percent of his economics areas might be backfire effect exist. There are two commercial zones has the probable to reason backfire effect in 13 states. More, the China's Govt and its local government would take complete explanation of the provincial difference whenever expressing the energy reforms to improve the burden on the energy protection and the carbon emission declining.

H. Wang, Zhou, Zhou, & Zha, (2017) investigate and conclude energy rebound in case of China's constructions industries. This manufacturing industry is also considered as major energy user and carbon emitter in case of China. For this China did serious effort to advance energy efficiency to protect the energy but on other hand the energy rebound effect alleviates

its efficiency. The study is based on significant connection among the input capital, technological variation, economy growth, and energy uses, adapting alternative estimate the energy rebound effect in case China for the constructions industries. This research work randomly collects data and furthermore, findings of study confirmed that there exists energy rebound effects in building manufacturing industry of China. But it is declining over time that is positive sign for future generations. This study indicates that approximately half of the potential energy saving by technological changes is achieved. They conclude that the proper energy pricing reforms and energy taxes should be implemented to promote sustainable development in the construction industry.

According to H. Li, (2017) China is a developing country in industrialization phase with population growth, economic development, and improving the living standard. Definitely the demand of energy will rise in the coming decades. So, improving energy efficiency is of energetic importance for energy conservation and CO2 emissions deduction, and Chinese government shown growing concern about those issues. cost of energy services decrease will lead to making the rebound, and opposite side supply of these services likewise increments when efficiency improves (technological progression) in the utilization of a physical energy. This study was involved to consider both cost and money changes in markets of energy supply. The energy consumption effects and this effect may become acknowledged hypothetical comprehension for energy rebound effect. Specifically, lower costs of energy markets may show the zero energy rebound effect while more significant expenses of energy markets show on the 100% energy rebound effect. Study discovers the potential energy is descending weight on economy wide energy consumption, from rising efficiency underway or consumption exercises. The normal energy saving through energy effectiveness is leave due to the rebound effect of energy. Concentrate and used econometric method to gauge the direct energy rebound from 1993-2009. They discover the magnitude of energy rebound was reached to 88% and furthermore, they indicate rebound effect trend is declining over the time. They indicate rebound needs to be considerations in evaluating energy efficiency measure on reducing energy use in different countries.

According to Zhang et al., (2016) improving energy efficiency sustainability is a target of Chinese government. However the effectiveness of energy conservation policy is affected by

the energy rebound effect which energy efficiency improvement reduced the effective price of energy services, thereby the completely or partially offsetting the energy saved by efficiency advancement. Based on the output distance function, this study develop estimation model of the energy rebound effect, which is logically consistent with the quantities of energy rebound and energy saving induced by technological progress. This study find out the aggregate of energy rebound effect of industrial sector in China over 1998-2011 is 88 percent.

According to Z. Wang (2014) energy is one of the important useful key variables in any economic events. Its conservations are energetic for poor energy nations i.e., China are huge consumption of energy state such as India, Europe and China. Currently energy efficiency is important input variable in any production of firms, which stay proper in economic events to produce output. Energy efficiency advancement considered as the one of the important methods for conservation of energy and further donate and refer to whole world to consume same energy but produced more goods. Study employs the Cobb Douglas production function to estimate the energy rebound effect for forty regions. Study take econometric technique like cointegration and (ECM) to find the direct energy rebound effects. These research work outcomes argue that energy rebound effects exist in town housing. Furthermore, they indicate the long-run energy rebound effect is seventy four percent, on the other side seventy two percent energy rebound effect over the short run. So, the energy rebound effect profoundly damage for energy efficiency programs. Study suggest that, Chinese local administration takings the rebound effect into the serious consideration when they making energy efficiency policies.

According to Belaid, Bakaloglou, & Roubaud, (2014) transportation is like a lifeline of economic growth and economic development, and similarly a major component of the energy, facilities and safety structure will lead to strong growth of whole country and its economy. Refining the energy efficiency (technological advancement) has measured an important method to decline transport consumption of fuel. While, the efficiency that drop transport expense might be cause to incremental energy use. Example, like as direct energy rebound effect. Study delivers a serious consideration of direct energy rebound effect, further they used error correction model to find the short run outcomes and further long run impact

investigate through the dual logarithmic regression and estimate the direct energy rebound effects reached to twenty five percent. Study uses the China provinces panel data set from the 1999-2011. The investigational results indicates that there is strong impact of energy rebound effect and its magnitude reached to twenty five percent in long run. Study suggests that energy rebound effect also disturb the whole country transportations system. Study indicates its magnitude of different provinces as 84%, 52%, 80% and 78%. A conventional of the expected energy reducing after effectiveness of energy improvement (technological advancement) might be leave cause to energy rebound effects. They suggest self-governing strategy of improving energy efficiency is not as the effectively as public probable. On the short-run aspect, a small super conservation impact occurs in Chinese road. Further they indicate that direct energy rebound effects for road cargo transport will lead to reduction of economic growth and economic development.

According to Liang &Qiedet, (2013) China has set an optimistic target to dropping its carbon intensity in 2020. Rising in production through the energy efficiency is the effective technique for attaining that target. Study main objective to estimate energy efficiency and the rebound effect. Researcher used the general equilibrium model to estimate the energy rebound effect. Study also concentrates how energy subsidy reform can lessen the rebound effect. Study outcome show that there is exist energy rebound effect in China and its magnitude was greater as compare to primary energies. Study suggests that dropping fossil energy subsidies, the rebound effect would be effectively moderated, and dropping all subsidies causing for decrease the rebound effect.

According to Lin & Liu, (2012) rebound effect of energy denote the idea that all or some expected energy saving due to energy advancement (technological advancement) were leave. The caused is that the energy consumption demand increase as effective price of these services reduced after the energy advancement (technological advancement) improved. The government of China in 1980 has become one of the main concerns building efficiency. For this purpose newly constructed buildings should achieve energy efficiency advancement by thirty percent phase by phase in 1980-1981. This study main goal was to find out the energy rebound effect in case of Chinese rural and urban areas. Researcher collects the primary data from different urban and rural areas. Furthermore, this study outcome indicate energy

rebound effect exist in both urban and rural areas. Study result show that the rural buildings energy rebound effect is larger than the urban residential areas.

Xie, & Tue Lin, (2009) study introduced the fundamental condition of growth economic, consumption of energy and other factors of inputs in case of China's foods manufacturing industry and find out the structure of the input factor to use the equation of DOLS_SUR statistically framework. Instead, based on estimated econometric model effects, they evaluated the substitution effect between input variables, and measured the indirect energy rebound effect of the energy inputs. The outcomes indicate that the substitutions relationship among the energy consumption and others input variables, where the energy-to-labor price elasticity of substitution (PES) is the highest, and the 1.5. It means 1 percent rise (decrease) in the energy price would result in a change in the L / E ratio of more than 1.5 percent, and vice versa. The association among the rebound effects and substitution effect was recognized in calculated formulation, and they confirmed the shrewdness of using elasticity of price energy also represent the energy rebound effect instigated by the substitution of inputs factors. For estimation, the direct energy rebound effects are divided into replacement effects and outputs effect. There are substitution interaction among energy input and other input factor like capital and labor in China food industries. According to the researcher, replacing energy with other factors is an appropriate solution for the purpose of energy conversion. On one side, the prices of energy input should be brought up; on the other side, a feasible solution is to eliminate the cost of others inputs factor. The elasticity of substitution among resources and labors is relatively higher, so reducing labor cost by maximizing the manufacturing process and increasing management performance is a viable solution provided that workers' and income stay unaffected.

In Case of Developed Nations

Greene (2017) investigated energy rebound effect for transport sector of US. For this, study used household vehicle travel data for over the period of 15 years. They verified the hypothesis mostly customers responds homogenously to given variation in fuel price per mile, even due to price change and fuel economy change. Study indicates positive response in form of more energy consumption due to energy efficiency. The findings of study have

important implication for policy purposes. Author find out improvement in fuel economy cause of small rebound effect, furthermore technical invention and supervisory morals can be effective in reducing for fuel consumption.

Freire (2017) investigated the indirect and the direct rebound effects of energy in EU's_27nations. Some progress was done over the last years in providing new methods to find indirect rebound effects form energy efficiency in different areas. More empirical evidence is necessary for research community and policy-makers to understand the limits of energy rebound effect and provide suitable measures to avoid it. Study uses the hybrid model to measuring the energy rebound effect. This examination leads a find the indirect and also the direct rebound effects in household of EU_27 nations. As indicated by author there are some inconsistencies in EU27 nations, author employ the ARDL technique to evaluate the rebound effect in EU27 nations. This examination result shows that seven total out of twenty seven nations has indirect and direct rebound effect more than hundred percent are exist over the short run and long run. This study suggest that for low estimations of the direct rebound effect, the indirect rebound effect have a large range of values that should be analyzed depending on the economic scenarios which could lead from low to high energy rebound effect. On the other hand, high result of direct rebound effect provide less variability of the indirect rebound effect converging to hundred percent. This is due to the fact that, if a high direct rebound effect is estimate close to hundred percent there is therefore is low room monetary saving to be consumed in other goods and services, or if direct rebound effect is low, there is large amount of money saving that can consume in other goods and services with high or low potential to direct and indirect rebound effect.

According to Liu, & Du, (2017) potential energy savings resulting from cost-effective energy efficiency improvements may be less than the originally expected because efficiency-induced price decreases cause to encourage the consumption of energy services, boost productivity, increasing the output and potentially effect energy use throughout the whole economy. In which economics, this phenomenon is also usually called rebound effect. In second way they defined the rebound, the actual energy saving from energy improvement may be less than expectation because of behavior response of micro units which is named rebound effect. In this study they want to explore the impact of marketization on rebound effect. So, they use

partial linear co efficient panel data model and they found that about 20% of originally expected energy conservation from energy improvement caused the rebound.

Gulried & Lord, (2016) conduct and analyzing energy rebound effect in private automotive transportation sectors furthermore, gain of energy efficiency also linked with fuel efficiency standards improvement. Purifying the energy efficiency (technological advancement) has measured an important technique to decline transport consumption of fuel. While, the efficiency that drop transport expense might be cause to increase in energy consumption. In this study they estimation transport energy rebound effect in case of USA and using the primary data set year of 2009. They find that a one present reduction in driving cost seventy eight percentage rise in automobile miles traveling, through the effect extra marked in single than multiple automobile families and between motorists by the lowest traveling power.

According to Greene, (2015) when decreasing the fuel price, than the vehicle efficiency reason to increase the traveling demand, so leaving the amount of energy savings also produced to a rebound effect. This study analyze USA vehicle per miles travel over the year 1966 to 1989. Study delivers a serious assessment of direct energy rebound effect, further they used error correction model to find out the short run effects, and further long run impact investigate through the dual logarithmic regression. Study estimate the direct energy rebound effects reached to thirty percent at regional level. Study uses primary data set of USA from the 1966-1989. The experimental results indicates that the characteristic of the long run, a limited energy rebound effects exist in the USA road transportation sector and further this size of energy rebound effect disturb the whole country transportations system. Study indicates its magnitude of different states as respectively 90%, 55%, 45% and 33%. Study analyzing of statistical issue that bears on the size of the energy rebound effects together with the error correction model and functional form. They indicate that the energy rebound effects has been smaller or lesser. The finding of this study, suggest that the energy saving were offset and fuel economy efficiency advancements in vehicles will be caused by increase vehicle travel.

Liu et al., (2015) investigated same study as above in different country. Now the energy efficiency is a serious approach for reduction in carbon emission and reduction in oil consumption in different vehicle. All main auto industries economies in the whole world have accept the similar from of fuel economy or greenhouse gas emission normal for all vehicles. Energy efficiency means technological advancement in manufacturing industries cheap the commodity price of energy services and thereby reassures greater consumption of energy services. Energy consumption improved take back similar of the possible discount in consumption of energy and so might be a significant cause of effectiveness of energy efficiency advancement a means of dropping greenhouse gas emission in transportation. The simple economics reply has been called the rebound effect of energy and the considerable previous studies have attempted to estimate it. Study use the vehicle traveling time series data of U.S over the period of 1966 to 2007 and estimate the energy rebound effect through the ARDL technique and estimate its magnitude in transportation. Study outcome indicates statistically significant effect the price of gasoline on vehicle traveling, but not being impact of direct energy rebound effect in oil efficiency on vehicles traveling.

Gillingham et al., (2015) investigate rebound effect of energy and its consequence on energy efficiency strategies. The objective of this study is to more clearly define the rebound effect in the circumstances of energy efficiency advancements, with clarifying its many channels. They differentiate between rebound effects from a complimentary exogenous energy efficiency improvement. The discussion about the size of the rebound effect moves on and has significant suggestions for energy efficiency program. Study uses the time series data from 1986 to 2010 to estimate energy rebound effect. This study has tried to notify this debate concluded three main contributions. First they presented the main conceptual distinction between a rebound effects related with costless energy efficiency advancement. Second, they have clear the empirical literature on the microeconomic rebound into the manageable number of the estimates that they believe the most reliable. And last one is, they try to clarify the nature of the macroeconomic rebound and presented an approach for conceptualizing or capturing the size of the rebound effect. The macroeconomics energy rebound effect, first one although there is some markets are macroeconomic price effect may be substantial, it must always be less than 100%. Secondly, the rebound based on sectoral reallocation is likely less than the price effect because, energy is more likely to be a complement rather than substitute for other inputs in production. Finally, the little is known

about the effects of induced innovations and productivity on the rebound effect, beyond observing that such development would almost certainly is welfare increasing.

Lin et al., (2015) study introduced the basic situation of economic growth, energy consumption and other input factors in China's food industry, and estimated the input factors' share equations system within the DOLS-SUR econometric framework. Study analyzed the substitution effect between input factors on the basis of estimated results of econometric model, and calculated the direct rebound effect of energy inputs. The outcomes indicate that: there exist substitution relationships among energy and other input factors, in which the price elasticity of substitution (PES) between energy and labor is the largest, more than 2. This means that, 1% increase (decrease) in energy prices will lead to more than 2% change in L/E ratio, and vice versa. The relationship among the substitution effect and the rebound effect was established in mathematical formula, and they verified the rationality of using own-price elasticity of energy to represent rebound effect caused by substitution of input factors. The direct rebound effect was divided into substitution effect and output effect for estimation. In China's food industry, there exist substitution relationships between energy inputs and other input factors such as capital and labor. According to author, for this purpose of energy conservation, replacing energy with other factors is a feasible solution. On one hand, the price of energy input should be raised; on the other hand, reducing the costs of other input factors is a practicable solution. The substitution elasticity between energy and labor is relatively higher, so it is a feasible solution to reduce labor costs by optimizing the production process and improving management efficiency given that the wages and salaries of workers remains unchanged.

According to Santin, (2013) occupant behavior in energy efficient residence, the energy required for space heating has been significantly reduced in recent decades by making use of insulation and more efficient heating and airing systems. The main objective of this study was to find out energy rebound effect in energy efficient houses of Netherland. This study statistically find the differences between occupant behavior and buildings features of the accommodation standard in the Netherland and highlight the expected energy rebound effect existence in which consumption on space heating. Many authors defined energy rebound effect by different ways but in this study they defined in simple words 'rise in consumption of

energy in services whenever technological advancement occurs in energy than also will lead to decrease the cost of energy'. Study uses the panel data from 1980 to 2005 and analyze in SPSS statistical software. Study outcome indicate consumption of energy are lower in the energy effectiveness houses, investigation of the behaviors variable show that their occupant tend to favor larger inside temperature and the ventilate low. Study conclusion also shows the energy rebound effect were existing's in different societies of Netherland.

According to Wang et al., (2012) increasing energy efficiency has been broadly regarded as one of the best ways for decreasing fossil energy consumptions. Traveler transport consumption of energy in Hong Kong rise quickly in the last some decades and consumption of energy reached to 19.7% in 2008. The main objective of this study to measuring the energy rebound effect in road transportation sector of Hong Kong. Saving of energy people expect due to energy efficiency was offset because energy rebound effects do not save energy. In another way author explain the energy rebound effect 'normal energy saving through energy effectiveness were leave due to the rebound effect of energy. This study used the general equilibrium model to estimate the direct energy rebound effect for private passenger transport in Hong Kong. For this purpose study takes the data from 1993-2009 for the private passenger transport in Hong Kong. Study outcome indicate energy rebound effect exist and furthermore its magnitude reached to 45% and its trend declining over the time. Study suggests that the energy rebound effect needs to more consideration in assessing the impact of energy efficiency measure on reducing energy consumption in Hong Kong.

The kindness of the rebound effect in private transport studied by (Frondel, Ritter, & Vance, 2012). The study explains the energy rebound as an increase in fuel efficiency ultimately reduces per unit cost of driving, their performance in removing emissions can be compensate through raised travel demand. The animations of this known as the energy efficiency overcome. Study used panel data to estimate and used quantile regression methods on travel data for households in Germany 1997-2009. They find out energy rebound effect exist and its range 57% to 62%. While the quantile regression results of this study suggest that the size of the calculated fuel price elasticity from which rebound effects can be derived therefore rebound effects that are significantly larger than those for high vehicle mileage households.

Kingston, (2011) investigate the study for renewable energy in case of Japan. The main objective of this study was to analyze the issue related to energy problem face by the Japanese manufacturing companies. This study used the computable general equilibrium CGE model. Study outcome indicate that the manufacturing industries which has a heavy reliance on the energy were badly effect by the energy crisis. Study found that the different manufacturing industries like steel, cement, paper and printing and wood had to cut their output severely only due to energy crisis. On the other hand some others industries like textile, transportation equipment and electric equipment do not affect by the energy crisis.

Hymel et al., (2010) conducted the study to examine the impact of driving cost on congestion. The main goal of this research work was to estimate aggregate energy rebound effect in transportation sector in case of USA. This study estimate energy rebound effect in circumstance of U.S over the period from 1966 to 2004. Study used the CGE model to estimate energy rebound effect. Findings of this study indicates that the increasing of income also negatively affect the demand for driving. Whenever, energy price reduced through technological advancement they will also lead to more consumption of fuel. Reducing the energy price also effect the customer behavior and its consumption pattern. Through price elasticity of fuel study capture the rebound effect. Furthermore, study used VECM to identifying the short run dynamic of energy rebound. Study result show that energy rebound effect is highly effect in transportation sector. Study suggest that the indirect energy rebound effect is higher than the direct energy rebound effect and its magnitude reached to 78% and 44% in the long run and in the short run it magnitude reached to 55% and 23%.

Do energy efficiency causes for increasing consumption of energy? The effect named rebound effect of energy in the literature. Past research work has broadly focused on only part of the world economy to study rebound effect of energy for the example, household energy consumption. Now the global economy is highly joined among the industries, these researches may lead misleading conclusion if the energy rebound effect in the rest of the economy are significant(Wei, 2010). Saunder (2008) estimates the demand sides by taking worldwide economy as a whole. Wei (2007) gives a general examination through Cobb-

Douglas production for the world economy. This investigation expands Wei (2007) generals examination to discover rebound effect of energy from an viewpoint of economist by taking the world economy as a whole and employ the forms of production function. This research work delivers the new perception related to the energy rebound effect.

Freire González (2010) conducted the study to measuring the direct and indirect rebound effect in households EU-27 countries. Study main object to show the existence of energy rebound effect. For this purpose study takes the Panel data set from the period of 2000-2012. Author estimate the energy rebound effect through hybrid model and statistically this study outcome significant over the long and short run. Formerly, they investigation taken the econometrics technique, both output and input investigation, they behavior a meticulous examination of together the indirect energy rebound and the direct energy rebound from the national viewpoint in case of the EU-27 under a combined investigation framework. This study result indicates that is the positive and the significant differences in the danger liability concerning the energy rebound between the different countries. Germany was also the supreme country in EU-27 region and sixty percent energy rebound effect was exist in which country.

Tomer & Rasmusse, (2010) investigate energy rebound effect and its consequences on energy efficiency strategies. Does technological advancement to increase the energy efficiency using the product and system lead to reduce the consumption of energy and reduced the environmental effect? Now this debate finally about the impact of technological change upon the economic advancement. The answer of this problem assumed by economist since the mid-19th century in no, the reason is that the direct energy rebound effect caused by the advancement of energy that reduced the price of energy frequently leading to more consumption and the furthermore indirect energy rebound effect reduce the cost of energy through energy efficiency is that the consumer may by more good and services. Therefore, only the promoting technological advancement to growth efficiency of energy is unlikely to lead to reduce the consumption of energy. Other policies like as regulation and taxation are required. This study main goal was to estimate the energy rebound effect. This research work applied the generalized method of moment methodology and EGLS. This study was taken the data from the period 2000-2010. Study was further clearly defining the rebound effects in the

situations of energy efficiency advancements. They differentiate the rebound from complimentary exogenous energy effectiveness advancement. The discussion about the size and magnitude of the energy rebound effects carries and has significant existence for the energy efficiency program. Outcomes of study indicate the magnitude of direct energy rebound effect reached to 54% or less. Furthermore the indirect energy rebound effect was reached to 41%. So, these two types of energy rebound effect can be join and estimate the overall energy rebound effect in a sector or economy, in this case total energy rebound effect reached to 95%. Overall energy rebound effect was estimate 46% and 59% of the potential energy savings gain from energy efficiency policies. Study suggests that the 95% of energy rebound effect donates to increase the customer facilities as well as to a superior economy.

Thompson et al., (2009) investigated automobile travelled in case of U.S customer automobiles for the 1970 to 1999 statistically find the energy rebound effect in consumption of fuel subsequent by improvement fuel efficiency. They established that a AR(1) model, and furthermore, they indicate the energy rebound effect in case of U.S is small and there is no significant effect log run modification, irrespective the supposed functional form from (log linear and linear). They find out the short run energy rebound effect exists but its magnitude is smaller than the long run. Its magnitude over the long run reached to thirty percent. Rebound effect of energy lead to rising in energy consumption of an improvement in the technological advancement effectiveness of carrying these energy services. These increase consumptions also leaving the expected energy saving that would be achieved. Whenever rebound effect of energy is significantly high it may be challenge the normal for the policy measure to reassure energy effectiveness. The magnitude and size of the rebound effect of energy are the focus of the long run disagreement with the energy economic. This study work carries organized earlier hypothetical work to deliver a demanding meaning of the rebound effect of energy. Study clarifies important theoretical problems and highlights the possible consequences of numerous suppositions for experiential estimations of the rebound effect of energy. Study focus only the direct energy rebound effect for the single energy services. Start with the Khazzom creative meaning of the rebound effect of energy, they representation to boundaries of three basically suppositions on which this meaning are created. First one, they claim that the capital cost from a significant portion of the total cost of provided that energy services and that experiential studies that estimation energy rebound effect from difference in energy services price is disposed to partiality. Second one, they say that the energy

effectiveness also preserved as endogenous variables or that the experiential estimation of the rebound effect of energy may necessity to use a real-time equations model to detention the dual resolve of important variables. Third one, they discover the suggestions of the opportunity cost of time in the production of energy services and best part the significances for energy use of improve time efficiency. Study discusses the suggestions of these three suppositions and debate that the numerous prevailing studies may overvalue the size of the rebound effect of energy. Study delivers a serious appraisal of direct energy rebound effect, further they used error correction model to find the short run outcomes and further long run impact investigate through the dual logarithmic regression and estimate the direct energy rebound effects reached to hundred percent.

According to Nässén & Holmberg (2009) energy efficiency (technological advancement) reduce the price of the energy services consequently, also caused to increasing consumption of energy demand. These phenomena named the price effect. Furthermore, energy efficiency (technological advancement) may be save the money which can be used for others goods and services. These phenomena called the income effect. Study investigated and find out the energy rebound effect of energy effectiveness enhancements (technological advancement) and energy consumption trend in case of Sweden. The study examines how diverse stricture expectations of energy of the energy rebound effect. Furthermore, income effect was quantified by using the data of Swedish services and goods from the period 1990-2007. Furthermore, study used the ARDL technique to estimate the long run impact and through VECM to find out the short run dynamic. Main contribution of this study was given a theory in which they discuss how people can save energy money on consumption one sectors may cause to increase energy uses in others sectors.

Akarca et al., (2008) conducted the study to analyze the relationship among the consumption of energy and economic development in case of United States. The main objective of this research work was measuring the strength of relationship among the economic development and energy consumption. The outcome of this research work there is no strong relationship among the energy consumption and economic development. However, there is some researcher showed the significant impact of energy on development and growth of a nation's economy. In case of Japan Shibata (1983) conducted the study to find out the relationship

between the energy crisis and economic growth and his outcome indicate the price of energy surge because of the oil crisis and increase the price of oil. This research work examined the period of gulf oil war when the rate of oil unexpectedly, and data taken from the period from 1973 to 1979. The finding of this research work indicate energy crisis significantly affect the industrial sector of Japan which consequently reduced the gross domestic product (GDP) of the country.

Madlener & Alcott (2007) study clarify the energy rebound is the energy utilization enabled by energy efficiency growths. Whenever, energy efficiency happens than people can have the option to purchase more energy products reason for that the cost of energy per unit has decline than this effect named income effect. The main objective of this research work was to find out the magnitude of energy rebound effect through the circumstances of income effect. This investigation also reviews some of debate about the rebound effect of energy and perspective to economic development. Study used the time series data from 1990-2010 and this research work applied the generalized method of moment methodology and EGLS. Study suggest that the efficient consumption of energy may actually through energy rebound effect will lead to higher instead of lower total consumption of energy. This research work outcome indicates energy rebound effect also affect the economic development and disturb the economic activity.

Ghalwash et al., (2007) investigated rebound effect of energy and energy efficiency in case of the Swedish households, and the important goal of this study was to analyze the exogenous technological shock, in term of an escalation and growth in energy advancement, and effect of consumption by the Swedish households. Another goal of this research work of this study also to estimate the rebound effect of energy, Study used annual time series data set from 1985 to 2005. Furthermore, study used the ARDL technique to estimate the long run impact and through VECM to find out the short run dynamic. The findings of study confirmed that there exists energy rebound effects in Swedish household furthermore, study indicate its declining trend over time that is helpful for coming generations.

Turner (2007) conducted the study on energy rebound effect in circumstances of price elasticity. If cost of energy services decrease than they lead to making the rebound, and opposite side supply of these services also increase due to efficiency improves (technological progression). This research work was engaged to consider both cost and amount changes in markets of energy supply. The energy supplier's refer to more profitability and capacity in different time as demand for their output shift may involve increasing or lowering therefore, which will further impact energy demand. In this circumstance the energy market also affect may become accepted the theoretical understanding for the rebound effect of energy. Specifically, lower energy price may confound the rebound effect of energy zero but on the other hand when energy market prices are higher may confound to the uncertainty means hundred percent rebound effect of energy. This study main objective was to gauging rebound effect of energy through the price elasticity. This research work applied the methodology of the generalized method of movement and EGLS. Now the Study was taken the data set from the period of 1990 to 2005 in case of Singapore. Study outcome indicate that the potential energy was downward pressure on economy wide consumption of energy; furthermore increased energy efficiency in production or energy consumption activities. Study indicate that the negative multiplier effect in case of energy supply, this only describe to downward pressure on energy rebound if these are considered within the actual rather than to potential energy saving.

According to Sorrell & Dimitropoulos, (2007) the rebound effect of energy lead to a rise in energy consumption an improvement in the technological advancement efficiency of carrying this energy services. This increase of consumptions also leaving the expected energy saving that would be achieved. Whenever rebound effect of energy is significantly high it may be challenge the normal for the policy measure to reassure energy effectiveness. The nature and size of the rebound effect of energy are the focus of the long run disagreement with the energy economic. This study work carries organized earlier hypothetical work to deliver a demanding meaning of the rebound effect of energy. Study clarifies important theoretical problems and highlights the possible consequences of numerous suppositions for experiential estimations of the rebound effect of energy. Study focus only the direct energy rebound effect for the single energy services. Start with the Khazzom creative meaning of the rebound effect of energy, they representation to boundaries of three basically suppositions on which this meaning are created. First one, they claim that the capital cost from a significant portion of

the total cost of provided that energy services and that experiential studies that estimation energy rebound effect from difference in energy services price is disposed to partiality. Second one, study suggest that the energy effectiveness also preserved as endogenous variables or that the experiential estimation of the rebound effect of energy may need to use a real-time equations model to detention the dual resolve of important variables. Third one, they discover the suggestions of the opportunity cost of time in the production of energy services and best part the significances for energy use of improve time efficiency. Study discusses the suggestions of these three suppositions and debate that the several fundamental studies may underestimate the size of the rebound effect of energy.

Edgar G (2005) conducted the study on the substitution effect and the income effect, as growth in energy efficiency that become cheaper as a result of the increase in demand for energy services because of a reallocation of income to this services knows the substitution effect and other side whenever the efficiency of energy occur than energy prices also cheaper than the available income also rise, so they lead to other energy consuming goods knows as the income effect. Energy efficiency advancement considered as the one of the important methods for protection of energy and further provided and refers to whole world to consume same energy but produced more goods. Study employs the Cobb Douglas production to estimate the energy rebound effect in case of Netherland. Study take econometric technique like cointegration and error correction model (ECM) to estimate the energy rebound effect. Study outcome indicate there is exist energy rebound effect in Netherland and furthermore, this impact also disturb the economic activities and creating the economic disequilibrium.

Haas & Biermayr, (2000) define the energy rebound as increase in demand of energy which result an increase in demand of service due to reduction in prices of energy. The main objective of this study was to estimate the energy rebound effect in case of Austria. For this purpose researcher take the data from the period 1980-1995 and used the different econometric technique to analyze the energy rebound effect. The outcome of this study indicate that there is exist energy rebound effect and its magnitude are not more than 15% and furthermore, some result of this study show that is not significant impact of energy rebound effect and final outcome of this study through the different econometric technique show relatively good coincidence. Study suggests that improvement energy efficiency will

lead to economic growth but rebound not do this therefore, government need to more intention for rebound.

Adjaye, (2000) investigate and conclude energy rebound effect in case of France constructions industries. Constructions industries are also considered as major energy user and carbon emitter in case of France. For this France did serious crack to advance energy efficiency to protect the energy but on other hand the energy rebound effect will not achieved this goals. The study is based on rational relationship among the capital, technological variation, economy growth, and energy uses. The findings of study confirmed that there exists energy rebound effects in constructions industries in case of France. But its magnitude is declining over time that is positive signal for producer of food industries. Study suggests that through the energy taxes and improvement of energy efficiency government should be achieved the energy saving goals.

According to Liu & Li, (2000) advancement of energy efficiency is usually observed as one of the important problems in dropping the energy usage, which can be help to identify the few main challenges linked to the carbon dioxide emission to mitigate climate change, reducing the air pollution to produce benefit of health, and improving the security of energy supply. Now the response to the energy efficiency (technological advancement) and the energy rebound effect has drawn substantial attention from policymakers and economists. Study employed the error correction model to find out the short run dynamic. Study takes the data from the period 1980-1995. Study statistical results indicate the direct energy rebound effect was exists in the industrial sector. And its range in short run and long run are 80% and 89% on average. Study indicate direct energy rebound effect vary high to low trend. The high magnitude of energy rebound is also referring the high consumption of energy. So there is trade-off between future environment and present economic growth. Lastly study suggests that the strategies of energy efficiency in industrial level are not too good, government need more intention for rebound effect of energy.

According to Greening et al., (2000) changing in technology also change the costumers preferences, alter the social institution, or the rearrange the organization of production.

According to the study technology is one of the best option to reducing the carbon emission and consumption of energy. Gain in efficiency of energy consumption also caused to reduction in per unit cost of energy services so, energy consumption will be increase (back-fire or rebound). Current study analyze US household time series data from the 1980-1990 and estimating direct, indirect and economy wide energy rebound effect. Study find out the magnitude of energy rebound effect is very low to moderate range. Furthermore, Study indicates its magnitude different time periods were different like as respectively 22%, 35%, 45% and 55%. Study analyzing of statistical issue that bears on the size of the energy rebound effects together with the error correction model and functional form. They indicate that the energy rebound effects has been higher and greater. The finding of this study, imply that the energy saving were offset due to energy efficiency.

Herring (2000) conduct the study on energy rebound in case of Germany. According to this research work energy efficiency will lead to energy rebound effect through the technological advancement. This study Ensures technical revolution also lead to improvement in energy efficiency, the use of energy and the system lead to a reducing in electricity consumption therefore, environment also affect. Main objective of this study was to estimate the aggregate energy rebound effect in case of Germany for this study used the time series data from the period 1970-1990. Study employed a generalized model with the help of microeconomics theory to highlight the economic implications of energy rebound effect. Furthermore, study used the econometric technique ARDL to estimate the long run impact and through vector error correction model (VECM) to find out the short run dynamic. The findings of this research work to indicate that there was exists energy rebound effects in case of Germany. Furthermore result show that the trend of energy rebound increasing trend.

Greene et al., (2000) conducted the study on energy efficiency and rebound effect. According to Greening expected carbon reduction caused from the technological advancement in the energy consumption also reduced these phenomena called the energy rebound effect. The rebound effect of energy and back-fire effect referred to increase in supply of energy services with a conforming reduction in effective price the magnitude of which depends on the fundamental price structure. This was turn also refer in rise in demand in reply to these price reduce, therefore, increasing in energy services demand without

leaving increase in oil price. Study used the efficiency coefficient to make the discussion or the frame and further the place the limitations of definitions through examination of statistical result for the magnitude of the rebound effect of energy. Study discussed the four different approaches and all the four approaches of the market response to variation the fuel effectiveness is the direct energy rebound effect, second one is fuel consumption effect thirdly market clearing price or quantity adjustment and last one is transformational effects. Study based on the some relevant study on U.S industrial energy consumption pattern. Study used the time series data set from the period 1970-1990. Now the gains in the effectiveness in consumption of energy also lead in the effective deduction the unit cost of energy services. As consequences, energy consumption also increased cause to rebound effect of energy. This study indicates that the magnitude of rebound effect of energy is varying high to low response of consumer behavior. When they analyze the data then they find out the energy rebound effect is significantly exists and its magnitude in indirect rebound effect is higher than the direct rebound effect. Furthermore, they indicate energy rebound effect over time increasing trend. Study suggests that the efficiency are functional to the energy services relatively the demand for fuel. There are some option to reduction the carbon emission and technological change only energy efficiency is one of the options to use the reduction in carbon emission.

According to Joyashree, (2000) back-fire and rebound effect of energy are verified the costumer behavior response to energy effectiveness development. The main objective of this study was to estimate the energy rebound effect in case of England. For this study used the data from the period 1980-1990. Study employs the Cobb Douglas production function to estimate the energy rebound effect in case of England. Study take econometric technique like cointegration and error correction model (ECM) to find the aggregate energy rebound effects. Research work outcomes argue that energy rebound effects exist in case of England. Technical advancement (energy efficiency) improve in the energy consumption would suggest enhancement in output of the input energy. In simple word study suggests that production quantity same as less energy consumption due to technological improvement in energy. The expected energy savings also leave because when productions are less due to saving of energy but do not this because reaming energy consume in other production process. This study suggests that the energy rebound effect exist whenever reduction in energy prices further they identified its impact bear to whole country.

In Case of Developing Nations

Jin (2018) conducts the study on South Korean residential sector. According to Jin energy efficiency only one source to maintain and reduced the energy consumption but whenever energy rebound occur then residential sector of South Korea not reduced the energy consumption. Study use ARDL technique to estimate energy rebound effect. Jin has taken time series data from 1985 to 2012. The find out energy rebound effect of energy intensive residential sector by using the two different scales. In macro level, estimate energy rebounds through price elasticity, while the other one micro stage, the rebound effect of energy was estimate by taking the energy intensity. Therefore, two approaches were using to find out the direct and indirect energy rebound effect. In direct estimation of energy rebound effect elasticity of energy price is use. Study statistical results indicate the direct energy rebound effect is exists in the residential sector. And its range in short run and long run are 60% and 80% on average. Study indicate direct energy rebound effect vary low to high trend. Lastly they argue the strategies of energy efficiency in household are not too good, government need more intention for energy rebound effect to awareness the people to use effective commodity.

In Pakistan, some research works were conducted to explore this field and only a few researchers conducted studies to examine the association between the economic growth and energy consumption. Aqeel et al., (2018) conducted the study for Pakistan to examine the relationship among energy consumption, economic growth. The findings of the study recommend the positive relationship among the three variables. Shah et al., (2013) examined same study in case of Pakistan textile sector. Study findings indicate the Pakistan textile industry contributes 60% to the exports of Pakistan. But due to few factors like energy crisis, inflation, instability of politic productivity of textile sector has drop. Demand for energy is associated with the energy crisis, and increase the energy cost. Therefore rise in energy price also affect the productivity of textile sector. To rise in energy price will lead to decline the productivity of textile. Study outcome indicate and suggested that the government of Pakistan can increase the productivity of the textile sector through research and development and innovations.

Nadel, (2018) conducted study on energy rebound and its causes. In simple words whenever improvement of energy efficiency in homes, industries, they convert less luxurious to work more. The rebound effect of energy is relating the response of people regarding to consumption of energy. If energy are providing in cheap price than people prefer to consume more as compare to own needs. But the other hand people consume less energy if energy price are high so this behavior also affects the demand for energy. In second phenomenon supply of energy are low prices also cause to rebound effect. Study finds out the direct and indirect energy rebound effect. Study used the time series data from the period 1990-2010. Outcomes indicate the magnitude of direct energy rebound effect reached to 10% or less. Furthermore the indirect energy rebound effect is reached to 11%. So, these two types of energy rebound effect can be join and estimate the overall energy rebound effect in a sector or economy, in this case total energy rebound effect reached to 20%. Overall energy rebound effect is estimate 20% and 80% of the potential energy savings gain from energy efficiency policies. And the 20% of energy rebound effect donates to increase customer facilities as well as to a superior economy.

Many existing studies focus on the direct-energy rebound on the customer demand side, while (Wu et al., 2016) focuses the indirect energy rebound effect in case of Taiwan industries for the perception of manufacturers. However, many studies on the manufacturers' perspective may manage inter industry relations. This study put on a supply driven and Error Correction model to measure the magnitude of the energy rebound effect in short run due to clearly seeing inter industries relationships. Experimental findings indicated that the total energy rebound effect for Taiwan sector is lower than ten percent in the year 2011. A assessment between the sector yield that sector with lower efficiency of energy had higher direct energy rebound effect, although the sectors with greater forward linkage generated higher indirect energy rebound effect were greater than the direct energy rebound effect. In simple words, when indirect energy rebound effect are neglect, than the total energy rebound effect may be under estimations therefore, the energy saving potential may be overestimated.

A similar study was investigate the (Kasperowicz, 2014) in case of Poland to watch the association between energy consumption of Poland and economic growth. Study used time series data for research purpose from 2000-2012. Comprehending the behavior of power

consumption in association with the economy is really significant to enhance a steady economic progress and development. Finding of this study is revealed that the bidirectional causality among the consumption of energy and economic growth. It was also exposed the bi directional causality among the economic growth and gross capital. Based on the causality results the study measured the aggregate production function in a single sector, where the energy consumption is the input variable. The estimate growth model showed that variable of energy consumption are a pro-growth, so the results showed that economic growth of any country is dependents on energy services and its efficiency.

Doe & Lie Tin, (2014) investigated study to examine the effect of electricity chances on the profitability and competiveness of small manufacturing industries in case of Ghana. This study based on cross sectional survey data set and used the mixed method approach. Study used the systematic sampling method to get the seventy of different Ghanaian small manufacturing enterprises. The criteria of sampling selection were based on the location of the SME and consumption of energy for their business. Researcher collect the data through a structured questionnaire and all questions related to the effect of the energy interruption on the business, profitability, operations, and the competiveness. Furthermore, study divided data into the different group and analyzed in SPSS statistical software. The outcome of this study is recommended that interruption of energy seriously affect the output of the small manufacturing enterprise and consequently it affect their profit and sale. It also affects the asset of the small manufacturing enterprise and return on the investment. The reduction in the profitability and operations also reduced the business competiveness.

Bayar & Özel, (2014) conducted the study that the under developed Asian nations of energy consumption have positively affects the economic growth. Study outcome indicate there is two main associations between the energy consumption and economic growth. Study used the time series data from 1995 to 2010. Study outcomes indicate there is strong relationship between energy consumption and economic growth. Growth of economic development also linked with the consumption of energy. Furthermore, study indicate energy consumption demand affect the energy prices. Less energy price will lead to high demand for energy consumption.

Khalil & Zaidi, (2014) investigate and conclude energy rebound in case of Brazil constructions industries. Some manufacturing industries are considered to consume more energy and carbon emitter in case of Brazil. For this Brazil did serious attention to advance energy efficiency to protect the energy but on other hand the energy rebound effect could not be achieved this efficiency target. The study is based on the main relationship among the input capital, technological variation, economy growth, and energy uses, and further they estimate energy rebound effect in case Brazil for the constructions industries. Study used annual time series data set from 1991 to 2010. Furthermore, study used the ARDL technique to estimate the long run impact and through VECM to find out the short run dynamic. The findings of study confirmed that there exists energy rebound effects building manufacturing of Brazil but it is declining trend over time that is positive sign for future generations. This study find out that the around partial of the expected energy savings due to technological changes are attained. They conclude and suggest that the proper energy efficiency improvements and energy tax could be working to encourage the supportable expansion in the constructions industries.

According to the Young et al., (2014) whenever growth in energy efficiency will not reduce the energy consumption than overall reduction in economic activity is called for energy rebound effect. The objective of this was to find out the energy rebound and its consequences. This research work based on time series data from 1990 to 2010 and analyzes the data through the ARDL econometric technique. Study findings indicate there is exist energy rebound effect and its magnitude were reached to forty percent. Study suggest there are two way government will achieved energy efficiency target first one is to maintain supply side through proper policing and second one is through subsidy on energy.

Hussain & Junaid, (2012) investigated the study to examine the impact of energy issues on the profit of food industry of Pakistan. This research work applied the methodology of the generalized method of movement and EGLS. Now the Study was taken the fifteen different food industries data set from the period of 2001 to 2010. Main objective of this study was to estimate energy contribution in production of different firms. Furthermore, when they analyze data than they indicate energy is more important element in production as compare to labor because without efficient energy supply any firm can't produce goods and services. for example, energy supply are efficient then worker produced more goods in short time if

energy supply not proper then worker waste time and not produce single goods. Therefore producer of any firms also prefer for efficient machines which they produce more goods in less energy consumption. Study suggests government should be serious attention on energy and make efficient policies to give benefit for producer than producer may less use energy.

Energy rebound effect refer the phenomenon the higher energy effectiveness (technological advancement), and basic energy conservation complete change in behavior or selections (van den Bergh, 2011). So, energy consumption net effect on the total consumption of energy becomes undefined over the time. The main objective of this study was to estimate indirect energy rebound effect. For this purpose study used the annual time series data from 1990-2010. This study finds out the problems of indirect energy consumption effect, also known as the energy efficiency of rebound. Now research area of rebound effect of energy have extremely attractive consideration from energy forecaster, but then again there is unexpectedly ignore in ecological economic, even however economist usually concerned by economy wide and indirect impact of technological change and programs. This study discussed different descriptions and clarifications of energy rebound effect in term of ecological, the existence of rebound effect phenomenon there have four fundamental problems.

Korakiene et al., (2011) conducted the study that the sustainable development of any nation linked on the rate of the economic growth and economic progress is depend on the price of energy and the supply of energy. The main objective of this study was to estimate the impact of energy price (gas, coal, oil, and electricity) on the industrial growth of Lithuanian economy. For this purpose study taken the data from 2000-2011 and econometric technique of correlation were used to estimate the impact of energy prices on the industrial growth of Lithuanian economy. The competiveness of the industrial sectors was estimate by exports of these industries and outcome of this study indicate that a rise in price of energy (oil, gas, coal and electricity) do not effect the industrial sector output. Furthermore study suggests that during the period of 2000-2011, problem link to the energy intensity were not resolve properly. Therefore, the observed time 2000-2011 there was no significant change in the energy intensity.

According to Hussain et al., (2011) transportation sector of any country also help to economic development. Energy efficiency (technological advancement) has one of the most and important technique to decline the energy consumption. The main goal of this study was to estimate the energy rebound effect in case of Libya. When energy advancement (energy efficiency) occur then they will lead to reduction in price of energy and energy consumption, but energy rebound not do this. Study used the error correction model to find the short run outcomes and further long run impact investigate through ARDL technique and estimate the direct energy rebound effects and its outcome indicate energy rebound effect reached to fifty nine at providence level. Study uses the Libya provinces panel data set from the 1992-2015. The experimental results indicates that the characteristic of the long run, a limited energy rebound effects happen in the Libyan's provinces road and further this size of energy rebound effect disturb the whole country transportations system. Study indicates that the magnitude of energy rebound at different provinces were different like 44%, 49%, 29% and 22%. A conventional of the expected energy falling after effectiveness of energy improvement (technological advancement) might be leave cause to energy rebound effects. They suggest self-governing strategy of improving energy efficiency is not as the effectively as public probable. On the short-run aspect, a small super conservation impact occurs in Libyan's road.

According to Turner & Hanley, (2011) technological progression only single element that used to justify the presence of an environmental Kuznets curve, and technological advancements has argued to be a key reason in mitigating the effects of economic growth on the environmental worth. Study main objective to energy efficiency and its impact on environment. For this purpose study used the Panel data set from 1996-2012. Study used the econometric methodology and CGE model to estimate the energy efficiency. Study outcome indicate that the energy efficiency are significantly and strong impact on environment. Study suggests through energy efficiency government will achieved the environment target. But here question is that how government will improve energy efficiency, this study argue if government reducing the energy price, technological up gradation, sharing the technology then government will achieved the energy efficiency goals.

According to Akinlo (2009) investigated the study in Nigeria to analyzed the relationship among the energy consumption and economic growth in the country. This research work

applied the methodology for the estimation was cointegration and this was based on the Cobb-Douglas production model. For the research purpose study was taken the data from 1980-2008. This research work used the econometric technique of VEC (vector error correction model) and Granger causality test to find out the direction of relationship between the couple of variables that are the energy consumption and economic growth. The outcome of this study exposed that the precise connection among these two variables and furthermore, this research work indicate the causality exists from the energy consumption to economic growth. This study suggests that the requirement for strong energy agencies that would confirm the nonstop energy supply and ensured the replacement of ancient and worn-out machines to decrease the energy losses.

Sorrell (2009) conducted the study on energy rebound, and investigate the specific rebound effect of energy that is the most common part of the energy economics. There are several indirect effects such as the energy affiliated with other goods and services which energy efficiency (technological advancement) consumption has increased. The main goal of this research work to find out the relationship between the energy rebound and economic growth. For this purpose researcher take the time series data from 1995-2005 in case of Thailand. This study statistically finds the energy rebound effect in case of Thailand. Study use the Cobb Douglas production function to find out the rebound effects of energy. This research work employed the econometric technique through vector error correction model to find out the short run impact of energy rebound effect. The result of this research work indicate there is exist energy rebound effect and its magnitude reached to twenty five percent. Furthermore, study concludes that the advancement in energy (technological advancement) makes the energy services affordable, therefore increasing energy demand.

According to Lee,(2005) energy efficiency refer to reduce the price of the energy services consequently will lead to increasing energy consumption demand. These situations named the price effect. And another, energy efficiency (technological advancement) may be save the money which the customer can be used for different goods and services. These situations called the income effect. Study investigated and examines the nature of energy rebound effect of energy effectiveness improvements (technological advancement) in case of Bhutan. This study main goal was to find out the overall expression of energy rebound effect of household

consumption. For this purpose study take the time series data from 182-2000. Furthermore, study used the ARDL econometric technique to find out the long run impact and through vector error correction model (VECM) to find out the short run dynamic. The findings of this study confirmed that there exists energy rebound effects in household and furthermore, it is increasing trend over the time that is negative sign for the Bhutan. Study result indicates income effect is more than the price effect in energy consumption. Research work result show that the energy rebound effect in case of Bhutan is significant and its magnitude is need serious attention. Furthermore, same as above study, author suggests the theory how people can save money on energy consumption one sectors may cause to increase energy uses in others sectors.

Hondroyianni et al., (2002) conducted the study in Greece to evaluate the impact consumption of energy on the economic growth of a country. This research work collects the data from the period 1960-1996. Study employed the econometric technique to analyze the impact of consumption of energy on economic progress through the vector error correction model (VECM). This study takes the economic growth as a dependent variable and energy price, consumption of energy and real GDP as independent variables. Through the price of energy, study was estimate the energy efficiency of a country. Empirical result of this study indicates the association between the all three variables namely consumption of energy, real GDP and price of energy exist in the long-term. Furthermore, this research work suggests the policy related to the structure of energy in the country. The policy should be made to improve the economic efficiency of a country without the interfering's its economic growth.

According to Binswanger, (2001) energy advancement (technological progression) due to technological up gradation also caused to economic stability and economic development. This research work define the energy rebound effect as an energy efficiency affect through the consumption of energy and energy demand or offset the energy saving an increase in energy efficiency these increase energy consumptions also offsetting the expected energy saving that would be achieved in this situation they lead to reduction in energy consumption resources this phenomena also refer to the rebound effect of energy. This research work used the econometric technique and the index decomposition model and find out the energy rebound effect in the textile sectors with the use of annual panel data from 1980–1995. This

study start with the traditional neo-classical examination of the rebound effect in a fractional framework of equilibrium, and that focus the demand of one specific energy consumption like temperature of room and mobility. Study outcome indicate rebound effect of energy is significantly high it may be challenge the common for the policy measure to reassure energy efficiency.

Greening et al., (2000) conduct the study on efficiency of energy and rebound effect. Study was describing the rebound effects in the circumstances of energy efficiency advancements. Study differentiates among the rebound from complimentary exogenous and the energy effectiveness advancement. The discussion about the magnitude of the energy rebound effects brings and has significant implications for the energy efficiency program. This study takes annual time series data to analyze the impact of energy rebound. Study employed the Cobb-Douglas production function and furthermore study use the vector error correction model to estimate the short-term impact of energy rebound effect. Study outcome indicates there was energy rebound effect and its magnitude reached to forty percent. This research work broadly three findings and that findings are, they presented the dynamic theoretical difference between the energy rebound effects and energy efficiency (technological advancement). Second one is, study measuring the energy rebound effect at the macro level through the statistical and empirical methods. And lastly, they try to explain the nature of the macro level energy rebound effect and find out the magnitude of the rebound effect of energy. This study outcome indicates that is the positive and the significant differences in the danger liability concerning the energy rebound between the different areas. The findings of study have important implication for the policy determinations. This research work suggests that the improvement in energy efficiency or technical invention and supervisory morals can be effective in reducing for energy consumption.

According to Roy, (2000) energy efficiency improvement through the technical process is going to be a no regret choice will finally depend on between other parameters the magnitude of energy rebound effect. The present research work looks at the impact of technological efficiency of energy gain on energy consumption in three sectors in case of India. The main objective of this study was to find out the aggregate energy rebound effect in selected three industries in case of India. For this purpose study take the data from 1985-1995 and

employed the econometric technique to analyze the data. Study outcome show that the there is significant and high positive energy rebound effect exist in these three industries. However, the main purpose of this study was to focus the different mechanism of the energy rebound effects that may exist in under developing nations with unmet demand. Study find out the magnitude of energy rebound effect in selected energy intensive industries cement, steel, and iron industries reached to50%, 70% and 47% correspondingly in case of India.

Birol & Keppler, (2000) conducted the study of the fundamental condition of economic growth, consumption of energy and other factors of inputs in case of Russia foods manufacturing industries. Main objective of this research work to find out the energy rebound effect. Now the energy efficiency is a parameter that also depends on the technology of the state and methods of production. It influences significantly also the amount of energy that is used per unit of GDP which indicate the energy intensity of an economy. Furthermore, the energy intensity also depend on the consumer preference and others structural parameters such as climate, culture and geography and find out the structure of the input factor use statistical framework. Therefore, both energy intensity and energy efficiency also depend on the various channels on the price of energy relative to other economically relevant inputs. This research work estimated the substitution effect between input variables, and measured the indirect energy rebound effect of the energy inputs. The results indicate that the substitutions relationship exist between the energy consumption and economic growth. The association among the rebound effects and substitution effect was recognized and considered formulation, and study confirmed elasticity of price energy also represent the energy rebound effect through the substitution of inputs factors. For this study estimation, the direct energy rebound effects are divided into two main categories such as income effects and outputs effect. Study suggests that replacing energy with other factors such as capital and labor is suitable solution for the purpose of energy conversion.

Literature Summary

Study focus on the reviews of (selected) existing literature in which bilateral relationship between energy efficiency and its impact on energy consumption investigated in form of energy rebound effect. Some study suggests that energy rebound effect is so negligible that it can be ignored. While some other study argues that the impact of energy rebound effect is so substantial that it has to be taken seriously. So reviewed the all articles on energy rebound

effect estimation in case of different countries they showed that there is no general rule and its range of energy rebound effect is very wide. For this many sectoral as well as firm level studies investigated. Many studies empirically checked this relationship with the help of elasticity's, and many did the same with the help of CGE modeling approach. But few uses aggregate production function for such analysis. In coming chapter, this study follows the aggregate production function-based approach for three industrial level analysis of rebound in case of Pakistan. Our main focus is on the measuring the energy rebound effect through energy efficiency improvement. In energy rebound effect theory still has a few issues. From this the conclusion can be drawn that the impact of energy rebound effect has to be gauged individually, because each sector and country has different consumption characteristics and patterns.

Author	Year	Title	Findings
Gillingham et al.,	2015	Theory of microeconomic in case of rebound effect ant its implication on welfare.	Study highlights the feature theory of microeconomic energy rebound effect. Study result indicates that energy rebound effect varies low to high range and its magnitude was more than 20%.
David L et al.,	1999	Energy rebound effect in fuel economy in case of U.S household.	The energy rebound effect estimate the tendency to take back the saving of energy from fuel economy development lead to increase the traveling. Current study analyze US household time series data from the 1980-1990 and estimating direct, indirect and economy wide energy rebound effect. Study find out the magnitude of energy rebound effect is very low to moderate range.
H. Li et al.,	2017	Rebound effect of energy for the constrictions industry of China.	The rebound effect of energy exist in China residential building sectors and its shows a declining pattern over the time.
David L. Greene	1992	Fuel economy and vehicle use. How big is the rebound effect of energy?	Study result indicates energy rebound effect has very small magnitude lower impact.
Guerra Santin	2013	Energy efficient behavior of occupants in dwelling, evidence of energy rebound effect.	Study finds that although consumption of energy is lower in energy efficient residences. Study uses the panel data from 1980 to 2005 and analyze in SPSS statistical software. Study outcome indicate consumption of energy are lower in the energy effectiveness houses, investigation of the behaviors variable show that their occupant tend to favor larger inside temperature and the ventilate low. Study conclusion also shows the energy rebound effect were existing's in different societies.
Kenneth et., al	2015	Energy efficiency policy and the energy rebound effect.	Study find out the indirect energy rebound effect is higher than the direct energy rebound effect and its magnitude reached to 78% and 44% in the long run and in the short run it magnitude reached to 55% and 23%.
Carlena Cochi.,et al	2014	Analyzing the energy rebound effect in personal automotive transports.	Study analyzing of statistical issue that bears on the size of the energy rebound effects together with the error correction model and functional form. They indicate that the energy rebound effects has been smaller or lesser.
Clifton T. Jones	1993	Different look for U.S. use vehicle and the energy rebound effect in case of fuel efficiency.	Author find out improvement in fuel economy cause of small rebound effect, furthermore technical invention and supervisory morals can be effective in reducing for fuel consumption. Reducing the energy price also effect the customer behavior and its consumption pattern. Through price elasticity of fuel study capture the rebound effect. Furthermore, study used VECM to identifying the short run dynamic of energy rebound. Study result show that energy rebound effect is highly effect in transportation sector.

Runar et al.,	2005	Growth in energy efficiency and the energy rebound effect on emissions and consumption.	They discover the magnitude of energy rebound was reached to 88% and furthermore, they indicate rebound effect trend is declining over the time.
Jaume Freire-Gonzalez	2017	Evidence of indirect and direct energy rebound effect in household in Europe 27 countries.	This examination result shows that seven total out of twenty seven nations has indirect and direct rebound effect more than hundred percent are exist over the short run and long run.
Yue-Jun Zhang et al	2017	Rebound effect of energy in China industries: an disaggregate and aggregate analysis.	They discover the magnitude of energy rebound was reached to 88% and furthermore, they indicate rebound effect trend is declining over the time.
Boqiang Lin et al	2015	Study on rebound effect of energy in China residential building energy efficiency.	Study result show that the rural buildings energy rebound effect is larger than the urban residential areas.
Jeroen C. J. M. van Bergh	2011	Service of energy is more real with energy rebound policy.	This study drafts the difficulties of indirect energy rebound effects. Study outcome indicate energy rebound effect exist and furthermore its magnitude reached to 45%.
Mathias Binswanger	2001	Technological growth and sustainable developments. What about the energy rebound effect?	Study analyze data than they indicate energy is more important element in production as compare to labor because without efficient energy supply any firm can't produce goods and services.
Nässén & Holmberg	2009	Analyzing the energy rebound effect of energy efficiency advancement and energy conserving in case of Sweden.	Main contribution of this study was given a theory in which they discuss how we can save energy money on consumption one sectors may cause to increase energy uses in others sectors.
Madlener & Alcott	2007	Economic growth and energy rebound effect. A review of the main problem and research need.	This research work outcome indicates energy rebound effect also affect the economic development and disturb the economic activity.
Grepperud & Rasmussen	2004	General assessment of the energy rebound effect.	Study presented the main conceptual distinction between a rebound effects related with costless energy efficiency advancement.
Aydin, Kok, & Brounen	2016	Efficiency of energy and behavior of household. The energy rebound effect in residential sectors.	Study statistical results indicate the direct energy rebound effect is exists in the residential sector. And its range in short run and long run are 60% and 80% on average. Study indicate direct energy rebound effect vary low to high trend.
Karen turner	2017	Energy rebound effect increase the efficiency of energy.	Study outcome indicate that the potential energy was downward pressure on economy wide consumption of energy; furthermore increased energy efficiency in production or energy consumption activities.
Lin, Yang, & Liu	2013	Study of the energy rebound effect on China's current emissions reduction and energy conservation.	The substitution elasticity between energy and labor is relatively higher, so it is a feasible solution to reduce labor costs by optimizing the production process and improving management

			efficiency given that the wages and salaries of workers remains unchanged.
Edgar G.	2005	Energy rebound effect and consumption of energy.	Study employs the Cobb Douglas production to estimate the energy rebound effect in case of Netherland. Study take econometric technique like cointegration and error correction model (ECM) to estimate the energy rebound effect. Study outcome indicate there is exist energy rebound effect in Netherland and furthermore, this impact also disturb the economic activities and creating the economic disequilibrium.
Freire González	2010	Empirical evidence of indirect energy rebound effect.	This study result indicates that is the positive and the significant differences in the danger liability concerning the energy rebound between the different countries.
Broberg et al	2014	Country wide energy rebound effect from improved efficiency of energy in Swedish industries.	The findings of study confirmed that there exists energy rebound effects in Swedish household furthermore, study indicate its declining trend over time that is helpful for coming generations.
Jin	2007	Effectiveness of energy efficiency advancement in case of developing nations. Energy rebound effect of residential energy use in South Korea.	Study statistical results indicate the direct energy rebound effect is exists in the residential sector. And its range in short run and long run are 60% and 80% on average. Study indicate direct energy rebound effect vary low to high trend.
Fatih Birol	2000	Technology advancement, price and energy rebound effect.	The results indicate that the substitutions relationship exist between the energy consumption and economic growth. The association among the rebound effects and substitution effect was recognized and considered formulation, and study confirmed elasticity of price energy also represent the energy rebound effect through the substitution of inputs factors.
Frank Figge et al	2014	Efficiency or sufficiency achieved lowers the resource emissions and consumption? The role of energy rebound effect.	Study outcome indicate consumption of energy are lower in the energy effectiveness houses, investigation of the behaviors variable show that their occupant tend to favor larger inside temperature and the ventilate low. Study conclusion also shows the energy rebound effect were existing's in different societies of Netherland.
Horace Herring et al	2007	Innovation through technological chang , energy efficient design and the energy rebound effect.	The findings of this research work to indicate that there was exists energy rebound effects in case of Germany. Furthermore result show that the trend of energy rebound increasing trend.
Sverre Grepperud et al	2004	A general analyzing energy rebound effect.	There are some option to reduction the carbon emission and technological change only energy efficiency is one of the options to use the reduction in carbon emission.
Li Hong et al	2013	Environmental gain and economic growth of China fossil energy subsidies reform.	Study indicates that the dropping fossil energy subsidies, the rebound effect would be effectively moderated, and dropping all

		Energy rebound effect case study with the EIMO model.	subsidies causing for decrease the rebound effect.
Ke Li et al	2016	The rebound effect of energy across China industrial sector. An output distance function approach.	This study find out the aggregate of energy rebound effect of industrial sector in China over 1998-2011 is 88 percent.
Hong Li et al	2017	Deducting the energy rebound effect through the fossil reform subsidies. A comprehensive evaluation in China.	This research work randomly collects data and furthermore, findings of study confirmed that there exists energy rebound effects in building manufacturing industry of China. But it is declining over time that is positive sign for future generations.
Jianglong Li et al	2019	Can market oriented reform rise the rebound effect of energy? Evidence from the China regional development.	Study assesses the direct energy rebound effect in China's industrial sectors. They find that the direct rebound effect for the industry is 37.0 percent.
Boqiang Lin et al	2015	Factors substitutions and the energy rebound effect in China foods industry	The substitution elasticity between energy and labor is relatively higher, so it is a feasible solution to reduce labor costs by optimizing the production process and improving management efficiency given that the wages and salaries of workers remains unchanged.
Hongxun Liu et al	2019	An improvement approach to analyze the direct energy rebound effect by incorporating energy advancement. A visit of China industrial energy demands.	Study indicates that the energy rebound effect highly affected by forty provinces at industrial level. Furthermore its range varies low to high over time. Wei et al conclude that China energy rebound effect significant and its magnitude reached to 84% in the short-run while 146% in the long-run.
Greening et al.,	2000	Consumption of energy and energy efficiency.	This study outcome indicates that is the positive and the significant differences in the danger liability concerning the energy rebound between the different areas. The findings of study have important implication for the policy determinations.
Herring & Roy	2007	Technological advancement and energy rebound effect.	The findings of this research work to indicate that there was exists energy rebound effects in case of Germany. Furthermore result show that the trend of energy rebound increasing trend.
Akacra et al.,	2008	Economic advancement and energy consumptions in Japan	The finding of this research work indicate energy crisis significantly affect the industrial sector of Japan which consequently reduced the gross domestic product (GDP) of the country.
Adjaye	2000	The relationship between energy price and energy consumption: a review of rebound	The findings of study confirmed that there exists energy rebound effects in constructions industries in case of France. But its magnitude is declining over time that is positive signal for producer of food industries.
Hondroyiannis	2000	Energy consumption and	Empirical result of this study indicates the

et al.,		economic growth.	association between the all three variables namely consumption of energy, real GDP and price of energy exist in the long-term. Furthermore, this research work suggests the policy related to the structure of energy in the country.
Lalk	2015	Electrical energy planning in Asia.	Study outcomes indicate there is strong relationship between energy consumption and economic growth. Growth of economic development also linked with the consumption of energy.
Pichler	2010	Increasing economy of China and the impact on energy system.	Study indicates that direct energy rebound effects for road cargo transport will lead to reduction of economic growth and economic development.
Korsakienė et al	2013	Consumption of energy and its significances on economic development.	This study find out that the around partial of the expected energy savings due to technological changes are attained.
Kingston	2017	Energy efficiency policy and economic development.	Study found that the different manufacturing industries like steel, cement, paper and printing and wood had to cut their output severely only due to energy crisis. On the other hand some others industries like textile, transportation equipment and electric equipment do not affect by the energy crisis.
Akinlo	2009	Consumption of electricity and economic development.	The outcome of this study exposed that the precise connection among these two variables and furthermore, this research work indicate the causality exists from the energy consumption to economic growth.
Kasperowicz	2014	Relationship of energy consumption and economic development in case of Poland.	The estimate growth model showed that variable of energy consumption are a pro-growth, so the results showed that economic growth of any country is dependents on energy services and its efficiency.
Doe	2014	Energy efficiency and energy consumption demand.	The outcome of this study is recommended that interruption of energy seriously affect the output of the small manufacturing enterprise and consequently it affect their profit and sale. It also affects the asset of the small manufacturing enterprise and return on the investment.
Bayar	2014	Economic growth and energy use in developing countries.	Growth of economic development also linked with the consumption of energy. Furthermore, study indicate energy consumption demand affect the energy prices. Less energy price will lead to high demand for energy consumption.

CHAPTER 3

3.1 Theoretical Framework

A theoretical framework is a theoretical perception of research area. We can say it is simple theory, but it can also be new approach to understand the existing literature with modern a proposition. Normally, a theoretical framework describes the variables connections that are under considerations. In this segment of study theoretical framework is going to discuss.

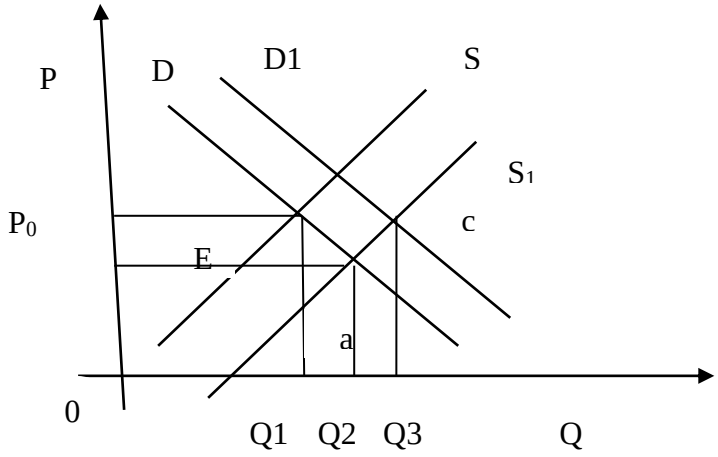
Actually, the idea of rebound effect was presented by Jevon (1865) (Wu et al., 2016). But it was largely ignored by energy economists due to premature state of knowledge. After some time, same idea is theoretically reassembled with the name of 'Khazzoom-Brookes Postulate (Brockway et al., 2017; Sorrel et al., 2009; Stapleton et al., 2016; Zhang et al., 2017). Now almost consensus is developed about the presence of energy rebound effect after a exogenous shock of energy efficiency. According to Jin, (2007) the backfire effect (extreme type of ER) is not possible in micro level analysis. While on other hand, Saunder, (2000) refuted this theory of energy rebound with the help of eight production and cost functions and argue that backfire is linked with the selection of production or cost function.

According to traditional theories of energy economics, there is negative relationship between energy efficiency and energy consumption. But in reality, energy consumption increases whenever energy efficiency (technological advancement) occur therefore, in modern approach positive relationship exist among the energy consumption and energy efficiency (technological advancement). Increase in energy efficiency (technological advancement) lead to higher energy consumption due to low price of energy services and substitution effect. Although the main objective of energy efficiency is to reduce the energy consumption but the energy rebound effect never allows doing so. At micro level its rational behavior of economic agents and on same to an aggregate level it is demand side behavioral that cause energy rebound effect (Brockway Heun, et al., 2017; Saunders, 1992; Wei, 2010). This demand side response in term of high consumption is real threat for environment and energy policies (Safarzadeh et al., 2019).

From the following figure 1, one can easily understand the phenomenon of energy rebound effect with the help of basic demand-supply framework of market at micro level. On vertical axis, there is price of energy and quantity of energy is on horizontal axis. There are demand and supply forces and market of energy is into equilibrium at point E. Then a positive

exogenous shock on supply side of energy that shifts the supply curve to the right hand that lowers the price of energy along with high quantity. Then through real-price channel the demand curve of energy shifts to the right hand side with more quantity of energy. Basically this incremental demand of energy is due to the first of shock of efficiency. At this point the price of energy remain same but with high level of consumption of energy. It is simple energy rebound effect at micro level (Chan & Gillingham, 2015; Gillingham et al., 2015; Saunders, 1992). With the same diagram, one can explain the economy-wide energy rebound effect by exchanging supply with aggregate supply and demand of energy with aggregate demand.

Figure 1Energy Rebound in Microeconomics perspective

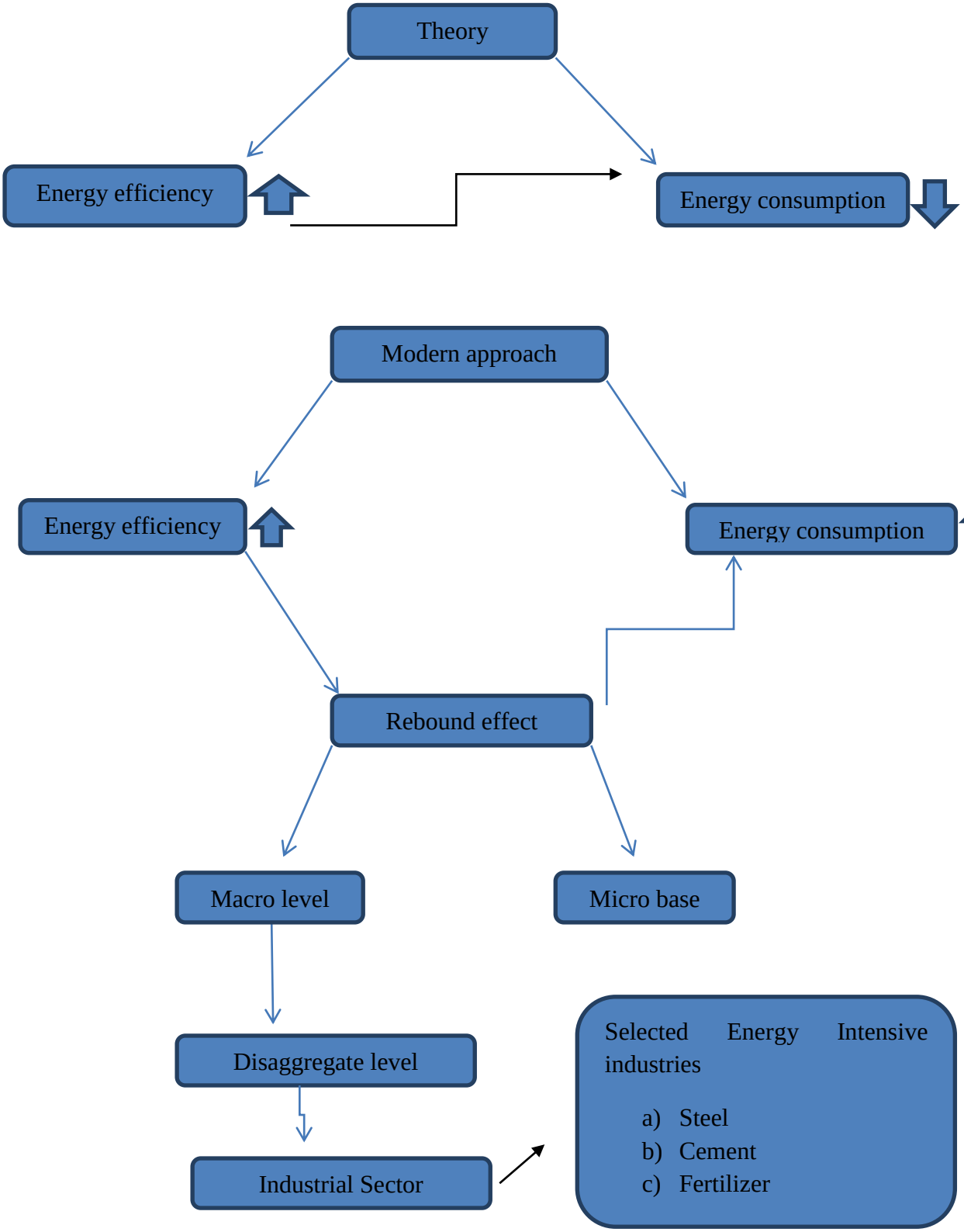


The other aspect of theoretical debate is the magnitude and direction of energy rebound effect which is highly discussed (Herring & Roy, 2007 Greene, 2012 Haas & Biermayr, 2000 Hymel et al., 2010). Some studies claimed that energy rebound effect is not big issue, so ignore it (Jin, 2007 Akarca et al., 2017 Brockway et al., 2017). While plethora of empirical research claims that the side effects of energy rebound effect are not ignorable. So, it required serious considerations regarding estimation and methodology (Santin, 2013 Thompson, 2014 Belaïd, Bakaloglou, & Roubaud, 2018). Therefore, it is dire need of time that energy rebound has to be estimated separately. Although, there is consensus about the presence of energy rebound effect among the energy economists but issues are involved about selection of model and methodology. It is because every model is not behaving in similar manners in response of energy efficiency shocks. The size energy rebound effect is also depending on many social and economic indicators that are ignored in mainstream empirical efforts (like high growth rate of population, energy supply, and price of energy etc.). These factors may also cause energy rebound effect (Y. J. Zhang et al., 2015 Broberg et al., 2014 Saunders, 2008(Sorrell et

al., 2009). In the following figure, study discusses the channels of energy rebound effect with the help of schematic figure.

3.2 Conceptual or Schematic Framework

Traditional Approach



CHAPTER 4

4.1 Model and Methodology

After reviewing the available literature, we enrich are considerate around the problem in focus and discovery the gap of literature and present movements of related variables. Model and Methodology chapter discussed the methodology to estimate the model. Methodology is basically planned assembling of significant thoughts, ideas, and clarification of association of the variables. Methodology helps to express an experiential model to estimation the hypothesis of the study and advance the dynamics of the issue. That is under examination.

This study starts from very basic neoclassical, economy wide production function in which output (Y) is function of capital and labor stock.

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

In above equation (01) capital (K) and labor (L) both are the primary inputs to achieve the long run output of an economy. Later (Kraft & Kraft, 1978) describe output is further function of another input energy and energy is a secondary input they use in production.

$$Y_t = f(K_t, L_t, F_t) \tag{2}$$

Where

Y_t = Gross production (the actual price of all goods created in a year)

K_t = Gross capital (a measure of total equipment and building)

L_t = Labor force (the all sum of individual work in a year)

F_t = Overall energy service use in production process in each year.

Kraft, 1978 further described that energy consumption is function of energy efficiency(τ).

$$F_t = g(\tau_t E_t) \tag{3}$$

Where

E_t = total consumption of energy services.

τ_t = efficiency of energy over time.

F_t = is total energy consumption.

Wei, (2007) argued that improvement in efficiency of energy lead to decrease the overall energy consumption but in reality, energy efficiency might increase energy consumption due to energy rebound effect.

Now equation (3) put into (2)

$$Y_t = f(K_t, L_t, g(\tau_t E_t)) \tag{4}$$

To estimate the consequence of energy efficiency (τ), this study takes Cobb Douglas production. Now literature, the production function of Cobb Douglas is generally used to express the connection between input and output. Cobb Douglas function was first time introduce and tested beside statistical confirmation by (Charles Cobb Paul Douglas) in the 1927-1947 (Wei, 2007).

The most standard form of C-D production function with three inputs is as follows.

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} (\tau_t E_t)^{1-\alpha-\beta} \tag{5}$$

Where,

A = Overall the productivity of factor

α and β represent output elasticity's labor and capital, individually. Values of these coefficients are constants to determine by available technology.

Elasticity also refers to the degree to which producer, consumer or individual change their demand or the supplied in response to price changes (Cooper, 2003).

4.1.1 Short Run Impact

We know that there are two primary factors (K, L) and one intermediate factor (E) to involve in the productions of an economy. These factors are labor force L, gross capital K and energy services E. Now (τ) parameter represents the technological change and increase of (τ) showing the gain of energy efficiency.

The Cobb Douglas production function denotes that

$$Y_t = a_t K_t^{\alpha} L_t^{\beta} (\tau_t E_t)^{1-\alpha-\beta} \tag{6}$$

Where

$\gamma = 1 - \alpha - \beta$

Y_t= gross output of an industry

Where (τ) capture the tecnological impact in terms of technological improvement.

The function of Cobb Douglas shows constant return to scale.

Now in short run, assume the capital K is remaining remain constant.

$$Y_t = a_t K_t^{\alpha} L_t^{\beta} (\tau_t E_t)^{1-\alpha-\beta} \tag{7}$$

$$Y_t = a_t L_t^{\beta} (\tau_t E_t)^{1-\alpha-\beta} \tag{8}$$

$$\frac{dy}{dE} = a_t L_t^{\beta} (1-\alpha-\beta)(\tau_t E_t)^{1-\alpha-\beta-1} \tag{9}$$

We know that $\frac{dy}{dL} = MP_{L=}P_L$

$$MP_E = P_E = a_t L_t^{\beta} (1-\alpha-\beta)\, {\tau_t}^{1-\alpha-\beta} {E_t}^{-\alpha-\beta} \tag{10}$$

$$\frac{P_E}{a_t L_t^{\beta} (1-\alpha-\beta) {\tau_t}^{1-\alpha-\beta}} = {E_t}^{-\alpha-\beta} \tag{11}$$

$$\frac{1}{{E_t}^{-\alpha-\beta}} = \frac{a_t L_t^{-\beta} (1-\alpha-\beta) {\tau_t}^{1-\alpha-\beta}}{P_E} \tag{12}$$

$${E_t}^{\alpha+\beta} = \frac{a_t L_t^{\beta} (1-\alpha-\beta) {\tau_t}^{1-\alpha-\beta}}{P_E} \tag{13}$$

$$E_t = \frac{1-\alpha-\beta}{P_E}\, Y_t \tag{14}$$

By inserting equation (14) into production function equation (6) and rearrange the equation we can obtain the

$$\boldsymbol{Y_t = a_t}^{1/\alpha+\beta}\, \boldsymbol{K_t}^{\alpha/\alpha+\beta} \boldsymbol{L_t}^{\beta/\alpha+B} \left(\frac{1-\alpha-\beta)}{P_E}\right) 1-\alpha-\beta/\alpha+B \cdot \boldsymbol{\tau_t}^{1-\alpha-\beta/\alpha+B} \tag{15}$$

According to Saunders, (2000) output Y_t is a function w.r.t technology (τ_t) alone since the value of gross capital K_t, value of labor force L_t and price of energy P_e are supposed to keep the constant. Then if the short-term measure (SM) is defined as the elasticity of gross output w.r.t energy services efficiency parameter (τ_t) by the differentiating (14) w.r.t, an expression for the short-run measure (SM) can also obtain exactly as:

$$SR = \varepsilon_{Y_t}^{S} = \frac{dY_t}{d\tau_t} . \frac{\tau_t}{Y_t} = \frac{1-\alpha-\beta}{\alpha+\beta} \tag{16}$$

Now the energy use of energy efficiency(τ_t) elasticity study can find by merging the equation (14), and (16)

$$\varepsilon_e = \frac{dE_t}{d\tau_t}.\frac{\tau_t}{E_t} = \frac{dY_t}{d\tau_t}.\frac{\tau_t}{Y_t} = \frac{1-\alpha-\beta}{\alpha+\beta} \tag{17}$$

The effect on energy use of energy advancement and gross output depend the worth of portion of energy consumption $(1-\alpha-\beta)$ are mention (Saunders, 2000).

4.1.2 Long Run Impact

In long run, we denote capital rental is R, then the first order conditions as

$$K = \alpha\frac{Y}{R} \tag{18}$$

or

$$R = \alpha\frac{Y}{K} \tag{19}$$

We know that the growth theory of neo classical tells the actual capital return also stable and will be output of growth rate equaling. Growth rate never affect whenever the improvement in the energy exact technology will rise the output in one time (Saunder, 2000, p444) . Therefore, resulting long-run investigation the capital returns R are continuously supposed to fix in the long-run. Via putting the equation (18) and (14) into the Cobb Douglas production function equation (6) further readjusting, then we can obtain

$$Y_t = a_t\, {}^{1}\!/_{\beta} \left(\frac{\alpha}{R}\right)^{\alpha}\!/_{\beta} \left(\frac{1-\alpha-\beta}{P_e}\right)^{1--\beta}\!/_{\beta}\; L_t\tau^{\,1-\alpha-\beta}\!/_{\beta} \tag{20}$$

At the moment the output Y is a function with respect to technology t alone. Then look for the long run estimation can be found accurately as

$$LR = \varepsilon_{Y_t}^{l} = \frac{dY_t}{d\tau_t}.\frac{\tau}{Y_t} = \frac{1-\alpha-\beta}{\beta} = \frac{1-\alpha-\beta}{\alpha+\beta}\frac{\alpha+\beta}{\beta} \tag{21}$$

$$= SR(1+\frac{\alpha}{\beta}) \tag{22}$$

$\frac{\alpha}{\beta}$ is closed to one, then the log run outcome here suggests the long run effect is near to double as compare to the short run effect (Wei, 2007). Moreover, energy use elasticity with respect to efficiency of energy parameter τ_t we can be found by merging the equation (14) and (21) than

$$\varepsilon_e = \frac{dE_t}{d\tau_t} \cdot \frac{\tau_t}{E_t} = \frac{dY_t}{d\tau_t} \cdot \frac{\tau_t}{Y_t} = \frac{1-\alpha-\beta}{\beta} \quad (23)$$

This equally suggests that effect on the energy use in the long-run also near to double in the short run. Moreover, long-run influence of the energy uses and energy effectiveness gain on output also depend on the actual value and the portion of in an economy $(1-\alpha-\beta)$ and the portion of labor force β.

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} (\tau_t E_t)^{1-\alpha-\beta}\, u_t \quad (24)$$

Now taking the natural log of above equation (24)

$$lnY_t = lnA_t + \alpha\, lnK_t + \beta\, lnL_t + (1-\alpha-\beta) ln\tau_t E_t + \mu_t \quad (25)$$

$$y_t = \beta_\circ + \beta_1 k_t + \beta_2 l_t + \beta_3 e_t + u_t \quad (26)$$

Where:

$y_t = lnY_t$

$k_t = lnK_t$

$l_t = lnL_t$

$e_t = ln\tau_t E_t$

$\beta_\circ$ = is total factor productivity

$\beta_1 = \alpha$

$\beta_2 = \beta$

$\beta_3 = (1-\alpha-\beta)$

α and β represent the elasticities of output correspondingly to gross capital and labor force. Values of these are constant determined by accessible technology (Wei, 2007). Now over time each industry (cement, fertilizer, steel) follow the same CD-PF.

4.2 Time Series Data and Related Issues

In time series econometrics, always we suppose the data is stationary. When time series data are non-stationary, then common statistical method like OLS is not acceptable (Dejong et al ., 1992). The forecast result might be bogus or worthless when time series data is trended over time with high R^2 (Granger et al., 1979). As time series data demonstrations trend over time therefore, followings functions are performed to solve this problem.

4.2.1 Unit Root Test

In dynamic analysis unit root test is required. It is necessary because on the basis of order of integration of each variable, we can apply a suitable technique to estimate the model (Ajide & Lawanson, 2012).

Augmented Dickey Fuller (ADF) test is widely used in literature. For better understanding let consider the following autoregressive AR(1) process (model), it can suffer from unit root. In time series investigation, a model of AR contain one and more lagged of the dependent variable along independent variables it named an Autoregressive model (Ng & Perron, 2001).

$$Y_t = \alpha_0 + \rho Y_{t-1} + \mu_t \quad (1)$$

In above equation (1) is the AR (1) process, it implies that the Y_t (it gross output of selected industries) depends on its previous value. Where the (ρ) is the coefficient of interest for the determination of unit-root. According to Engle & Granger, (2015), if the value of ρ is less than the one, shocks in Y_t will be transitory and will die out over the passage of time. In this scenario, the series will be stationary. Secondly, if the value of ρ is equal to one, shocks in Y_t are permanent in nature. In this situation, the series will as unit root. If it is greater than the one, then the series will explode (Ratha, 2003). The problem with this equation is that the upfront assumption is the presence of stationary, which is the very reason that equation has been estimated at level. However, theory suggests that the starting point should be the doubts, which we want to clear. Here the doubt is that the series is unit root; hence, we should incorporate these doubts in the testing model. Therefore, we can rewrite the model by the first difference, and the model will be as follows:

$$\Delta Y_t = (\rho - 1)Y_{t-1} + \mu_t = \delta Y_{t-1} + \mu_t \quad (2)$$

Here this study assumes the model is non stationary therefore the model is estimate in difference forms. Now δ is a coefficient for resolve of unit root or stationary. When the δ value are below than zero, shocks of Y_t also be temporary and also die out with over the time (Pesaran, Shin, & Smith, 2001). In that circumstance, series also be stationary in nature. Secondly, when the value of δ equivalent to 0, Y_t shocks in long-lasting in nature and not the die with over the time (Pesaran et al., 2001). In this situation, series are categorized as the unit root. This is named unit root supposition.

$$\Delta Y_t = \alpha_0 + (\rho - 1)Y_{t-1} + \mu_t = \alpha_0 + \delta Y_{t-1} + \mu_t \quad (3)$$

$$\Delta Y_t = \alpha_0 + \alpha_1 t + (\rho - 1)Y_{t-1} + \mu_t \quad (4)$$

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \delta Y_{t-1} + \sum_{i=2}^{k} \alpha_i Y_{t-i} + \mu_t \quad (5)$$

Equation (5) is basically equation of ADF (Engle & Granger, 2015). Some contend that this model has disregarded the intercept and trend and later the coefficient valued might not be true. This is true and logical criticism and needs a careful review. Therefore, we add the trend and intercept, and models also mention in equation (3) and (4).

To short and long run determinants of gross output the bound testing method are employed. Bounds testing technique used to predicate three corroborations. Firstly, Pesaren et al. (2001) indicate usage of ARDL model estimate at level relations for reason that the model proposes if order of the ARDL have recognized, than association of variable may possibly to estimate by OLS technique. Second, bound testing for co-integration permits a grouping of I(1) and I(0) variables as repressors. In simple wording we can say, the order of combination of appropriate variables might not unavoidably be the similar hence ARDL technique performance takes the benefit of not necessitating an exact proof of identity of the order of original figures. Lastly, bound test performance are appropriate for lesser and limited taster sizes (Pesarens et al., 2001).

4.3 Bound testing

The ARDL co-integration technique was first presented by (Pesaran et al., 1999). There are many advantages of ARDL over other time series techniques; therefore frequently researchers are using ARDL technique. ARDL provides robust results when the some variables of the model are integrated at level one and some are integrated at first difference (Shahbaz et al., 2013). Pesaran and Shin (1999) noted the ARDL technique produces the accurate parameters as compare to Johansen et al, (1989) co-integration method in case of small sample size. So, this is most applicable in our situation, because here we have small data and mixture of integrated level. So, the next step is checked for co-integration among the variables. For this purpose, bound testing process is useful, and which depend upon the F-test. Null hypothesis F-test is the all long run parameters of ARDL equation have no impact on dependent variable. All together a significance test that suggests no co-integration is done for equation (5).

Pesaran et al., (2001) compute two critical values. First one is, support that the variables stationary at I (0) and the other suppose that they stationary at I (1). When the calculated value greater the upper critical bound value, then the H_0 are rejected, when it drops into the critical bounds the test is measured questionable and if it drops lower the critical value it suggests no co-integration. Now ARDL modeling is adopt in current study. The Framework equation of ARDL is follows as:

$$\Delta lnY_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta lnY_{t-i} + \sum_{i=1}^{q} \beta_i \Delta lnK_{t-i} + \sum_{i=1}^{k} \Omega_i \Delta lnL_{t-i} + \sum_{i=1}^{l} \pi_i \Delta lnE_{t-i} + \lambda_1 lnY_{t-1} + \lambda_2 lnK_{t-1} + \lambda_3 lnL_{t-1} + \lambda_4 lnE_{t-1} + e_t \quad (5)$$

The above equation, expression from λ_1 to λ_4 represents long-run relationship among for the variables, but the look from α_1 to α_4 with the summation symbols matched to the short run subtleties of the variables. But on the other hand side, α_0 show drift constant or e_t is white noise Gaussian (Ratha, 2003).

Now the Null-Hypothesis is H_0: (λ_1=$\lambda_2 = \lambda_3 = \lambda_4 = 0$). It represent there is no log-run relationship exist among the variables. And the other one isH_1 : at least one parameter is not equal to zero (Ratha, 2003).

The critical stage of ARDL is testing of Bound testing stage that guide us about the long run relationship among the variables of the model. For this the calculated values of F-statistics are compared with the upper and lower critical values which are given by (Pesaran et al., 2001). If calculated F-statistic value is greater than the upper critical value then the null hypothesis will be rejected. After the confirmation of Bound-testing, the next task is to check the short run dynamic behavior of model. Whether the concerned model is dynamically stable or not is the hardcore area of concern of ECM (Belaïd et al., 2018)

4.4 The Error Corrections Model (ECM)

Error corrections model (ECM) expressions the short run dynamic with log-run relationship. ECM(-1) define the long-run relations and its negative sign confirm the constancy of the model. It is named as the adjustment parameter. The subsequent (ECM) are estimated in the thirds step.

$$\Delta Y_t = \beta_0 + \sum_{i=0}^{p} \delta_i \Delta Y_{t-i} + \sum_{i=1}^{p} \varphi_i \Delta K_{t-j} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-1} + \sum_{i=1}^{p} \varpi_i \Delta L_{t-1} + \sum_{i=1}^{p} \delta_i \Delta Y_{t-1} + \sum_{i=1}^{p} \lambda_i \Delta E_{t-1} + \sigma ECM_{t-1}\, \mu_t \quad (6)$$

The (ECM) defines the short run dynamic through the long run relationship. EC (-1) is the adjustment parameter and they telling about the convergence speed towards the equilibrium (Shahbaz et al., 2013). Further it shows that the disequilibrium of last year will be adjusted in the coming year. Sign of the error correction term (adjustment parameter) also negative(Ajide & Lawanson, 2012). This negative sign means the refer convergence towards the equilibrium.

The estimate of error correction model (ECM) elasticity of coefficient is estimated.

$$lnY_t = lnA_t + \alpha\, lnK_t + \beta\, lnL_t + (1-\alpha-\beta)ln\tau E_t + \mu_t \quad (7)$$

Short Run elasticity are defining as

$$SR = \varepsilon_y^S = \frac{dy}{d\tau}.\frac{\tau}{y} = \frac{1-\alpha-\beta}{\alpha+\beta} \quad (8)$$

Long run elasticity's are defined

$$LR = \varepsilon_y^l = \frac{dy}{d\tau}.\frac{\tau}{y} = \frac{1-\alpha-\beta}{\beta} \quad (9)$$

Last equations (9) give the long run elasticity's for ARDL model. In this study we take logs of every variables has been taken due to which the coefficient of the variables of the ARDL model will similarly denote the long run elasticity's of the valued variables.

To complete this we firstly express energy rebound effect, expanding on the explanations established in (Saunders, 2000). Preliminary with an elasticity's of energy use with deference to the effectiveness gain$\varepsilon_e = \frac{dE_t}{d\tau_t}.\frac{\tau_t}{E_t}$, so we can describe the energy rebound RE as:

$$\text{RE}=1+\varepsilon_e \quad (10)$$

There are five conditions of energy rebound effect and there is:

RE $>$ 1 Backfire

RE = 1 Full Rebound

$0 < RE < 1$ Partial Rebound

RE = 0 Zero Rebound

RE $<$ 0 Super conservation

4.5 Units of Data Collection

Study uses secondary data set from 1978 to 2015. The data of labor is collected from statistical year book annually published by Pakistan Bureau of Statistics (PBS various editions). While the energy consumption, gross fixed capital formation, and output of each industry is taken from Census of manufacturing industries of Pakistan (various editions).

Variables Name	Represent	Data Source	Definition
Gross Output i= 1,2, 3	lnY_t	Pakistan Economics Survey (PES) various issued	Gross production of particular industries (the actual price of total goods and services formed in a year)
Gross Capital i= 1,2, 3	lnK_t	Census of Manufacturing Industries of Pakistan (CMIP)	Gross capital of particular industries (a quantity of total apparatus, equipment, and constructions)
Labor Force i= 1,2, 3	lnL_t	Pakistan Bureau of Statistics (PBS)	Labor force of particular industries (the all sum of individual-hours' work in a year)
Energy Services i= 1,2, 3	lnE_t	Pakistan Energy Year Books (PEYB)	Total energy services in production

CHAPTER 5

5.1 Results and Discussion

In this section this study presents the estimation and economic meanings of models that discussed in previous section. In simple words, how much gross output of each selected energy intensive industry is affected by the gross capital, labor force, and energy services in long and short-run. Especially in time series modeling is a dynamic study zone which has concerned considerations of investigators and scholar's public over the previous some years. In time series literature has two components namely (a) forecasting and (b) dynamic analysis (Jalil, Mahmood, & Idrees, 2013). For better forecasting, it is prerequisite that selected series should be unit root free and for better dynamic analysis or level of unit root must be known. Mostly time series data also linked from unit root due inertia and macroeconomic nature (Corlett & Aigner, 1972).

Dickey and fuller augment the basic autoregressive unit root test to accommodate general ARMA (p, q) models with unknown orders and their test is referred to as the augmented Dickey Fuller (ADF) test. Null hypothesis of the (ADF) test that the (y_t) series has a unit root in contrast to the alternate I(0). Unique benefit of the PP test above the ADF test is that it provides strong outcomes in presence of hetero-skedasticity and auto correlation in the error term. Here both PP and ADF tests by used to confirm the stationary of series. In previous section, we discussed the reasons to adopt both tests. Two tests of unit root, we are going to apply ADF and PP to check the stationary level of our selected time series. The results of ADF and PP test are presented in table below. After this, on the basis of unit root tests this study moves toward some suitable techniques to estimate the model. First of all, we are going to discuss the results of cement industry. Here after, this study interrogate the fertilizer industry then at the end the steel industry. The average rebound effect of three industries is also calculated at end of this chapter.

5.2 Cement Industry

The level of integrated of each variable of our model is discussed with the help of two unit-root tests in following table 5.1.

Table 5.1 Unit Root Tests of Cement Industry

Variables	ADF				PP			
	At level		1st difference		At level		1st difference	
	t. stats	Prob	t. stats	Prob	t. stats	Prob	t. stats	Prob
Output	-0.623	0.866	-4.036	0.001**	-0.647	0.860	-4.090	0.001**
Capital	-3.873	0.002*	-3.443	0.010**	-3.359	0.012*	-3.567	0.006**
Labor	-1.850	0.356	-5.703	0.005**	-1.738	0.412	-3.616	0.006**
Energy	-0.228	0.935	-3.778	0.003**	-0.395	0.911	-3.927	0.002**

* Indicates variable is stationary at level. ** indicate variables are stationary at first difference

Above table contains the calculated values of ADF and PP unit root tests. In case of ADF, only gross capital is stationary at level whereas gross capital is proxy of economy wide capital stock. While the remaining variables of this model (gross output, labor force, and energy services) are stationary at first difference or (I (1)). We get the same results from both Augmented Dickey Fuller (ADF) and Phillips Parron (PP) tests. The main reason to apply PP test is confirmation the robust level of stationary. As we know that PP test provides efficient result especially when we have small data set (E.G., 2005). The higher the value of **t** also indicates the higher evidence against the null hypothesis. This means there is greater evidence that there is a significant difference. The closer **t** is to 0, the more likely there isn't **t** a significant difference. The current status of unit root level of variables allows us to apply Auto Regressive Distributed Lags (ARDL) technique to estimate the model. Because, we have one variable stationary at level but others are at 1st difference. So, according to (Pesaran, 2001), when model have mixture level of (I(0)) and (I(1)) then ARDL technique is appropriate. After that, the next task is check the bound test that confirm the whether there is cointegration exist or not.

Table 5.2: Bounds Test of Cement Industry

Test Statistics	**Value**	**K**
F Statistics	**11.33978**	**3**
Significance	**I0 Bound**	**I1 Bound**
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

This study chooses lag order of the model by Akaike information criterion (AIC). The suitable range of lag length is supportive to calculate, ARDL (F-statistic) in investigative whether co-integration happens or not (Joliansetp, 1989). This study select lag length which is one for our model and this study outcomes are based on the AIC information criterion. The AIC work well in selection of lag length due to its higher power properties (Jalil et al., 2013). Now the result of ARLD bounds testing are presented in above table and this study F-statistic calculated is greater than the upper critical bound at the % level of significance resulting (Pesaran et al., 2001). There is cointegration among gross output, capital, labor force, and energy services in cement industry. After confirmation of cointegration through bound testing, we move to next task of estimate the model. The short run and long run results of this study model are discussed in upcoming tables.

Table 5.3: Long Run of Cement Industry

Variables	Coefficient	Std.Error	t-Statistics	Prob.
LK	0.093	0.039	2.423	0.021
LL	0.291	0.230	1.269	0.214
LE	0.692	0.067	10.269	0.000
C	-2.939	0.543	-5.410	0.000
R-squared	0.996	**Adj R-squared**	0.996	
Akaike info	-4.92	**D-W**	1.99	

After confirming the presence of cointegration, the values of coefficient in long run for the selected ARDL are presented in the above table (5.3). Result of above table indicates that our independent variables have strong influence on the gross output of cement industry in the long-run. The coefficient of energy and gross capital are statistically significant, but the impact of labor forces in the long run statistically insignificant. It is because the main input of cement industry is raw rocks and it brings into plant through efficient mechanical chain system. It is easily operated by few workers (Dasgupta & Roy, 2017). So, we can say that the cement industry of Pakistan is capital abundant. The results of above table (5.3) show that estimated coefficient of energy have positive and significant effect on gross output. Accordingly, the result indicate that the value of energy coefficient shows that one percent increase in energy uses contributes to gross output of cement industry almost point sixty nine percent and vice versa all things being the same. The result of above table shows that the coefficient of gross capital of cement industry is significant and positively affects the gross output, further coefficient of gross capital suggests that the one percent increase in gross capital donates to gross output of almost point nine percent all things being the same. The values of R^2 and adjusted R^2 indicate that the model is good fit. Generally, a higher r-squared indicates a better fit for the model. The variation in output of cement industry is highly determined by these inputs. Furthermore, Durban-Watson (D-W) value similarly indicates that this study model is not suffering from Autocorrelation. The cement industry of Pakistan is efficient and earns foreign reserve by exporting the cement. The importance of energy in this industry is very crucial. The same coefficient of energy will be utilized in coming section, when this study compute the log run energy rebound effect. Anyhow, the long run effect of inputs should be dynamically stable in the short run. So, next task is to estimate the short-run constancy of study model if there is any exogenous shock.

Table 5.4: ECM and Model Diagnostics of Cement Industry Model

Variables	Coefficient	Std. Error	t-Statistic	Prob.
D(LK)	0.044	0.020	2.218	0.034
D(LL)	0.137	0.110	1.247	0.222
D(LE)	0.325	0.046	7.123	0.000
CointEq(-1)	-0.470	0.057	-8.200	0.000
Breusch-Godfrey LM Test	**Prob**	**White Test of Hetero**	**Prob**	
F-statistic	0.349	0.709	1.979	
Obs*R-squared	0.845	0.655	19.405	

Now in above table this study applied error correction model (ECM) to find the dynamic of short run relationship and outcomes are described in above table (5.4). The result shows that is energy services improves then gross output of cement industry also significantly improve. The above table result shows that one percent rise in energy services will rise to point thirty two percent of gross output and vice versa all things being same in short run. The coefficient of gross capital of cement industry is significant and positively affect the gross output over the short run, a simple point four percent increase in gross output is linked with a one percent increase in gross capital, all else the same. The most attractive term of above table is ECT term with magnitude of -0.47. It implies that if there is any exogenous shock that disturb the stable output path of cement industry then about point forty seven percent recoveries will be achieved in coming one time periods. In this study case the time is one year. Energy is highly important for short-run as compare for long-run. In individually short and long-run energy is statistically significant in time series analysis, after estimation the model. Next task is to check out the diagnostic of the model. It is because if our model suffers from any econometric problem then this study findings and policy suggestions are not valid (Figge et al., 2014). In our model give the biased outcome therefore, the following table outcomes specific diagnostic of our model.

To check the Hetero-skedasticity and Auto-correlation this study pass our model in all sensitivity analysis tests and confirmed there is not existence of Heteroscedasticity and serial correlation. And furthermore the error term are normally distributed. Next objective is to put the value of energy coefficient to calculate the energy rebound effect. The upcoming section (5.13) and (5.14) indicate the energy rebound effect in long and short run.

5.3 Fertilizer Industry

Table5.5: Unit root tests of Fertilizer Industry

Variables	ADF				PP			
	At level		1st difference		At level		1st difference	
	t. stats	Prob	t. stats	Prob	t. stats	Prob	t. stats	Prob
Output	-3.919	0.001*	-3.813	0.0028**	-3.573	0.006*	-3.701	0.004**
Capital	-0.569	0.877	-6.647	0.001**	-0.520	0.888	-6.664	0.000**
Labor	-4.942	0.000*	-3.897	0.002**	-5.554	0.000*	-3.884	0.002**
Energy	-1.605	0.481	-5.142	0.000**	-1.591	0.488	-5.112	0.000**

* Indicates variable is stationary at level. ** indicates variable is stationary at first difference

Finding the order of integrations of gross output and others variables is pre requisite for co-integration analysis. Variables of model are the integrated in mix order like; I(0) and I(1). For this, ADF, PP tests are useful to confirm the unit root level in such a way that no variables are integrated at second difference. Both tests provide reliable results in case of small sample data sets (Ratha, 2003). The results PP and ADF tests of unit root are described in above table 5.5. Results show that gross output (*ln*Y*)* and labor force (*lnL*) is unit root free at level. While gross capital (*lnK*) and total energy services (*lnE)* are integrated at first difference for example, I(1) by trend and intercept. In such condition, the ARDL bounds testing technique to cointegration is most appropriate to observe the long run relationship between variables (Pesaran et al., 2001). After confirmation of the stationary next task to examine the ARDL bound testing's method for log run relationship among the variables is exist or not.

Table 5.6: Bound Test of Fertilizer Industry

Test Statistics	**Value**	**K**
F Statistics	**15.406**	**3**
Significance	**I0 Bound**	**I1 Bound**
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

This study has selected Akaike information criterion (AIC) for suitable lag order of the variables. The suitable selection of variables lag length is supportive to calculate ARDL (F-statistic) in investigating whether co-integration occurs or not. This study chose two lags lengths for our model and findings are revealed in above table (5.6). The AIC performs better in selection of lag length due to its superior power properties (Shahbaz al., 2013) . Outcomes indicates the upper critical value is less than the calculated F-statistics value at % level of significance (Pesaran et al., 2001). One may conclude that there prevails a co-integration among gross output and other independent variables (gross capital, labor and energy). After confirmation of cointegration in bound testing next this study go to estimation for long-run and short-run.

Table 5.7: Long Run Fertilizer Industry

Variables	Coefficient	S.E	t-Stat	Prob
LK	0.291	0.071	4.086	0.000
LL	0.455	0.189	2.403	0.023
LE	0.392	0.186	2.110	0.044
C	0.367	0.449	0.817	0.421
R-squared	0.993	***Adj R-squared***	0.992	
Akaike info	-5.409	***D-W***	2.33	

Above table (5.7), indicate the empirical results of fertilizer industry for long run under a proportional scenario. After confirmation the existence of cointegration through bound-test, the long run coefficients results of ARDL are reported in the above table (5.7). The findings indicate that in our model, there is strong impact of energy, capital and labor on the gross output of fertilizer industry in the long run. The coefficients of all independent variables gross capital, labor force, and energy services are significant in statistically. The coefficient of gross capital foundation is statistically significant and there has the positive influence on gross output of fertilizer industry. For simplicity, we can also say that by holding all other factors constant (Z. Wang et al., 2014), on average one percent rise in gross capital contributes to gross output of fertilizer industry by point twenty nine percent and vice versa. This study also find the connection between gross output and energy is significant and outcomes show that one percent rise in energy uses donates to gross output of fertilizer industry by point thirty nine percent all else the same. Above table shows that the coefficient of labor force of fertilizer industry is significant and positively affect the gross output over the long run, a point four percent increase gross output linked with a one percent increase in labor force, all things being the same. Next this study goes to estimate ECM for analyze the short run impact.

Table 5.8: ECM and Model Diagnostics of Fertilizer Industry Model

Variables	Coefficient	Std. Error	t-Statistic	Prob.
D(LK)	0.391	0.064	6.111	0.000
D(LL)	0.705	0.297	2.375	0.025
D(LE)	0.216	0.097	2.214	0.035
CointEq(-1)	-0.551	0.074	-7.464	0.000
Breusch-Godfrey LM Test	**Prob**	**White Test of Hetero**	**Prob**	
F-statistic	4.179	0.027	0.649	
Obs*R-squared	8.769	0.012	5.041	

The purpose of ECM is to enable us to model the short run dynamics among gross output and gross capital, labor force and energy services. Here, study has applied ECM to find short-run dynamic connection and outcomes are presented in above table (5.8). The most attractive term of above table is ECT term with magnitude of -0.551. It implies that if there is any exogenous shock and balanced output vary from its potential level than about point fifty five percent recovery will be achieved in one time period. ECT term is also called stability term (Shahbaz et al., 2013). This study empirically finds that the relationship between all independent variables gross capital, labor, and, energy are positive or significant impact on gross output in fertilizer industry. This shows that one percent rise in gross capital will rise to point thirty nine percent of gross output all things being same. The result of above table show that the coefficient labor force of fertilizer industry is significant and positively affect the Gross output over the short run, a one percent rise in labor force is contributes with a point seventy percent rise in gross output, all else the same. A point twenty one percent rise in gross output related with a one percent rise in energy uses, all things being the same.

The model of fertilizer industry passes all sensitivity analysis tests and indicates that there is the serial correlation does not exist in our model. Now, in model error term is normally distributed and there is no heteroscedasticity. The value of R^2 indicates that the model is well specified.

5.4 Steel Industry

Table 5.9: Unit Root Tests of Steel Industry

Variables	ADF				PP			
	At level		1st difference		At level		1st difference	
	t. stats	Prob	t. stats	Prob	t. stats	Prob	t. stats	Prob
Output	-2.273	0.393	-2.922	0.000**	-2.273	0.370	-2.922	0.000**
Capital	-1.841	0.518	-4.883	0.003**	-1.841	0.407	-4.883	0.002**
Labor	-4.713	0.056*	-5.703	0.000**	-4.713	0.047*	-5.703	0.000**
Energy	-2.168	0.229	-6.558	0.000**	-2.168	0.259	-6.558	0.000**

* Indicates variable is stationary at level. ** Indicates variable are stationary at first difference.

The outcomes ADF and PP of unit root test steel industry are described in table 5.9. Study outcome show that the labor force is unit free and found to be it stationary at the level i.e. I(0). The remaining variables like as, gross output (lnY), gross capital (lnk) and energy (lnE) all is integrated at 1st difference i.e. I(1) with trend and intercept. This outcomes show that the all variables do have mix order of integration. In these such condition, the bound testing of ARDL process to co-integration is appropriate to observe long-run relationship between the variables (Jalil et al., 2013). After confirmation of stationary of all variables next task to examine the ARDL bounds test approach.

Table 5.10: Bound Test of Steel Industry

Test Statistics	Value	K
F Statistics	14.876	3
Significance	I0 Bound	I1 Bound
10%	2.72	3.77
5%	3.23	4.35
2.5%	3.69	4.89
1%	4.29	5.61

The presence of a long-run relationship is critical for effective estimate and interpretation near the model parameters. whenever the relationship equilibrium of long run is exist, than this study can be used the ARDL technique to find out the long run and the short run coefficient (Jalil et al., 2013). Now (F-statistic) calculated value is searching to the selected lags procedure the above table (5.10) result shows that the calculated F-statistic value greater than the value of upper critical bound, grounded on the critical values. We can see in above table the value of calculated F-statics is 14.87 is greater than upper bound value 5.61 and further this results indicates the presence of the long run association in the model.

Table 5.11: Long Run Steel Industry

Variables	**Coefficient**	**Std.Error**	**t-Statistics**	**Prob.**
LK	0.887	0.172	5.156	0.000
LL	0.847	0.392	2.159	0.039
LE	0.232	0.079	2.918	0.007
C	-0.009	0.008	-1.028	0.312
R-squared	0.827	**Adj R-squared**	0.789	
Akaike info	-2.212	**D-W**	1.987	

Above table (5.11), this study summarizes the empirical outcomes of steel industry for long run under a proportional scenario. After confirmation the existence of cointegration through bound-test, now long-run coefficients of ARDL are reported in the above table. The findings indicate that in our model of steel industry, there is strong impact of energy, capital and labor on the gross output in the long run. The coefficients of all independent variables gross capital, labor force, and energy service statistically significant. The gross capital foundation coefficient is statistically significant and has shown the positive impact on gross output of

steel industry. For simplicity, we can also say, on average increase one percent in gross capital formation contributes to gross output of steel industry by point eighty eight percent and vice versa in long run. We also find the relationship between gross output and energy services, and these outcomes shown that is significant and positive impact of energy on gross output. Result shows that one percent rise in energy services also contributes to gross output of steel industry by point twenty three percent all else the same. Above table shows that the coefficient of labor force of steel industry is significant and positively affect the gross output over the long run, simple we say that point eighty four percent increase gross output linked with a one percent increase in labor force, all things being the same. Next, we go to estimate ECT for analyze the short run impact.

Table 5.12: ECM and Model Diagnostics of Steel Industry Model

Variables	Coefficient	Std. Error	t-Statistic	Prob.
D(LK)	0.695	0.196	3.539	0.001
D(LL)	0.414	0.200	2.062	0.048
D(LE)	0.329	0.103	3.198	0.003
CointEq(-1)	-0.680	0.165	-8.581	0.000
Breusch-Godfrey LM Test	**Prob**	**White Test of Hetero**	**Prob**	
F-statistic	1.253	0.301	13.609	
Obs*R-squared	3.059	0.216	34.670	

Here, this study has applied the ECM to estimate the short run dynamic relationship and outcomes are presented in above table (5.12). Further, study estimate that the relationship among gross output and gross capital, labor, and, energy are positive or significant impact on gross output of steel industry. This shows that one percent rise in gross capital will rise to point sixty nine percent of gross output all things being same. The result of above table show that the coefficient labor force of steel industry is significant and positively affect the Gross output over the short run, a one percent rise in labor force is contributes with a point forty one percent rise in gross output, all things remain the same. A point thirty two percent rise in gross output associated with a one percent rise in energy services and vice versa, all things being the same. The most attractive term of above table is ECT term its magnitude -0.680 indicates that if there is any exogenous shock and balanced output vary from its potential

level than about point sixty eight percent recoveries will be achieved in one time period. ECT term is also called stability term.

The model of steel industry passes all sensitivity analysis tests and indicates that there is no serial correlation. The model error term is normally distributed and there is no heteroscedasticity. The value of R^2 indicates that the model is well specified.

Table5.13: Energy Rebound Effect for Long Run[1]

Industries	α=β_1	β= β_2	$1-\alpha-\beta$= β_3	$\varepsilon_e = 1-\alpha-\beta/\beta$	RE=1+ε_e
Cement	0.093	0.291	0.692	2.37	337%
Fertilizer	0.291	0.455	0.392	0.861	186%
Steel	0.887	0.847	0.232	0.273	127%

Above table (5.13) summarize outcomes of empirical estimations of energy rebound effect in long run under the proportional scenarios. The outcome here indicates the long-run effect is near to double of the short-run effect. Firstly, study found that there are exists energy rebound effect in all selected energy intensive industries of Pakistan specifically, during the period from 1978 to 2015. Furthermore, the magnitude of the energy rebound effect of cement industry is estimate, in long-run the gross output and energy use of energy efficiency gain τ impact is depend on the share of energy use$(1-\alpha-\beta)$ in cement industry this share is in the order of 237%. Then ε_e is in the range of $(\frac{0.692}{0.291}) \approx (2.37)$ which implies that 100% increase in energy efficiency τ corresponds to 237% rise in energy uses and furthermore, on average energy rebound effect in cement industry during the 1978 to 2015 reached 337% and indicate the significant backfire effect (i.e., more than 100%) in long run, we seen highly rebound effect exist in cement industry because in cement industry energy consumption in 2015 was 8 time greater than that in 1978. In cement industry 237% back-fire exists in the long run, because, savings of expected energy through the energy advancement were offset due to extra energy consumption by output growth (Gillingham et al., 2015).

[1] CD long run intensity and growth effects

Same above in long run effect of energy use of energy efficiency gain τ on gross output depend on the share of energy use$(1-\alpha-\beta)$ in fertilizer industry. This share fertilizer industry is in the order of 86.1%. Then ε_e is in the range of $(\frac{0.392}{0.455}) \approx (0.861)$ which indicates that 100% rise in energy advancement (τ) corresponds to 86.1% increase in energy uses all things being same. Secondly, in fertilizer industry average energy rebound effect during the 1978 to 2015 reached to 186.1% in long run. That means during the period from 1978 to 2015 100% of the probable savings of energy were offset due to extra energy consumption through the energy efficiency (technological advancement), and there is zero percent of the probable savings of energy gained in fertilizer industry.

Energy rebound effect in steel industry is a lower than cement and fertilizer industries in long run and the average magnitude effect of the energy rebound in steel industry reached to 127.3% in long run during the period from 1978 to 2015. Furthermore, our study finds out the aggregate rebound effect of all industries by the same process, and the outcomes shows that on average aggregate energy rebound effect of selected energy intensive industries reached to 216.8%.

Table 5.14: Energy Rebound Effect for Short Run[2]

Industries	$\boldsymbol{\alpha}$	$\boldsymbol{\beta}$	$\boldsymbol{\alpha+\beta}$	$\boldsymbol{1-\alpha-\beta}$	$\boldsymbol{\varepsilon_e = 1-\alpha-\beta/\alpha+\beta}$	$\boldsymbol{RE=1+\varepsilon_e}$
Cement	0.044	0.137	0.181	0.325	1.79	283.6%
Fertilizer	0.391	0.705	1.096	0.216	0.197	119.7%
Steel	0.695	0.414	1.109	0.329	0.296	129.6%

Table (5.14) this study summarize the outcomes of empirical estimations of energy rebound effect in the short-run under the proportionate scenario. As the all results come through the Input-output dataset, whenever energy efficiency improvement in these industries than they all helpful to compare effects on different economic structures. In all selected energy intensive industries (cement, fertilizer, and steel) same above long run the energy use of

[2]In literature and even in our methodology section, we argued about energy intensity and energy output effect due energy efficiency. These two effects are highly sensitive about the functional form of aggregate production functions. Hare in this study, we employ Cobb-Douglas production which is not appropriate form to calculate energy intensity and output effects. But Constant Elasticity of Substitution (CES) and many other production and cost functions provide these effects effectively (Saunders, 2008).

energy efficiency gains τ impact on output depends on the share of energy use$1-\alpha-\beta$ in short run. This share in cement industry is in the order of 179%. Then ε_e is in the range of $(\frac{0.325}{0.180}) \approx (1.79)$ which means 179% increase in energy uses whenever the 100% increase in energy efficiency (technological advancement) (τ) over the short run. Furthermore, 279% energy rebound effect exists in cement industry.

In fertilizer industry ε_e is in the range of $(\frac{0.215}{1.095}) \approx (0.197)$ which implies that 100% increase in technological advancement (τ) there would result increase in 19.7% increase in energy uses, and this result show the 19.7% energy rebound exist in short run.

Similarly, this share in steel industry is in the order of 29.6%. Then ε_e is in the range of $(\frac{0.329}{1.109}) \approx (0.296)$ which implies that 100% rise in energy efficiency (τ) there would result in 29.6% increase in energy uses and vice versa, and this result show the 129.6% energy rebound exist in in short run. Furthermore, study find out the short run aggregate rebound effect of all industries by the same process, and the outcomes shows that on average aggregate energy rebound effect of selected energy intensive industries over the short-run reached to 177.6%.

CHAPTER 6

Conclusion and Policy Recommendations

The real prestige for any society is enjoying energy-efficiency instead of gross energy consumption. Efficient energy is blessing for economic growth and it is required for sustainable growth. It is common belief that energy efficiency save energy. On other hand, the targeted goals of energy savings through energy efficiency might be partially achieved. It is due to energy rebound effect. This concept was given by Jevons in 1865 (van den Bergh, 2011). To calculate the behavioral reaction of demand side of energy due to energy efficiency in terms of energy rebound effect is a critical task. After calculating this, we are able to design effective policy measures related to energy to environment. Some empirical studies argued that the impact of energy rebound effect is so small we can be ignored (Jin, 2007), while others claim that the energy rebound effect is not so small and its impact is so substantial therefore its required serious consideration (Lin & Tan, 2017).

The prime goal of this study is to quantify the energy rebound effect of three selected energy intensive industries of Pakistan. Study analyzes the Cobb Douglas production function with the help of time series data from 1978 to 2015. The confirmation of unit root level is a prerequisite condition for efficient and consistent outcomes especially when time series data is under consideration. ADF and PP tests are applied on each variable of three models and find mix order of integration. After this estimate each model with ARDL technique. Findings of study confirm the presence of energy rebound effect in industrial sector of Pakistan. On average the energy rebound effect of three industries is about two hundred sixteen percent. It is the range of energy rebound effect approximately 186% fertilizer, 337% cement and 127% steel industries. Our findings are compatible with other studies like the magnitude of energy rebound effect of industries cement, steel, and iron industries reached to50%, 70% and 47% correspondingly in circumstance of India (Roy, 2000). These differences recommend that the energy services efficiency of energy specific technological change in selected energy intensive industries in Pakistan performs relatively not well. Manufacturing output growth verifies that a relatively dominant factor in the production process is energy consumption. The trend of energy consumption in selected industries is increasing over time. Energy consumption of cement industry in 2015 is 8 times greater than in 1978. On the same pattern, energy consumption of fertilizer industry is 1.4 times greater than that of 1978, the same in

steel industry exist. Manufacturing output growth is the main factor to promoting industrial energy consumption by 3.76 times greater than from 1978.

On the basis of results, this study draws conclusions as follows: first of all, the outcomes of our study confirm the presence of energy rebound effect exist in Pakistan energy intensive industries. So, energy saving from energy efficiency in these industries most probably counteracted. As compared to other countries, the energy rebound effect at industry level in Pakistan is significant. At public level effective support is not provided to industries to improve their efficiency. Such magnitude of rebound is a serious threat for the environment as well future generations. It is a dire need that reasonable checks on the energy consumption should be taken as extra to technical change. The high magnitude of energy rebound might be due to growth. It seems there is a trade-off between the future environment and present economic growth. The size of elasticity of output with respect to energy input suggests that industrial energy demand cannot be disturbed by tight policies. Otherwise, cost should be paid in the form of slow growth of the industrial sector.

- High magnitude energy rebound effect of the industrial sector of Pakistan suggests that energy and environment related policies should incorporate this.
- The rate of substitution between energy and all other factors of production should be calculated at the first stage then impose some restrictions on substitutability.
- The shares of capital and energy in production process at firm level should be analyzed for effective restrictions.
- At the end, this area of research is premature, so further analysis should be taken to identify the problematic area. There should be separate analyses to measure the welfare effect of energy rebound effect and environment effects of energy rebound.

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