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Decomposition and Decoupling Analysis of Electricity Consumption in Pakistan

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ABSTRACT: Electricity is a form of energy and plays a significant role in increasing the economic development of the country and covers all the sectors. Electricity consumption is increasing day by day with the increment of population. When the production of sectors is higher than power consumption required is also higher. This paper uses an index decomposition method to investigate the components that affect Pakistan's electricity consumption from 1990 to 2017 and examines the decoupling state. These analyses were achieved at the segment stage. The outcome indicates that the impact of economic activities was the major dynamic strength of rise in power consumption when the energy intensity impact prevents it. The industrial and service areas were the top two shares that boosted electricity consumption. The variations in power consumption are due to the gross domestic product development inside Pakistan as indicated by six de-coupling conditions. Service sector played an important role in the decoupling which presented electricity consumption as expansive negative and weak decoupling, while the agricultural sector described as expansive negative decoupling and the industrial sector illustrated as weak decoupling.

Keywords: Decomposition, Decoupling Method, Electricity Consumption, LMDI, Pakistan.

I. INTRODUCTION

Energy plays a significant role in the both social and economic growth of any country. Electricity is one of the most flexible forms of energy [1]. Most of the world's economies have recently experienced lack of energy due to rapid growth in energy demand. Electricity play a significant part in social-economic development in developing and developed countries [2]. Electricity generation is crucial to the total development of the nations. Sustainable generation of power will boost a country's economy, quality of life and social welfare. Various sectors and industries are responsible for a nation's sustainable development, including manufacturing, transportation, construction, urban development, agriculture, mining, education and most power generation [3].

Pakistan is among those developing nations and facing an energy deficiency problem. The past and current governments in the country have planned different energy approaches to satisfy the energy demand, however, they could not be able to connect the gap among demand and supply [4]. Power sector of Pakistan is in crises because of the unique problems and are caused by the financial situation, shortage of transformation of the electricity, debt recovery, electricity hookers, the excessive usage of electricity in the industrial, commercial areas, agriculture, transport sector, huge line losses, corruption, mismanagement, institutional weakness, and political controversy [5]. Pakistan's population is increasing day by day therefore, electricity consumption is also increasing, and the government has also ineffectual policies for the provision of infrastructure for the power sector [6]. Numerous studies have examined the relation in electricity usage and economic development. Generally, the commercial development of any nation depends on electricity consumption. Therefore, consumption of electricity is strongly associated with real GDP growth. So, it is significant to research the nexus in GDP growing and power consumption [7]. Its goal is to reduce the price of fuel subject to power stability, limitations of generators, transmission lines, and restrictions on the tie-line. Because of the model size, nonlinearity, and interconnections, it is difficult to solve the MAEED problem under the situations of deregulation. It concludes the amount of power that can be economically produced in the regions and, if necessary, shifted to other regions without violating the constraints of tie-line capability. To reduce the difficulty of the problem provided by "High-performance computing (HPC)" and the period to calculate by using parallel processing to safely, accurately and rapidly run advanced application programs[8].

There are various power quality problems with this integrated system, such as voltage variance, harmonics, and unbalancing, etc. Using a distribution static compensator (DSTATCOM), these problems are extensively discussed and answered in this article. DSTATCOM's voltage source converter (VSC) is regulated to provide the expected device with the required compensation. DSTATCOM injects compensating current into the reactive power delivery system and Zero Voltage Control (ZV) transient voltage helps. Via simulation in MATLAB 2011b, a full power balance analysis of the proposed system is also provided under different operating conditions of the delivery system [9].

Nowadays many analyses have emphasized on the relation among financial growth and electricity consumption, but the results remain inconclusive due to upgrading and economic transformation, this condition can be more obvious. Therefore, it is essential to examine the characteristic of dissimilar sectors, deviation in power usage. In recent years some research had showed on de-coupling and decomposition examination of Pakistan's electricity usage of nationwide and sector stages. The motive of our research is to seek out the electricity consumption (1990-2017) of different sectors using LMDI method and decoupling of Pakistan. (1) It is a combined study of the economic adjustment and electricity utilization in Pakistan from 1990-2017. (2) Pakistan's commercial sectors divided in 3 sub commercial sectoral groups i.e. (agricultural, industrial and services), analyze the changes of main drives at numerous scales on sectoral levels and electricity consumption depends on the LMDI method. (3) LMDI method and de-coupling approach combining, we analyze conditions of decoupling among economic output, electricity consumption and examine its practical implication and each driving factor changes in Pakistan. (4) We will estimate the decoupling index of 3 regions and discuss the decoupling association during 1990-2017.

II. MATERIALS AND METHODS

A. Background and Motivation of Study

China used the LMDI model and Decoupling approach to demonstrate that the relationship of decoupling is in state of alternate between extended negative decoupling and weak decoupling in 1985 to 2016. The 7 components have different effects on the decoupling relation. Here in power generation the energy consumption and energy intensity promote decoupling, but both economic scale and electrification are the 2 major components that hinder decoupling. The impact of the other three factors is relatively weak [1]. Fang *et al.,* (2019) of China using LMDI model to calculate the outcome has found that economic growth has greatly increased energy consumption, and technological growth can effectively curb energy usage. The results of power consumption are investigated from an industrial and regional perspective; economic formation and intensity expending have significantly dissimilar effects related to the east, central and west areas. In China, the LMDI & De-coupling Model to find the We use Tapio index for elastic decoupling to study the decoupling condition of CECL, by 6 factors driven by economic growth [11]. In 2002, 2012, 2014 and 2015, CECL's economic growth was strongly decoupled, and in the next 13 years, the decoupling phenomenon was weak. Decoupling is mostly due to the country's economic production and energy intensity. In the end, we eliminated the impact of economic land production, measured the cost of 5 components that decouple CECL as economic development, and pointed out that construction land is a viable political tool. In China, Decoupling Model [12] for the outcomes indicates that: (1) the rise CF from 23.34 MTOE to 32.25 MTOE of CO_2, an average annual enhancement of 4.01%. Energy utilization accounted for 69.51%, much higher than other accounts. (2) Xi'an's carbon dioxide load capacity reduction from 7.78 MTOE to 7.45 MTOE; with an average yearly reduce of 0.47%. The shortfall list of carbon varied from -2.57% to 17.09% representing that there is small improvement in reducing environmental pressure. (3) The main driving force for CF growth is per capita housing, and the urban rate limits the development of CF. In Philippines, LMDI method to calculate the outcomes demonstrate in the European district from 1990 to 2014 the impact was around 10.3 $MtCO_2$ because of electricity exchanging [13]. Carbon discharge increments because of electricity sending out even expanded because of population development. We examine arrangement and more extensive results for supportable routine with regards to electricity exchanging the substance of decreased discharge. In Portugal, a decoupling model to find the result confirms that in the sample of the countries studied [14], changing the technical scale of energy manufacture is the main factor affecting the better production limit. In addition, from the hybrid outcomes of the decoupling index, we can determine that the enhance/reduce in per capita carbon di oxide emissions are more due to other economic and environmental issues relatively than the -ve/+ve impact of GDP growth. In China, LMDI method for finding the main outcomes are as follows: (1) from 2000-2014, it was the Chinese non-ferrous metal industry [15]. Energy expending enlarged nearly 69.08% MTOE of standard coal. (2) ΔEG rises energy in all year's expending and contributes the most rise in energy expending (followed by ΔEL), while ΔEEI is the main factor for decreasing energy consumption during a similar time. This corresponds to 104.07% variation in the total worth of overall energy utilization; (3) ΔEES and ΔES contribute 0.24% and 1.45%. The decrease in ΔEEI is not able to fully compensate for the rise caused by another four impacts. This study presents some strategies guidance depends on the conclusions. China using LMDI method and LEAP model to calculate the inhibitory impact on the development of aggregate energy consumption because of structure impact and effectiveness efficiency effect on the structure impact for all intents and purposes induced [16]. Korea used LMDI to calculate the outcome from impacts are shown that the effect of activity is largely contributing to enhance in energy utilization where effect of intensity showed role in decreasing, Structure effect shows positive value but the structure effect from 1991 to 1993, from 1994 it reduces the energy consumption except in 1997-1998 & 2004-2005 [17]. In China LMDI and decoupling approach to find the outcomes demonstrate the power to produce and coal utilization assume important jobs in deciding the dimensions of CO_2 outflows [18]. The prime states between no de-coupling and weak de-coupling were in examination time. He discovered that the de-coupling list perform superior (as far as solidness) than did the power produce flexibility of CO_2 discharge. In China LMDI & Decoupling Model to find the outcomes demonstrate the China played out the relative de-coupling of economic development from carbon dioxide discharges between 1992 to 2012. This study relevant according to the method of carbon power in modern segment and energy discharge influence in service, industrial, agricultural and construction parts [19]. In Tunisia, the LMDI method to find the overall result of economic output, result shows that the population scale, transport scale, and transport structure is positive on consumption of energy and energy intensity is negative of the overall effect [20].

B. LMDI Mathematical Model

Index Decomposition Analysis (IDA) is a logical instrument created about in the late 1970s. It has since been touched out to different regions including CO2 outflow examination, ecological administration, and sustainable consumption of natural assets. Several specific decomposition methods can be produced, and LMDI is one of them. But we use additive decomposition analysis during this research. With the help of LMDI methodology, the whole electricity consumption impact on Pakistan has been mentioned according to the given below formulas: the overall electrical energy consumption in economic sectors in year n is X^n.

$$X^n = \sum_i X_i^n = \sum_i \frac{X_i^n}{Y_i^n} \cdot \frac{Y_i^n}{Z_i^n} \cdot \frac{Z_i^n}{Z^n} \cdot \frac{Z^n}{U^n} \cdot U^n = \sum_i M_i^n . N_i^n . O_i^n . P^n . U^n \quad (1)$$

$$\Delta X_{tot}^n = \Delta X_m^n + \Delta X_n^n + \Delta X_o^n + \Delta X_p^n + \Delta X_u^n \quad (2)$$

$$\Delta X_m^n = \sum_i V_{i,n} \ln\left(\frac{M_i^n}{M_i^{n-1}}\right) \quad (3)$$

$$\Delta X_n^n = \sum_i V_{i,n} \ln\left(\frac{N_i^n}{N_i^{n-1}}\right) \quad (4)$$

$$\Delta X_o^n = \sum_i V_{i,n} \ln\left(\frac{O_i^n}{O_i^{n-1}}\right) \quad (5)$$

$$\Delta X_p^n = \sum_i V_{i,n} \ln\left(\frac{P_i^n}{P_i^{n-1}}\right) \quad (6)$$

$$\Delta X_u^n = \sum_i V_{i,n} \ln(U^n/U^{n-1}) \quad (7)$$

$$V_{i,n} = \frac{X_i^n - X_i^{n-1}}{\ln(X_i^n) - \ln(X_i^{n-1})} \quad (8)$$

Hence;

$X^n$is the overall consumption of electricity in the economic sector in year n, where X_i^n,Y_i^n andZ_i^n signifies the overall electricity usage, energy usage and gross domestic product of sector i in year n. Z^n is the total gross domestic product in year n, and U^n is the total active population in any year.

$M_i^n = \frac{X_i^n}{Y_i^n}$ the equation indicates the ratio of the contribution of sector's electricity usage to the overall usage of energy, where 'i indicates to sector' and 'n indicates to year',

$N_i^n = \frac{Y_i^n}{Z_i^n}$ designates the 'energy intensity' of 'sector i in year n',

$O_i^n = \frac{Z_i^n}{Z^n}$ designates the 'economic structure' of 'sector i in year n',

$P^n = \frac{Z^n}{U^n}$ means per percent GDP outcome in year n, and U^n is the overall active population in year n.

The power consumption rises from the previous year 0 to present year n showed to ΔX_{tot}^n . It may be determined into 5 inducing drivers given below:

1) The variation of electricity sector outcome (ΔX_m^n)
2) The variation of energy intensity outcome (ΔX_n^n)
3) The variation of economic structure outcome (ΔX_o^n)
4) The variation of economic activity outcome (ΔX_p^n)
5) The variation of population outcome (ΔX_u^n)

$\boldsymbol{V_{i,n}}$ is equal to the weight which is used in the above equations.

C. Decoupling Model

The decoupling model is used to demonstrate the interconnection among connected factors. It takes place after two different asset classes that typically rise and fall together move in opposite directions, such as one increasing and the other decreasing.

$$B^n = \frac{\%\Delta X}{\%\Delta Z} = \frac{Z^{n-1}}{X^{n-1}} . \Delta X_m^n + \Delta X_n^n + \Delta X_o^n + \Delta X_p^n + \Delta X_u^n / \Delta Z^n \quad (9)$$

$$B^n = B_m^n + B_n^n + B_o^n + B_p^n + B_u^n \quad (10)$$

Where $\boldsymbol{B^n}$ the total Decoupling indicator is $B_o^n, B_u^n, B_m^n, B_p^n, and B_n^n$, denotes the indicators of the five effects of the decoupling: economic structure sub indicator (B_o^n), population sub indicator (B_u^n), electricity share sub indicator (B_m^n),

Economic activity sub indicator $(B_p^n) and$energy intensity sub indicator (B_n^n).

As per Tapio's description, around eight decoupling states among GDP and electricity consumption shown below Fig. 1, where ΔX indicates the change in electricity utilization and ΔZ indicates the change in population. There are the eight de-coupling states: i. Strong de-coupling ii. Weak de-coupling iii. Expensive coupling iv. Expensive -ve de-coupling v. Strong -ve de-coupling vi. Weak -ve de-coupling vii. Recessive coupling viii. Recessive de-coupling.

From the perspective of the relationship between economic growth and energy stress, de-coupling states classified into 2 major categories: "relative decoupling" and "absolute decoupling". Fig 1 depicts the length of time, when the economic growth rate was greater as compared to material expending rate, they displayed definite coupling proportion described as relative or weak de-coupling. When the utilization of materials declines with economic development, disappears the coupling ratio. This is called absolute or strong de-coupling. The -ve de-coupling relationship is in an expanding state, indicating that the development mode is unreasonable and economic development comes at the cost of high energy utilization and environmental pollution. Expansive connection is a more ordinary approach in the present time representing the near dependence and mutually reinforcing relation in both economy and energy. But extensive coupling is not conducive to long-term sustainable economic development. Like the other four states of decoupling, negative economic growth is not desirable.

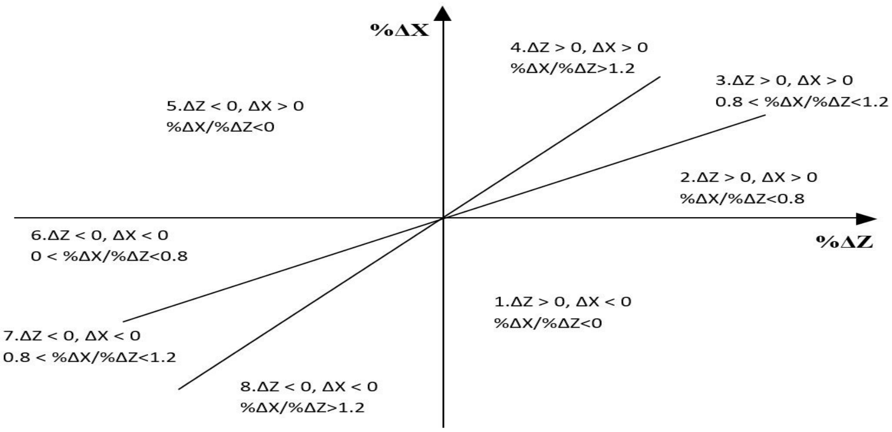

Fig. 1. Electricity consumption of degree of coupling from gross domestic product.

D. Data Description

The collection of data of electricity consumption and energy consumption is taken from the international energy agency (IEA) from 1990-2017 using three segments. Economic growth (GDP) of Pakistan has been taken from the world development indicators (WDI). The sectorial electricity consumption denotes to total electricity produced by primary, secondary and tertiary and the consumption of energy denotes to sum of agriculture, industrial and tertiary energy. Kilo-watt-hour (KWH) is the unit of electricity consumption and kilotons of equivalent (KTOE) is the unit of energy consumption. Pakistan's GDP is expressed in terms of US dollars.

III. RESULTS AND DISCUSSION

A. Electricity consumption and economic status analysis in Pakistan

The variations in actual gross domestic product per person and Pakistan's population from 1990 to 2017. The GDP rise from 40.01 billion (USD) to 304.56 billion (USD) in 1990-2017, indicating the annual growth rate was 8.05% as shown in Fig. 2.The economic structure of Pakistan is shown in Fig. (3) indicate that in 1990.

Pakistan's economy suffered from poor governance and small growth between the Pakistan People's Party (PPP) led by Benazir Bhutto and the Pakistan Muslim League (PMLN) by Nawaz Sharif. The growth rate fallen to 4% GDP and Pakistan continues to face external deficits and budget, triggering a debt crisis. Stagnate the exports and Pakistan lost its market proportion in a dynamic world trade environment. Poverty had doubled over 18% to 34%, causing the Human Development Index of the United Nations Development Program to rank Pakistan in one of its short development classification of the year [21]. Pakistan's improved and opening policies which promoted industrial transformation and varied structure of the economy at that time. In the beginning the industrial and service department was not fully developed in 1990 and associated departments were locomotive driven economic growth.

Fig. 2 indicates the population of Pakistan increases from 1990 to 2017 and GDP also increases from 1990 to 2017, in addition to economic growth, total electricity utilization indicates that simultaneous development in the initial years of improvements and opening policies. During the period 1990-2017**,** the economic section raised power consumption 28782 million kWh to 117236 million kWh. The growth rate of power usage and economic development in 1991 reached 9.67% and 0.21%, respectively. The growth of Pakistan's electricity consumption in 2002 and 2003 was 4.01% and 9.18% respectively, power consumption amount in the energy consumption increased year by year.

Fig. 3 represents the variation occurs from 1990 to 2017 in three sectors that is agriculture, industrial and service, where the service segment has higher economic structure impact as compared to agriculture and industrial.

In Fig. 4 which shows the difference in electricity consumption between three segments (agriculture, industrial and service) and also indicates that the service segment consumes electricity greater than 60% of the whole electricity utilization.

The Fig. 5 shows the energy intensity of three segments. It has decreased in pattern from 1990-2017. Which shows that the energy intensity of primary and service segments is minor compared to that of the industrial segment, which shows that primary and service segments are shorter energy consumers while the industrial segment is recognized as a higher energy consumer.

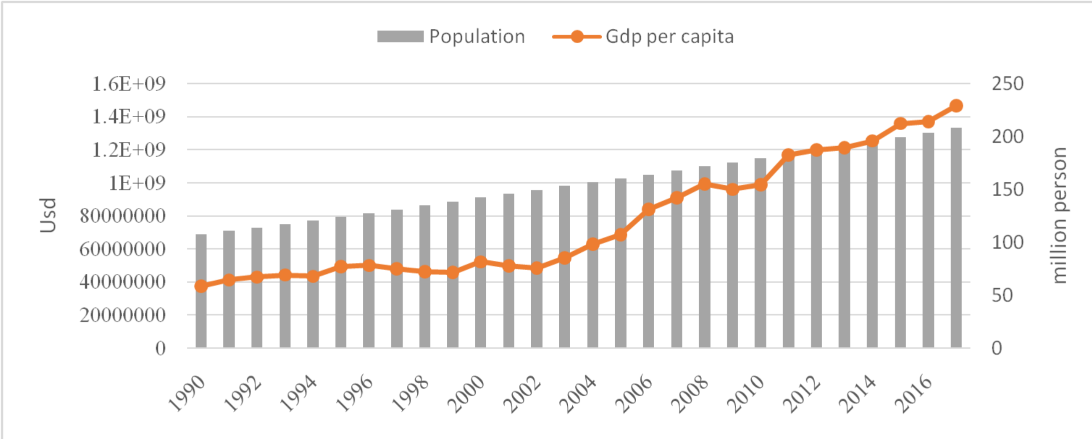

Fig. 2. Variations in actual gross domestic product per person and population in Pakistan from 1990 to 2017.

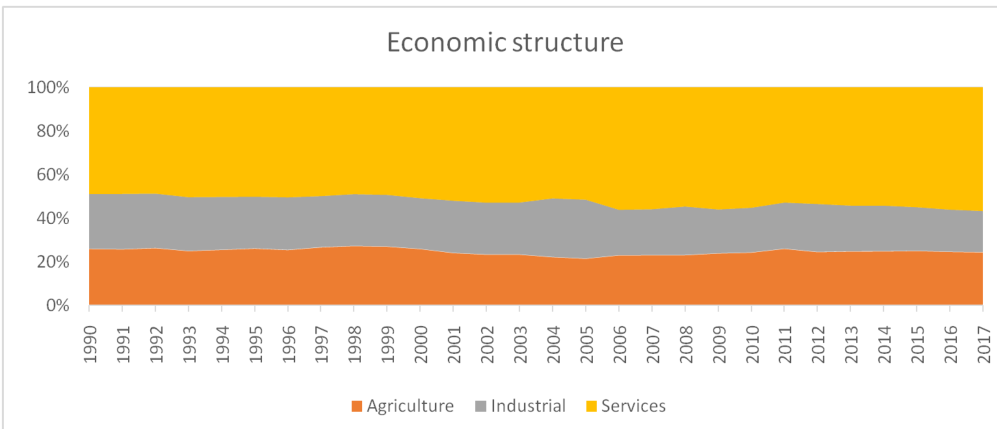

Fig. 3. Economic structure change in Pakistan in from1990-2017.

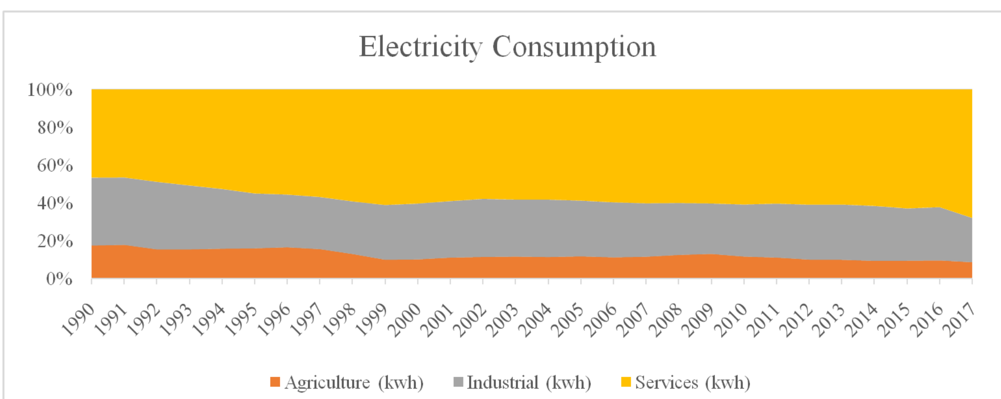

Fig. 4. Electricity consumption pattern in Pakistan from 1990 to 2017.

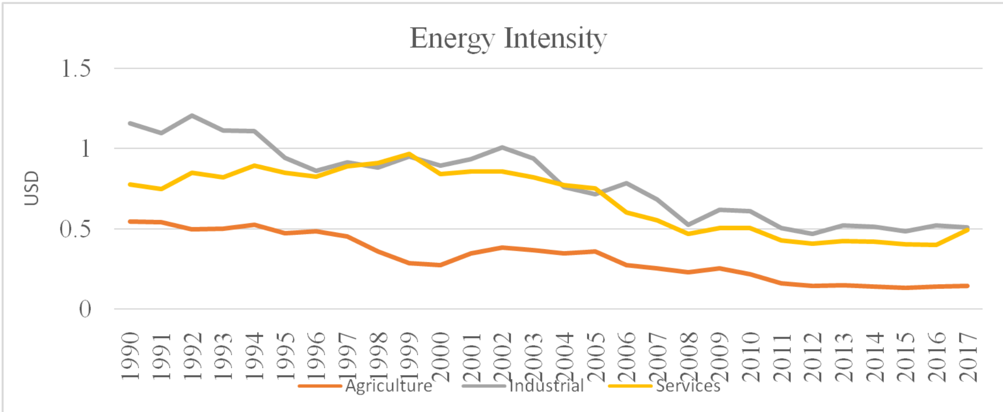

Fig. 5. Energy intensity changes in Pakistan from 1990 to 2017.

B. Decomposition analysis of electricity consumption in Pakistan

By LMDI approach, in fig 6 and tab: (1) LMDI outcomes of overall electrical energy utilization in Pakistan as shown.

As shown in Table 1 and Fig. 6 from 1990 to 2017, the power share effect enhances electricity consumption in Pakistan by 77.98%, and its share is +ve about each year. The electricity consumption of the 10th FYP (five-year plan) rise by 55.50% which was due to variation in power consumption. During 2016-2017, Pakistan's power share impact increased by 711.2 million kWh.

Table 1 indicates the five year difference of decomposition in overall electricity utilization in Pakistan 1990 to 2017. From Table 1, energy intensity played an essential part in decreasing power expending 115.39% between 1990 to 2017. The energy intensity impact has led to reduced power consumption in each FYP. The energy intensity impact enhances briefly during 1995-2000, as shown in Fig. 4. This is due to the initial improvement to the World Trade Organization (WTO) Pakistan was under pressure from high-quality foreign products without focusing on energy conservation, which has led to a short increase in energy intensity. In 11th FYP, Pakistan has achieved the goal of decreasing energy intensity by 36.32% through plans such as export tax credits and closure of low production efficiency.

The economic structure impact was the most indeterminate driver affecting electrical consumption every twelve-month. Through the total research, the decrease of power usage leads to the economic structure impact was 375.3 million kWh, considering 6.76% of the whole variation. The impact on economic structure is +ve in other years rather than 12th FYP. The impact of economic activity was the major dynamic strength of rise in electricity consumption in Pakistan during 1990-2017. Pakistan has experienced huge economic growth and GDP since 1990, and raises 304.56 billion USD in 2017 as indicated in Fig. 2. With the strength of the economy and rise in gross domestic product per person, individuals with rich income chosing further pleasant existing surroundings and industries increased performance.

While the overall inhabitant grows, production activities become further energetic and further power is required. Fig. 1. Indicate the Pakistan's inhabitants had enhanced 51.77% in 27 years. However, the population impact enhanced power consumption by 42.36% during 1990-2017 and Pakistan’s population growth rate was 2.46% per year.

Fig. 6 shows that the impact of Pakistan’s total power consumption from 1990 to 2017 indicates that the intensity impacts were -ve in 2014-2015 and 2017, and structure impacts were -ve in 2013-2014 and 2016 which reflects the contribution of the decoupling nexus.

Table 1: The outcomes of decomposition of overall electricity usage in Pakistan, 1990-2017 (Measured in: Million kWh).

Years	ΔX_m^n	ΔX_n^n	ΔX_o^n	ΔX_p^n	ΔX_u^n	ΔX_{tot}^n
1990-1995	149.5	-139.7	11.2	153.7	77.7	252.4
1995-2000	37.4	-2.26	12.7	16.07	38.2	102.2
2000-2005	110.4	-176.3	25.8	166.6	72.3	199.0
2005-2010	10.7	-158.2	17.5	142.3	43.5	55.9
2010-2015	30.7	-144.5	-10.7	171.3	56.9	103.7
2016-2017	711.2	-531.4	4.8	63.5	19.3	267.5
1990-2017	4328.0	-6404.3	375.3	4899.7	2351.2	5550.1

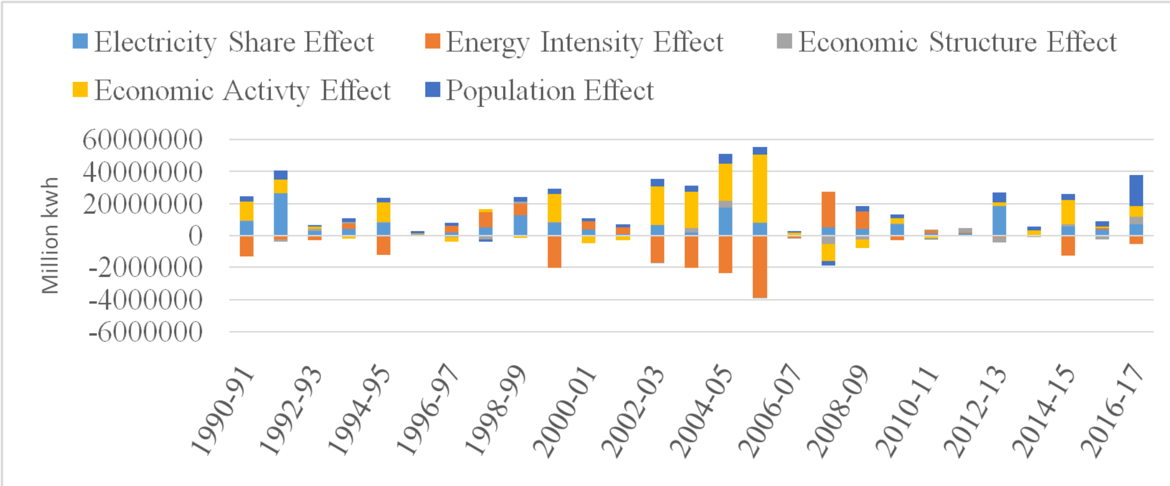

Fig. 6. The Overall electricity consumption outcomes from LMDI in Pakistan from 1990 to 2017.

Table 2: The outcomes of decomposition of Pakistan's sectorial power utilizations, 1990-2017 (Measured in: Million kWh).

Sectors	$\Delta X^n_{m,i}$	$\Delta X^n_{n,i}$	$\Delta X^n_{o,i}$	$\Delta X^n_{p,i}$	$\Delta X^n_{u,i}$	$\Delta X^n_{tot,i}$
Agriculture	113.4	-406.4	-1.3	303.7	145.7	155.1
Industrial	122.8	-710.5	-162.4	977.5	469.1	696.5
Services	2574.8	-5287.4	539.1	3618.5	1736.4	3181.4

From Table 2, the conclusion of high electricity utilization such as agricultural, industrial and services in Pakistan during 1990-2017. According to the data from the three segments in table 2, the impact of electricity proportion was the +ve effect on power utilization in 1990-2017.

In terms of energy intensity impact these three segments played -ve role. Compared with the other two industries, the Service segment is the major components that lead to the decline in energy intensity.

The outcome concludes of economic structure variation impact of three segments also given in Table 2. Which shows that the industrial sector and agriculture sector was the main contributor to reduce the structure effect from 1990-2017, while the service sector had an important influence on structure impact. The economic activity impact and Population impact of the service segment increased as compared to industrial and agriculture sectors.

C. Decoupling study of Pakistan's electricity consumption and economic development

There are six decoupling states occurred through the research as shown in table 3. Expansive -ve decoupling appeared in 1992, 1994, 1999, 2001, 2013 and 2016-2017. Strong negative decoupling appeared in 1997, 2002 and 2009. Recessive decoupling appeared in 1998. Expansive coupling appeared in 2005. Strong decoupling appeared in 2008 and 2011-2012. Power consumption indicates the weak decomposition relation with gross domestic product development, which shows that consumption of electricity increases by means of economic gross domestic product rise. The electricity variation share is lesser than its gross domestic product. This nature shows during the residual 12 years of research.

From Fig. 7 the conclusion of the power share impact and energy intensity impact was a powerful variable, the rise and fall of the 'economic structure', 'economic activity' and 'population' impact remained comparatively mild. The result trend is basically synchronized among the overall decoupling index and the sub-indicators of electrical share and energy intensity. As per preceding examination of LMDI which concluded the economic activity was the leading driver of sectorial power usage development. Tapio's decoupling model is used in Table 2 to study the decoupling state among production of economics and utilization of power. Table 3 shows the de-coupling relation in both Pakistan's GDP and electricity consumption, 1990-2017. Measure the decoupling index for every impact, and outcomes shown in Fig 7.

Table 3: The Pakistan's decoupling state of overall electricity use and gross domestic product in economic areas, 1990-2017.

	Year's	%ΔX	%ΔZ	Β	Decoupling states
8th FYP	1990-91	0.71	0.14	0.10	Weak Decoupling
	1991-92	2.23	0.07	0.16	Expansive -ve Dec:
	1992-93	0.42	0.06	0.02	Weak Decoupling
	1993-94	7.40	0.01	0.06	Expansive -ve Dec:
	1994-95	0.35	0.17	0.06	Weak Decoupling
9th FYP	1995-96	0.53	0.04	0.02	Weak Decoupling
	1996-97	-2.76	-0.01	0.04	Strong -ve Dec:
	1997-98	7.41	-0.004	-0.03	Recessive Decoupling
	1998-99	4.21	0.01	0.05	Expansive -ve Dec:
	1999-00	0.38	0.17	0.07	Weak Decoupling
10th FYP	2000-01	-1.88	-0.02	0.04	Expansive -ve Dec:
	2001-02	-9.96	-0.004	0.04	Strong -ve Dec:
	2002-03	0.61	0.15	0.09	Weak Decoupling
	2003-04	0.38	0.18	0.07	Weak Decoupling
	2004-05	0.89	0.12	0.10	Expansive Coupling
11th FYP	2005-06	0.29	0.25	0.07	Weak Decoupling
	2006-07	0.07	0.11	0.01	Weak Decoupling
	2007-08	-0.36	0.12	-0.04	Strong Decoupling
	2008-09	-5.03	-0.01	0.057	Strong -ve Dec:
	2009-10	0.70	0.05	0.04	weak decoupling
12th FYP	2010-11	-0.02	0.21	-0.003	Strong Decoupling
	2011-12	-0.04	0.05	-0.002	Strong Decoupling
	2012-13	2.83	0.03	0.09	Expansive -ve Dec:
	2013-14	0.53	0.06	0.03	Weak Decoupling
	2014-15	0.49	0.11	0.05	Weak Decoupling
	2015-16	1.31	0.03	0.04	Expansive -ve Dec:
	2016-17	2.66	0.09	0.25	Expansive -ve Dec:

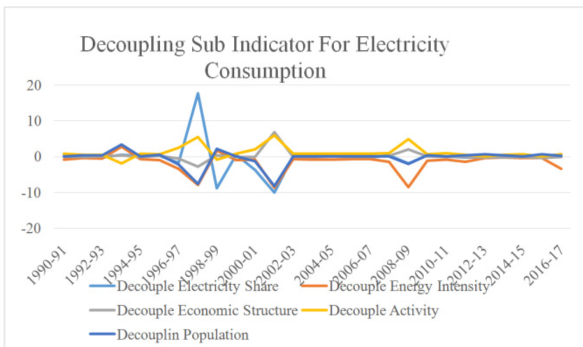

Fig. 7. Decoupling sub indicator for power utilization in overall economic structure from 1990-2017.

From Fig. 8 (a), (b) and (c) analyze the decoupling model of power consumption from three segments agriculture, industrial and service.

Fig. 8(a) indicates the decoupling index for the agriculture section had vast area of worth which indicates six de-coupling relations. In the agriculture segment weak de-coupling, expansive -ve de-coupling and strong de-coupling shows in many years.

Fig 8(b) shows the industrial segment had experienced six states of decoupling, the industrial segment gone weak de-coupling, expansive -ve de-coupling and strong de-coupling.

Fig. 8(c) indicates the service segment experience five states of decoupling in which weak decoupling takes place half of the research behind 2004. According to the decomposition outcomes the economic activity and structure impact remained the more important elements affecting the de-coupling in service segment. While indicate from Fig. 3. The GDP share of service segment in Pakistan increased from 43.34% to 53.17% in 1990-2017. However, the decoupling impact of service segment is slight as compared to industries; the service segment may depend on further power rather than fossil energy. Intensity energy was the major share to de-coupling through 11th and 12th FYP research it is described by advance energy productivity, like further power preserving illumination, air-conditioning, and associated power application organizations. 2017 was the 1st year of 13th five-year plan, and more segments comprise the tertiary segment, experience the force of maintainable growth. A large amount of power consumption is the cause for the temporary rise within de-coupling model. Then analyze the decoupling approach of power consumption of three sectors agriculture, industrial and service (see Table A1 the detail outcomes).

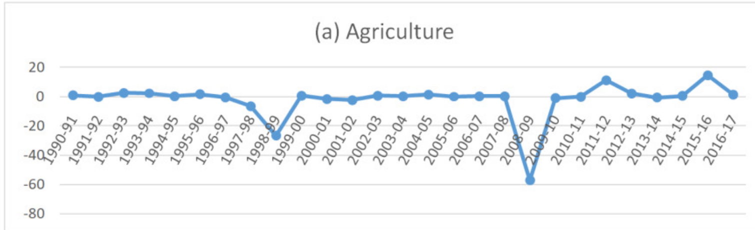

Fig. 8 (a) Decoupling index for Agriculture segment from 1990-2017.

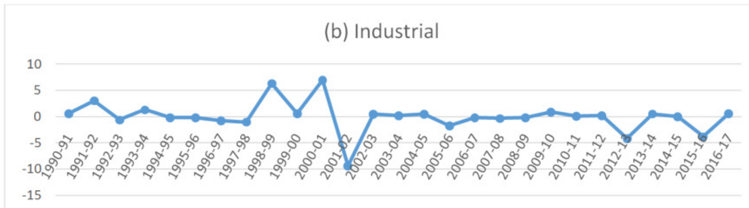

Fig. 8 (b) Decoupling index for Industrial segment, 1990-2017.

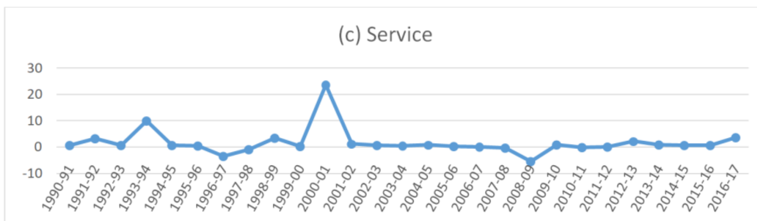

Fig. 8 (c) Decoupling index for Service segments, 1990-2017.

IV. DISCUSSION

The major results are summarized as follows.

(1) Pakistan's power consumption raised from 2786 million kwh to 23272 million kwh between 1990-2017. Agriculture, industrial and service segments remained the top 3 shares of growth. These consequences are reliable with the research of Wang [1]. But from previous 27 years in Pakistan, there is a shortage because energy demand is increasing day by day and the resources to generate electricity are not used effectively [22]. Energy intensity of the overall economy exhibited a decrease trend. The variation in energy intensity is comparatively large in agriculture and smaller in the industry and service segments.

(2) The development in energy intensity was the dominator share to reduce power consumption in the entire research and all FYP year period. The share from the service and industrial segment towards decrease of energy intensity remained small. The power contributor had a non-negligible impact on energy expending. The LMDI examination shows that service and industrial segment remained the highest 2 shares to electricity share rise from 1990-2017. The maximum production of economic structure had a least effect on reducing power and this hindering impact takes place single 12th FYP. The economic activity, power share effect and population impact had the important effect through 1990-2017.

3) Through 1990-2017, six decoupling states dependent on decoupling indicator takes place: weak decoupling, expensive -ve decoupling, strong -ve decoupling, recessive decoupling, expensive coupling and strong decoupling.

The decline in energy intensity upgrades relative decoupling among power consumption and GDP growth. The decoupling states happened 1992, 1995, 2000, 2003-04, 2006-08, 2015 in weak decoupling, 1993-1994, 1996, 2005, 2013, 2016-17 in expansive negative decoupling and 1997-99, 2010-11, 2014 in strong decoupling in many years in the Agriculture segment. The decoupling states happened 1991, 2000, 2003-05, 2011-12, 2014-15, 2017 in weak decoupling, 1993, 1995-96, 1998, 2007-08 in strong decoupling and 1992,1999,2001 in expansive negative decoupling in the Industrial segment. The decoupling states happened 1991, 1993, 1995-96, 2000, 2003-07, 2012, 2015-16 in weak decoupling,1992, 1994, 1999, 2001, 2013, 2017 in expansive negative decoupling and 2002, 2010, 2014 in expansive coupling in tertiary segment.

V. CONCLUSION

In this research first of all we have evaluated decomposition analysis of three sectors agriculture, industrial and service with the help of LMDI model in Pakistan from 1990-2017, then combine LMDI mathematical model and tapio's decoupling exponent to examine the 'decoupling condition' of electricity utilization and economic development of three segments. Pakistan is improving his GDP from industrialization and energy transformation to support its growing economy in next few years. Finally discussing the decoupling relations in power consumption and gross domestic product of three segments. On the whole collective decomposition and decoupling index supply better understand the nexus between power consumption and economic development in Pakistan.

In order to understand stable development of electricity utilization and its decoupling nexus with gross domestic product development, further consideration is necessary to increase efficiency of energy and optimizing the share of electricity. Mainly in few high energy consumption segments, such as in the service segment and industrial segment. At the same time, the modernization of the service segment offers great potential for more efficient use.

VI. FUTURE SCOPE

Through this research, several entrances have been opened for upcoming works that can help to cover and set the revelations made here. Due to the time limitations, some variations could not be done; further enhancements can be made on the following elements.

(i) The electricity consumption is higher so we need to install more power plants for the generation of electricity to meet the demand of all the sectors.

(ii) The electricity consumption is measured from 1990-2017, by examining these results further upcoming researchers can calculate results up to current years.

(iii) LMDI and decoupling are appropriate methods to conduct the effects of sectors in future studies.

(iv) Government of Pakistan should implement these methods and strategies to overcome the electricity shortage issues.

Table A1 indicates to analyze the decoupling approach of power consumption of three sectors agriculture, industrial and service from (1990 to 2017).

Table A1: Decoupling index of power consumption from three sectors, base equal to previous year.

Sectors	1991	1992	1993	1994	1995	1996	1997
Agriculture	0.9111	0.0285	2.6201	2.4010	0.3676	1.7037	-0.5158
Industrial	0.5971	3.0595	-0.6089	1.3256	-0.1909	-0.2139	-0.7824
Services	0.6882	3.2064	0.6496	9.8803	0.6453	0.5192	-3.4829
Sectors	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**
Agriculture	-6.446	-26.63	0.6697	-1.5331	-2.3105	0.7225	0.4032
Industrial	-1.007	6.3597	0.5695	6.9903	-9.385	0.4821	0.2259
Services	-0.940	3.521	0.2505	23.59	1.192	0.6616	0.5055
Sectors	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Agriculture	1.4574	0.084	0.301	0.250	-57.08	-0.928	-0.1565
Industrial	0.531	-1.753	-0.163	-0.319	-0.213	0.859	0.1285
Services	0.791	0.252	0.1484	-0.358	-5.447	0.964	-0.066
Sectors	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	
Agriculture	11.34	2.154	-0.585	0.554	14.68	1.555	
Industrial	0.171	-4.184	0.5463	0.0403	-3.812	0.571	
Services	0.123	2.175	0.830	0.6416	0.673	3.569	

Conflict of Interest. The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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