Information and Communication Technology, Energy Volatility and Output Volatility Nexus: A Global Panel Data Analysis

Submitted By

Huma Arshad

Supervisor

Dr. Muhammad Tariq Majeed

Associate Professor
School of Economics
Quaid-i-Azam University, Islamabad

Submitted in partial fulfillment of the requirements for the Master of Philosophy degree in Economics at School of Economics, Faculty of Social Sciences.
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Certificate

This is to certify that we accept the work contained in the dissertation titled **"Information and Communication Technology, Energy Volatility and Output Volatility Nexus: A Global Panel Data Analysis"** submitted by Huma Arshad, Registration number 02092011006 as a confirmation to the required standard for partial fulfillment of the degree of Master of Philosophy in Economics.

Supervisor: ----------

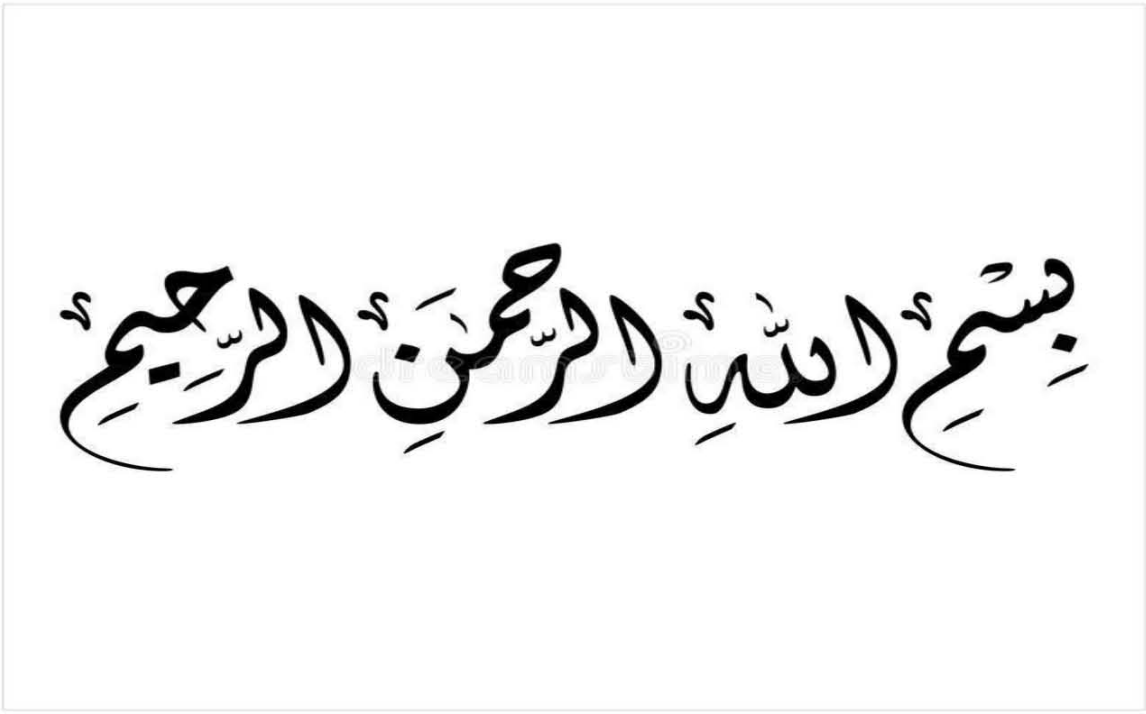
Dr. M. Tariq Majeed
Associate Professor
School of Economics
Quaid-i-Azam University,
Islamabad.

External: ----------

Dr. Muhammad Akram
Assistant Professor
School of Economics,
Islamic Banking & Finance,
International Islamic
University Islamabad.

Director: ----------

Dr. M. Tariq Majeed
Director and Associate Professor,
School of Economics,
Quaid-i-Azam University,
Islamabad.


بِسْمِ اللَّهِ الرَّحْمَٰنِ الرَّحِيمِ

Dedication

This thesis is dedicated to my parents, whose support, encouragement, efforts, love and prayers means a lot to me and make me able to complete my research work successfully on time. Also, I dedicated this thesis to my sister Sana Arshad who never left my side. Lastly, I dedicated this thesis to my best friend Ijlal Ahmad whose motivation always affects me and without him, I cannot be able to complete my research work.

Author's Declaration

I Huma Arshad hereby state that my M.Phil. thesis titled "Information and Communication Technology, Energy Volatility and Output Volatility Nexus: A Global Panel Data Analysis" is my own original work. I have not presented and submitted any part of this work anywhere else for any other degree previously. At any time if my statement is found to be incorrect even after my graduation the university has the right to withdraw my M.Phil. degree.

HUMA ARSHAD

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I owe my profound thanks to Allah Almighty. My creator, my strong pillar, my source of inspiration who blessed me with determination, potential and ability to complete this piece of research work. I offer my humblest and sincerest thanks to the greatest educator Holy Prophet Muhammad (PBUH) who taught us the purpose of life.

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Huma Arshad

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LIST OF ACRONYMS

IEA	International Energy Agency
WDI	World Development Indicator
GDP	Gross Domestic Product
GDPPC	Gross Domestic Product, per capita
EUV	Energy Use Volatility
ICT	Information Communication Technology
VTO	Volatility of Trade Openness
VINF	Volatility of Inflation
OLS	Ordinary Least Method
FE	Fixed Effect
RE	Random Effect
2SLS	Two Stage Least Square
GMM	Generalized Methods of Moments

Abstract

The basic purpose of this research is to ensure a greater understanding of information communication technologies and energy volatility consumption on the output volatility. There is a paucity of research that focused on the association among energy volatility consumption and information communications technologies. But there is no study which connects the effects of information technology communications on the output volatility as well as the effect of energy volatility on the output volatility. To fulfill this gap, we used different econometric techniques like pooled OLS, fixed effect, random effect estimation, two stage least square and generalized method of moments in our empirical analysis. The current investigation also applies endogeneity in the panel estimation. Moreover, to ensure that the study's findings were stable, we ran a series of robustness assessment also. The panel of global analysis is used for 154 nations for the span of 50 years, from 1971 to 2020. ICT is measured by fixed telephone subscription, mobile cellular subscription and individuals using the internet whereas energy volatility consumption is measured through the rolling window of 3-years moving average of standard deviation. Similarly, output volatility is also constructed through the 3-years moving average of standard deviation. The findings reveal that energy consumption volatility yields considerable results and has a distorted impact on output volatility whereas information communications technologies suggested the negative impact on the output volatility as it mitigate the economic instability and the output volatility. The findings for all of the nations covered in this empirical investigation are consistent in general. This study provides important policy recommendations for implementing ICT-enabled technologies, which will result in more inventive advances and growing financial economic growth. It is advised that the government should promote ICT technologies which results in the higher productivity in the economy and protracted development.

Chapter 01

Introduction

1.1 Importance of Study:

Every competitive economy relies on the stable economic growth to achieve the aim of a high standard of living and the long-term economic growth. It has an impact on the nation's current and future well-being. Stable economic growth is beneficial to an economy's overall well-being as well as individual well-being. Because economic growth has stable importance, the concept of output volatility has become a hot topic of contention among economists and the policymakers around the world in recent decades. Volatility is becoming a major development concern, according to the World Bank, due to indisputable linkages between volatility and lack of development.

Economists are concerned about high output volatility because several studies show that it has a negative effect on economic growth or is associated with the lower growth **(Bruno and Easterly, 1995; hnatkovska and Loayza, 2004; aghion et al., 2004).** Volatility in output has high welfare costs, especially in the poor countries. In some Latin American countries, the direct welfare cost of output volatility is around 5 to 10% of yearly consumption, compared to less than 1% in industrialized countries **(World Bank, 1999).** In this manner, the identification of a negative relationship between short and the long-term economic growth emphasizes the significance of determining the causes of production volatility so that measures can be made to reduce the output volatility.

Although business cycle theory and growth theory were once thought to be mutually exclusive and disconnected topics of macroeconomics, this viewpoint was shifted in the early

1980s **(Ramey and Ramey, 1995).** Because of its importance in establishing a stable and higher living standard for individuals, economists and the social scientists have been interested in understanding and exploring the topic of output volatility since the early 1980s. High macroeconomic volatility is thought to stifle economic growth, according to past research **(Hantkovska and Loayza, 2004; Kormendi and Meguire, 1985; Berument et al., 2012; Serven 1998).**

The majority of past research has found that political, institutional, and economic issues all have a significant impact on the output volatility. Even though it is a little-studied issue, the factors of output volatility have a lot of potential and room for more investigation.

1.2 Energy Consumption:

Energy would be seen as a basic intermediate and a production-accelerating factor. Energy has so far been vital for economic growth since ancient times, and it has played a central role in economic growth, development, and industrial growth. It is fundamental to human survival and economic development, as well as the foundation of contemporary communities. It is the lifeblood and foundation of economic growth. It is assisting in the expansion of trade and the acceleration of the rate of growth. The growth of a nation's economy and energy consumption are seen to be linked in a linear and positive way. Energy, as a necessary component of manufacturing, is critical to achieving appropriate growth and development goals.

Improved lifestyles, population growth, and increased production and economic competitiveness were the primary drivers of greater energy demand. The world's energy demand will accelerate the development of 1.8 percent per year in between 2005 and 2030, with developing

economies accounting for 74 percent of that growth as per reported by the International Energy Agency (IEA, 2009).

The core of the global energy system is fossil fuels, which contribute over 80% of overall energy output in the global economy. However, various risks have emerged in recent decades, most of which are related to the use of fossil fuels as an energy source.

1.3 Information Communication Technology:

Many structural changes have resulted from advances in information and communication technologies (ICT), including economic reorganization, trade expansion, and globalization, resulting in increased the capital flows and the information availability. ICT will have a significant impact on the development of every economic sector, particularly during the liberalization of the economy, and even growth experts predict that investments in ICT will drive economic growth **(Sassi & Goaied, 2013).** A growing number of companies and individuals employ computers to access the internet or to run a particular software application in order to achieve economic aspirations such as providing a wide and varied and tailored range of products to customers with better service quality and selling a number of products and services. Indeed, ICT encompasses the integration of electronics, software, networks, and telecommunications, as well as the integration of information media and the decentralization of computer workstations, all of which propel businesses, industries, and the country as a whole. It contains a variety of "communication equipment," such as television and radio, as well as a variety of software. The impact of ICT dilation on economic growth in both the developed and developing economies has exploded in the previous two decades, generating a lot of attention from academic scholars who want to undertake more research **(Farhadi, Ismail, & Fooladi, 2012).**

For the majority of authors, ICT promotion is critical for innovations, economic progress, better living conditions and entrepreneurship. Trade facilitation and regional integration can both benefit from ICT. It also facilitates the sharing of information, cross-border interaction, and banking transactions. ICT has also a positive impact on trade, financial development and R&D, as well as improving worker productivity and skills, all of which have an indirect effect on growth. ICT also plays a role in other significant economic areas like e-trading, e-business, e-banking, and e-commerce. By optimizing the information access, lessening market potential for isolation, and lowering high input prices, e-commerce reduces travel administration, market discovery, and communication costs, as well as addressing various limits faced by exporters/producers **(Xing, 2018).** In recent years, ICT has become the pivotal point of the finance scheme, as it increases commercial banks' cost efficiencies, hence increasing the market value of their stocks **(Lin and Lin, 2007).** Similarly, ICT has an impact on trade in a variety of ways. Technology, for example, just provide foundation for the future markets, business opportunities, and truly innovative goods and services in this digital economy, boosting e-commerce industrialization. ICT is a turning point for e-trading because it unveils potential and helps to improve bilateral trade, resulting in faster economic growth **(Were, 2015; Xing, 2018).** Digital communication infrastructure also helps to boost GDP by assisting capital inflows and increasing export growth **(Majeed and Ahmad, 2006; Zahra et al., 2008).**

The government is eager to find ways to employ information communication technologies to reduce energy consumption and prevent environmental degradation. In past studies, using information technology to increase economic growth while reducing the energy use was considered one of the probable answers **(Lu, 2018).** There is no evidence in the literature that energy conservation and economic growth are linked. Nonetheless, it is hoped that ICT would be

able to resolve the "win-win" problem, resulting in increased production with less energy **(Ishida, 2014).**

There are two methods in the present literature on the energy–economy–technology connection. The first evaluates the benefits of ICT adoption, such as higher efficiency, lower energy performance and growth **(Coroama et al., 2013; Moyer and Hughes, 2012**). From these findings, information and communication technology (ICT) can prevent the occurrence of global climate change while having minimal environmental impact. Furthermore, constructing smarter cities, electricity networks, traffic systems, and the industrial processes enhanced productivity, which assists in emission reduction **(Houghton, 2010).** The second component addresses the destructive consequences of ICT use, such as higher electrical demands or energy consumption which also increase CO2 emissions **(Danish et al, 2019; Kashem and Rahman, 2019).** This viewpoint says that an increase in the ICT usage will decrease labor demand, thereby boosting labor productivity; nevertheless, it may also lead to higher energy demand and consumption, which will results in the adverse environmental impact **(Avom et al, 2020).** This study will look into the interaction between ICT, the economy, and energy in order to better understand how they interact in terms of the two distinct elements depicted in the literature.

1.4 Contribution of Study:

Unfortunately, no study examined the link between output volatility and ICT. Secondly, neither study conducted the research on energy consumption volatility. Thirdly, most of the studies used a small no of countries for research or bound for just developed or developing countries. Considering these knowledge gaps, this study paves the path for a better understanding of the energy consumption volatility and the ICT-growth relationship in the following manner. First, the current study employs a novel concept called energy consumption volatility, which has never

been employed in the previous research. Second, this study employs a variety of unique information and communication technology (ICT) measurements as an index. Fixed telephone subscription, mobile cellular subscription as well individuals using the internet are included for this purpose. Third, the study does not limit itself to a single country's analysis; rather, it presents a global picture of analysis involving a large number of countries over the time period from 1971 to 2020. The current research takes the data from World Development Indicator (2021). Finally, this research uses a variety of essential econometric methodologies to investigate the better empirical results, as well as robustness analysis to ensure the integrity of data and the empirical results.

1.5 Objective of Study:

Present investigation is specifically designed to explore the linkage between energy consumption volatility, information communication technology and output volatility. The related research questions of the study are as follows:

- Does energy consumption volatility have encouraging impact on output volatility?
- Does ICT have favorable impact on output volatility?
- Do different proxies of ICT have similar and equal impact on output volatility?
- Is the relationship between “output volatility and energy consumption volatility” and “output volatility and information communication technology” sensitive to inclusion of additional determinants of output volatility?

1.6 Hypothesis of Study:

The study tries highlight links between energy consumption volatility, information communication technology and output volatility by testing the following hypothesis.

Hypothesis 1:

H_{01} = there is no relationship between energy consumption volatility and output volatility.

H_{A1} = there is positive relationship between energy consumption volatility and output volatility.

Hypothesis 2:

H_{02} = there is no relationship between information communication technology and output volatility.

H_{A2} = there is positive relationship between information communication technology and output volatility.

1.7 Research Plan:

- The study analytically investigates the impact of energy consumption volatility on output volatility by using one measure of energy consumption and impact of information communication technology by using three measures of information communication technology. The data of 217 countries during the period of 1971-2020 used in energy consumption volatility and output volatility nexus, and the information communication technology and output volatility nexus.
- The study employing various econometric techniques such as fixed and random effect to verify the output volatility outcomes of energy consumption and information communication technology. Moreover, the panel time series techniques also applying to understand the dynamics of research questions.

- The study examines the sensitivity of links determined among energy consumption, information communication technology and output volatility by inclusion of different variables.

1.8 Organization of Study:

The study is organized in the following pattern: Chapter 1 consists upon introduction. Chapter 2 provides extensive theoretical and empirical previous literatures on energy consumption, information communication technology and output volatility linkages. Chapter 3 encompasses the analytical framework and econometric methodology. Chapter 4 presents theory of variables used sources of the data and descriptive analysis of the data. Chapter 5 demonstrates the empirical findings of the study. The last chapter 6 comprises conclusion of the study, limitations and policy recommendations.

Chapter 02

Literature Review

2.1 Introduction:

This section documents the literature review on Energy Consumption, Information Communication and Technology (ICT) and Output Volatility. There is vast number of studies available on Energy Consumption and ICT linked with Output Volatility separately. However, we did not get too many papers which elaborate the relationship of Energy Consumption and ICT on output Volatility. So, here we try to connect all of the concepts together. For this purpose, we divided this section of literature review in different categories. The first category explains the significance of the Output Volatility. In the second category we try to explain or connect the linkages of ICT and Output Volatility. Third category explains the effects of Energy Consumption on Output Volatility and in the fourth category of this chapter, we explain the effects of Energy Consumption and ICT on Output Volatility.

2.2 Significance of Output Volatility:

Output Volatility promotes economic instability and impedes the investment due to the irreversible nature, resulting in weaker economic growth **(Antonakakis and Badinger, 2012).** About last 50 years, the output volatility upward in the developing world rather than in the industrial or developed world. We have seen the different trends of the output volatility across the developing countries. Despite the fact that some regions have seen a decline from high levels, such as South Asia, North Africa and in the Middle East in the era between 1970's and 1980's. Volatilities grew in East Asia, Eastern Europe and in Central Asia in 1990's, and it increased in the Sub- Saharan Africa and in Latin American countries from the era of 2001 to 2006. As a result

of variations in the trends between areas, the overall average volatility was greater in all emerging economies than in OECD countries. As a result, the high volatility in emerging countries does not appear to be abating as globalization progresses.

Economists have become concerned about the significance of the output volatility since it is intimately linked to negative elements of economic decline. When compared to OECD countries, most emerging countries' consumption volatility is much larger than their output volatility. As a result, the welfare costs of excessive volatility appear to be large in emerging countries. Furthermore, neither capital markets nor structural reforms are assisting in smoothing consumption in the majority of emerging nations. So, the high volatility has a negative influence on growth or is at least strongly related to poorer growth. In analyzing economic growth, output volatility is a critical topic. Generally, economists discuss the instability of Information and Communication Technologies (ICT) with economic development but with the scientific point of view there is no discussion of ICT with the output volatility. So, in our discussion, we try to explore the effect of ICT on output volatility, so for this purpose we take the gross domestic product as proxy of output volatility.

According to various macroeconomic scholars, output fluctuations have a favorable, adverse, or negligible effect on output growth. The empirical findings shows that higher average growth rates are related to higher fluctuations of the output growth rates. **(Kormendi and Meguire, 1985; Grier and Tullock, 1989).** Similarly, saving rates also leads to higher economic growth in the country. Because higher investment rates were compelled by income uncertainty, leading to higher equilibrium output rate of growth **(Sandmo, 1970),** because if there is a preventative purpose for saving, then an increment in the savings rate resulted in an increase in economic growth rates **(Mirman, 1971).**

However, there are reasons to infer that increased productivity has a detrimental consequence. The projected riskiness of investment initiatives is increased by output uncertainty. This will leads to results in lowering demand for investment and stifling economic growth. Furthermore, if an investment cannot be reversed, uncertainty undermines the economy's investment level **(Bernanke, 1983; Pindyck, 1990).** In the same framework, **Aizenman and Marion (1993)** supports the idea that greater exposure to the policy uncertainty leads to the slow growth by presenting a two-period investment irreversibility model. During recessions, a negative relationship observed in the form of credit market flaws that contain investments, or in the form of diminishing returns on investment **(Aghion and Howitt, 2006).** Similarly, **MARTIN and ROGERS (1997)** also concluded that when learning in practice is at the root of the long-term financial growth rate, output fluctuations and the output growths are adversely related.

Output volatility has also a negligible impact on the growth in output, which is justified by the fact that output variations and output growth are unrelated. Output growth is governed by actual economic factors like technology and labor skills. Although output volatility has a beneficial but minor impact on the growth in output. However, the bulk of studies found that the desired direction of the influence of production variations on output growth is equivocal **(Grier et al., 2004; Norrbin and Yigit, 2005).**

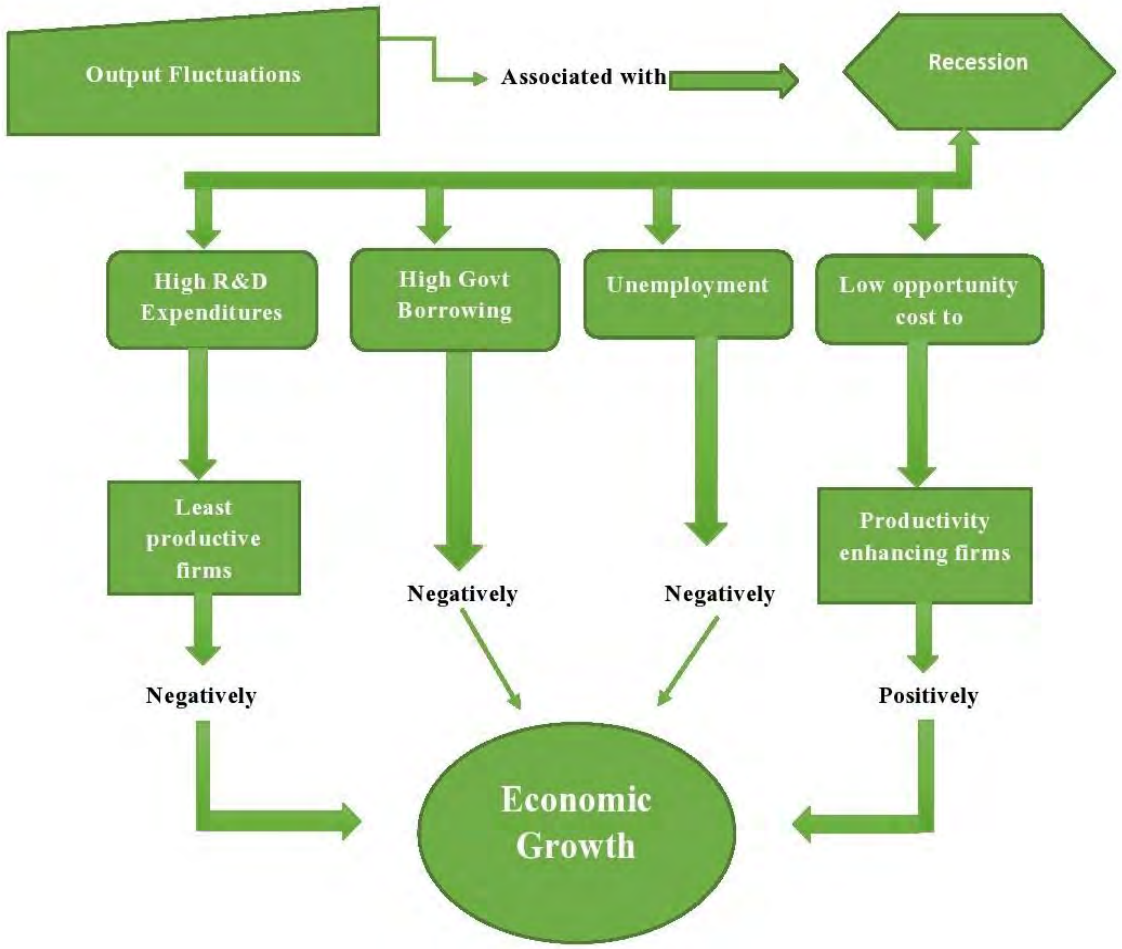

Figure 01: Relationship between economic growth and output volatility

2.3 Information Communication Technology and Output Volatility:

Since the 17th century, macroeconomic researchers have been looking into the various determinants of economic development. It is both a sign of progress and a necessity for economic density. Economic development is a vital factor in a society's well-being. It has widespread effects on people's well-being. People in different countries have various skills with their living conditions because of the large differences in the development rates and trends across economies over time.

There seems to be a lot of research on the sociocultural elements that determine productivity growth, but there isn't as much focus on the links between ICT and the output

volatility. Modern economic growth theories focus on the contribution of innovation, technology development (R&D), and awareness advances to the growth. These new theories also indicate that ICT investments are crucial to economic development. However, complete, and accurate empirical proof of this hypothesis is a work in progress which has piqued the best interest of many policymakers in the past few years. And per the World Bank, technological advances eliminate knowledge obstacles, supplement components thru the technology and cooperation, and transform goods through economies of scale and scope and operating systems. As a result, in an information economy, emerging technologies increase inclusiveness, productivity, and creativity.

Many empirical studies in advanced economics shows that ICT capital contributed positively to economic development after the 1990s. Like for instance, **(Oliner and Sichel, 2000; Jorgenson and Stiroh, 2002)** concentrates on the potentials of ICT in US and verified the ICT's contribute positively to US economic growth. They found that the spike in use of IT capital, as well as faster increased efficiency in computer production, account for roughly two-thirds of the acceleration in the increase in productivity during the two halves of the 1990s. Using data form 1979-2000, **Inklaar et al. (2005)** contrasted the provision of ICT in the United States with the European countries and found that the small number of service sector is primarily responsible for the rapid expansion of ICT capital in both regions the United States and in Europe. Furthermore, the contribution of ICT in the United States is greater than that of Europe.

Using panel regression and cross section regressions, (**Jalava and Pohjola, 2008)** examined the impact of electricity and ICT on economic development in Finland over the period from 1990 to 2004. As per the analyses, ICT contributes three times more to economic growth than electricity, and electricity's impact on growth was smaller than ICTs in the United States. **Czernich et al. (2011)** came up with the same results. Using panel data from 20 OECD nations

from 1996-2007, it was proved that the growing broadband penetration contributed to higher GDP per capita rate of growth.

There have also been studies on how to maximize the benefits of ICT-led breakthroughs and advances in order to accomplish significant and sustained levels of economic growth. Numerous studies are carried out this end. For example, **Madden and Savage (1997)** discussed the effects of telecommunications investment on growth and observed that, from 1990 to 1995, telecommunication had a favorable and positive impact on economic growth in a sample of 27 Central and Eastern European countries. Similarly, **ROLLER and WAVERMAN (2001)** comes up with the same results. They investigated that how telecommunications infrastructure affects the economic growth. By taking the data of 21 OECD countries from 1970-1990, they argued that advances in telecommunications make a greater contribution to economic development via FDI tributaries as well as network external effects. They also encountered evidence of a strong favourable significant relation, especially when there is a sufficient number of communications infrastructure.

MAHYIDEEN et al. (2012) empirically investigated the effects of infrastructures for information and communication technology (ICT) on economic development. By using the pooled mean group estimator technique, they were taken the sample of 5 ASEAN countries over the time-period of 1976-2010. They looked at the benefits of ICT for economic development from two perspectives. The first traditional channel proposes that ICT infrastructure increases private input efficiency while lowering production costs. The second channel demonstrates the importance of ICT in reducing people's time costs and increasing their productivity.

The theoretical literature probably predicts that ICT will have a positive impact on the economic growth of both developing and the developed nations. According to **Levine (1997)**

ICT facilitates in relaxation of the barriers to information access are removed, and investment and growth are increased.

Similarly, some researchers believe that broadband and the internet can contribute to the economic growth by lowering market attrition and the mandatory information price of entry into the market. **Koutroumpis (2009)** has been using 22 OECD countries since time period 2002-2007. And he cames up with the important and positive relationship between the broadband infrastructure and the growth of the economics. Similar results are provided by **(Zahra et al., 2009; Choi and Yi, 2009).**

The impact of IT financing on income growth was studied by **(Dewan and Kraemer, 2000).** They studied 36 countries' panel data from 1985 to 1993 and discovered meaningful variations in the way of capital returns on investments between industrialized and developing economies. Gains on IT new investments are expected to have strong and meaningful, whereas returns on non-IT investments in industrialized nations are not correlated with factor endowment shares. In the underdeveloped countries dataset, the situation is opposite. The non-IT capital returns are statistically significant in the underdeveloped nations, whereas IT capital returns are not statistically significant.

Kozma (2005), Saidi and Mongi (2018) looked at the association between Information Communication Technology and economic and social development related to educational reforms and discovered that there is considerable and favorable impact of ICT on the growth of economies. **Kozma (2005)** used data from high-income regions from 1990 to 2015 to identify the factors influencing growth in the economy and demonstrate how they reinforced socioeconomic development in the three main case histories: Singapore, Finland, and Egypt. **Saidi and Mongi (2018)** used the panel data set from 1990 to 2015 to analyze the relation for high-income regions

of the world. They observed two - way causality among ICT and Innovation in the short run, and determinism among education and ICT in the long-term. Similarly, **Farhadi et al. (2012)** researched the impact of Information and communication technologies (ICT) use for economic growth by taking the data of 159 countries over the time-period of 2000-2009. By using the technique of Generalized Methods of Moments (GMM), it was discovered that there is a significant relationship among GDP per capita and the ICT index. Moreover, it is also found that in high income nations, there is greater impact of information communication technologies on the economic growth rather than the low-income nations. The health of a person is measured by his or her average lifespan at birth as well as infant and child mortality. **Majeed and Khan (2018)** has examined the impact of the information and communication technology (ICT) on a population health. They were used the panel data set of 184 nations over the period from 1990 to 2014. Fixed effect model, generalized method of moments (GMM) and two stage least square (2SLS) techniques were used in the estimation with three proxies of the ICT infrastructure which are fixed telephone subscription, internet users and the mobile cellular subscriptions. The empirical findings suggest that Information technology and communications (ICT) has a positive and significant effect over the population health. Further-more the health-care initiatives should concentrate on policies that promote women's health. To improve the public health, information and communication technologies (ICTs) play a major part. Similarly, **AFROZ et al. (2020)** had been using a model which is based on health production to analyzed the linkages among population health, growth in the economy and the information communications technologies in Malaysia. They were using the bound test technique of the cointegration in their analysis and take the time series data over the period of 1993 to 2017. It was found that in both the short and in the long run, only ICT has an impact on population health substantially and in a positive manner. On the other

hand, there is no significant effect of the economic growth on the population's health in both short and in the long run. Likewise, the feeble global economy is affecting the Malaysian's growing economy and lowers health care costs per inhabitant. In accordance with the findings, policymakers should develop policies in order to improve the public health through spreading health information as well as making health care facilities more easily accessible.

As, **Ko (2007)** explored the influence of financial consolidation and information communication technology (ICT) development regarding output volatility. By taking the panel data of 10 Asian countries over the range from 1980 to 2003, he used the panel vector autoregression approach as well as the impulse response analysis. The paper shall apply the two-nation dynamism in the overall model in which Information and communications technology is considered to be volume up and the speed of capital inflows. Likewise, it transpires that countries with a high ICT evolution and high rate of financial inclusion demonstrates the greater output fluctuations. But this is in terms of monetary affairs, and on the fiscal policy lower output fluctuations exhibit.

Erumban and Das (2016) studied the role of economic development and the Information and Communications Technology (ICT) in under developing nation India. Conclusions point to a growing role for ICT investment in driving India's overall economic development, though it is largely confined to the service industry. Furthermore, the entire economy has not been able to spread the ICT spillover effect across all sectors, reducing the gains in the productivity from ICT utilization. Even through improved productivity advancement in ICT employing market infrastructure and their effect on the overall factor productivity, industrial lags further behind. Evidently, India's export-oriented Industry has bolstered in enhancing productivity in the region's fast-growing service-based economy, though ICT adoption in manufacturing remains limited.

Majeed and Ayub (2018) explored the role of various ICT indexes on both global and regional economic financial growth by using a data set of 149 economies covering the period 1980-2015. They were used different estimation techniques like ordinary least square (OLS), pooled OLS, generalized methods of moments (GMM) and two stage least square (2SLS) and discovered that ICT measures promote both regional and global economic growth, whereas, a number of indicators being more favourable to economic growth than others. More-over developing and emerging countries gaining more ICT as compared to the developed countries and Principal Component Analysis also confirms this. The paper also stated that investing in technological infrastructure is necessary to achieve maximum gains from the information economy of the twenty-first century.

Furthermore, by using Pooled OLS and Generalized methods of moments (GMM) techniques, **Majeed (2018)** experimentally evaluated the connections of ICT with environment. The study conducts the analysis of 132 advanced and developing economies through the time-period of 1960-2016 and majorly points out the heterogenous impacts of ICT on environment developed and developing economies. It was found that favorable outcomes are only observed in developed countries although it has negative consequences in developing countries. Additionally, the Environmental Kuznets hypothesis has been confirmed, suggesting that the connection between CO2 emissions and GDP per capita is nonlinear. Furthermore, developing countries should invest in the ICT infrastructure in order to secure environmental sustainability.

In contrast, ICT has also a negative impact on the output volatility also. For example, **Kiley (1999)** was using conventional growth method of accounting framework into United States by taking the data from 1948 to 1997 explain that computers contributes negatively to the economic growth due to the adaptation costs. He argues that the establishment of the new investment goods,

including computers able to impose substantial compliance costs for the economy and lessen growth in the economy.

STIROH (2002) tested the association among ICT accumulating capital and total factor production (TFP) emergence across U.S. manufacturing companies and discovered that ICT has a reverse bias elasticity. In the same way, **O'MAHONY and VECCHI (2005)** analyzed the influence of Information and Communication Technologies (ICT) on an increase in the production. To use the industrial data from the United kingdom and united states, they applied the heterogeneous dynamic panel approach and discovered that due to country diversity, typical industry data set fails to acknowledge a favorable influence. Analogously, ICT seemed to have a deleterious impact on increasing production in the Great Britain due to a shortage of skills and experience and ICT expenditure, but it had a favorable attack in the United States.

Lee et al. (2005) discovered that ICT influences economic development via a variety of routes, including FDI and spillover effects, and that ICT helps to promote economic growth in many advanced and newly developed economies but not in emerging economies. They were taking the sample of 20 countries. Furthermore in an effort to correct the potential shortcomings in ICT policies like helping to improve world competitiveness, the study suggested the ICT-complementary influences.

Information and communications technologies (ICT) are believed to give rise to both reducing energy consumption and heightened the economic development in Japan. **Ishida (2015)** looked at the effect of ICT on growth and power consumption in Japan by using an auto regressive distributive lag (ARDL) model. It was found that unlike the coefficients for labour, stock, and resources, a long-run factor estimate for Ict adoption was discovered to be statistically meaningless. In the electricity consumption mechanism, the indices for government

expenditure, prices of energy, and ICT expenditure are statically significant. The results also reveal that Private investment has a long-run energy consumption elasticity of 0.155, resulting in a minimal decrease in production as well as decrease in the GDP.

Hofman et al. (2016) investigated the role of information and communications technologies (ICT) in Latin American economic development and productivity from 1990 to 2013. There are two layers of the study. First, the analysis considers the economy's overall level for a group of 18 region countries. Second, it employs a growth accounting methodology to examine the relationship between ICT, financial growth, and productivity through the sector in five states. Their findings also showed that ICT has a smaller impact on the economic development.

Now, the question arises that why ICT have a greater effect on developing and emerging economies? According to UN (2011), there are various ties between the ICT and economic output in both advanced and emerging economies. First, with E-government adoption, ICT expenditure will reduce firms operating costs. Second, information technology and communications (ICT) will assist in preparation and advising services. Third, information technology enhances access to pertinent data. Fourth, information technology and communications (ICT) can be leveraged to lower travel expenses and processing fees. Although these facilities are not exclusive to emerging markets, they regularly offer services which have been previously unavailable in both digital and the non-digital markets.

Stanley et al. (2018) undertake a meta-analysis of the relationship between ICT and the economic development in established and emerging economies and found out that, on average, ICT has contributed positively to economic development. Landline and cell technologies favour both developed and developing countries, with cell technologies having a growth impact about twice as high as landlines. Developed countries, on the other hand, benefit far more from

computers than developing countries. In contrast, we see little proof that the Internet has had a constructive effect on development. By taken the sample of high quality sample of 59 countries over the time period of 1995-2010, **Niebel (2018)** explored the effects between information technologies and communications and the growth of the economy in the developing and developed nations. He were taken the sample of about 59 countries reporting period of 1995 to 2010. It was found that there are no substantial differences in the ICT output flexibility between the groups of emerging and advanced nations. Moreover, emerging nations would not get advantages from the technology investment as advanced nations will obtain.

Another type of ICT tool is e-government. E-government alludes to the government's use of information technology and communications to provide and to share information and enhance services to the public. E-government stimulates the economic development through eliminating bribery, promoting trade, and supporting financial development by supervising administrative improvements and cutting transaction costs.

According to **Ma et al. (2005),** e-government, broadband infrastructure, education and e-commerce can be improved to boost future economic growth by increasing the transparent and decentralized administration. Additionally, they were making a great point about how Chinese e-government initiatives are best acknowledged as vehicles for economic and social development. Similarly, **Majeed and Malik (2016)** analyzed the impact of e-government and press freedom on corruption. By using the techniques of OLS and 2SLS, they were taken the sample of 147 countries throughout time-period of 2003 to 2012. The observed results indicate that press freedom and e-government cannot combat corruption on their own. The combined effect of e-government and press freedom, on the other hand, effectively aids in the fight against corruption and boost the economic growth.

2.4 Energy Consumption and Output Volatility:

Energy's position in the growth of economy has long been a contentious issue in the literature. Energy inputs are intermediate in conventional neo-classical growth models, while land, labor and capital are considered basic variables, implying that energy consumption and production are neutral. Ecological models, on the other hand, indicate that electricity plays a significant role in income generation. Numerous investigations have been conducted to explore the link amongst the energy and the economy in several countries, with many of them focusing on the utilization of energy from the renewable sources **(Bhattacharya et al., 2016; Nathaniel et al., 2019; Rahman and Velayutham, 2020).** Entire of these trials do a commendable job of delving into such issues. Regards to investigating the energy and the economy relationship, the existing literature reveals ambiguity. **Nathaniel et al., (2019)** explored the relationship amongst renewable energy consumption, ecological footprint and the urbanization and found out that energy consumption will leads to the economic growth in the economy. They were taken the sub samples of Middle East and North African countries throughout 1990 to 2016 and were used the Augmented Mean Group technique in their analysis. According to the panel's findings, all the factors whether its urbanization, growth of the economy or the financial evolution would promote to environmental destruction. Furthermore, results indicate that renewable energy does not make a substantial contribution to the environmental quality, whereas non-renewable energy usage makes a significant contribution to the environmental degradation. Similarly, **Destek and Sinha (2020)** researched ecological footprint relative to role of OECD states, by using the renewable and nonrenewable energy consumption. They were taken the data of 24 OECD contries from the time period of 1980-2014 and concluded that with the increased nonrenewable energy consumption, there will be more environmental deterioration the economy.

Other researchers, on the other hand, sign up for the conservative assumption that the growth of the economy is affecting energy usage. For example, by taking the quarterly data from 1960Q1–2015Q4, **Shahbaz et al. (2017)** has reviewed an asymmetrical linkages among the growth of the economy and the energy consumption of India by integrating the economic development, capital and labour in a manufacturing feature. They were examined the links of variables by using the autoregressive distributed lad bounds approach in their analysis and their results demonstrates the cointegration among the variables. It was also found that only adverse shocks of the energy usage and financial growth will affect the growth of the economy in asymmetric way. Meanwhile symmetrically, capital formation will cause the growth of the economy.

For comparison purpose, **Popp et al. (2011)** explored a very small effect of technological progress. They were taken the data of 26 OECD countries over the time period 1991- 2004 and evaluated the change in the renewable investment from the technology and found out that technological innovations could lead to an increase in the investment. Whereas, **Kardooni et al. (2016)** researched the factors which have an impact on the declaration of the renewables technology to validate susceptibility acceptance of the renewable energy technologies due to a non-supportive commercial environment. The whole analysis was conducted on Peninsular Malaysian population. Furthermore, the Peninsular Malaysian population accompanies the utilization of renewable sources with a moderate level of effort and, as a result, has a negative attitude toward the renewable energy technology.

Moreover, **Bhattacharya et al. (2016)** found the long-run existence relationships among energy-related inflows and the growth of the economy. They were taken the data of 38 top renewable energy consumption nations throughout the data from 1991 to 2012. While using the

panel estimation techniques, their conclusions endorses cross-sectional dependency and discrepancy. Likewise, governments, power architects, international collaboration organizations, and the associated bodies should work together to raise renewable energy investing in most of these economies to accomplish low-carbon development. Similar reults are validated by **Nathaniel and Bekun (2019)** who experimentally explored the connection between urbanization and desertification. For this analysis, they were monitoring the role of energy usage, openness to trade, and the growth of the economy. Vector error correction-Granger causality approach and Pesaran's autoregressive distributed lag cointegration technique were used in the analysis during the time-period of 1971 to 2015. It was established that all variables have a major impact on deforestation in Nigeria, which will result in the lowering of ecological quality. Moreover, in short and in the long run, there is one-way casualty flows from urbanization to desertification. So, there should be suggested such policies which reduce the deforestation and enhance the environmental sustainability of the economy.

Oil and energy prices are often seen as more volatile than other commodities since the oil shock. **Regnier (2007)** investigated the volatility of oil and energy prices from January 1945 to August 2005 and discovered that crude oil, natural gas, and refined oil prices are more unpredictable than all domestically manufactured items. The whole analysis was based on the monthly data. Though, versus crude commodities, prices for crude oil are more precarious than the approximately 65 percent of other goods, and oil price fluctuations first has reached a average on crude oil in the commodity that followed the 1986 decline in oil prices.

Zhang and Cheng (2009) evaluated the concept of energy consumption, growth and the carbon dioxide emissions for the China nation. Granger causality technique were used for the whole analysis. They have been used the data throughout 1960 to 2007 and it was found that there

is unidirectional causality in the long run. But there is no evidence found for the short run. Additionally, it is also observed that carbon dioxide emissions and energy consumption do not stimulate the growth in the economy. In the same manner, **Akkemik and Goksal (2012)** have also been used the Granger causality analysis by taking the data of 79 countries over 1980 to 2007. They have been used the large panel for the estimation and also consider the panel heterogeniety. By observing the association among energy consumption and the growth, it was concluded that seven tenth of the nations have bi-directional granger causality and one tenth observed uni-directional causality. Moreover, two tenth of the nations do not show any kind of the granger causality between economic growth and energy consumption.

Now a days, electricity is a key component for the growth in the economy all over the world. For this purpose, **Mezghani and Haddad (2017)** analyzed the correlation of real GDP, carbon dioxide emissions and electricity consumptions for Saudi Arabia. They were used the Time- Varying Autoregressive model and taken the data from 1971 to 2017 for the analysis. It was found that there is a positive correlation among electricity consumption and carbon dioxide emissions. Moreover, it is proposed that there should be consider real GDP, electricity consumption, carbon dioxide emissions in the high volatility regimes as well as the low level regimes. Moreover, **Ali et al. (2020)** used the CCR, FMOLS and DOLS regression analysis to examine the association between energy consumption and the growth in the economy for Nigeria over the time period from 1971 to 2014. They were taken urbanization as further indicator in the estimation and underlines that it is a good indicator for Nigerian's growth. It is also appearing that electricity consumption propelled the desired growth of the Nigerian's economy which is highly dependent on the consumption of energy.

The environmental imapct of the renewable and the non- renewable energy consumption in the carbon dioxide emissions reduction in African region was studied by the **(Nathaniel and Iheonu, 2019).** They were used the panel data set of 19 countries from 1990-2014 and used the Augmented Mean Group estimation in their analysis. Likewise, cointegration and unit root tests have been employed in the analysis. The conclusion reveals that there is insignificant impact of the renewable energy on carbon dioxide emissions as it decreases the carbon emissions. On the other hand, non- renewable consumption of the energy substantially rises the carbon dioxide emissions. Policies to boost growth and reduce environmental degradation for sustainable development have been suggested.

Rashid and Kocaaslan (2013) were analyzed the association amongst energy consumption volatility and the real GDP in the United Kingdom. They were take over the quarterly data from 1964Q1 to 2009Q4 and used the ARCH model for the estimation. They were found out that there is a significant and positive role among energy consumption and real GDP and the impact is asymmetric which is based on the intensity of the volatilities of energy consumption and GDP. Moreover, when the economy is very unstable, then there is an increase in growth of the economy due to energy consumption volatility. Likewise, when there are no macroeconomic volatilities were taken place, than there is insignificant collision on the growth volatility in the economy.

Araç and Hasanov (2014) considered the potential correlation growth in the economy and the energy consumption in Turkey. They have been taken the data over the time period 1960-2010. Smooth transition vector autoregressive model was used for the analysis, and it was determined that rather than positive shocks, the negative shocks of energy consumption have much greater repercussions on the output of the economy. Likewise, on energy consumption, positive

energy shocks have a great influence whereas there is a trifling effect on the energy consumption when there are negative shocks in the economy.

By taking the data of 66 developing nations from all over the world, **Akram et al. (2019)** inspected the diverse effects of carbon dioxiude emissios on the renewable energies and on the energy efiiciencies. The data were observed from 1990 to 2014 and ordianry least square and fixe effect techniques were used for the analysis. They discovered that consequences of the critical emissions are different throughout distributions, energy efficiencies, renewable energy and squared of GDP reduces the emissions of CO2. Similarly, nuclear consumption reduces the emission CO2 but it is significantly influence at 50^{th} percentile whereas GDP increase the CO2 emissions. These results also shows that energy efficiency is the essential factor of environmental kuznet curve hypothesis in the developing countries. Likewise, **Ehigiamusoe and Lean (2019)** considered the effects of financial growth, energy consumption and the growth in the economy on the carbon dioxide emissions. With considering the global data of 122 nations throughout 1990 to 2014, they have been found out the harmful effects of carbon dioxide emissions. But when data were divided into the income groups, in the high-income countries, the effect of the financial development and the growth will lessen the carbon dioxide emissions. On the other hand, in the low-income countries and in the middle- income countries, the effect would be resisted. More-over energy consumption increases the carbon emissions. However, they were used the cointegration technique for their analysis. By taking the global data of 155 nations throughout 1971 to 2017, **Majeed and Mazhar (2019)** reviewed the connection among environmental indices as well as the output volatility. Pooled OLS, fixed effect and random effect techniques were used in the analysis and ut was suggested that carbon dioxide emissions will contribute more to the output volatility in the agricultural economies. However, it also provides the evidence of the

endogeniety problem which will be settled down throug different measures of the energy resources which will leads to emit fewer pollutants in comparison to the greenhouse gases.

Wang et al. (2019) has conducted a review of chauffeurs of energy use in China, USA and in India. They were used the Geographical Detector model for the estimation find out that coal intensity is the most important factor influencing China and India's overall energy consumption growth rates. Meanwhile in the United States, earnings of the individuals and the oil intensities are the major motorists of the consumption in energy. Furthermore, when it comes to influencing growth rates of energy consumption, India has the most powerful economy from this perspective among the three economies; however, none of the interactions between factors in the United States are as important as those in China and India. Similarly, **Wang et al. (2020)** applying the cointegration technique to investigate the association among environment and renewable energy consumption. They were used the income wise data and found out that in the high- income countries, policy boost up the renewable enerygy consumption while in the middle-income nations, research and development is a key factor which influence or raise the developing renewable energy. Moreover, energy consumption will rise when there is a massive decrease in the reseach and development and increase in the income. Data of G-20 countries were used in the analysis over the time period from 1990 to 2017.

By obtaining the panel data of five South Asian countries over the time period from 1990 to 2014, **Rahman and Velayutham (2020)** explored the impact of renewable and non-renewable energy consumption on the growth of the economy. It was determined that there is a positive and significant effect of both renewable and non-renewable energy on the growth in the economy. According to the **Mensah et al. (2020),** Africa needs ample energy to achieve long-term growth and success. They were taken the panel data of 24 African nations reporting period 1990 to 2015

for the analysis. It was found out that different indicators like urbanization, oil prices, capital and labor stock have had a positive and significant relationship towards energy consumption.

2.5 Energy and Information Communication Technology Nexux:

There are only few studies which examined the link between energy and information technology and communication (ICT) with the growth of the economy. Concerning with this, **Okushima and Tamura (2010)** has used the Multiple Calibration Decomposition Method (MCDM) technique in the analysis to explored the impact of technical change on carbon emissions and on energy use in Japan. Data regarding the time period 1970 to 1985 were used for the analysis and the conclusions provide the considerable and positive correlation among the variables and confirm the significant relationship between carbon emissions and energy consumption. Likewise, by obtaining the data sample of 10 Asian countries, **Sharma et al. (2020)** explored the link between information technology and communications, growth of the economy and the energy consumption over the time period 2000-2017. Robust heterogeneous technique was used in the analysis. It was found out that there is bidirectional causality among information technology and communications, growth of the economy and the energy consumption and energy consumption statement showing the negative and insignificant remification on the growth of the economy. Similar results will reported with the information communication technology.

By observing the data set from 1970 to 2009, **Tang and Tan (2013)** attempted to investigate the correlation amongst the technological innovations, energy consumption and the growth in the economy for Malaysian region. Autoregressive Distributed lag (ARDL) technique was used for the analysis, and it was found out that there is cointegration exist in the determinants of the energy consumption. It was concluded that technology and energy prices reported the negative influence on the growth of the economy of Malaysia while income has considerable

beneficial effect. In the same manner, **Sohag et al. (2015)** also used the ARDL for the regression analysis. They were taken the sample of Malaysia for a specific time period from 1980 to 2012 and looked at the short-run and long-run effects of technology on energy use consumption. It was revealed that higher trade openness and GDP per capita promote a rebound effect of technical interchange in the consumption of the energy. Whereas, **Ishida (2015)** estimated the long-term effect of the information technology and communications, growth in the economy and energy consumption in Japan. Autoregressive distributed lag model (ARDL) was used in the analysisfor the time period 1980 to 2010. She were take the ICT investment as an exogenous variable and conclude that in the long-run, there is a significant and stable impact of ICT, energy consumption and growth in the economy exists.

Only few studies investigated this link, yielding inconsistent and contradictory results. **Smulders and Nooij (2003)** evaluated the effect of energy consumption on the information technology and communications and on growth of the economy. In the long-run, increase in the energy consumption was observed. Meanwhile, when there is increase in the energy consumption, it will cause the positively influence on the production of the energy and gradually it will diminished the energy share in GDP or growth of the economy. By taking the panel data of 55 developing countries, **Seck (2012)** assessed the effect of technology and growth of the economy for explaining the indirect effects between variables. He was used the nonstationary panel technique to examined the advantages extracted from international technologies and found that there is diffusion system employed. While, this study totally ignore the stationarity techniques while estimation. Moreover, the previously described causal relationships are inevitably different for developed, developing, and emerging economies.

Adjaye (2000) explores the linkages among energy consumption, growth in the economy and energy prices in the Asian developing nations. Engle- Granger methodology was used for the analysis. It was found out that in the short-run, there is unidirectional causality in India and in Indonesia. Likewise, in Thailand and Philippens, there have been birectional causality observed. Furthermore, the research does not support the notion that energy and income are unrelated. Similarly, by using the Autoregressive Distributed Lag (ARDL) bounds test for cointegration and Granger causality test for causal link **Salahuddin and Alam (2015)** studied the linkages between technology and growth of the economy on electricity consumption. They were taken the macro data for Australia throughout time from 1985 to 2012. It was found that electricity use has no noticeable short-run relationship with internet use or economic development. Furthermore, the results are consistent across a variety of econometric requirements that Australia has yet to take advantages of ICT expansion, and it can implement energy conservation policies without harming its economy.

Jamil and Ahmad (2011) analysed the demand for electricity determinants in Pakistan at aggregates and industry-specific levels. The researcher employed exogenous factors such as the climate index, diesel oil price, and capital stock to demonstrate the establishment of a stable long term relationship between variables and to prove that demand for electricity is responsive to both price and in income at the aggregate level in the long run. In contrast, the coefficient of price and coefficient of income are quite tiny and mostly inconsequential in the short run.

2.6 Conclusion:

Relationship among information technology and communications as well as the economy has also been thoroughly studied at the firm, industry, and state levels in developed economies, suggesting a considerable and significant association **(Ishida, 2015; Rahman and Velayutham,**

2020; Salahuddin and Alam, 2015). The statistical findings has been sparse and ambiguous, particularly for developed and developing countries.It is noticed that the previous literature's results are contradictory. The causality between ICT, economic development, and energy use is inconsistent, and only a few studies have looked into it especially in the developed or the emerging economies. **(Mezghani and Haddad, 2017; Nathaniel and Iheonu, 2019; Shahbaz et al., 2017).**

The preceding analysis of the literature reveals various gaps in the current research on energy consumption volatility, output volatility, and information and communication technology. First, empirical studies often concentrate on the ICT-output volatility nexus exclusively in developed nations **(Jorgenson and Stiroh, 2000; Oliner and Sichel, 2000; Inklaar et al., 2005; Jalava and Pohjola, 2008).** Second, the research on developing economies presents contradictory evidence of the findings. Third, several research have been included for a small number of nations and a short period of time. The majority of the research are limited to a single nation or region **(Niebel, 2018; Stanley et al., 2018).** Energy consumption, on the other hand, has either a unidirectional or bidirectional connection with output volatility. Because there is little or no empirical research on this subject globally, the current study fills an essential gap in existing research by contributing to the discussion of output volatility, energy consumption volatility, and information communication technology. This study is not dependent on a certain period and also presents a global perspective of analysis employing a vast number of nations.

Summary of the Literature Review:

Study	Period/ Country	Major Variables	Estimation Techniques	Major Findings
Lars-hendrik Roller, Leonard Waverman (2001)	21 OECD countries (1970-1990)	GDP, GDP deflator, capital stock, population, CPI, unemployment rate	Perpetual inventory method (PIM)	Telecommunication contributes more to the growth of the economy in FDI inflows and the network externalities.
Kwan Wai Ko (2007)	10 Asian countries (1980-2003)	GDP, lending rate, total population, real GDP, mobile phone subscription, FDI inflows and outflows, fixed line	Panel vector autoregression approach and impulse response analysis	The economies exhibit greater output fluctuations with high ICT but fiscal policy lowers the output fluctuations.
Jukka Jalava, Matti Pohjola (2008)	Finland (1990-2004)	Real GDP, capital stock	Cross section panel regression	ICT plays threefold greater role in GDP growth than electricity in the US.
Nina Czernich, Oliver Falck, Tobias Kretschmer, Ludger Woessmann (2011)	20 OECD countries (1996-2007)	GDP per capita, fixed line and mobile phone subscription, telecommunication investment	Logistic diffusion model	Broadband subscription will result in a higher rate of GDP per capita growth.
Maryam Farhadi, Rahman Ismail, Masood Foolado (2012)	159 global countries (2000-2009)	GDP per capita, exchange rate, internet user penetration, fixed broadband subscription, mobile cellular subscription	Generalized method of moments (GMM)	There is significant and positive impact between real GDP per capita and information technology and communications.
Jamilah Mohd Mahyideen, Normaz Wana Ismail, Law Siong hook (2012)	5 Asian countries (1976-2010)	GDP per capita, population growth, gross fixed capital formation, trade openness, telephone line, mobile cellular subscription	Pooled mean group estimator technique	ICT infrastructure increases private input efficiency and productivity with lowering production cost, people's time cost.
Muhammad Tariq Majeed, Tayba Ayub (2018)	149 global and regional level countries (1980-2015)	GDP, labor force, inflation rate, mobile telephone subscription, fixed	OLS, pooled OLS, 2SLS, GMM	ICT accelerates both global and regional economic growth.

		broadband subscription, energy use		
Muhammad Tariq Majeed (2018)	132 developed and developing countries (1960-2016)	GDP per capita, CO2 emissions	Generalized method of moments (GMM)	There is positive effect of ICT in developed nations and negative consequences in developing nations. However, there is nonlinear association among GDP per capita and carbon dioxide emissions.
Kais Saidi, Chebli Mongi (2018)	High income countries (1990-2015)	GDP, research and development, mobile cellular telephone, internet user, education	Unit root and co-integration test in Panel	ICT and R&D have significant impacts on economic development.
Muhammad Tariq Majeed, Farzana Naheed Khan (2018)	184 global countries (1990-2014)	Internet user, mobile subscription, fixed telephone subscription	Fixed effect model, 2SLS, GMM	ICT has positive effect on population health.
Rafia Afroz, Md. Muhibullah, Mohammad Niaz Morshed (2020)	Malaysia (1993-2017)	Real GDP, fixed broadband subscription, mobile cellular subscription, mortality rate immunization, life expectancy,	Bound test technique of co-integration	ICT effects significant and positive impact on population and health in long and short run whereas growth in the economy has insignificant impact.
Michael T. Kiley (1999)	United States (1948-1997)	Real GDP, nominal GDP, labor hour, capital stock	Traditional growth accounting	ICT has negative impact on economic growth.
Kevin J. Stiroh (2002)	United States (1984-1999)	GDP. Computer capital, telecom capital	OLS, instrumental variable	There is a negative association between ICT and total factor production.
Mary O'Mahony, Michela Vecchi (2005)	United States, United Kingdom (1976-2000)	GDP, capital stock	Heterogenous dynamic panel	In United Kingdom ICT has had a significant effect in United States but insignificant in United Kingdom.
Sang-Yong Tom Lee, Roghieh Gholami, Tan Yit Tong (2005)	20 developed and developing countries	GDP, aggregate capital stock, labor force	Production function approach	ICT contributes to economic growth in developed world nut not in developing countries.
Hazuki Ishida (2015)	Japan (1980-2010)	Real GDP, capital stock, labor force, energy consumption	ARDL model	Coefficient of GDP, energy price and ICT has statistically insignificant but coefficient for labor, stock and resources for ICT is statistically insignificant.
Andre Hofman, Claudia	Latin America (1990-2013)	GDP, mobile cellular subscription, fixed	Growth accounting approach	ICT has minor impact on economic development.

Aravena, Vianka Aliaga (2016)		broadband subscription, internet user		
T.D. Stanley, Hristos Doucouliagos, Piers Steal (2018)	Developed and developing countries	GDP, landlines, cell phone, internet access	Meta- regression analysis	ICT has contributed positively effect to economic development.
Thomas Niebal (2018)	59 developed, emerging and developing countries (1995-2010)	GDP, ICT and non- ICT capital service	Pooled OLS	Developing and emerging economies do not get benefits from ICT investment than developed economies.
Muhammad Tariq Majeed Amna Malik (2016)	147 global countries (2003-2012)	GDP per capita, press freedom, e-government	OLS, 2SLS	E- government cannot combat corruption but boost the economic growth.
Xing-Ping Zhang, Xiao-Mei Cheng (2009)	China (1960-2007)	Real GDP, energy consumption, gross fixed capital formation, urban population, CO2 emissions	Generalized impulse response, unit root and causality test	There is one way causality that runs from GDP to energy consumption and carbon dioxide emissions. Carbon emissions and consumption in the energy cannot derive growth of the economy.
K. Ali Akkemik, Koray Goksal (2012)	79 global countries (1980-2007)	Real GDP, capital inputs, energy use, labor input	Panel heterogeneity	Seven tenth of the nations have bi-directional granger causality and one tenth observed uni-directional causality. Moreover, two tenth of the nations do not show any kind of the granger causality between economic growth and energy consumption.
Abdul Rashid, Ozge Kandemir Kocaaslan (2013)	United Kingdon (1960Q1-2009Q4)	Real GDP, total final energy consumption	Markov-Switching ARCH model	Adaptability of consumption in energy plays an important part in defining the behavior of output volatilities.
Aysen Arac, Mubraiz Hasanov (2014)	Turkey (1960-2010)	GDP, energy use	Smooth transition vector autoregressive model	There is a greater impact of the negative energy shocks rather than positive energy shocks in the growth of economy.
Mita Bhattacharya, Ilhan Ozturk, Sudharshan Reddy Paramati, Sankar Bhattacharya (2016)	38 renewable energy consumption countries (1991-2012)	Real GDP, total labor force, gross fixed capital formation, renewable and non- renewable energy consumption	Panel estimation	There is a long run significant relationship among energy related inputs and the growth of the economy.
Hamisu Said Ali, Slomon Prince	Nigeria (1971-2014)	GDP per capita, urbanization, electricity	FMOLS, DOLS, CCR regression	Electricity consumption driven out the economic growth.

Nathaniel, Gizem Uzuner, Festus Victor Bekun, Samuel Asumadu Sarkodie (2020)		consumption per capita		
Isaac Adjei Mensah, Cuixia Gao, Akoto Yaw, Omari-Sasu, Huaoing Sun, Benjamin Chris Ampimah, Alfred Quarcoo (2020)	24 African countries (1990-2015)	GDP, energy consumption, oil price, population growth, urbanization, capital stock	Dynamic heterogenous panel data model	Economic development, population growth, oil prices have positive influence on energy consumption.
John Asafu-Adjaye (2000)	Asian developing countries	GNP per capita, population, CO2 emissions per capita, energy use per capita	Engle- Granger methodology	In the short-run, there is unidirectional causality in India and in Indonesia. Likewise, in Thailand and Philippens, there have been birectional causality observed.
Faisal Jamil, Eatzaz Ahmad (2011)	Pakistan	real GDP, Temperature index, capital stock, electricity consumption, price of diesel oil,	Co-integration and Vector error correction model	There is a stable long-term relationship among the determinants of electricity. In contrast, the coefficient of price and coefficient of income are quite tiny and mostly inconsequential in the short run.
Abdoulaye Seck (2012)	55 developing countries (1980-2006)	Real GDP, labor force, physical capital stock, human capital, gross fixed capital formation	Non- stationary panel technique	There is diffusion system employed and developing nation indulge in large benefits has the tendency to expose trade openness and foreign activities rather than developed nations.
Chor Foon Tang, Eu Chye Tan (2013)	Malaysia (1970-2009)	Real GDP, electricity consumption per capita, energy prices per capita, technology innovation	Granger causality	There is cointegration exist in the determinants of the energy consumption. Also, technology and energy prices reported the negative influence on the growth of the economy of Malaysia while income has considerable beneficial effect.
Mohammad Salahuddin, Khorshed Alam (2015)	Australia (1985-2012)	Electricity consumption, GDP per capita, internet user	ARDL	Electricity has no relationship with internet use or economic development.

Kazi Sohag, Rawshan Ara Begum, Sharifah Mastura Syed Abdullah, Mokhtar Jaffar (2015)	Malaysia (1980-2012)	GDP per capita, technological innovation, Energy use, trade openness	ARDL	Higher trade openness and GDP per capita promote a rebound effect of technical interchange in the consumption of the energy
Muhammad Shahbaz,Thi Hong Van Hoang, Mantu Kumar Mahalik, David Roubaud (2017)	India (1960Q1-2015Q4)	Gross domestic product, energy use, labor force, total population, fixed capital formation	Non-linear autoregressive distributed lads bound testing approach	There is co- integration among consumption of the energy and growth of the economy. It was also found that only adverse shocks of the energy usage and financial growth will affect the growth of the economy in asymmetric way. Meanwhile symmetrically, capital formation will cause the growth of the economy.
Imed Mezghani, Hedi Ben Hadded (2017)	Saudi Arabia (1971-2010)	GDP, CO2 emission, energy consumption	Time- varying parameters vector autoregressive model	Fluctuations in the volatility of oil GDP levels have a favorable impact on CO2 emissions and electricity use.
Rabia Akram, Fuzhong Chen, Fahad Khalid, Zhiwei Ye, Muhammad Tariq Majeed (2019)	66 developing countries (1990-2014)	GDP, renewable energy, CO2 emissions, energy use, electricity consumption	Ordinary least square, Fixed effect quantile regression	Emissions are heterogenous across different quantiles, energy efficiency, renewable energy and squared of GDP reduces the CO2 emissions.
Kizito Uyi Ehigiamusoe, Hooi Hooi Lean (2019)	122 global countries (1990-2014)	GDP, energy consumption, CO2 emissions, financial development	Co-integration	In high income region, the growth of the economy and financial growth alleviates the carbon dioxide emissions as it increases the carbon dioxide emissions.
Solomon Prince Nathaniel, Ogochukwu Anyanwu, Muhammad Shah (2019)	Middle East and North Africa (1990-2016)	GDP, total energy consumption, non-renewable energy consumption, urbanization, financial development	Augmented mean group algorithm	Growth in the economy, economic development and urbanization will comes up with the significant and positive impact on environmental deterioration. On the other hand, renewable energy consumption will not present significant result while non-energy consumption does.
Solomon Prince Nathaniel, Festus Victor Bekun (2019)	Nigeria (1971-2015)	GDP, energy consumption, urbanization	Granger Causality approach, co-integration	Urbanization, consumption in energy and growth in the economy have positive and significant impact on the deforestation.

Solomon Prince Nathaniel, Chimere Okechukwu Iheonu (2019)	Africa (1990-2014)	GDP, renewable energy consumption, CO2 emissions, non-renewable energy use, trade, financial development	Augmented mean group estimation technique	Renewable energy lessens carbon dioxide emissions inconsequentially in the economy. However, non- renewable energy sources substantially elevate the carbon dioxide emissions.
Muhammad Tariq Majeed, Maria Mazhar (2019)	155 global countries (1971-2017)	GDP per capita, environmental degradation	Pooled OLS, Random and Fixed Effect	Carbon dioxide emissions will contribute more to the output volatility in the agricultural economies. However, it also provides the evidence of the endogeniety problem which will be settled down throug different measures of the energy resources which will leads to emit fewer pollutants in comparison to the greenhouse gases.
Qiang Wang, Shuyu Li, Zhanna Pisarenko (2020)	G20 countries (1990-2017)	Energy intensity, oil price, R&D investment, policy, environmental pressure	Co-integration regression	In the high- income countries, policy boost up the renewable enerygy consumption while in the middle-income nations, research and development is a key factor which influence or raise the developing renewable energy.
Mohammad Mafizur Rahman, Eswaran Velayutham (2020)	5 South Asian countries (1990-2014)	Non- renewable energy consumption, final energy consumption, energy use	Pedroni and Kao tests	There is a positive and significant effect of both renewable and non-renewable energy on the growth in the economy.
Gagan Deep Sharma, Mohammad Mafizur Rahman, Mansi Jain, Ritika Chopra (2020)	10 emerging Asian countries (2000-2017)	GDP, GNI, total population, energy use	Robust heterogenous technique	There is bidirectional causality among information technology and communications, growth of the economy and the energy consumption and energy consumption statement showing the negative and insignificant remification on the growth of the economy.

Study	Period/ Country	Major Findings
Gary Madden, Scott J. Savage (1997)	27 Asian and Eastern European countries (1990-1995)	Telecommunication had a favorable and positive impact on the growth of the economy.
Sanjeer Deenan, Kenneth L. Kraemar (2000)	26 developed and developing countries	Gains on IT new investments are expected to have strong and meaningful, whereas returns on non-IT investments in industrialized nations are not correlated with factor endowment shares. In the underdeveloped countries dataset, the situation is opposite.
Robert B. Kozma (2005)	Singapore, Finland, Egypt	Information technology and communications has the significant and positive effect on reducing poverty, growth of the economy and on productivity.

Abdul A. Erumben, Deb Kusum Das (2016)	India	Overall productivity growth increases in India, but the economy has failed to spread ICT spillover effect across all sectors.
Lianjie Ma, Jongpil Chung, Stuart Thorson (2005)	China	E- government, broadband structure and internet boost up the economic growth.
Eva Regnier (2007)	(1945-2005)	The price of crude oil, petroleum byproducts, and natural gas is much more volatile than that of the price of any other locally manufactured good.
David Popp, Ivan Hascic, Neelakshi Medhi (2011)	26 OECD countries (1991-2004)	There is a very small effect of technological progress and technological innovations could lead to an increase in the investment.
Mehmet Akif Destek, Avik Sinha (2020)	24 OECD countries (1980-2014)	There is more environmental degradation if there is an increase in non-renewable energy consumption.
Robert Inklaar, Mary O' Mahony, Marcel Timmer (2005)	European countries (1979-2000)	Small number of service sector is primarily responsible for the rapid expansion of ICT capital in both regions the United States and in Europe. Furthermore, the contribution of ICT in the United States is greater than that of Europe.
Pantelis Koutroumpis (2009)	22 OECD countries (2002-2007)	There is positive and significant relationship between the broadband infrastructure and the growth of the economics.

Study	Period/ Country	Technique	Main Findings
Qiang Wang, Xue-ting Jiang, Xue Jang, Shuting Ge (2019)	China, USA, India	Geographical Detector Model	Coal is important factor in China and India and oil is important factor in USA which led to increase the economic growth.
Shinichiro Okushima, Makoto Tamura (2010)	Japan (1970-1985)	Multiple Calibration Decomposition Method (MCDM)	There is significant effect of technological change in energy use and in carbon dioxide emissions.

Study	Main Findings
Sjak Smulders, Michiel de Nooij (2003)	In the long-run, increase in the energy consumption was observed which will cause the positively influence on the production of the energy and gradually it will diminished the energy share in GDP or growth of the economy.
Ross Levine (1997)	ICT facilitates in relaxation of the barriers to information access are removed, and investment and growth are increased.
Dale W. Jorgenson, Kevin J. Stiroh (2002)	There is a positive contribution to the growth of the economy.
Stephen D. Oliner, Daniel E. Sichel (2002)	There is an increase in the productivity growth.
Roozbeh Kardooni, Samiani Binti Yusoff, Fatimah Binti Kari (2016)	The renewables technology validate the susceptibility acceptance of the renewable energy technologies due to a non-supportive commercial environment.

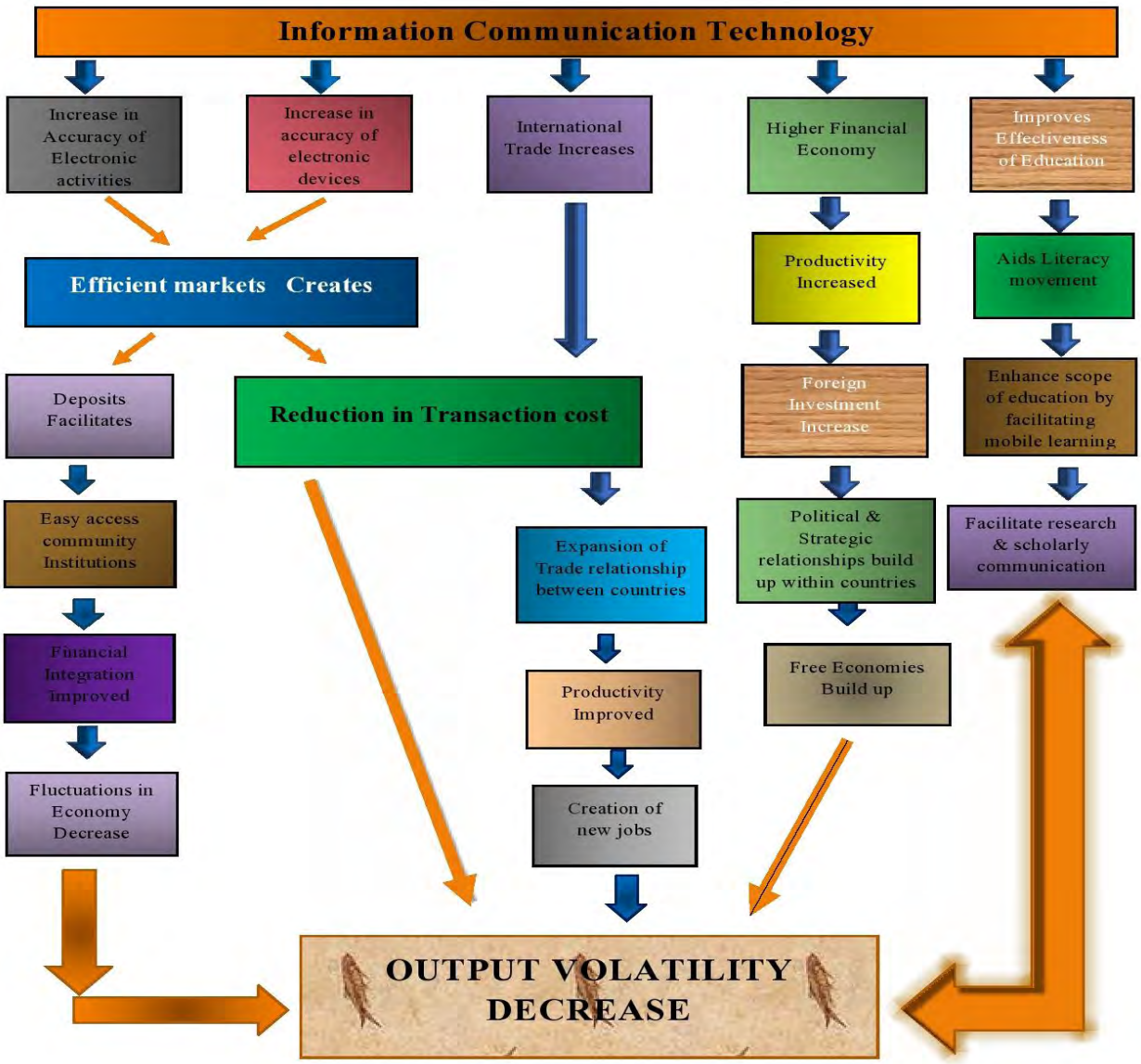

Figure 02: Impact of ICT on Output Volatility (a)

Reference:
Evgeniya Yushkova (2014)
Madhuri V. Tikam (2013)
Alshurubi et al., (2019) among others

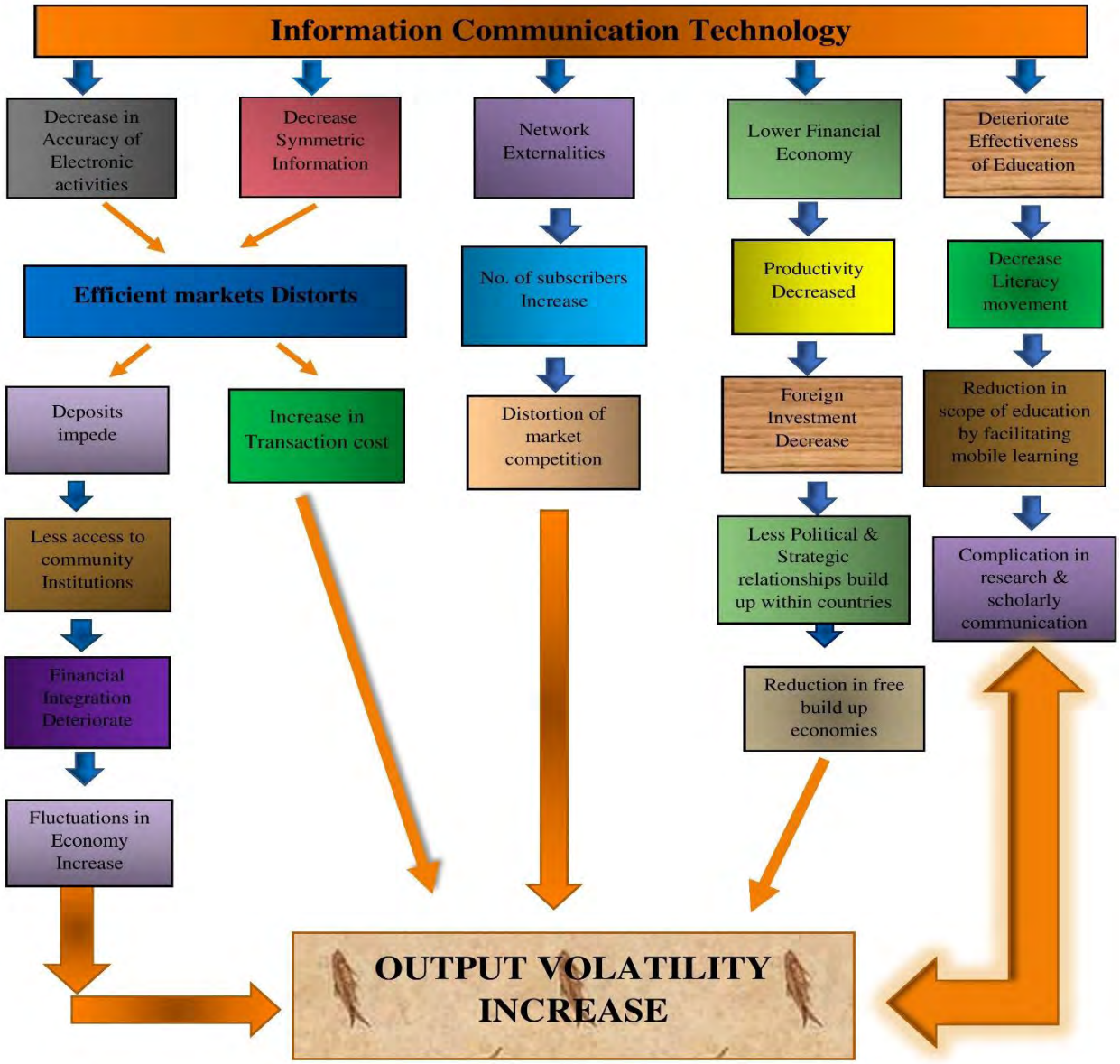

Figure 03: Impact of ICT on Output Volatility

Chapter 03

Theoretical Framework and Estimation Methodology

3.1 Introduction:

In this chapter we discussed the concept of output volatility and developed a methodology for the study to analyze the energy consumption volatility and information communication technology (ICT). The growth of the economy has been debated broadly in the literature with education, capital formation, consumption expenditure, inequality, investment, FDI, governance, unemployment, structural institutions, health, technology, R&D, human capital, remittances, financial development, foreign aid, inflation, wages, infrastructure, business cycle, environmental impact, demographic changes, quality of life, productivity, trade etc. A country's wealth is determined by its national output. As a result, fluctuations in output are critical to a country's prosperity and development. Nonetheless, we only find a few recent studies that address the issue of output volatility. These studies investigate the relationship between output volatility and financial development, trade openness, remittances, foreign direct investment, institutional quality, growth, political conditions, price volatility, and so on. However, due to the complexities of the subject and the scarcity of related literature, we are unable to discuss all of the potential determinants of output volatility in a single study.

The empirical findings on the drivers of the output volatility is broad in the sense that many different variables have been postulated and explored. The majority of these studies concentrate on a single factor of output volatility. In other words, there are few studies that look at a variety of potential causes of the output volatility at the same time. The lists of explanatory variables

employed in different empirical growth publications for the exploration of probable causes of growth volatility are not homogeneous.

During the last two decades, high output volatility adversely affects the growth of the economy, poverty and welfare especially in the emerging nations **(Ramey and Ramey, 1995).** Further to that, a number of studies have been indicated the deteriorating volatility in both the industrialized and in developing nations throughout the last two decades (due to structural change, sound policy, and luck), some developing countries have suffered large welfare losses as a result of extreme volatility episodes, resulting in large output drops in the 1980s and 1990s. Consequently, it is crucial to comprehend the reasons that cause output volatility and the magnitude of output declines, as well as the economic measures that could assist mitigate them.

Economic volatility is significant not only because of its short-term negative impact on the economy. It has been discovered to have a negative relationship with economic growth. There are numerous motivations to improve our understanding of the factors that influence economic volatility. However, we focused on energy consumption volatility and information and communication technology as determinants of output volatility in our study.

This chapter represented the five sections. Section 3.1 based on the introduction of this chapter. In section 3.2, old and new growth theories presented, in section 3.3, theoretical framework of the study is presented. Section 3.4 of the study developed empirical models and section 3.5 reports on the econometric techniques which are used to explore the linkages between information technology communications, volatility of consumption in the energy and in output volatility.

3.2 Old and New Growth Theories:

Technological advancement was a main source of growth in the old growth theory, and output was a function of labor, capital and land. Different sorts of technological advancement, such as labor, human and physical capital, land, technology, inventions, R&D, market imperfections, incomplete information, prices, and so on, are endogenously accounted in new growth theory.

3.2.1 Classical Growth Theories:

Growth was primarily a critical analysis for mainstream economists such as Adam Smith (1776), David Ricardo (1817), John Mill (1848), and neoclassical economists such as Alfred Marshall (1920) and A.C. Pigous (1933), as well as neoclassical economists including such Alfred Marshall (1920) and A.C. Pigous (1933), as well as neoclassical economists which including Alfred Marshall (1920) and A.C. Pigous (1933). (1933). Money was simply used to facilitate transactions as a tool of exchange (money had no intrinsic value). The majority of economic concerns might be answered without the use of money. Classical economics emphasized the economy's ability to self-correct. Government efforts aimed at ensuring a sufficient demand for output were seen as unnecessary and, in general, harmful. Growth, according to the classical school of thought, is a result of real economic shocks.

3.2.2 Keynesian Economics 1929:

Keynes drew economists' attention to the role of insufficient demand in causing and prolonging cyclical downturns. As a result of its effect on aggregate demand, Keynes argued that investment was the major engine driving the business cycle. According to Keynesian economists, private sectors bring inefficiency in the market. And in response to these inefficiencies public

sector will come with policies which will maintain stability and remove inefficiencies. The types of public policies are monetary and fiscal policies.

3.2.3 Monetarist Model:

Milton Friedman established the monetarist model in the 1940s, arguing that the Keynesian method exaggerates the level of macroeconomic volatility in the economy. Rather than swings in consumption or investment spending, the majority of real output fluctuations were generated by changes in the money supply. The Fed should implement a monetary growth rule, which is a strategy for raising money supply at a set rate. This will lower real GDP, employment, and inflation fluctuations. When unemployment and inflation were low in the late 1980s and early 1990s, support for this approach waned.

3.2.4 New Growth Theories:

Robert Lucas, Thomas Sargent, and Robert Barro made arguments in the mid-1970s that were comparable to those made by classical economics prior to the Keynesians Revolution. These economists also made the case for rational expectations. They also shared monetarists' belief that the Fed should implement a monetary growth rule. They claim that a monetary growth rule will make it easier for employees and businesses to estimate price levels effectively, minimizing real GDP swings. Robert Lucas devised a model that included imperfect information and market clearing and appeared to explain some of the most famous business-cycle characteristics.

3.2.5 Finn Kydland, Edward Prescott (1982):

Finn Kydland and Edward Prescott agreed that employees and corporations make rational decisions based on their expectations, but they were mistaken about real GDP swings. Temporary productivity shocks are the source of real GDP fluctuations. In 1982, Finn E. Kydland and Edward

C. Prescott, in their highly influential work, envisioned that the shocks of communication technology, or random fluctuations in productivity levels, were the fundamental variables that decided all indicators in the transition to endless growth.

Innovations, poor weather, an increase in the price of imported oil, stronger environmental and safety standards, and so on are examples of such shocks. The crux is that if something happens that has a direct impact on the effectiveness of capital as well as labor. It would have an impact on employee performance as well as business practices. As a result, this will also affect their purchasing power which has an impact on their output. Money supply, inaccurate information, coordination failure, and so on are indicators of financial development that, depending on their perspective, might cause output variations.

3.2.6 Output Fluctuations and Economic Growth:

In the modern macroeconomic viewpoint, competitive equilibrium model is a point where resources are efficiently utilized but not been fully utilized. As a result, variations in the output changes technology and the relationship among output and input. However, business cycle theories provide explanations on the growth rates variation as they struggle to provide convincing explanations for economic downturns in big, closed economies.

Fluctuations in output and the employment are inextricably associated to the economic shocks. These shocks are decided by the amount to which enterprises' and individuals' rational behavior, as well as government policy interventions. Such problems are particularly complex because what’s considered individually sensible behavior on behalf of households and corporations is dependent upon their perceptions on each other's performance as well as the government's policy regime. The policy system, for its part, may be influenced by the government's

perceptions of its citizens' actions. And, at least to some extent, the shocks themselves are endogenous, driven by outsiders' perceptions of economic institutions. As a result, contemporary macroeconomics discusses the dynamics of extremely complicated systems.

The classical theory of business cycles suggested the distinct viewpoint that the economy is defined by the cyclical differences collection and the differential equations. The two most known examples are business cycle theory of Hicks and the Samuelson's multiplier accelerator model. The basic flaw in these mechanical techniques is that if they were correct, downturns would be predictable. Countervailing actions could be taken by the government through monetary policy and the fiscal policy.

For just about a half-century, the downward rigidities in prices as well money wages were viewed as a potential explanation to the economic swings. Rigid real wages made unemployment simple to explain: a change to the left in the labor demand curve resulted in unemployment. And the change to the left in labor demand could be accounted by decreased demand for products, which is explained by intertemporal price rigidities. For example, interest rate rigidities that monetary policy appeared to be unable to reduce or reduce sufficiently to boost consumption and investment.

Following that, research has also pointed on the reasons behind nominal wage rigidities as well as real wage rigidities including theory of efficiency wage, adjustment theories of portfolio and the menu cost. However, even in the traditional framework, most of the standard research has overlooked some key first-order impacts, such as the dynamic consequences of declining wages and prices. The real balancing effect is commonly assumed, will increase consumption if prices fall. Lower pricing, more exactly, would be connected with higher levels of consumption. Though, in most cases, the price change is not immediate. Falling prices implies that real interest rates rise

at any level of the nominal interest rate, implying that investment reduces. Similarly, it is sometimes said that lower wages are related with higher employment levels. But wages must fall in order to move from one level to another (lower). If workers cut down on their spending as a result of lower earnings, the total effect on aggregate demand and employment could be negative.

Some study has focused on disparities in adjustment speeds, as well as the distributive effects of price increases, particularly those that are uninsurable to individuals. We're becoming more and more aware that income impacts resulting from changes in distribution often outweigh substitution effects resulting from price adjustments. This is especially true when there are asymmetries in the real-variable adjustments. Contracting rather than expanding the use of specific inputs, for example, is easier, less dangerous, and less expensive.

3.3 Theoretical Framework for Present Study:

After reviewing old and the new growth theories of the output volatility, the study now developed a theoretical framework for the study in this section, which enables us in diagnosing the effects of energy consumption volatility and information communications technologies on the output volatility. We would like to describe the empirical connection amongst dependent and the independent variables. For this principle, we investigate relation among output volatility, energy consumption volatility, and information communications technologies. Over the last two decades, it has been observed that there is a negligible impact of high output volatility on welfare, poverty, and growth of the economy, particularly in poor nations **(Ramey** and **Ramey, 1995).** Due to extreme volatility, some poor countries have incurred high welfare costs, resulting in large output declines in the 1980s and 1990s. Whereas some studies have shown that volatility has decreased in developing and industrial countries over the last two decades which is due to structural changes, luck and sound policies. So, according to this, it is imperative to comprehend the factors that drive

output volatility. For this purpose, the present study's goal is to determine the role of volatility in consumption of energy and information and communications technologies on the output volatility.

Many reasons have been predicted and investigated in previous studies, the empirical evidence on output volatility is diverse. The majority of these studies focus on a single source of output volatility. Or, to put it another way, there are few studies that address a variety of potential causes of output volatility at the same time. There is still a dearth of variables used in various studies to search for potential determinants of output volatility. Internal factors such as agricultural production, economic policy and natural disasters, as well as external factors such as international interest rate, terms of trade, exports and global prices contributes to output volatility. The studies on economic vulnerability highlight the important role that the degree and frequency of natural and external shocks play in the structural regions **(Combes and Guillaumont, 2002; Loayza and Raddatz, 2007).**

The previous literature investigates the various determinants of the output volatility, such as consumption volatility, oil prices, remittances, foreign direct investment, and fiscal policy. But no study investigated the effects of ICT and energy consumption volatility on output volatility. So, we will investigate the impacts of ICT and volatility of energy consumption on output volatility. We will check that whether the results mitigate output volatility or not. Among all the factors, GDP growth is the most essential determinant of the country's output volatility. Based on literature, for measuring the output volatility, we take the standard deviation of GDP per capita which is also considered the benchmark **(Beck et al., 2000; Hakura, 2007; Ahamada and Coulibaly, 2011).** In the empirical literature, it is also very common to use log of GDP to measure the growth to determine the volatility **(Posch, 2011).** But in our current research, we simply take the standard deviation of GDP per capita to measure the output volatility.

As a result, we build our output volatility model shown below.

OV = f (GDP)

Second, the literature has extensively emphasized the role of trade openness in determining output volatility. Terms of trade shocks account for a sizable portion of fluctuations. If trade regimes are opened, trade shares and growth will increase significantly. However, it is also argued that due to the increase in the trade openness, country's vulnerability will also be boost up. That is, if business cycles are ascertained by industry-specific external shocks, then trade openness and trade liberalization may result in increased the growth and more stabilized production patterns **(Wacziarg and Welch, 2008)**.

Cavallo and **Frankel (2008),** demonstrate that open countries are more susceptible to external shocks and that sudden and unexpected stops may result in losses in trade credit, particularly for imports, with the resulting decline in trade hurting more those countries that are more integrated into international markets. Similarly, emerging economies that are more financially open but have a more closed trade regime are more vulnerable to financial crises **(Martin** and **Rey, 2006). Cavallo (2006),** on other hand, describes that the stabilizing impact of trade openness outweigh the destabilizing impact of excess exposure to trade risk.

With the addition of trade openness, the model becomes as follows:

OV = f (GDP, TO)

Moreover, there are lots of determinants which affects the output volatility. For example, inflation, remittances, financial development, country size, human capital etc. According to previous research, inflation is also a potential determinant of the output volatility **(Bleaney** and

Fielding, 2002; Carboni and **Ellison, 2011).** So with the addition of inflation, our model becomes as follows:

$$\mathbf{OV = f\ (GDP,\ TO,\ INF)}$$

The research will look into the effects of two other indicators of output volatility: energy consumption volatility and information and communication technology (the two focused variables).

Researchers examined the various major economic sectors and their effects on the output volatility in the preceding discussion. In the economy, there is a huge impact of the energy consumption, and it also leads to great market fluctuations. Numerous studies pointed out that energy consumption is a source of contention in the growth of economy. There are lots of research conducted to estimate the impact of energy consumption on the growth of economy. It has both directly and indirectly impacts due to its effects on environmental quality. **Sek (2017)** pointed out that there is a direct positive impact of energy consumption on the growth, but on the other side, due to increase in the carbon emissions, it has indirect negative impact also. Furthermore, as the country's reliance on imports decreases, energy consumption leads more to the growth in the economy **(Esen and Bayrak, 2017).** This shows that the concept of energy consumption is important for the development of the economy.

For the growth in the economy, energy is considered as the important factor. Because the economy's several productions depend on the energy. Energy consumption policies that are prudent can lead to long-term GDP growth **(Asghar, 2008).** According to **Chaudry et al. (2012)** the energy consumption is rapidly increasing in a globalizing world. Among other energy sources, electricity consumption substantially simulates the economic growth. In our empirical analysis,

we use the volatility of energy consumption as our main focused variable. We used energy use variable to measure the volatility of energy consumption.

Even though energy consumption is an important factor in determining the output volatility, another variable called "information communication technology" is considered to play a significant role in determining output volatility. A lot of research examined the impact of the information communications technologies on the growth of the economy. Along with other macroeconomic factors, Information technology is a key driver of economic growth **(Toader et al. 2018).** Inflation, trade openness, unemployment rate, and government spending all have the considerable a significant and positive influence on growth of the economy.

Over the past few years, there is lots of technological progress arise in the economy. The basic reasons are globalization and trade expansion, due to which the economy grows as a result of technology. Furthermore, the technological progress contributes the advancement in the economy particularly in the liberalization. According to growth economists, investments in the ICT will drive economic growth. Different empirical research conducted on the impact of ICT on the growth of economy and concluded conflicting findings. Like **Farhadi et al. (2012)** concluded that due to the ICT technology, growth in the economy grows rapidly in the high-income economies as compared to the low and the middle income groups. Similarly, according to the **Yousefi (2011)** there is a significant and huge impact of ICT on the high income countries as well upper middle income economies. But there is no effect on the growth of the lower income economies.

Now the study extended the model by adding the energy consumption, information communication technology as follows:

OV = f (GDP, TO, INF, EC, ICT)

Based on these explanations, the general form of our regression equation as follows:

Output Volatility = f (GDP per capita, lag of output volatility, volatility of trade openness, volatility of inflation, volatility of energy consumption, Information Communication Technology)

3.4 Empirical Model Specification:

Following the discussion of the theoretical framework, the study now reports empirical requirements of all the models used in this study in this section. Our first independent variable is energy consumption, and our second independent variable is information communication technology (ICT). The relationship between "output volatility and energy consumption" and "output volatility and information communication technology" can be expressed as a panel equation.

$$\mathbf{SD\ (GDP)_{it}} = \boldsymbol{\alpha_1}\mathbf{(GDP)_{it}} + \boldsymbol{\alpha_2}\mathbf{SD(GDP)_{it-1}} + \boldsymbol{\alpha_3}\boldsymbol{SD(TO)_{it}} + \boldsymbol{\alpha_4}\mathbf{SD(INF)_{it}} + \boldsymbol{\alpha_5}\mathbf{SD(EC)_{it}} + \boldsymbol{\alpha_6}\mathbf{ICT_{it}} + \mu_{it} + \boldsymbol{\varepsilon_{it}}$$

Where we denote SD (GDP) as the standard deviation of the per capita GDP, GDP is the measure of the growth which is measured through per capita GDP. We used the lag of the dependent variable as well, so it is denoted as $\mathrm{SD(GDP)_{it-1}}$. SD (TO) and SD (INF) are standard deviation for trade openness and standard deviation of inflation respectively. SD (EC) is the standard deviation of the energy consumption. ICT is a novel concept so we will use three common measures of information communication technology, first is fixed telephone subscription, the second one is mobile cellular subscription and the third one is individuals using the internet. We used these proxies as in index form. In our model, the term μ represents the specific countries

effect while ε is said to be the error term. Likewise, terms i and t denote the country and time period respectively.

It would be determined whether the development of financial intermediaries has an impact of the real and the monetary sectors on output volatility or not. So, for this purpose we used the volatility of trade as well volatility of inflation in our empirical research. It is also projected that output volatility and growth will be negatively connected. Our main regression equation is:

$$\textbf{Output Volatility} = \boldsymbol{\alpha_1}(\mathbf{GDP})_{\mathbf{it}} + \boldsymbol{\alpha_2}(\mathbf{OV})_{\mathbf{it-1}} + \boldsymbol{\alpha_3 SD(TO)}_{\mathbf{it}} + \boldsymbol{\alpha_4}\mathbf{SD}(\mathbf{INF})_{\mathbf{it}} + \boldsymbol{\alpha_5}\mathbf{SD}(\mathbf{EC})_{\mathbf{it}} + \boldsymbol{\alpha_6}(\mathbf{ICTIndex})_{\mathbf{it}} + \mu_{\mathbf{it}} + \boldsymbol{\varepsilon_{it}}$$

3.4.1 Impact of Energy Consumption Volatility on Output Volatility:

For checking the relationship between volatility of energy consumption on the output volatility, following equation should takes place:

$$\mathbf{OV} = \boldsymbol{\alpha_1}(\mathbf{GDP})_{\mathbf{it}} + \boldsymbol{\alpha_2}(\mathbf{OV})_{\mathbf{it-1}} + \boldsymbol{\alpha_3 SD(TO)}_{\mathbf{it}} + \boldsymbol{\alpha_4}\mathbf{SD}(\mathbf{INF})_{\mathbf{it}} + \boldsymbol{\alpha_5}\mathbf{SD}(\mathbf{EC})_{\mathbf{it}} + \mu_{\mathbf{it}} + \boldsymbol{\varepsilon_{it}}$$

Where i= Countries 1,2,…..217, t= time period (1971-2020), OV is the output volatility which is our dependent variable, GDP is measured by the per capita GDP, $(\mathrm{OV})_{\mathrm{it-1}}$ is the first lag of the log of output volatility. TO is denoted as trade openness whereas INF is the inflation. Lastly, EC is energy consumption in our empirical research. However, we take the volatilities of the trade openness, inflation and energy consumption in our model.

In the above equation, the impact of the gross domestic product on output volatility is denoted as α_1, the impact of lag of output volatility on output volatility is α_2, impact of trade openness on output volatility is α_3, impact of inflation on output volatility is α_4 and the impact of energy consumption volatility on output volatility is α_5.

3.4.2 Impact of Information Communication Technology on Output Volatility:

We are also interested to check the impact of information communications technologies on output volatility, so the following equation should take place:

$$\mathbf{OV} = \boldsymbol{\beta_1}(\mathbf{GDP})_{\mathbf{it}} + \boldsymbol{\beta_2}\mathbf{SD}(\mathbf{OV})_{\mathbf{it-1}} + \boldsymbol{\beta_3}\boldsymbol{SD}(\boldsymbol{TO})_{\mathbf{it}} + \boldsymbol{\beta_4}\mathbf{SD}(\mathbf{INF})_{\mathbf{it}} + \boldsymbol{\beta_5}(\mathbf{ICTIndex})_{\mathbf{it}} + \mu_{\mathbf{it}} + \boldsymbol{\varepsilon_{it}}$$

Where i= Countries 1,2,…..217, t= time period (1971-2020), LOV is the log of output volatility, GDP is measured by per capita GDP. $(\mathrm{OV})_{\mathrm{it-1}}$ is used as the first lag of the output volatility. TO is trade openness, INF is the inflation and ICT index is information communication technology index. However, we will use the three proxies for the measure of information communication technology index including fixed telephone subscription, mobile cellular subscription and individuals using the internet. Whereas we take the volatilities of the trade openness and inflation in our model.

In the above equation, the impact of the gross domestic product on output volatility is measured by β_1, the impact of lag of output volatility on output volatility is measured by β_2. We measure the impact of trade openness on output volatility by β_3, impact of inflation on output volatility is measured by β_4. Lastly, the impact of information communications technologies on output volatility is measured by β_5 in our estimation.

3.5 Econometric Methodology:

In this section of chapter, econometric techniques are utilized for estimation on panel data set. There are many reasons of using panel data in empirical research analysis. (i) When comparing cross-sectional and time-series data, we found that dataset has to have a significantly greater level of freedom and sample variability. It will help to improve the accuracy, efficiency, and competency

of estimated econometric parameters. (ii) by pooling data, it generates accurate estimates for entity findings. (iii) Panel data deals with cross-sectional heterogeneity, allowing the impact of omitted and unobserved variables to be controlled. It also gives us information about variables on a time and cross-sectional basis.

Furthermore, panel data can also be balanced or unbalanced. If each country has an equal number of time-series observations, this is referred to as a balanced panel. However, if the number of observations varies across the cross section, this is referred to as unbalanced panel data.

Despite its advantages, the panel data set has some limitations. (i) problems with data collection due to the all-encompassing sampling design. (ii) no response when interacting with the micro panel. (iii) correlation between countries using macro panels. The panel data set is expected to have both cross section (heteroscedasticity) and time series (autocorrelation) issues. Though these issues could be addressed by employing appropriate estimation techniques. These techniques include fixed effect, random effect as well the generalized methods of moments.

The study will now go into detail about the econometric techniques of panel data that is used in our empirical analysis. The analysis began with the pooled OLS method. Likewise, fixed effect and random effect techniques will apply after pooled OLS. Then two stage least square as well generalized method of moments would apply to deal with the problem of heteroscedasticity and endogeneity by employing some internal and external instruments, and finally a sensitivity analysis could be used for checking the robustness.

3.5.1 Panel Data Regression Models:

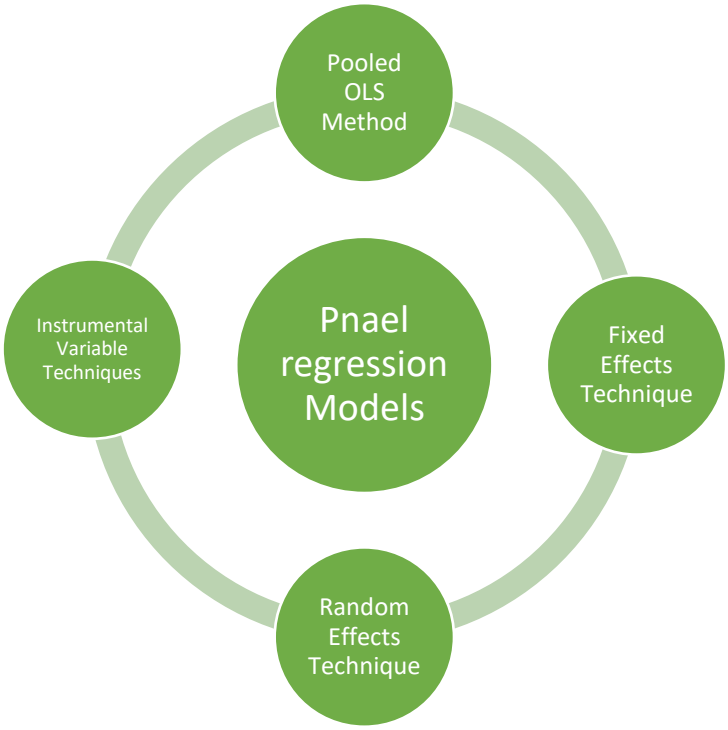

Figure 04: Panel Regression Techniques

3.5.1.1 Pooled OLS Method:

The pooled OLS is simply estimated by simple OLS regression is overly restrictive in that it specifies the constant intercept as well as coefficients assumptions. Error terms describe how things change over time and between entities. When the model is properly and correctly evaluated but the independent variables are not correlated with the residuals, than OLS can be used to estimate it. If each entity's error term is associated with time, a nonthless autocorrelation problem may occur. The pooled regression model is written as follows in its most general form:

$$\mathbf{OV} = \boldsymbol{\alpha_1}(\mathbf{GDP})_{\mathbf{it}} + \boldsymbol{\alpha_2}(\mathbf{OV})_{\mathbf{it-1}} + \boldsymbol{\alpha_3 SD(TO)}_{\mathbf{it}} + \boldsymbol{\alpha_4}\mathbf{SD}(\mathbf{INF})_{\mathbf{it}} + \boldsymbol{\alpha_5}\mathbf{SD}(\mathbf{EC})_{\mathbf{it}} + \boldsymbol{\alpha_6}(\mathbf{ICTIndex})_{\mathbf{it}} + \mu_{\mathbf{it}} + \boldsymbol{\varepsilon_{it}}$$

Moreover, pooled model regression suggests that the intercept is the same for all the countries and also that the slope coefficients for all cross sections are the identical. This assumption is highly strict, and it creates the distortion amongst the dependent and the independent variables. To overcome this situation, we used the fixed effect and random effect techniques in the analysis.

3.5.1.2 Fixed Effect Model:

When the main concern is evaluating the impact of variables that change over time, a fixed effect technique is used. It investigates the relationship between dependent and the independent variables within countries. Every nation has its own aspects which might or might not affects the estimated results, so it's important to keep track of them. The fixed effect technique has the advantage of removing time consistent features, allowing one to evaluate the impact of independent variables on dependent variables. Fixed effect models account for unobserved heterogeneity in a model by allowing separate intercepts for all countries in order to capture country-specific characteristics. It also allows the intercept variations to account for the effect of individual specific characteristics for each entity. It is also known as the least square dummy variable (LSDV), and it allows for separate intercepts for country-specific features. As a result, the model can be written as follows:

$$\mathbf{OV} = \boldsymbol{\alpha_1}(\mathbf{GDP})_{\mathbf{it}} + \boldsymbol{\alpha_2}(\mathbf{OV})_{\mathbf{it-1}} + \boldsymbol{\alpha_3 SD(TO)}_{\mathbf{it}} + \boldsymbol{\alpha_4}\mathbf{SD}(\mathbf{INF})_{\mathbf{it}} + \boldsymbol{\alpha_5}\mathbf{SD}(\mathbf{EC})_{\mathbf{it}} + \boldsymbol{\alpha_6}(\mathbf{ICTIndex})_{\mathbf{it}} + \mu_{\mathbf{it}} + \boldsymbol{\varepsilon_{it}}$$

Where i denotes that the intercepts for all countries cannot be the same because each country has unique characteristics. The advantage of using this approach is that the geographical and

the natural factors of any country are taken into account, which do not change over time. The disadvantage of using a fixed effect model is the loss of degree of freedom caused by the inclusion of so many dummy variables. Furthermore, because there are so many variables, multicollinearity may occur, complicating evaluation.

3.5.1.3 Random Effect Model:

When differences between countries have an effect on the predicted variables, the random effect technique is a better approach. The main advantage of the random effect technique is that it takes into account time-invariant variables. It divides the intercept into two parts: the fixed effect, which is the same for all countries, and the random part, which includes time-invariant country-specific attributes. The random component is the intercept's deviation from the mean. It is also known as the error component model. The model can now be expressed as follows:

$$\mathbf{OV} = \boldsymbol{\alpha_1}(\mathbf{GDP})_{\mathbf{it}} + \boldsymbol{\alpha_2}(\mathbf{OV})_{\mathbf{it-1}} + \boldsymbol{\alpha_3 SD(TO)_{it}} + \boldsymbol{\alpha_4}\mathbf{SD}(\mathbf{INF})_{\mathbf{it}} + \boldsymbol{\alpha_5}\mathbf{SD}(\mathbf{EC})_{\mathbf{it}} + \boldsymbol{\alpha_6}(\mathbf{ICTIndex})_{\mathbf{it}} + \mu_{\mathbf{it}} + \boldsymbol{\varepsilon_{it}}$$

The random effect model, as opposed to the fixed effect model, does not result in a loss of degree of freedom. It is more appropriate when predictors are uncorrelated to random intercept term.

Choice between Fixed and Random Effect Model:

Hausman test was introduced in 1978. Basically, this test was developed to determine the validity between fixed effect and the random effect technique. For checking the stability, we used the following null and alternative hypothesis.

H_0 = Random effect technique is the most consistent and appropriate one.

H_1 = Fixed affect technique is the most consistent and appropriate one.

In the analysis, if null hypothesis is rejected then we can say that the findings of the fixed and the random effect regressions differ systematically. When the findings reeject the null hypothesis, it means that fixed effect technique is most applicable technique. On the other hand, if we accept the null hypothesis and reject the alternative hypothesis, then we can say that rendom effect technique would be more appropriate.

3.5.1.4 Instrumental Variable Approach:

The OLS estimates would be inconsistent and biassed if exogenous explanatory variables are included in the model. Only when the assumption of a zero conditional mean is met will OLS estimates be efficient and consistent. In the presence of endogeniety, this assumption is violated. Endogeniety occurs when independent variables are correlated with error terms caused by measurement error or omitted variables. The instrumental variable technique could be used to resolve this issue.

The independent variable is said to be endogenous when the explanatory variable and the error terms are not zero. Therefore, energy consumption and information communication technology are endogenous if cov (energy, μ) $\neq$ 0 and cov (ICT, μ) $\neq$ 0. Furthermore, heteroscedasticity is expected to occur in panel data sets, so in this case, it is preferable to use the generalised method of moment to resolve these issues.

To address issues of potential endogeniety, omitted variables, measurement error, and heteroscedasticity in the study, **(Arellano and Bond, 1991)** system GMM is used. To eliminate time invariant (country specific) effect, system GMM includes lad of dependent variable as

independent variable. Furthermore, endogenous variables with their own lags are instrumented by system GMM .

For the instrumental variables to be valid, the following two conditions must be met.

(i) There must be a strong connection amongst instrumental variable (Z) and the endogenous variable (X).

$\text{Cov}(z,x) \neq 0$

(ii) Both the instrumental variable and the error term should be unrelated.

$\text{Cov}(z,x) = 0$

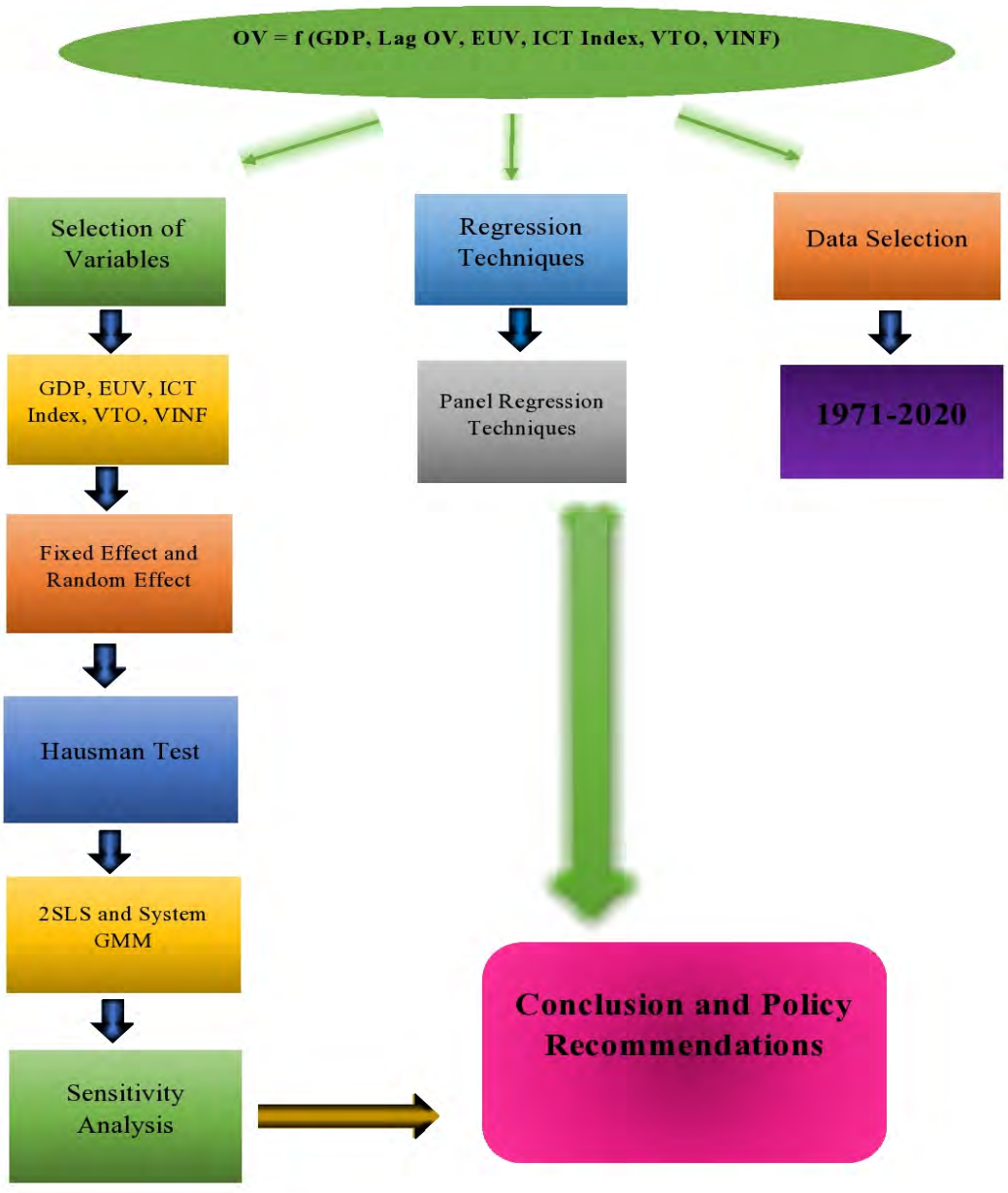

Figure 05: Analysis Flowchart

Chapter # 04

Data Collection, Variable construction, and Descriptive Statistics

For the good and effective macroeconomic data, it is essential to obtain coherent and well organized macroeconomic regulations. The focal purpose of the current research is to explore the impacts of ICT and energy consumption volatility on the output volatility. In this chapter, we'll go through how we gathered data for the variables and their statistical properties. To describe the effects of ICT and energy consumption volatility on output volatility, we used the panel data set. Panel data which is used in current reseach is including 154 global countries over the time period from 1971 to 2020. Our dependent variable is output volatility, whereas our focused variables are energy consumption volatility and information communication technology. We gathered the data of dependent, focused as well as other control variables from world development indicator (WDI). The study has also included the most relevant control variables that affect output volatility in some way, according to the literature.

This chapter is divided into five sections. Section 4.1 illustrate the sample and the time period selection with the variables description. Section 4.2 demonstrate theory, construction and description of the variables while section 4.3 explicate the statistical analysis of the variables. Lastly, section 4.4 reports the pre-estimation tests which are applied in our research.

4.1 Sample and Time Period Selection:

We want to analyze that if there's a link between output volatility and the independent variables which are energy consumption volatility and information communication technology. Thus the study created a worldwide panel data set made up of different emerging and developed nations. Over the period 1971-2020, the study used samples from 154 countries.

4.2 Theory, Description and Construction of Variables:

This section has presented a summary of all of the variables' theoretical justifications. The output volatility is the dependent variable in this research. Data on output volatility was developed using data from the Gross Domestic Product (Constant 2010 US dollars).

4.2.1. Dependent Variables:

4.2.1.1 Output Volatility (Standard deviation of GDP per capita):

Output volatility is our dependent variable. Volatility creates situations that are typically vulnerable and should be avoided. The standard deviation of GDP per capita is commonly used to measure macroeconomic volatility in economics. Volatility is reflected in the economy's business cycles, and every policy and effort has been made to lessen volatility and stabilize economic activity.

To estimate the output volatility, we have used standard deviation of GDP per capita as a proxy of output volatility. Data of GDP per capita is in constant 2010 US dollars form for all the countries are extracted from the world development indicators (2021) over the period from 1971 to 2020. In a given economy, GDP is the market value of all the goods which are produced, including taxes of the produced products and minus the subsidies. It is calculated by subtracting the asset depreciation and without the natural resources. The three-year moving Standard deviation (SD) of Gross Domestic Product in constant US dollars is used to measure output volatility.

4.2.2. Focused Variables (Independent Variables):

4.2.2.1 Energy Consumption Volatility:

Energy consumption volatility is a focused independent variable. Consumption refers to the quantity of energy or power which are consumed. There are many sources which are used to measure the energy consumption. But in current research, we only use a single energy source in our analysis. The data for the construction of energy consumption volatility are drawn from the world development indicators (2021) over the period from 1971 to 2020. The three-year moving Standard deviation (SD) of energy use in kg of oil equivalent per capita is used to measure the energy consumption volatility.

4.2.2.2 Information Communication Technology:

In the current study, information communication technology is our second focused variable. ICT is the combination of electronics, telecommunications, computer workstations, information media and networks which has an impact on the individuals, businesses, and the economy overall. With the increased in the ICT use, communication cost will be decreased which helps the information flow. In the developed nations, it is a vital driver of the growth in economy **(Farhadi et al., 2012).** In the past few decades, there is a tremendous increase in the usage of mobile phones and the internet due to the dissenimation of the technology. Globally, the rise of ICT has connected the economies. Its technological infrastructure and institutional superstructure are being rapidly integrated into a dense, multimodal network that connects individuals, micro-organizations, and global cities. We use different measures of the ICT in our reseach in which we used three proxies including fixed telephone subscription, mobile cellular subscription and individuals using the internet.

4.2.2.3 Fixed Telephone Subscription:

Fixed telephone subscription is defined as the sum of analogue fixed lines, voice-over IP, fixed payphone, fixed wireless loop as well as voice channel ISDN. The data of fixed broadband subscription is in the form of per 100 people. The data of the fixed telephone subscription which is used for the construction of information communication technology index is drawn from world development indicator (2021) over the period of 1971 to 2020.

4.2.2.4 Mobile Cellular Subscription:

Basically, mobile cellular subscription bust into the prepaid which were utilized over the past three months and the postpaid subscribers. By using the cellular technology, it provides the access to the public. However, in the mobile cellular subscription, the subscriptions which are from USB modems, private mobile radios, telemetry service are excluded. In our research, we used the data of mobile cellular subscription in per 100 people form and the data is drawn from the world development indicator (2021) over the period from 1971 to 2020.

4.2.2.5 Individuals Using the Internet:

It is the third proxy which we used for the construction of the ICT index. During the past twelve months, from anywhere, the individuals which used internet is consider as internet users. It can be used through personal computers, cell phones or any other device will be considered as the internet user. The data of individuals which are using the internet is drawn from the world development indicator (2021) over the period from 1971 to 2020 and we consider it in per 100 people form.

4.2.3. Control Variables (Independent Variables):

4.2.3.1 GDP per Capita:

In our conducted research, GDP per capita is our first control variable. In a given economy, GDP is the market value of all the goods and services which are produced, including taxes of the produced products and minus the subsidies. It is calculated by subtracting the asset depreciation and without the natural resources. Data of GDP per capita is in constant 2010 US dollars form for all the countries. And it is drawn from the World Development Indicator (2021) over the period from 1971 to 2020.

4.2.3.2 Volatility of Trade Openness:

In the study, trade openness is our first control variable. Trade openness is defined as the removal or decrease of all the barriers to the free flow of products between countries. As diversification of the products always plays an important part in shielding the economy against global shocks on volatility, trade openness plays a significant function in stabilizing the output variations **(Haddad et al. 2013).** While terms of trade, according to **Ahmed and Suardi (2009),** have a detrimental impact on output, consumption and export diversification may not be enough to reduce output volatility.

We've used the data of trade in this study and the data for construction of trade is drawn from world development indicator (2021) over the period 1971 to 2020. Moreover, volatility of trade openness which is calculated by the three years moving standard deviation of trade openness.

4.2.3.3 Volatility of Inflation:

In our research, the second control variable is inflation. In the economy, long-term increase in the prices of goods is consider as inflation. We've used the consumer price index as a proxy for the inflation. And the data is drawn from the world development indicator (2021) over the period 1971 to 2020. We utilized the standard deviation of inflation across the relevant periods as a proxy. However, volatility of inflation is calculated by the three years moving standard deviation of the consumer price index.

4.2.4. Other Variables for Sensitivity Analysis:

4.2.4.1 Life Expectancy at birth:

Life expectancy at birth is defined as the newborn infant who is expected to live in a year. The data of life expectancy at birth is calculated in years (total) which is drawn from the world development indicator (2021) over the period 1971 to 2020. We used the data of this variable in our sensitivity analysis.

4.2.4.2 Current account balance:

The total number of exports, primary and the secondary income which is in net form is consider as current balance account. We collect the data of current balance account from world development indicator (2021) over the period 1971 to 2020 and it is calculated in the form of percentage in GDP.

4.2.4.3 Fertility rate, total:

A total number of children which are born by the women who could live according to the age specific fertility rates is said to be the total fertility rate. We take the data of fertility rate in birth

per woman form. And the data is drawn from the world development indicator (2021) over the time period from 1971 to 2020.

4.2.4.4 Population growth:

The population growth rate is defined as the citizenship of all the residents in a year. It differs according to the population size which is dependent on the births and the death of the individuals in the population. The data of population growth is drawn from the world development indicator (2021) over the time period from 1971 to 2020.

4.2.4.5 Agriculture, forestry, and fishing, value added:

We use the variable agriculture, forestry and fishing in the sensitivity analysis. It is determined by the degradation of the natural resources as well as the devaluation of the manufactured assets. We take this variable from the world development indicator (2021) over the time period from 1971 to 2020. The data of agriculture, forestry and fishing which we used in our research is in percentage of GDP form.

4.2.4.6 General government final consumption expenditure:

Basically, it is the consumption of the government. It includes the expenditures of security and national defense as well as expenditures of all the goods and services of the government. On the other hand, from the government's final consumption expenditure, the expenditure on military is excluded. We used the data in percentage of GDP in our analysis. Moreover, the data is drawn from the world development indicator (2021) over the time period from 1971 to 2020.

4.2.4.7 CO2 emissions:

We take the data of carbon dioxide emissions in per capita metric tons form. It is obtained from the cement manufactures as well as the fossil fuel burnings. It includes the production of solid and liquid as well as the gas flaring. The data of carbon dioxide emissions are drawn from the world development indicator database (2021) over the time period from 1971 to 2020.

4.2.4.8 Nitrous oxide emissions:

Nitrous oxide emissions are generated from the wasteful waters which contains nitrogen organic material that found in animal and human waste. Acidity, nitrogen concentration, activities from industries, livestock management and temperature are the main factors which enhances the nitrous oxide emissions. The data of the nitrous oxide emissions is measured in the form of thousands metric tons of CO2. And we drawn the data form world development indicator (2021) over the time period 1971-2020.

4.2.4.9 Methane emissions:

Methane emissions is produced from agricultural faring practices, organic wastes, live stocks as well as the waste of solid landfills. We take the variable of methane emissions for checking the sensitivity impact. The data of methane emissions is drawn from the world development indicator (2021) over the time period from 1971 to 2020. Moreover, it is in the form of thousand metric tons of co2 form.

4.2.4.10 Total greenhouse gas emissions:

Total greenhouse gases are composed from carbon dioxide emissions. It includes all the anthropogenic sources, F gases like HFCs and SF6, nitrous oxides, biomass burnings like peat

fires, forest fires and the decay of the drained peat-lands. On the other hand, it excludes the savanna burning as well as agricultural wastes. The total greenhouse gas emissions are measure in thousand metric tons of CO2 form. Moreover, the data is drawn from the world development indicator (2021) over the time period from 1971 to 2020.

Now, the summary of the data sources of all the variables used in the construction of other variables are reported in the following table.

Table 4.2.3. Summary of Data Sources of Variables

Variables	Denoted by	Measured in	Sources
Dependent Variable			
Output Volatility	GDP	Standard deviation of GDP per capita, measured in the constant 2010 US dollars	WDI (2021)
Focused Variables			
Energy Use Volatility	EUV	Standard deviation of energy use which is measured in kg of oil equivalent per capita	WDI (2021)
Fixed telephone subscription	FTS	Per 100 people	WDI (2021)
Mobile Cellular Subscription	MCS	Per 100 people	WDI (2021)
Individuals using the Internet	IUI	Per 100 people	WDI (2021)
Control Variables			
GDP per capita	GDPPC	Constant 2010 US dollars	WDI (2021)
Volatility of Trade Openness	VTO	Standard deviation of trade openness measured in % of GDP	
Volatility of Inflation	VINF	Standard deviation of consumer price index measured in 2010 = 100	WDI (2021)
Other Variables for Sensitivity			
Life expectancy at birth	LE	Years	WDI (2021)

Current account balance	CAB	percentage of GDP	WDI (2021)
Fertility rate, total	FERR	Births per women	WDI (2021)
Population growth	AGRS	Percentage of GDP	WDI (2021)
Agriculture, forestry, and fishing, value added	POPG	Annual percentage	WDI (2021)
General government final consumption expenditure	GC	Percentage of GDP	WDI (2021)
CO2 emissions	CO2	Metrics tons per capita	WDI (2021)
Nitrous oxide emissions	NO	Thousand metric tons of CO2 equivalent	WDI (2021)
Methane emissions	ME	Kt of CO2 equivalent	WDI (2021)
Total greenhouse gas emissions	GGE	Kt of CO2 equivalent	WDI (2021)

4.3 Descriptive and Statistical Analysis:

4.3.1 Summary Statistics:

The descriptive statistics offered in this part include information about the two measures of central tendency, mean and median, minimum values of the variables as well as the maximum values of the variables. Moreover, standard deviation to reflect the data dispersion, and the total number of observations. The descriptive analytics finding for all variables are shown in the table below.

Table 4.3.1. Summary Statistics of Dependent and Independent Variables

Variables	Obs.	Mean	Median	Std. Dev.	Minimum	Maximum
Dependent Variable						
Output volatility	4233	487.55251	186.3893	1218.547	0.568753	27799.44
Focused Variables						
Energy Use Volatility	4233	85.50767	38.86661	149.1675	0.010218	2111.344
ICT Index	4233	25.39657	14.71435	27.48578	0.00000	126.4974
Control Variables						
GDP per capita	4233	14009.68	5322.385	17666.05	276.0559	111968.3
Volatility of Trade Openness	4233	5.351086	3.572547	6.031967	0.000175	113.0318
Volatility of Inflation	4233	4.207171	2.468004	10.84574	2.57e-10	296.8047

Table 4.3.1. reports the data where we take output volatility as our dependent variable which is measured through the three years moving standard deviation for the variable GDP per capita. Energy use volatility and ICT index are our focused and independent variables. We measured the energy use volatility by taking the three years standard deviation of variable energy use. However, average of three variables including fixed telephone, mobile cellular subscription and individuals using the internet is used to measure the ICT index. Volatility of trade openness is measured through the three-year standard deviation of variable trade which explains that just how the economy is exposed by the real sector. Lastly, we used the volatility of inflation in this study which is also measured through the three-year standard deviation method. It shows that how the economy will be exposed through the monetary sector.

The mean and the median values of the output volatility are 487.55251 and 186.3893 respectively, while standard deviation is 1218.547. The minimum value of the output volatility is

0.568753 and the maximum value of the output volatility is 27799.44. Mean value of the energy use volatility, ICT index, GDP per capita, volatility of trade openness and volatility of inflation are 85.50767, 25.39657, 14009.68, 5.351086 and 4.207171 respectively. While the median of energy use volatility, ICT index, GDP per capita, volatility of trade openness and volatility of inflation are 38.86661, 14.71435, 5322.385, 3.572547 and 2.468004 respectively. The standard deviation of energy use volatility, ICT index, GDP per capita, volatility of trade openness and volatility of inflation are 149.1675, 27.48578, 17666.05, 6.031967 and 10.84574 respectively. Moreover, the minimum value of the energy use volatility, ICT index, GDP per capita, volatility of trade openness and volatility of inflation are 0.010218, 0.000, 276.0559, 0.000175 and 2.57e-10 respectively. While the maximum value of energy use volatility, ICT index, GDP per capita, volatility of trade openness and volatility of inflation are 2111.344, 126.4974, 111968.3, 113.0318 and 296.8047 respectively.

4.3.2 Correlation Matrix:

Correlation is a statistical approach for determining the direction and degree of a linear relationship between two variables and explaining it. This is crucial to understand to process the issue of the multicollinearity. Correlation matrix of all of our variables which we used in our study is shown in the table below.

Table 4.3.2: Correlation Matrix

	Variables	1	2	3	4	5	6
1.	Output Volatility	1.0000					
2.	GDP Per Capita	0.3330	1.0000				
3.	Energy Use Volatility	0.2150	0.4337	1.0000			
4.	ICT Index	0.1424	0.5654	0.2673	1.0000		
5.	Volatility of Trade Openness	0.1801	-0.0520	0.1151	0.0137	1.0000	
6.	Volatility of Inflation	0.0246	-0.0038	-0.0061	-0.0101	0.0022	1.0000

From the table 4.3.2, it is clear that output volatility is positively correlated with the GDP per capita, volatility of energy use, ICT index, volatility of trade openness and volatility of inflation. As the correlation coefficient of any variable is positive, representing that the output volatility will also increases. Moreover, if the correlation coefficient of any variable is negative representing that the output volatility will also decrease. But in our study, no variable showing the negative correlation among variables.

4.4 Diagnostics/ Tests:

Different pre-estimation tests are used to examine the functional forms of the models, as well as issues of multicollinearity and heteroscedasticity in this study.

4.4.1 Functional Form/ Model Specification Test:

The link test was used in the study to ensure that all of the models had a functioning form or specification. For linear regression models, a link test is a broad specification test. The importance of the P- value of the square term in the link test is that if the probability value is less than 0.05, then we have the wrong form of the model. So we can say that the model is incorrectly

estimated. After analyzing or checking the functional form of our model, we summarizes the results of link test in the following table.

Table 4.4.1: Link Test Results of Output Volatility as dependent variable

Link Test			
Model	**Coefficient**	**T- Stats**	**P- Value**
Output Volatility (Dependent variable)			
Hat	0.9844404	43.71	0.000
Hat- Square	7.02e-06	0.80	0.427
Constant	3.357357	0.40	0.691

The link test results for the model estimated are shown in the table 4.4.1. Since the probability value of hat-square is less than the level of significance (P< 0.10), which means that our null hypothesis is rejected. So, we can conclude that the functional form is confirm in our model.

4.4.2 Multicollinearity Test:

The study used the variance inflation factor to investigate the topic of multicollinearity. It narrates that due to the multicollinearity problem, how much for the variance of the coeffoicient has been inflated. If the average value of the variance inflation factor is larger than 10, it indicates that multicollinearity is a major problem. Following table reports the result of multicollinearity for our estimated model.

Table 4.4.2: Multicollinearity Test Results of Output Volatility as Dependent Variable

Independent Variables	VIF	1/VIF
GDP per capita	1.82	0.548090
Lag of Output Volatility	1.19	0.840510
Energy Use Volatility	1.27	0.789250
ICT Index	1.49	0.669262
Volatility of Trade	1.09	0.921103
Volatility of Inflation	1.16	0.862613
Mean VIF	**1.34**	

Table 4.4.2 is reporting results of the VIF for model where output volatility is our dependent variable. It indicates that the average value for the variance inflated factor is less than 10 which means that there is no multicollinearity problem arise in our study.

4.4.3 Heteroscedasticity:

When the conditional variances with the independent variables are $\text{Var}(U_i|X_i) = \sigma^2$ or heteroscedasticity refers to scenarios in which variability of a variable is unequal throughout the range of values of another variable that predicts it, the issue of heteroscedasticity arises. Standard errors grow big or do not remain constant in the presence of heteroscedasticity. The Breusch-Pegan heteroscedasticity test was used to determine heteroscedasticity.

Table 4.4.3: Heteroscedasticity Test Results of Output Volatility as Dependent Variable

Null: constant variance	
Chi2 (1)	134687.22
Probability > chi2	0.0000

Table 4.4.3 reports the results of heteroscedasticity for our estimated model. It clearly shows that model has the problem of heteroscedasticity. Because the probability value is less than 0.05, so we can say that there is a problem of heteroscedasticity in model.

4.4.4. Robustness of the Model:

Whenever, there is heteroscedasticity problem arise in the data or model, we can tackle it by robustness. In our estimated model, we face the problem of heteroscedasticity which will need to be removed. For this purpose, we can use the robustness which will easily remove the heteroscedasticity problem from our model. Following tables reports the results of robustness.

Table 4.4.4: Robustness Results for removing Heteroscedasticity

Output Volatility	**Coefficients**	**Robust Std. Error**	**t- stats**	**P > |t|**
GDP per capita	.0149297	.0025205	5.92	0.000
Lag of Output Volatility	.4315909	.089391	4.83	0.000
Energy Use Volatility	.2367231	.1320713	1.79	0.073
ICT Index	-1.34872	.5115449	-2.64	0.008
Volatility of Trade	16.14208	3.881036	4.16	0.000
Volatility of Inflation	-138.4733	5.166705	4.41	0.000

Table 4.4.4 reports the results of robustness which is used to tackle or remove the heteroscedasticity problem from the model. Earlier, we faced the problem of heteroscedasticity as the probability value is less than 0.05. So, by using the robustness, it is concluded that now we have no problem of heteroscedasticity in our model.

Chapter # 05

Results and Discussion

Introduction:

Statically meaningful evidence merely indicates that it was most usually triggered by anything but chance. Significant is not suggest crucial. For the importance of the findings, we should not consider the sheer size of P-value as manifestation. The significancy only depend on the findings of the results and its consequences. Maybe we find the significant results, but it has no importance or a little bit importance at all. If we got significant findings or even extreme significant results, it doesn't mean that we found important discovery. The main thing is the consistency of the results according to the theory. If the findings imply inconsistency, then the whole theory will be rejected, which is not possible according to the economic point of view.

In this chapter, we have reported the results and deliberation that how information technology communications and volatility of energy consumption could affect the output volatility. Energy use is used as a proxy for the volatility of energy consumption while three measures are used to check the effects of ICT on the output volatility. It includes fixed telephone subscription, mobile cellular subscription and the individuals using the internet. We've used different econometric techniques for this purpose referenced in chapter 3. Present study used the panel data regressions for the analysis including pooled ordinary least square technique, fixed effect technique, random effect technique, two stage least square as well as the generalized methods of moments technique. To ensure that the study's findings were stable, current study employ sensitivity analysis for this purpose. The whole estimation done with 154 countries and the study has used famous statistical packages of Stata 15. We've taken the data from world development indicator (2021) for our analysis.

This chapter is divided into six sections. Section 5.1 illustrate the results and the interpretations of estimation of pooled OLS method. Section 5.2 explicate the fixed effect and random effect techniques while section 5.3 reports the difference between fixed and random effect techniques. Section 5.4 highlights the results of two stage least square regression while sectiom 5.5 illustrates the generalized methods of moments. Lastly, section 5.6 demonstrates the sensitivity analysis results and interpretation of the present reseach.

5.1. Pooled Ordinary Least Square Nexus:

The pooled ordinary least square technique is estimated by simple OLS regression which is overly restrictive in that it specifies the constant intercept as well as coefficients assumptions. Error terms describe how things change over time and between entities. When the model is properly and correctly evaluated but the independent variables are not correlated with the residuals, than OLS can be used to estimate it.

The study's estimation combines the output volatility of 154 economies with several main proxies of ICT and energy consumption volatility across a 50-year period from 1971 to 2020. The results of pooled ordinary least square regression reported in the following table.

Table 5.1: Pooled ordinary least square results of output volatility as dependent variable

Variables	Output Volatility
Constant	-138.5***
	(-6.83)
GDP per capita	0.0149***
	(16.21)
Lag of Output Volatility	0.432***
	(55.10)
Energy Use Volatility	0.237**
	(2.60)
ICT Index	-1.349*
	(-2.52)
Volatility of Trade Openness	16.14***
	(7.76)
Volatility of Inflation	22.77***
	(19.05)
R-Square	0.5871
F-Statistics	1001.44
F-Probability	0.0000
No of observations	4233

*Note: t-values are given in parenthesis. *, **, *** corresponds to significance at 10%, 5% and 1% respectively.*

Table 5.1 represents the results of pooled (OLS) technique of the estimated equation reported in chapter 03. There is a positive connection between GDP per capita and the output volatility. The results show that with the 1 percent increase in the GDP per capita, it will lead to increase in the output volatility by 0.0149 unit. We found the correct and significant results of the GDP per capita on the output volatility in our analysis.

Output volatility has substantially long-lasting concept, so we used the panel data set in our analysis. We used the lag of output volatility in our research which has a significant and positive impact on the output volatility. Same results are concluded by **Majeed and Mazhar (2019),**

Majeed et al. (2021). The results are consistent and correct according to the theory. It indicates that due to 1 percent increase in the lag of output volatility, it will lead to increase in the output volatility by 0.432 units.

There is considerable positive and significant impact of energy consumption volatility on the output volatility. The results are correctly estimated and indicates that due to 1 percent increase in the volatility of energy consumption, it will lead to increase in the output volatility by 0.237 units. The growth in the output is highly volatile if there are variations in the consumption of the energy.

ICT suggested that there is negative impact of output volatility as it reduces the output stability. It will also result in the decrease of the production in the economy. ICT is a novel concept, and we used the three common proxies to calculate the ICT index here. The results indicates that due to 1 percent increase in the ICT index, it will lead to decrease in the output volatility by 1.349 units. The results are consistent and correctly estimated in our analysis.

Volatility of trade shows the instability in the real sector. From the estimated result, it is found that the volatility of trade has a positive and significant impact. As the results indicates that the output volatility will be increased due to the deterioration and the interference in real sectors. Same results are concluded by **Beck et al. (2006), Easterly et al. (2001), Giovanni and Levchenko (2009), Majeed and Mazhar (2019).** According to them, due to the trade openness in the economy, the volatility will be increased which will leads to the external shocks in the economy. The results are consistent and correct according to the theory. It indicates that due to 1 percent increase in the volatility of trade openness, it will lead to increase in the output volatility by 16.14 units.

Volatility of inflation shows the instability in the monetary sector. From our findings, volatility of inflation has a positive and significant impacts on the output volatility. The results indicates that the output volatility will be increased due to the deterioration and the interference in monetary sectors. Same results are concluded by **Beck et al. (2006).** The results are consistent and correct according to the theory. It indicates that due to 1 percent increase in the volatility of inflation, it will lead to increase in the output volatility by 22.77 units.

Moreover, the findings reveal that the value of R- square is 0.5871 which indicates that there is 58% variation in the dependent variable that is output volatility due to the independent variables in our analysis. The total no of observations are 4233 while the value of the F- statistics is 1001.44 and the probability of the F- statistics is 0.0000.

5.2. Fixed Effects and Random Effects Results of Output Volatility:

The intercept does not change for all the countries in the pooled OLS model. Likewise, in the cross sections, the coefficients are remains identical. Due to the limitation of this assumption, sometimes we face the deformation among the variables. So, we move to the other techniques like fixed effect and the random effect technique for the analysis.

The study's estimation combines the output volatility of 154 economies with several main proxies of ICT and energy consumption volatility across a 50-year period from 1971 to 2020. The results of fixed effect and random effect techniques are reported in the following table 5.2. Firstly, we consider the fixed effect model results in column (1).

The findings of the fixed effect model suggested that there is consistency in the results. There is a positive association among GDP per capita and the output volatility. The results indicates that with the 1 percent increase in the GDP per capita, it will lead to increase in the output volatility by

0.0222 unit. We found the correct and significant results of the GDP per capita on the output volatility in our analysis. **Majeed and Noreen (2018)** also concluded the same results. In the same way, lag of output volatility has considerable positive and significant impact on the output volatility. The results are correctly estimated according to the literature provided. It indicates that due to 1 percent increase in the lag of output volatility, it will lead to increase in the output volatility by 0.418 units. Same results are concluded by **Majeed and Mazhar (2019), Majeed et al. (2021).**

Volatility of energy consumption has considerable positive and statically significant impact on the output volatility. The results suggests that due to 1% increase in the volatility of energy consumption, it will lead to increase the output volatility by 0.0907 units. The growth in the output is highly volatile if there are variations in the consumption of the energy. ICT reduces the output stability. It will also result in the decrease of the production which creates the asymmetric information in the economy. So, when asymmetric information is knockout from the economy, then volatility will also be halted. We used the three common proxies to calculate the ICT index here. The results indicates that due to 1 percent increase in the ICT index, it will lead to decrease in the output volatility by 3.011 units. The results are correctly estimated in our analysis.

Volatility of trade and volatility of the inflation shows the instability in the real and monetary sectors respectively. The results indicates that output volatility will also be increased due to the deterioration and the interference in real and monetary sector. Due to the trade openness, the output volatility will also be increased which cause the external shocks in the economy. The results are correctly estimated according to the literature. The results indicates that due to 1 percent increase in the volatility of trade, it will lead to increase in the output volatility by 17.37 units. Same results are concluded by **Majeed and Noreen (2018), Majeed and Mazhar (2019)** and **Majeed and Mazhar (2021).** Similarly, the results indicates that due to 1 percent increase in the volatility of

inflation, it will lead to increase in the output volatility by 24.94 units. Same conclusion is drawn by **Majeed and Noreen (2018)** and **Majeed and Mazhar (2021)** by using the spatial and non-spatial fixed effect models. The results are consistent and correctly estimated for the whole analysis.

Moreover, the findings reveal that the value of R- square is 0.5818 which indicates that there is 58% variation in the dependent variable that is output volatility due to the independent variables in our analysis. The total no of observations are 4233 while the value of the F- statistics is 747.19 and the probability of the F- statistics is 0.0000.

Table: 5.2 Fixed Effect and Random Effect Results of Output Volatility

Variables	(1)	(2)
	Fixed Effect Model	**Random Effect Model**
Output Volatility		
Constant	-192.9*** (-5.10)	-138.5*** (-6.83)
GDP per capita	0.0222*** (7.90)	0.0149*** (16.21)
Lag of Output Volatility	0.418*** (51.77)	0.432*** (55.10)
Volatility of Energy Use	0.0907 (0.71)	0.237** (2.60)
ICT Index	-3.011*** (-4.27)	-1.349* (-2.52)
Volatility of Trade Openness	17.37*** (7.05)	16.14*** (7.76)
Volatility of Inflation	24.94*** (20.08)	22.77*** (19.05)
R-Square	0.5818	0.5871
Chi2(6)	------	6008.61
Prob > Chi2	------	0.0000
F-Statistics	747.19	------
F-Probability	0.0000	------
No of Observations	4233	4233

*Note: t-values are given in parenthesis. *, **, *** corresponds to significance at 10%, 5% and 1% respectively.*

Now we consider the Random effect model results which is presented in the column 2. When there is increase in the number of observations, then it will also affect the unknown parameters in the fixed effect model. To tackle this situation, we move to the random effect regression.

The findings confirm that there is considerable significant impact of GDP per capita on output volatility. The results are consistent and correctly estimated in the analysis. Due to 1 percent

increase in the per capita GDP, it will lead to increase in the output volatility by 0.0149 units. However, the lag of output volatility has substantially positive impact on the output volatility. The results are correctly estimated according to the literature provided. It indicates that due to 1 percent increase in the lag of output volatility, it will lead to increase in the output volatility by 0.432 units. Same results are concluded by **Majeed and Mazhar (2019)** and **Majeed et al. (2021)** by using the FMOLS technique over the time period 1971-2017.

From the findings, it is clear that the volatility of energy consumption has positively significant impact on the output volatility. It shows that due to 1 percent increase in the volatility of energy consumption, it will lead to increase in the output volatility by 0.237 units. The findings reveal that coefficients are correctly estimated. Additionally, information and communications technology is considered to be volume up and the speed of capital inflows. It transpires that countries with a high ICT evolution and high rate of financial inclusion demonstrates the greater output fluctuations. But this is in terms of monetary affairs, and on the fiscal policy side, lower output fluctuations exhibit. Overall, ICT mitigate the economic stability and the output volatility. Results concluded that due to 1 percent increase in the ICT index, it will lead to increase in the output volatility by 1.349 units. Overall, ICT mitigate the economic stability and the output volatility. Coefficients are correctly estimated in the analysis.

Volatility of trade shows the instability in the real sector. Due to the trade openness, output volatility will also be increased which creates shocks. The results indicates that output volatility will also be increased due to the deterioration and the interference in real sector. Due to 1 percent increase in the volatility of trade, it will lead to increase in the output volatility by 16.14 units. Same conclusion is drawn by **Majeed and Noreen (2018), Majeed and Mazhar (2019), Majeed and Mazhar (2021)** and **Majeed et al. (2021).** Likewise, volatility of inflation shows the

instability in the monetary sector. The results indicates that output volatility will also be increased due to the deterioration and the interference in monetary sector. The results are correctly estimated according to the literature and indicates that due to 1 percent increase in the volatility of trade, it will lead to increase in the output volatility by 22.77 units. Same conclusion is drawn by **Majeed and Noreen (2018).**

Additionally, the findings reveal that the value of R- square is 0.5871 which indicates that there is 58% variation in the dependent variable that is output volatility due to the independent variables in our analysis. The total no of observations are 4233 while the value of the Chi-square is 6008.61 and the probability of the Chi-square is 0.0000.

5.3. Difference between Fixed Effect Technique and Random Effect Technique:

The fixed effect technique does not incorporate those variables in the estimation whose values donot change over the time. Whereas, the random effect technique measures the intercept of all the cross sections. The error term, on the other hand, is not directly observable and is thus handled as a latent or unobservable variable.

Choice between Fixed and Random Effects:

Hausman test was introduced in 1978. Basically, this test was developed to determine the validity between fixed effect and the random effect technique. For checking the stability, we used the following null and alternative hypothesis.

H_0: Findings of fixed effect regression and the random effect regression does not differ systematically.

H_1: Findings of fixed effect regression and the random effect regression differ systematically.

In the analysis, if null hypothesis is rejected then we can say that the findings of the fixed and the random effect regressions differ systematically. When the findings reeject the null hypothesis, it means that fixed effect technique is most applicable technique. On the other hand, if we accept the null hypothesis and reject the alternative hypothesis, then we can say that rendom effect technique would be more appropriate. The following table 5.3 reported the results of hausman test.

Table 5.3: Results of Hasuman Test

Hausman Test		
Variable	**Chi (6)**	**P-Value > Chi (6)**
Output Volatility	87.62	0.0000

From the above table, it is clearly indicated that probability value is less than 10%. In this situation, we can say reject our null hypothesis and concluded that fixed effect technique is more appropriate than the random effect technique.

5.4 Two Stage Least Square Results:

The OLS estimates would be inconsistent and biassed if exogenous explanatory variables are included in the model. Only when the assumption of a zero conditional mean is met will OLS estimates be efficient and consistent. In the presence of endogeniety, this assumption is violated. Endogeniety occurs when independent variables are correlated with error terms caused by measurement error or omitted variables. Then we used intrumental variable technique to tackle the endogeniety problem.

The independent variable is said to be endogenous when the explanatory variable and the error terms are not zero. Therefore, energy consumption and information communication technology are endogenous if cov (energy, μ) $\neq$ 0 and cov (ICT, μ) $\neq$ 0.

In our estimated model, it is possible that endogeniety problem exist. Because there is contemporaneous links between ICT, energy consumption volatility and output volatility. And, when there is endogeniety problem arises then OLS results is getting biased. So, we will tackle this problem by applying the two stage least square estimation. The findings of the two stage least square estimation is reported in the following table.

Table 5.4: Two Stage Least Square (2SLS) Results

Variables	Output Volatility
Constant	-137.6023***
	(-6.77)
GDP per capita	0.0150401***
	(16.29)
Lag of Output Volatility	0.4312033***
	(55.05)
Energy Use Volatility	0.2350334*
	(2.59)
ICT Index	-1.454228*
	(-2.69)
Volatility of Trade Openness	16.16851***
	(7.76)
Volatility of Inflation	22.80299***
	(19.07)
R-Square	0.5870
Chi2(6)	6005.09
Probability > Chi2	0.0000
No of observations	4224

*Note: z-values are given in parenthesis. *, **, *** corresponds to significance at 10%, 5% and 1% respectively.*

Table 5.4 comes up with the results of two stage least square estimation of 154 nations over the time period from 1971 to 2020. We used the lag of the ICT index as the instrumental variable in the analysis. The results which we get are pretty much consistent with the results obtained from OLS technique. Likewise, the literature also supports the findings.

The coefficients of GDP per capita and the lag of output volatility represents the positive and significant impact on the output volatility. The findings reveals that due to 1% increase in the GDP per capita, it will lead to increase in the output volatility by 0.0150401 units. **Majeed and Noreen (2018)** comes up with the opposite results. According to them, GDP growth is negatively linked

with the output volatility. The results of lag of output volatility showing that there is increase in output volatility. As, there is 1% increase in the lag of output volatility, the output volatility will increase by 0.4312033 units.

Energy consumption volatility is our focused variable in the analysis which shows the positive and substantial impact on output volatility. The results indicates that due to 1% increase in the volatility of energy consumption, it will lead to increase the output volatility by 0.2350334 units. The results showing the consistency. On the other hand, ICT index comes up with the opposite results. The findings shows that due to 1% increase in the ICT index will lead to decrease the output volatility by 1.454228 units. In the research world, ICT is a novel concept and there are lots of proxies used to measure the ICT index. But we used only three common and major proxies which includes fixed telephone subscription, individuals using the internet and mobile cellular subscription. The negative results indicate that output stability is also reduces which lower the production in the economy.

Volatility of trade and volatility of inflation shows the instability in the real and the monetary sectors respectively. The results are correctly estimated according to the previous literature. The findings reveals that due to 1% increase in the volatility of trade, it will lead to increase the output volatility by 16.16851 units. Similarly, due to 1% increase in the volatility of inflation, it will lead to increase the output volatility by 22.80299 units. Same conclusion is drawn by **Majeed and Noreen (2018).**

Moreover, the findings reveal that the value of R- square is 0.5870 which indicates that there is 58% variation in the dependent variable that is output volatility due to the independent variables in our analysis. The total no of observations are 4224 while the value of the Chi-square is 6005.09 and the probability of the Chi-square is 0.0000.

5.5 Generalized Methods of Moments (GMM) Results:

We used the technique of instrumental variable when we faced the problem of endogeneity in the analysis. Two stage least square technique is also applicable for the endogeneity problem which is a very common measure to deal with the endogeneity. But 2SLS is not appropriate measure when there is a problem of heteroscedasticity in the data. So based on this argument to address issues of potential endogeneity, omitted variables, measurement error, and heteroscedasticity in the study, **(Arellano and Bond, 1991)** system GMM is used. To eliminate time invariant (country specific) effect, system GMM includes lag of dependent variable as independent variable. Furthermore, endogenous variables with their own lags are instrumented by system GMM. The findings of the generalized methods of moments are reported in the following table.

Table 5.5: Generalized Methods of Moments (GMM) Results

Variables	Output Volatility
Constant	-137.6***
	(-5.12)
GDP per capita	0.0150***
	(5.98)
Lag of Output Volatility	0.431***
	(4.83)
Energy Use Volatility	0.235
	(1.78)
ICT Index	-1.454**
	(-2.81)
Volatility of Trade Openness	16.17***
	(4.16)
Volatility of Inflation	22.80***
	(4.41)
R-Square	0.5870
Chi2 (6)	1266.36
Probability > Chi2	0.0000
No of observations	4224

*Note: t-values are given in parenthesis. *, **, *** corresponds to significance at 10%, 5% and 1% respectively.*

Table 5.5 reported the results of generalized methods of moments for 154 countries over the time period from 1971 to 2020. We used the lag of the ICT index as the instrumental variable in the analysis. The findings provide the significant impacts of the GDP per capita, lag of output volatility on the output volatility. Due to 1% increase in the GDP per capita and the lag of output volatility, it will lead to increase in the output volatility by 0.0150 and 0.431 units respectively. The results provide us the highly positive and significant association among variables. **Majeed and Mazhar (2019)** comes up with the same results.

From the findings, it is clear that there is a significant impact of the volatility of energy consumption volatility on the output volatility. However, due to the consumption in energy, output growth is highly volatile in the economy. The findings suggested that due to 1% increase in the volatility of energy consumption, it will lead to increase the output volatility by 0.235 units.

The empirical analysis shows the negative relationship of the ICT on output volatility as it reduces the output stability. ICT is a novel concept. So, we used fixed telephone subscription, mobile cellular subscription and individuals using the internet to calculate the ICT index. The results indicates that due to 1 percent increase in the ICT index, it will lead to decrease in the output volatility by 1.454 units. The results are consistent and correctly estimated in our analysis.

On the other hand, there is a significant impact of the control variables on the output volatility. Our control variables are volatility of trade openness and volatility of inflation in the analysis. Findings reveal that due to 1% increase in the volatility of trade, it will lead to increase the output volatility by 16.17 units. Results are highly significant according to the literature. Same conclusion drawn by **Majeed and Noreen (2018), Majeed and Mazhar (2019).** Likewise, due to 1% increase in the volatility of inflation, it will lead to increase the output volatility by 22.80 units. Results are highly significant according to the literature. Same conclusion drawn by **Majeed and Noreen (2018).** Overall, the results supported by the real business cycle theories.

Additionally, the findings reveal that the value of R- square is 0.5870 which indicates that there is 58% variation in the dependent variable that is output volatility due to the independent variables in our analysis. The total no of observations are 4224 while the value of the Chi-square is 1266.36 and the probability of the Chi-square is 0.0000.

5.6 Sensitivity Analysis Results of Output Volatility and Energy Consumption by incorporating ICT indicators:

We examined the findings of the robustness in this section of the investigation. To ensure that the study's findings were stable, we ran a series of robustness assessments. We added some extra control variables to OLS to assess the sensitivity of the results. Life expectancy at birth, current balance account, total fertility rate, population growth, value added of forestry, fishing and agriculture, final consumption of general government expenditure, CO2 emissions, emissions of nitrous oxide, methane emissions and the total greenhouse gas emissions are the control variables which we included in our analysis to check the sensitivity of the variables. Following tables reported the findings of the model output volatility with the inclusion of additional variables.

Table 5.6(a): Results of Sensitivity Analysis Results of Output Volatility and Energy Consumption by incorporating ICT Index

	(1)	(2)	(3)	(4)	(5)	(6)
Variables	**Output Volatility**					
Constant	-138.5***	-224.6	-57.48***	-124.7**	-26.73	-157.2***
	(-6.83)	(-1.82)	(-4.57)	(-3.01)	(-0.87)	(-5.95)
GDP per capita	0.0149***	0.0147***	0.0117***	0.0149***	0.0130***	0.0150***
	(16.21)	(14.89)	(19.55)	(15.75)	(14.70)	(16.23)
Lag of Output Volatility	0.432***	0.432***	0.482***	0.432***	0.450***	0.432***
	(55.10)	(55.04)	(49.87)	(55.03)	(53.22)	(55.08)
Energy Use Volatility	0.237**	0.235**	0.321***	0.236**	0.252**	0.214*
	(2.60)	(2.59)	(5.29)	(2.59)	(3.05)	(2.30)
ICT Index	-1.349*	-1.554**	-0.911**	-1.451*	-1.769***	-1.185*
	(-2.52)	(-2.58)	(-2.84)	(-2.48)	(-3.44)	(-2.14)
Volatility of Trade	16.14***	16.18***	8.755***	16.15***	14.24***	16.20***
	(7.76)	(7.77)	(6.54)	(7.76)	(7.63)	(7.78)
Volatility of Inflation	22.77***	22.79***	14.03***	22.77***	16.51***	22.78***
	(19.05)	(19.05)	(11.96)	(19.04)	(13.02)	(19.05)
Life expectancy at birth	---	1.363	---	---	---	---
		(0.71)				
Current Account Balance	---	---	0.302	---	---	---
			(0.43)			
Fertility rate, total	---	---	---	-3.390	---	---
				(-0.38)		
Agriculture, forestry, and fishing	---	---	---	---	-3.996**	---
					(-3.17)	
Population Growth	---	---	---	---	---	9.973
						(1.09)
General government final consumption expenditure	---	---	---	---	---	---
CO2 Emissions	---	---	---	---	---	---

Nitrous Oxide Emissions	---	---	---	---	---	---
Methane Emissions	---	---	---	---	---	---
Total Greenhouse gas Emissions	---	---	---	---	---	---
R- Square	0.5871	0.5871	0.6533	0.5871	0.5810	0.5872
F- Statistics	1001.44	857.55	1002.87	857.43	750.25	858.51
F- Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
No of Observations	4233	4229	3734	4229	3795	4232

*Note: t- values are given in parenthesis. *, **, *** corresponds to significance at 10%, 5% and 1% respectively.*

Table 5.6(b): Results of Sensitivity Analysis Results of Output Volatility and Energy Consumption by incorporating ICT Index

	(7)	**(8)**	**(9)**	**(10)**	**(11)**
Variables	**Output Volatility**				
Constant	-104.9** (-2.91)	-142.4*** (-6.79)	-138.3*** (-6.45)	-140.1*** (-6.53)	-151.1*** (-7.10)
GDP per capita	0.0155*** (16.25)	0.0137*** (12.61)	0.0149*** (16.12)	0.0149*** (16.15)	0.0151*** (16.20)
Lag of Output Volatility	0.431*** (54.33)	0.432*** (54.64)	0.432*** (54.88)	0.431*** (54.87)	0.431*** (54.57)
Energy Use Volatility	0.197* (2.14)	0.141 (1.34)	0.235* (2.57)	0.235* (2.57)	0.224* (2.43)
ICT Index	-1.472** (-2.69)	-1.331* (-2.45)	-1.336* (-2.45)	-1.337* (-2.45)	-1.404* (-2.57)
Volatility of Trade	16.43*** (7.78)	15.27*** (7.19)	16.06*** (7.50)	16.13*** (7.54)	18.39*** (8.07)
Volatility of Inflation	22.84*** (18.79)	22.43*** (18.70)	22.80*** (18.97)	22.79*** (18.96)	23.27*** (19.12)
Life expectancy at birth	---	---	---	---	---

Current Account Balance	---	---	---	---	---
Fertility rate, total	---	---	---	---	---
Agriculture, forestry, and fishing	---	---	---	---	---
Population Growth	-2.510 (-1.14)	---	---	---	---
CO2 Emissions	---	6.931* (2.01)	---	---	---
Nitrous Oxide Emissions	---	---	-0.00000482 (-0.02)	---	---
Methane Emissions	---	---	---	0.0000257 (0.27)	---
Total Greenhouse gas Emissions	---	---	---	---	0.00000278 (0.20)
R- Square	0.5870	0.5858	0.5869	0.5869	0.5870
F- Statistics	835.60	843.68	851.01	851.04	844.94
F- Prob.	0.0000	0.0000	0.0000	0.0000	0.0000
No of Observations	4124	4183	4201	4201	4170

*Note: t-values are given in parenthesis. *, **, *** corresponds to significance at 10%, 5% and 1% respectively.*

Table 5.6 (a) and 5.6 (b) shown the empirical analysis with the inclusion of additional variables. The direction and the significance of the relationship between the independent variables including volatility of energy use and information communications technologies and the dependent variable which is output volatility are consistent with our baseline model when additional variables are included in our analysis. We've discovered that no matter how many extra variables are introduced, our base model results remain same. Overall, the findings concluded that the variables of the current research are robust. Moreover, these findings are not sensitive to the inclusion of the control variables.

Chapter 06

6.1. Conclusion:

Previous studies have compiled and concentrated on the vast literature on the various factors of output volatility. There are only few studies which are examining the collision of ICT between the economic growth and consumption of the energy. But there is no study which can connects the effects of information technology communications on the output volatility as well as the effect of energy volatility on the output volatility. Likewise, no study explored the combined effects of information communication technologies and energy use volatility on the output volatility. So, as per our knowledge, it is the first empirical analysis that attempts to figure out the association between energy use volatility, information communication technologies, and output volatility. For this purpose, we used different econometric techniques like pooled OLS, fixed effect, random effect estimation, two stage least square and generalized methods of moments in our empirical analysis. The current investigation also applies endogeneity in the panel estimation. Moreover, to ensure that the study's findings were stable, we ran a series of robustness assessment also. The panel of global analysis is used for 154 nations for the span of 50 years, from 1971 to 2020. ICT is a novel idea and concept. So, for the analyzation of supremacy of ICT on total growth of the economy, we take the average of fixed telephone subscription, mobile cellular subscription and individuals using the internet. Furthermore, for the energy consumption volatility, we use energy use variable for analysis.

The results of the study suggest that energy consumption volatility yields considerable positive and statistically significant outcomes and has a distorted impact on output volatility. Energy Volatility augmented output volatility which contributes to macroeconomic instability. The growth in the output is highly volatile if there are variations in the consumption of the energy.

It was discovered that when the macro-economy is extremely unreliable in the economy then the volatility of consumption of energy will substantially enhances the output volatility. Though, the volatility of consumption of energy has a negligible influence on the output volatility when macroeconomic activities will less volatile.

Information communications technologies suggested the negative impact on the output volatility as it reduces the output stability. Due to this, production in the economy decrease which will result in the increase of information gap. When the asymmetric information is knockout from the economy then volatility will also be halted. Information and communications technology is considered to be volume up and the speed of capital inflows. It transpires that countries with a high ICT evolution and high rate of financial inclusion demonstrates the greater output fluctuations. But this is in terms of monetary affairs, and on the fiscal policy side, lower output fluctuations exhibit. Overall, ICT mitigate the economic instability and the output volatility.

High output volatility has negative impact on the growth of the economy or clearly linked to the lower growth in the economy. But the findings for all of the nations covered in this empirical investigation are consistent in general. Conclusion of the research provide a clearer picture of the consistency. The research suggested that ICT has a more important role in mitigating the economic instability rather than the energy use volatility.

6.2. Policy Implications:

The current study provides important policy recommendations for implementing ICT-enabled technologies, which will result in more inventive advances and increased the growth in the economy. The state must stimulate the growth of the information communications technologies which will result in increased productivity and protracted development. The research findings

provide important policy implications for developing-country legislators, inspiring private and public firms to implement ICT-enabled innovations that will introduce developments to mobile phone users, such as online banking, internet shopping, resulting in increased output and the growth of the economy as well as lower the consumption of energy. It is suggested that governments boost its investment portfolio and attract foreign direct investment, which will result in greater exports and a more technologically advanced sector, leading to better productivity and the growth of the economy.

Moreover, for the policymakers, the findings of the study are important. As they recommend a bolstering consumption in the energy which can help to control the undesirable volatilities especially during periods of high real GDP instability.

6.3. Limitations and the Future Directions of the Study:

With the given available resources, opportunities, and time, we did our best to complete our research work in most efficient and effective way. But still the current study has some aspects and limitations which should be improved. Firstly, we measure the volatility of energy through one proxy, however future research can also use fossil fuel energy consumption and renewable energy consumption for the empirical analysis. Secondly, due to the limitations and restrictions of the data the current research practices the unbalanced data methods. Thirdly, present study includes the global analysis but did not assimilate the country specific as well regional specific analysis. So, the future research can extend this analysis by incorporating the region wise and country wise analysis.

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Algeria
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Bahrain
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