IMPACT OF INVESTMENT & GOVERNMENT SPENDING VOLATILITY ON ECONOMIC GROWTH: A PANEL DATA ANALYSIS OF OECD AND DEVELOPING COUNTRIES

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IN THE NAME OF

ALLAH

The Most Beneficent

The Most Merciful

"To Allah belongs whatever is in the heavens and whatever is in the earth. Whether you show what is within yourselves or conceal it, Allah will bring you to account for it. Then He will forgive whom He wills and punish whom He wills, and Allah is over all things competent."

(Al-Baqarah, 2:284)

GOLDEN SAYING OF

THE HOLY PROPHET

(Peace and Blessings of Allah be Upon Him)

"Do not wish to be like anyone except in two cases. (The first is) A person, whom Allah has given wealth and he spends it righteously; (the second is) the one whom Allah has given wisdom (the Holy Qur'an) and he acts according to it and teaches it to others".

(Al-Hadith)

DEDICATED

TO

MY BELOVED FAMILY

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Abstract

Impact of government spending and investment on economic growth has been widely discussed in the literature. However, impact of government spending volatility and investment volatility has been less explored. Aim of this study is to investigate the impact of investment volatility and government spending volatility on economic growth for the world representative sample. Furthermore, this study, also conducted disaggregated analysis for developed and developing countries. The full sample consists of a panel of 82 countries and the data from 1999 to 2016. Generalized Method of Moments technique is applied to the panel data. Results show that government spending volatility has a negative impact on economic growth in case of full sample and developing countries while it has an insignificant impact in case of OECD countries. Moreover, this study also finds that investment volatility doesn't have any impact on economic growth for full sample. However, there is very low level negatively significant impact in case of subsamples.

Chapter 1

Introduction

Impact of government spending and investment spending on long run economic growth has been widely discussed in the economic literature and has been one of the key concerns among economists and policy makers. Three main economic theories regarding the long run relationship between government spending and economic growth are: classical economists' theory; Keynesian theory; and Wagner's law. Similarly, long run growth theories consist of Solow growth model, Harrod Domar and endogenous growth models explain the role of investment in long run growth.

Classical economists' argue that there is no long run relationship between government spending and economic growth (Chipaumire, Ngirande, Method, & Ruswa, 2014). They believe in the power of invisible hand (free markets) to guarantee full employment equilibrium without any government intervention in the economy. Therefore, they argue that there should be very limited role of the government i.e. just to maintain law and order situation and internal security. According to them if the government intervention increases then it will reduce economic growth and hence the government spending will destabilize the economy. Classical economists believe that any increase in government spending while keeping money supply constant will only substitute private spending by government spending (Froyen, 2008). Moreover, according to (Glomm & Ravikumar, 1997; Nurudeen & Usman, 2010), from observations it can be seen that as government spending increases, the share of non-productive spending increases more than proportionally and is accompanied by reduction in economic growth which supports the hypothesis that as the share of government spending increases economic growth decreases.

In contrast to the classical view, Keynesian economists and Wagner's law states that there is a long-run relationship between government spending and economic growth but their views differs on the direction of causality. Keynesian hypothesis states that the causality between economic growth and government spending runs from government spending, not from economic growth. Thus, in the Keynesian hypothesis government spending is considered as an exogenous variable in determining growth (Loizides & Vamvoukas, 2005). The Keynesian school suggests that in stimulating economic growth, government expenditure is the most important instrument available for an economy. In addition, Keynesians hypothesis suggests that every kind of government spending will positively affect economic growth. Therefore they think that government spending is a driving force of economic growth. By increasing public spending or reducing tax, government can increase the speed of economic growth. Therefore, "fiscal policy is used to smooth out short run fluctuations in output and employment" (Zagler & Dürnecker, 2003).

However, Wagner's law, the "law of public finance", states that as "an economy grows public expenditures rises" (Wagner, 1883). In his law, he took public spending as an endogenous variable in determining economic growth. In other words, an increase in public spending is a result of economic growth. In his law, he stated that the causality between public spending and economic growth runs from economic growth, not from public expenditure. So this law suggests that the share of the public sector will rise as the economies grow. This in turn suggests that the demand for the role of government will increases as the countries become richer. Not only the need for regulatory and protective functions will increase but also the demand for public goods such as education and infrastructure will rise when countries become wealthier (Lamartina & Zaghini, 2011).

In addition to these three theories, there is another growth model known as the Solow neo-classical growth model. Solow, (1956) in his growth model argued that the long-run relationship between government spending and economic growth is absent. In addition to that, he also argued that economic growth is the result of population growth, the rate of labour force growth and the rate of technological progress and all of them determined exogenously (Solow, 1956).

Different studies have analysed the role of fiscal policy on economic growth (Gupta, Verhoeven, & Tiongson, 2002; Loizides & Vamvoukas, 2005). These works have tried to analyse the impact of fiscal policy restriction on output, consumption, and growth. In the same way, most of the researchers have also tried to find out the impact of government expenditure on economic growth, and there is a vast consent that government spending increases economic growth while there is very little consent on the impact of government spending volatility on economic growth (Alesina & Bayoumi, 1996; Fatás & Mihov, 2005). In fact, According to theory, restrictions on government spending volatility may have both positive and negative effects on long run economic growth (Canova & Pappa, 2005; Fatás & Mihov, 2005). An important variable for determining sign in the above case is business cycle volatility. Government can smooth out such volatility by use of fiscal policy, however, fiscal policy itself may be a source of macroeconomic volatility (Furceri, 2007). Furthermore, if fiscal policy is better controlled then it will reduce or even eliminate the possibility that fiscal policy is a source of macroeconomic volatility.

Another important component of economic growth is investment, as investment accounts for almost 30% of GDP in developing countries in 2016 (World Bank, World Development Indicators, 2017). The importance of investment for economic growth can be derived from the theories from Harrod Domar model, Solow neo classical growth model and Endogenous growth model. According to Harrod Domar model, countries with low level of investment will grow slowly than

those of high level of investment (Todaro & Smith, 2011). Therefore, capital formation is necessary for the economic growth of a country. They further argue that if countries want to become develop, they must decrease their capital-output ratio and brings up new investments. However, Solow neo-classical growth model also emphasis on investment for economic growth but according to him investment increases economic growth in short run and it will return to its study state level in the long run (Todaro & Smith, 2011). Moreover, increase in investment will increase equilibrium level of the capital-labour ratio as well as output-labour ratio. However, if this is the case, then the rise in equilibrium level of capita per worker and output per person is also a valuable contribution in the development of a country (Todaro & Smith, 2011). In addition to this, endogenous growth model introduces the importance of fiscal policy for economic development. They argue that investment is very important for economic growth but their importance is offset by lower spending in contemporary investment i.e. lower spending in education, infrastructures, etc. They argue that by using fiscal policies, governments can improve the efficiency of resource allocation i.e. by spending in infrastructures and by encouraging private investments in knowledge-based industries to improve the quality of human capital. Some studies also show that the role of investment is even more important for economic growth than government spending (Bakari, 2017; Rabnawaz & Jafar, 2016; Reinhart & Khan, 1989).

Business cycle volatility of investment is another form through which economic growth is affected. It was introduced by Solow in his neo classical growth model. According to him, any sort of new investment is a deviation from the study state level and it will return to its study state level in the long run (Solow, 1956). Some researchers have investigated the impact of investment spending volatility on economic growth and came up with different results and conclusions. Furceri (2010) found that investment volatility harms long-run economic growth and it has even more harmful

for the investment itself. However, Aghion et al. (2010) found that investment volatility hurts economic growth only when they are pro-cyclical.

There is a little consent on the impact of business cycle volatility of investment and government spending on economic growth, so, in this study, in addition to the relative size of investment and government spending, we have also attempted to find out the impact of business cycle volatility of investment and government spending on economic growth for the period 1990 to 2016. Furthermore, in previous studies, most of the focus were on OECD countries and European countries. This study focus on OECD countries as well as on developing countries.

1.1 Objectives

1. To evaluate the impact of government spending volatility on the economic growth of OECD & developing countries.
2. To explore the impact of investment volatility on the economic growth of OECD & developing countries.
3. To analyse the impact of relative size of government spending and investment as a percentage of GDP on the economic growth of OECD & developing countries.

1.2 Significance of the Study

This study is a valuable addition to the existing literature because it covers the gap by estimating the impact of both that is government spending and investment on economic growth at two different measures i.e. the relative size of each variable as a percentage of GDP and as well as the business cycle volatility of both variables. Moreover, this study also makes disaggregated analysis for OECD (Developed) countries and developing countries whereas in the previous literature most of the focus is on OECD and European Union Countries. In

addition to that, system GMM is also used as a technique which is absent in previous related literature and the updated data is also used for estimation.

1.3 Methodology

Empirical analysis has been performed for 82 cross sections in which 55 are developing countries and 27 are OECD countries. This study uses system GMM because it tackles potential endogeneity and reverse causality problem and it also increases efficiency by introducing more instruments and also have less data loss.

1.4 Plan of the study

Chapter 1 is the introductory part. In chapter 2 theoretical as well as an empirical review of literature has been discussed. In chapter 3 research methodology has been discussed, which comprises of model specification, variables description, estimation technique and descriptive statistics of full sample and subsamples. Chapter 4 comprise of model estimations and results while the last Chapter i.e. chapter 5 is the summary and conclusion.

Chapter 2

Literature Review

This chapter reviews the theories and empirical literature on investment and government spending volatilities and economic growth. The literature review, reported here, would help us in conceptualizing the relationship between investment and government spending volatilities and economic growth.

The chapter is organized as follows: section 2.1 discusses linkages between investment and economic growth. Section 2.2 discusses linkages between government spending and economic growth while section 2.3 discusses linkages between fiscal policy, volatility and economic growth.

2.1 Linkages between Investment and Economic Growth

From a theoretical point of view the importance of investment for economic growth can be derived from Harrod Domar model and Solow neo classical growth model. As Harrod Domar growth model emphasise the importance of new investment for economic growth (Todaro & Smith, 2011). According to them, new investment i.e. a net addition to the capital stock, is necessary for economic growth. Therefore, in order for development, a country must bring up new investments. However, Solow neo-classical growth model also stresses on the importance of investment for economic growth but according to him this rise in investment will only raise economic growth temporarily (Solow, 1956).

There is a huge empirical literature available on the linkages between investment and economic growth. However, different researchers concludes different results. As some found positive relation while some found no relationship between them. Opposing the Solow neo classical growth

model, Bakari, (2017) found that domestic investment increases economic growth in the long run. However, it did not affect economic growth in the short run. However, Chow, (1993) argue that there is very weak positive impact of investment on economic growth. On the other hand, Potiowsky & Qayum, (1992) found that domestic investment does not have any impact on economic growth. Efficient utilization of investment also gain some debate as if investment is utilized efficiently then it will increase economic growth, conversely if investment is not utilized efficiently then it will dampen economic growth (Anderson, 1990).

There is also a huge debate on the impact of private vs public investment on economic growth, as in this case there are also different views of different researchers, some found private investment is more important for economic growth while some argue that public investment in more important. Aziri, (2017) argues that public investment is more important for the economic growth of a country. As it works in a way that it redistributes wealth in a country and provide facilities available to each and every citizen of the country which is not possible in case of private investment. On the other hand, Ghani & Din (2006) argue that private investment increases economic growth but there is no evidence found that public investment increases economic growth. However, Reinhart & Khan, (1989) argue Private investment has more direct effect on economic growth than does public investment have on economic growth.

Another issue of debate among researcher is on the direction of the causality between investment and economic growth. As some argue that investment cause economic growth while some argue that economic growth cause investment. However, some also argue that there is a bidirectional causality between them. While according to Blomstrom, Lipsey, & Zejan, (1996) there is very strong evidence that economic growth increases investment than that of investment increases economic growth (Blomstrom et al., 1996). While Rabnawaz & Jafar, (2016) found that economic

growth increases investment in short run. In addition to that, there is a strong evidence that there is a bidirectional causality between them in case of long run.

2.2 Linkages between Government Spending and Economic Growth

There are three competing theories which discusses the linkages between government spending and economic growth. These are (i) Keynesian hypothesis, which advocates government spending for economic growth, (ii) Classical Economists argue that government intervention will reduce economic growth, (iii) Wagner's Law states that the causation between government spending and economic growth is from economic growth and not from government spending. These theories are discussed below in detail:

2.2.1 Keynesian Hypothesis

According to the Keynesian hypothesis, economic growth is an outcome of an increase in public spending. Huang, (2006) argued that public spending is used as a tool to stabilize short-run fluctuations in aggregate expenditure as well as it is used to boost up economic growth. This view strengthens the previous empirical findings of (Chimobi, 2009; Rabnawaz & Jafar, 2016) who also found same results. The Keynesian school economists advocated active intervention of government through an increase in government spending to stimulate the demand when there is lack of demand and to increase the employment level. This shows the importance of aggregate demand in the Keynesian hypothesis. Keynes (1936) argued that markets don't have the capacity to adjust full employment, therefore there is a need of government to intervene for the achievement of full employment.

Keynesian economists argue that markets do not have the capacity to sell all their inventories because of price and wage rigidity (Chipaumire, Ngirande, Method, & Ruswa, 2014). Therefore, when demand is low, government should increase its spending to inject new purchasing power in

an economy to stimulate the aggregate demand which in turn will increase output and employment level more than what is injected in the economy through the multiplier effect. Therefore, they argue that there is a long-run relationship between government expenditure and economic growth of a country. Moreover, they also argue that government expenditure increases national output.

2.2.2 Classical Economist's Hypothesis

Classical economists' view differ from Keynesian economists about the impact of government spending on growth. As classical economists argue that government spending has a destabilizing effects on the economy. According to them any government intervention in the economy will hurt the economic growth of that economy. Classical economists argue that free markets have a power to attain full employment equilibrium in an economy.

Classical economists state that governments should have minimum intervention in an economy because if their intervention increases then it will reduce growth and output. They argue that government should perform limited duties just to ensure the maintenance of a society i.e. ensuring internal security and maintenance of the rule of law (Chipaumire, Ngirande, Method, & Ruswa, 2014),

They argue that any increase in government expenditure, keeping money supply constant, will not affect employment level or output. According to them by keeping money supply constant, any increase in government expenditure will contest with the private investment in the money market which will increase interest rate. Thus borrowing costs will become higher for private firms and they will give up production. Therefore, the ultimate results of increase in government expenditure will just be the substitution from private investment to public investment.

Landau, (1983) found that there is a negative impact of government spending on economic growth. However, there is some threshold level of each country, till that point government spending increases economic growth and after that point it decreases economic growth (Iyidogan & Turan, 2017).

2.2.3 Wagner's Law

Wagner (1893) when evaluated historical process found that public expenditure increases continuously with the increase in economic growth. Therefore, he argues that circumstances of an economy changes with its growth, which increase responsibilities of the government and thus, increases the share of public spending in an economy. Further, it is argued that with the increase in development, the demand for public expenditure rises i.e. demand for state-owned health and infrastructures facilities increases. In order to meet these demands of public goods and services, the government should increase its expenditure. Besides these, due to economic growth, governments also undertake new tasks that does not exists before.

Musgrave (1988) argue that the share of public expenditure increases when nations become industrialized. Industrialization caused by economic growth increase the administrative and regulatory duties of the state which cause an increase in government expenditure. Cooray, (2009) argues that with the increase in technology, which is an outcome of growth, creates the production of new goods and services which requires public provision because they are highly expensive therefore they need government expenditure.

2.3 Linkages between Fiscal policy, Volatility and Economic Growth

Concept of business cycle volatilities generated from Solow neo classical growth model as he argues that business cycles are the deviation from the study state level (Solow, 1956). He argued

that a lower level or higher level of new capital formation than the study state level will return to its study state level. According to this theory if we increase saving it will increase capital and in return the rate of output growth will increase temporarily. The key implication of this theory is that the increase in investment increases equilibrium level of capital-labour ratio but not long-run growth. According to neo-classical business cycle models, uncertainty leads to economic fluctuations which have a negative impact on economic growth. As these fluctuations lead the consumption to deviate from a smooth path which have negative consequences for the risk-averse economies (Fatás & Mihov, 2009; Loayza et al, 2007). Business cycle volatility of government spending is another variable which affect economic growth. According to Afonso & Furceri, (2010) Economic growth is mostly affected by volatilities in government spending, as the more volatile the government spending will be, the more it will reduce economic growth. This finding is robust to different detrending methods But not robust in case of different samples (Afonso & Furceri, 2010). However, Furceri, (2007) found that Volatile government spending, investment, exchange rate and inflation dampens economic growth but among them investment volatility is a major source which reduces economic growth (Furceri, 2007). In an another study (Furceri, 2007) found that government spending volatility doesn't affect economic growth in case of developed countries. However there is a negative association between the two in case of developing countries. There is also evidence that higher volatility in the liberalization of economic freedom will reduce economic growth. Nevertheless, some studies also shows that the higher the size of the government the lower will be the volatility in the economic growth (Pitlik, 2002; Furceri & Ribeiro, 2008). Moreover, if government spending is divided into current and capital expenditure, even then their volatility will reduce economic growth (Gong & Zou, 2002). Huang, (2006) argue that Fiscal policy is a very effective tool in stabilizing short run fluctuation which reduces the risk of decrease

in economic growth. Furthermore, If fiscal policy is better controlled then there is a huge possibility that it will increase economic growth in the long run (Afonso & Furceri, 2010). However, the volatilities in fiscal policy and monetary policy are harmful for economic growth of a country (Brunetti, 1998). Moreover (Ali, 2005) found that the effect of fiscal policy on economic growth is inconclusive. However, he also finds that there exists a negative impact of fiscal policy volatility on economic growth.

Conclusion

If we conclude the above discussion we can say that a lot of work have been performed on impact of government spending on economic growth but still there is very little consent on the results among researchers, as some shows negative relationship while some shows positive relationship among them. There is also a huge differences among finding of the researchers regarding the impact of investment on economic growth. Moreover, there is very little work done on the relationship between their volatility and economic growth, yet their findings doesn't match with each other.

Chapter 3

Data and Methodology

3.1 Model Specification

Most of the researchers have found a bidirectional causality between government spending and economic growth, therefore we need to add several control variables to get clearer impact of government spending on growth (Easterly & Rebelo, 1993; Plosser, 1992). Therefore, it is required to know which control variable to include in such growth regression to eliminate this relationship. Sala-I-Martin, (1997) has run two million regressions and found that 60 variables are significant in one growth regression. While Levine; & Renelt, (1992) in a more robust regression, applying the Extreme Bound Analysis firstly proposed by (Leamer, 1983), have found four variables to be significant in a growth regression i.e. (i) the average investment share of GDP; (ii) the initial log of GDP per capita; (iii) initial human capital; and (iv) the average growth rate of the population (Levine; & Renelt, 1992).

Openness is also found to be significant in most of the studies of growth (Rodrik, 1998). On one hand, more open economies are more exposed to shocks while on the other hand they are less hurt by shocks in a sense that they absorb shocks by risk sharing in an integrated financial market.

In most of the studies, output volatility has found to affect growth negatively while it has also a correlation with government spending volatility (Fatás & Mihov, 2005; Ramey & Ramey, 1995). Therefore, we need to control for output volatility to get a clearer impact of government expenditure volatility on economic growth.

Therefore, this study have included several other control variables in addition to those which are suggested by Levine & Renelt, (1992). Thus, in this paper the control variables are; (i) the initial log of GDP per capita; (ii) initial human capital; and (iii) the growth rate of the population; (iv) openness (v) output volatility.

One of the most important issues in a cross-country growth regression to be discussed is the period of estimation. In most literature of growth models, large time spans are used and the average value of that period is taken to be the growth determinant which raises several problems such as the problem of endogeneity and problem of significance (Afonso & Furceri, 2010). For instance, fiscal policies over long periods are mostly influenced by demographics, like government spending is most likely to be affected by the share of elderly people. Therefore, in a growth regression, such type of errors will affect GDP, demographics, and government spending. Therefore, the independent variables government expenditure as a share of GDP will be correlated with the error term means that there will be a problem of endogeneity in the regression.

A second most important issue of concern, here, is that in a growth regression, the use of long time periods eliminates the information on within-country variation in terms of production and as well as in terms of growth (Afonso & Furceri, 2010). In addition to that, we also include time dummy for the fact that in 2007 and 2008 almost all of the countries experienced the financial crisis which also affects their fiscal policies.

For all those reasons mentioned above, this study will estimate panel data from 1990 to 2016. The equation is given below:

$$G_{i,t} = \beta_1 + \beta_2 E_{i,t} + \beta_3 \sigma E_{i,t} + \beta_4 I_{i,t} + \beta_5 \sigma I_{i,t} + \beta_6 X_{i;t} + \beta_7 T_t + \xi_{i,t}$$

where the index i denotes the country, the index t (t=1990–2016) indicates time period, G is the growth rate of GDP, E is general government expenditure as a share of GDP, σE is the vector of government expenditure volatility, I is the set of total investment as a share of GDP, σI is the vector of volatility in investment. X includes a set of control variables, and T is the time dummy.

3.2 Construction of Variables

We have constructed two types of variables: the first is the relative size of government spending and investment variables as a percentage of GDP and the second is the respective volatility of theses variables i.e. (i) Investment Volatility, (ii) Government Spending Volatility.

To find out business cycle volatility, this study have found cyclical component through Hodrick-Prescott filter in which λ is equal to 6.25 as suggested by (Afonso & Furceri, 2010; Furceri, 2007; Ravn & Uhlig, 2002) because it produces the smoothest series among all the four detrending methods. After getting cyclical component, this study used standard deviation to get business cycle volatility.

3.3 Data

This study estimates three different groups of countries. First, it estimates overall data in which the number of cross sections are 82, and then it is divided on the basis of subsets i.e. OECD countries in which number of cross sections are 27 and developing countries in which number of cross sections are 55. The data period of this study is from 1990 to 2016 and the variables we used are GDP growth, Government Spending, Government Spending volatility, Investment, Investment Volatility, Openness, Output Volatility, Population Growth and Initial Human Capital all of these are taken from World Development Indicators except Initial Human Capital which is taken from Penn World Table.

3.4 Panel Data Framework

This study uses panel data framework over time series and cross-section techniques because of several reasons. (i) Since panel data relate to cross sections over time, so there can be a potential heterogeneity in these units. The panel data estimation took these heterogeneities explicitly into account as it allows for cross section specific variables. (ii) Panel data give more information because it combines time series and cross-section observations and by doing so it has more degrees of freedom, more efficiency, more variability and less collinearity among variables. (iii) With panel data analysis the dynamics of change can be better estimated as it took each cross-section repeatedly into account. (iv) Panel data enables us to understand the behaviour of more complicated models in a better way. (v) In panel data, there are fewer chances of biasedness because it took a large number of observations. By summarizing the above discussion, we can say that "panel data can enrich analysis in such a way that might not be possible in cross sectional or time series data" (Gujarati, 2003). Due to all these reasons, this study uses panel data estimation technique.

3.5 Description of Variables

Sr.#	Variable name	Description
1	GDP growth	GDP growth annual
2	Government spending	Total government expenditure as a percentage of GDP
3	Initial output	GDP per capita at the beginning of time period
4	Initial Human capital	Average schooling years in the total population over age 25 at the beginning time period
5	Openness	Exports plus Imports divided by GDP

6	Investment share of GDP	Gross capital formation % of GDP
7	Output volatility	Standard deviation of output cyclical component
8	Population growth	The average growth rate of population of each time period
9	Government spending volatility	The SD of the cyclical component of the Government Expenditure
10	Investment volatility	The SD of the cyclical component of Gross Capital formation % of GDP

3.6 Estimation Technique

First of all, we have checked the stationarity of data. For this, we have used Philips Pearson and ADF test. Both give the same result that is all variables are stationary at level on trend and intercept so we cannot estimate panel cointegration rather we will move to simple panel data estimation which are Pooled OLS, Fixed Effect Model and Random Effect Model.

As we know that we cannot use panel co-integration, so, we have three other methods of estimation when estimating panel data i.e. (i) Pooled OLS, is used when a model is estimated as one grand model. And none of the assumptions of OLS is violated. (ii) Fixed Effect Model: in this estimation all data are pooled but each cross-section has its own intercept, it is done by placing dummy at each cross sectional unit and each of them is different and time invariant. If there is endogeneity in the data, then this model cannot be used. (iii) Random Effect Model: in this model cross-section specific characters are assumed to be part of a random term. The decision between FEM and REM is based on Hausman test.

Table 3.1 Unit Root Test for Stationarity

Variable	Level	Conclusion
Government spending	-3.02055	I(0)
Government spending volatility	-9.52038	I(0)
Investment	-4.53300	I(0)
Investment volatility	-4.84637	I(0)
Openness	-3.23158	I(0)
Output volatility	-5.31905	I(0)
Population growth	-22.6155	I(0)

More importantly, this study does not use any of them because of the problem of endogeneity, as the previous studies and theories suggest that there is a possibility of problem endogeneity and reverse causality. As Keynesian theory suggests that government spending affect economic growth while Wagner's law argued that economic growth affects government spending.

We have checked for the possibility of endogeneity using WU-Hausman test. The result of which showed that a problem of endogeneity exists in the data. . Therefore we cannot use any of the above-mentioned techniques. There are two possible techniques for estimation when data have endogeneity, these are: two stage least squares (2SLS) and Generalized Method of Moments (GMM). Between these two this study have decided on the basis of heterogeneity. As there is heterogeneity in the data and it is a better technique, so, this study have used Generalised Method of Moments.

GMM is a prominent econometric technique. It is a dynamic panel data estimation technique which deals with potential endogeneity, reverse causality, omitted variable bias and unobserved panel

heterogeneity. The most important advantage of this technique over other techniques is, it can be estimated in case of heterogeneous data and produces consistent and efficient estimates even in case of heteroskedasticity.

For dynamic panel data modelling, GMM have two methods of estimation, first proposed by Arellano and Bond (1991) which is called difference GMM while the second was proposed by Arellano and Bover (1996) and then later by Bundell and Bond (1999) which is called system GMM.

In order to avoid endogeneity, this study prefers to use system GMM as it deals with potential endogeneity, reverse causality, autocorrelation and also deals with non-stationary data. It also has one more advantage over difference GMM as it uses orthogonal deviation in which it subtracts the average of all future available observations of a variable, therefore it minimizes data loss while in difference GMM the previous observation is subtracted from the contemporaneous one and if there are data gaps then there will be a data loss. This study has also used robust standard errors to control heteroscedasticity and auto-correlation.

3.7 Descriptive statistics

3.6.1 Full Sample

In table 3.2 the descriptive summary of full sample is shown. The largest mean value among the variables is of investment which is 22.8%, followed by output volatility i.e. (21%) and the lowest mean value is of government spending volatility which is 0.6%, followed by openness (0.7%). In case of standard deviation, the largest is investment i.e. 6.9%, followed by government spending i.e. (5.2%) and the least among standard deviation is of openness (0.4%) which is followed by government spending volatility i.e. (0.8%).

Table 3.2 Descriptive Summary Of The Variables For Full Sample

Variables	No. of obs	Mean	Median	Maximum	Minimum	Std. dev
GDP Growth	2212	3.475700	3.659876	35.22408	-50.24807	4.088643
Government Spending	2214	15.61464	15.50900	43.47921	2.047121	5.252473
Investment	2213	22.83491	22.30079	61.46868	0.292870	6.912617
Government Spending Volatility	2132	0.625573	0.374036	7.797246	0.004593	0.808548
Investment Spending Volatility	2131	1.505027	0.983698	17.91930	0.017746	1.742581
Output Volatility	2132	21.62886	21.65182	27.01408	15.07801	2.319488
Openness	2214	0.743160	0.638033	4.101716	0.110875	0.423510
Population Growth	2213	1.574744	1.518096	7.917892	-6.184857	1.154624

Source: Author's own Calculations

Note: All data is in percentage form. Total number of cross sections are 82 while the data ranges from 1990-2016

3.6.2 Sub Samples

Table 3.3 shows the descriptive stats of OECD countries while table 3.4 shows the descriptive stats of developing countries. The highest mean value in table 3.3 is output volatility (23.7%), followed by investment (23.2%) and Government spending (19.2%). While the lowest average value is of Government spending volatility (0.3%) followed by the average value of population growth (0.70%), openness (0.79%), and by investment volatility (0.8%) while the average value of GDP Growth is 2.5%. Turning to the discussion of the results of the last column, the highest standard deviation is of investment (4.1%), followed by government spending (3.7%), which is followed

by GDP growth (2.9%). While the lowest value of standard deviation is of government spending volatility (0.27%), followed by openness (0.53%), which is then followed by investment volatility (0.65%) and population growth (0.65%). While the standard deviation value of output volatility is 1.35%.

Table 3.3 Descriptive Summary Of OECD Countries

Variables	No. of Obs	Mean	Median	Maximum	Minimum	Std. dev
GDP Growth	727	2.467962	2.506140	25.55727	-11.61494	2.920455
Government spending	729	19.18390	19.16953	27.93502	10.40007	3.753769
Investment	729	23.20533	22.78289	41.37406	9.818878	4.103884
Government spending volatility	702	0.319670	0.239512	2.024247	0.004593	0.270961
Investment volatility	702	0.796116	0.642199	5.640985	0.023310	0.656974
Output volatility	702	23.70736	23.66209	27.01408	19.06074	1.358332
Openness	729	0.794278	0.657368	4.101716	0.160139	0.530604
Population growth	728	0.703841	0.560384	6.017009	-1.853715	0.657998

Source: Author's own Calculations

Note: All data is in percentage form. Total number of cross sections are 27 while the data ranges from 1990-2016

From table 3.4, the highest average value is of investment (22.6%), followed by output volatility (20.5%), which is then followed by government spending (13.9). while the lowest average value is of openness (0.72%), followed by government spending volatility (0.78%), which is then followed by investment volatility (1.8%). While GDP growth and population growth have a mean

value of 3.9% and 2% respectively. Turning to the column of standard deviation, the highest value of standard deviation is of investment (8%), followed by Government spending (5%), which is then followed by GDP growth (4.5%). While the lowest value of standard deviation is of openness (0.35%), followed by government spending volatility (0.93%). While the standard deviation value of investment volatility, output volatility and population growth is 2%, 1.95%, and 1.11% respectively.

Table 3.4 Descriptive Summary Of Developing Countries

Variables	No. of obs	Mean	Median	Maximum	Minimum	Std. dev.
GDP Growth	1458	3.991253	4.349824	35.22408	-50.24807	4.491191
Government Spending	1458	13.92837	13.43515	43.47921	2.047121	5.008629
Investment	1458	22.63505	21.75193	61.46868	-2.424358	8.027404
Government Spending Volatility	1404	0.785588	0.490417	7.797246	0.015059	0.938416
Investment Volatility	1404	1.878648	1.314291	17.91930	0.017746	2.000375
Output Volatility	1404	20.55111	20.39743	26.29055	15.07801	1.952313
Openness	1458	0.721589	0.635840	2.204074	0.110875	0.358975
Population Growth	1458	2.009870	2.115907	7.917892	-6.184857	1.112847

Source: Author's Own Calculation

Note: All Values Are In Percentage Form. Total Number Of Cross Sections Are 55 While The Time Period Is From 1990-2016

Conclusion

After explaining methodology section in detail and discussing the econometric techniques, we may conclude that in this study, we should use system GMM because it corrects potential endogeneity and reverse causality and it also increases the efficiency by introducing more instruments and also have less data loss.

Chapter 4

Model Estimation and Results

After explaining the methodology briefly in the previous section and selecting the best suitable estimation technique, we now estimate the impact of investment and government spending volatility on economic growth using GMM technique. The first section i.e. 4.1 of this chapter deal with the aggregated analysis while the second section of this chapter i.e. 4.2 deals with disaggregated analysis.

4.1 Aggregated analysis

For estimating the impact of investment and government spending volatility on economic growth through GMM, first of all, we have tested the validity of instruments using the Hansen J test of over-identifying restrictions. The null hypothesis of the Hansen test is that instruments are invalid while the alternative hypothesis is that the instruments are exogenous or instruments are valid. By running the Hansen J test we found a high probability value i.e. 30.6%, which means that null hypothesis is rejected while alternative in accepted which says that all the instruments which we are using as a group are exogenous or valid.

Considering aggregated data, we found that all variables are significant except business cycle volatility of investment. From table 4.1, the lag of GDP growth has a positive and significant effect on economic growth. The coefficient of government spending as a share of GDP shows a negative and significant effect on economic growth at 1% significance level. This finding is consistent with the studies of (Afonso & Furceri, 2010; Hasnul, 2016; Landau, 2006). The Coefficient of government spending is -0.03 which means that if government spending increased by 1% then

economic growth will be decreased by 0.03%. There are many reasons behind this negative effect. For instance, it reduces private spending's which are usually more productive and less costly. Another reason of this relation may be due to a government spends mostly on defence which usually has a negative impact on economic development. Government spending volatility has also a negative effect on economic growth and is significant at 1% significance level. This result is similar with the results of (Afonso & Furceri, 2010; Furceri, 2007, 2010) who also found a negatively significant impact of government spending volatility on economic growth. The Coefficient value of government spending volatility is -0.44 which means that if government spending volatility increased by 1% then economic growth will be decreased by 0.44%. Investment as a percentage of GDP shows a positive impact on economic growth at 1% significance level. This result is similar to the findings of (Afonso & Furceri, 2010; Aziri, 2017; Sánchez-juárez & García-almada, 2016). The Coefficient value of investment is 0.07 which means that if investment increased by 1% then economic growth will be increased by 0.07%. The coefficient of business cycle volatility of investment shows a negative but insignificant effect on economic growth. Analyzing a set of control variables we have found that output volatility has a negative and significant effect on economic growth. This finding is in line with (Furceri, 2010). Trade openness has a positive and significant impact on the economic growth of a country. This relation is significant at 1% significance level, this result is same as of (Afonso & Furceri, 2010). The coefficient of population growth shows a positive impact on economic growth at 1% significance level. This finding is similar to the findings of (hart & Khan, 2009). The possible explanation of this is that with the increase in population labour force increases and in turn increases growth.

Table 4.1: Effect Of Volatilities And Other Factors On Economic Growth (Full Sample): Dependent Variable Is GDP Growth

Variables	Pooled data	Fixed effect model	Random Effect Model	GMM
Growth(-1)	-	-	-	0.086147*** (0.002274)
Government spending	-0.096838*** (0.019726)	-0.082442 (0.057410)	-0.103692*** (0.031665)	-0.031704*** (0.008119)
Government spending volatility	-0.707085*** (0.164910)	-0.629312*** (0.183712)	-0.719701*** (0.183574)	-0.444773*** (0.038791)
Investment	0.127808*** (0.016691)	0.129094*** (0.021145)	0.132734*** (0.019832)	0.074170*** (0.007925)
Investment volatility	-0.128241 (0.092505)	-0.038448 (0.095913)	-0.124037 (0.100188)	-0.005685 (0.024776)
Output Volatility	-0.138446*** (0.054398)	-0.606239*** (0.098616)	-0.236259*** (0.060992)	-0.563759*** (0.027164)
Openness	0.239734 (0.214517)	-0.282622 (0.798289)	0.362961 (0.314031)	0.926524*** (0.215554)
Initial GDP	-0.000237** (9.52E-05)	-	-0.000248 (0.000153)	-
Initial Human capital	-1.82E-05 (1.32E-05)	-	-1.99E-05 (2.10E-05)	-
Population Growth	0.968429*** (0.195283)	1.207742** (0.551785)	1.001385*** (0.303577)	1.003107*** (0.043256)
Time Dummy	-	-	-	0.745754** (0.290302)
Constant	1.461572** (0.697141)	0.751920 (1.301698)	1.342043 (0.993676)	-
R-Square	0.168155	0.302165	0.123303	-
Adjusted R-Square	0.164623	0.263050	0.119582	-
Hansen J-Probability	-	-	-	30.6%

Dependent variable: GDP growth
Robust standard errors are in parenthesis.
the HP6.25 filter is used to decompose government spending and investment
*****,** and * are used to shown 1%, 5% and 10% level of significance respectively.**
Hensen test is preferred over sargan test in case of robust measurement.

4.2 Disaggregated analysis

After discussing the results of the aggregated data, we now move to the discussion of disaggregated data. The reason behind making these sub-samples is that the full sample might be biased due to high diversity in the panel data as we have developing countries as well as OECD countries. Moreover, from the table 4.2, if we compare the business cycle volatilities of the two subsample we can easily note that the business cycle volatility of government spending and investment of OECD countries are more stable those of developing countries. While it can also be noted from the table given below that average volatility in investment is higher than the average volatility of government spending.

Table 4.2: Average Volatilities of investment and government spending

Variables	Countries Sample		
	Developing Data	OECD Data	Overall Data
Government Spending Volatility	0.794018	0.323155	0.633236
Investment Volatility	1.900858	0.801628	1.523217

Figure 4.1: Investment Volatility Of Developing Countries

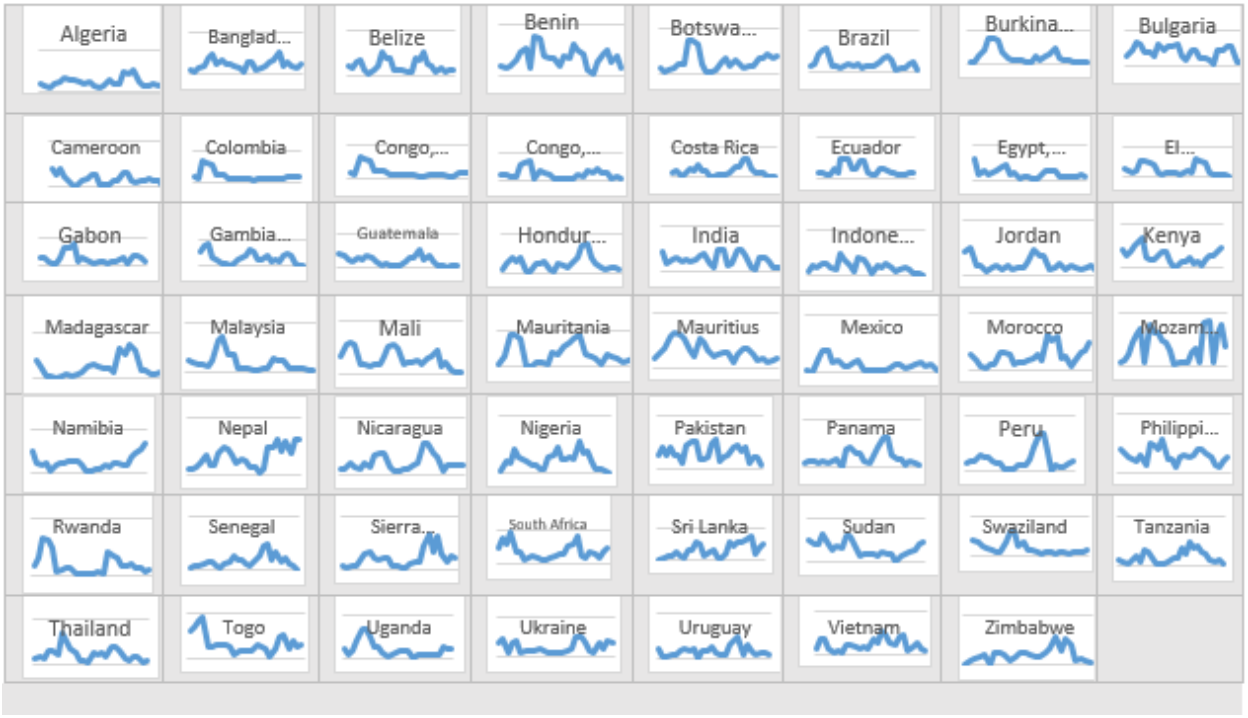


Figure 4.2 Investment volatility of OECD Countries

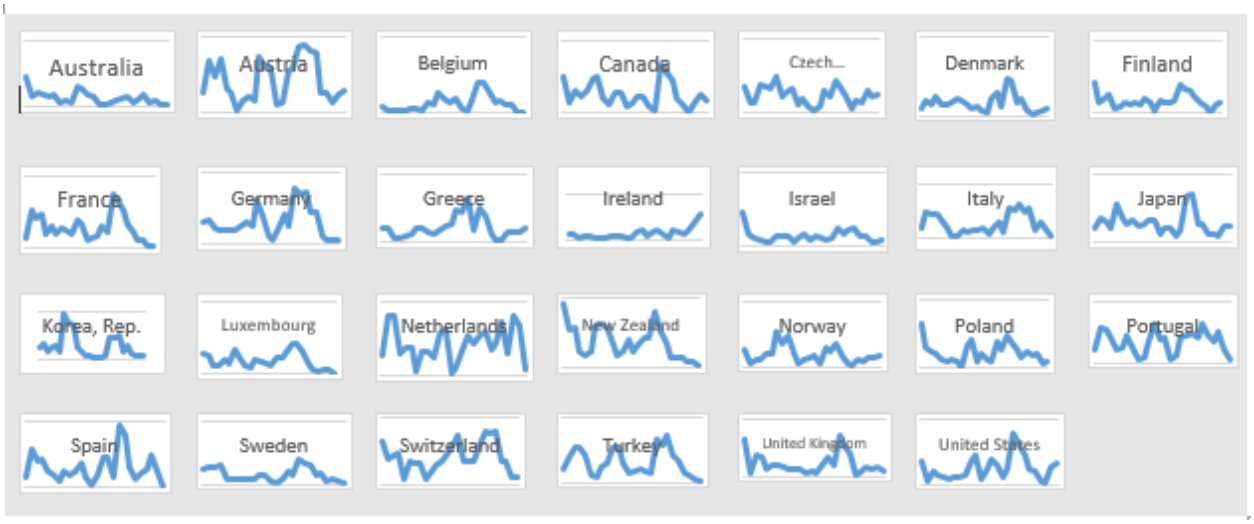


Figure 4.3 Government Spending Volatility Of Developing Countries

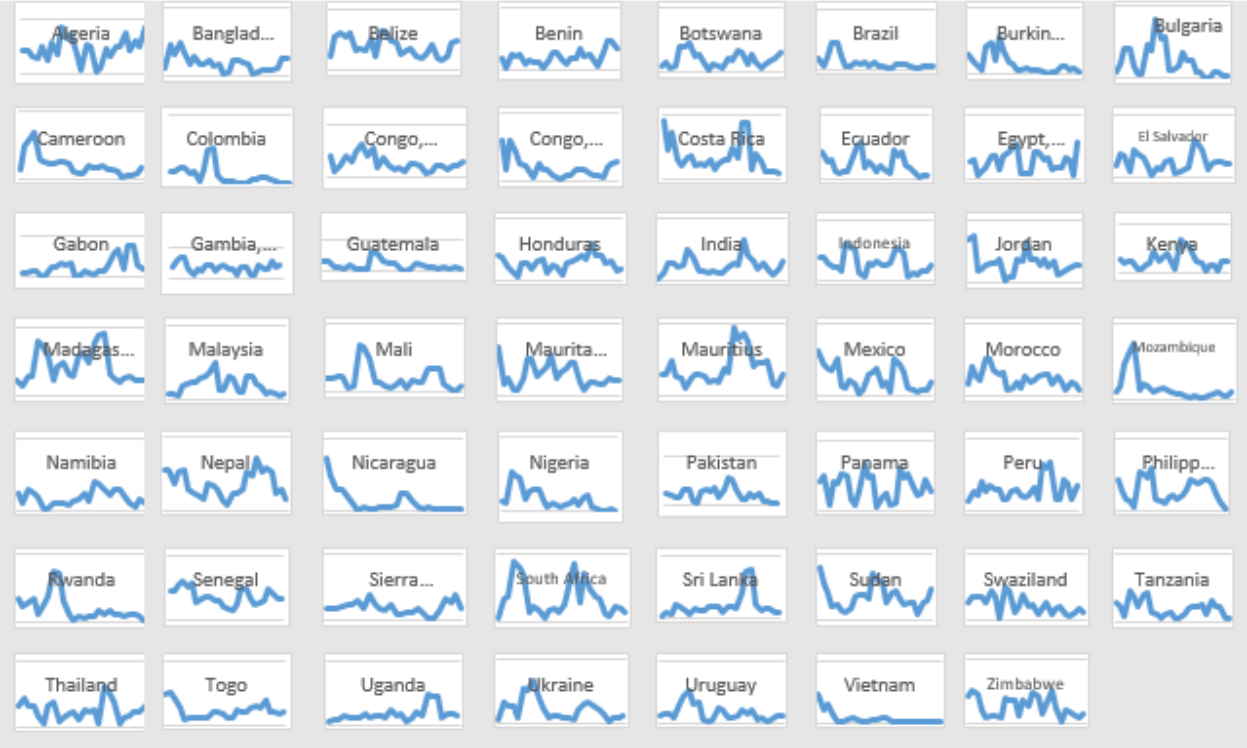
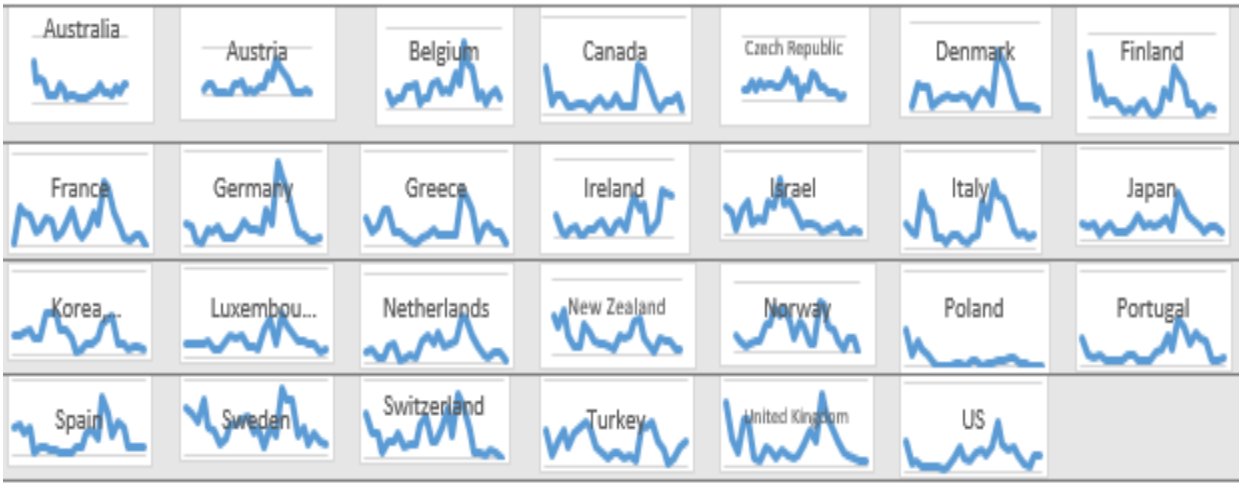


Figure 4.4 Government Spending Volatility Of OECD Countries



4.2.1 Developing countries

From table 4.3: Performing the same test for testing endogeneity in the sample of developing countries, we found that there is endogeneity in the developing countries data as well, so we estimate our results through the GMM. For the validity of instruments this study calculates Hensen J's test, the probability of which is 28.9% more than 5% means insignificant. This insignificance means that all the instruments as a whole are exogenous. The lag of GDP growth has a positively significant impact on growth. Just like full sample, government spending as a share of GDP in developing countries has negatively significant impact on economic growth. The Coefficient value of government spending is -0.08 which means that if government spending increased by 1% then economic growth will be decreased by 0.08%. The case of government spending volatility in developing countries is the same as it was in the overall sample i.e. government spending volatility has a negative and significant impact on economic growth at 1% level of significance. The Coefficient value of government spending volatility is -0.40 which means that if government spending volatility increased by 1% then economic growth will be decreased by 0.40%. Investment as a share of GDP has a positively significant effect on economic growth at 1% significance level. The value of Coefficient of investment is 0.12 which means that if investment is increased by 1% then economic growth will be decreased by 0.12%. The coefficient of investment volatility have a negative impact on growth and this relationship is statistically significant at 10% levels of significance. This finding is same as of (Furceri, 2010) who also find a negative impact of investment volatility on economic growth. The Coefficient value of Investment volatility is -0.11 which means that if investment volatility increased by 1% then economic growth will be decreased by 0.11%. Openness has positively significant effect on

economic growth. Output volatility has a negatively significant impact on economic growth at 1% level of significance. And Population growth has a positively significant effect on economic growth at 1% level of significance.

Table 4.3 Effect of Volatilities And Other Factors On Economic Growth (Developing Countries): Dependent Variable Is GDP Growth

Variables	Pooled data	Fixed effect model	Random Effect Model	GMM
Growth(-1)	-	-	-	0.010313** (0.004740)
Government spending	-0.044280* (0.026034)	-0.026723 (0.061069)	-0.048939 (0.035541)	-0.076546** (0.035189)
Government spending volatility	-0.704206*** (0.164764)	-0.542714*** (0.187962)	-0.706023*** (0.180570)	-0.399775*** (0.093583)
Investment	0.124298*** (0.019692)	0.102154*** (0.027780)	0.120794*** (0.023258)	0.119841*** (0.021981)
Investment volatility	-0.158059* (0.091778)	0.000451 (0.098954)	-0.122252 (0.098369)	-0.111109* (0.062382)
Openness	0.277944 (0.405340)	-0.576734 (1.249128)	0.439375 (0.585059)	1.557797*** (0.486716)
Output Volatility	-0.038945 (0.079068)	-0.499954 (0.146840)	-0.093733 (0.081281)	-0.534846*** (0.129576)
Population Growth	0.901566*** (0.343882)	1.455087** (0.645683)	1.035335** (0.462192)	1.330031*** (0.085962)
Initial GDP	-0.000243** (0.000121)	-	-0.000228 (0.000177)	-
Initial Human capital	0.036953 (0.670672)	-	0.168911 (0.952458)	-
Time Dummy	-	-	-	0.887786 (0.903012)
Constant	0.893266 (1.868414)	0.080897 (1.610183)	0.365724 (0.578524)	-
R-Square	0.126439	0.261974	0.124488	-
Adjusted R-Square	0.120799	0.214378	0.095602	-
Hansen J-Probability	-	-	-	28.9%

Dependent variable: GDP growth
Robust standard errors are in parenthesis.
the HP6.25 filter is used to detrend government spending and investment
*****,** and * are used to shown 1%, 5% and 10% level of significance respectively.**

4.2.2 OECD Countries

We have selected OCED Countries because they have the most accurate data. From table 4.4: For instruments validity we have applied the same test i.e. Hansen J's test, the result of which is quite high i.e. 20.8%, means that all the instruments are valid as a whole. The lag value of growth has an insignificant effect on economic growth. The coefficient of government spending shows a negatively significant impact on economic growth at 10% significance level, This result is same as of (Afonso & Furceri, 2010; Furceri, 2007, 2010) who also found a negatively significant effect of government spending on economic growth. The coefficient of government spending volatility on economic growth shows a negative impact on economic growth but this relation is statically insignificant at all levels of significance. This relationship is similar to (Afonso & Furceri, 2010) who also found same results when they did estimation for OECD countries. The coefficient of investment shows a positively significant impact on economic growth at 5% significance level. This result is consistent with the result of (Bakari, 2017; Fedderke, Perkins, Luiz, 2006). The impact of investment volatility on economic growth shows a negative impact on economic growth and is statistically significant at 10% significance level. This result is consistent with the results of Furceri, (2010) who also found a negatively significant impact of investment volatility on economic growth. In control variables, the coefficient of openness has a positive but insignificant impact on economic growth. Output volatility has negatively significant effect on economic growth at 1% significant level. This result is in line with the studies of (Furceri, 2007; Onyimadu, 2017). The coefficient of population growth has negatively significant impact on economic growth at 10% significance level.

Table 4.4: Effect Of Volatilities And Other Factors On Economic Growth (OECD Countries) Dependent Variable Is GDP Growth

Variables	Pooled data	Fixed effect model	Random Effect Model	GMM
Growth (-1)	-	-	-	-0.133493 (0.109452)
Government spending	-0.100596 (0.027516)	-0.418498*** (0.130875)	-0.174135*** (0.050611)	-0.513663* (0.286277)
Government spending volatility	-1.830433 (0.506570)	-0.898203 (0.694497)	-1.856216*** (0.514779)	0.248971 (2.180208)
Investment	0.167625 (0.023349)	0.287296*** (0.061447)	0.241523*** (0.035523)	0.609722** (0.264749)
Investment volatility	-0.179283 (0.319585)	-0.140684 (0.333032)	-0.315785 (0.319115)	-0.783958* (0.415962)
Openness	0.736703 (0.266085)	2.004632*** (0.715329)	0.887007** (0.392012)	1.575046 (1.693801)
Output Volatility	-0.485446 (0.113440)	-0.786662 (0.170887)	-0.529581*** (0.116992)	-0.81138*** (0.253187)
Population Growth	0.625577 (0.160862)	-0.324185 (0.403073)	0.207283 (0.227769)	-2.149630* (1.193939)
Initial GDP	-4.52E-05 (1.49E-05)	-	-3.86E-05* (2.20E-05)	-
Initial Human capital	0.436110 (0.264623)	-	0.614493 (0.464283)	-
-Time Dummy	-	-	-	2.391086 (6.273774)
Constant	-	2.809241 (2.692753)	-0.624806 (1.690747)	-
R-Square	0.241382	0.577616	0.236701	-
Adjusted R-Square	0.232930	0.540253	0.227120	-
Hansen J-Probability	-	-	-	20.8%

Dependent variable: GDP growth
Robust standard errors are in parenthesis.
the HP6.25 filter is used to decompose government spending and investment
*****,** and * are used to shown 1%, 5% and 10% level of significance respectively.**

Chapter 5

Summary and Conclusion

The core objective of this study was to analyze the impact of business cycle volatility of investment and government spending on economic growth. First we estimate overall sample and then we divide this sample into subsamples of developing and OECD countries. The data we used is from 1990-2016 and the number of cross-sections are 82 in overall sample while the number of cross-section in developing and OECD countries are 55 and 27 respectively. As there was endogeneity in the data, therefore this study uses GMM technique for estimation.

The estimation results showed that government spending volatility has a negative impact on economic growth. Furthermore, from sub-samples, we also found that this relation is only true for developing economies but it becomes insignificant when estimated for OECD countries.

In the case of investment volatility, we found that there is an insignificant impact of investment volatility on economic growth. However, we also found that investment volatility has a negative impact on economic growth when estimated for subsamples, but this impact is very small because of very low level of significance.

The intuition behind these finding is that developing countries have worse taxation system whereas developed economies have powerful domestic stabilizers and a better taxation system which absorbs most of the volatilities in government spending. Furthermore, the fiscal policy of developing countries are mostly pro-cyclical and economic uncertainty is very high in developing countries. Moreover, we can also note that government spending of OECD countries are less volatile than that of developing countries. Therefore, compared to developing countries, developed

(OECD) countries are less hurt by volatilities in government expenditure. However, there is very little evidence found on the impact of investment volatility on economic growth.

5.1 Policy Recommendation

Governments should implement counter-cyclical fiscal policies instead of pro-cyclical fiscal policies (especially developing economies). Second and most important, they should build strong automatic stabilizers (which absorb most of the volatilities of the business cycles). Automatic stabilizers are more important because there is no time lag in their implementation.

5.2 The Way Forward

There are various ways and aspects in which this research can be extended. Some of them are mentioned below:

1. This research can be extended by doing an estimation based on different sub-groups of developing countries having the same characteristics.
2. It can also be extended by dividing government spending into its composition and then finding its volatility.

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Appendix A

List of Developing Countries

ALGERIA	CONGOR	INDIA	MOROCCO	RWANDA	UGANDA
BANGLADESH	CONGOD	INDONESIA	MOZAMBIQUE	SENEGAL	UKRAINE
BELIZE	COSTRICA	JORDAN	NAMIBIA	SIERRALOANE	URUGUAY
BENIN	ECUADOR	KENYA	NEPAL	SOUTHAFRICA	VIETNAM
BOTSWANA	EGYPT	MADAGASCAR	NICARAGUA	SRILANKA	ZIMBABWE
BRAZIL	ELSALVADOR	MALAYSIA	NIGERIA	SUDAN	
BURKINAFASO	GABON	MALI	PAKISTAN	SWAZILAND	
BULGARIA	GAMBIA	MAURITANIA	PANAMA	TANZANIA	
CAMEROON	GUATEMALA	MAURITIUS	PERU	THAILAND	
COLOMBIA	HONDURAS	MEXICO	PHILIPPINES	TOGO	

List of OECD Countries

Austria	France	Korea, Rep.	Spain
Australia	Germany	Luxembourg	Sweden
Belgium	Greece	Netherlands	Switzerland
Canada	Ireland	New Zealand	Turkey
Czech Republic	Israel	Norway	United Kingdom
Denmark	Italy	Poland	United States
Finland	Japan	Portugal	

Appendix B – Cyclical Volatility

Business cycle measures are obtained by detrending the series of government expenditure and investment. There are Four different methods to detrend the series of each country i and estimate its cyclical component. Letting $y_{,i\,t} = \ln(Y_{i,t})$. The first measure is simple differencing (growth rate):

$$C_{i,t} = y_{i,t} - y_{i,t-1}$$

The second and the third method is the Hodrick-Prescott (HP) filter, proposed by Hodrick and Prescott (1997). The filter decomposes the series into a cyclical ($c_{I,t}$) and a trend ($G_{i,t}$) component, by minimizing with respect to $g_{i,\,t}$, for the smoothness parameter $\Lambda > 0$ the following quantity:

$$\sum_{t-1}^{T}\big(Y(i,t) - G(i,t)\big)^2 + \Lambda \sum_{t=2}^{T-1}\big(G(i,t+1) - G(i,t-1)\big)^2$$

The methods differ because the second one consists of using the value recommended by Hodrick and Prescott for annual data for the smoothness parameter (Λ) equal to 100, while the third method considers the smoothness parameter (Λ) to be equal to 6.25. In this way, as pointed out by Ravn and Uhlig (2002), the Hodrick-Prescott filter produces cyclical components comparable to those obtained by the Band-Pass filter. The fourth method makes use of the Band-Pass (BP) filter proposed by Baxter and King (1999), and evaluated by Stock and Watson (1999) and Christiano and Fitzgerald (2003) (who also compare its properties to those of the HP filter). The Low-Pass (LP) filter $\alpha(L)$,which forms the basis for the band pass filter, selects a finite number of moving average weights α_h to minimize:

$$Q = \int_{\pi}^{-\pi} |\delta(\omega)|^2 d\omega$$

Where $\alpha(L) = \sum_{h=-k}^{k} \alpha_h L^h$ and $\alpha_k(\omega) = \sum_{h=-k}^{k} e\text{^} - i\omega h$

The LP filter uses $\alpha_k(\omega)$ to approximate the infinite MA filter $\beta(\omega)$. Defining $\delta(\omega) = \beta(\omega) - \alpha(\omega)$, and then minimizing Q, we minimize the discrepancy between the ideal LP filter β(ω) and its finite representation α(ω) at frequency ω. The main objective of the BP filter as implemented by Baxter and King (1999) is to remove both the high frequency and low frequency components of a series, leaving the business-cycle frequencies. This is obtained by subtracting the weights of two low pass filters. We define $\omega_l - \omega_h$, the lower and upper frequencies of two low pass filters, as eight and two respectively for annual data. We therefore remove all fluctuations shorter than two or longer than eight years. The frequency representation of the band pass weights becomes $\alpha_k(\omega_h) - \alpha_k(\omega_l)$, and forms the basis of the Baxter-King filter, which provides an alternative estimate of the trend and the cyclical component.

In the above four we have used the third one i.e. HP (ʎ=6.25) because it produces the smoothest series among the four detrending methods.