Impact of Public and Private investments on Economic Growth of Developing Countries

Faruque Ahamed
z1854551@students.niu.edu

Follow this and additional works at: https://huskiecommons.lib.niu.edu/allgraduate-thesesdissertations

Part of the Statistics and Probability Commons

Recommended Citation
Ahamed, Faruque, "Impact of Public and Private investments on Economic Growth of Developing Countries" (2022). Graduate Research Theses & Dissertations. 6777. https://huskiecommons.lib.niu.edu/allgraduate-thesesdissertations/6777

This Dissertation/Thesis is brought to you for free and open access by the Graduate Research & Artistry at Huskie Commons. It has been accepted for inclusion in Graduate Research Theses & Dissertations by an authorized administrator of Huskie Commons. For more information, please contact jschumacher@niu.edu.
This paper aims to study the impact of public and private investments on the economic growth of developing countries. The study uses panel data from 39 developing countries covering the periods 1990-2019. The study is based on the neoclassical growth models or exogenous growth models, in which land, labor, capital accumulation, etc., and technology proved substantial for economic growth. The paper uses the impact on overall GDP growth and GDP per capita growth. The study used mixed-effect regression model and Bayesian logistic regression model to derive the findings. For private investments, domestic credit has positive association, but foreign direct investment is negatively correlated with economic growth. Public investment has a strong and a positive impact on economic growth compared to private investment. Public capital formation, labor growth, and government consumption expenditure were significant in explaining the economic growth. Overall, both public and private investments are substantial for the economic growth and development of developing countries.
IMPACT OF PUBLIC AND PRIVATE INVESTMENTS ON ECONOMIC
GROWTH OF DEVELOPING COUNTRIES

BY

FARUQUE AHAMED
© 2022 Faruque Ahamed

A THESIS SUBMITTED TO THE GRADUATE SCHOOL
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS
FOR THE DEGREE
MASTER OF SCIENCE

DEPARTMENT OF STATISTICS AND ACTUARIAL SCIENCE

Thesis Director:
Dr. Alan Polansky
ACKNOWLEDGEMENTS

I would like to express my profound gratitude to my thesis advisor, Professor Dr. Alan Polansky, for his invaluable guidance and support while writing this thesis. His dedication, patience and interest made this research possible. I also want to thank my thesis committee members, Professor Dr. Duchwan Ryu and Professor Dr. Michelle Xia, for their invaluable support and comments that improved my work greatly.
# TABLE OF CONTENTS

| Section                                                                 | Page |
|------------------------------------------------------------------------|------|
| LIST OF FIGURES                                                        | iv   |
| LIST OF TABLES                                                         | v    |
| LIST OF APPENDICES                                                     | vi   |
| CHAPTER ONE: INTRODUCTION                                              | 1    |
| 1.1 Objective of the Thesis                                           | 2    |
| 1.2 Research Questions                                                 | 2    |
| 1.3 Hypothesis of the Study                                           | 3    |
| CHAPTER TWO: THEORETICAL AND EMPIRICAL REVIEW                          | 4    |
| 2.1 Economic Growth Theory                                             | 4    |
| 2.2 Empirical Studies                                                  | 6    |
| CHAPTER THREE: EMPIRICAL METHOD                                       | 12   |
| 3.1 Data                                                               | 12   |
| 3.2 Methodology                                                        | 17   |
| CHAPTER FOUR: EMPIRICAL RESULTS AND ANALYSIS                           | 18   |
| 4.1 First Model                                                        | 18   |
| 4.2 Second Model                                                       | 22   |
| CHAPTER FIVE: BAYESIAN LOGISTIC REGRESSION MODEL                       | 25   |
| CHAPTER SIX: DISCUSSION AND CONCLUSION                                 | 29   |
| 6.1 Discussion                                                         | 29   |
| 6.2 Conclusion                                                         | 31   |
| REFERENCES                                                             | 32   |
| APPENDICES                                                             | 34   |
# LIST OF FIGURES

| Figure | Description | Page |
|--------|-------------|------|
| Figure 1 | Prior Distributions (Public Investments) | 38 |
| Figure 2 | Prior Distributions (Private Investments) | 39 |
| Figure 3 | Simulated Scatter Plots | 40 |
| Figure 4 | MCMC Trace Plots (CAP) | 40 |
| Figure 5 | MCMC Trace Plots (LAB) | 41 |
| Figure 6 | MCMC Trace Plots (DC) | 41 |
| Figure 7 | MCMC Trace Plots (FDI) | 41 |
| Figure 8 | MCMC Density Plots (CAP) | 42 |
| Figure 9 | MCMC Density Plots (LAB) | 42 |
| Figure 10 | MCMC Density Plots (DC) | 42 |
| Figure 11 | MCMC Density Plots (FDI) | 43 |
| Figure 12 | MCMC Autocorrelation Plot (CAP) | 43 |
| Figure 13 | MCMC Autocorrelation Plot (LAB) | 44 |
| Figure 14 | MCMC Autocorrelation Plot (DC) | 44 |
| Figure 15 | MCMC Autocorrelation Plot (FDI) | 45 |
| Figure 16 | Posterior Distribution | 45 |
| Figure 17 | Posterior Predictive Check | 46 |
LIST OF TABLES

Table 1: Variables Description ................................................................. 13
Table 2: Summary Statistics of the Variables ........................................... 15
Table 3: Correlation Matrix (GDP) ............................................................ 16
Table 4: Correlation Matrix (GDP Growth Capita) ................................... 16
Table 5: GLM Regression Output ............................................................... 19
Table 6: GLM Regression Estimates .......................................................... 20
Table 7: Random-Effect Regression Output .............................................. 21
Table 8: Random-Effect Regression Estimates ......................................... 21
Table 9: GLM Regression Output ............................................................... 22
Table 10: GLM Regression Estimates ......................................................... 23
Table 11: Random-Effect Regression Output ............................................ 24
Table 12: Random-Effect Regression Estimates ....................................... 24
Table 13: Bayesian Logistic Regression Model (Multiple Predictors) ............ 28
# LIST OF APPENDICES

| Appendix | Title | Page |
|----------|-------|------|
| APPENDIX A: | COUNTRY LIST | 34 |
| APPENDIX B: | FIXED-EFFECT REGRESSION OUTPUT (MODEL 1) | 36 |
| APPENDIX C: | FIXED-EFFECT REGRESSION OUTPUT (MODEL 2) | 37 |
| APPENDIX D: | FIGURES | 38 |
CHAPTER ONE: INTRODUCTION

In the last few decades, economists are trying to understand the global and country-specific factors contributing to economic growth. The variations in market fluctuations, financial crises, economic turmoil, and recessions made it hard to predict the economic uncertainty. An array of dynamic macroeconomic factors has been analyzed to determine a robust framework and effective model to explain the preceding performances and forecast future behavior of the economies. Both developed and developing countries face the change in macroeconomic dynamics and experience a complex relationship between public and private investment with economic growth. Public and private investments play a substantial role in the production functions by providing the required capital for development. Public investment may create scope for private investment through resource creation and socio-economic infrastructure support. Public investment provides supplementary supports to the private investment through government investments in education, infrastructure, defense, etc., and creating crowding-in effect on private investments through increasing demand. However, public investment can have a crowding-out effect on private investment. The IS-LM theory clearly states the impact of public investment on private investment. An increase in government spending, taxes, and domestic interest rate can lead to a parallel shift in the IS curve and adversely affect private investment. (Buiter, 1977; Ram, 1986). Public investment may also deprive private investment by competing in investment goods and utilizing physical and financial resources. Empirical studies by Aschauer (1989), Seitz (1994), and Pereira (2001) revealed that public investment is
supplementary to the private investment through investment in infrastructure, education, defense etc. whereas Zou (2006) finds that public investment has a crowding-out effect.

Researchers are yet to find a conclusive idea about the public and private investment collaboration and economic growth in the above circumstances. Public investments are working as business stimulus policy for almost the last three decades. Public capital enhances the productivity of the private capital and drives the return on investment upward.

1.1 **Objective of the Thesis**

The aim of the thesis is to identify the impact of public and private investments on the economic growth of developing countries. The study uses panel data from 39 developing countries covering the periods 1990-2019. The study is based on the neoclassical growth models or exogenous growth models, in which land, labor, capital accumulation, etc., and technology proved substantial for economic growth. The research contributes to the existing literature by using new growth variables and deep observations of the data.

1.2 **Research Questions**

The study tries to answer the following questions:

✓ What is the impact of domestic private credit on GDP growth and GDP growth per capita?

✓ What is the impact of foreign direct investment on GDP growth and GDP growth per capita?

✓ What is the impact of public capital formation on GDP growth and GDP growth per capita?

✓ What is the impact of labor growth rate on GDP growth and GDP growth per capita?
What is the impact of government consumption expenditure on GDP growth and GDP growth per capita?

1.3 Hypotheses of the Study

The hypotheses of the study are as follows:

✓ There exists a statistically significant relationship between public investment and GDP growth.

✓ There exists a statistically significant relationship between private investment and GDP growth.

✓ There exists a statistically significant relationship between public investment and GDP growth per capita.

✓ There exists a statistically significant relationship between private investment and GDP growth per capita.
CHAPTER TWO: THEORETICAL AND EMPIRICAL REVIEW

2.1 Economic Growth Theory

Researchers have identified two economic growth models: the neoclassical growth model and the new growth model. Neoclassical growth models or exogenous growth models state that factors of production such as land, labor, capital accumulation, etc., and technological variables affect long-run productivity and economic growth (Solow, 1956). The new growth model or endogenous growth model argues that the growth factors are endogenous rather than exogenous. The investment is in technological innovation, human capital development and knowledge are the key growth factors (Romer, 1996; Lucas, 1988; Barro, 1990; Rebelo, 1991). The model concentrates on positive externalities and spillover effects of a knowledge-based economy which will lead to economic growth. Aschauer (1989) uses Cobb-Douglas production function (1928) to assess the impact of growth factors such as physical capital, labor, and land on the total output where public and private investments stimulate the growth factors in an economy. Most of the models confirm that public investment influences economic growth affecting aggregate demand and aggregate supply.

Sims and Wolff (2018) developed a model that includes government expenditure by assuming that government consumption enters the utility function in a non-separable way with private consumption and that government capital enters the aggregate production function. The government spending is found to have strong multiplier effect on output, employment, and
individual consumption. Although the enhanced government spending increases the tax rate, the welfare multiplier benefits for government consumption outweigh the costs.

Let’s consider that there is a representative agent in the economy who wants to maximize the utility with the following function:

$$V = \sum_{t=1}^{\infty} \delta^{t-1} u(c_t, l_t g_t)$$

In the equation, $\delta$ is the discount factor, where $0 < \delta < 1$, $c$ is the consumption, $l$ is the work effort and $g$ represent the total government expenditure. Consumption and work effort are associated with the utility and disutility. It is assumed that government expenditure connects with private utility through private consumption of goods or leisure activities. The representative agent can draw the production function with constant return to scale as follows:

$$Y = f(L, K, G) = A L^{\alpha} K^{\beta} G^{\gamma} \quad (1)$$

where $L$ is labor, $K$ is private contribution in capital stock, $G$ is government contribution in capital stock and $A$ is technical coefficient.

Let’s consider $\alpha + \beta + \gamma = 1$ with $\gamma > 0$ where government investments/capital is an independent factor like the other two factors. When the public capital stock is independent and complements the private capital stock and labor, then an increase in public capital directly affects the output considering the *ceteris paribus* holds. Taking the derivates of labor, private capital, and public capital stock in Equation (1), we get,

$$Y = \frac{dF}{dL} L + \frac{dF}{dk} K + \frac{dF}{dg} G$$

$$= (\alpha A L^{\alpha-1} K^\beta G^\gamma)L + (\beta A L^{\alpha} K^{\beta-1} G^\gamma)K + (\gamma A L^{\alpha} K^\beta G^{\gamma-1})G$$
Until the marginal productivities of public capital, labor and private capital are equal there will be adjustments of labor and capital(s) to reach an equilibrium.

Placing the value $\alpha=1-\beta-\gamma$, we get

$$
\ln \frac{Y}{L} = \ln A + \beta \ln \frac{K}{L} + \gamma \ln \frac{G}{L}
$$

Setting $a=\ln A$, $y=Y/L$, $k=K/L$ and $g=G/L$ we can write

$$
\ln y = a + \beta \ln k + \gamma \ln g
$$

By adjusting two periods, $t$ and $t-1$, we can obtain,

$$
\ln \left( \frac{y_t}{y_{t-1}} \right) = a_t/a_{t-1} + \beta \ln \left( \frac{k_t}{k_{t-1}} \right) + \gamma \ln \left( \frac{g_t}{g_{t-1}} \right)
$$

Considering constant population growth rate,

$$
\ln \left( \frac{Y_t}{Y_{t-1}} \right) = a + \beta \ln \left( \frac{K_t}{K_{t-1}} \right) + \gamma \ln \left( \frac{G_t}{G_{t-1}} \right)
$$

The last two equations suggest that there exists a direct link between public and private investment with economic growth and it largely depends on both government and private investments.

### 2.2 Empirical Studies

Researchers have been working to investigate the relation of public and private investment with economic growth for many years. The studies, however, revealed different results depending on the sample and method used.
Le and Suruga (2005) investigate the impact of public investment and foreign direct investment (FDI) on economic growth using the panel data of 105 developed and developing countries for 1970-2009. The study uses fixed-effect model using the moving average per capital GDP growth as endogenous variable and the ratio of GDP to public capital expenditure, public capital expenditure, private capital flow, and FDI as exogenous variables. The results revealed that both public investment and FDI have a positive impact on GDP. The results also showed that when the public investment exceeds the threshold of 9%, the effect of FDI on economic growth becomes weaker, and the research concludes that excessive public investment erases the benefit from FDI.

Ashauer (1989) examines whether public investment crowds out private investment using the United States data for 1925-1985. The author uses the fixed-effect estimation methods by following the Cobb-Douglas production function theory. The results show that public investment increases the marginal productivity of the private capital, and higher public spending reduces private investment. The study found both the crowd-in and crowd-out effects of public investment. Everhart and Sumlinski (2001) tried to find the partial correlation between public and private investment using a data panel of 63 developing countries over the period 1970-2000. The research uses pooled ordinary least square method and random-effect model to understand the impact of public and lagged private investment on GDP, public investment interaction with corruption, and broad money supply on economic growth. The studies conclude that there exists a negative correlation between public and private investment. However, the correlation seems to be positive for the countries with a better institutional framework. Blejer and Khan (1984) explore the crowding out or crowding in public investment on private investment for 24 developing countries from 1971-1979 through statistical analysis. They identified that public
investment in infrastructure is beneficial for private investment, whereas another type dries the fund of private investment.

Deverajen et al. (1996) explore the relationship between public expenditure and economic growth using a sample of 43 developed and developing countries over 1970-1990. The five-years forward moving average per capita real GDP growth was the dependent variable and public expenditure to GDP, black-market economy premium, external shock, and continental dummy variable were the independent variables. The equation was estimated with ordinary least square regression. The study finds that public capital expenditure has a positive effect on the economic growth of developing countries, whereas the effect is negative for developed countries. Governments in developing countries spend an average of 26% of GDP on goods and services and the amount increased 8% in the last 15 years. Due to this excessive government expenditures, developing countries economies grow significantly. In case of developed countries, government expenditures are conducted to support and build structural private investments. The excessive allocation of resources by public investment can become unproductive and inefficient for the economy. Ghosh and Gregoriou (2007) also conclude similar results in developing countries' optimal fiscal policy framework.

Barro (1990) examines the relationship between the growth rate of per capita GDP and share of government expenditure using the extended endogenous growth model for 76 countries from 1960 to 1985. Applying regression analysis, he concluded that government consumption is inversely related to economic growth, but the relationship between public investment and economic growth is found to be insignificant. Hsieh and Lai (1994) used a similar model to analyze the relationship among the growth rate of per capita GDP, the ratio of private investment
to GDP, and government expenditure for G-7 countries. The authors conducted multivariate time series analysis with particular attention paid to the causal pattern and the shape of impulse-response function in the context of vector autoregressions. The study found that government spending has a significant impact on the growth rate of per capita GDP for Canada, the UK, and Japan but an insignificant impact for France, Germany, Italy, and the USA. However, the private investment to GDP ratio has a significant effect on the USA, Japan, Canada, Germany, and the UK. Zou (2006) performs a study on the interaction between public and private investment and economic growth for the USA and Japan. He suggests that both public and private investment have a significant contribution to Japanese economic growth. For the USA, the private investment seems to play a much more significant role than public investment.

Ghalı (1998) conducted a study in Tunisia, in which IMF implemented a debt-stabilization program and identified that public investment has a long-run inverse effect on economic growth. He used multivariate cointegration techniques to develop a vector error-correction model useful for investigating the long-run effects of public investment on private capital formation and economic growth to reach the conclusion. Ramirez and Nazmi (2003) made an empirical study for nine Latin American countries using panel regression from 1983–93. The authors used growth rate of real per capita GDP as dependent variable and human capital, private capital, public capital etc., as independent variables. The research suggests that government consumption expenditures are found to have a negative effect on private investment and growth. Public expenditures on education and healthcare are found to have a positive and statistically significant effect on private capital formation and long-term economic growth.
Phetsavong and Ichihashi (2012) investigate the impact of FDI, public investment, and private domestic investment using a sample of 15 Asian developing countries from 1984 to 2009. They used panel regression analysis for three different models and suggest that private domestic investment and FDI are the two most crucial contributing factors for economic growth, whereas public consumption is inversely related to economic growth. The studies also found that public investment reduces the positive impact of private domestic investment and FDI on economic growth. Nguyen and Trinh (2018) examined both short-term and long-term influences of public investment on private investment and economic growth. The authors use an autoregressive distributed lag model using Vietnam's macro data from 1990-2016. The results indicate that public investment has a positive effect on short-term and negative effects in constraining long-term growth. However, private investment and FDI have positive effects on short-term economic growth. State-owned capital stock has positive impacts on economic growth in both the short and long run.

Seitz (1994) investigates the impact of the provision of public capital on the demand for private capital and labor using a cost function where they considered public capital as fixed unpaid factor of production. The model was developed using the fixed-effect estimation using the panel data of 31 two-digit industries of the West German manufacturing industry. Government investment in health, social security, housing, traffic and transportation, recreational facilities, wages, wage growth, labor, etc., have been used as the variables. The study decomposes the adjustment of demand for private capital and labor and concludes that public capital has supplementary impact on private investments. Pereira (2001) conducts an empirical investigation of the effects of public investment on the evolution of private investment in the United States. Time series data for the period from 1956 to 1997 collected from U.S. Bureau of
Economic Analysis has been used in study. In case of private investments, investment in information processing, industrial equipment, transportation equipment, and other equipment has been considered. In the public investment variables, investment in transportation, infrastructure, education, sewage and water supply systems, healthcare, and defense as a percentage of GDP has been used. The researcher uses the impulse response analysis associated with vector auto-regressive (VAR) estimates and found that at the aggregate level, public investment crowds in private investment. This crowding-in effect on private equipment is particularly strong in the cases of industrial equipment and transportation equipment.
CHAPTER THREE: EMPIRICAL METHOD

3.1 Data

The study uses panel data of 39 developing countries throughout 1990-2019, which comprises 7,020 observations. The data has been collected from mainly two sources: World Development Indicator and the International Monetary Fund database. Sample data from developing countries across four continents (Asia, Africa, North America and South America) are chosen to balance the research. In the dependent variables, GDP growth and GDP growth per capita have been used (Table 1). Domestic private credit and foreign direct investment are used as a proxy of private investments, whereas the public capital formation and labor growth are considered public investments. Government consumption expenditure has been used as a control variable in the study. It consists of direct government expenditure on goods, services, and direct social security costs. Domestic private credit is comprised of credits from banks, non-bank financial institutions, microfinance institutions, etc. These institutions contribute heavily to the major formation of private equity and investments. Foreign direct investments are the investments received by the country from businesses located in other than domestic countries. Previous studies mostly used only foreign direct investments as the source of private investment; however, domestic private credit is included in this study to better reflect private investment formation. Public capital formation is the capital formed by the state-owned institutions, and government consumption expenditure reflects non-investment expenditures by the government.
Table 1: Variables Description

| Variable | Definition                          |
|----------|-------------------------------------|
|          | **Dependent Variable**              |
| GDP      | Gross Domestic Product Growth Rate  |
| GPC      | GDP Growth Capita                   |
|          | **Variables of Interest**           |
| DC       | Domestic Private Credit (% of GDP)   |
| FDI      | Foreign Direct Investment (% of GDP) |
| CAP      | Public Capital Formation (% of GDP)  |
| LAB      | Labor Growth Rate                   |
| CON      | Government Consumption Expenditure  |
|          | (% of GDP)                           |

The summary statistics of the variables are presented in Table 2. The average GDP growth rate is 3.94%, where the minimum growth rate is -50.25% and maximum growth rate is 35.22% achieved by Rwanda in 1994 and 1995 respectively. The GDP per capita has been linearized to achieve the normality in the data. The domestic private credit data shows that the average private credit is 30.64% of the GDP among the developing countries, where the minimum is 1.62% by Sudan in 1999 and the maximum is 160.12% by South Africa in 2007.
The foreign direct investment data shows that developing countries receive 2.40% of investment on average. Congo in 1998 witnessed negative 8.7% of FDI, which indicates a large withdrawal of investment that year. Another African country Chad received the maximum investment of 46.28% FDI compared to its GDP in 2002. Average 22.12% of public capital formation to GDP has been maintained by the developing countries over three decades. Zimbabwe formed the lowest public capital in 2005, and Congo formed the highest public capital in 2015. Developing countries have seen 0.03% of average labor growth in three decades, where Rwanda had negative growth of 0.04% in 1992 and Oman in 2012 saw the highest labor growth of 0.12%. The government consumption expenditure data show that developing countries had an average of 13.71% government expenditure compared to the GDP. Nigeria in 1996 had the lowest government expenditure and Malawi in 1994 had the highest government consumption expenditure.

The correlation matrix depicts the direction and magnitude of the relationship between the variables, represented in the Tables 3 and 4.
Table 2: Summary Statistics of the Variables

| Variable Description                  | Mean  | Min   | Max   |
|---------------------------------------|-------|-------|-------|
|                                        | (Std. Dev.) | Min   | Max   |
| **Dependent Variable**                |       |       |       |
| GDP Growth Rate                       | 3.9367 | -50.25 | 35.22 |
| (4.4138)                              |       |       |       |
| GDP Growth Capita                     | 1.6712 | -47.5033 | 37.5355 |
| (4.3768)                              |       |       |       |
| **Variables of Interest**             |       |       |       |
| Domestic Private Credit (% of GDP)    | 30.6404 | 1.6155 | 160.1248 |
| (31.6157)                             |       |       |       |
| Foreign Direct Investment (% of GDP)  | 2.4002 | -8.7031 | 46.2752 |
| (3.7685)                              |       |       |       |
| Public Capital Formation (% of GDP)   | 22.1185 | 1.5252 | 77.8900 |
| (8.6896)                              |       |       |       |
| Labor Growth Rate                     | 0.0261 | -0.0449 | 0.1208 |
| (0.0168)                              |       |       |       |
| Government Consumption Expenditure (% of GDP) | 13.7099 | 0.9112 | 31.5544 |
| (4.9718)                              |       |       |       |
| No. of observations                  | 7020  |       |       |
Table 3: Correlation Matrix (GDP)

|     | GDP  | DC   | FDI  | CAP  | LAB  | CON   |
|-----|-----|-----|-----|-----|-----|-------|
| GDP | 1.0000 |     |     |     |     |       |
| DC  | 0.0498 | 1.0000 |     |     |     |       |
| FDI | 0.0580 | 0.0989 | 1.0000 |     |     |       |
| CAP | 0.2455 | 0.2223 | 0.2912 | 1.0000 |     |       |
| LAB | 0.0663 | -0.1158 | 0.0406 | 0.0156 | 1.0000 |     |
| CON | -0.1341 | 0.1907 | 0.0319 | -0.0427 | 0.0732 | 1.0000 |

Table 4: Correlation Matrix (GDP Growth Capita)

|     | GPC  | DC   | FDI  | CAP  | LAB  | CON   |
|-----|-----|-----|-----|-----|-----|-------|
| GPC | 1.0000 |     |     |     |     |       |
| DC  | 0.1253 | 1.000 |     |     |     |       |
| FDI | 0.0449 | 0.0989 | 1.0000 |     |     |       |
| CAP | 0.2480 | 0.2223 | 0.2912 | 1.0000 |     |       |
| LAB | -0.1184 | -0.1158 | 0.0406 | 0.0156 | 1.0000 |     |
| CON | -0.1539 | 0.1907 | 0.0319 | -0.0427 | 0.0732 | 1.0000 |
3.2 Methodology

As the dataset for this study is a longitudinal panel dataset, the mixed-effects analysis has been used that contains both fixed and random effects. The Akaike information criterion (AIC), Akaike information criterion-corrected (AICC), and Bayesian information criterion (BIC) have been used to identify the proper model. The model is:

\[ Y_{it} = X_{it}\delta + Z_{it}\alpha + \varepsilon_{it} \]

where \( \varepsilon \sim N(0, \delta^2 I) \)

Here \( Y \) is the vector of the dependent variable and \( X \) is the vector of the covariates, \( \delta \) is the vector of the coefficient of the covariates, \( Z \) is the design matrix for random effects that includes intercept, \( \alpha \) is the subject specific vector, and \( \varepsilon \) is the vector of the error terms.

The first model is described below:

\[ \text{GDP}_{ij} = \delta_0 + \alpha_i + \delta_1 \text{DC}_{ij} + \delta_2 \text{FDI}_{ij} + \delta_3 \text{CAP}_{ij} + \delta_4 \text{LAB}_{ij} + \delta_5 \text{CON}_{ij} + \varepsilon_{ij} \]

The second model is as follows:

\[ \text{GPC}_{ij} = \gamma_0 + \alpha_i + \gamma_1 \text{DC}_{ij} + \gamma_2 \text{FDI}_{ij} + \gamma_3 \text{CAP}_{ij} + \gamma_4 \text{LAB}_{ij} + \gamma_5 \text{CON}_{ij} + \varepsilon_{ij} \]

In the estimation, \( \alpha_i \) is the year-specific effects, \( i \) and \( j \) denote for the number of cross-section country (1,2,3…N) and time (1990,1991….2019) respectively.
CHAPTER FOUR: EMPIRICAL RESULTS AND ANALYSIS

The study implemented the generalized linear model (GLM) and mixed-effect regression model to understand the impact of public and private investment on Gross Domestic Product (GDP) and GDP per capita.

4.1 First Model

The GLM results are depicted in Table 5. The r-squared is 0.1764, which indicates that 17.64% of the systematic variations in the GDP is explained by the dependent variables. The study used only a small portion of the GDP growth components that are reflected in the r-squared value of the model. The F-value of the model is 5.61 and probability value is around 0.0001, which is less than the 5% significance value. Therefore, the overall impact of the covariates on GDP growth and the model is statistically significant.
Table 5: GLM Regression Output

| Source          | DF  | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|-----|----------------|-------------|---------|--------|
| Model           | 43  | 4016.6484      | 93.4104     | 5.61    | <.0001 |
| Error           | 1126| 18758.1681     | 16.6591     |         |        |
| Corrected Total | 1169| 22774.8165     |             |         |        |
| R-Square        | 0.1764 | Coeff Var      | 103.6783    |         |        |
| Root MSE        | 4.0816 | LnGPC Mean     | 3.9368      |         |        |

Compared to the fixed-effect regression model the random effect regression model has the lower Akaike information criterion (AIC), Akaike information criterion-corrected (AICC), and Bayesian information criterion (BIC) value; therefore, the random-effect model has been chosen over the fixed-effect regression model. The outcome of the fixed-effect regression model has been presented in the Appendix B. Hence, the random-effect model fits better and explains the covariates well. The regression output shows that domestic credit has positive and significant impact on the economic growth of the country. The coefficient has a value of 0.0441 and it is significant at 5% significance level (Table 6). The foreign direct investment has an estimate of 0.0366 and it is not significant at 5% significance level. FDI seems to have positive and insignificant association with economic growth. Public capital formation estimate has been found to be positive and significant in the economic growth of the developing countries. The labor growth of the developing countries is higher than the labor growth of the developed countries.
Labor growth has a strong positive and significant impact on the GDP growth of the country. The growth of the labor enhances the consumption and expenditure of the other GDP growth components that affect the GDP significantly. Government consumption expenditure has a negative and significant relationship with GDP. The relationship between the dependent and independent variable is very much consistent with the Solow growth model. The results of random-effect model are shown in Table 7 and 8.

**Table 6: GLM Regression Estimates**

| Parameter | Estimate | Standard Error | t Value | Pr>|t| |
|-----------|----------|----------------|---------|------|
| Intercept | 1.7975   | 1.1260         | 1.60    | 0.1107 |
| DC        | -0.0440  | 0.0114         | -3.88   | 0.0001 |
| FDI       | 0.0366   | 0.03814        | 0.96    | 0.3369 |
| CAP       | 0.1362   | 0.0216         | 6.32    | <.0001 |
| LAB       | 19.4809  | 8.5651         | 2.27    | 0.0231 |
| CON       | 0.0996   | 0.0458         | -2.17   | 0.0299 |
Table 7: Random-Effect Regression Output

| Covariance Parameter Estimates | Fit Statistics          |
|-------------------------------|-------------------------|
| Residual                      | 16.6591 -2 Res Log Likelihood 6534.8 |
| Number of Observations        | 1170 AIC (Smaller is Better) 6536.8 |
|                               | AICC (Smaller is Better) 6536.8 |
|                               | BIC (Smaller is Better) 6538.4 |

Table 8: Random-Effect Regression Estimates

| Parameter | Estimate | Standard Error | t Value | Pr>|t| |
|-----------|----------|----------------|---------|-----|
| Intercept | 1.7975   | 1.1260         | 1.60    | -   |
| DC        | 0.0441   | 0.0114         | -3.88   | 0.0001 |
| FDI       | 0.0366   | 0.0381         | 0.96    | 0.3369 |
| CAP       | 0.1362   | 0.0216         | 6.32    | <.0001 |
| LAB       | 19.4809  | 8.5651         | 2.27    | 0.0231 |
| CON       | -0.0996  | 0.0458         | -2.17   | 0.0299 |
4.2 Second Model

The GLM results are depicted in Table 9 and Table 10. The r-squared is 0.1959, which indicates that 19.59% of the systematic variations in the GDP growth per capita is explained by the dependent variables. The study used only a small portion of the GDP growth per capita components that are reflected in the r-squared value of the model. The F-value of the model is 6.38 and probability value is around 0.0001, which is less than the 5% significance value. Therefore, the overall impact of the covariates on GDP growth per capita and the model is statistically significant.

Table 9: GLM Regression Output

| Source            | DF   | Sum of Squares | Mean Square | F Value | Pr > F |
|-------------------|------|----------------|-------------|---------|--------|
| Model             | 43   | 4386.6780      | 102.0258    | 6.38    | <.0001 |
| Error             | 1126 | 18007.6983     | 15.9923     |         |        |
| Corrected Total   | 1169 | 22394.3763     |             |         |        |
| R-Square          | 0.1959 | Coeff Var    |             |         |        |
| Root MSE          | 3.9991 | GPC Mean     |             |         |        |
Table 10: GLM Regression Estimates

| Parameter | Estimate | Standard Error | t Value | Pr>|t| |
|-----------|----------|----------------|---------|--------|
| Intercept | 1.1107   | 1.1032         | 1.01    | 0.3142 |
| DC        | -0.0365  | 0.0111         | -3.28   | 0.0011 |
| FDI       | 0.0333   | 0.0373         | 0.89    | 0.3736 |
| CAP       | 0.1262   | 0.0211         | 5.97    | <.0001 |
| LAB       | -15.7358 | 8.3920         | -1.88   | 0.0610 |
| CON       | -0.1048  | 0.4490         | -2.33   | 0.0198 |

The random-effect regression output and estimates are shown in Table 11 and Table 12. Similar to the first model, the current model was also chosen based on the AIC, AICC, and BIC values. The random-effect regression is the best fit model based on the fit statistics. The output shows that the domestic credit has negative but significant association with the GDP growth per capita. The foreign direct investment has found to have positive and insignificant association with the GDP growth per capita. The public capital formulation is vital for economic growth and has both positive and strong association with the GDP growth per capita as well. The labor growth rate is negatively associated with the GDP growth per capita. The government consumption expenditure is also negatively correlated and statistically significant at 5% significance level. The findings are very much consistent with Solow growth model.
### Table 11: Random-Effect Regression Output

| Covariance Parameter Estimates | Fit Statistics            |
|-------------------------------|---------------------------|
| Residual 15.9926              | -2 Res Log Likelihood 6488.8 |
| Number of Observations 1170   | AIC (smaller is better) 6490.8 |
|                               | AICC (smaller is better) 6490.8 |
|                               | BIC (smaller is better) 6492.5 |

### Table 12: Random-Effect Regression Estimates

| Parameter | Estimate | Standard Error | t Value | Pr>|t| |
|-----------|----------|----------------|---------|-----|
| Intercept | 1.1107   | 1.1032         | 1.01    | -   |
| DC        | -0.0365  | 0.0111         | -3.28   | 0.0011 |
| FDI       | 0.0333   | 0.0374         | 0.89    | 0.3736 |
| CAP       | 0.1262   | 0.0211         | 5.97    | <.0001 |
| LAB       | -15.7358 | 8.3920         | -1.88   | 0.0610 |
| CON       | -0.1048  | 0.0449         | -2.33   | 0.0198 |
CHAPTER FIVE: BAYESIAN LOGISTIC REGRESSION MODEL

In the previous literatures, the Solow economic growth model has been proved by several econometric models. The study also uses the Bayesian logistic regression model to test the predictors’ probability impact on the response variable. In this research, we want to model the endogenous variable as binary categorical response variable, converted to a 0/1 indicator for convenience. As the GDP growth rate can take both positive and negative value, the data is a good fit for the Bayesian logistic regression model. Thus, the Bernoulli probability model suits best the data and the Bernoulli mean depends upon the predictors through a logit link function. There exists a prior understanding of the GDP growth probability based on previous similar studies. As the Y value is categorical, the use of normal or Poisson regression model can provide wrong outcomes. The relationship between the odds and probability scales is represented by nonlinear functions and the transformation preserves the properties of odds and probability. The probability π has a range of 0 to 1, whereas the odds can range from 0 to infinity. As we have probability \( \pi \in [0,1] \) and corresponding odds \( \pi/(1−\pi)\in[0,\infty) \), we can say that the odds of an event are \( 1 > \) when \( \pi < 0.5 \) and \( > 1 \) when \( \pi > 0.5 \). In our model structure, Y is a discrete variable that can have values 0 or 1, so the Bernoulli probability model shows they can be a very good fit for the dataset. Here:

\[
Y = \begin{cases} 
1 & \text{if GDP growth is positive, or} \\
0 & \text{otherwise}
\end{cases}
\]
Here, the Bernoulli probability model is:

\[ Y_{i} | \beta_0, \beta_1, \ldots \beta_p \sim \text{Bernoulli}(\pi_i) \]

\[ \log(\pi_i / (1- \pi_i)) = \beta_0 + X_{i1}\beta_1 + \ldots + X_{ip}\beta_p \]

Here, \( E(Y_i=1|\pi_i) = \pi_i \). Where:

\( \beta_0 \sim \text{Normal}(\mu_0, \sigma_0) \)

\( \beta \sim \text{Normal}(\mu_{\beta}, \sigma_{\beta}) \)

We have developed the prior based on the previous similar studies and figured out that there exists around a 20-30% chance of the GDP being positive based on the studied parameters. The prior model coefficients also suggest that the chances of GDP increase based on the predictors that may vary and open to the possibility of non-existence. After the prior selection, 100 datasets were simulated from the prior models to plot the relationship between GDP and the studied predictors. The visualization of the patterns in the relationship shows that the chances of GDP growth being positive are greater than being negative. Hence, the posterior simulation of the model is required to update based on new observations to reflect the true model statistics.

The Markov chain Monte Carlo (MCMC) diagnostic plots have been used to check the stability of the simulation. The study performs a posterior predictive check to confirm that data simulated from the posterior logistic regression model has similar features to the original data and assumptions of the Bayesian logistic regression model are reasonable.

The model uses an uninformative prior and uses the existing dataset to run the simulation. The Markov chain Monte Carlo (MCMC) diagnostic plots have been used to check the stability of the simulation. In the trace plots, the non-existence of flat bits and too many consecutive steps in the same direction prove that there exists a burn-in of about ten thousand iterations and the MCMC sampler seems to mix well. The marginal density plots of the simulated model indicate a
good mixing. The sample autocorrelation coefficient measures the similarity between MCMC draws as a function of the time separation between them and the plot confirms that the simulation has very good mixing. The convergency of the autocorrelation between the samples returned by the MCMC can have lag-k autocorrelation. As the k increases, the autocorrelation becomes smaller and samples are more independent and vice versa. To have an efficient and more precise estimate, we burn the first 100 samples. The burn-in samples are non-informative and enhances the optimal estimate of the output. The after-simulation posterior plausible model confirms that the smoothing nature of the distribution and the model is less variable than the prior counterparts (Johnson, Ott, & Dogucu, 2022).

The multiple predictors of Bayesian logistic regression model (Table 13) show that predictors such as CAP, LAB and DC have strong positive association with the response variable. The other predictors such as FDI and CON have negative impact on the response variable. Testing the significance shows that CAP, LAB, and FDI are significant at 5% significance level, CON is significant at 10% significance level, and DC is found to be insignificant. The multiple predictor regression output is quite similar to the individual posterior predictive simulation.
### Table 13: Bayesian Logistic Regression Model (Multiple Predictors)

|      | Estimate | Std. Error | Conf. Low | Conf. High |
|------|----------|------------|-----------|------------|
| Intercept | 0.831    | 0.383      | .326      | 1.32       |
| CAP   | 0.0622   | 0.0132     | 0.0459    | 0.0794     |
| LAB   | 18.9     | 5.59       | 11.7      | 26.1       |
| DC    | 0.00480  | 0.00338    | 0.000685  | 0.00930    |
| FDI   | -0.0675  | 0.0224     | -0.0959   | -0.0380    |
| CON   | -0.0488  | 0.0186     | -0.0726   | -0.0250    |
CHAPTER SIX: DISCUSSION AND CONCLUSION

6.1 Discussion

A general conception is public and private investment induces economic growth and creates development opportunities. However, previous researchers suggest the situation varies depending on various circumstances of investments. The infrastructural capital stock and budgetary positions vary in developing countries, but the majority of the countries have greater supply of labor force, so the impact of public investment affecting economic growth is higher than the private investment in those countries. Earlier studies show that in developed countries, however, private investment seems to have a strong effect due to the supplementary public investments on infrastructure and private capital formation. Although government investment in infrastructure, etc., sectors is crucial, excessive public investment in developing countries can have a crowding-out effect on the private investment (Shen, et al., 2018). The disparity of public-private investment rates of return creates disparity and discourages private domestic investors. The same is applicable for developed countries as well.

Public investment may influence private investment and boost the economy for the short term, but it may have significant adverse effects in the long term. In some developing countries, the government budgetary decisions are inefficient and unfocused; overspending may require borrowing from private sources (Nguyen & Trinh, 2018). State-owned enterprises lack transparency and accountability, which hinder the plan of creating clean and sustainable
development. Developing countries have a greater population growth rate and an increased workforce. Still, due to poor-quality education and inadequate investment in education, the majority of the workforce stays in unskilled territory. Transition to developed countries from developing countries requires policymakers to prioritize private investments and design public policies to stimulate private investment. Public investment works as a complementary service for domestic private investment and foreign direct investments. Developing countries follow public investment-driven economies in terms of sustainable economic growth and exert a strong influence over the private sector. Realizing the importance of private investment, China has empowered private sectors through synchronization with the public policies and investment to create a robust bidirectional relationship. This private-public investment correlation triggers economic growth and fosters economic development.

The neoclassical growth theory implies that a steady economic growth rate results from three driving forces: labor, capital, and technology. Capital accumulation and technological investment are the critical challenges faced by developing countries. Limited resource availability can only be offset by technological innovation considering capital and labor productivity. The main instrument of economic growth varies at various stages of a country’s development. Physical capital accumulation and labor forces are substantial for early development stages but maintaining steady growth investments in technological research and development is vital. Some developing countries lack appropriate policies, skilled human resources, and infrastructure to support the determinants of economic growth variables that fail to generate interactive relationships.
6.2 Conclusion

The study uses panel data from 39 developing countries during the period 1990-2019. The effect of public and private investments in determining economic growth rate has been explored in the study. The results of this paper suggest some implications in constructing theoretical models which structure the impact of public-private investments on economic growth. The empirical results show that domestic credit has positive and significant effect on economic growth and on GDP per capita growth. Foreign direct investment has a slightly negative yet insignificant impact on economic growth. Consistent with the Solow growth model, the labor force growth rate drives the overall GDP growth but has negative association with GDP per capita growth. Public capital formation has positive correlation with higher economic growth, while the government consumption expenditure is inversely related to the growth. Most of the countries in the study focus on public investment-driven growth and try to exert control over private investments. Focusing on skilled labor force growth is substantial for economic development, but the countries have less concentration on that sector. The evidence suggests the countries need to improve the public-sector productivity and develop an analytical framework to stimulate private investment. Policy support to facilitate the private investment and skilled labor force can ensure a stable macroeconomic environment and sustainable economic growth.
REFERENCES

Aschauer, D. A. (1989). Is public expenditure productive? *Journal Of Monetary Economics*, 23(2), 177-200.

Barro, R. J. (1990). Government spending in a simple model of endogeneous growth. *Journal Of Political Economy*, 98(5, Part 2), S103-S125.

Blejer, M. I., & Khan, M. S. (1984). Government policy and private investment in developing countries. *Staff Papers, 31*(2), 379-403.

Buiter, W. H. (1977). ‘Crowding out’and the effectiveness of fiscal policy. *Journal of Public Economics, 7*(3), 309-328.

Devarajan, S., Swaroop, V., & Zou, H. F. (1996). The composition of public expenditure and economic growth. *Journal of Monetary Economics, 37*(2), 313-344.

Everhart, S. S., & Sumlinski, M. A. (2001). *Trends in private investment in developing countries: statistics for 1970-2000 and the impact on private investment of corruption and the quality of public investment* (Vol. 44). World Bank Publications.

Ghali, K. H. (1998). Public investment and private capital formation in a vector error-correction model of growth. *Applied Economics, 30*(6), 837-844.

Ghosh, S. and Gregoriou, A. (2007) The Composition of Government Spending and Growth: is Current or Capital Spending Better? *Oxford Economic Papers*, Vol. 60, pp. 484–516.

Hsieh, E., & Lai, K. S. (1994). Government spending and economic growth: the G-7 experience. *Applied Economics, 26*(5), 535-542.

Johnson, A. A., Ott, M. Q., & Dogucu, M. (2022). Bayes Rules!: An Introduction to Applied Bayesian Modeling. CRC Press.

Le, M., & Suruga, T. (2005). Foreign direct investment, public expenditure and economic growth: the empirical evidence for the period 1970–2001. *Applied Economics letters, 12*(1), 45-49.

Lucas Jr, R. E. (1988). On the mechanics of economic development. *Journal of Monetary Economics, 22*(1), 3-42.

Nguyen, C. T., & Trinh, L. T. (2018). The impacts of public investment on private investment and economic growth. *Journal of Asian Business and Economic Studies, 25*(1), 15-31
Pereira, A. M. (2001). On the effects of public investment on private investment: what crowds in what?. *Public Finance Review*, 29(1), 3-25.

Phetsavong, K., & Ichihashi, M. (2012). *The impact of public and private investment on economic growth: evidence from developing Asian countries*. Hiroshima University.

Ram, R. (1986). Government size and economic growth: A new framework and some evidence from cross-section and time-series data. *The American Economic Review*, 76(1), 191-203.

Ramirez, M. D., & Nazmi, N. (2003). Public investment and economic growth in Latin America: An empirical test. *Review of Development Economics*, 7(1), 115-126.

Rebelo, S. (1991). Long-run policy analysis and long-run growth. *Journal of Political Economy*, 99(3), 500-521.

Romer, P. M. (1996). Increasing returns and long-run growth. *Journal of Political Economy*, 94(5), 1002-1037.

Seitz, H. (1994). Public capital and the demand for private inputs. *Journal of Public Economics*, 54(2), 287-307.

Shen, W., Yang, S. C. S., & Zanna, L. F. (2018). Government spending effects in low-income countries. *Journal of Development Economics*, 133, 201-219.

Solow, R. M. (1956). A contribution to the theory of economic growth. *The Quarterly Journal of Economics*, 70(1), 65-94.

Sims, E., & Wolff, J. (2018). The output and welfare effects of government spending shocks over the business cycle. *International Economic Review*, 59(3), 1403-1435.

Zou, Y. (2006). Empirical studies on the relationship between public and private investment and GDP growth. *Applied Economics*, 38(11), 1259-1270.
## APPENDICES

### APPENDIX A: COUNTRY LIST

| Serial | Country                                      | Continent  |
|--------|----------------------------------------------|------------|
| 1      | People's Democratic Republic of Algeria      | Africa     |
| 2      | Argentine Republic                           | South America |
| 3      | Kingdom of Bahrain                           | Asia       |
| 4      | People's Republic of Bangladesh              | Asia       |
| 5      | Barbados                                     | North America |
| 6      | Belize                                       | North America |
| 7      | Republic of Benin                            | Africa     |
| 8      | Republic of Botswana                          | Africa     |
| 9      | Federative Republic of Brazil                | South America |
| 10     | Burkina Faso                                 | Africa     |
| 11     | Republic of Burundi                           | Africa     |
| 12     | Republic of Cameroon                          | Africa     |
| 13     | Republic of Chad                              | Africa     |
| 14     | People's Republic of China                   | Asia       |
| 15     | Republic of Colombia                          | South America |
| 16     | Union of the Comoros                         | Africa     |
| 17     | Republic of the Congo                         | Africa     |
| 18     | Republic of Côte d'Ivoire                    | Africa     |
|   | Arab Republic of Egypt | Africa |
|---|------------------------|--------|
| 20 | Republic of Kenya      | Africa |
| 21 | Republic of Madagascar | Africa |
| 22 | Republic of Malawi     | Africa |
| 23 | Malaysia               | Asia   |
| 24 | Republic of Mali       | Africa |
| 25 | Nepal                  | Asia   |
| 26 | Republic of the Niger  | Africa |
| 27 | Federal Republic of Nigeria | Africa |
| 28 | Sultanate of Oman      | Asia   |
| 29 | Islamic Republic of Pakistan | Asia |
| 30 | Republic of Paraguay   | South America |
| 31 | Republic of Peru       | South America |
| 32 | Republic of the Philippines | Asia |
| 33 | Republic of Rwanda     | Africa |
| 34 | Republic of Senegal    | Africa |
| 35 | Republic of South Africa (RSA) | Africa |
| 36 | Democratic Socialist Republic of Sri Lanka | Asia |
| 37 | Republic of the Sudan  | Africa |
| 38 | United Republic of Tanzania | Africa |
| 39 | Republic of Zimbabwe   | Africa |
## APPENDIX B: FIXED-EFFECT REGRESSION OUTPUT (MODEL 1)

| Covariance Parameter Estimates | Fit Statistics                  |
|--------------------------------|---------------------------------|
| Residual 17.2650              | -2 Res Log Likelihood 6670.3   |
| Number of Observations 1170   | AIC (Smaller is Better) 6672.3 |
|                                | AICC (Smaller is Better) 6672.3|
|                                | BIC (Smaller is Better) 6677.4 |

| Parameter | Estimate | Standard Error | t Value | Pr>|t| |
|-----------|----------|----------------|---------|--------|
| Intercept | 1.3181   | 0.5091         | 2.59    | 0.0097 |
| DC        | 0.0132   | 0.0041         | 3.25    | 0.0012 |
| FDI       | -0.0268  | 0.0338         | -0.79   | 0.4273 |
| CAP       | 0.1151   | 0.150          | 7.67    | <.0001 |
| LAB       | -24.5856 | 7.1488         | -3.44   | 0.0006 |
| CON       | -0.1376  | 0.0251         | -5.48   | <.0001 |
APPENDIX C: FIXED-EFFECT REGRESSION OUTPUT (MODEL 2)

| Covariance Parameter Estimates | Fit Statistics               |
|--------------------------------|-----------------------------|
| Residual                       | -2 Res Log Likelihood 6716.5|
| Number of Observations         | AIC (Smaller is Better) 6718.5|
|                                | AICC (Smaller is Better) 6718.5|
|                                | BIC (Smaller is Better) 6723.5|

| Parameter | Estimate | Standard Error | t Value | Pr>|t| |
|-----------|----------|----------------|---------|------|
| Intercept | 2.3098   | 0.5193         | 4.45    | <.0001 |
| DC        | 0.0046   | 0.0042         | 1.12    | 0.2632 |
| FDI       | -0.0137  | 0.0345         | -0.40   | 0.6902 |
| CAP       | 0.1191   | 0.0153         | 7.78    | <.0001 |
| LAB       | 19.6814  | 7.2921         | 2.70    | 0.0071 |
| CON       | -0.1193  | 0.0256         | -4.66   | <.0001 |
APPENDIX D: FIGURES

Figure 1: Prior Distributions (Public Investments)
Figure 2: Prior Distributions (Private Investments)
Figure 3: Simulated Scatter Plots

Figure 4: MCMC Trace Plots (CAP)
Figure 5: MCMC Trace Plots (LAB)

Figure 6: MCMC Trace Plots (DC)

Figure 7: MCMC Trace Plots (FDI)
Figure 8: MCMC Density Plots (CAP)

Figure 9: MCMC Density Plots (LAB)

Figure 10: MCMC Density Plots (DC)
Figure 11: MCMC Density Plots (FDI)

Figure 12: MCMC Autocorrelation Plot (CAP)
Figure 13: MCMC Autocorrelation Plot (LAB)

Figure 14: MCMC Autocorrelation Plot (DC)
Figure 15: MCMC Autocorrelation Plot (FDI)

Figure 16: Posterior Distribution
Figure 17: Posterior Predictive Check