Essays on Foreign Aid and Macro-Economic Performance of Sub-Saharan African Countries

by

Omar Saleh

M.A., Simon Fraser University

M.B.A., University of Toledo

Post Baccalaureate Diploma in Economics, Simon Fraser University

B.Sc., Lebanese American University

A dissertation submitted to the Faculty of Graduate Studies in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

in the Department of Economics

Supervisory Committee

Essays on Foreign Aid and Macro-Economic Performance of Sub-Saharan African Countries

by

Omar Saleh

M.A., Simon Fraser University

M.B.A., University of Toledo

Post Baccalaureate Diploma in Economics, Simon Fraser University

B.Sc., Lebanese American University

Supervisory Committee

Dr. Alok Kumar, Department of Economics

Supervisor

Dr. Merwan Engineer, Department of Economics

Departmental Member

Dr. Sorin Rizeanu, Gustavson School of Business

Outside Member

Abstract

Foreign aid is a major flow of income into sub-Saharan African (SSA) countries, averaging roughly 12% of GDP over the last four decades. Yet, SSA countries are characterized by very low per capita output, low human capital attainment, and widespread poverty. This dissertation investigates the macroeconomic and welfare effects of foreign aid to SSA countries. The empirical part of the dissertation studies 22 SSA countries, and uses a cointegrated vector autoregressive analysis (CVAR). This methodology identifies long-run effects without imposing strong statistical priors. I introduce tradable and non-tradable sectors into the analysis to determine if the so-called "Dutch Disease" is the reason for the plight of SSA countries. "Dutch Disease" occurs when a positive shock to foreign aid perversely reduces GDP, by decreasing the relative price of tradable to non-tradable goods, thus reducing the size of the tradable sector. While I find that aid reduces GDP in eight countries, this result is inconsistent with the "Dutch Disease" as it is not accompanied by large relative price changes. The analysis controls for a number of country-specific characteristics including extraordinary events. Overall, I find non-positive impacts of foreign aid on GDP and the tradable sector, with a few exceptions. I also consider the reverse causal channel and test whether country-specific macroeconomic variables drive foreign aid flows. I find that GDP, tradable output, and tradable and non-tradable goods prices do affect the amount of aid a country receives in 15 countries. These variables have no impact on foreign aid (aid is considered as weakly exogenous) in six countries.

The theoretical part of the dissertation develops two dynamic stochastic general equilibrium — real business cycle — (DSGE-RBC) models to analyze the effects of foreign aid on human capital investment and the business cycle. The distinguishing feature of the models is to embed a human capital investment in a small open economy model of Mendoza (1991). The first model considers one-sector DSGE model, which is followed by two-sector (tradable and non-tradable) DSGE model. Both models distinguish between physical and human capital investment and allow for labor-leisure choice. In the analysis, labor supply and time spent studying or acquiring skills are optimally chosen. The models are calibrated to match the key features of the Kenyan economy. In both models, a positive aid shock initially has a negative impact on labor supply and output. However, the shock subsequently has a positive effect on physical and human capital investment, and time spent studying. This is due to a positive income effect from the shock. A rise in foreign aid increases consumption; consumption smoothing across periods raises physical and human capital investment, labor productivity, and output. I also find that reducing the volatility of aid has

a significant positive effect on human capital investment and welfare. Policymakers should focus on reducing the volatility of foreign aid and not solely concentrate on the average level of aid.

The analysis of the two-sector DSGE-RBC model incorporates the role for the “Dutch Disease” mechanism. Consistent with the “Dutch Disease”, I find that a shock to foreign aid appreciates the relative price of non-tradable goods that causes the factors of production to reallocate from the tradable sector to the non-tradable sector, leading to a decline in GDP and the tradable output. Finding the “Dutch Disease” result here is not necessarily at odds with the CVAR estimation results as the DSGE-RBC simulation is a short-run analysis and the CVAR estimation is a long-run analysis.

Table of Contents

Lists of Tables

Lists of Figures

Acknowledgements

I would like to express my sincere gratitude to my supervisor Dr. Alok Kumar for his enormous support, abundant supervision, and encouragement over the course of my Ph.D. research. In addition, I am very thankful to my advisor Dr. Merwan Engineer who has been an outstanding mentor. Dr. Kumar's and Dr. Engineer's flexibility, understanding, and their valuable suggestions were of immense value without which I could not have finished my Ph.D. dissertation. I am grateful to both of them for their trust in me. I'd also like to thank Dr. Sorin Rizeanu for serving on my Doctoral committee and for his support.

I would like to express my gratitude to the faculty and staff of the Department of Economics. In particular, I'd like to thank Dr. Graham Voss, Dr. Fatemeh Mokhtarzaddeh, Dr. Felix Pretis, Dr. Ke Xu, Dr. Kenneth Stewart, Dr. Marco Cozzi, Dr. Chris Auld, Dr. Paul Schure, and Dr. Maggie Jones for their valuable comments and suggestions.

I am deeply and eternally grateful to my dear wife, Nahla. Throughout my studies, she has been a pillar of support. Without her loving and unconditional support, completing my Ph.D. dissertation would have been impossible. My love goes to my little daughters, Ikram and Syrine, who give me the determination to succeed.

Finally, I would like to express my deep appreciation and thankfulness to my mother, Ikram, Uncle Akram, and to my sisters, Zeinab and Lara, who with their love, support, and encouragement enabled me to persevere through the challenges of my Ph.D. studies.

Dedications

To my mom, dad, wife, daughters, and sisters.

Chapter 1

Introduction

The people of sub-Saharan Africa (SSA) are the poorest in the world: about 42% of the estimated 910 million people in SSA, in 2013, lived below the World Bank's extreme poverty line of US $1.90 a day[1]. This extreme poverty persists despite SSA countries receiving more than a trillion dollars[2] in foreign aid since 1960. The ratio of foreign aid (official development assistance) to GDP in SSA countries has averaged 12% from 1970 to 2014, averaging around 8% in 2014. It is an open question of whether foreign aid to SSA countries has been effective in promoting economic development and growth.

Education is the cornerstone of economic development. It improves the efficiency of physical capital utilization and accelerates an economy's technological progression. It stimulates development and improves people's lives by increasing efficiency and fostering democracy (Barro, 1997; 2001), thus creating better conditions for quality governance, improving the health care system, and reducing inequality (Aghion et al., 1999). In particular, Barro (1991), Lucas (1988), Mankiw et al. (1992), and Sen (1999) emphasize the role of education and human capital accumulation, in the growth process from a macroeconomic perspective.

At the beginning of the 21st century, the United Nations (UN) had included universal access to education as the second of its Millennium Development Goals (MDGs). Yet, many parts of sub-Saharan Africa are still struggling to achieve primary school completion rates above 68%. The average number of schooling years completed in SSA was only five years in 2010. In 2016, UNESCO[3] stated that SSA countries had the highest rates of children and youth out of school: 20% of children aged six to 11 years, 33% of youth aged 12 to 14 years, and nearly 60% of the youth

---

[1] Calculations based on the database from World Development Indicators (2018). "Poverty headcount ratio at $1.90 a day is the percentage of the population living on less than $1.90 a day at 2011 international prices" (WDI, 2018).

[2] In 2010 constant US dollars, OECD database.

[3] http://uis.unesco.org/en/news/263-million-children-and-youth-are-out-school

aged 15 to 17 were not attending school. Guarcello et al. (2015) examine 25 developing countries, including eight SSA countries, and find that the majority of out-of-school children are usually engaged in child labor[4]. Education is one of the key components that can help in reducing child labor.

The UN's Sustainable Development Goals (SDGs) for the period 2015–2030 emphasize universal secondary education as well as access to job-skills training at higher education levels (Sustainable Development Solutions Networks Thematic Group on Early Childhood Development, Education and Transition to Work, 2014). By 2030, more than 600 million children in the world need to be enrolled in school to achieve the SDG goal of education for all. According to the UNESCO Global Education Monitoring (GEM) Report (2015), the world needs $39 billion annually to provide 12 years of quality education for all. According to the UNICEF Report (2015), 46 low-income countries, mostly located in sub-Saharan Africa, would need $26 billion yearly to achieve this goal. Poor educational attainment in SSA is a result of numerous factors including insufficient educational infrastructure which can be traced to insufficient resources available in these countries (Birdsall et al., 2001). Foreign aid can be aimed to bridge the resource gap between the required investment and the available resources, and can play a crucial role in meeting the SDGs.

Foreign aid is a major source of income for SSA countries. If well targeted, it can help recipient countries progress along their developmental paths (Sachs, 2005). From 1971 to 2016, total aid to education increased in real terms[5] from $10.3 billion to $12.2 billion - a 20% increase. However, over the same period, total aid disbursed to developing countries has increased by 400% and reached $176 billion in 2016 (See Figure 1.1a). During this period, aid to education as a share of total aid fell from around 23% to 7%. Figure 1.1b shows that aid to education as a share of total aid is decreasing, which means that achieving the SDG goal of education for all is likely to become more difficult. Figure 1.1c shows the distribution of aid to education from 2002 to 2016, whereas Figure 1.1d illustrates the averages for the period. On average, aid to tertiary education constituted 37% of total aid to education followed by aid to primary education which constituted around 30%, while aid to secondary education only constituted 10% of total aid to education.

[4] 32% of children aged seven to 11 years and 23% of children aged 12 to 14 years are working.
[5] Constant 2016 US$.

Figure 1.1: Aid to developing countries (Source: OECD 2017)

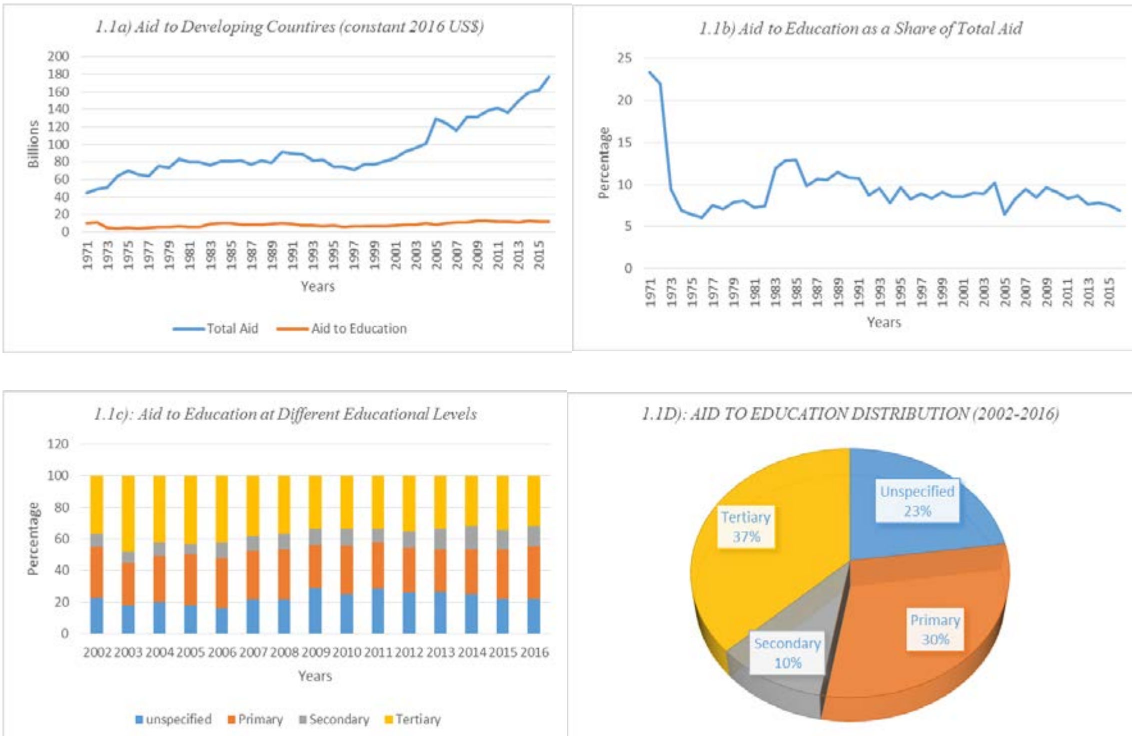
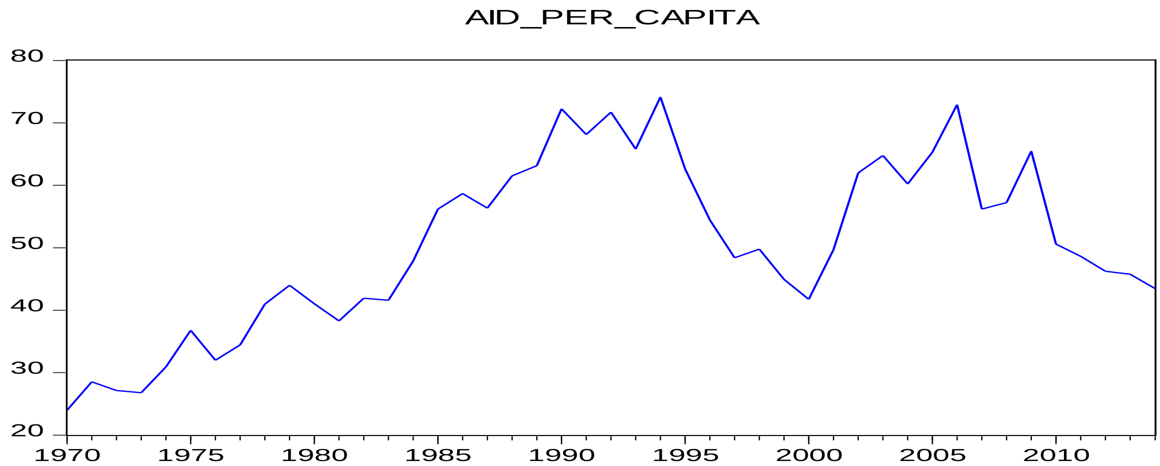


Figure 1.2 illustrates the behavior of the net official development assistance (ODA) per capita to SSA countries, for the last four decades. During the 1970–1994 period, the net ODA per capita was increasing; however, between 1994 and 2000, aid per capita declined due to structural adjustment programs adopted by the World Bank and the International Monetary Fund (IMF). Since 2001, the net ODA per capita began to increase, but by 2006 it started to decline. In 2005, the G8[6] held their meeting in Gleneagles, Scotland, and agreed to double the net ODA per capita to Africa by 2010, and keep it at that level thereafter. Unfortunately, the net ODA per capita started to fall shortly after the Gleneagles commitment. The decline in the net ODA per capita raises an important policy question: How can the SSA countries achieve the SDG goal of universal education?

[6] Group of Eight: Canada, France, Germany, Italy, Japan, Russia, UK, USA

Figure 1.2: Net per capita official developments assistance to SSA countries (Source: WDI, 2017)



While foreign aid may increase human capital investment by increasing resources; it may also have adverse effects. Foreign aid may appreciate the relative price of non-tradable goods (i.e. real exchange rate), leading to the reallocation of resources away from the tradable sector. The appreciation of the relative price of non-tradable goods reduces the competitiveness of exports, especially the manufactured goods (Corden, 1984), and has an adverse effect on the productive efficiency (Doucouliagos and Paldam, 2009). This so-called "Dutch Disease" has received considerable attention in the literature. Foreign aid is argued to have a negative impact on income and growth. Aid may also have adverse effects on economic sectors that are most in need of development such as the human-capital intensive tradable sector; this may reduce the return to education and decrease human capital investment. The manufacturing and services sectors are skill-intensive; skills must be continuously improved to maintain high profits and returns to skills which can be achieved by investing in education (Gylfason, 2001).

Another important question is whether the variability and uncertainty of foreign aid have detrimental welfare effects that undo the possible welfare benefits of foreign aid. The volatility in the flow of foreign aid arises largely from irregular aid disbursement patterns and donors conditionality (Pallage and Robe, 2001; Bulir and Hamann, 2003, 2008; Bulir and Lane, 2004). Unexpected aid shortfalls can lead recipient governments to reduce investment in human and physical capital, whereas aid windfalls increase government consumption (Celasun and Walliser, 2008). Fluctuations in the amount of foreign aid to the low development countries may have significant implications on the volatility of total output, consumption, and investment in those countries. The volatility of aid may negatively affect investment and welfare.

This dissertation provides a comprehensive analysis of the long-run impact of foreign aid to SSA countries. In particular, I investigate the impact of foreign aid on GDP as well as its impact on the tradable and non-tradable outputs and prices. First, I start with an empirical investigation of 22 SSA countries, using a cointegrated vector autoregressive (CVAR) model. Then, I provide a theoretical analysis, by using dynamic stochastic general equilibrium — real business cycle — (DSGE-RBC) models. A one-sector DSGE-RBC model is used to investigate the short-run impact of foreign aid on output, private human capital investment, and time devoted to acquire new skills. A two-sector DSGE-RBC model is developed to incorporate the role of the "Dutch Disease" mechanism and its effect on the GDP's structure, in addition to total output and human capital accumulation.

Both DSGE-RBC models are calibrated to match the salient features of the Kenyan economy for the 1970–2014 period. Because I study Kenya in greater details, Chapter 2 provides a description of the key features of the Kenyan economy.

Chapter 3 develops the empirical CVAR analysis of the long-run impact of aid flows on GDP and its composition for 22 sub-Saharan African countries. I find that aid has a persistent negative long-run impact on GDP in eight countries, a positive impact in three countries, and no effect on the rest of the countries. Foreign aid also appears to have diverse impacts on the GDP's composition. I find that aid has a positive impact on the tradable output in four countries and on the non-tradable output in six countries. On the other hand, aid flows have persistent negative impacts on the tradable and non-tradable sectors in 16 and five countries, respectively. I do not find that the negative impacts on the tradable sector are caused by the mechanism of a decline in the relative price of tradable to non-tradable goods. Thus, the analysis does not support that foreign aid to SSA countries causes the "Dutch Disease". For Kenya, a foreign aid shock has a persistent negative impact on GDP and the tradable output. However, foreign aid has only a transitory impact on tradable and non-tradable goods prices.

In Chapter 4, I develop a one-sector DSGE-RBC model of the Kenyan economy. I find that a positive shock to aid has business cycle implications. Initially, it lowers labor supply and output. However, subsequently, it has a positive effect on output which is due to the positive income effect. A rise in foreign aid increases consumption; consumption smoothing across periods raises physical and human capital investment, time spent studying, and labor productivity. The one-sector DSGE-RBC model finds that reducing the volatility of foreign aid has a significant positive effect on human capital investment and welfare. Policymakers should focus on reducing the volatility of foreign aid and not only on the average level of aid as foreign aid is highly volatile in SSA countries.

Chapter 5 extends the one-sector DSGE-RBC model in Chapter 4 into a two-sector DSGE-RBC model, by splitting the total output into tradable and non-tradable sectors. This extension incorporates the “Dutch Disease” mechanism into the model. Here, I find results similar to those in Chapter 4 concerning output, private human capital investment, study time, labor supply, physical capital investment, and consumption. In addition, the two-sector DSGE-RBC model suggests that a positive foreign aid shock leads to an appreciation of the relative price of non-tradable goods. The appreciation of the relative price of non-tradable goods leads to a reallocation of resources from the tradable to non-tradable sector, causing the tradable sector to shrink and the total output to drop. In addition, results show that decreasing the volatility of aid increases private human capital investment and study hours. Finally, a vector error correction model (VECM) analysis provides results that are consistent with the dynamics of the two-sector DSGE-RBC model.

The rest of this dissertation is organized as follows: Chapter 2 introduces Kenya, the country I choose to calibrate my DSGE-RBC models. The empirical part of the dissertation is presented in Chapter 3. Chapter 4 develops the one-sector DSGE-RBC model. In Chapter 5, I develop the two-sector DSGE-RBC model. The conclusion is discussed in Chapter 6.

Chapter 2

Kenya

2.1- Introduction

Kenya is located in East Africa and covers an area of 581,309 km^2 and has an estimated population of 50 million people in 2017; per capita income in Kenya was estimated at $3000 (PPP). Kenya is considered a typical aid recipient country where the aid-to-GDP ratio averaged around 6% for the period 1970–2014 period. I have chosen Kenya for the following reasons. First, it is an aid-dependent country. Second, Kenya's aid receipts as a share of GDP have been about half those of other sub-Saharan countries (See Table 3.1A), so doubling or tripling foreign aid is more applicable than elsewhere. Third, Kenya has produced higher-quality macroeconomic data than many other SSA countries.

Kenya gained its independence from the United Kingdom on December 12th, 1962. Since independence, Kenya has been a relatively stable country in sub-Sahara Africa with only one military coup attempt on August 1st, 1982. However, a political and humanitarian crisis occurred between December 2007 and February 2008 that led to chaos where 1,500 people were killed and about 600,000 people were displaced. Below, I discuss the structure of the Kenyan economy.

2.2- Agricultural Sector

Agriculture in Kenya is an important sector. It employed around 61.1% of the total employed labor force in 2005 (KILM, 2005). In 2014, the agricultural sector including forestry and fishing contributed 28% of the Kenyan value-added GDP, a decline from around 31% in 1970 (WDI, 2017). For the period 1970–2014, the agricultural sector grew at an average growth rate of 3.2% which is the same rate of population growth in Kenya. The agricultural sector is characterized by a poor performance which has negative implications on poverty levels as well as on the standard of living of the Kenyan people.

Around 48% of Kenyan land (274500 km^2) is classified as agricultural land; however, 16% of Kenyan land (91500 km^2) is considered as high to medium agricultural potential, while the rest is arid and semi-arid land (ASAL) with low agricultural potential. About 11% of the Kenyan population lives in the ASAL region and the rest lives in high to medium agricultural potential land regions. Most of the agricultural products are produced by small farms. There are about three million small-scale farms[7], where 81% of these farms are less than 20,000 m^2 each[8]. The small-scale farms contribute between 70-75% of the country's total value of the agricultural output and about 85% of the total employment in the agricultural sector; the rest is produced by the large-scale farms[9] (Odhiambo et al., 2004). The main agricultural products are maize, rice, sugar cane, coffee, tea, raw milk and horticultural.

The usage of agriculture machinery (tractors) is not intensive in Kenya. In 2002, tractors per 100 km^2 of arable land were 25, up from 20 in 1970. This number is 10% of that of the USA (WDI, 2017). The production in the large-scale farms relies heavily on techniques that are capital intensive (i.e. mechanised harvesting, tractors, etc…) and are more productive than the small-scale farms which are characterized by high labor intensity and the usage of traditional technologies (i.e. ox-drawn carts for plowing) (Odihiambo et al., 2004).

2.3- Manufacturing, Mining and Quarrying Sectors

The manufacturing sector in Kenya contributed 10% of the value added GDP in 2014. For the period 1970–2014, the manufacturing sector averaged about 10.5% of the total output, peaking to 12.8% in 2007 (WDI, 2017). On average the manufacturing sector grew by 5% for the same period. In 2005, only 4.2% of the total employed labor force was employed in the manufacturing sector (KILM, 2005).

There are many obstacles facing the manufacturing sector in Kenya. For instance, private and public investments in the manufacturing sector are low and are not enough to enable the sector to take off. Public infrastructure investments are essential to reduce transaction costs, while private investments in technology and research and development (R&D) are essential to increase efficiency and productivity. Both types of investment are required for the manufacturing companies in Kenya to compete internationally (Bigsten et al., 2010). However, R&D expenditure as a percentage of GDP in Kenya is very low compared to developed countries. In 2010, Kenya spent 1% of its GDP

---

[7] Areas of the farms range from 5,000 to 100,000 m^2.
[8] Kenya's Agricultural Produce. Retrieved from:
http://www.kenyabrussels.com/index.php?menu=6&leftmenu=88&page=89
[9] Average size: 7 million sq. m.

on R&D (WDI, 2017). In reality, Kenyan manufacturing firms rely heavily on foreign technology and foreign R&D. The location of Kenya at the equator makes it far from the countries that are technology leaders. This remoteness is a disadvantage relative to countries that are closer to the leaders (Keller, 2002). The main manufacturing products in Kenya are the following: food manufacturing, textiles, footwear, leather, rubber and plastic, petroleum, industrial chemicals, paints, furniture and fixtures, soft drinks, cement, and metal products.

The mining and quarrying sector contributed less than 0.8% of the Kenyan GDP in 2014 (KNBS, 2015). The main minerals produced are: soda ash, limestone, gold, salt, and fossil fuel.

2.4- Other Industries

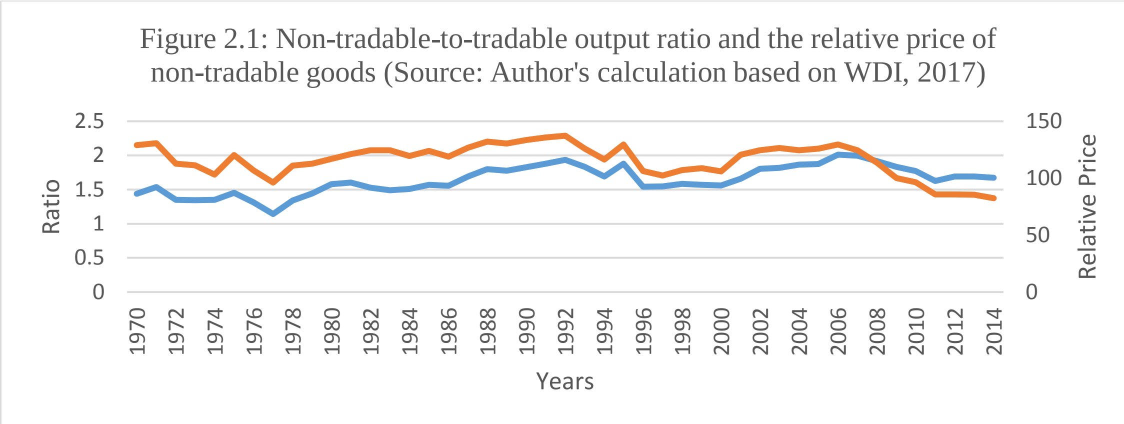
This sector includes telecommunication, construction, electricity, gas, and water. This sector is heavily capital intensive and contributed 7.25% of the total value added GDP in 2014. This sector grew on average by 5% for the 1970–2014 period (WDI, 2017). In 2005, 2.6% of the total employed labor force was working in other industries (KILM, 2005).

2.5- Service Sector

The service sector in Kenya is the largest sector. Service sector’s contribution represented 48% of the Kenyan economy in 2014 (WDI, 2017). In 2005, 32.2% of the employed labor force was employed in the service sector (KILM, 2005). The service sector as a share of GDP has increased from 42% in 1970 to 48% in 2014 and grew on average by 5%. The service sector includes the following services: wholesale and retail trade, hotels and restaurants, storage, transport and communications, insurance, financial intermediaries, real estate, business services, government, education and healthcare, community social and other personal services.

2.6- GDP’s Composition and the Relative Price of Non-tradable Goods

The tradable output is composed of following sectors: agricultural, forestry, hunting, fishing and manufacturing sectors. The rest of the GDP is assumed to be a non-tradable output. The tradable output-to-GDP ratio has declined from 41% in 1970 to 37% in 2014. Figure 2.1 below shows the non-tradable-to-tradable output ratio and the relative price of non-tradable goods. Consistent with the “Dutch Disease” phenomenon, the movements in the non-tradable-to-tradable output ratio is positively related to the movement of the relative price of non-tradable goods.



2.7- Schooling System in Kenya

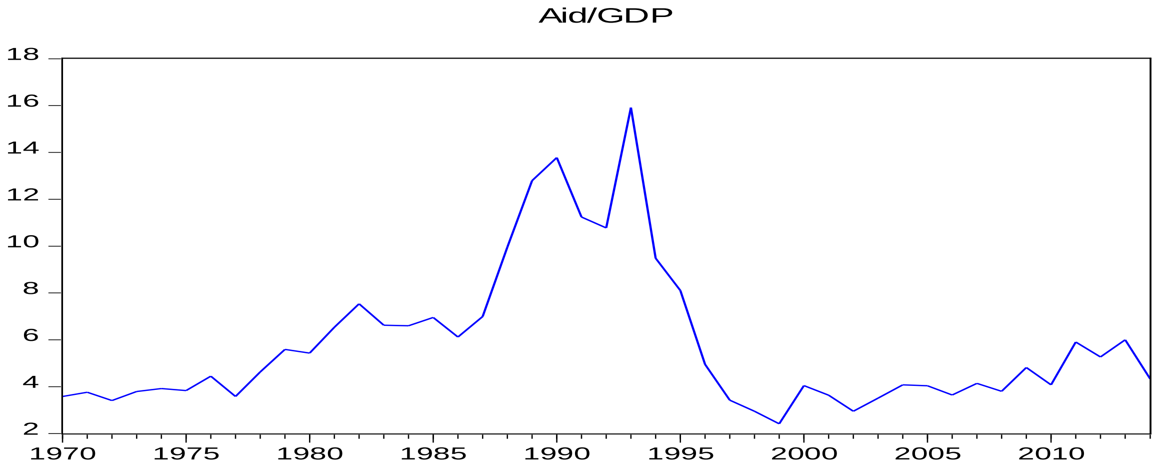
The current system of education was established in 1985. It follows the USA educational system model; the basic (primary and middle) education consists of 8 years followed by 4 years of secondary education and 4 years of university education. The average years of schooling in Kenya was 6.3 years[10] in 2015, which means that on average the majority of Kenyans did not complete their basic education. In 2010[11], 55% of Kenyans aged 15 and above had attended primary school but only 22% had completed it; 22.5% had attended secondary school but 13.3% had completed it; and 6.5% had attended tertiary schooling, but with a completion rate of only 3.4%. Government spending on public education was on average 5.36% of the total GDP for the 1970–2014 period and 5.45% of the total GDP during the 2002–2014 period.

2.8- Foreign Aid

Kenya is a typical aid recipient country that receives a considerable amount of foreign aid. Aid flows to Kenya (in 2010 constant USD) have been volatile, increasing from US $242 million in 1970 (3.6% of GDP) to a peak of US $3.5 billion in 1993 (16% of GDP - see Figure 2.2). However, foreign aid dropped during the 1994–1999 period due to actions that were taken by international donors, the International Monetary Fund (IMF) and the World Bank, who forced the Kenyan government to start economic reforms in 1994. Foreign aid reached a low of $630 million (2.4% of GDP) in 1999 with some recovery thereafter in response to the devastating drought that hit Northern Kenya in 2000 where 3 million people starved. The resumption of aid coincided with the change of the Kenyan government after the 2002 elections.

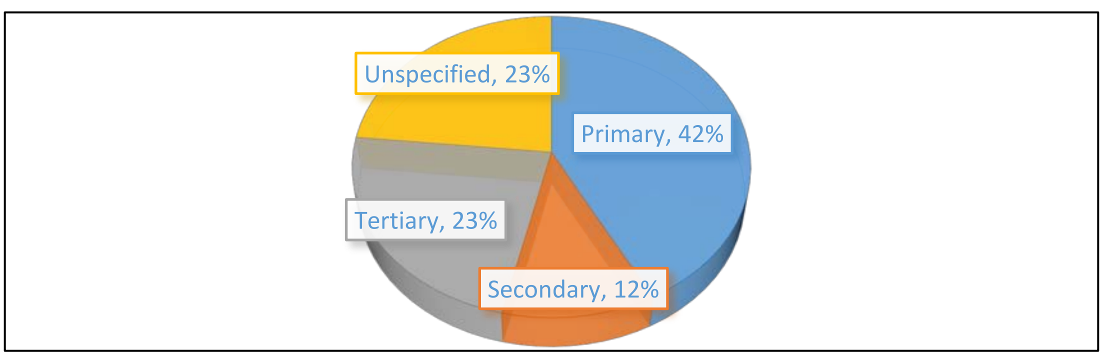
[10] Education Index issued by UN.
[11] See Baroo and Lee (2013).

Figure 2.2: Kenyan aid-to-GDP ratio 1970-2014 (Source: WDI, 2017)



From 2002 till 2014 aid-to-GDP averaged around 5% and aid to education as a total percentage of total aid disbursed did not exceed 5%, that is only 0.25% of total aid went directly to support the education system in Kenya. Figure 2.3 illustrates the distribution of aid into education among different educational levels for the 2002-2014 period. The primary education received 42%, secondary education received 12%, tertiary education received 23% of total aid to education, and the rest were used for unspecified purposes.

FIGURE 2.3: AID TO EDUCATION SHARE BY EDUCATIONAL LEVELS(AVERAGES 2002-2014. SOURCE: OECD, 2017)



Chapter 3

Have Sub-Saharan African Countries Caught the "Dutch Disease" from Foreign Aid? A Cointegrated VAR Analysis

3.1-Introduction

The literature on the effectiveness of foreign aid has widely diverse results and views (e.g. Howes (2011)). In a recent paper, Juselius et al. (2014) discuss the methodological issues behind the widely varying results in the literature. The use of a single equation to estimate the effect of foreign aid usually suffers from endogeneity bias; a valid instrumental variable for foreign aid is hard to find. In addition, the use of cross-country data analysis does not capture the dynamic effects of aid and its short-run and long-run effects on the macro economy. Durlauf (2002) argues that cross-country growth regressions are not informative for policymakers as there is no relationship between statistical significance and policy implications. Furthermore, panel data models are estimated under strict assumptions about the causal mechanisms. In contrast to these approaches, the unrestricted country-specific cointegrated vector autoregressive (CVAR) methodology allows for the identification of long-run results, without imposing strong statistical priors while controlling for country-specific characteristics and extreme events.

Juselius et al. (2014) apply their CVAR methodology to examine SSA countries, as this region is the leading case for identifying whether foreign aid is effective. They provide an overview of the long-run impact of foreign aid on real GDP, investment, private consumption, and government expenditure in 36 SSA countries. They find that in 27 SSA countries, foreign aid has a positive impact on either GDP or investment, or on both. The findings of Juselius et al. (2014) are compelling because they employ a CVAR methodology and control for a number of country-specific characteristics including extraordinary events. However, they use PPP adjusted data which precludes the change in the relative prices within the country.

I extend the Juselius et al. (2014) model to examine the impact of aid on GDP and its composition into tradable and non-tradable sectors. In addition to being more disaggregated, my approach allows for the identification of the "Dutch Disease". The "Dutch Disease" occurs when a positive shock to the foreign aid reduces GDP by decreasing the relative price of tradable to non-tradable goods, and reducing the size of the tradable sector.

The term "Dutch Disease" was coined by *The Economist* in 1977; Corden (1984) describes the situation in the Netherlands following the discovery of natural gas in the 1960s. The appreciation of the Dutch Guilder following the discovery reduced the competitiveness of manufactured goods exporters. In the same way, foreign aid in less-developed countries may negatively impact those sectors most in need of development, such as the tradable sector (Larrain and Sachs, 1993).

This chapter provides a comprehensive analysis of the long-run impact of foreign aid on GDP, tradable and non-tradable outputs, and tradable and non-tradable goods prices. Based on the reliable data for the tradable and non-tradable sectors for 22 SSA countries, during a period spanning from the mid-1960s to 2014, I contribute to the literature in three ways.

First, I develop a CVAR model designed to examine the long-run impact of aid flows on GDP and its composition for each country. I draw several conclusions motivated by the presence of two types of heterogeneity: aid heterogeneity, where each country receives a different aid-to-GDP share; and GDP's composition heterogeneity, where GDP's structure of tradable and non-tradable sectors differs across countries. I find that aid has a persistent negative long-run impact on GDP in eight countries, a positive impact in three countries, and no effect on the rest of the countries. Foreign aid also has diverse impacts on GDP's structure. I find that foreign aid has a positive impact on the tradable output in four countries and on the non-tradable output in six countries. On the other hand, aid flows have persistent negative impacts on the tradable and non-tradable sectors in 16 and five countries, respectively.

Second, the analysis does not support that foreign aid to SSA countries causes the "Dutch Disease" in the long-run. I do not find that negative impacts on the tradable sector are caused by the mechanism of a decrease in the relative price of tradable to non-tradable goods[12]. This raises a future research question of what transmission mechanism in the SSA countries causes the tradable sectors to shrink when aid increases.

[12] No single country has experience the four phases of "Dutch Disease": decrease in the price of tradable goods, increase in the price of non-tradable goods, decrease in the tradable output, and decrease in total output.

Third, I examine whether country's macro variables impact the amount of foreign aid a country receives. I find that GDP, tradable output, and tradable and non-tradable goods prices do affect the amount of foreign aid a country receives: aid is found to be neither weakly exogenous nor completely endogenous in 15 countries. These variables have no impact on foreign aid in six countries: aid is considered as weakly exogenous.

In my model, I take into account a number of variables and factors that reflect country-specific characteristics. Some idiosyncratic events have a significant impact on the economy. For instance, structural reforms, civil wars, conflicts, droughts, floods, and policy interventions may impact the variables of interest in ways which may change the results (Nielsen, 2008). These variables tend to bias the model parameter estimates unless adequately controlled for. In addition to permanent and transitory impulse dummies to account for extraordinary shocks, I use step dummies to account for equilibrium mean shifts in the equilibrium long-run relations.

The impact of aid on GDP and its composition is also examined by Arndt et al. (2015), Kumi et al. (2017), and Selaya and Thiele (2010). My paper differs in five key ways. First, I investigate the long-run impact of aid on the tradable and non-tradable sectors, whereas these papers analyze the impact of aid on the main sectors (agriculture, manufacturing, industry, and services sectors). Second, I use aid in levels, whereas aid as a share of GDP is used in the other papers. Unlike aid-to-GDP ratio in some countries, aid in levels is non-stationary. Third, the econometric methodology is different: I use a time series approach for each country similar to the Juselius et al. (2014) methodology. Arndt et al. (2015) use cross-section data analysis, and the other two papers use a generalized method of moments (GMM-SYS). Fourth, heterogeneity is more robustly addressed in my model, where each country is modeled with its idiosyncratic characteristics. Fifth, for policy implications, it is preferable to separately study the impact of aid on each country's economy, since one policy that works well in one country may not necessarily work in another.

Understanding the roles of the tradable sector is important for development policy. In 2015, the United Nations adopted a set of seventeen Sustainable Development Goals (SDGs). Goal 2 is to "end hunger, achieve food security and improved nutrition, and promote sustainable agriculture" by 2030; Goal 9 is to "build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation".[13] These objectives could be better achieved if less-developed countries were able to increase agricultural productivity, manufacturing productivity, and the incomes of small-scale food producers. The tradable sector is composed of agricultural and

[13] UNDP. Retrieved on 10/11/2018.

manufacturing sectors and is important for several reasons. First, the tradable sector in less-developed countries is labor intensive (Arellano et al., 2009; Rajan and Subramanian, 2006; 2008), and any change in its size would have a direct impact on the return to labor. Second, paying back foreign debt to the lenders involves tradable goods and is problematic when the tradable sector is shrinking. Third, exports of tradable goods are beneficial for economic growth.

The remainder of this chapter is organized as follows. Section 3.2 reviews the literature. Section 3.3 introduces the key variables and discusses the data sources and stationarity testing. The econometric approach is discussed in Section 3.4. Section 3.5 discusses the causal links between foreign aid and other variables. Section 3.6 shows the results of my analysis of the impact of foreign aid on the key variables. Robustness checking is presented in Section 3.7. Section 3.8 examines the impact of GDP and the tradable output on the flows of foreign aid. Section 3.9 summarizes and concludes.

3.2- Literature Review

The empirical literature on aid effectiveness on economic growth has not yielded clear and unambiguous results due to "heterogeneity of aid motives, the limitations of the tools of analysis, and the complex causality chain linking external aid to final outcomes" (Bourguignon and Sundberg, 2007). A number of studies find a positive effect of foreign aid on economic growth (e.g. Collier and Hoeffler, 2004; Dalgaard et al., 2004; Feeny and McGillivary, 2010; Hansen and Tarp, 2000; Karras, 2006; Kosack and Tobin, 2006; Loxley and Sackery, 2008; Juselius et al., 2014). On the other hand, there exist a number of studies that find little or no impact of aid on economic growth (e.g. Boone, 1996; Brumm, 2003; Easterly et al., 2004; Markandya et al., 2010; Ovaska, 2003; Rajan and Subramanian, 2008).

Researchers have been trying to answer if foreign aid is effective or not for recipient countries economic growth and development, but there is no definitive answer. Howes (2011) has classified the conflicting views on aid effectiveness into four categories depending on two dimensions — good or bad (outcome kind) and large or small (outcome scale) —as follows. First, good and large: Sachs (2005) argues that foreign aid could have a transformative effect on growth if applied in the right way and large volumes. Second, bad and large: Bauer and Yamey (1982) argue that aid has a negative large impact. Third, good and small: foreign aid has a minor and positive effect on development (Birdsall et al., 2005). Fourth, bad and small: aid has a little and negative effect on development (Easterly, 2006).

According to Feeny and McGillivary (2010), foreign aid spurred economic growth in recipient countries and it works better in some countries than in others. They find that foreign aid is found to have diminishing returns and specific types of aid are likely to be effective in poverty reduction and on economic growth. On the other hand, Rajan and Subramanian (2008) find little robust evidence of a positive or negative relationship between foreign aid and economic growth by using cross-sectional and panel data from 107 countries for a period spanning from 1960 till 2000. They also find no evidence that aid works better in countries adopting better policies, contradicting Burnside and Dollar (2000) who argue that aid is effective in a good policy environment.

3.2.1- Foreign Aid and the GDP's Composition

Arndt et al. (2015) study the effect of foreign aid on economic transformation for 78 countries for the 1970–2007 period and show that aid reduces poverty and stimulates growth. They also find that these countries experience economic transformation as the agricultural sector as a share of GDP is shrinking, while industrial and services sectors as a share of GDP are expanding. Their results coincide with Arndt et al. (2010) in a similar study but for a shorter period (1970–2000).

In a recent study, Kumi et al. (2017) examine the impact of aid and its volatility on agricultural, manufacturing, and services sectors in 37 SSA countries for the period 1980–2014 using a GMM-SYS. They find a positive and significant effect of aid on agricultural, manufacturing, and service sectors suggesting that aid inflows spur both the tradable[14] and non-tradable sectors. They find that the volatility of aid inflows has a negative impact on the manufacturing and services sectors. On the other hand, Arellano et al. (2009) find that aid inflows, to 73 aid-receiving countries for a period spanning from 1981 to 2000, have a negative effect on the manufacturing exports. Their results suggest that an additional 1% increase in the aid-to-GDP ratio is associated with a decrease in the manufactured exports by about 0.3-0.5% of total exports.

Selaya and Thiele (2010) examine the effect of aid on GDP's sectoral growth in 65 countries using a GMM-SYS regressions over a period spanning from 1962 to 2001. They disaggregate GDP into three parts: agriculture, industry, and services; they estimate the role of aid as a share of GDP on each sectoral growth rate. Their main findings suggest that aid has a positive effect on economic growth and on the tradable[15] and non-tradable growth sectors. Their results show no evidence of the "Dutch Disease" type effects. Demekas et al. (2002) propose that post-conflict reconstruction aid may raise the capital stock equilibrium level and does not necessarily lead to a shrinkage of the

[14] They assume agriculture and manufacturing sectors as tradable sectors.
[15] They assume agriculture and industry sectors as tradable sectors.

tradable sector. In addition, Collier and Hoeffler (2004) find that aid is effective if introduced between three to seven years after the end of the war.

3.2.2- Foreign Aid and the "Dutch Disease"

There is a small empirical literature on the effect of foreign aid on the real exchange rate[16] (RER) and on the tradable output. Some studies have found that foreign aid leads to an appreciation of the real exchange rate while others have found the opposite. Rajan and Subramanian (2006) examine the impact of aid on the recipient countries and find no long-term effects on growth even with countries that adopt good policies. They use data for 32 developing countries and report that aid inflows have adverse effects on country's competitiveness, "as reflected in a decline in the share of labor intensive and tradable industries in the manufacturing sector". They also show that high-labor share industries grow slower than low-labor share industries in the developing countries that receive a substantial amount of aid. Poor countries are labor abundant and depend on exporting labor-intensive and low-skill technologies. Thus, aid inflows would have negative effects by slowing the trade that is essential to promote growth (Michaeely, 1981, Rajan and Subramanian, 2008). Moreover, Rajan and Subramanian (2011) find that aid inflows have negative implications on the country's competitiveness reflected by the lower growth rate of exportable industries due to real exchange rate appreciation caused by foreign aid.

Yano and Nugent (1999) observe that aid is associated with the real exchange rate appreciation in about half of 44 aid-dependent countries between 1970 and 1990, and find the reverse for the other half. Elbadawi (1999) finds that aid flows have caused substantial real exchange rate appreciation in many African and non-African countries; the real exchange rate appreciation hinders export expansion. He uses data for a panel of 62 developing countries (28 from Africa). Fielding and Gibson (2013) use data for 26 African countries and estimate a VAR of three endogenous variables (GDP, RER, and GDP deflator growth rate), in addition to aid which was considered as a weakly exogenous variable. Their main conclusion suggests a presence of a real exchange rate appreciation in most SSA countries and the size of effects differ from one country to another. In contrast, they only find one country exhibiting real exchange rate depreciation.

Using a VAR model, Addison and Baliamoune-Lutz (2013) find evidence that aid causes real exchange rate appreciation in Morocco in the long run, but has no effect on the real exchange rate

[16] The real exchange rate is defined by Mendoza and Uribe (2000) as the relative price of non-tradable goods in terms of tradable goods (i.e. $\frac{P^N}{P^T}$). Other studies use a proxy for the real exchange rate such as the relative consumer prices between the major trade partners.

in Tunisia. Lartey (2007) observes that an increase in official aid causes a real appreciation of the exchange rate and its magnitude is greater than that associated with foreign direct investments (FDI) in a sample of SSA countries from a period spanning from 1980 till 2000. In a recent study, Juselius et al. (2017) find that a shock to foreign aid causes the real exchange rate to appreciate in the long-run in Ghana, but not in Tanzania. Kang et al. (2013) study the effect of aid shocks on GDP per capita growth, exports, and imports in 30 aid-receiving countries, using a heterogeneous panel VAR model. They find that in 16 countries, global aid has a negative effect on GDP per capita growth, consistent with the "Dutch Disease" hypothesis.

On the other hand, Li and Rowe (2007) find, by using a vector error correction model (VECM), that increases in aid inflows are associated with a depreciation in the real effective exchange rate in Tanzania from 1970 till 2005. Issa and Ouattara (2008) find, by using autoregressive distributed lag (ARDL) model, no evidence in the short-run or in the long-run of the "Dutch Disease" in Syria during the 1965–1997 period. Mongardini and Rayner (2009) use a pooled mean group estimator for 24 SSA countries from 1980 to 2006. They find that grants and remittances are not associated with an appreciation of the real exchange rate in SSA countries in the long run, therefore no "Dutch Disease" effects.

The existing empirical papers estimate the real exchange rate indirectly; while the present chapter directly constructs the real exchange rate from tradable and non-tradable goods prices. In contrast to most of the existing literature which uses cross-country or panel regressions, my approach is based on a single country time-series analysis where 22 CVAR models are estimated. This chapter extends the above empirical literature by employing a multivariate time-series approach to investigate the long-run impact of foreign aid on GDP, tradable and non-tradable outputs, and tradable and non-tradable goods prices.

3.3- Data Sources and Stationarity Tests

3.3.1- Data Sources

Data for GDP, tradable and non-tradable outputs in current and constant value-added prices are taken from the World Development Indicators (WDI, 2017)[17]. Official Development Aid (ODA) data[18] are sourced from the Organisation for Economic Co-operation and Development (OECD). Most African countries have big informal and subsistence sectors and even in the formal sectors not all the transactions are formally recorded (Jerven, 2010). The international agencies (The World Bank, IMF, OECD, etc…) supply aggregate national data and apply different statistical methods to gather them into continuous series over different base years. The main sources of publicly available data are the WDI, IMF, and Penn Tables (PWT); using different data sources and data transformation may lead to different results (Juselius et al., 2014). The WDI database are better suited for this study as the WDI is a reliable source at disaggregated level data in constant and current prices of agricultural, manufacturing, industrial, and services value-added.

Table 3.1A, presented at the end of the chapter, shows the SSA countries that are included in this study. Out of the 48 SSA countries only 22 countries are included. The rest are excluded (See Table A1, Appendix A.1) due to many reasons such as missing data on the tradable and non-tradable outputs, negative aid (Gabon and Mauritius in 2003), stationarity of aid time-series data (Comoros, Congo Republic, Namibia, and Swaziland), and prices (prices are found to be I(2) in Zambia). To mitigate the problem of degrees of freedom erosion in the CVAR model, I make the sample size as big as possible. The availability of data constraints the sample size to a minimum of 33 annual observations for Madagascar to a maximum of 51 for Sierra Leone.

The heterogeneity of aid-to-GDP and the heterogeneity of tradable output-to-GDP ratios are addressed in this empirical study. The aid-to-GDP ratio ranges from 4% in Cameroon to 25.3% in Cape Verde with an average of 12% for the overall sample. When agricultural and manufacturing sectors constitute the tradable sector, tradable output-to-GDP ratio ranges between 18.3% in Botswana to 53.65% in Central African Republic. When the tradable output is composed of agricultural and industrial sectors, tradable output-to-GDP ranges from 32.8% in Cape Verde to 61% in Sierra Leone. Kenya's aid-to-GDP ratio equals 5.75% (half of the sample), while Kenya's tradable output constitute 38% of GDP.

[17] Downloaded on 15/09/2017.

[18] Foreign aid data disaggregated at sectorial level starts from 2002. This short period considers inapplicable to CVAR model, as I need at least 30 observations to evaluate a CVAR model. I use aid at aggregate level.

The data on exports and imports as a share of GDP are presented in Table 3.1B. This table gives a perspective on how dependent each economy is on exporting and importing goods and services. Exports-to-GDP ranges from 2.65% in Ethiopia to a maximum of 49% in Botswana. Whereas, imports-to-GDP ranges between 9.4% in Ethiopia to a maximum of 74% in Seychelles. All SSA countries exhibit a trade deficit that ranges from 3.2% in Botswana to 47% in Lesotho. Furthermore, aid-to-GDP exceeds exports-to-GDP in five SSA countries[19]; whereas, in 12 SSA countries[20] aid-to-GDP ratio exceeds the trade deficit. These numbers emphasize the importance of aid to SSA countries as a source of income.

3.3.1.1 Human Capital Data

For this empirical analysis, I have not included a relevant variable to measure human capital such as educational attainment or enrollment for the following reasons:

a. The data on the average years of schooling are available only every 5 years (Barro and Lee, 2013). These data are not continuous.
b. The data on the education index which is one of three components of the UN Human Development Index starts from 1990.
c. The number of pupils attending primary, secondary, and tertiary education has a lot of missing data.
d. The human capital index which is introduced by PWT version 8 and is "based on the average years of schooling from Barro and Lee (2013) and an assumed rate of return to education, based on Mincer equation estimates around the world (Psacharopoulos, 1994)". These data seem to be I(2) and cannot be used in the present model.

3.3.2- Data Transformation

The data are annual observations and comprise of the following variables: net Official Development Assistance (aid_t), Gross Domestic Product (gdp_t), tradable output ($trad_t$), non-tradable output ($ntrad_t$), price of the tradable goods (p_t^T), and price of the non-tradable goods (p_t^{NT}). Small letters denote logarithmic values. Macroeconomic variables are usually trending over time, suggesting a multiplicative rather than an additive specification; by taking logs an additive model form can be

[19] Burkina Faso, Burundi, Ethiopia, Lesotho, and Rwanda.
[20] Botswana, Burundi, Cameroon, Central Africa, Ethiopia, Gambia, Malawi, Mali, Mauritania, Rwanda, Sierra Leonne, and Uganda.

achieved. I follow Juselius et al. (2014) logarithmic transformation of the variables at levels instead of using ratios such as aid-to-GDP and tradable output-to-GDP as these ratios are usually bounded between 0% and 100%. In addition, I do not use GDP per capita as the logarithm of population is usually found close to I(2), in contrast to logarithm of real GDP which is found to be I(1) (Juselius et al., 2014). Dividing GDP (I(1) variable) with population (I(2) variable) is likely to weaken any statistical inferences as Kongsted (2005) suggests. Data definitions and measurements are presented in Appendix A.4.

3.3.3-Stationarity Tests

Time-series data are time dependent and it is crucial that the data are investigated and tested if they are stationary[21], non-stationary[22], and whether the series are subject to structural breaks. It is preferable to start with graphical representations of the level and first difference of the series to reveal data features[23]. The variables' series (aid_t, $gdp_t, ntrad_t$, $trad_t$, p_t^T $and\, p_t^{NT}$)[24] in levels exhibit trend like behavior over the sample period (i.e. trending) and the first difference appears stationary around the trend (i.e. trend-stationary).

Time series data are in general non-stationary data and cross estimations can result in spurious results that lead to meaningless statistical results. To get credible results, time series data should be differenced *d* times to become stationary; that is, the series is integrated of order *d* and denoted by I(d).

3.3.3.1- Unit Root Tests[25]

I begin with a preliminary assessment of the presence of unit roots in the data by conducting several unit-root tests. In this study, the time-series property of each variable is investigated through the Augmented Dickey-Fuller (ADF), the Philipps-Perron (PP), and the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) tests for the unit root[26].

The ADF (1979) tests the null hypothesis that the series has a unit root versus the alternative hypothesis that the series is stationary or trend stationary. If the test t-statistic is less than the critical value (negative), then the null hypothesis can be rejected and no unit root is present in the series.

---

[21] Mean is constant; variance is finite and does not depend on time.

[22] Mean and variance vary over time.

[23] The graphs are not presented in this paper and can be presented upon request.

[24] The relative price of non-tradable good is stationary in most countries; as it is a ratio of 2 ratios: $p^N = \frac{p^{NT}}{p^T}$

[25] I have relied on testing individual series and not rely only on rank testing alone as some variables are I(2) such as the prices in Zambia (excluded from the study).

[26] The tests' results can be obtained upon request.

Whereas, if the test t-statistic is greater than the critical value, then the null hypothesis cannot be rejected and a unit root is present in the series. The PP (1988) tests the null hypothesis that the series has a unit root versus the alternative hypothesis that the series is stationary or trend stationary. PP test is similar to the ADF test, but it is robust to unspecified autocorrelation and heteroscedasticity in the disturbance process of the test equation. On the other hand, the KPSS (1992) tests the null hypothesis that the series is stationary around a deterministic trend versus the alternative of a presence of a unit root in the series. Contrary to the ADF and the PP tests, the presence of the unit root is under the alternative hypothesis and not under the null hypothesis.

All the variables under the ADF and the KPSS tests are found to be non-stationary in levels. The variables under the PP test are also found to be non-stationary in levels except for aid series in the following countries (Burkina Faso, Cameroon, Mauritania, Senegal, and Seychelles), where aid is found to be stationary. Furthermore, the tradable output in Senegal, tradable goods price in Togo, and non-tradable goods price in Cape Verde are found to be stationary. At first differencing, the ADF's and the KPSS's calculated test statistics clearly reject the presence of a unit root, confirming stationarity of each variable at first differencing and depicting the same order of integration (i.e. I(1)). However, the first differencing variables under the PP test find a presence of a unit root for tradable goods price in Uganda and non-tradable goods price in Sudan and Uganda, depicting the order of integration of 2 (i.e. I(2)). These conflicts at levels and first differences for some series originate from the fact that PP test performs worse in finite samples than the ADF test (Davidson and MacKinnon, 2004). In this study, all the variables are treated as I(1).

3.3.3.2- Unit Root Tests with Structural Breaks

Time series data are subject to structural breaks and in this study the variables' (aid_t ,gdp_t, $trad_t$, $ntrad_t$, p_t^T, and p_t^{NT}) series are no exceptions. The ADF unit root test is known to have a low power if the series exhibits a "permanent" regime shift during the period under consideration (Harris and Sollis, 2003) or if there exist outliers in the regression residuals. The ADF test in a presence of structural break is biased toward non-rejection of the null hypothesis and the rejection frequency is inversely related to the magnitude of the break (Perron, 1989).

There are usually two types of structural breaks: exogenous and endogenous and it is difficult to distinguish between those two types. For this, I have applied the Perron test that deals with exogenous structural break as well as the Zivot-Andrews test that deals with endogenous structural break. Moreover, some series are subject to more than one structural breaks, the Lumsdaine-Papell

(LP) test with multiple endogenous structural breaks is applied for such series[27]. The three tests test the null hypothesis of a unit root under the structural break versus the alternative hypothesis that the series is stationary under structural break.

Tables 3.2A-3.2C report the series that are subject to the structural break. The tables show the break type, break year, and the series order of integration based on Perron, Zivot-Andrews, and Lumsdaine-Papell tests, respectively. All the variables subject to the structural breaks are found to be non-stationary and depict the same order of integration (i.e. I(1)) behavior[28].

3.4- Econometric Approach: The Cointegrated VAR (CVAR) Framework

3.4.1- Methodological Motivation

The variables of interest are found to be non-stationary and there is a possibility of cointegration between them which are represented by the long-run economic relationships. The CVAR approach enables us to distinguish between the short-run dynamic adjustments and the long-run equilibria. The CVAR model also identifies the common trends that push the variables and determines the long-run impact of shocks on these variables.

Macroeconomic empirical analysis usually uses a VAR model where the variables are assumed to be stationary, but in the case of non-stationary data, either a VAR model in difference[29] or a CVAR model[30] are usually considered. Non-stationarity data usually show no sign to return to or to fluctuate around a constant mean or a linear trend. In contrast, the shocks accumulate and form a stochastic trend that is associated with a non-deterministic shift in the mean in non-stationary unit root data (Hoover et al., 2008). These exogenous shocks affect the behavior of the variables by moving them away from the long-run equilibrium. These shocks activate the adjustment forces that pull the system back to a new equilibrium position.

The CVAR approach is based on a statistically well-specified VAR model that simplifies the general model by imposing testable constraints. Unlike other empirical approaches where data are restricted in specified directions, the CVAR model uses statistical principles to draw out meaningful relations from the data (Spanos, 2009). The unrestricted CVAR model represents the

[27] The three tests can be obtained upon request.
[28] It is also noted that the break year differs from one test to another due to the assumptions of endogenous and exogenous breaks.
[29] In a presence of no cointegration.
[30] In presence of cointegration.

covariance in the data and is constructed to provide a good fit of the data. The advantage of "let the data speak" is one of the CVAR model strengths where the data are not constrained (Juselius, 2006).

The main purpose of using a well-specified CVAR model is to apply the maximum likelihood function to estimate the model's parameters. The CVAR model has many advantages, in addition to allowing stationary and non-stationary variables[31]. For instance, a CVAR model is a system of multiple equations where all the variables are treated as endogenous. This helps us in modeling the interdependence and feedback effects that might be present among the variables in the system. Furthermore, using a CVAR model allows us to build a statistical framework describing the fluctuations in the data. The unrestricted CVAR model follows the principle of "general-to-specific" modeling (Hendry, 2009). In a sense that a VAR model is a convenient way to describe the "stylized facts" of the data, where economic hypotheses (expressed by shocks, steady state behavior, feedback, and other effects) are tested within a "statistically valid framework".

Although the county-specific CVAR approach allows us to address issues related to a single country, other problems may arise. First, the sample size is usually small; this has implications on lowering the power and the size of the test. The CVAR model requires long time-series data and a small number of variables to avoid the erosion of the degrees of freedom. Second, some variables that are useful in explaining variations in economic growth may not be applicable to use in the VAR modeling since these variables[32] evolve slowly over time (M'Amanja and Morrissey, 2006). Third, the CVAR model is dependent on the quality of data and its results are vulnerable to data measurement errors and data problems.

3.4.2- The Cointegrated VAR Model

I introduce a reduced form p-dimensional vector autoregressive (VAR(k)) model of the form:

$$y_t = \Phi_1 y_{t-1} + \Phi_2 y_{t-2} + \dots + \Phi_k y_{t-k} + \Theta D_t + v_t \tag{3.1}$$

Here, y_t is a (p x 1) vector of endogenous variables, in the present case p = 5 and y_t' = [aid_t, gdp_t, $trad_t, p_t^T,\ p_t^{NT}$] ; Φ_i (i = 1,2,… k) is a (p x p) matrix of parameters; D_t is a (m x 1) vector of m deterministic terms (such as a constant, linear trend, mean-shift dummy, permanent, and transitory intervention dummies); Θ is a (p x m) matrix of coefficients; and k is the lag length. The VAR(k) model is assumed to be linear in parameters and constant over time. The error terms are identically

[31] In the CVAR model the long-run equilibrium is the stationary part where there exists a linear stationary relationship between the variables in the long-run (i.e. I(0)) and the first difference of the variables are stationary, whereas the variables alone are non-stationary (i.e. I(1)).

[32] i.e. rule of law, institutions, corruption, and governance indexes are not evolving over time, thus cannot be used in the present model.

and independently distributed and serially uncorrelated (i.e. $E(\upsilon_t \upsilon'_{t-k}) = 0$, for $k \neq 0$), have a zero-mean ($E(\upsilon_t) = 0$), and a positive definite covariance matrix, Σ, that captures all the possible contemporaneous effects. Hence, the error terms follow a white noise process such that $\upsilon_t \sim NIID(0,\Omega)$.

According to Engle-Granger representation theorem (1987), when there is cointegration between the variables, the VAR model can be written as a vector error correction model (VECM) or as a cointegrated vector autoregressive (CVAR) that captures both short-run and long-run dynamics[33]. Providing all data are I(1), the CVAR is written as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_1 \Delta y_{t-i} + \Psi D_t + \varepsilon_t \qquad (3.2)$$

Here, Δy_t is a vector of growth rates where Δ is the first difference operator, $\Pi = -[I - \sum_{i=1}^{k} \Phi_i]$ is a (p x p) impact matrix of parameters containing the long-run adjustments information. Whereas, Γ_1 is a (p x p) matrix of short-run adjustment coefficients capturing the short-run effects. The CVAR model is structured around r cointegration relations[34] corresponding to $p - r$ stochastic trends[35] (Hoover et al., 2008).

If $r = p$ (i.e. Π matrix is of full rank), then $y_t \sim I(0)$. Thus, there exist p cointegration relationships and the data in level are stationary by themselves and a regular VAR model can be used. Whereas, if $r = 0$ (a zero rank), then there exist p autonomous (independent) trends where the data are non-stationary, but not cointegrated and a VAR in difference model should be used.

If $y_t \sim I(1)$, then $\Delta y_t \sim I(0)$ implying that Π matrix cannot have full rank. If $\Pi = I$ as a simple full rank matrix, and in this case, each equation in Δy_t which is a stationary variable is equal to a non-stationary variable (y_{t-1}), some lagged stationary variables (Δy_{t-i}), and a stationary error term. This creates a logical inconsistency since a stationary variable cannot be equaled to a non-stationary variable (Juselius, 2006). In the latter case, either $\Pi = 0$ or it must have a reduced rank. In the case of a reduced rank, Π matrix can be split into 2 parts, such that $\Pi = \alpha\beta'$, where α and β are (p x r, r < p).

Therefore, a CVAR model in a reduced error correction form is written as:

$$\Delta y_t = \alpha\beta' y_{t-1} + \Gamma_1 \Delta y_{t-1} + \ldots + \Gamma_{k-1} \Delta y_{t-k-1} + \Psi D_t + \varepsilon_t \qquad (3.3)$$

---

[33] VECM is a different name for the CVAR model.
[34] Pulling forces or endogenous.
[35] Pushing forces or exogenous.

where $\beta' y_{t-1}$ are r long-run relations representing the stationary process with a linear combination. α is (p x r) matrix of adjustment coefficients, β are the cointegration parameters that form the linear stationary relations with the non-stationary data series in y_t, and k corresponds to the lag length. When k = 1, then Γ_1 = 0 and if the system hits by an exogenous shock that pushes the system away from equilibrium, the system will adjust back to its equilibrium only through α. Whereas, in the case of k = 2, the system will be adjusted back by Γ_1 in addition to α.

The advantage of model (3.3) lies in the interpretation of the parameters, the long term effects are captured by the $\alpha\beta'$ matrix, while the short term dynamics are captured by $\Gamma_1 \ldots\ldots \Gamma_{k-1}$ matrices (Johansen, 1996). The r columns of β represent the long-run equilibrium relations between the variables in the model (i.e. the cointegration vectors); whereas, the r columns of α represent the adjustment parameters that ensure the system is coming back to its long-run equilibrium after an exogenous shock hits the system. The reformulation of the unrestricted VAR model of (3.1) as a CVAR in (3.3) does not impose any "binding restrictions on the model parameters" (i.e. the maximum likelihood function does not change (Juselius, 2006)).

Another advantage of the CVAR approach over regular regression analysis in levels is that the multicollinearity disappears due to the removal of the trends between the stationary differences (Δy_t) and the stationary long-run relations ($\beta' y_{t-1}$). The CVAR model in (3.3) reduces the multicollinearity that is present in the time-series data as the differenced data are more "orthogonal" than the data at levels (Juselius, 2006). If there exists a multicollinearity between the variables (i.e. GDP and the tradable output or between the prices), this will not cause an imprecise estimates of the cointegration relations ($\beta' y_{t-1}$) as these variables are cointegrated and share a common stochastic trend which is defined as the accumulation of all the permanent shocks that push the variables out of equilibrium. Thus, when y_t ~ I(1), Δy_t ~ I(0), and $\beta' y_{t-1}$ ~ I(0), then the standard inference on (α, Γ_1, Σ) can be applied for any given β. The cointegration coefficients are invariant to increasing or decreasing the information set[36] (Johansen, 2012).

I consider a general case of two cointegration vectors (i.e. r = 2; p - r = 3; k = 2) as an illustrative example of the CVAR model:

[36] The long-run cointegration relation still exist.

$$\begin{bmatrix} \Delta aid_t \\ \Delta gdp_t \\ \Delta trad_t \\ \Delta p_t^T \\ \Delta p_t^{NT} \end{bmatrix} = \begin{bmatrix} \alpha_{11} & \alpha_{12} \\ \alpha_{21} & \alpha_{22} \\ \alpha_{31} & \alpha_{32} \\ \alpha_{41} & \alpha_{42} \\ \alpha_{51} & \alpha_{52} \end{bmatrix} \begin{bmatrix} \beta_1' y_{t-1} \\ \beta_2' y_{t-1} \end{bmatrix} + \Gamma_1 \Delta y_{t-1} + \Psi D_t + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \tag{3.4}$$

To distinguish between the long-run effects associated with foreign aid and other variables, and between the variables themselves, it is useful to split the data vector of y_t' as: $y_t' = [y_{1t}, y_{2t}']$ where $y_{1t} = [aid_t]$, $y_{2t}' = [gdp_t, trad_t, p_t^T, p_t^{NT}]$, and the Γ_1 matrix as:

$$\Gamma_1 = \begin{bmatrix} \gamma_{11} & \Gamma_{12} \\ \Gamma_{21} & \Gamma_{22} \end{bmatrix} \text{ equivalent to } \begin{bmatrix} \gamma_{11} & \gamma_{12} & \gamma_{13} & \gamma_{14} & \gamma_{15} \\ \gamma_{21} & \gamma_{22} & \gamma_{23} & \gamma_{24} & \gamma_{25} \\ \gamma_{31} & \gamma_{32} & \gamma_{33} & \gamma_{34} & \gamma_{35} \\ \gamma_{41} & \gamma_{42} & \gamma_{43} & \gamma_{44} & \gamma_{45} \\ \gamma_{51} & \gamma_{52} & \gamma_{53} & \gamma_{54} & \gamma_{55} \end{bmatrix}$$

Where $[\gamma_{11}, \Gamma_{12}]$ and $[\gamma_{11}, \Gamma'_{21}]'$ represent the first row and first column in Γ_1.

In (3.4), α_{ji} are the adjustment coefficients and $\beta_i' y_{t-1}$ are *r* equilibrium error terms that define which variable will take the adjustment after the system has been pushed out of its equilibrium. In a sense that the variables are Granger-caused by foreign aid if α_{21}, α_{31}, α_{41} and $\alpha_{51} \neq 0$ and γ_{21}, γ_{31}, $\gamma_{41}$and $\gamma_{51} \neq 0$; while foreign aid itself is exogenous[37], that is, $\alpha_{11} = \alpha_{12} = 0$ and $\gamma_{12} = \gamma_{13} = \gamma_{14} = \gamma_{15} = 0$. In the latter case, foreign aid is considered strongly exogenous with respect to β; i.e. foreign aid is not Granger-caused by the variables.

To test for the endogeneity of foreign aid, I follow Juselius et al. (2014) hypotheses testing. I focus on five hypotheses tests based on parameter restrictions in α, β, and Γ_1 coefficients:

(i) $\mathcal{H}_1$: Aid is long-run exogenous or aid is weakly exogenous for the long-run parameters. This hypothesis is tested as: H_0: $\alpha_{11} = \alpha_{12} = 0$. In this test hypothesis, aid has not been affected by any deviations from the long-run equilibrium in the economy, but foreign aid might affect the variables in the short-run. If the null hypothesis is rejected, then aid has a long-run impact on the variables unless $\mathcal{H}_5$ cannot be rejected.

(ii) $\mathcal{H}_2$: Aid is strongly exogenous. This hypothesis is tested as: H_0: $\alpha_{11} = \alpha_{12} = 0$ and $\gamma_{12} = \gamma_{13} = \gamma_{14} = \gamma_{15} = 0$. If the test hypothesis null is not rejected, then aid

[37] The exogeneity in the present CVAR model is different from the strict exogeneity causal inference in micro studies (Correlations with the error term). In the CVAR model, aid is considered exogenous for the long-run relationship if does not adjust to the long-run relation equilibrium. $\mathcal{H}_1$ and $\mathcal{H}_2$ (k =2) test for aid exogeneity in the present model.

has not been affected in the short-run and in the long-run by the other variables. Aid may affect these variables unless $\mathcal{H}_5$ cannot be rejected.

(iii) $\mathcal{H}_3$: Aid is completely endogenous and purely adjusting. This hypothesis is tested as: H_0: $\alpha_{11} \neq 0$, $\alpha_{21} = \alpha_{31} = \alpha_{41} = \alpha_{51} = 0$ (i.e. testing a unit vector in α first column). In this test, aid is determined by the variables and aid shocks have no permanent effect on the variables if the null hypothesis cannot be rejected.

(iv) $\mathcal{H}_4$: Aid is long-run excludable from the cointegration equations. In this test, the first row of β is tested as: H_0: $\beta_{11} = \beta_{12} = 0$. If the null hypothesis of this test is not rejected, then aid is unrelated to any long-run movements of the variables.

(v) $\mathcal{H}_5$: Aid is short-run and long-run excludable. In this test, the first row of β is tested as: H_0: $\beta_{11} = \beta_{12} = 0$ and $\gamma_{21} = \gamma_{31} = \gamma_{41} = \gamma_{51} = 0$. In a case of null hypothesis non-rejection, foreign aid has neither effect in the short-run nor in the long-run.

3.4.3- The Common Trends Representation

The CVAR model in (3.4) can be represented in a form of moving average or "Granger representation" model. This means that the data generating process, y_t, is written as a function of previous innovations of the system. This representation allows us to investigate the role of common stochastic trends that are responsible for the non-stationarity of the process. The moving average form of the CVAR model can be obtained from equation (3.4) with initial values as follows[38]:

$$y_t = C\sum_{i=1}^{t}(\varepsilon_i + \Psi D_i) + C^*(L)(\varepsilon_t + \Psi D_i) + P_0 \qquad (3.5)$$

where $C = \beta_\perp(\alpha'_\perp \Gamma \beta_\perp)^{-1}\alpha'_\perp$ is a (p x p) long-run impact matrix with a reduced rank, (p - r), which is related to the stochastic part of the process (i.e. cumulation of error), and Γ = -(I - Γ_1 - Γ_1 - … - Γ_{k-1}). For an I(1) process, the number of unit roots defined as the common stochastic trends are (p - r). $\alpha_\perp$ and $\beta_\perp$ are p x (p - r) orthogonal complements of α and β, respectively; $C^*(L) = \sum_{i=0}^{\infty} C_i^* L^i$ is a stationary lag polynomial matrix; and P_0 contains the initial values.

The (p - r) common stochastic trends or the "pushing forces" are measured by $\alpha'_\perp \sum_{i=1}^{t} \varepsilon_i$ which push the system away from the long-run equilibrium (i.e. steady state) and have permanent effects.

[38] See Appendix A.4 for derivation.

These pushing forces affect the variables by the loadings $\widetilde{\beta_{\perp}} = \beta_{\perp}(\alpha'_{\perp}\Gamma\beta_{\perp})^{-1}$. Whereas, the shocks $\varepsilon'_t = [\varepsilon_{aid}, \varepsilon_{gdp}, \varepsilon_{trad}, \varepsilon_{pt}, \varepsilon_{pnt}]$ are measured by the estimated CVAR residuals.

The CVAR model in (3.5) can be written as follows:

$$\begin{bmatrix} aid_t \\ gdp_t \\ trad_t \\ p_t^T \\ p_t^{NT} \end{bmatrix} = \begin{bmatrix} c_{11} & c_{12} & c_{13} & c_{14} & c_{15} \\ c_{21} & c_{22} & c_{23} & c_{24} & c_{25} \\ c_{31} & c_{32} & c_{33} & c_{34} & c_{35} \\ c_{41} & c_{42} & c_{43} & c_{44} & c_{45} \\ c_{51} & c_{52} & c_{53} & c_{54} & c_{55} \end{bmatrix} \begin{bmatrix} \sum_{i=1}^{t} \varepsilon_{1i} \\ \sum_{i=1}^{t} \varepsilon_{2i} \\ \sum_{i=1}^{t} \varepsilon_{3i} \\ \sum_{i=1}^{t} \varepsilon_{4i} \\ \sum_{i=1}^{t} \varepsilon_{5i} \end{bmatrix} + C\,\Psi \sum D_i + C^*(L)(\varepsilon_t + \Psi D_i) + P_0 \tag{3.6}$$

The main differences between the CVAR model in (3.4) and (3.6) can be summarized as follows. First, the long-run C matrix is written as a product of two matrices i.e. $C = \widetilde{\beta_{\perp}}\alpha'_{\perp}$, where $\widetilde{\beta_{\perp}} = \beta_{\perp}(\alpha'_{\perp}\Gamma\beta_{\perp})^{-1}$. The decomposition of the C matrix in (3.6) resembles the decomposition of $\Pi = \alpha\beta'$ in (3.4); hence, there is a duality between the two matrices. In the C matrix, $\alpha_{\perp}$ determines the common stochastic trends that drive the long-run relation out of the equilibrium, while $\beta_{\perp}$ defines the loadings to the (p - r) common stochastic trends, $\alpha'_{\perp}\sum_{i=1}^{t}\varepsilon_i$. Whereas, in the Π matrix, β determines the long-run relations and α defines the load deviations from equilibrium for correction. Providing the data are non-stationary, there exist (p - r) unit roots equals to the number of stochastic trends which represent the long-run movement that describe the cumulated residuals of each variable[39].

Second, although the cointegration relation ($\beta'_i y_{t-1}$ *in* (3.4)) is defined as a deviation from the long-run equilibrium (equilibrium error) and describes the variables co-movement overtime, it does not say anything about the causality between the variables. For example, a long-run relationship represented by: (gdp_t - $\beta_1\, aid_t$) ~ I(0) describes the positive co-movement between GDP and aid. If the adjustment coefficient (α_{gdp}) is significantly negative, then Δgdp_t has been equilibrium correcting. In addition, if α_{aid} is insignificant, then I can draw a direction of causality from aid to GDP. However, if α_{aid} is positive and significant, then both GDP and aid are equilibrium correcting representing simultaneous feedback[40].

Third, a cointegration of three or more variables creates a problem in interpreting the sign effects among them. For instance, a long-run relationship represented by: (gdp_t - $\beta_1\, aid_t - \beta_2\, trad_t$) ~ I(0) suggests that GDP is positively associated with both aid and the tradable output. It also can be

[39] Put it in other words, the cointegrated variables have the same stochastic trend and the cointegration and common trends are two sides of the same coin (Johansen, 1995).
[40] I choose to normalize on a β variable that is significantly equilibrium correcting in α.

interpreted that aid is positively associated with GDP but negatively associated with the tradable output. In contrast to the regression coefficients, the cointegration coefficients are invariant to the choice of the normalizing variable. The problem escalates when the number of the long-run cointegration relations exceeds one.

Fourth, the long run equilibrium relationships differ from one country to another and this makes it difficult to compare the variables co-movement among countries. The long-run impact matrix uncovers the causal links between aid and the variables and make it is easier to compare the result. The *C* matrix is a function of $\alpha_{\perp}$ and $\beta_{\perp}$ and contains the long-run impact information among the variables. For example, the c_{21} coefficient in (3.6) if significant describes the long-run impact response of foreign aid shocks on GDP.

By focusing on the individual coefficients of the long-run impact matrix in (3.6), I can get a clear picture which shocks have been significant in pushing the economy out of equilibrium. It is very important to note that the estimated results of the *C* matrix coefficients are strongly affected by the choice of economic variables as well as the deterministic components. Therefore, any change in one or more economic variables or in the intervention dummy variables, the estimated stochastic trends are likely to change.

The causal link hypothesis about foreign aid endogeneity, exogeneity, excludability, and purely adjustability could be tested as nested hypotheses. The long-run matrix *C* in equation (3.6) can be partitioned as follows:

$$C = \begin{bmatrix} c_{11} & C_{12} \\ C_{21} & C_{22} \end{bmatrix}$$

where $C'_{21} \equiv (c_{21}, c_{31}, c_{41}, c_{51})$ captures the long-run effects of foreign aid on any of the variables, $C_{12} \equiv (c_{12}, c_{13}, c_{14}, c_{15})$ captures if aid is being influenced by the variables or not (i.e. exogenous or not), and the submatrix C_{22} contains the coefficients that describe the long-run impulse-responses between the variables themselves. The latter effects are not discussed in this dissertation.

The five testable hypotheses in Section 3.4.2 can be tested as nested hypotheses. I can classify SSA countries into 4 Cases groups following Juselius et al. (2014). Case I: Aid and other variables are unrelated; Case II: Aid has no long-run impact on the variables; Case III: Aid is exogenous; Case IV: Both aid and the variables have long-run effects on each other. The sequence of causal testing starts with Case I the most restrictive one and ends up with the least restrictive Case IV.

Case I: Aid and other variables are unrelated; i.e. C_{21} = 0 ($c_{21} = c_{31} = c_{41} = c_{51} = 0$) and C_{12} = 0 ($c_{12} = c_{13} = c_{14} = c_{15} = 0$). This can be jointly tested as $\mathcal{H}_1$ ($k = 1$) or $\mathcal{H}_2$ ($k = 2$) and $\mathcal{H}_5$. Case I is the most restrictive hypothesis; that is, if not rejected it implies a rejection of the other three remaining cases (II, III, and IV). If case I is rejected, then proceed to test Case II.

Case II: Aid has no long-run impact on the variables; i.e. c_{11} = 0, C_{21} = 0 ($c_{21} = c_{31} = c_{41} = c_{51} = 0$) and $C_{12} \neq 0$ (c_{12}, c_{13}, c_{14} and $c_{15} \neq 0$). This is tested as $\mathcal{H}_3$. If case II is not rejected, it means that foreign aid is purely adjusting; it implies a rejection to the other two remaining Cases (III and IV).

Case III: Aid is exogenous; i.e. $C_{21} \neq 0$ (c_{21}, c_{31}, c_{41} and $c_{51} \neq 0$) and C_{12} = 0 ($c_{12} = c_{13} = c_{14} = c_{15} = 0$). This is tested as $\mathcal{H}_1$ ($\mathcal{H}_2$ in case k = 2) is not rejected, $\mathcal{H}_3$ and $\mathcal{H}_5$ are rejected. If Case III cannot be rejected, then it implies that case IV is rejected. This test focuses on the role of aid and other variables and is performed by imposing a set of restrictions on the error vector adjustment coefficient α. Following Johansen (1996) a set of restrictions on α is tested (i.e. a zero row in α) as α measures the speed of adjustment of the aid variable in (3.4) due to any deviations from equilibrium.

Case IV: Both aid and the variables have long-run effects on each other; i.e. $C_{21} \neq 0$ (c_{21}, c_{31}, c_{41} and $c_{51} \neq 0$) and $C_{12} \neq 0$ (c_{12}, c_{13}, c_{14} and $c_{15} \neq 0$).The testable hypotheses $\mathcal{H}_1$ - $\mathcal{H}_5$ are rejected. This is the general case where foreign aid is neither exogenous nor completely endogenous; i.e. any shock to foreign aid will push the variables and shocks to variables have impacts on aid flows.

3.4.4- Model Specifications

3.4.4.1- Deterministic Components

Based on graphical expositions of aid, GDP, tradable and non-tradable outputs, tradable and non-tradable goods prices it is advisable to allow for a deterministic trend in levels and unrestricted constant, μ_0, to be included in the model. The constant, μ_0, serves as a constant in the equations of first difference and cumulates as a linear trend for the variables in levels. The deterministic trend might not be canceled in the cointegration relations, thus a trend, μ_1, will be restricted in the cointegration relations and included in the model. The CVAR model in (3.2) is written as:

$$\Delta y_t = \alpha\beta' y_{t-1} + \sum_{i=1}^{k-1} \Gamma_1 \Delta y_{t-i} + \Psi D_t + \mu_0 + \mu_1 t + \varepsilon_t \quad (3.7)$$

In (3.7), μ_0 = αβ_0 + γ_0 and μ_1 = αβ_1 + γ_1. Consequently, the CVAR model in (3.7) can be written as:

$$\Delta y_t = \alpha[\beta', \beta_0, \beta_1]\begin{bmatrix} y_{t-1} \\ 1 \\ t \end{bmatrix} + \sum_{i=1}^{k-1} \Gamma_1 \Delta y_{t-i} + \Psi D_t + \gamma_0 + \gamma_1 t + \varepsilon_t \quad (3.8)$$

There exist five different specifications arising from imposing different restrictions on the deterministic components in (3.8). The five cases are presented as follows (Johansen, 1996; Juselius, 2006):

Case 1: γ_0= γ_1=β_0=β_1=0. There is no deterministic terms in the model.

Case 2: γ_1=β_0=β_1=0. A restricted constant in the cointegration vectors.

Case 3: γ_1=β_1=0. An unrestricted constant (i.e. no linear trend in VAR, but in variables)

Case 4: γ_1 = 0. A restricted trend in the cointegration vectors, but an unrestricted constant in the model.

Case 5: No restrictions. Unrestricted constant and trend in the model (i.e. a presence of quadratic trend).

In terms of deterministic components, case 4 is chosen where an unrestricted constant and a deterministic trend are restricted in the cointegration relations. The advantage of this specification is that it allows for a linear trend in the cointegration space and also in the variables in levels. Case 4 is considered a good starting point for most empirical applications as the variables in levels are trending. Case 5 has a problem of creating a quadratic trend in levels and a trend in differences which is not applicable for all of SSA countries in this study.

3.4.4.2- Dummy Variables

The initial model specification does not satisfy all the desirable conditions such as normality condition under which the model is derived, thus is going to fail some misspecification tests[41]. These issues can be fixed by examining the origin of the misspecifications and modify the model accordingly[42].

Economies in general are subject to extraordinary shocks such as wars, military coups, institutional reforms, social unrest, famine, and drought. These events affect the time-series data and the model

[41] Discussed in Appendix A.5.

[42] The use of dummy variables is a common way to deal with the outlier observations.

parameters' stability. To control for such extraordinary events that may cause long-run trends, growth rates, and equilibrium means to move to a new level. A set of intervention dummy variables are used to improve the stability of the parameters. These events show up as large extraordinary shocks in the VAR model where the normality condition is usually violated.

For most of the SSA countries the multivariate normality assumptions are rejected. For this reason, some intervention dummy variables are included in the CVAR model. The dummy variable types are based on structural break tests, economic calendar, political calendar, and the standardized residuals[43] that show big outliers.

Many SSA data series are subject to structural breaks which are of two types. The first one is a break in linear trend which is corrected by adding a dummy trend variable D$trendYY_t$ defined as (0,..,0,1,2,3…T) and the second type is a break in level and is corrected by including a step dummy DsYY_t defined as (0,…,0,1,1,1,…,1), where YY_t stands for the year 19*YY* or 20*YY* - the break year.

In addition to the structural break dummies, there are two forms of intervention dummy variables: a transitory "blip" impulse dummy $DtrYY_t$, defined as (0,……,0,1,-1,0,0…..0), the transitory innovational outlier usually has delayed dynamic effect in the data and is described as +/- blip dummy variable. The second is a permanent "blip" impulse dummy $DpYY_t$, defined as (0,0,….0,1,0,0,…0), the permanent intervention is usually with a delayed dynamic effect in the data and it is due to large shocks[44]. The latter dummy variable is used in case of innovational outlier. The additive outlier resulting from a typing mistake or measurement error and is unrelated to the data-generating process with no delayed dynamic effect in the data should be removed before evaluating the CVAR model (Juselius, 2006). Since it can distort inferences on cointegration rank in small samples (Nielsen, 2004). All the variables in this study do not show the presence of additive outliers.

A break in linear trend or a break in level is usually restricted in the cointegration long-run relations to avoid quadratic trends in the data. Thus the long-run relations would be trend stationary around a linear trend with a changing slope at year YY_t. The dummy variables D$trendYY_t$ and DsYY_t if restricted in the cointegration vectors their differences (i.e. ΔD$trendYY_t$ = DsYY_t; ΔDsYY_t = DpYY_t) enter the model automatically if the model has two lags. The transitory and permanent

---

[43] The value of standardized residuals are computed as X = $\Phi^{-1}(1\text{-}0.025)^{\frac{1}{T}}$, where X is the value of standardized residuals, Φ is the cumulative normal distribution function and T is the number of observations. Any number greater than the value of X is considered an outlier and the appropriate intervention dummy variable is included.

[44] $|\hat{\varepsilon}_{i,t}| > 3.0\hat{\sigma}_{\varepsilon}$

“blip” dummies enter the VAR model unrestrictedly. Usually $DtrendYY_t$ and $DsYY_t$ are likely to affect the asymptotic distribution of the trace test critical values[45], while the permanent and transitory impulse dummies do not affect the asymptotic distributions but are likely to affect the “finite sample distribution” (Giles and Godwin, 2012; Hendry and Juselius, 2001; Juselius, 2006). Table A3 in Appendix A.1 shows the dummy variables included, their motivations, and their impact on the variables.

3.4.5- Misspecification Tests

It is of particular interest to conduct some misspecification tests to ensure valid statistical inferences. Various diagnostic misspecification tests include optimal lag length, residual cross correlations[46], residual autocorrelation tests, residual heteroscedasticity tests, and normality tests are reported in Appendix A.5. The CVAR models are successful to pass all the misspecifications tests.

3.4.6- Rank Determination

Having determined a well-specified CVAR model, the Johansen trace test can be applied to determine the cointegration rank and for the presence of unit roots in the multivariate framework given the cointegration space. The characteristic of the cointegration rank is dividing the data into r linearly independent long-run cointegration relations and (p - r) common driving trends. The cointegration relations (stationary part) are interpreted as long-run equilibria (steady states), to which the process is adjusting after a shock hits the system; whereas, the common trend (non-stationary part) are the pushing forces of the process.

The distinction between stationary and non-stationary parts of the process is not a straight forward process and several steps should be taken into considerations in addition to the trace test - the formal test. The choice of r is of particular importance since all the econometric analysis are based on the choice of rank and this affects the model statistical inference procedures in later stages.

The rank of matrix $\Pi = \alpha\beta'$ is tested and the parameters are estimated using a maximum likelihood methodology. Formally, to determine the number of cointegration vectors, the likelihood ratio test is used and the trace statistic is derived from the following equation:

---

[45] I have conducted simulation tests to determine the new critical values to determine the choice of rank.

[46] A residual cannot be considered an estimate of the structural shock, unless the CVAR model is complete and this rarely happens (Juselius, 2006).

$LR_t(r_0)$ = $-T\sum_{i=r_0+1}^{n}\ln(1-\widehat{\lambda_i})$

Where LR is the likelihood ratio test, $\widehat{\lambda_i}$ denotes the estimated eigenvalues or the *ith* largest canonical correlation, and T is the number of the usable observations. The Johansen's LR statistic tests the nested hypotheses as follows:

The null hypothesis $H_0(r)$: $r = r_o$ versus the alternative hypothesis $H_a(r_o)$: $r > r_o$

The trace test does not give the exact number of the unit roots. Thus, to determine the cointegration rank (*r*), I follow Juselius (2006) "top-to-bottom" sequential procedure which is asymptotically better than the "bottom-to-top" alternative. In particular, in this model, there are up to five null hypotheses that can be tested. In the trace test, the null hypothesis tests for $r = r^* < p$ versus the alternative hypothesis for $r = p$. For example, the null hypothesis (rank (Π) = *r*) is rejected if one of the estimated (*p* - *r*) is greater than zero. I start to test the most restricted model, the null hypothesis (*r* = 0) against the alternative hypothesis (*p* - *r* = 5). If the test statistic is larger than the critical value, the null hypothesis is rejected which means that (*p* - *r*) unit roots exist. Then the next step is to test the null hypothesis (*r* = 1) against the alternative one (*p* - *r* = 4); I stop when the test cannot be rejected.

However, Juselius (2006) states that the asymptotic distributions are poor approximations of the true distributions in a small sample[47]. Many simulation studies suggest that the asymptotic distribution of the trace test suffers from the size and power distortions. Thus, I report the small sample "Bartlett correction" to ensure the correct test size which can be substantial in a sample size (Johansen, 2002b). Although the Bartlett small-sample correction trace test leads to a more accurate size, unfortunately it does not solve the power problem. In using the trace test, I would like the probability of rejecting a true null hypothesis (*r* = *r**) to be small and the probability of not rejecting a true alternative hypothesis (*r* ≠ *r**) to be high.

As stated before, most SSA data series are subject to structural breaks. These breaks (restricted in the cointegration space) are going to affect the asymptotic distribution of the critical values of the trace test (Giles and Godwin, 2012; Johansen et al. 2000; Nielsen, 2004), where the "asymptotic tables are shifted to the right for each deterministic component included in the cointegration relations" (Juselius, 2006). The transitory and the permanent intervention dummies usually influence the finite-sample distribution, but not the asymptotic distribution (Juselius, 2006). The distribution to the Johansen trace test is non-standard and is usually determined by simulations

[47] The samples range from 33 to 51 observations.

(Johansen, 1996). Including the break dummy variables have a direct impact on the asymptotic distribution of the trace test under the null hypothesis and thus this test should be used as indicative only (Juselius, 2006).

SSA countries are subject to civil wars, social unrests, severe droughts and famine, interventions and adjustment reforms in addition to the small sample periods drive the test power to be lower. In such cases, choosing the rank based on small p-value (5%) is likely to pick up the cointegration relations with fast adjustment coefficients and "very stationary" roots (Juselius, 2006). In the latter case, the probability of type II error will increase, i.e. the probability of excluding long-run stationary relations will be high. Thus, it is important to use other sources of information when determining the best choice of rank. The determination of the cointegration rank is not an easy task especially with small samples. Specifically, the trace test becomes less informative (i.e. the test power is low); therefore I exploit additional information suggested by Juselius (2006). Some robustness checks include:

i) Characteristic roots examinations: if additional cointegration (i.e. $r^* + 1$) vector is wrongly included in the model, then the largest characteristic root is close to a unit circle.

ii) The adjustment α-coefficients significance to the additional cointegration vector: if all the t-statistic values are less than |2.6|, then no gain in information would result if including one extra cointegration vector and would not improve the explanatory power of the model.

iii) Recursive graphs of the trace statistic: the calculated components of the recursive trace statistic grow linearly while the rest stay constant.

iv) Cointegration relations graphs: plot all the potential cointegration vectors and deduct from visual inspections any stationary relation.

v) The economic interpretability of the additional results.

Table 3.3 provides an overview of the trace test, Bartlett corrected trace test, a test based on the adjustment α-coefficients t-ratios[48], and the characteristic roots of the model. The trace test and Bartlett corrected trace test are based on 5% p-value[49]. The forward and backward recursive graphs of the trace test are not reported due to the small sample size and the cointegration relations graph can be obtained upon request.

[48] At least three coefficients are greater than |2.6|.
[49] The test results can be obtained upon request.

The trace test is based on the premise of "no prior economic knowledge" about the choice of rank. However, the statistical null hypothesis may not coincide with the plausible economic null hypothesis. Hence, it is of particular interest to pre-specify an economic prior for the number of shocks (p - r^*), where r^* corresponds for long-run relation consistent with this prior. This helps to avoid not rejecting an implausible economic null just because it founds a conveniently statistical null. For instance, in this study, GDP and the tradable output are in real terms. Thus, I should expect two stochastic trends originating from the cumulated productivity shocks and trends in population. Foreign aid flow is assumed to be exogenous in the model for some countries and I could expect a third driving trend. Further, tradable goods price can be reasonably considered exogenous (the law of one price) and could constitute a fourth driving trend. For instance, take Kenya as an example, the "prior economic knowledge" about the choice of rank tells that two stochastic trends originated from the cumulated productivity shocks of GDP and the tradable output. In addition, both prices seem to be exogenous in the model and I would expect another two driving trends, raising the number of driving trends to four.

In Ethiopia, foreign aid and tradable goods price are both exogenous in the model which constitute for two driving trends. In addition, the other two stochastic trends are driven by the productivity shocks and trends in population, these raise the number of roots to four. Both in Ethiopia and Kenya, the trace test which is based on statistical null hypothesis coincides with the economic null hypothesis; thus the best choice of rank is one.

In this chapter, the economic prior interpretation corresponds to either $\{r = 1, p - r = 4\}$ or $\{r = 2, p - r = 3\}$ case. According to the rank chosen in Table 3.3, the first case is empirically supported by 11 SSA countries and the second case is empirically supported by 10 countries.

The choice of choosing the best choice of rank r^* is a dilemma especially when the trace test, the α-adjustment coefficients test, and the largest unrestricted root of the characteristic polynomial of the model give different results. The rank choice which is based on the trace test and the Bartlett correction trace test coincides in 18 out of 22 SSA countries; the rank choice which is based on the trace test and the significance of α-adjustment coefficients test coincides in 14 SSA countries. In this chapter, the chosen best rank of choice is based on the formal trace test.

3.4.7- The CVAR Stability Parameter Tests

Even though the empirical CVAR models have passed the misspecification tests, further tests should be conducted to ensure parameters' constancy (stability of α and β coefficients); since a VAR model is usually derived under constant parameter assumption. These batteries of tests are based on tests suggested by Hansen and Johansen (1999). Those tests are divided into forward and backward recursive tests and are designed to examine if the model suffers from parameter non-constancy or not. Usually the parameter instability can be corrected by introducing the intervention dummy variables, but unfortunately and due to the small samples size (33-51 observations) splitting the full sample into two samples to perform such recursive testing is barely doable and creates more problems (Juselius, 2006).

3.5 – Causal Links between Foreign Aid and the Variables in the SSA Countries

The causal interpretation of the four cases (presented in Section 3.4.3) is built on the aid residuals that measure the "true shocks" to foreign aid over time. For this reason, aid residuals should not be strongly correlated with other variables residuals. The residual correlations between foreign aid and the variables are small and not statistically significant for 20 SSA countries. Under the assumptions of no cross residual correlations between foreign aid and the other variables, except for Madagascar and Sudan (very moderate correlations)[50] where their result should be taken with cautious and as indicative at most, I can proceed my analysis.

The sequence of causal testing starts with Case I, the most restrictive one, and ends up with the least restrictive, Case IV. Table 3.4 presents the testable hypotheses p-values of the causal links between foreign aid and the variables for the 22 SSA countries. Based on the hypotheses test outcomes, SSA countries are classified as follows:

I) - Foreign Aid and the Variables are Completely Unrelated (Case I group)

This causal condition is tested as $C_{21} = 0$ and $C_{12} = 0$. Based on joint testable hypothesis no SSA country belongs to Case I group.

II) - Foreign Aid is Purely Adjusting to the Variables (Case II group)

This test corresponds to testing the hypothesis that the aid variable in (3.4) is purely adjusting to the system or is completely endogenous in the system. If the null hypothesis is not rejected, then a shock to aid has no permanent impact on any other variable in the system including itself. Case II is tested as: $c_{11} = 0$, $C_{21} = 0$ and $C_{12} \neq 0$.

In Madagascar, aid is found to be purely adjusting and has no permanent impact on the variables, only a transitory effect. When interpreting the hypothesis testing in Case II, I need to keep in mind

[50] See Table A4 in Appendix A.5.

that the test result is sensitive to the omitted variables and in case the null hypothesis is not rejected; it is evidence that aid is ineffective in the present CVAR model. If a relevant variable is included the test result might change (Juselius et al., 2014).

III) - Testing Foreign Aid Exogeneity (Case III group)

This test is tested as $C_{21} \neq 0$ and $C_{12} = 0$. Thus, zero coefficients in C_{12} and non-zero coefficients in C_{21} mean that aid has a long run impact on the other variables and at the same time is not influenced by them (Juselius, 2006). Hence, aid is considered as weakly exogenous for the long-run coefficients *β*. Foreign aid has been found to have an impact on the variables and at the same time is not affected by them in Botswana, Burundi, Central Africa, Ethiopia, Mali and Sudan. These countries are classified as Case III countries.

IV) - Endogeneity of Foreign Aid (Case IV group)

Case IV classification is tested as $C_{21} \neq 0$ and $C_{12} \neq 0$. If the first three cases are rejected, then the remaining countries would belong to the Case IV group. In this group, foreign aid has a long-run impact on the variables and vice versa. The majority of SSA countries[51] belongs to this group. To get a clear idea, I have classified SSA countries into four groups to describe the different impacts between foreign aid and the variables. However, classifying SSA countries into such groups will add no information about the long-run impact of aid on the variables; the long-run impact of aid on the variables is the core objective of the next section.

3.6-The Long-Run Impact of Aid on the Variables

The signs and significances of C_{21} elements describe the long-run impact of the aid shocks on other variables. Many studies in the economic literature examine the effectiveness and ineffectiveness of aid on growth, consumption, government fiscal policy, and investment. The present CVAR model, in particular, is designed to examine the long-run impact of foreign aid on GDP, tradable and non-tradable outputs, and tradable and non-tradable goods prices. I have used tradable and non-tradable goods prices instead of the relative price of non-tradable goods (the real exchange rate) since the latter seems to be stationary in most countries[52]. Using a CVAR model, there would be no long-

---

[51] Benin, Burkina Faso, Cameroon, cape Verde, Gambia, Kenya, Lesotho, Malawi, Mauritania, Rwanda, Senegal, Seychelles, Sierra Leone, Togo, and Uganda.

[52] The relative price of non-tradable goods $P_t^N = \frac{P_t^{NT}}{P_t^T}$, P_t^{NT} and P_t^T are calculated as current prices over constant prices. Thus, P_t^N is a ratio of two ratios which makes it stationary in most SSA countries.

run relationship among the relative price (if stationary) and other non-stationary variables. I emphasize here that the asymptotic standard errors, on which t-statistics are computed, may not be the true ones due to the fact that the samples are small. Although the t-statistics may not follow the student's t-distribution, they still, in general, give information on the relative significance of the estimated long-run impact of foreign aid shocks on the variables (Juselius et al., 2014). The bold t-statistics reported in Table 3.5 are above |1.96|.

Table 3.5 reports the estimated C_{21} individual coefficients that show the long-run impact of foreign aid on *gdp*, *trad*, p^T, and p^{NT}. The cumulated shocks to aid have a negative persistent impact on GDP in eight SSA countries, a positive persistent impact on GDP in three SSA countries, and no effect on the rest countries. The positive effect of aid on GDP in Lesotho, Malawi, and Rwanda coincides with the results in Juselius et al. (2014). Whereas, the negative effect of aid shocks on GDP coincides with Juselius et al. (2014) results only in Botswana and Burundi. Overall, Juselius et al. (2014) find that aid shocks have a negative impact on GDP in nine SSA countries and a positive effect in 19 SSA countries. However, I believe my result is plausible since the data and variables used in my model are different from those used in Juselius et al. (2014)[53]; I also incorporate the role of the "Dutch Disease" mechanism. In addition, Juselius et al. (2017) investigate the final impact of the aid shocks in Tanzania and Ghana; they include the real exchange rate[54] and inflation to the CVAR model used in Juselius et al. (2014). The result has changed in both countries, suggesting that adding one or two variables can change the result.

As for the long-run impact of aid on the tradable sector, the final long-run impact of a shock to the foreign aid has been negative and significant for the tradable output in 16 out of 22 SSA countries, but positive and significant in the Gambia, Malawi, Rwanda, and Sierra Leone. The latter result coincides with Demekas et al. (2002) where they suggest that post-conflict reconstruction aid does not necessarily lead to a shrinkage in the tradable sector. Both Rwanda and Sierra Leone received reconstruction aid after the end of their civil wars in 1994 and 2002, respectively.

The cumulated shocks to aid on the prices are more complex and hard to interpret. For instance, aid shocks have a positive and significant impact on tradable goods price in six SSA countries[55] and on non-tradable goods price in nine SSA countries[56]. On the other hand, aid shocks are found

[53] Variables used in Juselius et al. (2014) model: foreign aid, real GDP, government expenditures, private consumption, and investment.

[54] Computed as the relative consumer prices between USA and the domestic currency multiplied by the nominal domestic exchange rate.

[55] Burkina Faso, Burundi, Malawi, Rwanda, Seychelles, and Uganda.

[56] Cameroon, Cape Verde, Gambia, Malawi, Mali, Rwanda, Seychelles, Sierra Leone and Uganda.

to have a negative and significant impact on tradable goods price in only four SSA countries[57] and on non-tradable goods price in four SSA countries[58]. No single country has shown all the four phases of the "Dutch Disease" in the long-run: a decrease in the price of tradable goods, an increase in the price of non-tradable goods, a decline in the tradable output, and a decline in total output. "Dutch Disease"[59] seems to be a short-run phenomenon[60] rather than a long-run one. Adam and Bevan (2006) evaluate the impact of an aid-induced "Dutch Disease" and find that aid funds cause short-term "Dutch Disease" in the recipient economy.

Taking the impact of aid on prices country by country, I can see that only in Cameroon there is significant evidence that in the long run aid has a negative effect on tradable goods price and a positive effect on non-tradable goods price[61], the opposite is found in Burundi. Furthermore, there are four SSA countries[62], where aid is found to have a significant and positive impact on both prices; in two other SSA countries[63], aid has had a negative impact on both of them. Finally, foreign aid has no long-run impact on the prices in seven SSA countries[64].

The results in Table 3.5 can be used to check the consistency of the classifications into Case I, II, III or IV groups in Section 3.5. For instance, I expect insignificant coefficients in C_{21} in Case I and II countries and significant coefficients in Case III and IV countries. Table 3.6 reports the long-run impact of the aid shocks on the variables and shows their distribution in each category based on their significant signs. It appears that aid has no long-run impact on the variables for Madagascar; this is consistent with Case II economies. For the Case III group, aid has a negative long-run impact on all the six SSA countries' tradable sector and a negative and persistent impact on two SSA countries' GDP. In 10 out of 15 SSA countries belonging to Case IV economies, aid is found to have a negative persistent effect on the tradable output; in six out of 15 SSA countries, the effect of aid on GDP is negative and statistically significant. On the other hand, aid has a positive persistent effect on the tradable output in four SSA countries and a positive and significant effect on GDP in only three SSA countries. Table 3.6 shows that the classifications of SSA countries into three groups are consistent with the aid significance or insignificance results. Including or excluding some variables may have an effect on the statistical inferences of the CVAR model. In

[57] Cameroon, Senegal, Sudan and Togo.
[58] Burundi, Central Africa, Senegal and Sudan.
[59] "Dutch Disease" mechanism and the factors affecting the real exchange rate are explained in Appendix A.2.
[60] Discussed in more details in Chapter 5.
[61] This is consistent with first three phases of the "Dutch Disease" phenomenon.
[62] Malawi, Rwanda, Seychelles, and Uganda.
[63] Senegal and Sudan.
[64] Benin, Botswana, Ethiopia, Kenya, Lesotho, Madagascar, Mauritania.

Section 3.7, I explore the idea of including the non-tradable output instead of GDP as a process of robustness checking.

3.7-Robustness Checking

In this section, I check the consistency of the results from Section 3.6. I show that if the results of the long-run impact of foreign aid shocks on the variables change or not when GDP is split between tradable and non-tradable outputs. The CVAR model in (3.6) is re-estimated by replacing gdp_t by $ntrad_t$.[65] I call the latter model as Model 2 and the previous one as Model 1.

Table 3.7 demonstrates the long-run impact of aid shocks on GDP, tradable output, and non-tradable output based on Model 1 and Model 2 results. A quick comparison between the long-run impacts of the aid shocks to the tradable output in both models, aid shocks have a positive and significant impact on the tradable output in four SSA countries[66] in both models. Foreign aid shocks have a negative persistent effect on the tradable output in 14 SSA countries in both models. Sudan and Uganda are the only two countries where the results have been changed. In Model 1, the impact of foreign aid shocks on the tradable output is negative and significant, while in Model 2, the long-run impact of aid shocks on the tradable output is still negative, but not significant in both countries. In addition, the cumulated shocks to aid have had a persistent negative effect on both GDP and the non-tradable output in five SSA countries[67] and a persistent positive effect only in two SSA countries[68].

The changes in the tradable and non-tradable outputs as a result of the aid shocks differ from one country to another. In Burundi, for example, the final impact of a shock to aid has a persistent positive effect on the non-tradable output and a negative effect on the tradable output and GDP. Thus, the shrinkage of the tradable output significantly exceeds the expansion in the non-tradable output in Burundi. Whereas in Lesotho, the final impact of the aid shock has positive effects on the non-tradable output and GDP and a negative effect on the tradable output. In Lesotho, the expansion in the non-tradable output exceeds significantly the contraction of the tradable output. Further, there are three SSA countries[69] where aid shocks have positively affected the non-tradable output and

[65] In Appendix A.6, I evaluate a CVAR model where the tradable sector is composed of agricultural and industrial sectors instead of agricultural and manufacturing sectors. The results are still robust.
[66] Gambia, Malawi, Rwanda, and Sierra Leone.
[67] Botswana, Cape Verde, Kenya, Seychelles, and Togo.
[68] Lesotho and Rwanda.
[69] Central Africa, Mali and Sudan.

negatively affected the tradable output, but no effect on GDP. In the Gambia, foreign aid shocks have negatively affected the non-tradable output and have positively affected the tradable output[70].

Countries classified as Case III economies are exhibiting a shrinkage in the tradable sector and an expansion in the non-tradable output as a result of the aid cumulated shocks except for Botswana - both sectors are shrinking. In contrast, for Case IV economies, foreign aid has different effects. For instance, only in Lesotho, aid has been found to have a negative effect on the tradable output and a positive effect on the non-tradable output and GDP. In addition, aid shocks have negative and significant effects on both sectors in three SSA countries[71], a negative effect on the tradable output only in three SSA countries[72], negative impacts on the tradable output and GDP in two countries[73], and negative effects on the non-tradable output and GDP only in Cape Verde. Finally, foreign aid has positive and significant impacts on the tradable and non-tradable outputs only in Rwanda, a positive effect on the tradable output only in the Gambia and Sierra Leone, and positive effects on the tradable output and GDP in Malawi. This heterogeneity in results raises a question whether aid is effective or not and whether aid has a long-run impact on the GDP's structure.

3.7.1- Aid Effectiveness/Ineffectiveness

Inflows of foreign aid into SSA countries have persistent positive and/or negative effects on GDP, tradable and non-tradable outputs; however, the impact differs from one country to another. To get a clear idea about the long-run impact of foreign aid, it is of particular interest to define two economic hypotheses. The first economic hypothesis describes where aid is harmful to GDP, tradable output, and non-tradable output. The second one describes aid effectiveness for at least one of them. Table 3.8 reports the results for both economic hypotheses. In Model 1, foreign aid is found to be harmful to GDP, tradable output, and non-tradable output in eight, 16, and five SSA countries, respectively. On the other hand, foreign aid has been effective to GDP, tradable output, and non-tradable output in three, four, and six SSA countries, respectively.

The results so far have provided a strong support for the aid harmfulness hypothesis; the results are robust in both models. The significant negative effects on either GDP, tradable output, and non-tradable output receive far more support than the significant positive effects in SSA countries. The above results strengthen my previous conclusion that foreign aid has been harmful to the majority of SSA countries under study. The results reflect the fact that regardless of the aid-to-GDP share

[70] Opposite of "Dutch Disease" effect.t
[71] Kenya, Seychelles and Togo.
[72] Benin, Burkina Faso, and Cameroon.
[73] Mauritania and Senegal.

and the tradable output-to-GDP share discrepancies among SSA countries. Foreign aid has been harmful to the majority of SSA countries.

My results on the shrinkage of the tradable sector coincide with Rajan and Subramanian (2005, 2011) and Arellano et al. (2009), but the methodology used in this study is different from their cross-sectional methodologies. My results contradict Juselius et al. (2014) results, where aid has been found to have a positive long-run effect on GDP in 19 SSA countries; it contradicts Feeny and McGillvary (2010) results, where aid has been found to spur economic growth in recipients' countries. Selaya and Thiele (2010)[74] and Kumi (2017)[75] find that aid has a positive effect on GDP and the tradable sector, in contrast to my results except for four SSA countries where aid has a positive impact on the tradable sector. Only in Rwanda, my result coincides with Selaya and Thiele (2010) and Kumi et al. (2017), where both sectors are expanding as a result of the aid shocks. Finally, Arndt et al. (2010, 2015) find that aid has a positive effect on GDP, manufacturing, industrial, and services sectors, but the agricultural sector shrinks as a result of aid injection.

3.7.2- The Impact of Aid on the GDP's Structure

The shrinkage and/or the expansion of the tradable and non-tradable sectors have a direct effect on the country's economic transformations and on the GDP's structure. Given the information from Table 3.7, I can draw inferences on the GDP's structural changes. For instance, in Central Africa, the tradable sector is significantly shrinking and the non-tradable output is significantly expanding as a result of aid inflows; whereas, aid has no impact on GDP. So, I can draw an inference that the share of non-tradable output-to-GDP is expanding at the expense of the tradable output-to-GDP share. In Lesotho, aid has a negative and significant impact on the tradable sector and a positive and significant impact on the non-tradable output and total output. I can draw an inference that the tradable output as a share of GDP is decreasing and the non-tradable as a share of GDP is increasing.

The long-run impact of foreign aid on the tradable and non-tradable sectors seems to alter GDP's structure in 15 SSA countries given the information from Table 3.7. The situation is ambiguous in the rest of the countries. For example, in Botswana, Kenya, Seychelles, and Togo both sectors are shrinking and in Rwanda both sectors are expanding. Table 3.9 reports the long-run impact of aid on GDP and both sectors as a share of GDP based on estimations from Table 3.7. For Case III economies, where foreign aid is treated as weakly exogenous; foreign aid appears to increase the

[74] Tradable output (agriculture and industry).
[75] Tradable output (agriculture and manufacturing).

non-tradable output-to-GDP share at the expense of the tradable output-to-GDP share in five out of six countries. For Case IV economies, the situation is slightly different, the final impact of a shock to aid has a negative effect on the tradable output as a share of GDP in seven SSA countries and a positive effect in other three countries at the expense of the non-tradable share. In 12 out of 22 SSA countries, the non-tradable output-to-GDP ratio is expanding at the expense of the tradable output-to-GDP ratio; in three SSA countries the situation is the opposite.

3.8- The Impact of GDP and the Tradable Output on Foreign Aid Flows

The CVAR methodology enables me to answer a political economy research question (Does domestic economic activity affect the allocation of donors foreign aid?) with the vector $C_{12} \equiv (c_{12}, c_{13}, c_{14}, c_{15})$ that captures if foreign aid has been influenced by the variables or not. As far as I am aware, this chapter is the first to test for the causal relationship from the recipient's GDP and the tradable sector to the level of foreign aid.

Foreign aid motivations to the developing countries have influenced the donors' government decisions in their aid allocations. From the supply side point of view, aid is provided to reduce human suffering (Berthelemy, 2006), to improve social welfare of both recipient and donor (Sayanak and Lahiri, 2009), to support trade interests of donors (Berthelemy, 2006; Macdonald and Hoddinott, 2004), to promote democracy and human rights in the recipient countries (Neumayer, 2003), to compensate for colonialism (Edgren, 2002), and to achieve global political aspirations and increase donor's influence in the developing world (Riddell, 2007).

McGillivary (1989) assesses the extent to which donors provide aid based on the needs of the recipient countries using an "income-weighted per capita aid index" for 85 countries. He finds that Scandinavian countries score higher (i.e. provide aid for countries performing well); the United States of America performs poorly suggesting that their aid allocations are influenced by political, strategic, and commercial interests. Collier and Dollar (2001; 2002) develop a "poverty efficient aid allocation" model that aims to reduce poverty in countries adopting good policies and they introduce a policy based on the World Bank Country Policy and Institutional Assessment index (CPIA). They suggest that aid should be allocated to countries that show improvements in the CPIA index. They also argue that donors should allocate more aid to countries where there is more poverty and where aid is found to have more impact on reducing poverty. However, Anderson and Waddington (2007) argue that countries with high levels of poverty may be missed out if they are not efficient in reducing their poverty levels.

Having analyzed the long-run impact of aid on the variables, it is of particular interest to examine how GDP and the tradable output influence the flow of foreign aid. That is, how donors provide aid and how the recipients' macroeconomic performance affects the flow of aid. The first two elements of C_{12} (c_{12} and c_{13}) describe the cumulated effect of the long-run movement in GDP and the tradable output permanent shocks to the aid variable in the system. In other words, I am trying to investigate how the macroeconomic performance of the SSA countries influences the inflows of foreign aid allocated by donors. Panel A of Table 3.10 presents the long-run influences of GDP and the tradable output on the aid inflows, while Panel B shows the long-run impact of aid on GDP and the tradable output. It appears that shocks to GDP and shocks to the tradable output work in opposite directions in eight SSA countries[76] in influencing the flow of aid. For Madagascar (Case II economy), the flow of foreign aid has been permanently and negatively influenced by the shocks to GDP and positively influenced by the shocks to tradable output; foreign aid shocks seem to have no permanent effect. For Case III economies, where aid is considered exogenous, aid has not been influenced by either GDP or the tradable output cumulated shocks in the long-run; this is consistent with the expectations of aid exogeneity. However, foreign aid shocks have influenced at least one of them.

The situation differs while considering Case IV economies, the flow of foreign aid has been negatively influenced in Benin, Burkina Faso, and the Gambia and positively influenced in Cameroon and Uganda by GDP shocks; at the same time, aid has no long-run impact on GDP. In Kenya and Senegal, aid has been positively influenced by GDP shocks (i.e. donors allocate more aid for the country performing well); aid injection seems to be harmful to GDP. Only in Malawi and Rwanda, aid has been negatively influenced by GDP shocks (i.e. donors allocate less aid for the country performing well); at the same time, aid seems to be effective to GDP. This situation is different in Mauritania, Seychelles, and Togo where aid has been negatively affected by GDP shocks, but aid injection has a persistent negative effect on GDP.

In addition to GDP shock, the shocks to the tradable output have a long-run influence on the flow of foreign aid in SSA countries. For instance, aid has been negatively influenced by the tradable output shocks (more aid is allocated for countries exhibiting shrinkage in the tradable output or less aid is allocated for countries exhibiting an expansion in the tradable output); however, aid has a negative impact on the tradable output in Burkina Faso, Kenya, Lesotho, Senegal, and Togo. In Cape Verde, aid has no effect on the tradable output, although it has been negatively influenced by

[76] Benin, Gambia, Kenya, Madagascar, Malawi, Mauritania, Rwanda, and Senegal.

the tradable output shocks. In contrast, I have found evidence that the tradable output shocks have been positively influenced the flow of foreign aid in the Gambia, Malawi, Rwanda, and Sierra Leone; aid shocks have a positive long-run impact on the tradable sector. In these countries, the tradable output is expanding and the new injections of aid have a persistent positive effect on expanding this sector. In Benin and Mauritania, the latter situation is different, where aid has been positively influenced by the tradable output shocks, but aid shocks have a negative persistent effect on the tradable output.

The results of the long-run impact of the variables shocks are summarized in Table 3.11. Only in Malawi and Rwanda, attracting less aid has a positive effect on GDP. In the Gambia, Malawi, Rwanda, and Sierra Leone, attracting more aid has a positive effect on the tradable output. These countries are of particular importance to investigate the mechanism through which foreign aid has been effective and this is left for future research.

3.9- Summary and Conclusion

This chapter explores the long-run impact of aid on GDP, on each of the tradable and non-tradable sectors, and on the prices of tradable and non-tradable goods in 22 SSA countries from the 1960s to 2014. I develop a CVAR model which takes into account major extraordinary events and use it to analyze the impact of foreign aid on each country. I show that aid has had a negative long-run impact on GDP and the tradable output in the majority of countries (17 out of 22 SSA countries). I find only three countries where aid has positively impacted GDP. In 16 out of 22 SSA countries, aid has a significant negative effect on the tradable output, and in only four SSA countries aid has a significant positive impact on the tradable sector. For countries classified as Case III economies (Foreign aid is weakly exogenous), the tradable sector is shrinking in all the six SSA countries as a result of cumulated aid shocks. To some extent, the impact of foreign aid seems to vary from one country to another; this is very important in determining the proper policy for each country.

Further, aid flows are found to be weakly exogenous: GDP, tradable output, tradable and non-tradable prices have no long-run impact on foreign aid in six SSA countries. Aid is found to be endogenous (purely adjusting) in only one country. In 15 countries, foreign aid is found to be neither weakly exogenous nor completely endogenous: GDP, tradable output, tradable and non-tradable prices have long-run impact on foreign aid.

Overall, I do not find evidence consistent with the mechanism of the “Dutch Disease” being active in the long-run. Still, I find mainly non-positive impacts of aid on GDP, in contrast to much of the literature including, the work of Juselius et al. (2014). A possible reason for the difference in conclusions is my use of a more disaggregated model which involves using new sources of data. To concentrate on the disaggregation, I exclude some variables included in previous analyses. Future work points to the need to integrate other dimensions such as trade flows (imports and exports) and monetary variables, as well as other mechanisms which might be differentially affecting sectors within countries. For example, food aid (13% of total aid is Humanitarian in 2016) may reduce the tradable sector, possibly by destroying local agriculture.

Table 3.1A: Countries, sample period, aid, tradable output, exports and imports as percentage of GDP and components of the tradable sector (Source: WDI, 2017)

Country	Period	Aid/GDP	Trad/GDP	Exp/GDP	Imp/GDP	Tradable
Benin	1971-2014	9.00%	41.80%	20.10%	33.25%	Agr + Man
Botswana	1965-2014	7.80%	18.30%	49.00%	52.20%	Agr + Man
Burkina Faso	1970-2014	12.00%	44.50%	11.15%	27.00%	Agr + Man
Burundi	1970-2014	18.60%	63.25%	9.35%	24.70%	Agr + Ind
Cameroon	1965-2014	4.00%	35.40%	22.35%	23.20%	Agr+ Man
Cape Verde	1980-2014	25.30%	32.80%	26.30%	64.75%	Agr + Ind
Central Africa	1977-2012	12.25%	53.65%	18.75%	27.10%	Agr + Man
Ethiopia	1981-2014	9.80%	52.35%	2.65%*	9.40%*	Agr + Man
Gambia	1966-2014	14.90%	31.65%	33.55%	45.40%	Agr + Man
Kenya	1967-2014	5.75%	38.35%	26.20%	32.00%	Agr + Man
Lesotho	1975-2013	15.40%	24.50%	14.65%*	61.75%*	Agr + Man
Madagascar	1982-2014	8.70%	40.00%	21.90%	32.80%	Agr + Ind
Malawi	1975-2014	19.25%	47.65%	24.35%	35.75%	Agr + Man
Mali	1967-2014	13.50%	57.60%	17.95%	28.45%	Agr + Ind
Mauritania	1973-2014	19.00%	56.50%	41.15%	59.05%	Agr + Ind
Rwanda	1975-2014	18.20%	48.85%	10.25%	24.55%	Agr + Man
Senegal	1979-2014	10.25%	30.10%	26.90%	39.40%	Agr + Man
Seychelles	1978-2014	6.15%	14.80%	44.15%	74.05%	Agr + Man
Sierra Leone	1964-2014	12.30%	61.10%	21.50%	30.00%	Agr + Ind
Sudan	1976-2011	4.85%	41.45%	10.50%	16.10%	Agr + Man
Togo	1976-2014	9.50%	43.00%	40.10%	52.00%	Agr + Man
Uganda	1982-2014	12.20%	44.35%	12.50%	23.00%	Agr + Man

Agr, Man and Ind stand for agriculture, manufacturing and Industry

*, exports and imports data are taken from PWT 9.0

Agriculture sector includes agriculture, fishing, forest and hunting; Manufacturing sector includes manufacturing; Industry sector includes mining and quarrying, manufacturing, electricity and water, and construction; Exports and Imports include both goods and services.

In Botswana and Gambia, Agr + Ind constitute to 51.75% and 38.5% of GDP respectively. In Seychelles, commercial services exports composed 65% of total exports.

Table 3.1B: Composition of tradable sector
(Source: WDI, 2017)

Country	Agr	Man	Ind	Trad = Agr+Man	Trad = Agr+Ind
Benin	30.02%	11.79%	17.78%	41.80%	47.80%
Botswana	12.45%	5.86%	39.29%	18.30%	51.75%
Burkina Faso	31.15%	13.39%	20.47%	44.50%	51.60%
Burundi	48.55%	NA	14.67%	NA	63.25%
Cameroon	22.48%	12.90%	25.55%	35.40%	48.05%
Cape Verde	11.86%	NA	20.96%	NA	32.80%
Central Africa	46.18%	7.47%	15.62%	53.65%	61.80%
Ethiopia	47.70%	4.64%	10.28%	52.35%	58.00%
Gambia	26.15%	5.51%	12.32%	31.65%	38.50%
Kenya	27.82%	10.54%	16.96%	38.35%	44.80%
Lesotho	12.96%	11.51%	26.53%	24.50%	39.50%
Madagascar	27.21%	NA	12.83%	NA	40.00%
Malawi	35.03%	12.61%	18.45%	47.65%	53.50%
Mali	41.09%	NA	16.53%	NA	57.60%
Mauritania	28.23%	NA	28.25%	NA	56.50%
Rwanda	38.25%	10.60%	17.96%	48.85%	56.20%
Senegal	16.89%	13.19%	20.19%	30.10%	37.10%
Seychelles	4.21%	10.57%	18.46%	14.80%	22.70%
Sierra Leone	41.65%	NA	19.46%	NA	61.10%
Sudan	34.57%	6.88%	17.36%	41.45%	51.95%
Togo	34.95%	8.06%	20.09%	43.00%	55.05%
Uganda	37.35%	7.01%	16.43%	44.35%	53.80%

Table 3.2A: Perron test for exogenous structural break

Country	Variable	Break Type	Break Year	Outlier Type	t-statistics	Order
Benin	*trad*	Intercept	1982	IO	-0.96 (0.75)	I(1)
Burundi	*aid*	Intercept	1994	IO	-4.01 (0.37)	I(1)
	gdp	Intercept	1992	IO	-4.19 (0.15)	I(1)
	non-trad	Intercept	1991	IO	-3.92 (0.24)	I(1)
	trad	Intercept	1993	IO	-3.28 (0.55)	I(1)
Cape Verde	p^T	Trend	1994	IO	-1.57 (0.73)	I(1)
Central Africa	*aid*	Intercept	1996	IO	-3.89 (0.26)	I(1)
Ethiopia	p^{NT}	Intercept	1996	IO	-1.43 (0.96)	I(1)
Gambia	*aid*	Intercept	1990	IO	-4.06 (0.19)	I(1)
Kenya	*aid*	Intercept	1995	IO	-3.11 (0.87)	I(1)
Lesotho	*trad*	Intercept	1979	IO	-3.88 (0.26)	I(1)
Mali	*aid*	Intercept	1972	IO	-4.41 (0.16)	I(1)
Rwanda	*aid*	Intercept	1996	IO	-3.80 (0.31)	I(1)
	gdp	Intercept	1994	IO	-3.42 (0.43)	I(1)
	non-trad	Intercept	1995	IO	1.95 (0.99)	I(1)
	trad	Intercept	1994	IO	-3.02 (0.67)	I(1)
Seychelles	p^{NT}	Intercept	2003	IO	-2.72 (0.95)	I(1)
Sierra Leone	*gdp*	Trend	2000	IO	-2.89 (0.76)	I(1)
	non-trad	Trend	1999	IO	-2.82 (0.78)	I(1)
Sudan	p^T	Trend	1995	IO	-2.21 (0.71)	I(1)
	p^{NT}	Trend	1995	IO	-2.45 (0.62)	I(1)
Togo	*aid*	Trend	2003	IO	-2.83 (0.72)	I(1)
Uganda	*aid*	Trend	1993	IO	-1.01 (0.78)	I(1)

p-value in parentheses and depends on the time of break

Table 3.2B: Zivot-Andrews test for endogenous Structural Break

Country	Variable	Break Type	Break Year	t-statistics	Order
Benin	*trad*	Intercept	2008	-3.64	I(1)
Burundi	*aid*	Intercept	1995	-3.75	I(1)
	gdp	Intercept	1993	-4.84	I(1)
	non-trad	Intercept	1996	-4.11	I(1)
	trad	Intercept	1993	-3.56	I(1)
Cape Verde	p^T	Trend	1991	-4.37	I(1)
Central Africa	*aid*	Intercept	1997	-3.02	I(1)
Ethiopia	p^{NT}	Intercept	2008	-2.04	I(1)
Gambia	*aid*	Intercept	1991	-3.59	I(1)
Kenya	*aid*	Intercept	1996	-4.62	I(1)
Lesotho	*trad*	Intercept	2000	-4.44	I(1)
Mali	*aid*	Intercept	1997	-3.81	I(1)
Rwanda	*aid*	Intercept	1997	-4.44	I(1)
	gdp	Intercept	1990	-3.13	I(1)
	non-trad	Intercept	1991	-3.06	I(1)
	trad	Intercept	1989	-3.47	I(1)
Seychelles	p^{NT}	Intercept	2008	-4.20	I(1)
Sierra Leone	*gdp*	Trend	2002	-2.53	I(1)
	non-trad	Trend	2000	-3.05	I(1)
Sudan	p^T	Trend	1996	-3.93	I(1)
	p^{NT}	Trend	1998	-3.03	I(1)
Togo	*aid*	Trend	2003	-2.83	I(1)
Uganda	*aid*	Trend	1991	-3.61	I(1)
Critical	Intercept		Trend		Both
Value 5%	-4.800		-4.420		-5.080

Table 3.2C: Unit-root test results with two structural breaks

Lumsdaine-Papell Test

Country	Variable	Intercept	1st Break	2nd Break	Order
Cameroon	*gdp*	-5.840	1976	1987	I(1)
	non-trad	-5.720	1976	1989	I(1)
Madagascar	*gdp*	-5.197	1990	2004	I(1)
	non-trad	-5.093	1990	2003	I(1)
	trad	-5.4038	1991	2001	I(1)
Critical Value 5%		-6.16			

Table 3.3: Ranking test

Country	Trace	Trace Bartlett	Alpha	Roots	Rank chosen
Benin	2	1	2	1	2
Botswana	1	0	1	2	1
Burkina Faso	2	1	2	3	2
Burundi	2	2	2	1	2
Cameroon	2	2	3	1	2
Cape Verde	2	2	3	2	2
Central Africa	1	1	1	2	1
Ethiopia	2	2	3	3	2
The Gambia	1	1	1	2	1
Kenya	1	1	2	1	1
Lesotho	2	2	2	2	2
Madagascar	3	3	3	3	3
Malawi	1	1	1	2	1
Mali	1	0	2	4	1
Mauritania	1	1	1	2	1
Rwanda	1	1	2	1	1
Senegal	1	1	1	3	1
Seychelles	2	2	2	3	2
Sierra Leone	2	2	2	3	2
Sudan	1	1	2	2	1
Togo	1	1	1	4	1
Uganda	2	2	3	3	2

Table 3.4: Testable hypotheses of causal links between aid and the variables

Country	H_1	H_2	H_3	H_4	H_5	H_1&H_4	H_2&H_5	Case
Madagascar	0.011		0.124	0.000		0.000		II
Botswana	0.069	0.078	0.000		0.021		0.050	III
Burundi	0.616		0.001	0.069		0.038		III
Central Africa	0.389		0.000	0.001		0.006		III
Ethiopia	0.339		0.008	0.001		0.008		III
Mali	0.965		0.000	0.046		0.031		III
Sudan	0.905		0.000	0.000		0.000		III
Benin	0.025		0.049	0.009		0.033		IV
Burkina Faso	0.003		0.006	0.000		0.000		IV
Cameroon	0.000		0.000	0.009		0.000		IV
Cape Verde	0.000		0.000	0.056		0.005		IV
The Gambia	0.000		0.029	0.080		0.050		IV
Kenya	0.000		0.012	0.000		0.000		IV
Lesotho	0.008		0.011	0.018		0.029		IV
Malawi	0.002		0.000	0.000		0.000		IV
Mauritania	0.000		0.000	0.000		0.000		IV
Rwanda	0.029		0.000	0.000		0.000		IV
Senegal	0.017		0.001	0.020		0.038		IV
Seychelles	0.038		0.000	0.041		0.037		IV
Sierra Leone	0.008	0.000	0.000		0.000		0.000	IV
Togo	0.003		0.000	0.000		0.000		IV
Uganda	0.009		0.014	0.027		0.001		IV

Table 3.5: Long-run impact of aid (rank based on trace test)

Country	*gdp*	*trad*	p^T	p^{NT}	Case
Madagascar	0.035 (1.705)	0.015 (1.494)	-0.095 (-1.922)	-0.118 (-1.642)	II
Botswana	**-0.190 (-2.147)**	**-0.207 (-2.342)**	0.015 (0.444)	-0.077 (-1.129)	III
Burundi	**-0.132 (-2.814)**	**-0.354 (-4.728)**	**0.272 (2.694)**	**-0.368 (-2.770)**	III
Central Africa	0.015 (0.590)	**-0.050 (-2.925)**	-0.063 (-1.353)	**-0.103 (-2.035)**	III
Ethiopia	-0.045 (-0.661)	**-0.207 (-3.616)**	0.281 (1.593)	0.130 (0.957)	III
Mali	-0.008 (-0.520)	**-0.049 (-2.673)**	0.008 (0.321)	**0.069 (3.004)**	III
Sudan	-0.002 (-0.070)	**-0.096 (-1.997)**	**-0.521 (-2.490)**	**-0.364 (-2.178)**	III
Benin	0.026 (0.585)	**-0.247 (-2.234)**	0.394 (1.752)	0.192 (1.538)	IV
Burkina Faso	-0.002 (-0.029)	**-0.164 (-2.390)**	**0.212 (2.069)**	0.144 (1.561)	IV
Cameroon	-0.003 (-0.357)	**-0.010 (-2.271)**	**-0.034 (-2.325)**	**0.025 (2.508)**	IV
Cape Verde	**-0.099 (-2.241)**	-0.062 (-1.761)	-0.004 (-0.162)	**0.170 (5.445)**	IV
Gambia	-0.005 (-0.612)	**0.050 (3.606)**	-0.024 (-1.582)	**0.051 (3.759)**	IV
Kenya	**-0.118 (-2.894)**	**-0.085 (-2.106)**	-0.054 (-0.647)	0.089 (1.562)	IV
Lesotho	**0.077 (2.241)**	**-0.104 (-2.366)**	0.010 (0.096)	0.107 (1.349)	IV
Malawi	**0.073 (2.620)**	**0.181 (3.637)**	**0.390 (3.767)**	**0.444 (2.893)**	IV
Mauritania	**-0.101 (-4.261)**	**-0.098 (-2.828)**	-0.018 (-0.361)	0.022 (0.575)	IV
Rwanda	**0.383 (4.103)**	**0.403 (3.873)**	**0.261 (2.126)**	**0.566 (3.719)**	IV
Senegal	**-0.019 (-3.725)**	**-0.066 (-6.135)**	**-0.054 (-3.272)**	**-0.033 (-2.231)**	IV
Seychelles	**-0.060 (-2.860)**	**-0.085 (-2.984)**	**0.083 (2.163)**	**0.088 (3.787)**	IV
Sierra Leone	0.006 (0.312)	**0.085 (5.682)**	0.100 (0.903)	**0.250 (2.260)**	IV
Togo	**-0.030 (-5.702)**	**-0.024 (-3.025)**	**-0.063 (-6.034)**	-0.024 (-1.389)	IV
Uganda	-0.021 (-1.242)	**-0.026 (-2.108)**	**0.557 (4.758)**	**0.415 (5.823)**	IV

t-ratios are in parenthesis (Bold figures are significant at 5%)

Table 3.6: The number of Case I-IV SSA countries according to sign and statistical significance of the effect of foreign aid on the variables

	Countries number	(++)	(--)
Case I	0		
gdp		-	-
trad		-	-
p^T		-	-
p^{NT}		-	-
Case II	1		
gdp		-	-
trad		-	-
p^T		-	-
p^{NT}		-	-
Case III	6		
gdp		-	2
trad		-	6
p^T		1	1
p^{NT}		1	3
Case IV	15		
gdp		3	6
trad		4	10
p^T		5	3
p^{NT}		8	1

(++) indicates t-statistics > 1.96

(--) indicates t-statistics < -1.96

Table 3.7: Long-run impact of aid (rank based on trace test)

	Model 1		Model 2		
Country	*gdp*	*trad*	*non-trad*	*trad*	Case
Madagascar	0.035 (1.705)	0.015 (1.494)	-0.052 (1.319)	0.014 (1.390)	II
Botswana	**-0.190 (-2.147)**	**-0.207 (-2.342)**	**-0.191 (-1.968)**	**-0.191 (-2.120)**	III
Burundi	**-0.132 (-2.814)**	**-0.354 (-4.728)**	**0.408 (5.650)**	**-0.279 (-4.190)**	III
Central Africa	0.015 (0.590)	**-0.050 (-2.925)**	**0.104 (2.444)**	**-0.050 (-2.690)**	III
Ethiopia	-0.045 (-0.661)	**-0.207 (-3.616)**	0.127 (1.813)	**-0.214 (-4.656)**	III
Mali	-0.008 (-0.520)	**-0.049 (-2.673)**	**0.038 (2.300)**	**-0.049 (-2.551)**	III
Sudan	-0.002 (-0.070)	**-0.096 (-1.997)**	**0.075 (1.983)**	-0.089 (-1.915)	III
Benin	0.026 (0.585)	**-0.247 (-2.234)**	0.160 (1.824)	**-0.231 (-2.322)**	IV
Burkina Faso	-0.002 (-0.029)	**-0.164 (-2.390)**	0.121 (1.426)	**-0.146 (-2.014)**	IV
Cameroon	-0.003 (-0.357)	**-0.010 (-2.271)**	0.001 (0.004)	**-0.010 (-2.278)**	IV
Cape Verde	**-0.099 (-2.241)**	-0.062 (-1.761)	**-0.163 (-2.098)**	-0.067 (-1.411)	IV
Gambia	-0.005 (-0.612)	**0.050 (3.606)**	-0.005 (-0.612)	**0.023 (3.193)**	IV
Kenya	**-0.118 (-2.894)**	**-0.085 (-2.106)**	**-0.146 (-2.883)**	**-0.090 (-2.229)**	IV
Lesotho	**0.077 (2.241)**	**-0.104 (-2.366)**	**0.141 (2.605)**	**-0.108 (-2.385)**	IV
Malawi	**0.073 (2.620)**	**0.181 (3.637)**	-0.010 (-0.276)	**0.181 (3.643)**	IV
Mauritania	**-0.101 (-4.261)**	**-0.098 (-2.828)**	-0.037 (-1.571)	**-0.066 (-5.221)**	IV
Rwanda	**0.383 (4.103)**	**0.403 (3.873)**	**0.373 (3.874)**	**0.406 (3.849)**	IV
Senegal	**-0.019 (-3.725)**	**-0.066 (-6.135)**	0.002 (0.334)	**-0.066 (-6.172)**	IV
Seychelles	**-0.060 (-2.860)**	**-0.085 (-2.984)**	**-0.056 (-2.306)**	**-0.085 (-2.970)**	IV
Sierra Leone	0.006 (0.312)	**0.085 (5.682)**	-0.060 (-1.324)	**0.101 (3.977)**	IV
Togo	**-0.030 (-5.702)**	**-0.024 (-3.025)**	**-0.033 (-3.691)**	**-0.020 (-2.889)**	IV
Uganda	-0.021 (-1.242)	**-0.026 (-2.108)**	-0.036 (-1.364)	-0.021 (-1.673)	IV

t-ratios are in parenthesis (Bold figures are significant)

Table 3.8: A sensitivity analysis of the long-run impact of foreign aid on GDP, the tradable and non-tradable outputs under two economic hypothesis

	Economic hypothesis 1: Foreign aid is harmful		Economic hypothesis 2: Foreign aid is effective	
	Number of countries with significantly negative effects		Number of countries with significantly positive effects	
	Model 1	Model 2	Model 1	Model 2
gdp	8		3	
ntrad		6		6
trad	16	14	4	4

Source: Author's calculations

Table 3.9: The long-run impact of aid on GDP structure

Country	*Trad/GDP*	*Ntrad/GDP*	*GDP*	Case
Madagascar	Unknown	Unknown	No effect	II
Botswana	Unknown	Unknown	Negative	III
Burundi	Decrease	Increase	Negative	III
Central Africa	Decrease	Increase	No effect	III
Ethiopia	Decrease	Increase	No effect	III
Mali	Decrease	Increase	No effect	III
Sudan	Decrease	Increase	No effect	III
Benin	Decrease	Increase	No effect	IV
Burkina Faso	Decrease	Increase	No effect	IV
Cameroon	Decrease	Increase	No effect	IV
Cape Verde	Unknown	Unknown	Negative	IV
Gambia	Increase	Decrease	No effect	IV
Kenya	Unknown	Unknown	Negative	IV
Lesotho	Decrease	Increase	Positive	IV
Malawi	Increase	Decrease	Positive	IV
Mauritania	Decrease	Increase	Negative	IV
Rwanda	Unknown	Unknown	Positive	IV
Senegal	Decrease	Increase	Negative	IV
Seychelles	Unknown	Unknown	Negative	IV
Sierra Leone	Increase	Decrease	No effect	IV
Togo	Unknown	Unknown	Negative	IV
Uganda	Decrease	Increase	No effect	IV

Source: Author's estimations based on Table 3.7.

Table 3.10: Long-run impact of the variables (rank based on trace test)

	Panel A		Panel B		
	Long-run impact of variables on aid		Long-run impact of aid on variables		
Country	$\widehat{\varepsilon_{gdp}}$	$\widehat{\varepsilon_{trad}}$	*gdp*	*trad*	Case
Madagascar	**-5.482 (-1.968)**	**5.518 (2.160)**	0.035 (1.705)	0.015 (1.494)	II
Botswana	1.249 (0.503)	-2.631 (-1.647)	**-0.190 (-2.147)**	**-0.207 (-2.342)**	III
Burundi	-0.275 (-0.844)	0.775 (0.724)	**-0.132 (-2.814)**	**-0.354 (-4.728)**	III
Central Africa	1.904 (1.033)	-2.451 (-1.033)	0.015 (0.590)	**-0.050 (-2.925)**	III
Ethiopia	1.351 (0.953)	-1.870 (-1.209)	-0.045 (-0.661)	**-0.207 (-3.616)**	III
Mali	-0.075 (-0.056)	0.073 (0.056)	-0.008 (-0.520)	**-0.049 (-2.673)**	III
Sudan	-0.054 (-0.118)	0.218 (0.118)	-0.002 (-0.070)	**-0.096 (-1.997)**	III
Benin	**-0.523 (-2.102)**	**0.485 (2.780)**	0.026 (0.585)	**-0.247 (-2.234)**	IV
Burkina Faso	**-1.547 (-4.103)**	**-1.266 (-4.711)**	-0.002 (-0.029)	**-0.164 (-2.390)**	IV
Cameroon	**4.685 (3.932)**	1.318 (-1.169)	-0.003 (-0.357)	**-0.010 (-2.271)**	IV
Cape Verde	-0.655 (-1.650)	**-0.801 (-5.246)**	**-0.099 (-2.241)**	-0.062 (-1.761)	IV
Gambia	**-1.811 (-4.260)**	**1.655 (4.260)**	-0.005 (-0.612)	**0.050 (3.606)**	IV
Kenya	**4.553 (9.962)**	**-4.486 (-9.962)**	**-0.118 (-2.894)**	**-0.085 (-2.106)**	IV
Lesotho	0.512 (0.874)	**-1.928 (-4.485)**	**0.077 (2.241)**	**-0.104 (-2.366)**	IV
Malawi	**-0.887 (-5.139)**	**1.981 (5.139)**	**0.073 (2.620)**	**0.181 (3.637)**	IV
Mauritania	**-1.667 (-9.037)**	**0.187 (9.037)**	**-0.101 (-4.261)**	**-0.098 (-2.828)**	IV
Rwanda	**-0.770 (-3.664)**	**0.991 (3.664)**	**0.383 (4.103)**	**0.403 (3.873)**	IV
Senegal	**0.558 (2.318)**	**-1.482 (-2.318)**	**-0.019 (-3.725)**	**-0.066 (-6.135)**	IV
Seychelles	**-2.404 (-3.821)**	0.204 (0.274)	**-0.060 (-2.860)**	**-0.085 (-2.984)**	IV
Sierra Leone	-0.318 (-0.314)	**1.159 (2.065)**	0.006 (0.312)	**0.085 (5.682)**	IV
Togo	**-2.439 (-2.880)**	**-0.106 (-2.880)**	**-0.030 (-5.702)**	**-0.024 (-3.025)**	IV
Uganda	**1.114 (2.183)**	-1.083 (-0.770)	-0.021 (-1.242)	**-0.026 (-2.108)**	IV

t-ratios are in parenthesis (Bold figures are significant)

Table 3.11: Comparison between the impacts of the variables' shocks

		Long-run impact of *gdp*'s shock on aid		
		Positive	Negative	No-effect
Long-run impact of aid's shock on *gdp*	Positive	0	2	1
	Negative	2	3	3
	No-effect	2	4	5
		Long-run impact of *trad*'s shock on aid		
		Positive	Negative	No-effect
Long-run impact of aid's shock on *trad*	Positive	4	0	0
	Negative	2	5	9
	No-effect	1	1	0

Chapter 4

Foreign Aid, Human Capital Investment, and Business Cycle

4.1- Introduction

Government policy usually aspires to provide good educational infrastructure and good quality education. Most governments in the world provide free public schooling up to Grade 12. However, the presence of free education does not mean that households do not incur expenses in educating their children. For instance, households still incur expenses related to tuition fees, school uniforms, books, school supplies, and other educational supplies. In addition, some households register their children in private schools where they have to pay tuition fees. In the Philippines for example, households spend 3.17% of their monthly expenditure on education (Tabuga, 2007), while in Kenya[77] they spend around 3.4%.

Households decide whether their children attend the school or not[78]. However, private investment[79] in human capital decisions is usually affected by the opportunity cost of education which increases by student age. Hega and Hokenmaier (2002) find that there exists a negative relationship between private and public education spending[80] (i.e. the more the government spends on education, the less the citizens invest in education). Educating children today would enhance their future labor income as well as their social capabilities. The Global Economic Symposium (2018) urges developing countries to act wisely and quickly to face the increasing demand for education, so that the new generation has adequate skills to achieve economic competence and independence. From a macroeconomic perspective, investment in human capital and knowledge contributes to economic growth in the long-run by increasing labor productivity which is reflected in increasing output.

In Chapter 3, foreign aid was found to have a negative impact on GDP in eight countries and on the tradable output in 16 countries. Foreign aid can be used to increase the household's investment

---

[77] See Appendix B.6 for details.
[78] Unless school attendance is mandatory especially for primary education.
[79] Tuition fees, books, uniforms, school supplies, time devoted to study, and other educational supplies.
[80] Their study only includes 18 advanced industrialized countries.

in education, thus increasing their children productivity. This chapter examines the role of foreign aid on household's education spending as well as time allocated to acquire skills. I look at both the level and volatility of foreign aid. In particular, I use a calibrated dynamic stochastic general equilibrium — real business cycle — (DSGE-RBC) model of a small representative-agent economy to examine the dynamic implications of foreign aid on private human capital investment, study hours, and human capital accumulation in addition to macro variables. To the best of my knowledge, the impact of a change in the volatility of foreign aid has not been previously examined in a DSGE-RBC model, in a context of two forms of capital[81].

The model is calibrated to match the Kenyan economy for the period of 1970–2014. In the calibrated model, a positive temporary shock to foreign aid generates a positive income effect, which manifests in several ways. First, an increase in foreign aid in the short run[82] produces a positive income effect, leading to an increase in consumption and leisure time upon impact[83]. Thus, labor supply declines, causing output to drop. Second, a positive foreign aid shock raises representative agent human capital investment. Thus, the agent devotes more time to human capital skills acquisitions[84]. Hence, labor productivity increases, thereby raising output in the future. Third, as a result of consumption smoothing behavior of the representative agent, the saving rate increases, thus physical capital investment and physical capital stock increase.

The findings in this chapter suggest that, over the short run, foreign aid has a positive effect on consumption, physical capital investment, private human capital investment, and time devoted to acquire new skills. On the other hand, foreign aid has a negative impact on output (consistent with the long-run negative impact of aid on total output for Kenya - Chapter 3) and labor working hours. These findings are affected by the degree of persistence in the level of aid shock. Study hours are more sensitive to the persistence level of aid shock than working hours. With a high persistence shock ($\rho^f = 0.90$), the representative agent devotes less time to study (below the trend), whereas with a low persistence shock the representative agent devotes more time to study. The same pattern occurs for private human capital investment. When aid persistence (ρ^f) equals to 0.95, the representative agent decreases his investment in human capital.

---

81 Some theoretical models study the impact of remittances on human capital accumulation such as Batu (2015), others study the impact of aid on human capital accumulation such as Mongardini and Samake (2009) and Farah et al. (2009). The similarities and differences with these papers are discussed later.

82 Definition of short-run, long-run, temporary vs permanent aid shocks, and permanent increase in aid level are defined later.

83 This is consistent with Annen and Kosempel (2012), Annen et al. (2016).

84 Consistent with Batu (2015), however his model is considering workers remittances instead of foreign aid and his country of consideration is the Philippine.

The behavior of the representative agent for a high persistence shock is similar to his behavior when there is a permanent increase in aid levels. A permanent increase in the level of foreign aid dis-incentivises the representative agent to acquire new skills. It increases agent consumption, while investment in physical and human capital are not affected. As a consequence, both study hours and working hours drop, leading to a permanent decline in labor productivity and thus output.

Another result that emerges from the benchmark model is that aid shock is dominated by other shocks. However, as aid-to-GDP ratio increases foreign aid becomes more influential in explaining the fluctuations in consumption, physical capital investment, private human capital investment, physical and human capital, study hours, and working hours. Finally, decreasing (increasing) the volatility of foreign aid would increase (decrease) output, physical capital investment, private human capital investment, study, and working hours. For instance, delivering foreign aid in a stable manner is equivalent to an increase in the level of foreign aid by 4.5%. Foreign aid to SSA countries is highly volatile and its relative volatility with respect to GDP ranges between 1.6 and 12.5, averaging 6 for the 22 countries presented in Chapter 3. Delivering aid in a predictable way would have a positive implication on welfare as well as on human capital accumulation.

The rest of the chapter is organized as follows: Section 4.2 provides a brief literature review. Section 4.3 introduces data sources used to calibrate the model. Section 4.4 outlines the model. The calibrated model and results are presented in Section 4.5. Section 4.6 describes the simulation results of the model. Sensitivity analyses are shown in Section 4.7. Finally, Section 4.8 concludes.

4.2- Literature Review

There exist a number of theoretical models that examine the impact of aid flows and remittances using calibration and simulation techniques. Further, the literature contains articles that study business cycle characteristics associated with foreign aid, in addition to studies that analyze the cyclical behavior of school enrollment and human capital accumulation.

4.2.1- Schooling and Business Cycle

Dejong and Ingram (2001) develop an RBC model for the USA based on skill acquisition and show that during a positive productivity shock, agents try to increase working hours at the expense of study hours. Thus, the agent accumulates less human capital due to the fact that the opportunity cost of study goes up. Wei (2005) uses a DSGE model and examines asset pricing and business cycle implications in the USA. He finds that during an economic recession, the agent spends more time to acquire education and to build her human capital stock. Dejong and Ingram (2001) and Wei (2005) findings are consistent with empirical evidence that people spend more time in schooling during recessions.

Betts and McFarland (1995) examine the business cycle implications on the U.S. college enrollments from the late 60s to mid-80s. They find that community college enrollment is counter-cyclical, where a 1% increase in unemployment rates of new high school graduates and other adults raises college enrollment by 0.5% and 4%, respectively. Dellas and Sakellaris (2003) and Dellas and Koubi (2003) find evidence that school enrollment in the U.S. is counter-cyclical, where human capital investment and other economic activities are substitutes. The decision to enroll in post-secondary activities is affected by labor market conditions that are characterized by unemployment rates and earnings. On the other hand, Kane (1994) find no impact of the business cycle on school enrollments decision.

Sakellaris and Spilimbergo (2000) study the effect of the business cycle fluctuations on investment in higher education in OECD and non-OECD countries. They find that enrollments in OECD countries are counter-cyclical and pro-cyclical in non-OECD countries[85]. They explain that for OECD countries, the opportunity cost plays a dominant role in enrollment decisions; whereas, "the ability to pay and credit constraints seem more prevalent at non-OECD countries" (Sakellaris and Spilimbergo, 2000).

4.2.2- Cyclicality of Foreign Aid

Pallage and Robe (2001) analyze the business cycle characteristics of foreign aid to developing countries. They find that two-thirds of the African countries and half of other developing countries experience a high positive correlation between aid flows and domestic output, 30% of recipients' countries experience a-cyclical behavior, and 10% of countries have counter-cyclical behavior. They also show that aid flow is a major source of African countries income and is highly volatile. The volatility of foreign aid may contribute to economic instability; however, Chauvet and Guillaument (2001; 2003) show that aid can absorb the negative effects of external shocks on growth and is more effective in countries that are more vulnerable to external shocks. Chauvet and Guillaument (2009) find that aid flows make growth more stable, whereas its volatility reduces this effect.

[85] Non-OECD students enrolled in USA universities.

4.2.3- Effects of Foreign Aid

Annen and Kosempel (2012) use a one-sector DSGE-RBC model with one form of capital, physical capital, to examine the effects of a temporary change and a permanent change of untied aid on economic growth. They find that only a temporary change in aid flow produces a positive impact on growth and physical capital investment. A permanent increase in foreign aid yields a negative association between aid flows and economic growth. They also find that the aid shock is dominated by the productivity shock and this explains the small response of output to foreign aid shock. Annen et al. (2016) provide another DSGE-RBC model to evaluate the impact of wealth transfer such as foreign aid and workers' remittances on output, when the transfer is temporary or permanent. They find that a permanent increase in foreign aid has a negative impact on output, due to the induced income effect. In contrast, there is a lagged positive response on output following a positive temporary aid shock.

Mongardini and Samake (2009) use a human-capital augmented Solow production function model focusing on physical and human capital investments[86] in a one-sector model to examine the macroeconomic implications of increasing aid to Benin. Their model is based on the supply side, which is determined by the production function, and the demand side, which is determined by the private consumption, government revenues, investment, and net exports. They find that if half of the additional aid flows are allocated to education and health, then human capital investment ratio to GDP will rise from 2.2% in 2008 to 4.7% in 2015. This suggests that more skilled and healthier workers enter the labor force, leading to higher potential growth for Benin after 2015. They also demonstrate that additional resources to infrastructure would increase physical capital stock by 27.5% beyond 2015. Farah et al. (2009) investigate the impact of aid on growth, physical and human capital accumulation in Niger. They find that if foreign aid as a share of GDP increases to 10%; Niger's income per capita would be 12.5% higher by 2020. They also find that foreign aid has a positive impact on physical and human capital accumulation, but the impact on human capital lasts more.

Arndt et al. (2015) find that the aid-to-GDP level has a positive impact on the average years of schooling, in particular, secondary education for 72 developing countries. Michaelova (2004) examines the role of aid in education in 76 recipient countries. Her estimates suggest that if aid for education increases by $25 million in absolute terms or 0.15% relative to the average recipient

[86] Physical and human capital law of motion are symmetric.

country's GDP, the gross primary enrollment increases by 1%. Michaelowa and Weber (2007) find that if aid to education increases by 1% of the recipient country's GDP, the completion rate in primary education would increase by 2.5%. In a recent study, Birchler and Michaelowa (2016) find that aid has a positive contribution to enhancing primary enrollment; aid has been found to be more relevant in increasing enrollment more than in increasing achievements. Dreher et al. (2008) investigate the impact of aid on primary enrollment for 96 developing countries over the 1972–2004 period. They find that if aid to education increases by 1% of GDP, the primary enrollment increases between 2.5% and 5%. No evidence has been found that the government expenditure on education increases primary enrollment nor does democracy.

4.2.4- Effects of Remittances

Batu (2015) extends Dejong and Ingram's (2001) model, by including education expenditure and investigates the effects of worker remittances on human capital accumulation in the Philippines. He finds that remittances lead to an increase in education spending and study time; an initial decline in labor supply and an increase in consumption. The increase in study time and education spending raises human capital stock and labor productivity.

4.2.5- Foreign Aid and Welfare

Gomanee et al. (2005) show that foreign aid improves welfare indicators, especially in low-income countries. Aid seems to increase recipient countries welfare either directly or indirectly through its effect on economic growth. On the contrary, aid's variability has a negative implication on welfare. Arellano et al. (2009) find that the volatility of aid brings significant welfare losses and is reflected in both consumption and private investment volatilities. They recommend that if aid can be delivered in a predictable way the donors could reduce their aid flows by 8% keeping the same level of well-being for aid recipient countries' citizens. In addition, they suggest that delivering aid to insure households against productivity shocks effects on consumption could benefit the Ivorian welfare by 3.3% of consumption and 0.6% of consumption on the sample average country.

4.2.6- Similarities and Differences between the Present Model and Previous Models

The current chapter develops a one-sector DSGE-RBC model that has physical and human capital and a labor-leisure-education choice. The model is used to examine business cycle effects of four different exogenous shocks. The model differs from the existing literature in several ways:

First, the present model extends Dejong and Ingram (2001) and Wei (2005) models, by adding an exogenous foreign aid flow, public and private human capital investment, and government expenditures. The model is calibrated to match the stylized business cycle facts for a developing country, Kenya, instead of a developed country. In addition, my model differs from Batu (2015), by including foreign aid instead of remittances and by incorporating the role of government in human capital investment and other government expenditures.

Second, although Annen and Kosempel (2012) and Annen et al. (2016) focus on the impact of aid on GDP growth, they do not investigate the role of aid on private human capital investment and time devoted to acquire new skills.

Third, the main departure from Mongardini and Samake (2009) and Farah et al. (2009) is the inclusion of labor-leisure-education choice. Moreover, my model is based on the optimization behavior of the representative agent which is not a feature of Mongardini and Samake (2009) and Farah et al. (2009) models.

4.3- Data Sources

Kenyan output is measured by real GDP, consumption by households' expenditures, government expenditures by general government consumption, public education by government's expenditures on education, private human capital investment by households' expenditures on schooling[87], investment by gross capital formation, and aid by net official development aid. All the data cover a period from 1970 till 2014. All the data[88] are in real terms and are sourced from the World Bank Indicators database[89], except for aid data which are obtained from the Organisation for Economic Co-operation and Development (OECD) database. The variables are defined in Appendix B.7.

4.4- DSGE-RBC Model

The model is a one-sector DSGE model of a small representative-agent economy that produces a homogenous good which can be either consumed or invested. There are two forms of capital: physical capital and human capital. Human capital involves activities of formal education (in terms

[87] Appendix B.6 shows the method used to evaluate the private human capital investment.
[88] Yearly data.
[89] Downloaded on 15/09/2017.

of time) along with investment (private and public in terms of goods) to produce human capital stock that increases labor productivity. This economy has no access to international capital markets, but it receives aid in a form of an untied transfer of wealth (in terms of goods) every period. The representative agent lives infinitely and has preference over real consumption and leisure, denoted by C_t and L_t, respectively at time *t*. His objective is to maximize his expected lifetime inter-temporally additive utility function:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t [log(C_t) + \gamma \log(L_t)] \qquad (4.1)$$

The parameter $\gamma > 0$ is the weight of leisure in the utility function and β is the discount factor.

The representative agent is endowed with one unit of time every period:

$$L_t + N_t + S_t = 1 \qquad (4.2)$$

where N_t is the fraction of time spent in the production of goods, S_t is the fraction spent in acquiring skills (i.e. study time), and L_t is the leisure time.

The production technology of the real good of the economy is represented by:

$$Y_t = A_t \exp(z_t) K_t^{\alpha} (N_t H_t)^{1-\alpha} \qquad (4.3)$$

where Y_t denotes the production of the real goods (i.e. GDP); A_t is the productivity shifter; $\exp(z_t)$ is the output productivity shock (or the total factor productivity (TFP) shock); K_t is the physical capital stock accumulated at the beginning of period *t*; H_t is the human capital stock accumulated at the beginning of period *t*; $N_t H_t$[90] represents the "effective labor input" used in the production of goods; $\alpha \in (0, 1)$ represents the elasticity of output with respect to the stock of physical capital.

The representative agent owns the representative firm which operates in a competitive market. The firm chooses physical capital and effective labor to maximize profits; it produces output following the Cobb-Douglas production function with a constant return to scale technology taking prices as given. Factor markets are competitive and in equilibrium they earn their marginal productivity. Marginal productivities are calculated as follows:

$$r_t^k = \alpha A_t \exp(z_t) \left(\frac{K_t}{N_t H_t}\right)^{\alpha-1} \qquad (4.4)$$

[90] The labor force is normalized to 1.

$$w_t^h = (1-\alpha) A_t \exp(z_t) \left(\frac{K_t}{N_t H_t}\right)^{\alpha} \tag{4.5}$$

Human capital is reproducible with a constant return to scale in terms of time spent in acquiring skills (S_t), private human capital investment (I_t^h), and public human capital investment (I_t^{gh}). The human capital law[91] of motion is given by:

$$H_{t+1} = A_t^h S_t^{\theta_1} I_t^{h^{\theta_2}} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} + (1\text{-}\delta_h) H_t \tag{4.6}$$

Here, $\exp(z_t^{gh})$ is the public human capital productivity shock; θ_1 and $\theta_2 \in (0, 1)$ represent the elasticity of the production of human capital with respect to schooling time and private human capital investment, respectively; δ_h is the human capital depreciation rate; A_t^h is the human capital productivity shifter.

Human capital accumulation in the second period depends on the current private and public human capital investment, in addition to the time devoted to acquire new skills. I assume here that there is no learning-by-doing, and the representative agent acquires human capital through formal education, private human capital investment, and public human capital investment. Education does not have any direct impact on the representative agent utility; however, the representative agent invests in education to increase his human capital stock and earns a higher income in the future.

The representative agent receives rent on physical capital he leases to the firm, wage for his labor services to the firm, invests his saving in physical and human capital, consumes goods, pays lump-sum taxes to the government, and receives profits from the firm. The household budget constraint is given by:

$$C_t + I_t^k + I_t^h + T_t = r_t^k K_t + w_t^h N_t H_t + D_t \tag{4.7}$$

where C_t is the consumption of real goods; I_t^k and I_t^h are household's investment in physical and human capital, respectively in period *t*; T_t is a lump-sum tax paid to the government to finance its expenditures including investment in public human capital; K_t and H_t are the economy's physical

[91] Other forms of human capital law of motion could be considered; for instance, $H_{t+1} = I_t^h + (1\text{-}\delta_h) H_t$, but this law of motion could not capture schooling time. The Lucas-Uzawa human capital law of motion is: $H_{t+1} = (1 - N_t) H_t + (1-\delta_h) H_t$. Here H_{t+1} is linear in H_t which is a driving force for endogenous growth (Einarsson and Marquis, 1998). Adding another shock $\exp(z_t^h)$ to (4.6) $\exp(z_t^h) S_t^{\theta_1} I_t^{h^{\theta_2}} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}$ would not change the result. The impact of both shocks would be similar.

and human capital stocks, respectively in period t; r_t^k is the gross rental rate of physical capital in units of goods delivered in period t; w_t^h is the price per unit of effective labor in period t expressed in units of goods delivered in period t (i.e. real wage); D_t is the dividend distributed by the firm to the household each period[92].

Physical capital accumulation follows the following law of motion:

$$K_{t+1} = I_t^k + (1-\delta_k) K_t - \frac{\phi}{2}\left(\frac{K_{t+1}}{K_t} - 1\right)^2 K_t \tag{4.8}$$

In (4.8), an adjustment cost associated with the capital holdings is added to the physical capital law of motion and is weighted by ϕ to avoid high volatility in physical capital investment generated by the model; and $\delta_k \in (0, 1)$ is the depreciation rates of physical capital.

The government levies lump-sum taxes, T_t , to finance its expenditures and receives foreign aid[93]. Hence, the government budget constraint is:

$$T_t + F_t = I_t^{gh} + G_t \tag{4.9}$$

F_t = Fexp(z_t^f) is a stochastic exogenous aid inflow given each period. The government total expenditure could be split into public human capital investment, I_t^{gh}, and general government expenditure, G_t. Both public human capital investment and general government expenditure are assumed to be exogenous and stochastic, where $I_t^{gh} = I^{gh}\exp(z_t^{gh})$ and $G_t = G\exp(z_t^g)$.

The exogenous shocks of this representative agent economy follow a vector autoregressive [VAR(1)] process with AR coefficients that are restricted to be diagonal and given by:

$$\begin{bmatrix} z_t \\ z_t^g \\ z_t^{gh} \\ z_t^f \end{bmatrix} = \begin{bmatrix} \rho^z & 0 & 0 & 0 \\ 0 & \rho^g & 0 & 0 \\ 0 & 0 & \rho^{gh} & 0 \\ 0 & 0 & 0 & \rho^f \end{bmatrix} \begin{bmatrix} z_{t-1} \\ z_{t-1}^g \\ z_{t-1}^{gh} \\ z_{t-1}^f \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^z \\ \varepsilon_t^g \\ \varepsilon_t^{gh} \\ \varepsilon_t^f \end{bmatrix} \tag{4.10}$$

[92] Since the firm operates in a competitive market and uses a constant return to scale technology, the profit generated and the dividend distributed to the household are zero in equilibrium.
[93] Lump-sum taxes would be adjusted as a result of foreign aid injections.

where $|\rho^i|$<1 are the autocorrelation coefficients and ε_t^i ~ $nid(0,\sigma_\varepsilon^{i2})$ with i = z, g, gh, f are the innovations sequences of identically distributed normal random variables with mean zero and variances σ_ε^{i2}.

The variance-covariance matrix of the exogenous shocks is presented as follows:

$$\begin{bmatrix} \sigma_\varepsilon^{z2} & 0 & 0 & \rho^{zf}\sigma_\varepsilon^z\sigma_\varepsilon^f \\ 0 & \sigma_\varepsilon^{g2} & 0 & \rho^{gf}\sigma_\varepsilon^g\sigma_\varepsilon^f \\ 0 & 0 & \sigma_\varepsilon^{gh2} & 0 \\ \rho^{zf}\sigma_\varepsilon^z\sigma_\varepsilon^f & \rho^{gf}\sigma_\varepsilon^g\sigma_\varepsilon^f & 0 & \sigma_\varepsilon^{f2} \end{bmatrix}$$

where ρ^{zf} and ρ^{gf} are the correlations between aid and the TFP shocks and between aid and the government expenditure shocks, respectively[94]. The zero off-diagonal shows that shocks are not contemporaneously correlated.

The decisions taken in this economy follow a time sequence. At the beginning of period *t*, the values of the stochastic shocks are realized. The representative agent chooses consumption and makes investment decisions (in terms of time and goods). The representative firm chooses how much physical and effective labor to hire.

With no externalities and no distortionary taxes, the competitive equilibrium is Pareto optimal. For the representative agent, the Pareto-optimality means that utility maximizations and the representative agent's problem can be represented by the social planner's problem. The first and second welfare theorems state that the solution to a competitive equilibrium yields the same allocation of consumption, time devoted to work and study, and physical and human capital investment. Those allocations are chosen to maximize the representative agent utility subject to resource constraints and technology restrictions.

The social planner[95] maximizes the following expected utility of the representative agent:

---

[94] ρ^{zf} is added to match the pro-cyclicality between output and aid in the data. ρ^{gf} is added to match the negative correlation between the government expenditure and aid in the data. I have not included a correlation between foreign aid and public human capital shocks in the model since in Kenyan data the correlation between foreign aid and public human capital is very low (0.16), which is not different from zero as in Pallage and Robe (2000).

[95] Appendices B.1-B.4 describe in details the representative agent's optimization problem, firm's optimization problem, social planner problem and the steady state.

$$max_{\{C_t,\, L_t, N_t,\, S_t, I_t^h, K_{t+1},\, H_{t+1},\}} E_0 \sum_{t=0}^{\infty} \beta^t [log(C_t) + \gamma log(L_t)] \qquad s.t. \qquad (4.11)$$

$$L_t + N_t + S_t = 1$$

$$C_t + I_t^k + I_t^h + I_t^{gh} + G_t = A_t \exp(z_t) K_t^{\alpha} (N_t H_t)^{1-\alpha} + F_t$$

$$K_{t+1} = I_t^k + (1\text{-}\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t$$

$$H_{t+1} = A_t^h S_t^{\theta_1} I_t^{h\,\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} + (1\text{-}\delta_h) H_t$$

4.4.1- Competitive Equilibrium

Definition A competitive equilibrium for this representative-agent economy is a set of prices $\{w_t^h,\ r_t^k\}_{t=0}^{\infty}$ and allocations $\{C_t, L_t, N_t, S_t, I_t^h, K_{t+1},\ H_{t+1}\}_{t=0}^{\infty}$ such that the following conditions hold:

(i) The representative agent maximizes utility subject to his budget constraint taking prices as given.

(ii) The representative firm maximizes profits subject to output technology taking input prices as given.

(iii) The market-clearing conditions and the government budget constraint hold:

$$L_t + N_t + S_t = 1$$

$$C_t + K_{t+1} - (1\text{-}\delta_k) K_t + \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t + I_t^h + I_t^{gh} + G_t = A_t \exp(z_t) K_t^{\alpha} (N_t H_t)^{1-\alpha} + F_t$$

$$H_{t+1} = A_t^h S_t^{\theta_1} I_t^{h\,\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} + (1\text{-}\delta_h) H_t$$

$$T_t + F_t = I_t^{gh} + G_t$$

4.4.2- Equilibrium Dynamics

The optimality conditions of the social planner's maximization problem show the following equilibrium conditions:

$$\frac{\gamma C_t}{1-N_t-S_t} = (1-\alpha) A_t \exp(z_t) \left(\frac{K_t}{N_t H_t}\right)^{\alpha} H_t \qquad (4.12)$$

$$\frac{\gamma C_t}{1-N_t-S_t} = \frac{\theta_1 I_t^h}{\theta_2 S_t} \qquad (4.13)$$

$$\frac{1}{C_t}\,[1+\emptyset(\frac{K_{t+1}}{K_t}-1)] = \beta E_t\{\frac{1}{C_{t+1}}(\alpha A_{t+1}\exp(z_{t+1})\left(\frac{K_{t+1}}{N_{t+1}\,H_{t+1}}\right)^{\alpha-1} + (1\text{-}\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}}-1)\,\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1}-1)^2\} \quad (4.14)$$

$$\frac{\frac{\gamma}{1-N_t-S_t}}{\theta_1 A_t^h S_t^{\theta_1-1} I_t^{h^{\theta_2}}(\exp(z_t^{gh})I_t^{gh})^{1-\theta_1-\theta_2}} = \beta E_t\{\frac{\gamma}{1-N_{t+1}-S_{t+1}}[\frac{N_{t+1}}{H_{t+1}} + \frac{1-\delta_h}{\theta_1 A_{t+1}^h S_{t+1}^{\theta_1-1} I_{t+1}^{h^{\theta_2}}(\exp(z_{t+1}^{gh})I_{t+1}^{gh})^{1-\theta_1-\theta_2}}]\} \quad (4.15)$$

Equation (4.12) is the first intra-temporal Euler equation for leisure and consumption. It sets the marginal rate of substitution between consumption and leisure (LHS) equals to the marginal productivity of labor (RHS). Equation (4.13) is the second intra-temporal Euler equation that shows the relationship between consumption, private human capital investment, leisure time, and time devoted to acquire human capital. It sets the marginal rate of substitution between consumption and leisure (LHS) equals to the marginal rate of substitution between private human investment and time allocated to study; this relationship holds every period.

Equation (4.14) corresponds to the inter-temporal Euler equation for consumption that equates the marginal social cost (LHS) of giving up one unit of current consumption with the marginal social benefit (RHS) of allocating extra savings into physical capital; i.e. Euler equation for physical capital. It states that the loss of utility from foregone present consumption equates the expected benefit from increasing future consumption. Equation (4.15) corresponds to Euler equation for human capital that equates the current marginal social cost (LHS) for an extra unit of time spent on acquiring human capital with the marginal social benefit of the human capital in the future. In other words, the marginal social cost of human capital is equated with the discounted expected marginal social benefit of future human capital.

Euler equation equates the marginal utility of consumption to the marginal utility of saving and has an economic interpretation: along the optimal path the marginal utility from consumption at any point in time is equal to its opportunity cost. Thus, the representative agent cannot gain from redistributing consumption between periods. Hence, consumption and leisure smoothing are accomplished by adjustments in physical and human capital stocks.

The above model cannot be solved analytically, a Dynare program in Matlab is used to solve it.

4.5- DSGE-RBC Calibration and Results

4.5.1- Parameters

The data used to calibrate the model are yearly data and one-sided HP filter[96] is used to remove the cyclical component of the time series data. Regular HP filter (or two-sided) is not recommended, since it uses the full sample that leads to end-point sensitivity. However, one-sided HP filter (i.e. backward looking) only uses data available at a given point of time. On the other hand, Hamilton (2017) argues that HP filter is characterized by spurious dynamic as the filtered values in the middle of the sample are different from those at the end of it. He proposes an alternative filter called Hamilton filter[97].

The parameters used to calibrate the benchmark model are summarized in Table 4.1. The parameters are classified into three categories: parameters that are taken from other studies, parameters that are estimated directly from the data, and the rest are calibrated to mimic the Kenyan economy as observed in the 1970–2014 period.

The parameters which are taken from the literature and remain fixed are as follows: The value of α which corresponds to the elasticity of physical capital with respect to output is set to 0.36 (Prescott 1986). The autocorrelation coefficients of the total factor productivity, public human capital, and government expenditure shocks are set to 0.81 (equivalent to 0.95[98] quarterly Kydland and Prescott (1982)). The discount factor (β) is set to 0.95 (Arellano et. al (2009)). The cost of adjustment (ϕ) is set to 2[99]. The productivity shock of output (A) and the human capital sector shock (A^h) are normalized to 1. Physical and human capital depreciation rates are set to 5% (Arellano et. al (2009) and 3% (Jorgenson and Fraumeni (1989)), respectively which are also standards in the literature. The autocorrelation of foreign aid shock and its standard deviation are estimated directly from the Kenyan data.

The rest of the parameters are calibrated to match the long-run average ratios of the Kenyan economy. These parameters are: 1) the share parameter of schooling time in the human capital

---

[96] $\lambda = 100$ (for yearly data).
[97] Appendix B.8 compares the three filters' business cycle stylized facts and highlights their major similarities and differences.
[98] I have followed Kydland and Prescott (1982) and set the autocorrelation coefficients for public human capital investment and government expenditure equal to the autocorrelation coefficient for the TFP shock.
[99] The cost of adjustment in literature ranges between 0.005 and 5. García-Cicco et.al (2010) 95% confidence interval < 4.9 with median 3.3.

production function (θ_1 = 0.7); 2) the share parameter of the private human capital investment in the human capital production function (θ_2 = 0.10); 3) weight of leisure (γ = 1.6); 4) correlation coefficient between aid and the TFP shocks ($\rho^{zf} = 0.50$); 5) correlation coefficient between aid and the government expenditure shocks ($\rho^{gf} = -0.30$); 6) public human capital parameter (G = 0.0995); 7) government expenditure parameter (Gv = 0.21); 8) foreign aid parameter (F = 0.1085); 9) standard deviation of the TFP shock[100] ($\sigma^{z} = 0.0282$); 10) standard deviation of the public human capital shock ($\sigma^{gh} = 0.1067$); and 11) standard deviation of the government expenditure shock ($\sigma^{g} = 0.0827$).

The Kenyan economy long-run average ratios that the model matches (the targeted moments) in the calibration process are: 1) private human capital investment-to-consumption ratio of 3.4%; 2) working time of 33.33%[101]; 3) physical capital investment volatility of 10.25%; 4) pro-cyclicality between aid and output; 5) negative correlation between aid and the government expenditure; 6) public human capital investment-to-GDP ratio of 5.36%; 7) government expenditure-to-GDP ratio of 11.3%; 8) aid-to-GDP ratio of 5.85%; 9) standard deviation of GDP of 2.88%; 10) standard deviation of public human capital investment of 9%; and 11) standard deviation of government expenditure of 6.86%.

4.5.1- Calibration Results

The calibration results are represented in this sub-section. Table 4.2 below presents the stylized facts of the benchmark model which is calibrated to match the Kenyan data. Table 4.2A shows the variables' mean levels that the model is calibrated to match (discussed in the previous section) and Table 4.2B shows other means produced by the benchmark model. Tables 4.2C-4.2F present the standard deviations of some selected stationary variables[102] and the correlations with output, aid, public human capital, and government expenditure, respectively. The benchmark model is able to mimic successfully the eleven target moments with the calibration process. Furthermore, the benchmark model has an overall good fit with regard to other means.

The benchmark model underestimates the volatility of consumption[103] (see Table 4.2B). In the DSGE model, consumption is smoothed across periods where the theory suggests that consumption

---

[100] The strategy followed here is to calibrate the volatility of productivity shock so that the model can mimic the actual GDP's volatility.

[101] No data available for Kenyan working hours, I have calibrated the working hours to match one-third of the total time.

[102] Stationarity of the variables are explained in Appendix B.5.

[103] The volatility of consumption could reach GDP's by calibrating ϕ = 4.5 and σ^{z} =0.0320; but the volatility of physical investment drops to 8.64%; however, this will have adverse effects on other variables. impulse

does not vary significantly even if output fluctuates across periods. The Kenyan data show that the volatility of consumption is higher than that of output, suggesting that consumption is not smoothed over different periods. In addition, the Kenyan data available on consumption contain durable and non-durable goods and it is impossible to disaggregate them. Backus et al. (1995) find that the volatility of consumption declines when the durable goods data are excluded from the consumption data in some developed countries. Özbilgin (2004) finds that the relative consumption volatility drops from 1.14 to 0.67, when the consumption of durable goods are excluded in Turkish data. Kenyan data show that Kenyan's relative consumption volatility is 1.7, while it is 0.8 in the benchmark model. Naoussi and Tripier (2013) and Melina et al. (2016) estimate the volatilities of consumption for SSA countries and find that the relative consumption volatility is 1.76 and 1.5, respectively.

The literature suggests two approaches to generate greater consumption's volatility. First, Aguiar and Gopinath (2007) introduce a trend shock. They show that including a trend shock generates higher volatility of consumption for Mexico. The other approach is discussed by Garcia-Cicco et al. (2010). They find that financial friction, preference shocks, and country-premium shocks generate higher consumption's volatility rather than introducing a trend shock. Including a trend shock or a financial friction shock[104] is left for further research.

The volatility of foreign aid is 6.9 times the volatility of GDP in the benchmark model compared to 7 in the data; the benchmark model has a good fit in generating the volatility of aid even though foreign aid's standard deviation was estimated from the data rather than been calibrated. Public human capital investment volatility is 3.13 times of output's volatility and government expenditure's volatility is 2.38 of output's volatility; this is also consistent with Melina[105] et al. (2016) which is found to be 2.62 for SSA countries. The volatility of physical capital investment is 4 times of GDP's[106]. Naoussi and Tripier (2013) find that the relative physical capital investment volatility in SSA countries is 4.13; it is higher than in developed and emerging economies which is found to be 3.12 and 3.43, respectively. Moreover, there is no time series data available for Kenyan working time and private human capital investment to make the proper comparison between the Kenyan data moments and the moments generated by the calibrated RBC model. In Appendix B.6,

function. The high consumption volatility in data is consistent with Melina et al. (2016) where consumption volatility is 1.5 times of outputs in SSA.

[104] To match consumption's volatility.

[105] In their paper, there is no mention if the HP filter is one or two sided.

[106] This is also consistent with the high volatility in SSA countries that Melina et al. (2016) find (4.4 times of GDP's).

I have calculated the mean level of how much the Kenyan household is spending from his monthly income on education based on a survey conducted by the University of Nairobi in 2009.

In terms of correlations with GDP, the benchmark model matches the pro-cyclicality of consumption, physical capital investment[107], and foreign aid. In addition, it matches the positive correlation between aid and consumption and the negative correlation between aid and government expenditure. However, the benchmark model does not match the correlation sign between foreign aid and physical capital investment. The model does not match the correlation signs between government expenditures and other macro variables since government shock is assumed to be exogenous. The correlation between public human capital investment and foreign aid in Kenyan data is estimated at 0.16 which is very low, while it is zero in the DSGE-RBC model because both the public human capital investment and foreign aid shocks are assumed to be exogenous. Most of those correlations lie between (-0.29 and +0.29) which can be judged to be non-different from zero, as proposed by Pallage and Robe (2001). Government expenditure in data is a-cyclical; this is not consistent with Melina et al. (2016) which is found to be pro-cyclical. However, the benchmark model generates a positive correlation (although small) between GDP and government expenditure.

4.6- Simulation Results

The behavior of the economy in the periods following the shock[108] can be analyzed by studying the behavior of the impulse response functions[109]. Figures 4.4-4.5 demonstrate the effects of a one-standard-deviation increase of the desired shock on output, consumption, investments in private human and physical capital, time devoted to study and work, prices, and the marginal productivity of study hours.

4.6.1- Short Term Impact from Temporary Changes in Shocks

4.6.1.1- Foreign Aid Shock

Figure 4.1 illustrates the impulse response functions following a positive one-standard-deviation shock to foreign aid. Foreign aid is designed to enter the model as an untied wealth transfer and any change in foreign aid level would have an impact on the selected stationary variables.

[107] This is also consistent with SSA countries, HIC, UMIC and LLMIC in Melina (2016).
[108] TFP and government expenditure shocks impulse response functions are presented in Appendix B.9.
[109] We refer here to the first period after the shock as a short term impact.

The effects of a foreign aid shock are as follows. First, the positive income effect of foreign aid raises the consumption of leisure time, leading to an immediate reduction in labor working hours. Both consumption and private human capital investment increase on impact and decline gradually afterward. Second, as a result of the representative agent's consumption smoothing behavior, investment in physical capital increases on impact and declines gradually afterward. Third, higher private human capital investment increases the time spent on education, leading to an increase in labor productivity.

Fourth, the effect of an aid shock can be felt on both human and physical capital accumulations. The reaction of physical and human capital stocks is small on impact, but increases in subsequent periods. Both types of capital impulse responses show a humped shape, peaking in the 6^{th} period and then decline gradually and stay above their trends for a long period of time. Fifth, GDP declines immediately as a result of reduced working hours; however, over time, output rises above its trend due to the increase in labor productivity and physical and human capital stocks. Sixth, an aid shock affects the prices, where the real interest rate declines on impact and stays below its trend for a long period of time. The real wage increases on impact and stays above trend for a long period of time. Finally, the marginal productivity of study time declines on impact, but increases gradually, reaches the peak above the trend after 11 periods, and stays above trend afterward.

In my empirical study presented in Chapter 3, I have found that aid shocks have a negative long-run impact on GDP in eight sub-Saharan African countries and a positive long-run impact on GDP in only three SSA countries. For Kenya, aid shocks have a negative and persistent impact on GDP in the long-run, a result which coincides with the present DSGE-RBC impulse response of GDP due to a positive aid shock in the short-run.

4.6.1.2- Public Human Capital Shock

Here, I consider the impulse response functions of some selected stationary variables to a positive one-standard-deviation public human capital shock. A positive public human capital shock corresponds to a decline in the opportunity cost of acquiring education and to an increase in leisure opportunity cost. Figure 4.2 depicts the impulse responses to a positive one-standard-deviation public human capital shock. A positive public human capital shock could be explained by increases in government-sponsored training programs or any policy changes that increase educational budget. The shock to the public human capital decreases the cost of accumulating human capital relative to physical capital. Thus, the agent devotes more time into education activities at the expense of leisure and labor hours. Consequently, the agent increases his investment in human capital.

Consumption and physical capital investment decrease on impact and increase in subsequent periods and stay below the steady stay for four years after the realization of the shock. Then, both consumption and physical capital investment increase and stay above their trends for a long period of time.

The rise in studying hours along with the increase in private human capital investment would increase human capital stock which takes a humped shape. The peak response occurs in the 8th period after the realization of the shock, declines monotonically afterward, and stays above its trend for a long period of time. On the other hand, the public human capital shock has a negative impact on physical capital accumulation due to the initial decline in physical capital investment. The physical capital stock stays below its trend for nine years before rising above trend in the subsequent years and stays for a long period of time.

GDP declines on impact due to a decline in labor working hours. However, over time, the positive effects of the increase in human and physical capital lead output to rise above trend after the 2nd period and stays there for a long period of time. Moreover, public human capital sector shock results in an initial decline in the real interest rate (due to an initial decline in physical capital investment), which rises above the steady state in the second period. The shock to public human capital results in an immediate rise in the real wages, which declines below its trend in the second period following the shock. The marginal productivity of study hours increases on impact, declines monotonically, and stays above its long-run trend for a long period of time.

4.7- Sensitivity Analyses

One of the features of the calibration and simulation approaches is to measure the impact of foreign aid on the economy by distinguishing between a permanent change (increase in the mean level of aid) in aid levels and a temporary change in aid (change in the level of the persistent shock of aid). In the former case, I keep all the parameters fixed and change the mean level of aid; in the latter case, I only change the persistence level of the aid shock.

4.7.1- Permanent Changes in Foreign Aid Levels

Table 4.3 reports the impacts of a permanent increase in the aid-to-GDP ratio. The main idea is to compare the benchmark model to different hypothetical scenarios, when the representative agent economy receives a different amount of aid levels. In this part of the analysis, all the parameters stay fixed as in Table 4.1 except for the mean level of aid which changes to get an average aid-to-GDP of 0, 12, 18, and 24%.

One of the findings of the calibrated model is that a permanent increase in aid levels keeps the investment rates in physical and private human capital investment as a share of GDP the same. This means that the permanent increase in aid is totally consumed rather than invested; this is consistent with Annen et al. (2016) and Arellano et al. (2009). However, physical capital and private human capital investment as a share of income (GDP + aid) decline. For instance, physical capital investment-to-income and private human capital investment-to-income decline when aid-to-GDP level increases.

On the other hand, consumption-to-GDP and consumption-to-income ratios increase when the aid level increases. Government expenditure and public human capital investment as a share of GDP and income increase, although both are treated as exogenous[110]. The reason for this increment in both ratios is that when aid level increases it produces a positive income effect that raises leisure consumption, thus working hours would fall, causing a decline in the production. As the aid level increases both study hours and labor working hours decline. Further, when the aid-to-GDP level is tripled to 18%, study and working hours decline by 7.4%. However, the study to work time ratio[111] stays the same at 25.4%.

Another result that emerges from a permanent increase in the aid level is the increment of the volatility of the variables. For example, if aid is tripled to 18% of GDP, the volatilities of output, consumption, physical capital investment, private human capital investment, study hours, and work hours increase substantially.

4.7.1.1- Foreign Aid Shock at Different Aid Levels

Figure 4.3 illustrates the impulse responses of study hours, working hours, private human capital investment, physical capital investment, output, consumption, and the marginal productivity of study hours to a one-standard-deviation increase in foreign aid shock for different aid-to-GDP ratios (3, 6, 12, and 18%) keeping aid shock autocorrelation coefficient fixed at 0.69. As aid increases, aid shock has more impact on the above-mentioned impulse responses. For instance, when foreign aid is doubled to 12% of GDP, the reaction of the above mentioned stationary variables are less than doubled on impact. At 5.85% aid-to-GDP levels, study hours impulse function experiences its

[110] Government expenditures and public human capital investment are exogenous and their mean levels are fixed when aid mean level is increased.
[111] See Appendix B.4 for steady state variables.

maximum deviation of 0.0075% above trend; this happens in the first period following the shock. Doubling the aid level, study hours impulse function experiences a maximum deviation of 0.012% above trend. Lowering (raising) aid-to-GDP levels would reduce (raise) the response of study hours. The same pattern occurs to the private human capital investment and physical capital investment. However, the private human capital investment stays above trend, while study hours and physical capital investment deviate below the trend after 8th and 12th years, respectively.

On the other hand, the reaction of labor working hours is negatively affected by the aid shock. Increasing the aid level would decrease working hours; this can be felt in the output reaction as a result from the drop in working hours. The higher the aid level, the lower is the magnitude of the working hours and output responses. However, over time, as the positive effects of the increase in human and physical capital investment that increase labor productivity; output starts to rise above its trend in the 6th year[112]. At a higher aid-to-GDP level, output experiences a larger initial decline after the shock; however, output experiences a higher deviation above its trend in the subsequent periods and stays for a long period of time due to higher labor productivity.

Consumption is less responsive among the variables and as aid level increases the consumption's impulse response increases and stays above its trend for a longer period of time. Finally, the marginal productivity of study hours is also affected by the aid levels. For example, doubling aid-to-GDP ratio, the response of the marginal productivity of study hours declines below the trend (lower of that in the benchmark model), but it starts to increase and reaches its maximum above its trend in the 11th year following the shock.

4.7.2- Foreign Aid Shock at Different Persistent Levels

Now, I focus on the effects of foreign aid on some of the selected stationary variables' impulse responses, when the persistence level of the aid shock ranges between 0 (i.e. a temporary shock for one time only) up to 0.95[113] (a very persistent shock). The impulse responses of the selected stationary variables seem to be affected by the magnitude of the aid shock autocorrelation. The impulse response functions of study hours, working hours, private human capital investment, physical capital investment, output, consumption, and the marginal productivity of study hours to a positive one-standard-deviation from the trend in the aid level are presented in Figure 4.4. As expected, the magnitude of the responses depends on the persistence level of the aid shock (ρ^f)

[112] In all aid-to-GDP levels.

[113] For instance, if aid persistence level is 0.90, then if aid in period 1 is 1million, next period it would be 0.9 million, 3rd period it would be 0.81 million etc…

level. For this part of sensitivity analysis, five cases are considered: when ρ^f = 0.00, $\rho^f = 0.30$, ρ^f = 0.69 (the benchmark model), ρ^f = 0.90, and ρ^f = 0.95.

As the persistence level changes, consumption is the less responsive compared to output, investment in physical and human capital, study hours, working hours, and the marginal productivity of study hours, which are more responsive. The income effect from the aid shock causes leisure time to increase and working hours to fall for any level of ρ^f. However, the study time reaction seems to be sensitive to the choice of persistence level of aid shock. For instance, when $\rho^f < 0.90$, foreign aid has a positive impact on study hours; however, when $\rho^f \geq 0.90$, foreign aid starts to have a negative impact on study hours. At a high persistent aid shock, the behavior of the representative agent is similar to his behavior in the case of permanent increase in the aid level. Foreign aid would discourage the agent to put more effort to study and would encourage him to rely on aid. With a less persistent shock, study time increases initially on impact and then returns to steady state, but experiences a deviation below its trend in the 5th, 6th, and 7th year when ρ^f = 0.00, 0.30, and 0.69, respectively. When $\rho^f \geq 0.90$, the study hours response function never experiences a positive deviation above its trend.

The reaction of the private human capital investment is also affected by the level of aid shock persistence. For instance, when ρ^f = 0.95, aid shock would have a negative impact on private human capital investment, in contrast to the benchmark model.

For the working hours, the magnitude of the initial drop due to the aid shock depends little on the level of the persistence shock. However, the higher the aid shock persistence level, the longer the working hours stays below its trend. The immediate drop in the working hours explains the initial decline in output. The reaction of output in subsequent periods depends on the aid shock persistence level. For example, when ρ^f = 0.00, output experiences its deviation above the trend in the 5th year following the shock. In the benchmark model, output reaches its positive deviation above trend in the 7th period. Whereas, when ρ^f sets to 0.90, output stays below its trend for a long period of time after the realization of aid shock and never experiences a deviation above its trend. Output increases and stays above its trend is mainly resulted from the increase in private human capital investment and time devoted to study that increase labor productivity. Whereas, with a very persistence shock, output stays below its trend for a long period of time. This results from lowering the labor productivity, where the agent devotes less time to acquire education and invests less in acquiring human capital.

The reaction of consumption initially increases and then declines gradually in the subsequent periods. As the persistence level increases, consumption response increases. For instance, increasing the persistence level in the benchmark model to 0.90, consumption response increases (0.74% to 0.96% above the trend) and stays for a longer period of time above the trend.

Finally, the different responses of study hours and private human capital investments due to the changes in the persistence level of aid shock affect the marginal productivity of study hours. When the aid shock persistence level is small, the marginal productivity of study hours declines on impact. However, with a very persistence shock, the marginal productivity of study hours increases on impact and stays above trend for a long period of time. This may be due to the decline of study hours and private human capital investment at a high persistence level.

4.7.3- Effects of Changing the Volatility of Aid: Mean-Preserving Spread

Now, consider comparing the benchmark model to hypothetical scenarios when the same representative economy receives the same amount of aid but with different volatility of aid levels. This exercise studies the impact of the aid shocks on the variables when the aid shock's standard deviation change.

The second column of Table 4.4 shows the mean levels of GDP, consumption, private human capital investment, physical capital investment, study hours, and working hours of the benchmark model. The 3rd, 5th, and 7th columns show the mean levels of the correspondent variables, when the volatility of aid (i.e. standard deviation) sets at 0, 10, and 40%. Lowering the volatility of foreign aid to half, there would be a gain in GDP, physical capital investment, private human capital investment, study hours, and working hours. However, consumption would be slightly negatively affected. Lowering the volatility of foreign aid to 10%, is equivalent to lowering the aid level by 3.5%. On the other hand, doubling the volatility of aid to 40%, would have adverse effects on the correspondent variables except for consumption; it is equivalent to increasing aid level by 13.15%. Delivering aid in a stable manner (i.e. volatility of aid equals 0%) is equivalent to dropping aid level by around 4.5%. In this case, all the variables and welfare would increase.

Table 4.7 below shows the volatility of foreign aid in the 22 SSA countries. The volatility of aid ranges from 11.8% in Benin and Cape Verde to 42% in Sudan. However, the relative volatility of foreign aid varies from 1.6 in Rwanda to around 12.5 in the Gambia, averaging around 6 for the whole sample. The high volatility of foreign aid for the 22 SSA countries coincides with Pallage and Robe (2001) where they find that aid is highly volatile in African countries and this might contribute to economic instability. Understanding that aid is highly volatile would draw a conclusion about the policy implication of the theoretical model. Decreasing the volatility of foreign aid would have a positive implication on human capital accumulation as well as welfare in SSA countries. Donors are encouraged to provide aid in a stable and predictable manner to avoid the loss in countries' recipient welfare.

4.7.4- Forecast Error Variance Decomposition

The contribution of each shock on business cycle fluctuations is now examined. Forecast Error Variance Decomposition (FEVD) separates the endogenous variables variations into the component shocks. It describes the relative importance of each innovation in affecting the variables over a particular forecast horizon. Table 4.5 reports the variance decompositions of the calibrated DSGE model for aid-to-GDP level of 5.85% and 24%.

A number of interesting observations emerge from Table 4.5. First, for the benchmark model, the TFP shock dominates other shocks in explaining output, consumption, physical capital investment and physical capital stock fluctuations. Second, public human capital shock dominates other shocks in explaining study and working hours fluctuations, in addition to private human capital investment and human capital fluctuations. Third, foreign aid is dominated by the TFP and public human capital sector shocks in explaining all the variables' fluctuations. Finally, government expenditure shock seems to have a negligible influence on the variables of interest fluctuations. However, at higher aid-to-GDP ratio, foreign aid becomes more influential.

In addition to the variance decomposition, I analyze the implications of counterfactual cases (Table 4.6) in which the variances of the TFP, aid, public human capital, and government shocks are set to zero, and compare these results to those in the benchmark model economy, keeping other parameters fixed as in Table 4.1.

Business cycle statistics can still be generated by removing from the model all the sources of volatilities but keeping one. In the absence of the aid, public human capital, and government shocks, there are substantial variabilities in output, consumption, and physical capital investment associated with the TFP shock. Physical capital investment, private human capital investment, consumption, and employment are pro-cyclical. Study hours is counter-cyclical which is consistent with the benchmark calibrated model.

Keeping the aid shock, while switching off other volatilities, shows how small the impact of foreign aid is on the volatilities of output and consumption. With only a foreign aid shock, there is still some volatility for investment in both forms of capital, study and working hours, but output and consumption volatilities are low. In fact, the volatility of aid shock (σ^f) would need to be set to 1.03[114], which is 4.8 times that of the benchmark model in order to produce the benchmark model output's volatility of 2.88% in the absence of the TFP shock. The idea behind this is that foreign aid creates a positive income effect, causing labor working hours to fall, leading to an initial drop in output. As a consequence, foreign aid is strongly counter-cyclical (correlation with output is -0.96), when other shocks are absent. However, to smooth consumption behavior, both private human capital and physical capital investment should rise and hence study time increases. The rise in investment in both forms of capital would have a positive effect on output in subsequent periods due to higher labor productivity.

In a presence of only public human capital shock, there remains some amount of private human capital investment, physical capital investment, and study hours volatilities; however, output, consumption, and labor supply volatilities are quite low. Study hours and private human capital investment are countercyclical; the rest of the variables are pro-cyclical.

Government expenditure shock alone does not contribute to any of the variables' volatilities. All the variables' volatilities are quite low in the presence of government shock and the variables are counter-cyclical with output except working hours.

Figure 4.5 below shows the impulse responses' of the selected stationary variables for the benchmark model to a one-standard-deviation of the TFP, aid, private and public human capital, and government expenditure shocks.

For study hours and private human capital response functions, it seems that public human capital shock dominates other shocks. The impact of public human capital shock is almost 15 times that of foreign aid shock. For the aid shock to equate the impact of public human shock on study hours, for example, the volatility of aid[115] should be increased to 60% and aid-to-GDP level should be increased to 40%. For working hours, the TFP and government expenditure shocks act positively on increasing labor working hours[116], in contrast to the aid and public human capital shocks. In addition, aid and the TFP shocks stimulate physical capital investment and consumption, while public human capital and government shocks have a negative effect on them. Output is increased due to the TFP and government shocks, but there is an initial decrease in output due to the foreign

[114] Aid's volatility equals to 85%.
[115] There are other combinations by increasing aid volatility and decrease aid-to-GDP ratio.
[116] With similar magnitude.

aid and public human capital shocks. However, over time, output starts to increase due to an increase in labor productivity. Finally, the public human capital shock seems to have the biggest impact on the marginal productivity of study hours compared to other shocks.

4.7.5- Correlated Shocks versus Uncorrelated Shocks

Two models[117] are presented (Tables 4.2A-4.2F): the benchmark model, where aid and the TFP shocks and aid and the government expenditure shocks are correlated, and Model A, where shocks are uncorrelated. The main idea of this part of analysis is to compare both models' moments. For the mean levels, there are no differences in the mean levels of the variables in both models. However, the volatility of consumption, physical capital investment, and private human capital investment are lower, when the shocks are not correlated compared to the benchmark model. Concerning the correlation between the variables, there are only two distinctions. First, in the benchmark model, foreign aid is pro-cyclical (correlation equals 0.32); in Model A, there is a negative correlation between aid and GDP (-0.12). Second, the benchmark model exhibits a negative correlation between aid and government expenditure reflecting that in Kenyan data; in Model A, there is no correlation between aid and government expenditure, as per model design.

4.8- Conclusion

This chapter uses a dynamic stochastic general equilibrium model to evaluate the effectiveness of foreign aid and its volatility on private human capital investment, study and working hours, in addition to consumption, output, and physical capital investment. It also examines its business cycle implications. In an attempt to understand the role of foreign aid on human capital accumulation, a theoretical calibrated one-sector DSGE-RBC model is used to investigate the interaction between foreign aid and economic activities. The calibrated model is able to replicate the major macroeconomic key relationships observed in the Kenyan data.

The results suggest that, first of all, the effect of foreign aid injections depend on the magnitude of the persistence level of aid shock. In the benchmark model, an aid shock has a positive impact on private human capital investment, study hours, and human capital accumulation. However, increasing aid shock persistence level (i.e. to 0.90 and 0.95), reduces representative agent's incentive to invest in acquiring human capital and decreases his time devoted to acquire new skills (below the steady state), compared to the benchmark model. The representative agent adjusts his

[117] The impulse response functions of both models are roughly the same.

investment decision to acquire human capital in response to the shock of foreign aid to achieve his utility maximization objectives. The more temporary the aid shock, the higher the agent's incentive to invest in human capital and time devoted to study and vice versa.

Second, output responds negatively to an aid shock regardless of the persistence level. Third, the magnitude of the responses of the selected variables also depends on the aid-to-GDP level. Increasing aid-to-GDP levels, the magnitude of the variables' responses increases. Fourth, lowering the volatility of foreign aid to half would have a positive implication on the variables: this would be equivalent to lowering the aid level by 3.5%. From a policy point of view, donors should focus on lowering the volatility of aid by making it more predictable. Fifth, the marginal productivity of study hours seems to be negatively affected by aid shock in contrast to the TFP, public human capital, and government expenditure shocks.

A final result suggests that as aid increases, it becomes an increasingly dominant influence on macro economy. With more aid, the marginal propensity to consume is 100%, meaning that a permanent higher level of aid is associated with a permanent higher level of consumption. At a higher aid-to-GDP level, the representative agent enjoys more leisure time at the expense of reducing working and studying times.

The present model does not incorporate the role of foreign aid and its effects on the tradable and non-tradable goods prices. The one-sector DSGE-RBC model does not allow an analysis of the phenomena known as "Dutch Disease". In the following chapter, I extend the one-sector DSGE-RBC model into a two-sector DSGE-RBC and examine the impact of foreign aid on the composition of GDP, in a context of "Dutch Disease" mechanism.

Table 4.1: Calibration for the benchmark model

Parameters		Value	Source
Physical capital share	α	0.36	Prescott (1986)
Schooling time share in human capital production	θ_1	0.7	Calibrated
Private human capital share in human capital production	θ_2	0.1	Calibrated
Discount factor	β	0.95	ABLL*
Weight of leisure	γ	1.6	Calibrated
Cost adjustment parameter	ϕ	2.0	GPU**
Physical capital depreciation rate	δ_k	0.05	ABLL*
Human capital depreciation rate	δ_h	0.03	JF***
Autocorrelation coefficient of output productivity	ρ^z	0.81	RBC Standard
Autocorrelation coefficient of public human capital	ρ^{gh}	0.81	RBC Standard
Autocorrelation coefficient of government expenditure	ρ^g	0.81	RBC Standard
Autocorrelation coefficient of foreign aid inflow	ρ^f	0.69	Kenyan Data
Correlation between aid and TFP shocks	ρ^{zf}	0.50	Calibrated
Correlation between aid and government expenditure shocks	ρ^{gf}	-0.3	Calibrated
Output technology	A	1	Normalized
Human capital technology	A^h	1	Normalized
Public human capital parameter	G	0.0995	Calibrated
Government expenditure parameter	Gv	0.21	Calibrated
Foreign aid parameter	F	0.1085	Calibrated
Standard deviation of output productivity shock	σ^z	0.0282	Calibrated
Standard deviation of government expenditure	σ^g	0.0827	Calibrated
Standard deviation of public human capital	σ^{gh}	0.1067	Calibrated
Standard deviation of foreign aid shock	σ^f	0.213	Kenyan Data

(*) Arellano et al. (2009); (**) García-Cicco et.al (2010): 95% confidence interval < 4.9 with median 3.3.;

(***) Jorgenson and Fraumeni (1989)

Table 4.2A: Data and the references of the benchmark model (Means)

Targeted Means	Kenyan Data[118]	Benchmark Model[119]	Model A[120]
Private human capital investment-to-GDP	0.0234	0.0232	0.0232
Private human capital investment-to-Income	0.0221	0.0219	0.0219
Public human capital investment-to-GDP	0.0536	0.0535	0.0535
Public human capital investment-to-Income	0.0506	0.0506	0.0506
Private human capital investment-to-consumption	0.0340	0.0334	0.0334
Government expenditure-to-GDP	0.1131	0.1130	0.1130
Government expenditure-to-Income	0.1065	0.1067	0.1067
Aid-to-GDP	0.0585	0.0585	0.0585
Other Means			
Consumption-to-GDP	0.6643	0.6933	0.6933
Consumption-to-Income	0.6255	0.6549	0.6549
Physical capital investment-to-GDP	0.2075	0.1755	0.1755
Physical capital investment-to-Income	0.1955	0.1657	0.1657
Working time	NA	0.3344	0.3341

Table 4.2B: Data and the references of the benchmark model

Standard Deviations			
GDP	0.0288	0.0288	0.0288
Consumption	0.0493	0.0230	0.0201
Physical capital investment	0.1025	0.1161	0.1040
Private human capital investment	NA	0.1088	0.1080
Exogenous Variables			
Government expenditure	0.0686	0.0686	0.0680
Public human capital investment	0.0901	0.0901	0.0899
Aid	0.2080	0.1988	0.1973

Table 4.2C: Data and the references benchmark model

Correlations with GDP			
Consumption	0.83	0.86	0.84
Physical capital investment	0.42	0.89	0.88
Private human capital investment	NA	-0.08	-0.12

[118] Annual data for a long period of time is criticized as it might be subject to structural break points. However, the stylized facts generated from the annual data can be compared to that of the advanced economy as well as to other developing countries that use quarterly data.
[119] Benchmark model with correlated shocks.
[120] Model A (uncorrelated shocks) is calibrated by changing σ^z = 0.0266 and setting the correlation coefficients to zero and keeping other parameters fixed as per Table 1.

Table 4.2D: Data and the references of benchmark model

Correlations with Aid	Kenyan Data	Benchmark Model	Model A
GDP	0.35	0.32	-0.12
Consumption	0.09	0.60	0.24
Physical capital investment	-0.06	0.57	0.17
Government expenditure	-0.29	-0.29	-0.00
Private human capital investment	NA	0.13	0.05

Table 4.2E: Data and the references of the benchmark model

Correlations with public human capital			
GDP	0.18	-0.22	-0.22
Consumption	0.18	-0.34	-0.39
Physical capital investment	0.17	-0.40	-0.45
Private human capital investment	NA	0.97	0.98

Table 4.2F: Data and the references of the benchmark model

Correlations with government expenditure			
GDP	-0.04	0.17	0.14
Consumption	0.03	-0.22	-0.18
Physical capital investment	0.16	-0.10	-0.06
Private human capital investment	NA	-0.06	-0.05

One-Sided HP filter

Income = GDP + aid

Table 4.3A: Sensitivity analysis of the benchmark model (Means)

	Aid-to-GDP ratio equals to				
Steady state values	0%	6%	12%	18%	24%
Consumption-to-GDP	0.6463	0.6955	0.7415	0.7885	0.8359
Consumption-to-Income	0.6463	0.6549	0.6618	0.6679	0.6733
Physical capital investment-to-GDP	0.1755	0.1755	0.1755	0.1755	0.1755
Physical capital investment-to-Income	0.1755	0.1652	0.1566	0.1487	0.1414
Private human capital investment-to-GDP	0.0232	0.0232	0.0232	0.0232	0.0232
Private human capital investment-to-Income	0.0232	0.0218	0.0207	0.0196	0.0187
Public human capital investment-to-GDP	0.0497	0.0538	0.0578	0.0620	0.0664
Public human capital investment-to-Income	0.0498	0.0507	0.0516	0.0525	0.0534
Private human capital investment-to-consumption	0.0359	0.0333	0.0313	0.0294	0.0278
Government expenditure-to-GDP	0.1053	0.1139	0.1223	0.1312	0.1405
Government expenditure-to-Income	0.1053	0.1073	0.1092	0.1112	0.1132
Study Hours	0.0884	0.0847	0.0817	0.0786	0.0759
Working Hours	0.3484	0.3341	0.3218	0.3100	0.2991
GDP	1.9905	1.8388	1.7126	1.5966	1.4916
Income	1.9905	1.9529	1.9187	1.8848	1.8518

Table 4.3B: Sensitivity analysis of the benchmark model

Standard deviations					
GDP	0.0275	0.0288	0.0303	0.0306	0.0324
Consumption	0.0198	0.0228	0.0261	0.0297	0.0334
Physical capital investment	0.1295	0.1361	0.1442	0.1541	0.1650
Private human capital investment	0.2267	0.2313	0.2356	0.2402	0.2448
Study hours	0.2196	0.2239	0.2279	0.2322	0.2363
Working hours	0.0265	0.0265	0.0282	0.0313	0.0354

Table 4.4: Impacts of changing aid's volatility

Variable's Mean	Aid Volatility						
	Benchmark Model	0%	% change	10%	% change	40%	% change
GDP	1.866083	1.87317	0.38%	1.869985	0.21%	1.84916	-0.91%
Consumption	1.295719	1.296955	0.10%	1.295399	-0.02%	1.29645	0.06%
Physical capital investment	0.328757	0.329667	0.28%	0.32923	0.14%	0.32637	-0.73%
Private H. Cap. investment	0.043188	0.043331	0.33%	0.043262	0.17%	0.04284	-0.80%
Study hours	0.084709	0.084837	0.15%	0.084805	0.11%	0.0843	-0.49%
Working hours	0.334557	0.335017	0.14%	0.334968	0.12%	0.33279	-0.53%

Table 4.5: Variance decomposition

	Shocks			
	tfp	*aid*	*gov hcap*	*gov*
GDP	88.48	2.69	7.66	1.18
Consumption	77.74	6.36	12.66	3.24
Physical capital investment	76.74	2.36	20.35	0.55
Private human capital investment	3.03	0.53	96.32	0.12
Working hours	13.15	26.61	48.26	11.98
Study hours	0.08	0.28	99.6	0.04
Physical capital	76.37	2.09	20.98	0.56
Human capital	0	0.13	99.84	0.03
Variance decomposition, aid-to-GDP = 24%				
	tfp	*aid*	*gov hcap*	*gov*
GDP	62.02	29.46	6.84	1.68
Consumption	61.67	29.74	6.56	2.03
Physical capital investment	72.25	16.25	11.07	0.43
Private human capital investment	6.54	4.48	88.88	0.1
Working hours	0.93	83.58	10.54	4.94
Study hours	0.34	2.38	97.26	0.03
Physical capital	72.7	14.67	12.18	0.45
Human capital	0.3	1.16	98.52	0.02

Table 4.6: The benchmark model and the shocks

	Shocks				
	Model	*tfp*	*aid*	*gov hcap*	*gov*
Standard Deviation					
GDP	0.0288	0.0273	0.0046	0.0080	0.0032
Consumption	0.0230	0.0180	0.0054	0.0081	0.0042
Private human capital investment	0.1161	0.0159	0.0085	0.1092	0.0039
Physical capital investment	0.1088	0.0960	0.0190	0.0533	0.0089
Study hours	0.1048	0.0058	0.0063	0.1020	0.0022
Working hours	0.0132	0.0081	0.0068	0.0095	0.0049
Correlations with GDP					
Consumption	0.86	0.98	-0.93	0.92	-0.97
Private human capital investment	-0.08	0.97	-0.98	-0.82	-0.98
Physical capital investment	0.89	0.98	-0.99	0.95	-0.99
Study hours	-0.28	-0.98	-0.99	-0.83	-0.99
Working hours	0.62	0.95	0.98	0.93	0.99
Correlations with aid					
GDP	0.32	NA	-0.96	NA	NA
Consumption	0.60	NA	0.96	NA	NA
Private human capital investment	0.13	NA	0.96	NA	NA
Physical capital investment	0.57	NA	0.96	NA	NA
Study hours	0.02	NA	0.95	NA	NA
Working hours	-0.24	NA	-0.98	NA	NA
Correlations with public human capital					
GDP	-0.22	NA	NA	-0.75	NA
Consumption	-0.34	NA	NA	-0.92	NA
Private human capital investment	0.97	NA	NA	0.99	NA
Physical capital investment	-0.40	NA	NA	-0.89	NA
Study hours	0.99	NA	NA	0.99	NA
Working hours	-0.64	NA	NA	-0.93	NA
Correlations with government					
GDP	0.17	NA	NA	NA	0.99
Consumption	-0.22	NA	NA	NA	-0.98
Private human capital investment	-0.06	NA	NA	NA	-0.98
Physical capital investment	-0.10	NA	NA	NA	-0.98
Study hours	-0.05	NA	NA	NA	-0.96
Working hours	0.51	NA	NA	NA	0.99

Table 4.7: Volatilities and correlations of GDP and foreign aid

Country	GDP	Aid	Relative Volatility	Correlation
Benin	0.0229	0.1188	5.1877	-0.3222
Botswana	0.0529	0.3394	6.4158	0.0879
Burkina Faso	0.0195	0.1342	6.8820	-0.1394
Burundi	0.0464	0.2802	6.0388	0.5567
Cameroon	0.0620	0.2380	3.8387	-0.1365
Cape Verde	0.0503	0.1186	2.3578	0.2314
Central Africa	0.0560	0.1835	3.2769	0.0362
Ethiopia	0.0426	0.1568	3.6807	-0.2180
Gambia	0.0232	0.2887	12.4439	0.2631
Kenya	0.0292	0.2048	7.0147	0.3071
Lesotho	0.0386	0.2341	6.0647	0.1281
Madagascar	0.0292	0.2526	8.6506	0.2131
Malawi	0.0351	0.1875	5.3418	0.0075
Mali	0.0371	0.1465	3.9487	-0.1692
Mauritania	0.0324	0.1772	5.4691	-0.1552
Rwanda	0.0968	0.1540	1.5910	-0.4234
Senegal	0.0169	0.1208	7.1479	0.1544
Seychelles	0.0466	0.3731	8.0064	0.1581
Sierra Leone	0.0602	0.2308	3.8338	0.0265
Sudan	0.0478	0.4244	8.8786	0.2928
Togo	0.0424	0.2611	6.1580	0.1033
Uganda	0.0269	0.1744	6.4832	-0.2822

Author's Calculations using one-sided HP Filter

Figure 4.1: Impulse responses to a positive one-standard foreign aid shock

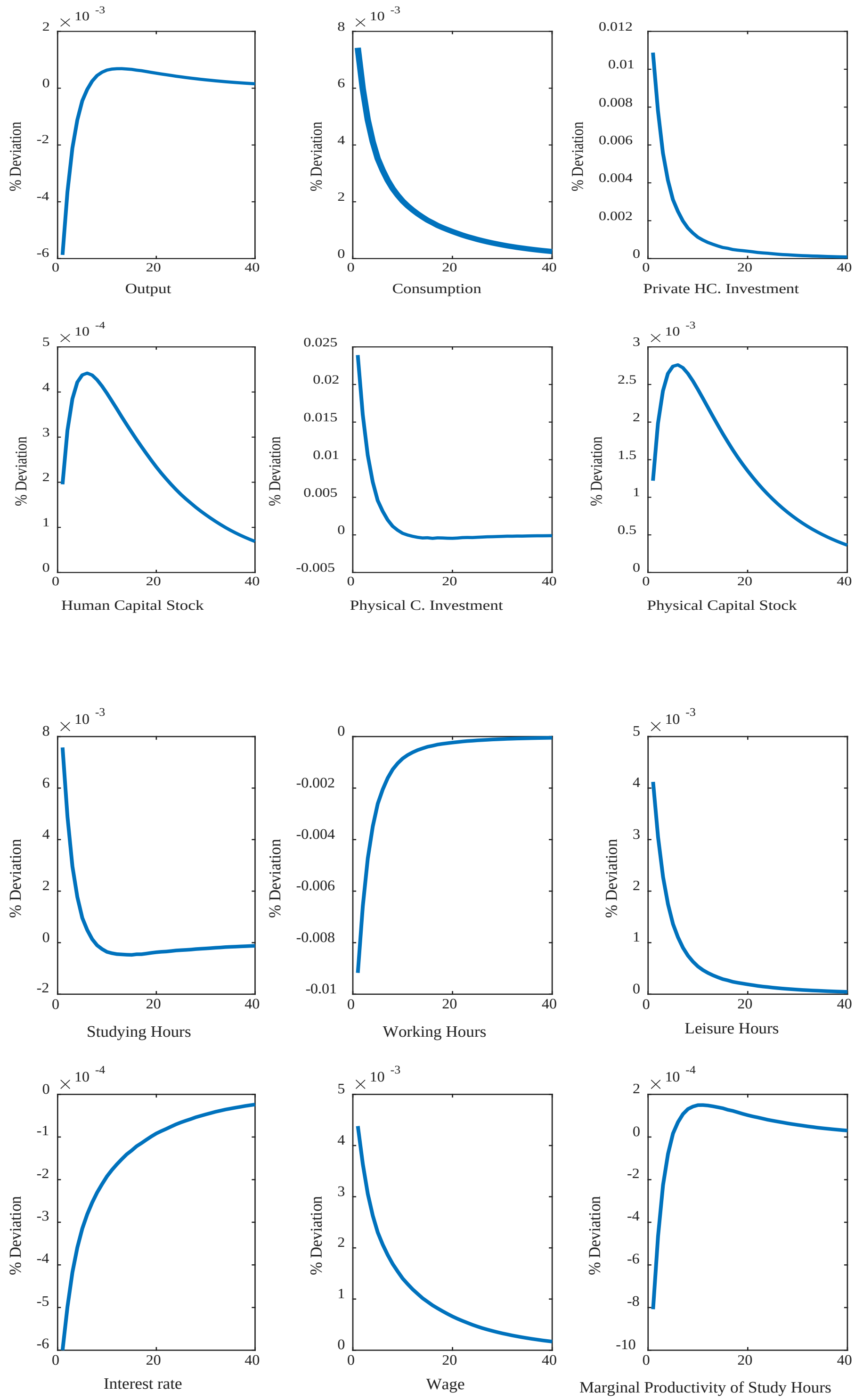


Figure 4.2: Impulse responses to a positive one-standard public human capital shock

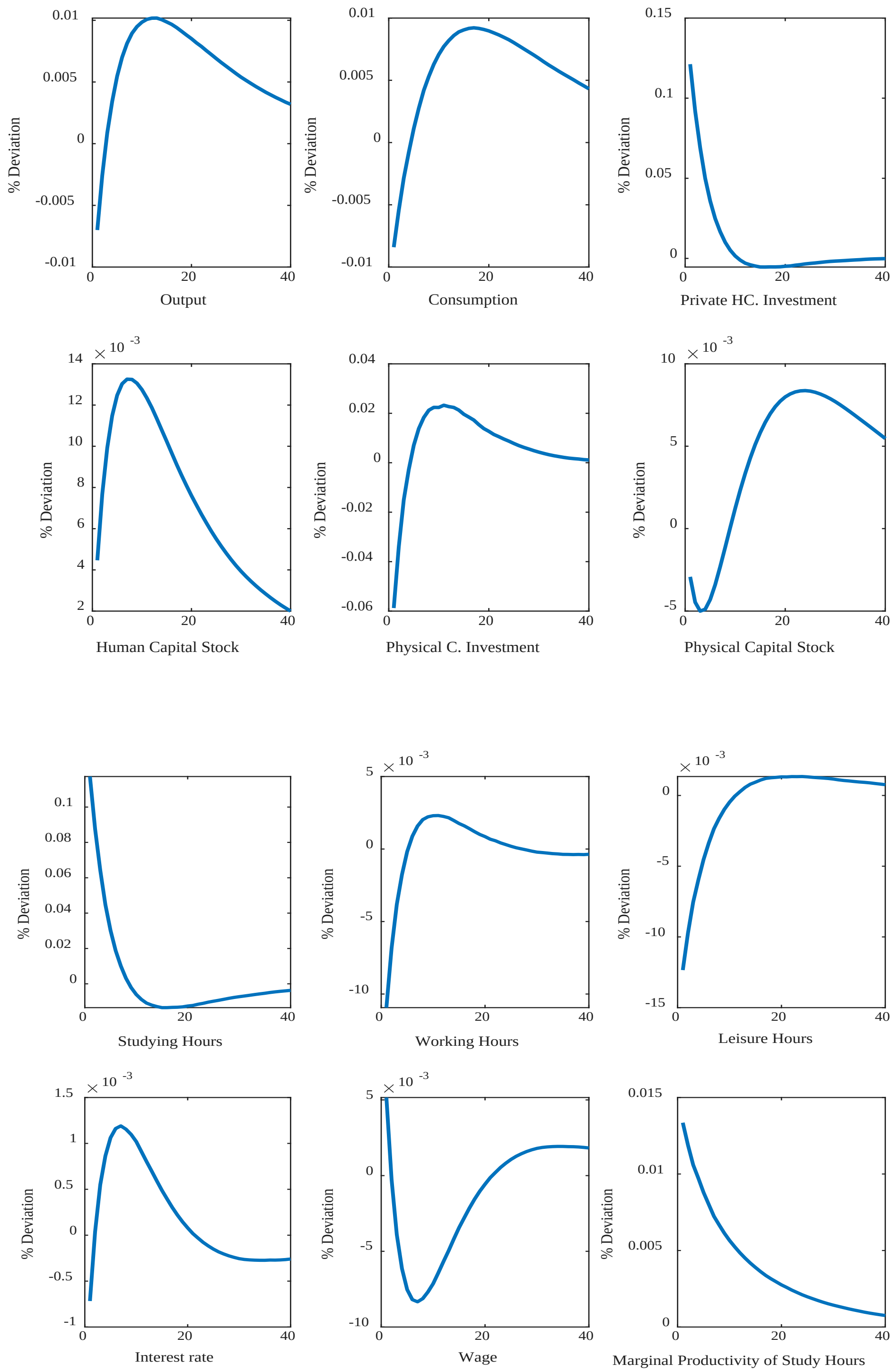


Figure 4.3: Sensitivity analysis for aid shock impact on selected variables at different aid-to-GDP levels

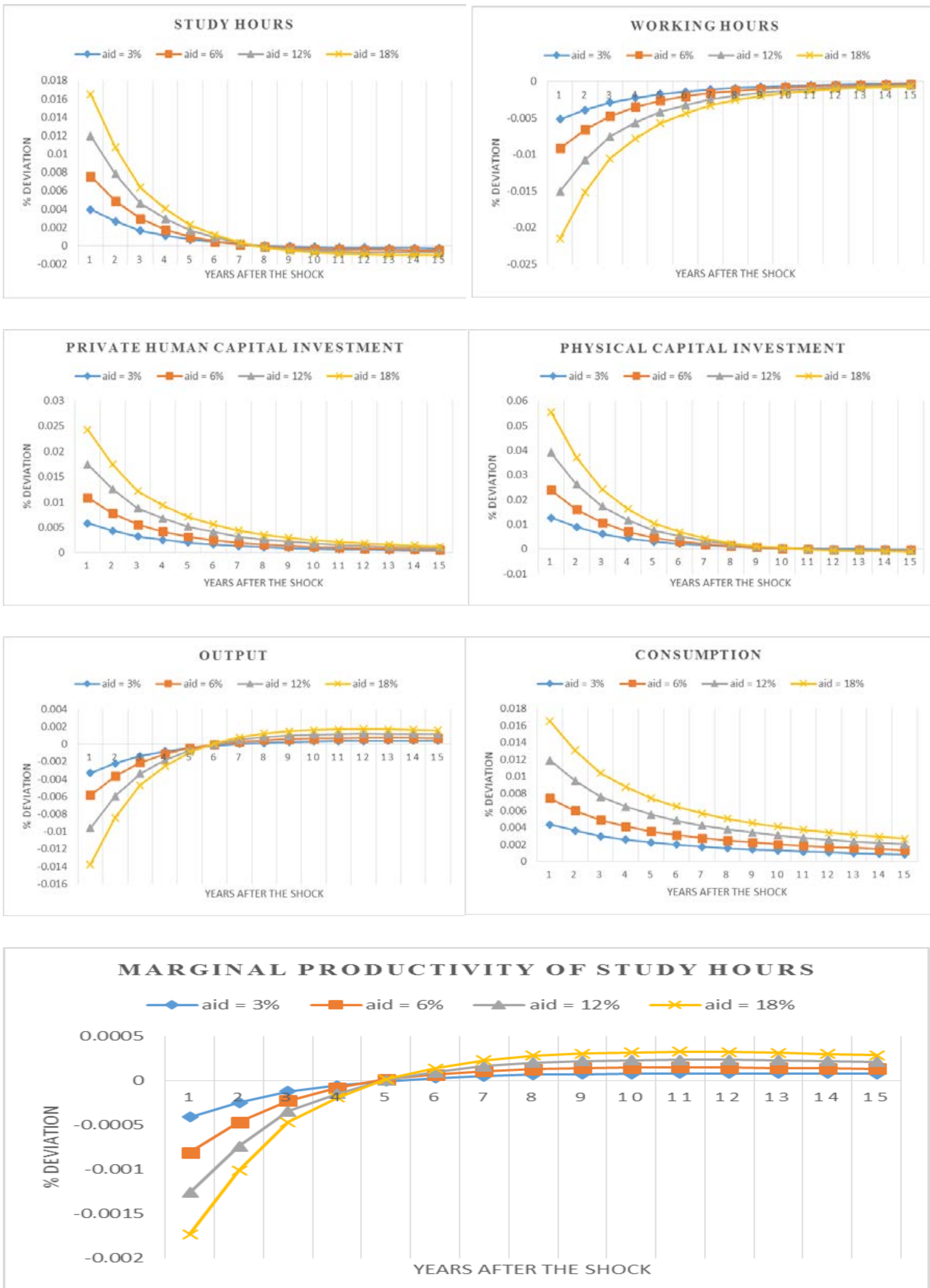
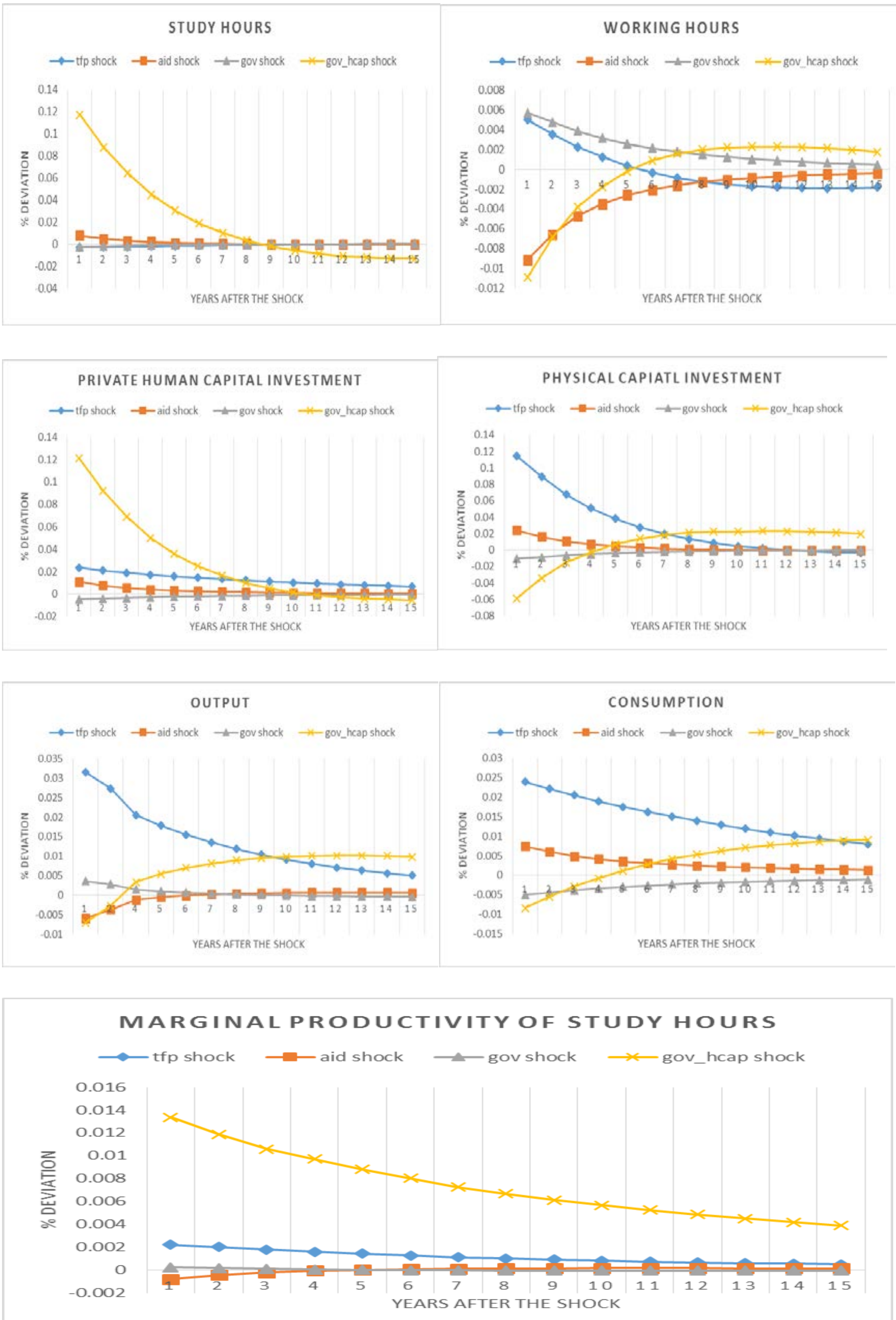


Figure 4.4: Sensitivity analysis for aid impact on selected variables at different aid shock persistence levels

Figure 4.5: Impulse responses to a one-standard-deviation of different shocks



Chapter 5

Human Capital Investment, Foreign Aid, and the "Dutch Disease"

5.1- Introduction

This chapter extends the model presented in Chapter 4 into a two-sector DSGE-RBC model that has a tradable and a non-tradable sector. The two-sector calibrated DSGE-RBC model enables the analysis of the effects of foreign aid on the relative price of non-tradable goods to tradable goods (i.e. the real exchange rate) and on the composition of GDP by sector output. The model allows us to address the question: Does foreign aid inflow lead to an appreciation of the relative price of non-tradable goods, and generate a reduction in the size of the tradable sector (human capital intensive[121] for Kenya), which reduces overall GDP, consistently with the "Dutch Disease"? The previous variables studied are also included in the analysis. To the best of my knowledge, this analysis is the first one using a two-sector DSGE-RBC model to analyze the impact of foreign aid and its volatility on GDP's composition, the relative price of non-tradable goods, private human capital investment, and study time.

In Chapter 3, a foreign aid shock had a negative and persistent impact on GDP, tradable and non-tradable outputs for Kenya. However, there was only a transitory effect of foreign aid on tradable goods price (negative, but not significant) and on non-tradable goods price (positive, but not significant). The symptoms of "Dutch Disease" were reflected in the shrinkage of the tradable output and total output in the long-run. However, the mechanism of the "Dutch Disease", which requires an appreciation of the relative price of non-tradable goods, was not found in the long-run empirical CVAR analysis. This chapter uses a calibrated two-sector DSGE-RBC model to match the Kenyan economy and study the short-run business cycle implications in a context of "Dutch Disease"[122].

This chapter has several findings consistent with "Dutch Disease". An increase in foreign aid increases the availability of the tradable goods relative to the non-tradable goods, leading to a rise

[121] A shrinking human capital intensive sector would reduce return to human capital or education.
[122]A vector error correction model (VECM) analysis provides results that are consistent with the dynamics of the two-sector DSGE-RBC model. (For more details see Appendix C.8)

in the relative price of non-tradable goods. The consequence of the relative price appreciation is the reallocation of resources from the tradable to the non-tradable sector, causing the tradable sector to shrink. Thus, tradable working hours, tradable physical capital, and tradable human capital decline on impact. On the other hand, non-tradable working hours, non-tradable physical capital, and non-tradable human capital increase. The reallocation of resources causes the total output to decline. The shrinkage of the human capital intensive tradable sector would lower the return to human capital.

Furthermore, the positive income effect of foreign aid increases the saving rate, leading to an increase in physical capital investment and private human capital investment as a result of consumption smoothing behavior of the representative agent. Thus, the agent devotes more time to human capital skills acquisitions. Hence, labor productivity and output increase in the future.

The findings in this chapter suggest that, over the short run, foreign aid has a positive impact on the relative price of non-tradable goods, consumption, non-tradable output, non-tradable labor, physical capital investment, private human capital investment, and time devoted to acquire new skills. On the other hand, foreign aid is found to have a negative impact on output, tradable output, tradable labor, and total labor working hours. As in the one-sector model, study time reaction and private human capital are sensitive to the choice of the persistence level of the aid shock.

Another result emerging from the model is that aid shock is dominated by other shocks. However, as aid-to-GDP ratio increases, aid flows become more influential. Further, decreasing (increasing) the volatility of foreign aid would increase (decrease) output, tradable output, physical capital investment, private human capital investment, study hours, and tradable working hours. For instance, delivering foreign aid in a stable manner is equivalent to increasing the aid level by 7.85%[123]. From policy perspective and as shown in Chapter 4, the average relative volatility of foreign aid for the 22 SSA countries is 6. Thus, if aid can be delivered in a predictable manner by donors, the welfare of the SSA countries would increase as well as human capital accumulation.

Finally, I have found empirical evidence that is consistent with the simulation result of the two-sector DSGE-RBC model. I used an empirical VECM analysis and find an evidence of the “Dutch Disease”, resulting from aid injections. Foreign aid shock has a negative impact on the tradable goods price and a positive impact on the non-tradable goods price in the short-run. The appreciation of the relative price of non-tradable goods leads to a drop in GDP and the tradable output.

[123] Higher than in the one-sector DSGE-RBC model which is found to be 4.5%.

The two-sector DSGE model results coincide with the results of one-sector DSGE model presented in Chapter 4, concerning the behavior of the impulse response functions of GDP, consumption, physical capital investment, private human capital investment, and study and total working hours. However, the magnitudes of the impulse response functions are higher in the one-sector DSGE model[124].

The rest of the chapter is organized as follows: Section 5.2 provides a brief literature review. Section 5.3 introduces the data sources that are used to calibrate the model. Section 5.4 outlines the model. The calibrated model and results are presented in Section 5.5. Section 5.6 describes the simulation results of the model. Sensitivity analyses are shown in Section 5.7. The vector error correction model (VECM) is analyzed in Section 5.8. Finally, Section 5.9 concludes.

5.2- Literature Review

There exist a number of theoretical models that examine the impact of capital inflows. Corden and Neary (1982) use a small open economy to explain the resource movement effect in response of a boom (technology shock of one part of the tradable goods sector), which rises the relative price of non-tradable goods. The outcome is a decline in the non-booming part of the tradable goods sector (manufacturing sector), leading to what is called de-industrialization. This process causes a reallocation of resources toward the non-tradable sector, thereby hurting the tradable sector.

Lartey (2008) develop a two-sector small open economy. He shows that large capital inflows to a developing country cause a real exchange rate appreciation that has a negative effect on the tradable sector - a "Dutch Disease" phenomenon. His results show that an increase in capital inflows increase the demand for non-tradable goods, increase the price of non-tradable goods relative to tradable goods, and expand the production of non-tradable goods. The appreciation of the real exchange rate hurts the tradable sector by losing international trade competitiveness. On the other hand, Lartey (2011) finds that an increase in foreign direct investments (FDI) leads to real exchange rate appreciation only in more financially open countries. His result suggests that there is a trade-off between the resource allocation effect and the spending effect following an increase in capital inflows, "such that the more the tradable sector expands relative to the non-tradable sector, the greater is the real exchange rate appreciation" (Lartey, 2011). He finds that the less the resource

[124] This may be related to the relative volatility of aid being higher in one-sector DSGE-RBC model.

reallocation from the tradable sector toward the non-tradable sector, the higher is the appreciation of the real exchange rate.

Arellano et al. (2009) use a DSGE model focusing only on physical capital investment in a two-sector (tradable and non-tradable sectors). Their main findings suggest that continuing flows of aid finance consumption rather than investment. In addition, their model suggests that a permanent and large amount of aid flows are positively associated with the relative price of non-tradable goods, resulting in the shrinking of the tradable sector.

Acosta et al. (2009) develop a two-sector DSGE model with physical capital and analyze the impacts of remittances on an emerging economy of El Salvador. They find that an increase in workers' remittances leads to a decline in labor supply and an increase in consumption. In addition, they find that remittances lead to an appreciation of the non-tradable prices and to an expansion of the non-tradable sector. This leads to the reallocation of labor from the tradable to non-tradable sector.

The current chapter differs from the above models in several ways. First, the main departure from Arellano et al. (2009) is the inclusion of labor-leisure-education choice, incorporating the role of human capital beside the physical capital, and the government expenditures. Second, the present model differs from Lartey (2008) and Acosta et al. (2009) by including the education choice beside labor-leisure choice, the inclusion of the private and public human capital investment, and the role of government expenditures.

5.3- Data Sources

In the absence of other data, the tradable output is approximated by the output of following sectors: agricultural, hunting, fishing, forestry, and manufacturing. The rest of the GDP is assumed to comprise the non-tradable output. Kenyan output is measured by GDP, consumption by households' expenditures, government expenditures by general government consumption, public education by government's expenditures on education, private human capital investment by households' expenditures on schooling[125], investment by gross capital formation, and aid by net official development aid. The data cover a period from 1970 to 2014. All the yearly data are sourced

[125] Appendix B.6 shows the method used to evaluate the private human capital investment.

from the World Bank Indicators database[126] except for aid data which are obtained from the Organisation for Economic Co-operation and Development (OECD).

Tradable and non-tradable prices' indexes are computed from the Kenyan national account series in constant and current prices following Goldstein et al. (1980) methodology[127].

5.4- The Theoretical DSGE-RBC Model

The model is a two-sector DSGE-RBC model of a small representative-agent economy that produce tradable and non-tradable goods. There are two forms of capital: physical capital and human capital. Human capital involves activities of formal education (in terms of time) along with investment (private and public in terms of tradable and non-tradable goods) to produce human capital stock that increases labor productivity. This economy has no access to international capital markets, but it receives aid in a form of untied transfer of wealth (in terms of tradable goods) every period. The representative agent lives infinitely and has preference over real consumption and leisure, denoted by C_t and L_t, respectively at time *t*. His objective is to maximize his expected lifetime inter-temporally additive utility function:

$$U = E_0 \sum_{t=0}^{\infty} \beta^t [log(C_t) + \gamma \log(L_t)] \tag{5.1}$$

The parameter $\gamma > 0$ is the weight of leisure in the utility function and $\beta \in (0, 1)$ is the subjective discount factor.

The representative agent consumption index C_t is given by the composite constant elasticity of substitution (CES) form as:

$$C_t = [\omega (C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} \tag{5.2}$$

where $\omega \in (0, 1)$ is the share of the tradable goods consumption (C_t^T) and $(1-\omega)$ is the share of the non-tradable goods consumption (C_t^N) in the total consumption bundle. The superscripts T and N denote the tradable and non-tradable sectors, respectively. The subscript *t* represents the consumption in period *t*. Here the intra-temporal constant elasticity of substitution ψ^C between

[126] Data from WDI were downloaded on September 15th, 2017.
[127] See Appendix A.3.

C_t^T and C_t^N is equal to $\frac{1}{1+\mu}$. Lower (larger) value of μ implies greater (lower) responsiveness to the relative price of non-tradable goods.

The representative agent is endowed with one unit of time every period:

$$S_t + N_t^T + N_t^N + L_t = 1 \tag{5.3}$$

where S_t is the fraction spent in acquiring skills (i.e. study time), N_t^T and N_t^N are the fractions of time spend in the production of the tradable and non-tradable goods, respectively, and L_t is the leisure time.

The production technologies of the tradable and non-tradable goods of the economy are represented by:

$$Y_t^T = A_t^T \exp(z_t^T)\, K_t^{T\alpha} (N_t^T H_t^T)^{1-\alpha} \tag{5.4}$$

$$Y_t^N = A_t^N \exp(z_t^N)\, K_t^{N\theta} (N_t^N H_t^N)^{1-\theta} \tag{5.5}$$

where Y_t^T and Y_t^N denote the production of the tradable and non-tradable goods which correspond to the tradable and non-tradable outputs, respectively; A_t^T and A_t^N are the productivity shifters; $\exp(z_t^T)$ and $\exp(z_t^N)$ are the tradable and non-tradable sector output productivity shocks (TFP shocks) and are assumed to be perfectly correlated; K_t^T and K_t^N are the tradable and non-tradable sector physical capital stock; H_t^T and H_t^N are the tradable and non-tradable sector human capital; $N_t^T H_t^T$ and $N_t^N H_t^N$ represent the "effective labor input" used in the production of tradable and non-tradable goods, respectively; $\alpha \in (0, 1)$ represents the elasticity of the tradable output with respect to the tradable physical sector capital stock; and $\theta \in (0, 1)$ represents the elasticity of the non-tradable output with respect to the non-tradable physical sector capital stock.

Following Mussa (1978), Mendoza and Uribe (2000), and Arellano et al. (2009) specifications, physical capital is assumed to be sector-specific in a sense that physical capital becomes less effective if accumulated only in one sector. The physical capital factor transformation curve used in the model is defined as follows:

$$K_t = \kappa^k(K_t^T, K_t^N) = [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}} \tag{5.6}$$

In this model, the factor transformation curve (κ^k) is assumed to be a constant elasticity of substitution function with an elasticity of substitution[128] between K_t^T and K_t^N being $\psi^k = \frac{1}{1+\nu_k}$. With a special case where $\nu_k = -1$, then physical capital is perfectly homogenous.

I also assume that human capital in the tradable and non-tradable sectors is also sector-specific (i.e. not perfectly mobile). The human capital is aggregated by the following CES function:

$$H_t = \kappa^h(H_t^T, H_t^N) = [(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}} \quad (5.7)$$

In (5.7), $\psi^h = \frac{1}{1+\nu_h}$ is the elasticity of substitution between H_t^T and H_t^N. In a special case when $\nu_h = -1$, the human capital is assumed to be perfectly homogenous and perfectly mobile across sectors. ν_h captures the difficulty[129] with which human capital can be substituted between sectors, thereby measures the degree of human capital mobility from one sector to another[130]. Sector-specific factors is used in trade literature and the trade models recognize that factors of production are specific to each sector to some degree.

In equilibrium, the relative price of non-tradable goods (P^N) is equal to the marginal rate of substitution between the tradable and non-tradable goods, which is equal to the slope of the concave production possibility frontier (PPF) of Y^T and Y^N. The relative price of non-tradable goods is determined by the relative technologies and the relative sectoral capital (physical and human)[131] stocks. The slope of PPF is the main key to the variations in the relative price of non-tradable goods in the model. The concavity of the PPF is determined by the differences in factor intensities in tradable and non-tradable sectors ($\alpha < \theta$) [132]as well as by the curvature of the physical (Mendoza and Uribe, 2000) and human capital transformation functions, κ^k and κ^h.

If factors of production are homogenous and can be freely allocated between sectors, the production function of the tradable and non-tradable goods yields a constant slope PPF that is determined by the fraction (α - θ) of the shift in sectoral physical-human capital ratio. A constant slope PPF yields a constant real exchange rate. Discarding the assumption that factors of production (physical and

[128] Physical capital is costly to move from one sector to another.
[129] Skills needed in the tradable sector may be different from skills used in the non-tradable sector. Some training is needed when human capital is transferred from one sector to another.
[130] Sensitivity analysis of changing the values of ν_k and ν_h is left for future research.
[131] See equations 5.32 and 5.33.
[132] The result is also robust even when $\alpha > \theta$.

human capital) are homogeneous between the two sectors yields large changes in the relative price of non-tradable goods.

The representative agent owns the representative firms[133] in both sectors which operate in a competitive market. Both type of firms choose physical capital and effective labor to maximize profits and produce output following Cobb-Douglas production function with a constant return to scale technology taking prices as given. Factor markets are competitive and in equilibrium they earn their marginal productivities. Since physical and human capital are industry-specific, the return of physical capital and the return of human capital must take into account the degree of factor suitability between the tradable and non-tradable sectors which are given by the derivative of $\kappa^k(K_t^T, K_t^N)$ and $\kappa^h(H_t^T, H_t^N)$ with respect to the sectoral physical and human capital, respectively. Marginal productivities across sectors are equalized and are calculated as follows:

$$r_t^k = \frac{\alpha A_t^T \exp(z_t^T)\,(\frac{K_t^T}{N_t^T H_t^T})^{\alpha-1}}{\kappa_T^k(K_t^T, K_t^N)} = P_t^N \frac{P_t^N \theta A_t^N \exp(z_t^N)\,(\frac{K_t^N}{N_t^N H_t^N})^{\theta-1}}{\kappa_N^k(K_t^T, K_t^N)} \tag{5.8}$$

$$w_t^h = \frac{(1-\alpha) A_t^T \exp(z_t^T)\,(\frac{K_t^T}{N_t^T H_t^T})^{\alpha}}{\kappa_T^h(H_t^T, H_t^N)} = P_t^N \frac{(1-\theta) A_t^N \exp(z_t^N)\,(\frac{K_t^N}{N_t^N H_t^N})^{\theta}}{\kappa_N^h(H_t^T, H_t^N)} \tag{5.9}$$

Human capital is reproducible with a constant return to scale in terms of time spent in acquiring skills (S_t), private human capital investment (I_t^h), and public human capital investment (I_t^{gh}). The human capital law of motion is given by:

$$H_{t+1} = A_t^h {S_t}^{\eta_1} {I_t^h}^{\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} + (1\text{-}\delta_h)\, H_t \tag{5.10}$$

Here, $\exp(z_t^{gh})$ is the public human capital productivity shock; η_1 and η_2 ϵ (0, 1) represent the elasticity of the production of human capital with respect to schooling time and private human capital investment, respectively; δ_h is the human capital depreciation rate; A_t^h is the human capital productivity shifter.

The representative agent receives rent on the physical capital he leases to the firms, wage for his labor services to the firms, invests his saving in physical and human capital, consumes both goods,

[133] One firm produces tradable good and the other produces non-tradable good.

pays lump-sum taxes to the government, and receives profits from firms. His budget constraint is given by:

$$C_t^T + P_t^N C_t^N + I_t^h + I_t^k + T_t = r_t^k K_t + w_t^h N_t H_t + D_t^T + P_t^N D_t^N \tag{5.11}$$

where P_t^N is the relative price of non-tradable goods; I_t^k and I_t^h are the household's investment in physical and human capital[134], respectively in period *t*; T_t is a lump-sum tax paid to the government to finance its expenditures including investment in public human capital; r_t^k is the gross rental rate of physical capital in units of tradable good delivered in period *t*; w_t^h is the price per unit of effective labor in period *t* expressed in units of tradable good delivered in period *t* (i.e. real wage); D_t^T and D_t^N are the dividends distributed by the firms to the household each period[135].

Physical capital accumulation follows the following law of motion:

$$K_{t+1} = I_t^k + (1\text{-}\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t \tag{5.12}$$

In (5.12), an adjustment cost associated with capital holdings is added to the physical capital law of motion and is weighted by ϕ to avoid the high volatility in physical capital investment generated by the model; $\delta_k \in (0, 1)$ is the depreciation rates of physical capital.

The government levies lump-sum taxes, T_t, to finance its expenditures[136] and receives foreign aid[137]. Hence, the government budget constraint in terms of tradable goods is:

$$T_t + F_t = P_t^N I_t^{gh} + P_t^N G_t \tag{5.13}$$

[134] Private human capital in the model is assumed to be tradable, i.e. buying textbooks, supplies, uniforms, and other educational supplies.

[135] Since both firms operate in a competitive market and use a constant return to scale technology, the profits generated and the dividends distributed to the household are zero in equilibrium.

[136] $I_t^{gh} + G_t$ are the total government expenditures, falling entirely in the non-tradable goods category and financed through lump-sum taxation which is assumed to be tradable. The data available on public human capital investment is the government education expenditure which refers to the current operating expenditures in education. It includes wages and salaries and excludes physical capital investment in buildings and equipment. In the absence of educational infrastructure data which is included in gross capital formation (defined in Appendix B.7), I assume teachers' salaries and wages (I_t^{gh}) paid by the government as a non-tradable good investment in the human capital production function.

[137] Lump-sum taxes would be adjusted as a result of foreign aid injections.

F_t = Fexp(z_t^f) is a stochastic exogenous aid inflow given each period. The government expenditure is composed of public human capital investment, I_t^{gh}, and general government expenditure, G_t. Both public human capital investment and general government expenditure are assumed to be exogenous and stochastic, where $I_t^{gh} = I^{gh}\exp(z_t^{gh})$ and $G_t = G\exp(z_t^g)$.

The exogenous shocks of the representative agent economy follow a vector autoregressive [VAR(1)] process with AR coefficients that are restricted to be diagonal and given by:

$$\begin{bmatrix} z_t^T \\ z_t^N \\ z_t^g \\ z_t^{gh} \\ z_t^f \end{bmatrix} = \begin{bmatrix} \rho^T & 0 & 0 & 0 & 0 \\ 0 & \rho^N & 0 & 0 & 0 \\ 0 & 0 & \rho^g & 0 & 0 \\ 0 & 0 & 0 & \rho^{gh} & 0 \\ 0 & 0 & 0 & 0 & \rho^f \end{bmatrix} \begin{bmatrix} z_{t-1}^T \\ z_{t-1}^N \\ z_{t-1}^g \\ z_{t-1}^{gh} \\ z_{t-1}^f \end{bmatrix} + \begin{bmatrix} 1 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} \varepsilon_t^T \\ \varepsilon_t^N \\ \varepsilon_t^g \\ \varepsilon_t^{gh} \\ \varepsilon_t^f \end{bmatrix} \quad (5.14)$$

where $|\rho^i|<1$ are the autocorrelation coefficients and $\varepsilon_t^i \sim nid(0,\sigma_\varepsilon^{i2})$ with $i = T, N, g, gh, f$ are the innovations sequences of identically distributed normal random variables with mean zero and variances σ_ε^{i2}.

The variance-covariance matrix of the exogenous shocks is presented as follows:

$$\begin{bmatrix} \sigma_\varepsilon^{T2} & \sigma_\varepsilon^T\sigma_\varepsilon^N & 0 & 0 & \rho^{Tf}\sigma_\varepsilon^T\sigma_\varepsilon^f \\ \sigma_\varepsilon^T\sigma_\varepsilon^N & \sigma_\varepsilon^{N2} & 0 & 0 & \rho^{Nf}\sigma_\varepsilon^N\sigma_\varepsilon^f \\ 0 & 0 & \sigma_\varepsilon^{g2} & 0 & \rho^{gf}\sigma_\varepsilon^g\sigma_\varepsilon^f \\ 0 & 0 & 0 & \sigma_\varepsilon^{h2} & 0 \\ \rho^{Tf}\sigma_\varepsilon^T\sigma_\varepsilon^f & \rho^{Nf}\sigma_\varepsilon^N\sigma_\varepsilon^f & \rho^{gf}\sigma_\varepsilon^g\sigma_\varepsilon^f & 0 & \sigma_\varepsilon^{f2} \end{bmatrix} \quad (5.15)$$

where ρ^{Tf}, ρ^{Nf}, and ρ^{gf} are the correlations between aid and the TFP shocks and between aid and the government expenditure shocks, respectively[138]. The zero off-diagonal shows that shocks are not contemporaneously correlated.

The decisions taken in this economy follow a time sequence. At the beginning of period *t*, the values of the stochastic shocks are realized. The representative agent chooses consumption and makes

[138] ρ^{zf} is added to match the pro-cyclicality between output and aid in the data and ρ^{gf} is added to match the positive correlation between aid and government expenditures. No correlation between public human capital shock and foreign aid shock has been added as the correlation in the Kenyan data is low.

investment decisions (in terms of time and tradable goods). The representative firm chooses how much physical capital and effective labor to hire.

With no externalities and no distortionary taxes, the competitive equilibrium is Pareto optimal. For the representative agent, the Pareto-optimality means that utility maximizations and the representative agent's problem can be represented by a social planner's problem. The first and second welfare theorems state that the solution to a competitive equilibrium yields the same allocation of consumption (tradable and non-tradable goods), time devoted to work (in tradable and non-tradable sectors), study time, and physical and private human capital investment. Those allocations are chosen to maximize the representative agent utility given the resource constraints and technology restrictions.

The social planner[139] maximizes the following expected utility of the representative agent:

$$max_{\{C_t^T, C_t^N, C_t, N_t^T, N_t^N, S_t, L_t, I_t^h, K_{t+1}, H_{t+1}, K_t^T, H_t^T, K_t^N, H_t^N\}} E_0 \sum_{t=0}^{\infty} \beta^t \{logC_t + \gamma logL_t\} \tag{5.16}$$

subject to

$$S_t + N_t^T + N_t^N + L_t = 1 \tag{5.17}$$

$$C_t = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} \tag{5.18}$$

$$C_t^T + I_t^k + I_t^h = A_t^T \exp(z_t^T) K_t^{T\alpha} (N_t^T H_t^T)^{1-\alpha} + F \exp(z_t^F) \tag{5.19}$$

$$C_t^N + G_t + I_t^{gh} = A_t^N \exp(z_t^N) K_t^{N\theta} (N_t^N H_t^N)^{1-\theta} \tag{5.20}$$

$$K_{t+1} = I_t^k + (1-\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t \tag{5.21}$$

$$H_{t+1} = A_t^h S_t^{\eta_1} I_t^{h\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} + (1-\delta_h) H_t \tag{5.22}$$

$$K_t = [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}} \tag{5.23}$$

$$H_t = [(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}} \tag{5.24}$$

[139] Appendices C.1-C.4 describe in details the representative agent's optimization problem, firm's optimization problem, social planner problem, and the steady state.

5.4.1- Competitive Equilibrium

Definition A competitive equilibrium for this model is a set of prices $\{P_t^N,\ w_t^h,\ r_t^k\}_{t=0}^{\infty}$ and allocations $\{C_t^T,\ C_t^N, C_t, N_t^T,\ N_t^N, S_t, L_t, I_t^h, K_{t+1},\ H_{t+1}, K_t^T, H_t^T, K_t^N, H_t^N\}_{t=0}^{\infty}$ such that, the following conditions hold:

(i) The representative agent maximizes utility subject to his budget constraint taking prices as given.

(ii) The representative firms maximize profits subject to output technology taking input prices as given.

(iii) The market-clearing conditions and the government budget constraint hold:

$$S_t + N_t^T + N_t^N + L_t = 1$$

$$C_t = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}}$$

$$C_t^N + G_t + I_t^{gh} = A_t^N \exp(z_t^N)\, K_t^{N\theta}(N_t^N H_t^N)^{1-\theta}$$

$$C_t^T + K_{t+1} - (1-\delta_k)\, K_t + \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t + I_t^h = A_t^T \exp(z_t^T)\, K_t^{T\alpha}(N_t^T H_t^T)^{1-\alpha} + F_t$$

$$H_{t+1} = A_t^h S_t{}^{\eta_1} I_t^{h\eta_2}(\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} + (1-\delta_h)\, H_t$$

$$K_t = [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}}$$

$$H_t = [(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}}$$

$$T_t + F_t = P_t^N I_t^{gh} + P_t^N G_t$$

5.4.2- Equilibrium Dynamics

The optimality conditions of the social planner's maximization problem show the following equilibrium conditions:

$$\frac{1}{C_t}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1}\ \omega(C_t^T)^{-(1+\mu)}\left[1 + \emptyset\left(\frac{K_{t+1}}{K_t} - 1\right)\right] =$$

$$\beta \mathrm{E_t}[\frac{1}{C_{t+1}}\ [\omega(C_{t+1}^T)^{-\mu} + (1-\omega)(C_{t+1}^N)^{-\mu}]^{-\frac{1}{\mu}-1}$$

$$\omega(C_{t+1}^T)^{-(1+\mu)}[(\frac{(\alpha A_{t+1}^T \exp(z_{t+1}^T)\left(\frac{K_{t+1}^T}{N_{t+1}^T H_{t+1}^T}\right)^{\alpha-1})}{\left[(K_{t+1}^T)^{-\nu_k} + (K_{t+1}^N)^{-\nu_k}\right]^{\frac{-1}{\nu_k}-1}(K_{t+1}^T)^{-(\nu_k+1)}} + (1-\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}} - 1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1} - 1)^2)] \quad (5.25)$$

$$\frac{\frac{\gamma}{(1-N_t^T - N_t^N - S_t)}}{\eta_1 A_t^h S_t{}^{\eta_1 - 1} I_t^{h\,\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2}} =$$

$$\beta \mathrm{E_t}\{\frac{\gamma}{1-N_{t+1}^T - N_{t+1}^N - S_{t+1}} (\frac{N_{t+1}^T}{\left[\left(H_{t+1}^T\right)^{-\nu_h} + \left(H_{t+1}^N\right)^{-\nu_h}\right]^{\frac{-1}{\nu_h}-1} \left(H_{t+1}^T\right)^{-(\nu_h)}]} +$$

$$\frac{(1-\delta_h)}{\eta_1 A_{t+1}^h S_{t+1}{}^{\eta_1 - 1} I_{t+1}^{h}{}^{\eta_2} (\exp(z_{t+1}^h) I_{t+1}^{gh})^{1-\eta_1-\eta_2}})\} \tag{5.26}$$

$$\alpha A_t^T \exp(z_t^T) \left(\frac{K_t^T}{N_t^T H_t^T}\right)^{\alpha-1} = (\frac{1-\omega}{\omega}) (\frac{C_t^N}{C_t^T})^{-(1+\mu)} \theta A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta-1})(\frac{K_t^T}{K_t^N})^{-(\nu_k+1)} \tag{5.27}$$

$$(1-\alpha) A_t^T \exp(z_t^T) \left(\frac{K_t^T}{N_t^T H_t^T}\right)^{\alpha} N_t^T =$$

$$(\frac{1-\omega}{\omega})(\frac{C_t^N}{C_t^T})^{-(1+\mu)} (1-\theta) A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta} N_t^N (\frac{H_t^T}{H_t^N})^{-(\nu_h+1)} \tag{5.28}$$

$$\frac{\gamma C_t}{1-N_t^T - N_t^N - S_t} = [\omega (C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega (C_t^T)^{-(1+\mu)} (1\text{-}\alpha) A_t^T \exp(z_t^T) (\frac{K_t^T}{N_t^T H_t^T})^{\alpha} H_t^T \tag{5.29}$$

$$\frac{\gamma C_t}{1-N_t^T - N_t^N - S_t} =$$

$$[\omega (C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} (1-\omega)(C_t^N)^{-(1+\mu)} (1\text{-}\theta) A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta} H_t^N \tag{5.30}$$

$$\frac{\gamma C_t}{(1-N_t^T - N_t^N - S_t)([\omega\left(C_t^T\right)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega \left(C_t^T\right)^{-(1+\mu)})} = \frac{\eta_1 I_t^h}{\eta_2 S_t} \tag{5.31}$$

Equation (5.25) corresponds to the intra-temporal Euler equation for consumption that equates the marginal social cost of giving up a one unit of current consumption with the marginal social benefit of allocating extra savings into aggregate physical capital; i.e. physical capital Euler equation. It states that the loss of utility from foregone present consumption equates the expected benefit from increasing future consumption. Equation (5.26) corresponds to the intra-temporal Euler equation for human capital; it equates the current marginal social cost (LHS) for an extra unit of time spent on acquiring human capital with the marginal social benefit of the human capital in the future. In other words, the marginal social cost of human capital is equated with the discounted expected social benefit of future human capital.

Equations (5.27) and (5.28) equate the marginal productivities of physical capital and human capital across sectors, respectively. Equation (5.29) is the intra-temporal Euler for leisure and consumption (tradable). It equates the effective opportunity cost of leisure to the marginal rate of substitution between leisure and consumption. Whereas, equation (5.30) is the intra-temporal Euler for leisure and consumption (non-tradable). It equates the effective opportunity cost of leisure to the marginal rate of substitution between leisure and consumption.

Equation (5.31) is the intra-temporal Euler equation that shows the relationship between consumption, private human capital investment, leisure time and time devoted to acquire human capital. It sets the marginal rate of substitution between consumption and leisure (LHS) equals to the marginal rate of substitution between private human investment and time allocated to study and this relationship holds every period.

From equations (5.8), (5.9), (5.27), and (5.28), the relative price of the non-tradable goods is determined:

$$P_t^N = \left(\frac{1-\omega}{\omega}\right) \left(\frac{C_t^N}{C_t^T}\right)^{-(1+\mu)} \tag{5.32}$$

Equation (5.32) equates the relative price of the non-tradable goods, P_t^N, to the marginal rate of substitution between the consumption of tradable and non-tradable goods.

Combining equations (5.8) and (5.9) and taking logs, I obtain the equilibrium relative price of non-tradable goods (equation 5.33), which is a function of the relative technologies of the tradable and non-tradable sectors as well as the allocations of physical and human capital in both sectors:

$$\ln P_t^N = (\alpha - \theta)\ln\left(\frac{K_t^N}{N_t^N H_t^N}\right) + \ln\left[\left(\frac{A^T}{A^N}\right)\left(\frac{1-\alpha}{1-\theta}\right)^{1-\alpha}\left(\frac{\alpha}{\theta}\right)^{\alpha}\right] + (\alpha)\ln\frac{N_t^N}{N_t^T} - \alpha(\nu_k+1)\ln\left(\frac{K_t^N}{K_t^T}\right) + (\alpha-1)(\nu_h+1)\ln\left(\frac{H_t^N}{H_t^T}\right) \tag{5.33}$$

Here, P_t^N is the slope of the PPF (tradable and non-tradable outputs) in equilibrium. Equation (5.33) represents the supply side of the relative price of non-tradable goods that equates the marginal productivities in both sectors. While equation (5.32) represents the demand side of the real exchange rate that equates the marginal rate of substitution between the consumption of tradable and non-tradable goods. The calibrated DSGE model also incorporates the Balassa-Samuelson hypothesis that changes in the relative price of the non-tradable goods originate from the labor productivity differentials, adjusted for sector-specific physical and human capital.

The above model cannot be solved analytically, a Dynare program in Matlab is used to solve it.

5.5- DSGE-RBC: Calibration and Results

5.5.1- Parameters

The data used to calibrate the model are yearly data and one-sided HP filter[140] is used to remove the cyclical component of the time series data. The parameters used to calibrate the benchmark model are summarized in Table 5.1. The parameters are classified into three categories: parameters which are taken from other studies and remain fixed, parameters that are directly estimated from the data, and the rest of parameters that are linked to the steady state values are calibrated to mimic the Kenyan economy as observed in the 1970–2014 period.

When considering the elasticity of substitution between the tradable and non-tradable consumptions, I follow Ostry and Reinhart (1992) and fix μ at 0.316, reflecting the developing countries estimate. For the elasticity of substitution between physical capital used in the tradable and non-tradable sectors, I fix the value of υ_k at -11 as in Mendoza and Uribe (2000). Following Cardi and Restout[141] (2015), I fix ν_h at -2.2 that represents the mean value for some advanced countries that ranges between -9 and -1.5.

The autocorrelation coefficients of the total factor productivity for both sectors, public human capital, and the government expenditure shocks are set to 0.81 (equivalent to 0.95[142] quarterly Kydland and Prescott (1982)). The discount factor (β) is set to 0.95 (Arellano et al. (2009)). The cost of adjustment (ϕ) is set to 3[143]. The productivity shock of the tradable output (A^T) and the human capital sector shock (A^h) are normalized to 1. Physical and human capital depreciation rates are set to 5% (Arellano et al. (2009)) and 3.5% (Jorgenson and Fraumeni (1989)), respectively. The autocorrelation of the foreign aid shock and its standard deviation are estimated directly from the Kenyan data and set to 0.71 and 0.248, respectively. The values of technology parameters for both sectors (α (tradable) and θ (non-tradable)) are determined from the Kenyan national accounts data on the production accounts by industry, sectoral factor payments, and GDP at factor cost for a period of 25 years (1990–2014). The shares of labor income in value-added are set to $1 - \alpha = 0.65$

[140] $\lambda = 100$ (for yearly data).
[141] In their model, they estimate labor mobility.
[142] I have followed Kydland and Prescott (1982) and set the autocorrelation coefficients for public human capital investment and government expenditure equal to the autocorrelation coefficient for the TFP shock.
[143] The cost of adjustment in literature ranges between 0.005 and 5. García-Cicco et.al (2010) 95% confidence interval < 4.9 with median 3.3.

(in the tradable sector) and 1 - θ = 0.55 (in the non-tradable sector), which are the averages over the period for which data are available[144].

The rest of the parameters are calibrated to match the long-run average ratios of the Kenyan economy. These parameters are: 1) the share parameter of schooling time in the human capital production function (η_1 = 0.7); 2) the share parameter of the private human capital investment in the human capital production function (η_2= 0.10); 3) weight of leisure (γ = 1.45); 4) weight of the tradable consumption (ω =0.24); 5) correlation coefficient between aid and the TFP shocks ($\rho^{fT} = \rho^{fN} = 0.50$); 6) correlation coefficient between aid and the government expenditure shocks ($\rho^{gf} = 0.25$); 7) the productivity shock of the non-tradable output ($A^N = 1.61$); 8) public human capital parameter (I^{gh} = 0.277); 9) government expenditure parameter (G = 0.585); 10) foreign aid parameter (F = 0.153); 11) standard deviation of the TFP shock ($\sigma^T = \sigma^N = 0.0473$); 12) standard deviation of the public human capital shock (σ^{gh}=0.1055); 13) standard deviation of the government expenditure shock (σ^g=0.092).

The Kenyan economy long-run average ratios that the model matches (targeted moments) in the calibration process are: 1) tradable output-to-GDP ratio of 38%; 2) private human capital investment-to-consumption ratio of 3.4%; 3) working time of 33.33%[145]; 4) pro-cyclicality of aid; 5) positive correlation between aid and the government expenditures; 6) public human capital investment-to-GDP ratio of 5.38%; 7) government expenditure-to-GDP of 11.3%; 8) aid-to-GDP level of 5.85%; 9) standard deviation of GDP of 4.34%; 10) standard deviation of the public human capital investment of 8.92%; 11) standard deviation of the government expenditure of 7.94%.

5.5.2- Calibration Results

Tables 5.2A-5.2F below present the stylized facts of the benchmark model that is calibrated to match the Kenyan data for the 1970–2014 period. Table 5.2A shows the means of the variables that the model is calibrated to match which were discussed in the previous section and other means produced by the benchmark model. Tables 5.2B-5.2F present the standard deviations of some selected stationary variables[146] and the correlations with output, aid, public human capital, and government expenditure, respectively. The benchmark model is able to mimic successfully the targeted means and the targeted standard deviations with the calibration process. For instance, the

---

[144] See Appendix C.6 for details.
[145] No data available for Kenyan working hours, I have calibrated the working hours to match one-third of the total time.
[146] Stationarity of the variables are explained in Appendix C.5.

benchmark model is able to match tradable output-to-GDP, aid-to-GDP ratio, public human capital investment-to-GDP, government expenditure-to-GDP, foreign aid-to-GDP, and private human capital investment-to-GDP. Furthermore, it has an overall good fit with regard to other mean levels.

The benchmark model underestimates the volatility of consumption for the reasons discussed in Chapter 4. The Kenyan data show that the relative consumption volatility is 1.14, while it is 0.72 in the benchmark model. The benchmark model is also able to match the volatility of GDP; however, it overestimates the volatilities of the tradable output and underestimates the volatilities of non-tradable output and the relative price of non-tradable goods. Further, the benchmark model has a good fit in estimating the volatility of physical capital investment[147].

Foreign aid volatility is 4.7 times more volatile than that of GDP in the benchmark model compared to 5.14 in the data. This is due to that aid's standard deviation was estimated from the data rather than calibrated. Kenyan data show that the volatility of public human capital investment is twice that of output and the volatility of government consumption is 1.8 times that of output. The benchmark model is able to match the volatility of public human capital investment.

In terms of the correlations with GDP, the benchmark model matches the pro-cyclicality of consumption, physical capital investment, and tradable and non-tradable outputs. The benchmark model generates a negative correlation between GDP and the relative price of non-tradable goods, which is the feature of the "Dutch Disease" phenomenon. It also matches the positive correlation signs of aid with GDP[148], non-tradable output, consumption, physical capital investment, and government expenditures[149].

5.6- Simulation Results

The behavior of the economy in the periods following the shock[150] can be analyzed by studying the impulse response functions. Figures 5.5-5.6 demonstrate the effects of a positive one-standard-deviation increase in a desired shock on the selected stationary variables such as: output, tradable

[147] Without including the cost adjustment parameter physical capital investment's volatility would reach 24%.
[148] The reason is that aid and TFP shocks are correlated.
[149] In Appendix C.7, I compare two other models with the benchmark one. Model A where aid and government expenditure shocks are only correlated, and Model B where TFP and government expenditure shock are only correlated.
[150] TFP shock and government expenditure shock effects are presented in Appendix C.8.

and non-tradable outputs, consumption, investments in human and physical capital, time devoted to study, tradable and non-tradable labors, relative price of non-tradable goods, tradable and non-tradable consumption, tradable and non-tradable physical and human capital, and the marginal productivity of study hours.

5.6.1- Short-Term Impact from Temporary Changes in Shocks

5.6.1.1- Foreign Aid Shock

Figure 5.1 illustrates the impulse response functions following a positive one-standard-deviation shock to exogenous foreign aid. Foreign aid is designed to enter the model as an untied wealth transfer and any change in the foreign aid level would have an impact on the selected stationary variables.

The positive income effect of foreign aid increases the representative agent's income, resulting in an immediate reduction in the total labor working hours. The increase in the agent's income leads to an increase in consumption demand and leisure time; thus, the tradable and non-tradable consumption increase. The relative price of non-tradable goods is determined by the ratio of the marginal utilities of the tradable and non-tradable consumption. In response, the relative price of non-tradable goods significantly increases, leading to the reallocation of resources from the tradable sector to the non-tradable sector (more profitable), causing the tradable sector to shrink, non-tradable sector to expand, and total output to decline. The reallocation of the resources channel leads to an immediate increase in non-tradable labor, non-tradable physical capital, and non-tradable human capital. On the other hand, tradable labor, tradable physical capital, and tradable human capital decrease upon the impact of the foreign aid shock.

The behavior of physical capital investment depends on two factors. First, the availability of foreign aid that acts as a substitute for the tradable goods produced in the economy and decreases physical capital investment. On the other hand, a shrinking total labor supply and an increase in the relative price of non-tradable goods are negatively affecting the physical capital productivity. Second, household's consumption increases the demand for goods. The increase in the demand and the possibility of substituting labor with physical capital are positively affecting physical investment. Thus, the net effect of these two factors is a slight increase in the physical capital investment upon impact.

Human capital investment increases as a result of an aid shock due to the positive income effect caused by the flow of aid. Hence, the representative agent devotes more time to acquire skills which increases his productivity in the future. Finally, the marginal productivity of study hours decreases on impact, increases gradually, reaches its peak in the 9th period, and then decreases to its long-run trend.

In comparison with the one-sector DSGE model presented in Chapter 4, a shock to foreign aid yields the same behavior of the impulse response functions for GDP, consumption, physical capital investment, private human capital investment, time devoted to study, total labor supply, and the marginal productivity of study hours. However, the magnitudes or the percentages of deviations of the impulse responses are higher in the one-sector DSGE model.

In the empirical study presented in Chapter 3, I have found that aid shocks have a negative long-run impact on GDP in eight sub-Saharan African countries and a positive long-run impact on GDP in only three SSA countries. In addition, I find that aid shocks have more impacts on the GDP's composition. Foreign aid shocks have a negative and persistent impact on the tradable and non-tradable outputs in 16 and five countries and a positive and persistent impact on the tradable and non-tradable outputs in four and six SSA countries, respectively. For Kenya, aid shocks have a negative and persistent impact on GDP, tradable and non-tradable outputs. However, in the two-sector DSGE-RBC model[151], a positive aid shock has a negative impact on GDP and the tradable output and a positive impact on the non-tradable output.

5.6.1.2- Public Human Capital Shock

A positive one-standard-deviation public human capital shock corresponds to a decline in the opportunity cost of skill acquisition activities and an increase in leisure opportunity cost. Figure 5.2 depicts the impulse responses to a positive one-standard-deviation public human capital shock. The shock in the public human capital decreases the cost of accumulating human capital relative to physical capital. Thus, the agent devotes more time into education activities at the expense of leisure and total labor hours. Consequently, the agent increases his investment in human capital. Consumption and physical capital investment decrease on impact and increase in subsequent periods and stay below the steady state for four years after the realization of the shock. Both tradable

[151] The DSGE-RBC model impulse response functions are short-run; in contrast to the CVAR impulses which are long-run.

and non-tradable consumption decrease; in response, the relative price of non-tradable goods increases.

The appreciation of the relative price would reallocate the resources from the tradable to non-tradable sector. Thus, the tradable output declines and the non-tradable output increases, leading to an initial decline in the total output. The initial decline in output is affected by two factors. First, the decrease in total labor supply even though non-tradable labor increases; the decline in the tradable labor exceeds the increase in non-tradable labor. Second, the increase in the non-tradable output does not overweigh the decline in the tradable output. However, by time, output starts to increase due to higher labor productivity which is associated with the increase in human capital investment and time devoted to education. The marginal productivity of study time increases on impact, declines monotonically, and stays above its long-run trend for a long period of time.

Both models, the one-sector and the two-sector DSGE-RBC models, yield the same impulse response functions behavior for GDP, consumption, physical capital investment, private human capital investment, time devoted to study, labor supply, and marginal productivity of study hours. However, the magnitude of response is greater in the one-sector model compared to the two-sector model.

5.7- Sensitivity Analyses

One of the features of the calibration and simulation approaches is to measure the impact of foreign aid and its volatility on the economy by distinguishing between the permanent changes in aid levels and the temporary changes in aid. In the former case, I keep all the parameters fixed and change the mean level of aid; in the latter case, I only change the persistence level of aid shock.

5.7.1- Permanent Changes in Foreign Aid Levels

Table 5.3 reports the impacts of a permanent increase in the aid-to-GDP ratio. The main idea is to compare the benchmark model to different hypothetical scenarios, when the representative agent economy receives a different amount of aid levels. In this part of the analysis, all the parameters stay fixed as in Table 5.1 except the mean level of aid which changes to get an average aid-to-GDP of 0%, 12%, 18%, and 24%.

I find that as aid increases, the relative price of non-tradable goods increases and the tradable output-to-GDP ratio shrinks. Table 5.4 below reports the first and second moments of the selected stationary series in the model computed at different aid levels. The permanent increase of foreign aid changes the composition of output, consumption, physical capital, human capital, labor, as well as the relative price of non-tradable goods.

The main findings of the simulation results are as follows. First, a permanent increase in the level of aid is associated with a permanent increase in consumption. For instance, at an aid-to-GDP level of 18%, consumption as a share of GDP and as a share of income (GDP + aid) increases from 67% to 76% and from 63% to 64.4%, respectively. Physical capital investment-to-GDP[152] also increases as aid-to-GDP increases; whereas, physical capital investment-to-income declines. Private human capital investment-to-GDP[153] ratio declines a little as aid level increases as a share of GDP. However, the private human capital investment-to-income ratio declines more relative to GDP. For instance, when aid is tripled, the private human capital-to-income ratio declines to 1.96% compared to 2.2% in the benchmark model. The tradable consumption as a share of GDP increases by 14%, when the aid level is tripled relative to the benchmark model.

Second, the higher the aid-to-GDP level, the higher is the relative price of non-tradable goods. In the simulation case, when aid-to-GDP is 18%, the relative price of non-tradable goods is almost 2.5% higher; it is 3.5% higher when aid equals to 24% of GDP relative to the benchmark model. With higher aid levels, the availability of the tradable goods increases the tradable goods supply relative to the non-tradable goods, causing the equilibrium price of the latter to increase.

A third result emerging from the second one is the relative size of the tradable sector which is decreasing with increasing the level of foreign aid. With no aid, the tradable sector comprises 42.5% of GDP in the steady state. As aid increases to 24% of GDP, the tradable sector shrinks to 25.3% of GDP. The relative decline of the tradable sector is linear: a 1 percentage point increase in aid is associated with a 0.70 percentage point decline in the tradable-to-GDP ratio.

Fourth, an appreciation of the relative price of non-tradable goods would induce the representative agent to shift his labor hours from the tradable sector to the non-tradable sector. In the benchmark model, the representative agent supplies more time in the tradable sector compared to the case when aid is equivalent to 24% of GDP. On the other hand, the representative agent increases his non-

[152] In one-sector DSGE model this ratio stays the same as aid-to-GDP increases.
[153] In one-sector DSGE model this ratio stays the same as aid-to-GDP increases.

tradable working hours by 9.4% when aid is quadrupled. However, the total labor supplied declines when aid-to-GDP reaches 24%. The study time also declines by 11% when aid is quadrupled relative to the benchmark model. Furthermore, as aid-to-GDP level increases, tradable-to-non-tradable physical and human capital ratios decline indicating that the more aid is injected in the economy, the higher is the reallocation of resources from tradable to non-tradable sector.

A fifth result is that as aid increases, it becomes more influential in the model economy. Increasing aid levels would increase the volatility of all variables. For instance, the volatility of consumption increases relative to the benchmark model. The relative price of non-tradable goods is 1.45 times as volatile when aid flows is 24% of GDP relative to the benchmark model. Output, tradable and non-tradable outputs, private human capital, and physical capital investment are becoming more volatile with higher aid flows. The volatility of tradable output is 55% higher than in the benchmark when aid increase to 24% of GDP; whereas, the volatility of non-tradable goods increases by 30%. Moreover, the volatilities of tradable labor, tradable human capital, and tradable physical capital exceed their counterparts in the non-tradable sector as aid increases.

Finally, a permanent increase in the aid levels is found to be negatively associated with study hours, private human capital, tradable output, and total labor supply. Higher and volatile aid flows introduce high volatility in the economy in terms of consumption, investment in both forms of capital, and the relative price of non-tradable goods.

5.7.2- Foreign Aid Shock at Different Persistent Levels

As discussed in Chapter 4, the impulse responses of the selected stationary variables are affected by the magnitude of the aid shock persistence level. Here, I analyze study hours, private human capital investment, tradable and non-tradable labor supply, physical capital investment, the relative price of non-tradable goods, and the tradable and non-tradable outputs impulses to a positive one-standard-deviation from a trend in the aid level, when the persistence level of aid shock changes. The impulse response functions are presented in Figure 5.3. The magnitude of the responses and the behavior of some selected variables depend on the persistence level of the aid shock (ρ^f) level. For this part of sensitivity analysis, five cases are considered: when ρ^f = 0.00, $\rho^f = 0.35$, ρ^f = 0.71 (the benchmark model), ρ^f = 0.90, and ρ^f = 0.95.

As aid shock persistence level changes, the most affected variables are the study hours and private human capital investment[154]. The income effect from an aid shock causes leisure time to increase and total labor working hours to fall for any level of ρ^f. However, the study time reaction is sensitive to the choice of the persistence level of the aid shock. For instance, when $\rho^f < 0.90$, foreign aid has a positive impact on study hours; however, when $\rho^f \geq 0.90$ foreign aid starts to have a negative impact on study hours. At a high persistent aid shock, the behavior of the representative agent is similar to his behavior when there is a permanent increase in the aid level. In this case, aid inflows discourage the representative agent in putting effort to study and increase his dependence on foreign aid. On the contrary, with a less persistent shock, study time increases initially on impact and then returns to its steady state; it experiences a deviation below its trend in the 2nd, 3rd , and 7th year when ρ^f = 0.00, 0.35, and 0.71, respectively. When $\rho^f \geq 0.90$, study time response function never experiences a positive deviation above its trend. These results are also consistent with the results found in Chapter 4.

The reaction of private human capital investment is also affected by the level of aid shock persistence. For instance, increasing the persistence level of an aid shock decreases the positive magnitude of the aid impact on the private human capital investment. However, when ρ^f = 0.90[155], foreign aid shock starts to have a negative impact on the private human capital investment, in contrast to the benchmark model. Physical capital investment reaction does not change its behavior as the persistence level goes up. However, the magnitude of the physical capital investment impulse response function is negatively affected as the persistence shock level goes up.

Tradable and non-tradable labor working hours are also influenced by the persistence level of aid shock. The magnitude of the initial decline in the tradable labor supply is not affected by the persistence level; however, increasing the persistence value would affect the period the tradable labor impulse function stays below its trend. On contrary, the magnitude of the initial increase in the non-tradable labor supply increases with the persistence value of the shock of aid; the higher the persistence shock level, the longer the non-tradable labor working hours impulse response function stays above its trend.

Finally, both the impulse response functions for the relative price of non-tradable goods and the non-tradable output increase with the persistence level of the aid shock. As the shock persistent

[154] Same results as in one-sector DSGE model.
[155] In the one-sector DSGE-RBC model this happens when ρ^f = 0.95.

level goes up, the longer both responses stay above their trends. Both responses never experience a deviation below their trends at any level of persistence. The magnitude of the initial decline in the tradable output is not affected by the aid shock persistence level. However, as ρ^f increases, the longer the tradable output response function stays below its trend and never deviates above it.

5.7.3- Effects of Changing the Volatility of Aid: Mean-Preserving Spread

Now, consider comparing the benchmark model to hypothetical scenarios when the same representative economy receives the same amount of aid but with different aid volatility levels. This exercise captures the impact of the aid shocks on the variables when the standard deviation of an aid shock changes.

The second column of Table 5.4 shows the mean levels of GDP, tradable and non-tradable outputs, the relative price of non-tradable goods, consumption, private human capital investment, physical capital investment, study hours, and tradable and non-tradable working hours for the benchmark model. The 3rd, 5th, and 7th columns show the mean levels of the correspondent variables when the volatility of aid (i.e. standard deviation) sets at 0%, 10%, and 40%, respectively. Lowering the volatility of aid to half, GDP, tradable output, physical capital investment, private human capital investment, study, and tradable working hours are slightly higher relative to the benchmark model. On the other hand, non-tradable output, the relative price of non-tradable goods, consumption, and non-tradable working hours are slightly lower relative to the benchmark model. Decreasing the volatility of aid to half would be equivalent to decreasing the aid level by 5.5%.

Setting the volatility of aid to zero (donors deliver aid in a stable and predictable manner) is equivalent to a 7.85%[156] decrease in the mean level of aid. In this case, GDP, consumption, and the tradable output would increase; private human capital investment and study hours would increase by 1.63% and 0.32%, respectively. The relative price of non-tradable goods decreases and the non-tradable output increases even though the non-tradable working hours decreases relative to the benchmark model. On the other hand, doubling the volatility of aid to 40% has an adverse selection on GDP, the tradable output, physical and private human capital investment, study hours, and tradable working hours with tradable output the biggest loser (-2.9%). Increasing the volatility of aid to 40% is equivalent to increasing aid level by 19.4%. From a policy point of view, the donors

[156] 4.5% in the one-sector DSGE-RBC model.

are encouraged to decrease the volatility of aid rather than just the level of aid. The donors could increase the welfare of the recipient countries by delivering aid in a stable and predictable way.

5.7.4- Forecast Error Variance Decomposition

The contribution of each shock on business cycle fluctuations is now examined. Forecast Error Variance Decomposition separates the endogenous variables variations into the component shocks. It describes the relative importance of each innovation in affecting the variables over a particular forecast horizon. Table 5.5 reports the variance decompositions of the calibrated DSGE model for aid-to-GDP level of 5.85% and 24%.

A number of interesting observations emerge from Table 5.5. First, for the benchmark model, the TFP shock dominates other shocks in explaining output, tradable output, non-tradable output, consumption, physical capital investment, tradable labor, non-tradable labor, and both sectors' physical and human capital stocks fluctuations. Second, public human capital shock dominates other shocks in explaining study hours and private human capital investment fluctuations. Third, foreign aid shock is dominated by the TFP and public human capital sector shocks in explaining all the variables' fluctuations. Finally, the government expenditure shock seems to have a negligible influence on the variables of interest fluctuations except for the non-tradable labor hours and the relative price of non-tradable goods. However, at a higher aid-to-GDP ratio, an aid shock becomes more influential.

In addition to the variance decomposition, I extend the analysis and examine the implications of counterfactual cases. Table 5.6 reports the stylized facts of the model when the variances of the TFP, aid, public human capital, and government shocks are set to zero; I compare these results to those in the benchmark model economy, keeping other parameters fixed as in Table 5.1.

In the absence of aid, public human capital, and the government shocks there are substantial variabilities in output, tradable output, non-tradable output, consumption, private human capital investment, physical capital, study hours, tradable labor, and the non-tradable labor working hours associated with the TFP shock. All the variables of interest are pro-cyclical except for the relative price of non-tradable goods, study hours, and non-tradable labor working hours which are counter-cyclical. This is consistent with the benchmark calibrated model.

Keeping an aid shock, while switching off other volatilities, shows how small the impact of foreign aid is on all the macro variables' volatilities except for the tradable labor. In fact, aid shock's standard deviation (σ^f) would need to be set to 1.44[157], which is 5.8 times the benchmark model level in order to produce the benchmark output volatility of 4.34% in the absence of the TFP shock. The idea behind this is that foreign aid creates a positive income effect, causing labor working hours to fall, leading to an initial drop in output. As a consequence, foreign aid is strongly counter-cyclical (correlation with output is -0.94) when other shocks are absent. In addition, aid is found to have a strong positive correlation with the relative price of non-tradable goods, the non-tradable output, and non-tradable labor supply. Foreign aid has been found to have a strong negative correlation with the tradable output and tradable labor supply. However, to smooth consumption behavior, both private human capital and physical capital investment should increase; hence study time increases. The increase in investment in both physical and human capital would have a positive effect on output in subsequent periods due to higher labor productivity.

In a presence of only public human capital shock, there remains some amount of private human capital investment and study time volatilities but others' volatilities are quite low. Study hours and private human are counter-cyclical; the rest of the variables are pro-cyclical.

Government expenditure shock alone does not contribute to any of the variables' volatilities except for the non-tradable output and non-tradable labor supply. All macro variables volatilities are quite low in the presence of government shock. The variables are counter-cyclical except for the non-tradable output, the relative price of non-tradable goods, and non-tradable labor working hours.

5.7.5- Correlated Shocks versus Uncorrelated Shocks

Two models are presented in Tables 5.2A-5.2F. The benchmark model, where aid and the TFP shocks and aid and the government shocks are correlated, and Model A, where all the shocks are uncorrelated. For the mean levels, both models generate the same mean levels for all the stationary variables. The main differences between the models are in the correlation signs. For instance, there is zero correlation between foreign aid and government expenditure in Model A, while there is a positive correlation in the benchmark model. In Model A, aid is counter-cyclical with GDP and the tradable output, while in the benchmark model, aid is pro-cyclical. Further, Model A overestimates the volatilities of the tradable output and the relative price of non-tradable goods; Model A underestimates the volatilities of the non-tradable output, consumption, and physical capital investment.

---

[157] Aid's volatility equals 118%.

5.8- The Vector Error Correction Model (VECM)[158]

In this section, I consider a vector error correction model (VECM). The purpose of this analysis is to see whether the observed dynamic implications of the calibrated DSGE-RBC model are consistent with ones from a non-theoretical VECM model. I show that the VECM impulse responses functions match well with the implications of the theoretical DSGE-RBC model. In the short-run, I find evidence that foreign aid causes tradable goods price to depreciate, non-tradable goods price to appreciate, the tradable output to decrease, and total output to decline[159]. These empirical results are consistent with the "Dutch Disease" phenomenon.

I start with a *p*-variable vector autoregressive (VAR) model with *k* lags of the form:

$$y_t = c + \mu + A_1 y_{t-1} + A_2 y_{t-2} + \ldots + A_k y_{t-k} + \varepsilon_t \qquad (5.34)$$

where y_t is a *p* x *1* vector of variables under study, A_i, *i* = 1,2,…,*k*, is *p* x *p* matrix of parameters, μ is a vector of deterministic components, and ε_t is *i.i.d.* (0, Σ). According to Granger's representation theorem, the VAR model given in (5.34) can be reformulated into a vector error correction model (VECM) when there is cointegration. The VECM model incorporates short-and long-run dynamics and can be written in the following form (Sims, 1980):

$$\Delta y_t = c + \mu + \Pi y_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \, \Delta y_{t-i} + \varepsilon_t \qquad (5.35)$$

where $\Pi = \sum_{j=1}^{p} A_j - I_p$ and $\Gamma_i = - \sum_{j=1}^{p} A_j$

The term Πy_{t-1} captures the long-run relationship and the term $\sum_{i=1}^{p-1} \Gamma_i \, \Delta y_{t-i}$ captures the short-run dynamics.

I use the above model to estimate a VAR model containing five variables (i.e. $p = 5$): real aid in levels (aid_t), real GDP (gdp_t), real tradable output ($trad_t$), tradable price (p_t^T), and non-tradable price (p_t^{NT}). All the variables are in logarithmic form. Tests indicate that all the data series are non-stationary (See Tables C3.1-C3.4 in Appendix C.8). In the present VAR model, statistical tests indicate that one lag is the optimal lag length. An inspection of the diagnostic tests for the individual series indicates that the normality condition is violated for gdp_t, $trad_t$, p_t^T, p_t^{NT}, and aid_t. To account for this problem and to solve for the outliers problem in the above data series, a set of

[158] The CVAR presented in Chapter 3 shows that in the long-run there is no evidence of "Dutch Disease" in Kenya and it shows that there is only a transitory impact on the prices. The VECM model impulse response functions show the short-run effects of aid on the prices. So there is no contradictions in the results presented.
[159] I have not included any educational indicator due to missing data and reasons presented in Section 3.3.1.1.

dummy variables[160] has been introduced, in addition to a step dummy variable to account for a break in intercept for the aid data series. I introduce a transitory impulse dummy, *Dtr*70, defined (0,…,0,1,-1,0,…,0) to account for the drought that hit Kenya in 1970. I also introduce two permanent impulse dummies, *Dp*75 and *Dp*96, defined as (0,….,0,1,0,….0) to account for the inflation that affected prices in 1975 (18%) and in 1996 (42%), respectively. Finally, a step dummy, *Ds*95, defined as (0,……,0,1,1,….,1) is added to account for the shift in the equilibrium mean[161] of the aid series.

The formal trace test (Table C4 in Appendix C.8) has been used to determine the rank[162] of the Π matrix in (5.35). The trace test and the Bartlett small sample corrected test statistic indicate a presence of one long-run cointegration relationship.

5.8.1- Long-run Result

With a unique long-run relationship among the variables, the identification of the long-run equilibrium (i.e. cointegration relation) is relatively direct. A cointegration relation is interpreted as a deviation from a long-run value and corresponds to an equilibrium error. A cointegration relation only tells us how the variables co-move over time; it does not say anything about the causality between the variables unless the adjustment coefficients α is combined with it[163].

5.8.1.1- Long-run Exclusion Test

The long-run exclusion test is performed to test whether (or not) a variable can be excluded from the cointegration relation[164]. The unique long-run relationship[165] that is found in (5.35) can be written as:

$$trad_t = -0.223*aid_t + 1.015*gdp_t - 0.27*p_t^T + 0.221*p_t^{NT} - 0.326*Ds95 + 0.017*trend \quad (5.36)$$

(-6.419)*** (9.891)*** (-4.53)*** (2.707)** (-4.256)*** (2.131)**

[160] All the dummy variables introduced in the model are significant as per the f-statistics in Table C6.

[161] This dummy variable is accounted for the break in intercept for aid series due to the adjustment program of IMF and the World Bank where aid declined substantially.

[162] Other informal tests can be used and are more explained in the first paper. In the present paper I prefer to use the formal test.

[163] The long-run effects are more investigated in the empirical CVAR paper.

[164] I have normalized on *trad* and not on GDP since the β of *trad* bears a different sign from the α of *trad* meaning that normalizing on *trad* is preferred and it is error correcting. α and β for GDP bear the same sign indicating that they are not error correcting.

[165] Without imposing any exclusion tests. T-statistics are in parenthesis (** significant at 5%, *** significant at 1%).

Although the t-statistics in (5.36) imply that all the variables are significant, the variable exclusion test should be conducted. The exclusion test if accepted means that the variable is redundant to the long-run relation and at most have a short-run impact (Juselius, 2006). I perform an exclusion test (exclude both prices) in the long-run relationship and the test cannot be rejected[166], suggesting that both prices can be excluded from the long-run equilibrium and at most have a short-run impact in the model. The new long-run relationship after excluding the prices is as follows:

$$trad_t = -0.589{*}aid_t + 0.722{*}gdp_t - 1.069{*}Ds95 + 0.057{*}trend \qquad (5.37)$$

(-6.464)*** (2.679)** (-6.071)*** (4.413)***

The long-run cointegration in (5.37) is interpreted as the tradable output relation. The tradable output relation tells us the co-movement of the cointegrated variables over time. For instance, there is a negative association between aid and the tradable output, a negative association between aid and GDP, and a positive association between the tradable output and GDP in the long-run. A surprise finding comes from the significant negative relationship between the tradable output and the long-run effect of the shift dummy variable (*Ds*95). A possible interpretation of the negative relationship of the shift dummy is that the tradable output was higher before cutting foreign aid to Kenya and lower after 1995.

5.8.2- The VECM Results

The VECM in (5.35) is estimated with an optimal lag length of one. As a result of only one lag, the term $\sum_{i=1}^{p-1} \Gamma_i \, \Delta y_{t-i}$ has vanished and the short-run dynamics of the VECM model can be captured by the impulse response functions. The results of the VECM model are presented in Table 5.7 and the impulse response functions of aid, GDP, tradable output, tradable price, and non-tradable price to a one-positive-standard deviation of the variables' shock are presented in Figure 5.4.

In the growth rate of foreign aid[167] equation, the constant term is positive and significant implying that there are omitted variables in the model. The dummy variables have no impact on aid, while the tradable output long-run relation which is represented by the error correction term (ECT(-1)) has a strong negative influence on the growth rate of foreign aid. The error correction term coefficient bears the correct negative sign, suggesting that foreign aid is adjusting[168] to its long-run equilibrium after the shock[169]. The growth rates of GDP and the tradable output have been

[166] The $\chi(2)^2$ = 3.707 with p-value = 0.1507 (Bartlett sample correction).
[167] Aid equation (Equation 1 in Table 5.7).
[168] The speed of adjustment for aid is approximately 21 months.
[169] Changes in the cointegration relation variables.

negatively affected by the drought that hit Kenya in 1970. The transitory impulse dummy (*Dtr*70) coefficient is negative and significant in both GDP and the tradable output growth equations. The error correction term is negative and significant in the GDP growth equation, whereas in the tradable output growth equation, it is not significant although it bears the correct sign.

Turning into the prices of tradable and non-tradable goods, *Dtr*70 and *Dp*96 have positive and significant impacts on both prices, suggesting that during the drought in 1970 and the high inflation in 1996 both tradable and non-tradable prices went up. Inflation in 1975 only affects the non-tradable price. Although the error correction term in the tradable price bears the correct sign, it is not significant. Whereas, the coefficient of the error correction term in the non-tradable price bears the incorrect sign and it is significant. One interpretation for the incorrect sign[170] is that the growth rate of non-tradable price is increasing due to any changes in the error correction term (i.e. the tradable output long-run relationship) presented as ($trad_t$ + 0.589*aid_t - 0.722*gdp_t + 1.069*Ds95 - 0.057*$trend$). To decrease the growth rate for non-tradable goods price, thus either foreign aid should decrease, or GDP should increase, or both.

5.8.2.1- The VECM Impulse Response Functions

Figure 5.4 presents the impulse responses of the VECM model presented in (5.35). In the Cholesky decomposition, the shocks are orthogonalized in the following order: the log of tradable output (*trad*), the log of foreign aid (*aid*), the log of GDP (*gdp*), the log of tradable goods price (P^T), and the log of non-tradable goods price (P^{NT}). The results closely reflect the predictions of the calibrated DSGE-RBC model as I observe the following. First, a positive one-standard-deviation of the aid shock results in tradable goods price depreciation and in non-tradable goods price appreciation. Consequently, there is a decline in the tradable output followed by a decline in total GDP. This is exactly what happens in the responses for the relative price of non-tradable goods, the tradable output, and the total output in the two-sector DSGE-RBC model.

Second, a positive one-standard-deviation of the GDP shock results in an increase in the tradable output, an appreciation in tradable goods price, and a depreciation in non-tradable goods price. This is also consistent with the impulse responses of the productivity shock in the two-sector DSGE-RBC model. Third, the impulse responses of the tradable output and GDP act differently to the shocks of the tradable and non-tradable goods prices. For instance, a positive one-standard-deviation of the tradable price shock has a positive impact on the tradable output as well as on GDP.

---

[170] The incorrect sign cannot be interpreted as divergence from equilibrium as the P^{NT} is not entered in the error correction term. See the impulse response functions for the P^{NT}; no IRF is diverging (Figure 5.4).

Whereas, a positive one-standard-deviation of non-tradable price has a negative impact on the tradable output and GDP. The observed “Dutch Disease” phenomenon features that are found in the VECM is consistent with the theoretical specifications included in the two-sector DSGE-RBC model in the short-run. The VECM results here do not contradict the CVAR results presented in Chapter 3 for Kenya for the following reasons. First, VECM impulse response functions show the short-run effects of aid on the variables, while the CVAR model shows the effects of the cumulated shock of foreign aid on the variables. Second, the CVAR model shows that there is only a transitory effect on tradable price (negative, but not significant) and on non-tradable price (positive, but not significant) which matches the behavior of the VECM impulse response functions for the prices. Third, VECM impulse response functions and CVAR results coincide on the negative impact of aid on the tradable output and GDP.

5.9- Conclusion

This chapter uses a dynamic stochastic general equilibrium model to evaluate the effectiveness of foreign aid and its volatility on the economy. I study the business cycle implications on GDP’s composition, the relative price of non-tradable goods, private human capital investment, study hours, and working hours, in addition to consumption and physical capital investment. In an attempt to understand the role of foreign aid on the macro economy in a context of “Dutch Disease”, I extend the one-sector DSGE-RBC model into two-sector DSGE-RBC model. I use it to investigate the interaction between foreign aid and economic activities incorporating the role of the “Dutch Disease” mechanism. The calibrated model is able to replicate the major macroeconomic key relationships observed in the Kenyan data.

The analysis yields several results, first of all, a positive aid shock has a positive effect on the relative price of non-tradable goods. The relative price of non-tradable good appreciation reallocates the available resources from the human capital intensive tradable sector to the physical capital intensive non-tradable sector, causing the former sector to shrink. The model suggests that a 1% increase of aid-to-GDP level is associated with a 0.7% decrease in tradable output-to-GDP level. A consequential result is a reduction in tradable labor, tradable human capital, and tradable physical capital. The reduction in the human capital intensive tradable sector has a negative implication on the return for education. On the other hand, there is an increase in non-tradable labor, non-tradable human capital, and non-tradable physical capital.

Second, the effect of foreign aid injections depends on the magnitude of the persistence level of the aid shock. In the benchmark model, an aid shock has a positive impact on private human capital investment and study time. However, increasing the aid shock persistence level (to 0.90 and up), the positive income effect of aid reduces the representative agent's incentive to invest in human capital and decreases the time devoted to acquire new skills (below the steady state) compared to the benchmark model. The representative agent adjusts his investment decision to acquire human capital in response to a shock of foreign aid to achieve his utility maximization objectives. The more temporary the aid shock, the higher the agent's incentives to invest in human capital and time devoted to study and vice versa.

Third, lowering the volatility of foreign aid to half, would have a positive implication on private human capital investment and time devoted to study. Decreasing the volatility of aid is equivalent to lowering aid level. This result suggests that the donors should focus on lowering the volatility of aid rather than just the level of aid. Fourth, the marginal productivity of study hours is positively affected by the TFP, public human capital, and government expenditure shocks, while it is negatively affected by an aid shock. Fifth, as foreign aid increases, aid becomes an increasingly dominant influence on the macro economy. At a higher aid-to-GDP level, the representative agent enjoys more leisure time at the expense of reducing total labor working and studying times.

Finally, I have used an empirical VECM analysis to determine how well the theoretical two-sector DSGE-RBC model does in matching the observed facts in the Kenyan economy that receive a substantial amount of foreign aid. I find that foreign aid has a negative implication on the tradable output as well as on the total output. In addition, I find evidence of "Dutch Disease" resulting from aid injections; aid injections result in a depreciation of tradable goods price and an appreciation in non-tradable goods price in the short-run. The VECM results suggest that the aid level should decrease to Kenya as non-tradable goods price diverges from its long-run equilibrium.

Table 5.1: Calibration for the benchmark model

Parameters		value	Source
Tradable Physical capital share	α	0.35	Kenyan data
Non-tradable physical capital share	θ	0.45	Kenyan data
Schooling time share in human capital production	η_1	0.7	Calibrated
Private human capital share in human capital production	η_2	0.1	Calibrated
Discount factor	β	0.95	Arellano et. al (2009
Weight of leisure	γ	1.45	Calibrated
Cost adjustment parameter	Φ	3	GPU ***
Physical capital depreciation rate	δ_k	0.05	Arellano et. al (2009
Human capital depreciation rate	δ_h	0.035	JF**
Coefficient used to determine elasticity of substitution	μ	0.316	Ostry & Reinhart*
Coefficient used to determine elasticity of sub. in Ph. cap function	υ_k	-11	Mendoza & Uribe*
Coefficient used to determine elasticity of sub. in H. cap function	υ_h	-2.2	Cardi & Restout*
Weight of tradable consumption in CES function	ω	0.24	Calibrated
Autocorrelation coefficient of productivity in tradable sector	ρ^T	0.81	RBC Standard
Autocorrelation coefficient of productivity in non-tradable sector	ρ^N	0.81	RBC Standard
Autocorrelation coefficient of foreign aid inflow	ρ^f	0.71	Kenyan Data
Autocorrelation coefficient of Gov. human capital investment	ρ^{gh}	0.81	RBC Standard
Autocorrelation coefficient of government expenditure	ρ^g	0.81	RBC Standard
Correlation between aid and TFP shocks	ρ^{fN}, ρ^{fT}	0.50	Calibrated
Correlation between aid and government expenditures	ρ^{fg}	0.25	Calibrated
Tradable sector technology	A^T	1	Normalized
Non-tradable sector technology	A^N	1.61	Calibrated
Human capital technology	A^h	1	Normalized
Public human capital parameter	I^{gh}	0.277	Calibrated
Government expenditure parameter	Gv	0.585	Calibrated
Foreign aid parameter	F	0.153	Calibrated
Standard deviation of productivity shocks in tradable sector	σ^T	0.0473	Calibrated
Standard deviation of productivity shocks in tradable sector	σ^N	0.0473	Calibrated
Standard deviation of public human capital shock	σ^{gh}	0.1055	Calibrated
Standard deviation of government expenditure shock	σ^g	0.092	Calibrated
Standard deviation of foreign aid shock	σ^f	0.248	Kenyan Data

(***) García-Cicco et al. (2010): 95% confidence interval < 4.9 with median 3.3; (**) Jorgenson and Fraumeni (1989); (*) Ostry and Reinhart (1992), Mendoza and Uribe (2000), Cardi and Restout (2015);

Table 5.2A: Data and the references of the benchmark model (Means)

Targeted Means	Kenyan Data	Benchmark Model	Model A
Tradable output-to-GDP	0.3808	0.3830	0.3830
Non-tradable output-to-GDP	0.6192	0.6170	0.6170
Non-tradable-to-tradable output	1.6420	1.6229	1.6229
Government human capital investment-to-GDP	0.0538	0.0539	0.0539
Government human capital investment-to-income	0.0506	0.0509	0.0509
Private human capital investment-to-GDP	0.0234	0.0235	0.0235
Private human capital investment-to-income	0.0221	0.0222	0.0222
Private human capital-to-consumption	0.0340	0.0352	0.0352
Government expenditure-to-GDP	0.1131	0.1143	0.1143
Government expenditure-to-income	0.1065	0.1080	0.1080
Aid-to-GDP	0.0585	0.0585	0.0585
Other Means			
Consumption-to-GDP	0.6643	0.6672	0.6672
Consumption-to-income	0.6255	0.6305	0.6305
Physical capital investment-to-GDP	0.2075	0.1996	0.1996
Physical capital investment-to-Income	0.1955	0.1884	0.1884
Working Time	NA	0.3422	0.3422

Table 5.2B: Data and the references of the benchmark model

Standard Deviations			
GDP	0.0434	0.0434	0.0434
Tradable output	0.0251	0.0781	0.0829
Non-tradable output	0.0616	0.0273	0.0243
Relative price of non-tradable goods	0.0606	0.0043	0.0048
Consumption	0.0495	0.0356	0.0321
Physical capital investment	0.1079	0.1384	0.1263
Private human capital investment	NA	0.1059	0.1046
Exogenous Variables			
Government expenditure	0.0794	0.0794	0.0790
Public human capital investment	0.0892	0.0894	0.0898
Aid	0.2235	0.2027	0.1988

All series are filtered with one sided HP filter with λ =100; Income = GDP + aid; the variables are calculated in terms of tradable goods in data and models; GDP = $Y^T + P^N Y^N$

Table 5.2C: Data and the references benchmark model

Correlations with GDP			
Tradable output	0.6368	0.96	0.97
Non-tradable output	0.9783	0.87	0.84
Relative price of non-tradable goods	0.7438	-0.69	-0.74
Consumption	0.7179	0.95	0.91
Physical capital investment	0.6626	0.95	0.93
Private human capital investment	NA	0.15	0.10

Table 5.2D: Data and the references of benchmark model

Correlations with Aid			
GDP	0.6145	0.46	-0.06
Tradable output	0.2388	0.30	-0.18
Non-tradable output	0.6402	0.65	0.22
Relative price of non-tradable goods	0.4764	-0.08	0.20
Consumption	0.2784	0.55	0.20
Physical capital investment	0.4789	0.57	0.16
Government expenditure	0.2503	0.25	0.02
Private human capital investment	NA	0.19	0.08

Table 5.2E: Data and the references of the benchmark model

Correlations with public human capital			
GDP	0.3554	-0.14	-0.14
Tradable output	0.4893	-0.24	-0.23
Non-tradable output	0.7191	0.06	0.08
Relative price of non-tradable goods	0.5261	0.19	0.19
Consumption	0.5052	-0.25	-0.27
Physical capital investment	0.4659	-0.28	-0.31
Private human capital investment	NA	0.94	0.95

Table 5.2F: Data and the references of the benchmark model

Correlations with government expenditure			
GDP	0.5759	0.08	0.09
Tradable output	0.3939	-0.14	-0.10
Non-tradable output	0.5700	0.47	0.48
Relative price of non-tradable goods	0.5088	0.50	0.44
Consumption	0.3685	-0.09	-0.16
Physical capital investment	0.4051	-0.02	-0.06
Private human capital investment	NA	0.01	-0.02

All series are filtered with one sided HP filter with λ =100; Income = GDP + aid; the variables are calculated in terms of tradable goods in data and models; GDP = $Y^T + P^N Y^N$

Table 5.3: Foreign aid sensitivity simulations

	Benchmark	Aid-to-GDP percentage is equal to			
Means	Model	0%	12%	18%	24%
Tradable output-to-GDP	0.3830	0.4250	0.3388	0.2961	0.2530
Non-tradable output-to GDP	0.6170	0.5750	0.6612	0.7039	0.7470
Non-tradable-to-tradable output	1.6229	1.3616	1.9718	2.4180	3.0372
Consumption-to-GDP	0.6672	0.6222	0.7143	0.7603	0.8051
Consumption-to-income	0.6305	0.6222	0.6380	0.6446	0.6500
Tradable consumption-to-GDP	0.2185	0.2041	0.2334	0.2480	0.2622
Relative price of non-tradable goods	0.5360	0.5298	0.5423	0.5482	0.5543
Physical capital investment-to-GDP	0.1996	0.1973	0.2022	0.2052	0.2076
Physical capital investment-to-income	0.1884	0.1973	0.1800	0.1731	0.1663
Private human capital investment-to-GDP	0.0235	0.0236	0.0233	0.0231	0.0230
Private human capital investment-to-income	0.0222	0.0236	0.0208	0.0196	0.0186
Tradable labor hours	0.1449	0.1666	0.1237	0.1047	0.0868
Non-tradable labor hours	0.1973	0.1905	0.2039	0.2099	0.2158
Total labor hours	0.3422	0.3571	0.3276	0.3146	0.3026
Study hours	0.0953	0.0994	0.0914	0.0877	0.0846
Tradable-to-non-tradable physical capital	0.9359	0.9509	0.9196	0.9031	0.8851
Tradable-to-non-tradable human capital	0.8693	0.9412	0.7967	0.7281	0.6595
Standard deviations					
GDP	0.0434	0.0429	0.0441	0.0449	0.0457
Aid	0.2027	NA	0.2027	0.2027	0.2027
Tradable output	0.0781	0.0764	0.0956	0.0982	0.1221
Non-tradable output	0.0273	0.0250	0.0297	0.0324	0.0353
Consumption	0.0356	0.0335	0.0382	0.0408	0.0440
Physical capital investment	0.1384	0.1309	0.1475	0.1568	0.1677
Private human capital investment	0.1059	0.1028	0.1098	0.1136	0.1179
Tradable labor hours	0.0468	0.0433	0.0589	0.0803	0.1122
Non-tradable labor hours	0.0199	0.0196	0.0199	0.0204	0.0206
Study hours	0.0985	0.0969	0.1009	0.1032	0.1056
Tradable physical capital	0.0152	0.0143	0.0165	0.0183	0.0210
Non-tradable physical capital	0.0152	0.0147	0.0161	0.0171	0.0181
Tradable human capital	0.0199	0.0178	0.0246	0.0320	0.0440
Non-tradable human capital	0.0135	0.00143	0.0144	0.0158	0.0177
Relative price of non-tradable goods	0.0043	0.0044	0.0046	0.0054	0.0062

Table 5.4: Impacts of changing aid's volatility

Variable's Mean	Aid Volatility						
	Benchmark Model	0%	% change	10%	% change	40%	% change
GDP	2.82157	2.86014	1.37%	2.82738	0.21%	2.79731	-0.86%
Tradable output	1.08762	1.11372	2.40%	1.09577	0.75%	1.05609	-2.90%
Non-tradable output	1.73395	1.74642	0.72%	1.73161	-0.14%	1.74122	0.42%
Relative price	0.53605	0.5356	-0.08%	0.53584	-0.04%	0.53696	0.17%
Consumption	1.88194	1.90105	1.02%	1.87877	-0.17%	1.8913	0.50%
Physical capital investment	0.57132	0.57697	0.99%	0.57134	0.01%	0.56962	-0.30%
Private human cap. investment	0.06601	0.06708	1.63%	0.0661	0.13%	0.06553	-0.72%
Study hours	0.09535	0.09566	0.32%	0.0955	0.15%	0.09474	-0.64%
Tradable working hours	0.14491	0.14639	1.02%	0.14587	0.67%	0.14114	-2.60%
Non-tradable working hours	0.1973	0.19637	-0.47%	0.19704	-0.13%	0.19838	0.55%

Table 5.5: Variance decomposition

	Shocks							
	aid-to-GDP = 5.85%				aid-to-GDP = 24%			
	tfp	*aid*	*gov hcap*	*gov*	*tfp*	*aid*	*gov hcap*	*gov*
GDP	95.56	0.21	3.16	1.07	88.87	6.29	3.13	1.71
Tradable output	87.81	4.49	7.11	0.59	35.6	57.57	6.08	0.75
Non-tradable output	73.96	7.69	1.23	17.13	59.8	29.47	0.8	9.93
Consumption	90.72	1.2	6.32	1.75	77.53	17.35	3.81	1.32
Physical capital investment	89.5	0.96	9.36	0.18	82.16	12.4	5.31	0.14
Private human capital investment	9.6	0.33	89.9	0.17	14.55	4.55	80.78	0.12
Tradable labor hours	60.93	15.22	23	0.85	8.43	83.12	7.85	0.59
Non-tradable labor hours	49.63	8.22	0.11	42.04	36.82	23.21	0.04	39.93
Study hours	0.15	0.2	99.58	0.07	0.41	2.42	97.13	0.04
Relative price of non-tradable goods	61.44	12.47	5.74	20.34	24.1	61.88	3.17	10.84
Tradable physical capital	86.51	2.73	9.97	0.79	60.7	33.74	4.78	0.78
Non-tradable physical capital	88.83	0.94	9.82	0.41	82.11	11.28	6.33	0.28
Tradable human capital	49.4	11.28	33.68	5.64	11.73	72.31	13.24	2.73
Non-tradable human capital	57.08	12.69	23.57	6.66	11.96	72.19	12.99	2.86

Table 5.6: The benchmark model and the shocks

	Shocks				
	Model	*tfp*	*aid*	*gov hcap*	*gov*
Standard Deviation					
GDP	0.0434	0.0427	0.0038	0.0084	0.0046
Tradable output	0.0781	0.0690	0.0172	0.0211	0.0063
Non-tradable output	0.0273	0.0210	0.0048	0.0037	0.0114
Consumption	0.0356	0.0307	0.0061	0.0092	0.0047
Private human capital investment	0.1059	0.0297	0.0090	0.0996	0.0046
Physical capital investment	0.1384	0.1207	0.0179	0.0418	0.0061
Relative price of non-tradable good	0.0043	0.0040	0.0011	0.0013	0.0020
Tradable labor	0.0469	0.0461	0.0198	0.0220	0.0045
Non-tradable labor	0.0199	0.0149	0.0020	0.0009	0.0132
Study hours	0.0985	0.0065	0.0063	0.0975	0.0029
Correlations with GDP					
Tradable output	0.96	0.99	0.99	0.96	-0.99
Non-tradable output	0.87	0.99	-0.94	0.24	0.99
Consumption	0.95	0.99	-0.93	0.92	-0.99
Private human capital investment	0.15	0.99	-0.97	-0.75	-0.99
Physical capital investment	0.95	0.99	-0.98	0.93	-0.99
Relative price of non-tradable good	-0.69	-0.97	-0.99	0.05	0.99
Tradable labor	0.86	0.98	0.98	0.89	-0.99
Non-tradable labor	-0.62	-0.99	-0.99	0.27	0.99
Study hours	-0.20	-0.99	-0.99	-0.78	-0.99

Correlations with aid					
GDP	0.46	NA	-0.94	NA	NA
Tradable output	0.30	NA	-0.96	NA	NA
Non-tradable output	0.65	NA	0.96	NA	NA
Consumption	0.55	NA	0.95	NA	NA
Private human capital investment	0.19	NA	0.93	NA	NA
Physical capital investment	0.57	NA	0.94	NA	NA
Relative price of non-tradable good	-0.08	NA	0.95	NA	NA
Tradable labor	0.08	NA	-0.96	NA	NA
Non-tradable labor	-0.11	NA	0.97	NA	NA
Study hours	0.01	NA	0.92	NA	NA

Table 5.6: continued

Correlations with public human capital					
Tradable output	-0.24	NA	NA	-0.84	NA
Non-tradable output	0.06	NA	NA	0.52	NA
Consumption	-0.25	NA	NA	-0.90	NA
Private human capital investment	0.94	NA	NA	0.99	NA
Physical capital investment	-0.28	NA	NA	-0.88	NA
Relative price of non-tradable good	0.19	NA	NA	0.65	NA
Tradable labor	-0.44	NA	NA	-0.92	NA
Non-tradable labor	-0.02	NA	NA	-0.69	NA
Study hours	0.98	NA	NA	0.99	NA
Correlations with government					
Tradable output	-0.14	NA	NA	NA	-0.98
Non-tradable output	0.47	NA	NA	NA	0.99
Consumption	-0.09	NA	NA	NA	-0.99
Private human capital investment	0.01	NA	NA	NA	-0.97
Physical capital investment	-0.02	NA	NA	NA	-0.97
Relative price of non-tradable good	0.50	NA	NA	NA	0.99
Tradable labor	-0.22	NA	NA	NA	-0.97
Non-tradable labor	0.70	NA	NA	NA	0.99
Study hours	0.01	NA	NA	NA	-0.94

Table 5.7: VECM Results

Variable	Equation 1 Δaid	Equation 2 Δgdp	Equation 3 $\Delta trad$	Equation 4 ΔP^{T}	Equation 5 ΔP^{NT}
Constant	11.916	1.361	0.898	0.150	-1.859
	(3.867)***	(3.056)***	(1.607)	(0.121)	(-2.522)**
Dtr70	-0.135	-0.118	-0.120	0.129	0.105
	(-0.970)	(-5.902)***	(-4.741)***	(2.293)**	(3.166)***
Dp75	-0.169	-0.046	0.011	-0.066	0.110
	(-0.850)	(-1.617)	(0.312)	(-0.818)	(2.308)**
Dp96	-0.074	0.044	0.037	0.387	0.122
	(-0.323)	(1.339)	(0.904)	(4.180)***	(2.225)**
ECT(-1)	-0.575	-0.064	-0.042	-0.003	0.095
	(-3.846)***	(-2.954)***	(-1.544)	(-0.048)	(2.634)**

t-Statistics in parenthesis; ***,**,* significant at 1, 5, and 10%, respectively

F-Stat for Dtr70 = 7.856 with p-value = 0.000; F-Stat for Dp95 = 4.227 with p-value = 0.003;

F-Stat for Dp96 = 5.291 with p-value = 0.001.

Figure 5.1: Impulse responses to a positive one-standard-deviation foreign aid shock

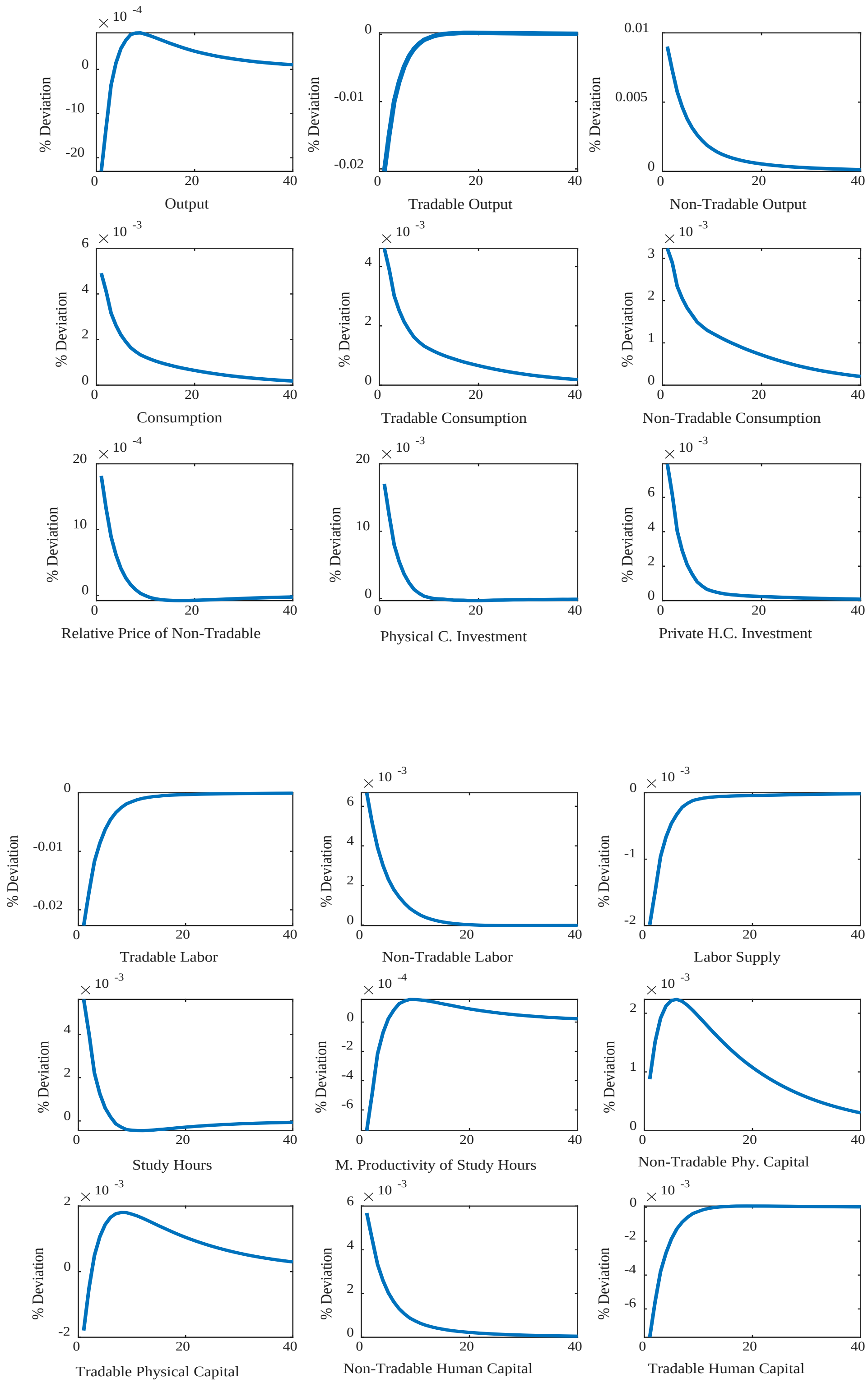


Figure 5.2: Impulse responses to a positive one-standard-deviation public human capital shock

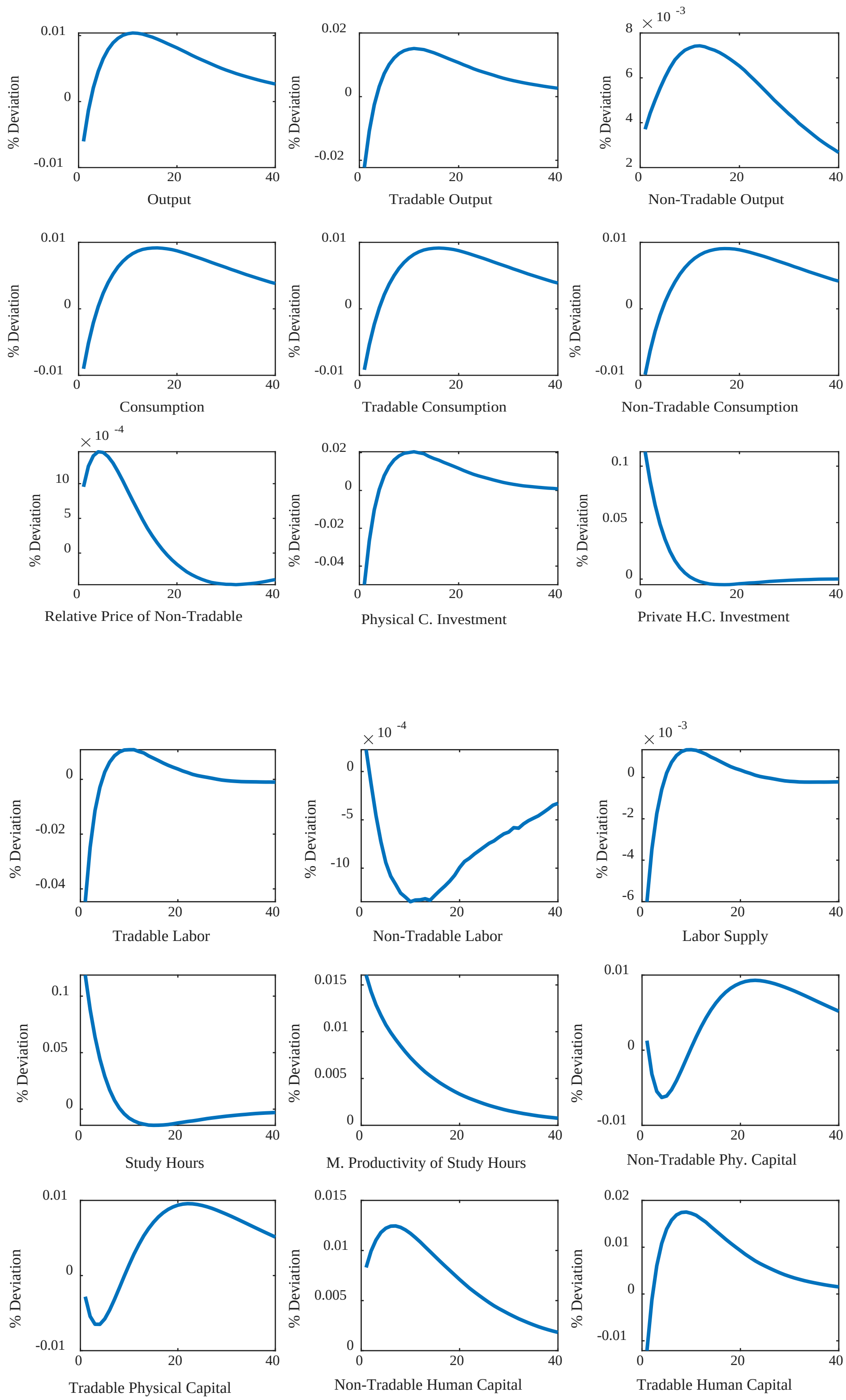
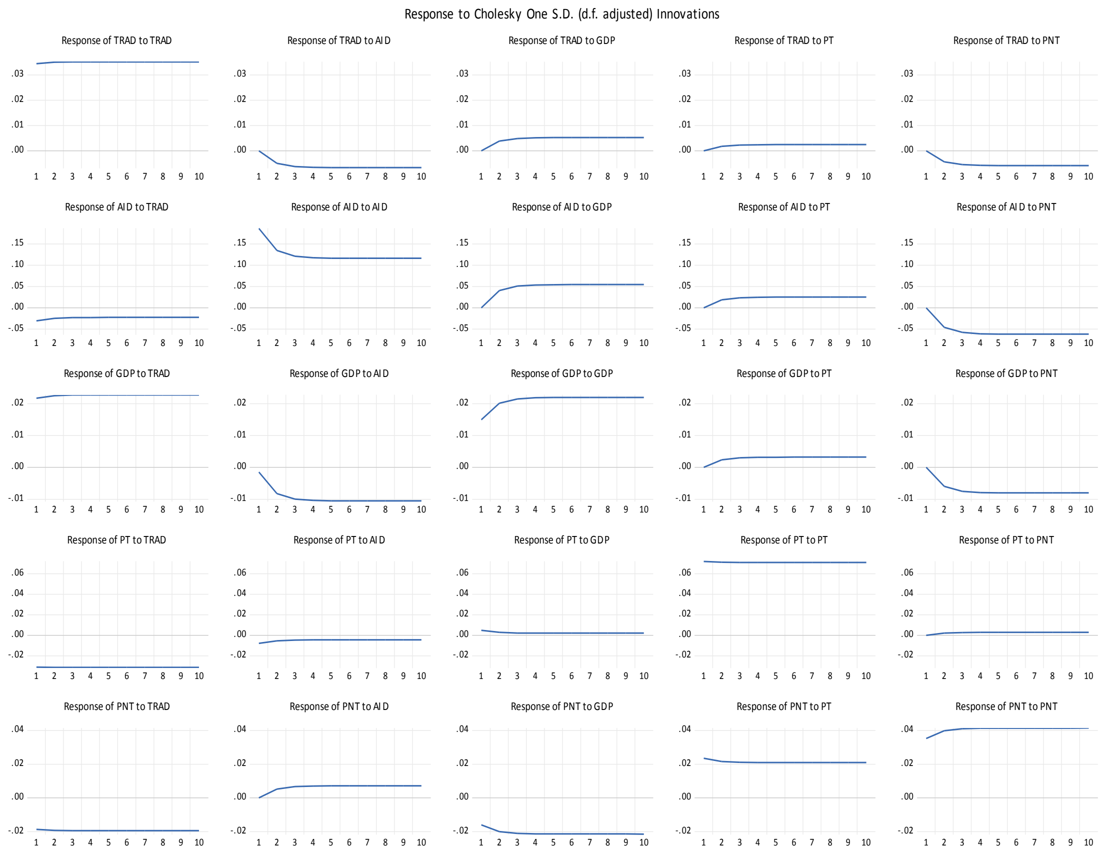


Figure 5.3: Sensitivity analysis for aid impact on selected variables at different aid shock persistence levels

Figure 5.4: The VECM impulse response functions



Chapter 6

Conclusion

This dissertation investigated the effect of foreign aid on the economies of 22 sub-Saharan countries. In particular, I examined the impact of foreign aid on GDP, tradable and non-tradable outputs, private human capital investment, and time devoted to acquire new skills. The analysis employed both empirical estimation methods as well as simulations of calibrated theoretical models. Though the analyses based on these different methodological approaches stand on their own, they together shed more light on the effects of foreign aid. This conclusion briefly highlights the main findings of the dissertation, particularly from the perspective of policy.

The empirical estimation analysis was developed in Chapter 3. A cointegrated vector autoregressive analysis (CVAR) was used to estimate the long-run impact of foreign aid on GDP and its components tradable and non-tradable outputs, for 22 sub-Saharan African countries. The CVAR methodology used in the study made it possible to identify the long-run effects, without imposing strong statistical priors. Examining tradable and non-tradable sectors made it possible to identify the key mechanism behind the so-called "Dutch Disease". My empirical analysis used a CVAR approach for each country individually, after taking into consideration extraordinary events. The results suggested that a positive shock to foreign aid had a negative and persistent impact on GDP in eight SSA countries, on the tradable output in 16 SSA countries, and on the non-tradable output in five SSA countries. In addition, I found that a positive shock to foreign aid had a positive and persistent impact on GDP in only three SSA countries, on the tradable output in four SSA countries, and on the non-tradable output in six SSA countries. However, the shrinkage in GDP and in the tradable output was not linked to the "Dutch Disease" mechanism. I could not find evidence that an aid shock caused tradable goods price to depreciate and non-tradable goods price to appreciate in the long-run.

The analyses using theoretical dynamic stochastic general equilibrium — real business cycle — (DSGE-RBC) models were developed in Chapters 4 and 5. These models were calibrated to match the Kenyan economy for the 1970–2014 period. Chapter 4 developed a one-sector DSGE-RBC model, which distinguishes between physical and human capital and allows for labor-leisure choice. In this model, initially, a positive shock to foreign aid had a negative impact on labor supply and output. However, due to the positive income effect, it had a positive effect on physical and human capital investment and time spent studying. Thus, labor productivity and output increase in subsequent periods. In addition, lowering the volatility of aid had a positive and significant impact on human capital investment, time devoted to study, and welfare.

To investigate the role of foreign aid on the GDP's composition through the "Dutch Disease" mechanism, I extended the one-sector DSGE-RBC model into a two-sector DSGE-RBC model that has a tradable goods sector and a non-tradable goods sector. In Chapter 5, I examined the business cycle implications of foreign aid on the relative price of non-tradable goods, GDP's composition, private human capital investment, and time devoted to acquire skills. A positive shock to foreign aid had a positive effect on the relative price of non-tradable goods, leading to a reallocation of resources from the tradable to non-tradable sector, causing the tradable output and GDP to shrink. This finding is consistent with the "Dutch Disease" phenomenon. Moreover, I found that a positive shock to foreign aid raises private human capital and physical capital investment as well as time devoted to study. Thus, over time labor productivity increases, leading to an increase in total production. Further, decreasing the volatility of aid increased private human capital investment and study hours, suggesting that policymakers should focus on reducing the volatility of foreign aid and not only focus on the level of aid. Finally, a vector error correction model (VECM) analysis provided results that are consistent with the dynamics of the DSGE-RBC model.

The main results of the empirical estimation suggest that foreign aid had not been beneficial in the long-run to the tradable sector as well as to the total output in the majority of SSA countries under study. However, in the theoretical analysis, a shock to foreign aid had a positive impact on human capital accumulation as it increased investment in human capital and time devoted to acquire new skills. Hence, labor productivity increases, leading to an increase in total production over time. From a policy perspective point of view, DSGE-RBC models suggest that donors should first focus on decreasing the volatility of aid, before considering decreasing the mean level of foreign aid. If the donors provide aid in a predictable pattern, there would be a significant positive effect on human capital accumulation and welfare.

In future research, I would like to extend my empirical work and identify the mechanisms behind the shrinkage of the tradable sector in SSA countries. To do this, I need to integrate other mechanisms into the model. For example, food aid may be differentially impacting the agricultural sector. Including other dimensions such as trade flows (imports and exports) and monetary variables would generalize the analysis and make it more comparable with the literature. In addition, I would like to investigate in more depth the reasons behind the positive impact of foreign aid on the tradable sector in the four SSA countries.

Regarding extensions to the calibrated DSGE-RBC model, I would like to incorporate the role of the Central Bank in mitigating the appreciation of the real exchange rate as well as the role of the government debt and its effect on growth. Further, I would like to investigate the impact of foreign aid and its volatility on educational attainment, enrollment, and health outcomes in developing countries.

References

Acosta, P., Lartey, E., and Mandelman, F. (2009). Remittances and the Dutch Disease. *Journal of International Economics*, 79, 102-116.

Adam, C., and Bevan, D. (2006). Aid and the Supply Side: Public Investment, Export Performance, and Dutch Disease in Low-Income Countries. Economics Series Working Papers 201, University of Oxford, Department of Economics.

Addison, T., and Baliamoune-Lutz, M. (2013). Aid and Dutch Disease: Evidence from Moroccan and Tunisian Time-Series Data. WIDER Working Paper Series 132, World Institute for Development Economic Research (UNU-WIDER).

African Development Report (2015). Growth, Poverty and Inequality Nexus: Overcoming Barriers to Sustainable Development. African Development Bank, Côte d'Ivoire, 148.

Aghion, P., Caroli, E., and García-Peñalosa, C. (1999). Inequality and Economic Growth: The Perspective of the New Growth Theories. *Journal of Economic Literature*, 37, 1615-1660.

Aguiar, M., and Gopinath, G. (2007). Emerging Market Business Cycles: The Cycle is the Trend. *Journal of Political Economy*, 115 (1), 69-102.

Anderson, E., and Waddington, H. (2007). Aid and the Millennium Development Goal Poverty Target: How Much is Required and How Should it be Allocated?. *Oxford Development Studies*, 35(1), 1-31.

Andrews, D., and Zivot, E. (1992). Further Evidence on the Great Crash, the Oil-Price Shock, and the Unit-Root Hypothesis. *Journal of Business & Economic Statistics*, 10 (3), 251-270.

Annen, K., and Kosempel, S. (2012). On the Effectiveness of Foreign Aid: A DSGE Approach. Department of Economics and Finance, Working Paper, University of Guelf.

Annen, K., Batu, M., and Kosempel, S. (2016). Macroeconomic Effects of Foreign Aid and Remittances: Implications for Aid Effectiveness Studies. *Journal of Policy Modeling*, 38, 1136-1146.

Arellano, C., Bulíř, A., Lane, T., and Lipschitz, L. (2009). The Dynamic Implications of Foreign Aid and Its Variability. *Journal of Development Economics*, 88, 87-102.

Arndt C., Jones, S., and Tarp, F. (2010). Aid, Growth, and Development Have We Come Full Circle?. WIDER Working Paper Series 096, World Institute for Development Economic Research (UNU-WIDER).

Arndt C., Jones, S., and Tarp, F. (2015). Assessing Foreign Aid's Long-Run Contribution to Growth in Development. *World Development*, Elsevier, 69(C), 6-18.

Arratibel, O., Rodriguez-Palenzuela, D., and Thimann, C. (2002). Inflation Dynamics and Dual Inflation in Accession Countries: A "New Keynesian" Perspective. Working Paper Series 0132, European Central Bank.

Asea, P., and Mendoza, E. (1994). The Balassa-Samuelson Model: A General Equilibrium Appraisal. *Review of International Economics*, 2(3), 244-267.

Backus, D.K., Kehoe, P.J., Kydland, F. (1995). International Business Cycles: Theory and Evidence. In Cooley, T.F. (Ed.), *Frontiers of Business Cycle Research. Princeton University Press*, 331-356.

Banful, A. (2011). Old Problems in the New Solutions?. Politically Motivated Allocation of Program Benefits and the “New” Fertilizer Subsidies. *World Development,* 39(7), 1166-1176.

Barro, R. (1991). Economic Growth in a Cross Section of Countries. *The Quarterly Journal of Economics*, 106 (2), 407-44.

Barro, R. (1997). *Determinants of Economic Growth: A Cross-Country Empirical Study*. MIT Press, Cambridge, Massachusetts.

Barro, R. (2001). Human Capital and Growth. *American Economic Review*, 91 (2), 12-17.

Barro, R., and Lee, L. (2013). A New Data Set of Educational Attainment in the World, 1950–2010. *Journal of Development Economics*, 104, 184-198.

Batu, M. (2015). International Worker Remittances and Human Capital Formation across Countries. Department of Economics and Finance, University of Guelph.

Bauer, P., and Yamey, B. (1982). Foreign Aid: What is at Stake?. Reprinted in Meier, G.M. (ed.) (1984) Leading Issues in Economic Development, Fourth Edition. Stanford, CA: Stanford University.

Becker, G. (1962). Investment in Human Capital: A Theoretical Analysis. *Journal of Political Economy*, 70, 9-49.

Becker, G., and Chiswick, B. (1966). Education and the Distribution of Earnings. *American Economic Review*, 56, 358-369.

Berthelemy, J. (2006). Bilateral Donors’ Interest vs. Recipients’ Development Motives in Aid Allocation: Do all Donors Behave the Same?. *Review of development Economics*, 10(2), 179-197.

Betts, J., and McFarland, L. (1995). Safe Port in a Storm: The Impact of Labor Market Conditions on Community College Enrollments. *Journal of Human Resources*, 30, 741–765.

Bigsten, A., Kimuyu, P., and Söderbom, M. (2010). Chapter 10: The Manufacturing Sector. forthcoming in (ed.) C. Adam, P. Collier and N. Ndung’u, Kenya: Policies for Prosperity. *Oxford University Press* and Central Bank of Kenya.

Birchler, K., and Michaelowa, K. (2016). Making Aid Work for Education in Developing Countries: An Analysis of Aid Effectiveness for Primary Education Coverage and Quality. *International Journal of Educational Development*, 48, 37-52.

Birdsall, N., Rodrik, D., and Subramanian, A. (2005). How to Help Poor Countries. *Foreign Affairs*, 84(4): 136-52.

Birdsall, N., Pinckney, T., and Sabot, R. (2001). Natural Resources, Human Capital, and Growth. In R.M. Auty (Ed.), *Resource Abundance and Economic Growth,* Oxford University Press, pp. 57-75.

Boone, P. (1994). The Impact of Foreign Aid on Savings and Growth. Centre for Economic Performance Working Paper No. 677.

Boone, P. (1996). Politics and the Effectiveness of Foreign Aid. *European Economic Review*, 40, 289-329.

Bourguignon, F., and Sundberg, M. (2007). Aid Effectiveness - Opening the Black Box. *AEA Papers and Proceedings*, 97(2), 316–21.

Brautigam, D. (2000). *Aid Dependence and Governance*. Stockholm: Almqvist and Wiksell International.

Brumm, H. (2003). Aid, Policies and Growth: Bauer was Right. *Cato Journal*, 23, 167–74.

Bulíř, A., and Hamann, J. (2003). Aid Volatility: An Empirical Assessment. IMF Staff Papers, 50(1), 64-89.

Bulíř, A., and Hamann, J. (2008). Volatility of Development Aid: From the Frying Pan into the Fire?. *World Development*, 36 (10), pp. 2048-2066.

Bulíř, A., and Lane, T. (2004). Aid and fiscal Management. IMF Working Paper No. 02/112.

Burhop, C. (2005). Foreign Assistance and Economic Development: A re-Evaluation. *Economic Letters*, 86, 57-61.

Burnside, C., and Dollar, D. (2000). Aid, Policies and Growth. *American Economic Review*, 90(4), 847-868.

Cardi, O., and Restout, R. (2015). Imperfect Mobility of Labor across Sectors: A Reappraisal of the Balassa–Samuelson Effect. *Journal of International Economics*, 97(2), 249-265.

Celasun, O., and Walliser, J. (2008). Predictability of Aid: Do Fickle Donors Undermine Aid Effectiveness?. *Economic Policy*, 55, 546–94.

Chatterjee, S., Giuliano, P., and Kaya, I. (2012). Where has all the Money Gone?. Foreign Aid and the Composition of Government Spending. *The B.E. Journal of Macroeconomics Contributions*, 12(1), article 26.

Chauvet, L., and Guillaumont, P. (2001). Aid and Performance: A Reassessment. *Journal of Development Studies*, 37(6), 66–92.

Chauvet, L., and Guillaumont, P. (2003). Aid and Growth Revisited: Policy, Economic Vulnerability and Political Instability. Working Papers 200327, CERDI.

Chauvet, L., and Guillaumont, P. (2009). Aid, Volatility, and Growth Again: When Aid Volatility Matters and when it does not. *Review of Development Economics*, 13(3), 452-463.

Chinn, M., and Johnson, L. (1997). Real Exchange Rate Levels, Productivity and Demand Shocks: Evidence from a Panel of 14 Countries. IMF Working Paper 1997/66.

Ciccone, A. (2000). Business Cycles and Investment in Human Capital: International Evidence on Higher Education: A Comment. *Carnegie-Rochester Conference Series on Public Policy*, 52, 257-262.

Colclough, C., and Otieno, W. (2010). Financing Education in Kenya: Expenditures, Outcomes and the Role of International Aid. Kenyatta University and University of Cambridge.

Collier, P., and Dollar, D. (2001). Can the World Cut Poverty in Half?. How policy Reform and Effective Aid Can Meet International Development Goals. *World Development*, 29(11), 1787-1802.

Collier, P., and Dollar, D. (2002). Aid Allocation and Poverty Reduction. *European Economic Review*, 46(8), 1475-1500.

Collier, P., and Hoeffler, A. (2004). Aid, Policy and Growth in Post-Conflict Societies. *European Economic Review*, 48(5), 1125–45.

Corden W., and Neary, J. (1982). Booming Sector and De-industrialisation in a Small Open Economy. *The Economic Journal*, 92, 825-48.

Corden, W. (1984). Booming Sector and "Dutch Disease" Economics: Survey and Consolidation. *Oxford Economic Papers*, 36, 359-380.

Crawford, E., Jayne, T., and Kelly, V. (2006). Alternative Approaches for Promoting Fertilizer Use in Africa. Agriculture and Rural Development Discussion Paper 22, Washington D.C., The World Bank.

Dabla-Norris, E., Minoiu, C., and Zanna, L. (2015). Business Cycle Fluctuations, Large Macroeconomic Shocks, and Development Aid. *World Development*, 69, 44-61.

Dalgaard, C-J., Hansen, H., and Tarp, F. (2004). On the Empirics of Foreign Aid and Growth. *Economic Journal*, 114(496), 191–216.

Davidson, R., and MacKinnon, J. (2004). *Econometric Theory and Methods*. New York: Oxford University Press.

De Gregorio, J., and Wolf, H. (1994). Terms of Trade, Productivity, and the Real Exchange Rate. NBER Working Papers 4807, National Bureau of Economic Research, Inc.

De Gregorio, J., Giovannini, A., and Wolf, H. (1994). International Evidence on Tradables and non-Tradables Inflation. *European Economic Review*, 38, 1225-1224.

DeJong, D., and Ingram, B. (2001). The Cyclical Behavior of Skill Acquisition. *Review of Economic Dynamics*, 4(3), 536-561.

Del Negro, M., and Schorfheide, F. (2006). How Good is What You've Got?. DGSE-VAR as a Toolkit for Evaluating DSGE Models. *Federal Reserve Bank of Atlanta Economic Review*, 91(2), 21-37.

Dellas, H., and Sakellaris, P. (2003). On the Cyclicality of Schooling: Theory and Evidence. *Oxford Economic Papers*, 55, 148-172.

Dellas, H., and Koubi, V. (2003). Business Cycle and Schooling. *European Journal of Political Economy*, 19, 843-859.

Demekas, D., McHugh, J., and Kosma, T. (2002). The Economics of Post Conflict Aid. IMF Working Papers 02/198, International Monetary Fund.

Dickey, D., and Fuller, W. (1979). Distribution of the Estimators for Autoregressive Time Series with a Unit Root. *Journal of the American Statistical Association*, 74, 427-431.

Doornik, J., and Hansen, H. (2008). An Omnibus Test for Univariate and Multivariate Normality. *Oxford Bulletin of Economics and Statistics*, 70, 927-939.

Dorward, A. (2009). Rethinking Agricultural Input Subsidy Programmes in Developing Countries. NON-DISTORTING FARM SUPPORT TO ENHANCE GLOBAL FOOD PRODUCTION, A. Elbehri, A. Sarris, eds., 311-374, Rome, Food and Agriculture Organisation of the United Nations.

Doucouliagos, H., and Paldam, M. (2009). The Aid Effectiveness Literature: The Sad Results of 40 years of Research. *Journal of Economic Surveys*, 23(3), 433-461.

Dreher, A., Nunnenkamp, P., and Thiele, R. (2008). Does Aid for Education Educate Children?. Evidence from Panel Data. *World Bank Economic Review*, 22(2), 291-314.

Durlauf, S. (2002). Policy Evaluation and Empirical Growth Research. Central Banking, Analysis, and Economic Policies Book Series, in: Norman Loayza & Raimundo Soto & Norman Loayza (Series Editor) & Klaus Schmidt-Hebbel (Series Editor) (ed.), Economic Growth: Sources, Trends, and Cycles, edition 1, volume 6, chapter 6, pages 163-190 Central Bank of Chile.

Easterly, W. (1999). The Ghost of Financing Gap: Testing the Growth Model Used in the International Financial Institutions. *Journal of Development Economics*, 60, 423-438.

Easterly, W. (2006). *The white Man's Burden: Why the West's Efforts to Aid the Rest have done so Much Ill and so Little Good*. New York, NY: Penguin.

Easterly, W., Levine, R., and Roodman, D. (2004). New Data, New Doubts: A Comment on Burnside and Dollar's: Aid, Policies, and Growth. *American Economic Review*, 94(3), 774-780.

Edgren, G. (2002). Aid is an Unreliable Joystick. *Development and Change*, 33(2), 261-67.

Education in Kenya. Retrieved from: http://educationispower.org/kenya-overview/education-in-kenya/

Edwards, L. (1976). School Retention of Teenagers over the Business Cycle. *Journal of Human Resources*, 11, 200–208.

Effective Investments in Education. Global Economic Symposium. (2018). Retrieved from https://www.global-economic-symposium.org/knowledgebase/the-global-economy/effective-investments-in-education.

Egert, B. (2002). Estimating the Impact of the Balassa-Samuelson Effect on Inflation and the Real Exchange Rate during Transition. *Economic Systems*, 26, 1-16.

Elbadawi, E. (1999). External Aid: Help or Hindrance to Export Orientation in Africa. *Journal of African Economies*, 8 (4), 578-616.

Engle, R., and Granger, C. (1987). Co-integration and Error Correction: Representation, Estimation, and Testing. *Econometrica*, 55, 251-276.

Farah, A., Sacerdoti, E., and Salinas, G. (2009). The Macroeconomic Impact of Scaled-Up Aid: The Case of Niger. IMF working paper, WP/09/36.

Feenstra, R., Inklaar, R., and Timmer, M. (2015). The Next Generation of the Penn World Table. *American Economic Review*, 105(10), 3150-3182.

Feeny, S., and McGillivray, M. (2010). Aid and Growth in Small Island Developing States. *Journal of Development Studies*, 46(5), 897-917.

Fielding, D., and Gibson, F. (2013). A Model of Aid and "Dutch Disease" in sub-Saharan Africa. *Journal of African Economies*, 22 (1), 1-21.

Garcia-Cicco, J., Pancrazi, R., and Uribe, M. (2010). Real Business Cycles in Emerging Countries. *American Economic Review*, 100, 2510-2531.

Giles, D., and Godwin, R. (2012). Testing for Multivariate Cointegration in the Presence of Structural Breaks: P-values and Critical Values. *Applied Economics Letters*, 19 (16), 1561-1565.

Global Economic Symposium (2018). Effective Investments in Education. Retrieved from: https://www.global-economic-symposium.org/knowledgebase/the-global-economy/effective-investments-in-education.

Godfrey, L. (1988). *Misspecification Tests in Econometrics*. Cambridge University Press, Cambridge.

Goldstein, M., Khan, M., and Officer, L. (1980). Prices of Tradable and non-Tradable goods in the Demand for Total Imports. *The Review of Economics and Statistics*, 62(2), 190-199.

Gonzalo, J. (1994). Five Alternative Methods of Estimating Long-Run Equilibrium Relationships. *Journal of econometrics*, 60(1-2), 203-233.

Griffin, K. (1970). Foreign Capital, Domestic Savings and Economic Development. *Bulletin of the Oxford University Institute of Economics and Statistics*, 32(1), 99–112.

Guarcello L., Lyon, S., and Rosati, F. (2015). Child Labor and Out-of-School Children: Evidence from 25 Developing Countries. Understanding Children's Work (UCW) Programme, UNICEF.

Gylfason, T. (2001). Natural Resources, Education, and Economic Development. *European Economic Review*, 45, 847-859.

Hamilton, J. (2017). Why You Should Never Use the Hodrick-Prescott Filter. NBER Working Paper No. 23429.

Hansen, H., and Tarp, F. (2000). Aid Effectiveness Disputed. *Journal of Development Economics*, 12(3), 375-398.

Hansen, H., and Tarp, F. (2001). Aid and Growth Regressions. *Journal of Development Economics*, 64, 547-570.

Hansen, H., and Johansen, S. (1999). Some Tests for Parameter Constancy in Cointegrated VAR Models. *The Econometrics Journal*, 2(2), 306-333.

Harris, R., and Sollis, R. (2003). *Applied Time Series Modelling and Forecasting*. John Wiley and Sons Ltd. England.

Hega, G., and Hokenmaier, K. (2002). The Welfare State and Education: A Comparison of Social and Educational Policy in Advanced Industrial Societies. Journa*l of European Social Policy*, German Political Studies, 2, 143–73.

Hendry, D. (2009). The Methodology of Empirical Econometric Modelling: Applied Econometrics through the Looking-Glass. In Mills, T. and Patterson, K. (eds), The New Palgrave Handbook of Empirical Econometrics, MacMillain, London, 3-68.

Hendry, D., and Juselius, K. (2000). Explaining Cointegration Analysis: Part I. *The Energy Journal*, 21(1), 1-42.

Hendry, D., and Juselius, K. (2001). Explaining Cointegration Analysis: Part II. *The Energy Journal*, 22(1), 75-120.

Heylen, F., and Pozzi, L. (2007). Crises and Human Capital Accumulation. *Canadian Journal of Economics*, 40(4), 1261-1285.

Hoover, K., Johansen, S., and Juselius, K. (2008). Allowing the Data to Speak Freely: The Macroeconometrics of the Cointegrated Vector Autoregression. *Am Econ Rev Papers Proc*, 98(2), 251-255.

Howes, S. (2011). An Overview of Aid Effectiveness Determinants and Strategies. Development Policy Centre Discussion Paper No. 1.

Human Development Report (2005). United Nations Development Programme. UN, New York.

IMF (2013). Energy Subsidy Reform in Sub-Saharan Africa: Experiences and Lessons. IMF report at head of title: African Department, 73, 46.

Issa, H., and Ouattara, B. (2008). Foreign Aid Flows and Real Exchange Rate: Evidence from Syria. *Journal of Economic Development*, 33(1), 133-46.

Ito, T., Isard, P., and Symansky, S. (1997). Economic Growth and Real Exchange Rate: An Overview of the Balassa-Samuelson Hypothesis in Asia. NBER Working Paper 5979.

Jarque, C., and Bera, A. (1980). Efficient Tests for Normality, Homoscedasticity and Serial Independence of Regression Residuals. *Economic Letters*, 6(3), 5-59.

Jerven, M. (2010). Random Growth in Africa?. Lessons from an Evaluation of the Growth Evidence on Botswana, Kenya, Tanzania and Zambia, 1965-1995. *Journal of Development Studies*, 46 (2), 274-294.

Johansen, S. (1991). Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models. *Econometrica*, 59 (6), 1551–1580.

Johansen, S. (1995a). Identifying Restrictions of Linear Equations with Applications to Simultaneous Equations and Cointegration. *Journal of Econometrics*, 69(1), 111-132.

Johansen, S. (1995b). *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models*. Oxford University Press.

Johansen, S. (1996). *Likelihood-Based Inference in Cointegrated Vector Autoregressive Models. Advanced Texts in Econometrics*. Oxford University Press.

Johansen, S. (2002a). Modelling of Cointegration in the Vector Autoregressive Model. *Economic Modelling*, 17, 359-373.

Johansen, S. (2002b). A Small Sample Correction for Tests of Hypothesis on the Cointegrating Vectors. *Journal of Econometrics*, 111(2), 195-221.

Johansen, S. (2005). The Interpretation of Cointegrating Coefficients in the Cointegrated Vector Autoregressive Model. *Oxford Bulletin of Economics and Statistics*, 67(1), 93-104.

Johansen, S., and Juselius, K. (1990). Maximum Likelihood Estimation and Inference on Cointegration with Applications to the Demand for Money. *Oxford Bulletin of Economics and Statistics*, 52(2), 169-210.

Johansen, S., and Juselius, K. (1994). Identification of the Long-Run and the Short-Run Structure an Application to the ISLM Model. *Journal of Econometrics*, 63, 7-36.

Johansen, S., Mosconi, R., and Nielsen, B. (2000). Cointegration Analysis in the Presence of Structural Breaks in the Deterministic Trend. *Econometrics Journal*, 3, 216–49.

Johansen, S. (2012). The Analysis of Nonstationary Time Series Using Regression, Correlation and Cointegration. *Contemporary Economics*, 6, 40-57.

Johnson, S., Larson, W., Papageorgiou, C., and Subramanian, A. (2013). Is Newer Better?. Penn World Table Revisions and their impact on growth estimates. *Journal of Monetary Economics*, 60(2), 255-274.

Jorgenson, D., and Fraumeni, B. (1989). The Accumulation of Human and Non-Human Capital, 1948-1984. In: Lipsey, R.E. and Tice, H.S., Eds., The Measurement of Savings, Investment and Wealth, University of Chicago Press, Chicago, 227-282.

Juselius, K. (2006). *The Cointegrated VAR model: Methodology and Applications. Advanced Texts in Econometrics*. Oxford University Press.

Juselius, K., Moller, N., and Trap, F. (2014). The Long-Run Impact of Foreign Aid in 36 African Countries: Insights from Multivariate Time Series Analysis. *Oxford Bulletin of Economics and Statistics*, 76(2), 153-184.

Juselius, K., Reshid, A., and Trap, F. (2017). The Real Exchange Rate, Foreign Aid and Macroeconomic Transmission Mechanisms in Tanzania and Ghana. *The Journal of Development Studies*, 53, 1075-1103.

Kane, T. (1994). College Entry by Blacks since 1970: The Role of College Costs, Family Background, and the Returns to Education. J*ournal of Political Economy*, 102, 878-911.

Kang, J., Prati, A., and Rebucci, A. (2013). Aid, Exports, and Growth: A Time-Series Perspective on the Dutch Disease Hypothesis. IMF Working Paper WP/13/73.

Karras, G. (2006). Foreign Aid and Long-Run Economic Growth: Empirical Evidence for a panel of Developing Countries. *Journal of International Development*, 18, 15–28.

Keller, W. (2002). Geographic Localization of International Technology Diffusion. *American Economic Review*, 92(1), pp. 120-142.

Kenny, C., and Williams, D. (2001). What Do We Know About Economic Growth?. Or Why Don't We Know Very Much?. *World Development*, 29 (1), 1-22.

Kenya National Bureau of Statistics (1994–2018). Economic Survey, Nairobi.

Key Indicators of the Labor Market, KILM. Fourth edition. (2005).

Kongsted, H. (2005). Testing the Nominal-to-Real Transformation. *Journal of Econometrics*, 124, 205-225.

Kosack, S., and Tobin, J. (2006). Funding Self-Sustaining Development: The Role of Aid, FDI and Government in Economic Success. *International Organisation,* 60, 205-43.

Kumar, A. (2017). Foreign Aid, Incentives and Efficiency: Can Foreign Aid Lead to Efficient Level of Investment. *Review of Development Economics*, 21(3), 678-697.

Kumi, E., Muazu, I., and Yeboah, T. (2017). Aid Volatility and Structural Economic Transformation in Sub-Saharan Africa: Does Finance Matter?. ERSA working paper 655.

Kwiatkowski, D., Phillips, P., Schmidt, P., and Shin, Y. (1992). Testing the Null Hypothesis against the Alternative of a Unit Root. *Journal of Econometrics*, 54, 159-178.

Kydland, F., and Prescott, E. (1982). Time to Build and Aggregate Fluctuations. *Econometrica*, 50(6), 1345-70.

Kydland, F., and Prescott, E. (1990). Business Cycles: Real Facts and a Monetary Myth. Federal Reserve Bank of Minneapolis.

Larrain, F., and Sachs, J. (1993). *Macroeconomics in the Global Economy*. Prentice Hall.

Lartey, E. (2007). Capital Inflows and the Real Exchange Rate: An Empirical Study of Sub-Saharan Africa. *Journal of International Trade and Economic Development*, 16(3), 337-357.

Lartey, E. (2008). Capital Inflows, Resource Reallocation and the Real Exchange Rate. *International Finance*, 11, 131-52.

Lartey, E. (2011). Financial Openness and the "Dutch Disease". *Review of Development Economics*, 15(3).

Li, Y., and Rowe, F. (2007). Aid Inflows and the Real Effective Exchange Rate in Tanzania. Policy Research Working Paper Series 4456, The World Bank.

Loxley, J., and Sackey, H. (2008). Aid Effectiveness in Africa. *African Development Review*, 20(2), 163-199.

Lucas, R. (1976). Econometric Policy Evaluation: A Critique. In *Carnegie-Rochester Conference Series on Public Policy,* Amsterdam.

Lucas, R. (1987). *Models of Business Cycles.* Basil Blackwell, New York.

Lucas, R. (1988). On the Mechanics of Economic Development. *Journal of Monetary Economics*, 22, 3-42 North-Holland.

Lumsdaine, R., and Papell, D. (1997). Multiple Trend Breaks and the Unit Root Hypothesis. *The Review of Economics and Statistics*, 79(2), 212-218.

M'Amanja, D., and Morrissey, O. (2006). Foreign Aid, Investment, and Economic Growth in Kenya: A Time Series Approach. Discussion Papers 06/05, University of Nottingham, CREDIT.

Macdonald, R., and Hoddinot, J. (2004). Determinants of Canadian Bilateral Aid Allocations: Humanitarian, Commercial or Political?. *Canadian Journal of Economics,* 37(2), 294-312.

Mankiw, G., Romer, D., and Weil, D. (1992). A Contribution to the Empirics of Economic Growth. *The Quarterly Journal of Economics*, 107 (2), 407-437.

Markandya, A., Ponczek, V., and Yi, S. (2010). What Are the Links Between Aid Volatility and Growth?. World Bank Policy Research Working Paper 5201.

Masih, I., Maskey, S., Mussá, F., and Trambauer, P. (2014). A Review of Droughts on the African Continent: A Geospatial and Long-Term Perspective. *Hydrol. Earth Syst. Sci.*, 18, 3635-3649.

Mattila, J. P. (1982). Determinants of Male School Enrollments: A Time-series Analysis. *Review of Economics and Statistics*, 64, 242-51.

McGillivary, M. (1989). The Allocation of Aid among Developing Countries: A Multi-Donor Analysis Using a Per Capita Aid Index. *World Development*, 17(4), 561-68.

Melina, G., Portillo, R., and Zanna, L. (2016). Stylized Facts about Business Cycles in Sub-Saharan Africa. IMF and U.K.'s Department for International Development (DFID) Working Paper.

Mendoza, A. (1991). Real Business Cycles in a Small Open Economy. *The American Economic Review*, 81(4), 797-818.

Mendoza, E., and Uribe, M. (2000). Devaluation Risk and the Business-Cycle Implications of Exchange-Rate Management. *Carnegie-Rochester Conference Series on Public Policy*, (53), 239-96.

Michaelowa, K. (2004). Aid Effectiveness Reconsidered: Panel Data Evidence for the Education Sector. HWWA Discussion Papers 264, Hamburg Institute of International Economics (HWWA).

Michaelowa, K., and Weber, A. (2007). Aid Effectiveness in the Education Sector: A Dynamic Panel Analysis. In S. Lahiri (ed.): *Theory and Practice of Foreign Aid*. Amsterdam (Elsevier), 357-385.

Michaely, M. (1981). Foreign Aid, Economic Structure, and Dependence. *Journal of Development Economics*, 9, 313-330.

Micossi, S., and Milesi-Ferretti, G. (1994). Real Exchange Rates and the Prices of Nontradable Goods. IMF Working Paper 94/19.

Minde, I., Jayne, T., Crawford, E., Ariga, J., and Govereh, J. (2008). Promoting Fertilizer Use in Africa: Current Issues and Empirical Evidence from Malawi, Zambia, and Kenya. Paper 33 prepared for the Regional Strategic Agricultural Knowledge Support System (Re SAKSS) for Southern Africa, Working Paper No.13, Food Security Group, Michigan State University.

Mongardini, J., and Rayner, B. (2009). Grants, Remittances, and the Equilibrium Real Exchange Rate in Sub-Saharan Africa Countries. IMF Working Papers 09/75, International Monetary Fund

Mongardini, J., and Samake, I. (2009). The Macroeconomics of Scaling up Aid: The Gleneagles Initiative for Benin. IMF Working Papers 09/115, International Monetary Fund.

Morrissey, O. (2001). Does Aid Increase Growth?. *Progress in Development Studies*, 1(1): 37-50.

Mussa, M. (1978). Dynamic Adjustment in the Heckscher-Ohlin-Samuelson Model. *Journal of Political Economy*, 82, 1191-1203.

Naoussi, C., and Tripier, F. (2013). Trend Shocks and Economic Development. *Journal of Development Economics*, 103, 29-42.

Neumayer, E. (2003). *The Pattern of Aid Giving - The Impact of Good Governance on Development Finance*. London: Routledge.

Nielsen, H. (2004). Cointegration Analysis in the Presence of Outliers. *The Econometrics Journal*, 7(1), 249-271.

Nielsen, H. (2008). Influential Observations in Cointegrated VAR Models: Danish Money Demand 1973-2003. *The Econometrics Journal*, 11(1), 39-57.

Odhiambo, W., Nyangito, H., and Nzuma, J. (2004). Sources and Determinants of Agricultural Growth and Productivity in Kenya. Productive Sector Division Kenya Institute for Public Policy Research and Analysis, KIPPRA Discussion Paper No. 34.

OECD (2017). OECD Stat. Retrieved from: http://stats.oecd.org/qwids/

Officer, L. (1976). The Productivity Bias in Purchasing Power Parity: An Econometric Investigation. IMF Staff Paper 23, 545-579.

Ostry, J., and Reinhart, C. (1992). Private Saving and Terms of Trade Shocks. IMF Staff Papers, 39 (3), 495-517.

Ovaska, T. (2003). The Failure of Development Aid. *Cato Journal*, 23, 175-188.

Özbilgin, H. (2004). Turkish Business Cycles. University of California, Santa Barbara.

Pallage, S., and Robe, M. (2001). Foreign Aid and the Business Cycle. *Review of International Economics*, 9(4), 641-675.

Psacharopoulos, G. (1994). Returns to Investment in Education: A global Update. *World Development* 22 (9), 1325–1343.

Perron, P. (1989). The Great Crash, the Oil Price Shock and the Unit Root Hypothesis. *Econometrica*, 57, 1361-1401.

Perron, P. (1990). Testing for a Unit Root in a Time Series Regression with a Changing Mean. *Journal of Business and Economic Statistics*, 8, 153-162.

Perron, P. (2005). Dealing with Structural Breaks. *Handbook of Econometrics*, (1): Econometric Theory, North-Holland.

Phillips, P., and Perron, P. (1988). Testing for a Unit Root in Time Series Regression. *Biometrika*, 75(2), 335–346.

Prescott, E. (1986). Theory Ahead of Business Cycle Measurement. Quarterly Review, Federal Reserve Bank of Minneapolis, Vol. 10, NO. 4.

Rahbek, A., Hansen, E., and Dennis, J. (2002). ARCH Innovations and Their Impact on Cointegration Rank Testing. Department of Applied Mathematics and Statistics, University of Copenhagen, Working Paper 22.

Rajan, R., and Subramanian, A. (2006). What Undermines Aid's Impact on Growth?.. NBER Working Paper No. 11657.

Rajan, R., and Subramanian, A. (2008). Aid and Growth: What Does the Cross-Country Evidence Really Show?. *The Review of Economics and Statistics*, 90(4), 643-665.

Rajan, R., and Subramanian, A. (2011). Aid, "Dutch Disease", and Manufacturing Growth. *Journal of Development Economics*, 94(1), 106-118.

Remmer, K. (2004). Does Foreign Aid Promote the Expansion of Government?. *American Journal of Political Science*, 48(1), 77-92.

Riddell, R. (2007). *Does Foreign Aid Really Work?.* Oxford University Press.

Rother, P. (2000). The Impact of Productivity Differentials on Inflation and the Real Exchange Rate: An Estimation of the Balassa-Samuelson Effect in Slovenia. In IMF Staff Country Report, 00/56, 26-38.

Sachs, J. (2005). *The End of Poverty: Economic Possibilities for Our Time*. New York: Penguin.

Sakellaris, P., and Spilimbergo, A. (2000). Business Cycles and Investment in Human Capital: International Evidence on Higher Education. *Carnegie-Rochester Conference Series on Public Policy*, 52, 221-256.

Salvatore, D. (2012). *Introduction to International Economics.* Third Edition, John Wiley and Sons, Inc.

Samuelson, P., and Stopler, W. (1941). Protection and Real Wages. *Review of Economic studies*, 9(1), 58-73.

Savvides, A., and Stengos, T. (2009). *Human Capital and Economic Growth*. Stanford University Press.

Sayanak, T., and Lahiri, S. (2009). Foreign Aid as Prize: Incentives for a Pro-Poor Policy. *Review of Development Economics*, 13(3), 403-415.

Selaya, P., and Thiele, R. (2010). Aid and Sectoral Growth: Evidence from Panel Data. *Journal of Development Studies*, 46(10), 1749-1766.

Sen, A. (1999). *Development as Freedom*. Oxford University Press.

Sims, C. (1980). Macroeconomics and Reality. *Econometrica*, 48(1), 1-48.

Spanos, A. (2009). The Pre-eminence of Theory versus the European CVAR Perspective in Macroeconometric Modeling. *Economics - The Open-Access Open-Assessment E-Journal*, 3, 21-39.

Stolper, W., and Samuelson, P. (1941). Protection and Real Wages. *The Review of Economic Studies Oxford Journals*, 9 (1), 58-73.

Sustainable Development Solutions Networks Thematic Group on Early Childhood Development, Education and Transition to Work. (2014). *The Future of our Children: Lifelong, Multi-Generational Learning for Sustainable Development*. New York: Sustainable Development Solutions Network.

Tabuga, A. (2007). International Remittances and Household Expenditures: The Philippine Case. Discussion Paper Series, Philippine Institute for Development Studies.

The Dutch Disease (November 26, 1977). *The Economist*, 82-83.

Tiba, Z. (2009). The Role of Input Subsidies: Operational Guidelines on Implementation. Policies for Good Economic Management of Food Price Swings in African Countries. Rome, FAO Trade and Markets Division.

Tica, T., and Druzic, I. (2006). The Harrod-Balassa-Samuelson Effect: A Survey of Empirical Evidence. EFZG Working Papers Series 0607, Faculty of Economics and Business, University of Zagreb.

UNESCO Global Education Monitoring (GEM) report (2015). UNESCO Publications.

UNICEF Report (2015). The Investment Case for Education and Equity. UNICEF Publications.

Wei, M. (2005). Human Capital, Business Cycles and Asset Pricing. Federal Reserve Board of Governors, Division of Monetary Affairs, Washington, DC 20551.

World Development Indicators (2017). The World Bank. Retrieved from https://data.worldbank.org/indicator

Yano, M., and Nugent, J. (1999). Aid, Nontraded Goods and the Transfer Paradox in Small Countries. *American Economic Review*, 89(2), 431-449.

Appendix A: The CVAR Model

A.1- SSA Countries not included in the Study and Dummy Variables

Table A1: SSA countries not included in the study

Country	Reasons for non-inclusion
Angola	No data available for the tradable sector
Chad	Data for the tradable sector in constant prices start in 2007
Cote d'Ivoire	Missing data for manufacturing sector and no constant prices
Comoros	Aid is stationary
Congo Rep.	Aid is stationary
Congo (Dem. Rep. of)	Data for manufacturing sector starts in 1996
Djibouti	Data missing for tradable sector
Equatorial Guinea	Data for the tradable sector starts in 2006
Eritrea	Data missing for the tradable sector
Gabon	Negative aid in 2003
Ghana	Data for the tradable sector in constant prices starts in 2006
Guinea	Data for the tradable sector starts in 1988
Guinea-Bissau	Data for the tradable sector starts in 2000
Liberia	Data for the tradable sector starts in 2000
Mauritius	Negative aid in 2003
Mozambique	Data on the tradable sector starts in 1985
Namibia	Aid is stationary
Niger	Data in constant prices available in 2006
Nigeria	Aid/GDP < 1% and normality condition violation
Sao Tome and Principe	Data for the tradable sector starts in 2001
Somalia	Data Missing
South Africa	Aid data available in 1993
Swaziland	Aid is stationary
Tanzania	Data for the tradable sector starts in 1990
Zambia	Prices are I(2)
Zimbabwe	A fundamental structural break in 2001 and 2008 and poor quality data

Table A2: Ease of doing business rank

Country	World Ranking
Rwanda	41
Kenya	80
Botswana	81
Seychelles	95
Lesotho	104
Malawi	110
Uganda	122
Cape Verde	127
Senegal	140
Mali	143
Gambia, The	146
Burkina Faso	148
Mauritania	150
Benin	151
Togo	156
Sierra Leone	160
Ethiopia	161
Madagascar	162
Cameroon	163
Burundi	164
Sudan	170
Central African Rep.	184

Table A3: Dummy variables and reasons for inclusion

Country	Dummy	Reason	Impact on
Benin	Dp75	Marxist-Leninist regime began	GDP
	Dp77	Inflation 65%	Tradable price
	Ds82	Oil production started	Tradable output
	Dp83	Oil production started	GDP
	Dp94	Inflation 35%	Prices
Botswana	Dtr08	Aid increased from USA	Aid
Burkina Faso	Dtr00	World Bank implements 5-year structural adjustment program for foreign aid in 1999	Aid
Burundi	Ds93	Assassination of the Burundi President followed by massacre and violations	GDP, aid and tradable output
	Dp96	Substantial drop in foreign aid after the 1996 coup (economic embargo)	Aid
	Dp97	Inflation 33%	Non-tradable price
Cameroon	Dp67	Second five socio-economic plan and the creation of extension service demonstration plots	GDP
	Ds76	Discovery of oil in 1976 and exports of agricultural products increased	GDP
	Dp78	Production of oil started	GDP
	Dtr80	Petroleum sector and steady increase in agricultural output	Tradable output
	Dp82	Fifth economic plan	Tradable output
	Ds87	Cameroon economic crises begins	GDP
	Dp93	Inflation 23%	Prices
	Dtr06	Aid increased as Cameroon signed Paris Declaration on Aid Effectiveness (2005)	Aid
Cape Verde	Dp87	Aid dropped due to American sanctions	Aid
	Dp93	Inflation 50%	Non-tradable price
	Dtrend94	Inflation average before 1993 was 10%	Tradable price

		and dropped to an average of 1% afterward	
	Dtr93	Inflation dropped from 50% in 1993 to -30% in 1994	Non-tradable price
	Dp10	Aid increased as a result of signing second Millennium Challenge Corporation (MMC)	Aid
Central Africa	Dp85	Inflation 35% and dropped to -4% in 1986	Prices
	Ds96	Aid decreased due to ethnic tensions	Aid
Ethiopia	Dp85	Drought and famine	Tradable output
	Dp91	Inflation increased from 3 to 20%	Prices
	Dp92	Civil War	GDP
	Ds97	Inflation dropped from 13 to 0%	Non-tradable price
Gambia	Dp81	Coup attempt	Tradable output
	Dp85	Inflation 40%	Prices
	Dp86	Inflation 39%	Prices
	Ds91	USA cut aid to Gambia	Aid
Kenya	Dtr70	Drought	GDP
	Dp75	Inflation 18%	Non-tradable price
	Ds95	IMF regulations to cut aid	Aid
	Dp96	Inflation 42%	Prices
Lesotho	Ds78	LLA militants launched an insurgency against the government of Lesotho in 1978	GDP and tradable output
	Dtr79	Inflation jumped from 2.5 to 42% then return to12%	Non-tradable price
	Dp82	Inflation increased from -5 to 12%	Tradable price
	Dp99	Aid increased to meet UN millennium goals	Aid
Madagascar	Ds90	Tourism went down due to civil unrest	GDP
	Dp94	Inflation 42%	Prices
	Dp97	IMF structural adjustment program	Aid
	Ds01	Drought and civil unrest	Tradable output
	Dp04	Aid increases to support new government after political instability	Aid

Malawi	Dtr79	Inflation decreased from 13 to 0% and then raised to 16%	Prices
	Dp92	Drought	GDP and tradable output
	Dtr93	Drought	GDP and tradable output
	Dp02	Inflation 112%	Prices
Mali	Ds72	Aid increased due to drought	Aid
	Dp80	Outlier	Non-tradable price
	Dp94	Inflation 40%	Prices
Mauritania	Dp91	Inflation 42%	Prices
Namibia	Ds91	Aid decreased	Aid
	Ds02	Trend break in non-tradable price	Non-tradable price
	Dp03	Outlier	Tradable price
Rwanda	Dp93	Outlier due to 1994 Genocide	GDP
	Ds94	1994 Genocide	GDP and tradable output
	Dtr95	Inflation increased from 17 to 52% in 1995 and then dropped to 10%	Prices
	Dp97	Aid dropped after the 1994 Genocide	Aid
	Dp99	Inflation dropped from 16 to -7%	Tradable price
Senegal	Dp83	Casamance conflict started 1982	GDP and tradable output
	Dp94	Inflation 35%	Prices
	Dp04	Aid increased to finance the trade deficit of $1.4 billion USD	Aid
Seychelles	Dtr02	Aid increased to meet UN's MDGs	Aid
	Ds04	Inflation 25%	Non-tradable price
	Dp08	Inflation 35%	Non-tradable price
	Dp09	Inflation 28%	Tradable price
Sierra Leone	Dp87	Inflation 165%	Tradable price
	Dp90	Inflation 128%	Non-tradable price
	Dp96	Inflation dropped from 30 to 2%	Prices

	Dtrend01	Civil war ended and GDP growth rate on average jumps from 1 to 7%	GDP
Sudan	Dp88	Inflation 80%	Tradable price
	Dtr89	Drought	Tradable output
	Dp92	Sudan relation with the World Bank and IMF soured as its debt increased to a high level and aid dropped	Aid
	Dp93	Inflation 100%	Prices
	Dp94	Inflation 115%	Prices
Togo	Dtr83	Inflation dropped from 15 to 1.5%	Tradable price
	Dp93	Political unrest (public and private sectors strikes)	GDP
	Dp97	Inflation dropped from 12 to 25%	Non-tradable price
	Dtrend03	EU cut aid due to human rights violations in 1993 and in 2003 aid was resumed	Aid
	Dp09	Floods affects the agricultural sector	Tradable output
	Dp12	Aid decreased due to political unrest after elections	Aid
Uganda	Dtrend93	GDP deflator averages 94% (1982–1992) and 9% afterward	Aid

A.2- Aid, "Dutch Disease" Mechanism, and Exports Competitiveness

The transfer of aid funds from a donor's country to a developing country may reduce the impact of aid on growth and development. Large injections of aid funds may result in an aid-induced "Dutch Disease" that can have negative effects on a recipient country's economy. Many factors play a role in determining the real exchange rate such as: trade balance[171], government intervention, and the Central Bank.

I begin with an example as an illustration of the effect of increasing supply and demand of a particular good. Suppose that demand for good "X" which is produced in country "A" increases. This increase in world demand for good "X" increases its exports, leading to an appreciation of the real exchange rate of country "A" that has negative effects on the exports of other goods in country

[171] Trade balance = Exports - Imports

“A”. The effect on total exports depends on the expansion of good “X” exports and the shrinkage of other goods’ exports. The appreciation of the real exchange rate in country “A” would make imports cheaper, thus imports would increase.

The changes in exports and imports have effects on country’s “A” trade balance. These changes depend on 3 forces: expansion of good “X” exports, shrinkage of other goods’ exports, and the increase in imports. Thus, there exist a relationship between country’s “A” income and the trade balance, which can be summarized in three cases: First, in the case of trade surplus, country’s “A” GDP would increase. Second, in the case of trade neutral, country’s “A” GDP would stay the same. Third, in a case of trade deficit, country’s “A” GDP would decrease. In the latter case, the value of country’s “A” imports exceeds the value of country’s “A” exports, thus the nominal exchange rate would rise (i.e. the domestic currency depreciates). This makes imports for country “A” more expensive to domestic residents and exports cheaper to foreigners. Hence, country’s “A” exports would rise and its imports fall until the trade is balanced.

The amount and the speed of adjustment depend on the elasticity of exports and imports. This approach is called the trade or elasticity approach; it measures how much is the responsiveness of imports and exports to a change in the price (the exchange rate). The magnitude of domestic currency depreciation depends to some extent to the country’s employment level. If country “A” is near full employment, then a larger depreciation of the domestic currency is required to shift the domestic resources to the production of imports’ substitutes (Salvatore, 2012). Moreover, the effect of the real exchange appreciation seems to have an impact on GDP’s composition depending on the elasticity of goods’ demands. For instance, if the world demand for other goods in country “A” is very elastic, then total exports would decrease; if the demand for importable goods is very elastic, then imports would increase. Thus, the tradable output share would shrink.

Further, country “A” cannot permit its trade deficit for a long-period of time, since it cannot expand its external debt continually. The time would come and country “A” should pay its obligations; at that time, the price level should be reduced to service its external obligations.

The “Dutch Disease” hypothesis is usually associated with the flows of foreign aid to the recipient country. Thus, it is crucial to investigate the impact of foreign aid on the GDP’s structure and whether it leads to appreciate the domestic real exchange rate. Adapting the “Dutch Disease” mechanism to foreign aid funds helps us investigating this issue.

The mechanism through which aid is affecting the relative price of non-tradable goods (i.e. real exchange rate) is a complicated process and can be summarized as follows:

Foreign aid increases the supply and consumption of the tradable goods, lowering its price relative to non-tradable goods. The appreciation of the relative price of non-tradable goods has an adverse effect on productive efficiency (Doucouliagos and Paldam, 2009). A plausible consequence is inter-sectoral resource transfers from the tradable to non-tradable sector, squeezing the tradable sector. This leads the factors of production reallocated toward the more profitable sector (non-tradable), resulting in a decline in the production of the tradable goods (Stolpler-Samuelson theorem, 1941). The real appreciation may induce labor reallocation toward the non-tradable goods sector, raising the real wages in terms of the price of tradable goods.

Foreign aid is usually converted into local currency to make local purchases; this expands the monetary base. This increment in the money supply leads to, ceteris paribus, a decrease in the domestic interest rates, causing the domestic currency to depreciate. Furthermore, from a dynamic point of view, the effect of aid on the real exchange rate depends on how fast aid is spent and on its effects on the productive capacity of the economy (the supply side). With supply constraints on domestic production, the prices of the non-tradable goods and the overall price level increase. However, if aid is used to ease the supply bottlenecks[172], foreign aid can have a deflationary impact. The responsiveness of the firms to enter the market to relax the supply constraint is faced by many obstacles. First, labor market regulations, where the majority of African labors are classified as informal labors. Second, the easiness of doing business plays a crucial rule in increasing production. Most of the SSA countries still rank in the bottom half of 190 countries of doing business index (WDI, 2017) — an index that measures the easiness in starting a new business, getting electricity, registering property, getting credit, trading across borders, and enforcing contracts (See Appendix A.1, Table A2).

Increasing the domestic money supply leads the Central Bank to interfere in the foreign exchange market in a phenomenon called sterilized intervention[173] to prevent currency depreciation. This process can be described as follows:

1- The Central Bank can sell off foreign exchange to the private sector in exchange for local currency.
2- The domestic money supply shrinks and the foreign currency supply increases (fall in the international reserves), leading to a real appreciation of the domestic currency. In this step, the volatility of the nominal exchange rate has an impact on inflation.

[172] When workloads arrive too quickly for the production process to handle. The inefficiencies brought about by the bottleneck often create delays and higher production costs.
[173] The Central Bank engages in acts so that there is no impact on the monetary base and money supply.

3- The Central bank can use open market operations: the Central Bank sells domestic currency bonds to the private sectors (usually local banks). This action leads the domestic money supply to shrink and appreciate the domestic currency.

The concept of the "Dutch Disease" is not a straight forward process; many things interfere and complicate things. Prices are usually flexible and can change in response to market signals in the competitive markets. This situation is different in most of SSA countries where many prices of commodities are fixed and controlled by governments. Many African countries pursued large-scale subsidy programmes from the 1960s up to the 1980s. During that period, African governments had controlled the input and output marketing system, where agricultural inputs at controlled and subsidized prices were supplied to the farmers (Dorward, 2009). These subsidy programs were inefficient where government monopolies, political manipulation, and high administrative costs were associated with such programs (Banful, 2010). During the 1990s, African countries stopped working with such subsidy programs as part of structural adjustment programs where the input markets liberalized; however, the input use and agricultural productivity declined (Crawford et al., 2006). In the mid of the 2000s, another form of subsidy has also been launched in Africa after a summit in Abuja, Nigeria, called "smart subsidy"; it targeted specific farmers and has been based on market rather than on state-controlled distribution systems (Minde et al., 2008; Tiba, 2009).

In addition to the agricultural subsidy programs, many African countries adopted energy (fuel and electricity) subsidies. Energy subsidies absorb a large share of scarce public resources in the SSA countries. According to the 2013 IMF report, the cost of energy subsidies was estimated at 1.4% of the SSA countries' GDP in 2012. Energy subsidies are used to avoid the price spikes transmissions to the domestic economy, where people consume petroleum products below the international market prices.

Furthermore, the type of nominal exchange rate plays a role in the real exchange rate appreciation as a result of aid inflows. For example, with a fixed exchange rate, the increase in the relative price of non-tradable goods leads to a real exchange rate appreciation. In the case of a flexible exchange rate, the increased supply of foreign currency could lead to a nominal domestic currency appreciation if foreign aid is not fully absorbed by higher imports. The majority of SSA countries had adopted a fixed exchange rate regime until the 1980s, when they started to adopt a float exchange rate regime.

The price and quantity rigidities[174] in the SSA countries and the role of the Central Banks in determining the nominal exchange rate regimes seem to have an impact on determining the prices and quantities produced. These factors interact with each other and from my point of view "Dutch Disease" seems to be a short-run phenomenon. This coincides with Adam and Bevan (2006), where they evaluate the impact of aid-induced "Dutch Disease" and find that aid funds cause short-term "Dutch Disease" in the recipient economy.

The "Dutch Disease" phenomenon provides one rationale for transfer at a disaggregated level of GDP. One can argue if there are any other rationales. The macroeconomic policies may mitigate the effect of the real exchange appreciations, but what about the quantity produced. Increasing foreign aid can finance a higher level of imports. Usually, these imports are of two kinds: goods that are already produced in the domestic economy and goods that are not produced domestically. The first kind of imported goods is usually characterized by a higher quality compared to the domestic goods. People prefer to purchase such foreign goods especially if their prices are similar. The demand for such imported goods would increase (keeping its price fixed); this might discourages the existing domestic companies to increase their productions and some businesses may go out of business. The second kind of imported goods which are not produced locally is usually characterized by high technology that can be a barrier for any new local companies to establish new businesses in the tradable sector. The high technology barriers encourages them to invest in new businesses in the non-tradable sectors. Thus, the increase in imports due to higher injections of foreign aid may have implications on the GDP's structure, regardless of the "Dutch Disease" phenomenon.

A.3- Data Definitions and Measurements

The variables are defined as follows:

i) **Aid:** net official development assistance (ODA) consists of net loan disbursements and grants given by official agencies of the Development Assistance Committee (DAC) and other international donors to promote economic development and increase welfare in developing countries. It also includes loans with at least 25 % grant element and excludes military aid. As net loans are net repayments, ODA net disbursements can be negative (Gabon and Mauritius in 2003).

[174] Due to the government intervention with subsidized programs.

Foreign aid is converted into constant local currency as follows:

$cuaid(lcu)_t = cuaid(usd)_t * ex_t$

where $cuaid(lcu)_t$ stands for aid in current local currency, $cuaid(usd)_t$ stands for aid in current USD and ex_t is the nominal exchange rate of domestic currency versus US dollar rate. Aid in constant local currency is calculated as:

$aid_t = \frac{cuaid(lcu)_t}{pgdp_t}$

where aid_t is expressed in constant local currency and $pgdp_t$ is the country's GDP deflator and is obtained as the ratio of GDP at current prices to GDP at constant prices in local currency unit.

ii) **GDP[175]:** the sum of all goods and services value added at purchaser's prices using constant local currency.

iii) **Tradable and Non-Tradable Output:**

Determinants of the tradability and goods classifications

Goods, in general, are classified into two categories: tradable and non-tradable goods. Tradable goods can be freely traded across the nation's borders and non-tradable goods are produced and consumed domestically. There are two factors that determine the tradability and non-tradability of goods (Larrain and Sachs, 1993). The first one is the transportation cost which creates barriers to trade. The lower the transportation costs as a proportion of the total production costs the more likely the good will be traded internationally. The second factor is the trade protectionism, where the trade quota and tariffs can block the flow of goods across nations, even in the presence of low transportation costs. The categories that determine if the goods are classified, as tradable or not, are not fixed over time. Any technological improvements which lead to a reduction in transportation costs would increase the list of tradable goods and an increase in the trade protectionism will make more goods non-tradable. For example, recent technological innovations in communications have made many financial services tradable in the international market.

The United Nations constructs the standard industrial classifications that classify goods and services into 9 categories by major industries as follows:

[175] GDP = C+G+S ≡ C+G+I+X-M

1- Agriculture, hunting, fishing, and forestry
2- Mining and quarrying
3- Manufacturing
4- Electricity and water
5- Construction
6- Wholesale and retail trade, restaurants, and hotels
7- Transport, storage, and communications
8- Financing, insurance, real estate and business services
9- Community, social and personal services

In theory, goods included in the first three categories are the most tradable and the rest are assumed to be non-tradable. In reality, the classification of the tradable and non-tradable goods is much more complicated. A few commodities fall easily in the non-tradable category, since in practice most goods are traded within some geographical area, depending on the transportation costs. Therefore, researchers argue that most goods are tradable and they differ in the degree of tradability, depending on the factors listed before. Moving from theory to empirical work one should follow a precise quantitative definition of classifications (Tica and Druzi, 2006).

De Gregorio et al. (1994) empirical work test the tradability of 20 different sectors in 14 OECD countries between 1970 and 1985. They use the ratio of exports to total production of a certain economic sector as a tool to classify the goods. They define a sector as tradable if more than 10% of its production is exported. They find that agricultural, mining, and most manufacturing sectors have a share in exports in total production between 23.6% and 60%. On the other hand, they find that the share of services that is exported is less than 5% of the total service production, but within the service sector they find that 27.8% of the transportation sector is exported. With the 10% threshold, they classify agriculture, mining, manufacturing, and transportations sectors as tradables and the remaining services as non-tradables. Their guidelines of classifications did not become a standard for future classifications. Arratibel et al. (2002) and Egert (2002) use only industry as being tradable, while Chinn (1997) and Rother (2000) use manufacturing as tradables. De Gregorio and Wolf (1994), Asea and Mendoza (1994) and Chinn and Johnson (1997) add agriculture and mining to the tradables. The transportation and the construction sectors are distributed equally between tradable sector (Asea and Mendoza, 1994; De Greogorio and Wolf, 1994) and non-tradable sector (Micossi and Milesi-Ferretti, 1994; Ito et al., 1997).

The tradability of sectors are conducted in the most advanced countries in De Gregorio et al. (1994) study where the availability of data on each economy's sector is not an issue. However, the availability of data for SSA countries play a crucial role in such classifications. Following Officer's (1976) and Kumi (2017) classifications, I assume that agriculture, forestry, fishing and hunting, and manufacturing as tradable goods and the rest of the economy as non-tradable goods for 16 out of 22 SSA countries. Thus, tradable output is calculated as follows:

Tradable output = Agriculture + Fishing + Forest + Hunting + Manufacturing

For the rest six countries, industry value added sector is added to the agricultural value added following Selaya and Thiele (2010), where data for manufacturing sector is missing for those countries. For those six countries tradable output is calculated as follows:

Tradable output = Agriculture + Fishing + Forest + Hunting + Mining + Quarrying + Manufacturing + Other Industries.

Non-tradable output is defined as the rest of the economy:

Non-tradable output = GDP – Tradable output.

iv) Tradable and Non-Tradable Good Prices:

I have followed Goldstein et al. (1980) methodology to calculate the prices of tradable and non-tradable good as follows:

$GDPC_t = GDPCT_t + GDPCNT_t$

$Y_t = {Y^T}_t + {Y^{NT}}_t$

where

$GDPC_t$ = Gross Domestic Product at current prices at time *t*

$GDPCT_t$ = Tradable output at current prices at time *t*

$GDPCNT_t$ = Non-tradable output at current prices at time *t*

Y_t= Gross Domestic Product at constant prices at time *t*

${Y^T}_t$= Tradable output at constant prices at time *t*

${Y^{NT}}_t$ = Non-tradable output at constant prices at time *t*

The implicit GDP deflator ($PGDP_t$) is obtained as the ratio of GDP at current prices to constant prices:

$PGDP_t = GDPC_t / Y_t$.

Similarly, one can obtain the price indices of tradable and non-tradable goods, p^T and p^{NT}, as follows:

$p^T{}_t = GDPCT_t / Y^T{}_t$

$p^{NT}{}_t = GDPCNT_t / Y^{NT}{}_t$.

A.4- The CVAR Model

A.4.1- The Common Trends Representation

The CVAR model in (3.4) can be written in a form of moving average or "Granger representation". This means that the process (y_t) is written as a function of previous innovations of the system. This can help us to investigate the role of common stochastic trends which are responsible for the non-stationarity of the process (Juselius, 2006).

Since there exist a unique relationship between α and $\alpha_{\perp}$, and between β and $\beta_{\perp}$(i.e. $\alpha'\alpha_{\perp} = 0$ and $\beta'\beta_{\perp} = 0$), I can define this identity:

$$\alpha(\beta'\alpha)^{-1}\beta' + \beta_{\perp}(\alpha'_{\perp}\beta_{\perp})^{-1}\alpha'_{\perp} = I \quad \text{(A.4.1)}$$

Using the identity in (A.4.1), y_t can be decomposed into two parts as follows:

$$y_t = \alpha(\beta'\alpha)^{-1}\beta' y_t + \beta_{\perp}(\alpha'_{\perp}\beta_{\perp})^{-1}\alpha'_{\perp} y_t \quad \text{(A.4.2)}$$

In (A4.2), $\beta' y_t$ represents the pulling forces (cointegration relations) and is defined as:

Pre-multiply equation (A.4.2) with β' and solve for $\beta' y_t$ (case k = 1):

$$\beta' y_t = (I + \beta'\alpha)\, \beta' y_{t-1} + \beta'\mu + \beta'\Psi D_t + \beta'\varepsilon_t \quad \text{(A.4.3)}$$

and $\alpha'_{\perp} y_t$ represents the pushing forces (common trends) and is defined as:

Premultiply equation (A.4.2) with $\alpha'_{\perp}$ and solve for $\alpha'_{\perp} y_t$ (case k = 1):

$$\alpha'_{\perp} y_t = \alpha'_{\perp} \sum_{i=1}^{t} \varepsilon_i + \alpha'_{\perp}\Psi D_t + \alpha'_{\perp}\mu_0 + \alpha'_{\perp} y_0 \quad \text{(A.4.4)}$$

Substituting (A.4.3) and (A.4.4) in (A.4.2) to get the moving average form of the CVAR:

$$y_t = C\sum_{i=1}^{t}(\varepsilon_i + \Psi D_i) + C^*(L)(\varepsilon_t + \Psi D_i) + P_0 \quad \text{(A.4.5)}$$

A.4.2- The Unrestricted MA Representation

The decomposition of $C = \widetilde{\beta_{\perp}}\alpha'_{\perp}$ helps us to transform $\widetilde{\beta_{\perp}}$ and $\alpha_{\perp}$by a non-singular (*p* - *r*) x (*p* - *r*) matrix Q such that: $C = \widetilde{\beta_{\perp}}\, QQ^{-1}\alpha'_{\perp} = \widetilde{\beta^{c}_{\perp}}(\alpha^{c}_{\perp})'$ without changing the likelihood value function. This transformation leads to just-identified common trends, where testing is not necessary. Any additional restrictions on $\widetilde{\beta_{\perp}}$ and $\alpha_{\perp}$will change the likelihood value function and is hence testable. However, these over-identifying restrictions on the common trends are nonlinear and are difficult to implement (Juselius, 2006).

The unrestricted estimates of $\alpha_{\perp}$ and $\widetilde{\beta_{\perp}}$ are determined based on one particular estimate of $\alpha_{\perp}$ and $\beta_{\perp}$, so they are not uniquely determined. I can impose (*p* - *r* - 1) identifying restrictions on each cointegration vector keeping the likelihood function value constant. However, the space spanned by $\alpha_{\perp}$ and $\beta_{\perp}$ is uniquely determined and so is the long-run impact matrix *C*. The estimated coefficients of the *C* matrix describes the overall long-run effects of the stochastic driving forces in the system. The column coefficients of the C matrix describes how the cumulated residuals from each CVAR equation load on each of the variables. For instance, significant coefficients indicate that cumulated empirical shocks of the corresponding variable have permanent impacts on the variables of the system. Whereas, insignificant coefficients exhibit temporary effects on the system. The C matrix rows coefficients show the weights with which each variable has been influenced by the shocks of the system (Juselius, 2006).

Appendix A.5: Misspecification Tests

It is of particular interest to conduct some misspecifications tests to ensure valid statistical inferences. Various diagnostic misspecification tests include optimal lag length, residual cross-correlations, residual autocorrelation tests, residual heteroscedasticity tests, and normality tests are reported in this section.

A.5.1- Determination of the Lag Length

The optimal lag length of the VAR model is determined by the likelihood ratio (LR) test procedure as follows:

$$-2lnQ(\mathcal{H}_k/\mathcal{H}_{k+1}) = T(ln|\widehat{\Omega_k}| - ln|\widehat{\Omega_{k+1}}|)$$

where $\mathcal{H}_k$, the null hypothesis of *k* lags, is tested against $\mathcal{H}_{k+1}$, the alternative hypothesis of (*k* + 1) lags, *T* is the size of the effective sample that is kept fixed, when testing $\mathcal{H}_k$ against $\mathcal{H}_{k+1}$ and

$\hat{\Omega}$ represents the residual covariance matrix. The LR test statistic -2lnQ is asymptotically distributed as $\chi^2(p^2)$ with p^2 degrees of freedom. The LR test weakness is in adding extra lags that improve the log-likelihood value function. Thus, it is proper to discount the log-likelihood by a penalizing factor that represents the loss of degrees of freedom. There are three information criteria[176] that serve this purpose, as they add a penalizing factor associated with the increase in estimated parameters numbers as a result of adding extra lag length.

Avoiding too many lags is important; for instance, a five-dimensional VAR(2) model and 5 intervention dummy variables with 40 observations requires an estimation of 50 autoregressive parameters, 25 dummy variables parameters, 5 constant terms, 5 trends, 15 parameters in the residual covariance matrix, a total of 100 parameters with a total of 200 data points. After accounting for extraordinary events, a VAR(1)[177] is chosen for all SSA countries except for Botswana and Sierra Leone, where a VAR(2) is found to be a more efficient representation of the data generating process with no signs of residual autocorrelation.

A.5.2- Residual Cross-Correlations Tests

The VAR residuals are usually correlated and the residual matrix, Ω, is not usually a diagonal matrix (Juselius, 2006). The VAR model in its reduced form is not a function of current values, but a function of lagged values of the process. This implies that the residual covariance matrix Ω contains all the current effects in the data. High residual correlations can be a result of the aggregation of data overtime, where the causal link get blurred as a result of temporal aggregation of the data, inadequate expectations, and omitted variables (Juselius, 2006). To find if aid residual is correlated with other variables, I have determined a significant correlations level computed as follows: $|\sigma_{ij}|$ = 2*$T^{\frac{-1}{2}}$ where σ_{ij} denotes the residual correlation and T is the number of observation. Table A4 presents the residual correlations between foreign aid and the variables for 22 SSA countries. Aid residuals have been found moderately correlated with *gdp* and *trad* in Madagascar and with the prices in Sudan. So aid shocks in these two countries should be interpreted with more cautious.

---

[176] Schwartz information criterion defined as: SIC = $ln|\hat{\Omega}|$ + $(p^2k)\frac{lnT}{T}$; Akaike information criterion defined as: AIC = $ln|\hat{\Omega}|$ + $(p^2k)\frac{2}{T}$; and Hannan-Quinn information criterion defined as: H-Q = $ln|\hat{\Omega}|$ + $(p^2k)\frac{2lnlnT}{T}$.

[177] SIC is used to determine the optimal lag length in this dissertation.

Table A4: Residual cross-correlation with aid

Country	*gdp*	*trad*	p^T	p^{NT}	Significance level
Benin	-0.156	-0.337	0.045	-0.070	0.302
Botswana	-0.083	0.128	-0.235	-0.129	0.283
Burkina Faso	0.025	-0.094	0.261	0.316	0.298
Burundi	-0.095	-0.081	-0.297	-0.223	0.298
Cameroon	0.207	0.245	0.090	-0.039	0.283
Cape Verde	-0.158	0.111	0.155	0.322	0.338
Central Africa	0.234	0.098	-0.044	-0.026	0.333
Ethiopia	-0.132	-0.236	-0.243	-0.276	0.343
The Gambia	0.095	0.091	0.021	0.183	0.286
Kenya	-0.223	-0.172	-0.178	0.106	0.286
Lesotho	0.156	-0.018	0.102	0.175	0.321
Madagascar	**0.368**	**0.379**	-0.256	-0.305	0.343
Malawi	0.098	0.280	0.349	0.312	0.338
Mali	-0.062	-0.156	-0.079	0.061	0.289
Mauritania	-0.188	-0.116	-0.261	0.118	0.309
Rwanda	0.169	0.266	-0.155	0.318	0.316
Senegal	-0.054	-0.096	-0.201	-0.122	0.338
Seychelles	0.078	0.214	-0.014	0.125	0.329
Sierra Leone	0.278	0.304	-0.252	0.140	0.280
Sudan	-0.117	-0.249	**-0.370**	**-0.352**	0.333
Togo	-0.247	-0.052	-0.085	0.319	0.321
Uganda	-0.067	-0.327	0.146	0.044	0.348

A.5.3- Residual Autocorrelations Tests

The assumption of uncorrelated residuals is of particular importance in the VAR framework for the reason that all χ^2 test are derived under the assumption of uncorrelated errors. The Lagrange Multiplier (LM) test (Godfrey, 1988) of n^{th}-order for the presence of residual autocorrelation with a small sample correction is used. The null hypothesis is for the residual errors are serially independent while the alternative hypothesis is that the errors are serially dependent. The LM test is asymptotically χ^2 distributed with p^2 degrees of freedom. Table A5 presents the multivariate LM test, where there is no significant residual autocorrelation of order one, two, three or four for all the SSA countries.

Table A5: Autocorrelation tests (LM tests)

Country	Lag 1	Lag 2	Lag 3	Lag 4
Benin	0.112	0.168	0.274	0.444
Botswana	0.177	0.066	0.561	0.091
Burkina Faso	0.179	0.787	0.071	0.826
Burundi	0.327	0.871	0.534	0.723
Cameroon	0.116	0.950	0.065	0.180
Cape Verde	0.844	0.854	0.505	0.367
Central Africa	0.333	0.443	0.820	0.502
Ethiopia	0.270	0.774	0.065	0.384
The Gambia	0.239	0.505	0.378	0.059
Kenya	0.315	0.696	0.477	0.341
Lesotho	0.074	0.520	0.995	0.311
Madagascar	0.101	0.134	0.834	0.241
Malawi	0.461	0.109	0.349	0.947
Mali	0.199	0.505	0.281	0.440
Mauritania	0.233	0.828	0.494	0.964
Rwanda	0.811	0.555	0.060	0.297
Senegal	0.215	0.360	0.698	0.866
Seychelles	0.241	0.292	0.979	0.773
Sierra Leone	0.500	0.780	0.297	0.059
Sudan	0.140	0.324	0.428	0.673
Togo	0.393	0.656	0.493	0.958
Uganda	0.126	0.764	0.301	0.769

A.5.4- Residual Heteroscedasticity Tests

Heteroscedasticity test evaluates if the residuals have constant variance. To estimate if the residuals have a constant variance, the autoregressive conditional heteroscedasticity (ARCH) test is applied of m^{th}-order to each of the VAR equations' residuals. The null hypothesis assumes homoscedastic errors while the alternative assumes heteroscedastic errors. The test statistic is calculated as (T + k - m)* R^2 , where T is the number of observations, k is the VAR length and R^2 is taken from the auxiliary regression. The multivariate ARCH test is asymptotically distributed as χ^2 with $\frac{m}{4}p^2(p+1)^2$ degrees of freedom. The univariate test is asymptotically distributed as χ^2 with k degrees of freedom. The p-value results of the multivariate LM tests and univariate ARCH effects are presented in Table A6.

The univariate ARCH test cannot be rejected for all the variables except for *gdp* (Sierra Leone), p^T (Sudan) and p^{NT} (Ethiopia), whereas the multivariate LM tests for no conditional heteroscedasticity can be rejected for some SSA countries (Burundi, Lesotho Mali, and Rwanda at lag 1, Cameroon, Mali, Rwanda, sierra Leone Sudan, and Togo at lag 2). This may not be a serious problem, since the rank test is robust against moderate ARCH effects (Gonzalo, 1994; Rahebek et al., 2002).

Table A6: ARCH tests

	Univariate Statistics					Multivariate Statistics	
Country	*aid*	*gdp*	*trad*	p^T	p^{NT}	LM(1)	LM(2)
Benin	0.181	0.655	0.964	0.501	0.243	0.736	0.277
Botswana	0.161	0.921	0.327	0.823	0.813	0.744	0.235
Burkina Faso	0.862	0.997	0.022	0.108	0.798	0.923	0.134
Burundi	0.628	0.858	0.355	0.758	0.793	0.003	0.063
Cameroon	0.928	0.017	0.261	0.329	0.734	0.366	0.034
Cape Verde	0.095	0.693	0.461	0.634	0.137	0.177	0.079
Central Africa	0.880	0.256	0.333	0.553	0.723	0.570	0.073
Ethiopia	0.970	0.917	0.682	0.871	0.047	0.439	0.070
The Gambia	0.225	0.743	0.775	0.418	0.780	0.221	0.142
Kenya	0.549	0.743	0.753	0.062	0.728	0.212	0.123
Lesotho	0.441	0.385	0.328	0.281	0.393	0.016	0.080
Madagascar	0.326	0.355	0.954	0.755	0.717	0.306	0.158
Malawi	0.073	0.519	0.562	0.511	0.058	0.600	0.132
Mali	0.293	0.808	0.295	0.368	0.117	0.022	0.015
Mauritania	0.141	0.178	0.961	0.581	0.097	0.299	0.083
Rwanda	0.619	0.129	0.688	0.117	0.299	0.012	0.004
Senegal	0.259	0.380	0.711	0.186	0.921	0.202	0.112
Seychelles	0.223	0.052	0.473	0.890	0.381	0.270	0.174
Sierra Leone	0.548	0.047	0.556	0.801	0.268	0.470	0.035
Sudan	0.034	0.137	0.382	0.036	0.052	0.466	0.025
Togo	0.729	0.951	0.218	0.926	0.554	0.246	0.034
Uganda	0.535	0.970	0.718	0.940	0.744	0.449	0.158

A.5.5- Normality Tests

Normality tests are based on skewness and kurtosis, i.e. third and fourth moment around the mean, respectively. They are asymptotically χ^2 distributed with *2p* degrees of freedom in the multivariate normality case and 2 degrees of freedom in the univariate case. The null of the test is normally distributed errors, which means that the skewness and kurtosis of the residuals are asymptotically normal with the following mean and variance:

$$\text{Skewness: } \sqrt{T}\ (skewness_i - 0) \sim N(0,6) \text{ and}$$

$$\text{Kurtosis: } \sqrt{T}\ (kurtosis_i - 3) \sim N(0,24)$$

The asymptotic univariate test for normality of a residual ($\hat{\varepsilon}_{i,t}$) is calculated as:

$$\eta_i^{as} = T(skewness_i)^2/6 + T(kurtosis_i - 3)^2/24 \sim \chi^2(2).$$

The skewness values are expected to be around 0, while the kurtosis tends to be around 3.

The asymptotic multivariate test is calculated as:

$$m\eta_i^{as} = \sum_{i=1}^{p} \eta_i^{as} \sim \chi^2(2p).$$

As it is noticed that the variance of kurtosis is three time that of skewness, which means that the normality test is more sensitive to the deviations from normality due to skewness (presence of outliers) than to excess kurtosis (fat tails). I report the Doornik-Hansen multivariate test (Doornik and Hansen, 2008). Table A7.1 shows the p-value results of the multivariate and univariate cases after controlling for the extraordinary events; Table A7.2 shows the values of skewness and kurtosis for each variable in each country.

The figures shown in bold are the p-values which are less than 5% significance level where the normality assumption is rejected. The asymptotic multivariate normality test cannot be rejected for all SSA countries, whereas the univariate normality test for individual series can be rejected for some countries and the reason for rejection is due to excess kurtosis rather than from skewness (Table A7.2). For example, the univariate normality test for aid's residual is rejected in Burkina Faso and Rwanda, for *gdp's* residual in Kenya, for *trad's* residual in Mauritania and Rwanda, for p^T in Cape Verde, Lesotho and Rwanda, and for p^{NT} in Benin, Kenya, Senegal and Togo. The CVAR is quite robust towards excess kurtosis, but not towards the existence of skewness (Juselius, 2006).

Table A7.1: Normality tests (P-Value)

	Univariate Statistics					Multivariate
Country	*aid*	*gdp*	*trad*	p^T	p^{NT}	
Benin	0.385	0.101	0.967	0.132	**0.027**	0.076
Botswana	0.481	0.811	0.476	0.102	0.941	0.523
Burkina Faso	**0.040**	0.979	0.452	0.858	0.372	0.225
Burundi	0.750	0.145	0.005	0.881	0.246	0.462
Cameroon	0.057	0.230	0.489	0.600	0.846	0.092
Cape Verde	0.803	0.597	0.487	**0.018**	0.384	0.132
Central Africa	0.475	0.411	0.220	0.174	0.125	0.788
Ethiopia	0.887	0.121	0.212	0.515	0.788	0.764
The Gambia	0.915	0.239	0.363	0.354	0.128	0.252
Kenya	0.663	**0.014**	0.146	0.567	**0.048**	0.131
Lesotho	0.680	0.124	0.369	**0.028**	0.405	0.101
Madagascar	0.335	0.449	0.800	0.842	0.611	0.344
Malawi	0.303	0.089	0.067	0.565	0.292	0.142
Mali	0.213	0.091	0.383	0.053	0.518	0.051
Mauritania	0.914	0.106	**0.028**	0.070	0.773	0.159
Rwanda	**0.004**	0.488	**0.036**	**0.017**	0.253	0.154
Senegal	0.838	0.265	0.127	0.639	**0.005**	0.462
Seychelles	0.975	0.475	0.076	0.547	0.157	0.212
Sierra Leone	0.066	0.227	0.074	0.389	0.459	0.055
Sudan	0.889	0.088	0.063	0.537	0.913	0.667
Togo	0.765	1.873	0.505	0.270	**0.005**	0.271
Uganda	0.180	0.460	0.355	0.386	0.613	0.265

Table A7.2: Skewness and Kurtosis Values

	Skewness					Kurtosis				
Country	*aid*	*gdp*	*trad*	p^T	p^{NT}	*aid*	*gdp*	*trad*	p^T	p^{NT}
Benin	0.27	-0.536	-0.08	-0.019	0.315	3.335	4.015	2.634	3.758	**4.353**
Botswana	0.368	0.185	0.239	0.697	0.107	2.687	2.545	3.23	3.906	2.678
Burkina Faso	**0.866**	0.006	-0.284	-0.174	0.401	3.606	2.49	3.23	2.725	3.3
Burundi	-0.246	0.265	-0.338	-0.096	0.481	2.775	3.766	4.828	2.809	3.531
Cameroon	-0.511	0.515	0.383	0.223	0.071	4.218	3.51	2.908	2.393	2.89
Cape Verde	-0.238	0.337	0.102	0.508	-0.521	2.541	2.949	3.182	**4.661**	2.972
Central Africa	0.383	-0.469	-0.328	0.675	0.791	3.128	2.711	2.068	3.69	3.615
Ethiopia	0.049	-0.765	-0.686	0.297	0.087	2.749	3.955	3.363	3.116	2.857
Gambia	-0.102	-0.283	-0.264	0.4	0.322	2.743	3.566	3.367	3.339	3.831
Kenya	0.221	0.295	0.165	0.345	0.567	3.002	**4.525**	3.742	2.796	**4.334**
Lesotho	-0.229	0.318	-0.251	-0.828	0.325	2.949	3.839	3.346	**4.843**	2.294
Madagascar	-0.57	0.401	-0.049	0.2114	0.121	3.15	3.162	2.843	2.503	3.033
Malawi	0.326	-0.764	-0.871	-0.333	0.545	3.45	4.113	4.162	2.526	2.91
Mali	0.275	0.615	0.452	0.426	0.171	3.618	4.066	3.097	4.198	3.198
Mauritania	-0.122	0.368	-0.247	0.1	-0.189	2.487	3.923	**4.309**	3.976	2.865
Rwanda	0.323	0.011	0.498	0.387	0.411	**4.942**	3.211	**4.402**	**4.552**	3.544
Senegal	-0.032	-0.364	-0.766	0.326	**1.136**	2.828	3.511	3.338	2.872	**6.185**
Seychelles	0.036	-0.044	0.848	0.386	-0.675	2.63	3.208	3.514	2.943	3.777
Sierra Leone	0.595	0.177	-0.159	-0.179	0.158	3.995	3.58	3.966	3.349	3.27
Sudan	0.149	-0.809	-0.51	0.315	0.059	2.377	4.221	4.201	3.067	2.691
Togo	0.066	0.158	-0.148	-0.422	0.757	2.902	2.873	3.167	2.316	**7.216**
Uganda	0.734	0.005	0.26	0.221	0.352	3.515	1.949	2.051	2.027	2.542

A.5.6- The CVAR Stability Tests

I evaluate the stability of the estimated CVAR model. For a *p*-dimension CVAR model with *r* cointegration vectors, the companion matrix should have (*p* - *r*) unit eigenvalues. For CVAR stability, the moduli of the *r* eigenvalues should be strictly less than unity or lie within the unit circle. For all the 22 SSA CVAR models, the moduli of the *r* eigenvalues rely within the unit circle[178], satisfying the CVAR stability condition with no presence of any explosive roots.

[178] The characteristics root of the CVAR model can be obtained upon request.

A.6- Tradable Sector: Change in Composition

One can argue that some economic sectors like mining and quarrying and oil sectors are tradable goods. These sectors are included under the industry value-added output and cannot be disaggregated. For more robustness checking, I have evaluated a CVAR model for the 16 SSA countries, where the tradable sector is composed of the agriculture and the industry value added outputs instead of the agriculture and the manufacturing value added outputs. Table A8 reports the long-run impact of aid on GDP, tradable output, and tradable and non-tradable goods prices. The results of the negative impact of aid on GDP (seven countries in the previous model versus eight countries in the present model) and the tradable sector (15 countries in the previous model versus 16 countries in the present model) have not changed too much.

Table A8: Long-run impact of aid (Tradable = Agriculture + Industry)

Country	gdp	$trad$	p^T	p^{NT}	Case	Rank
Madagascar	0.035 (1.705)	0.015 (1.494)	-0.095 (-1.922)	-0.118 (-1.642)	II	3
Benin	-0.033 (-1.667)	**-0.068 (-2.261)**	**-0.214 (-3.881)**	**-0.226 (-4.946)**	III	1
Burundi	**-0.132 (-2.814)**	**-0.354 (-4.728)**	**0.272 (2.694)**	**-0.368 (-2.770)**	III	2
Central Africa	0.001 (0.045)	**-0.049 (-2.700)**	**0.249 (3.557)**	**0.252 (3.222)**	III	1
Ethiopia	-0.333 (-1.916)	**-0.343 (-2.032)**	**-0.591 (-2.109)**	**-0.500 (-2.120)**	III	3
Lesotho	0.004 (0.222)	**-0.061 (-3.493)**	**0.078 (3.263)**	**0.078 (4.652)**	III	2
Mali	-0.008 (-0.520)	**-0.049 (-2.673)**	0.008 (0.321)	**0.069 (3.004)**	III	1
Sudan	-0.004 (-0.405)	**-0.033 (-4.411)**	-0.167 (-1.868)	**-0.149 (-2.074)**	III	1
Botswana	-0.065 (-0.899)	**-0.200 (-2.137)**	0.105 (1.467)	-0.007 (-0.400)	IV	2
Burkina Faso	-0.003 (-0.191)	**-0.054 (-3.472)**	0.051 (1.705)	**0.091 (3.609)**	IV	1
Cameroon	**-0.129 (-2.259)**	**-0.148 (-2.259)**	**-0.276 (-2.259)**	**-0.325 (-2.259)**	IV	4
Cape Verde	**-0.099 (-2.241)**	-0.062 (-1.761)	-0.004 (-0.162)	**0.170 (5.445)**	IV	2
Gambia	-0.006 (-0.661)	-0.001 (-0.075)	**0.194 (8.581)**	**0.222 (11.232)**	IV	1
Kenya	**-0.140 (-3.191)**	**-0.131 (-2.760)**	0.012 (0.156)	0.108 (1.785)	IV	1
Malawi	0.073 (2.518)	**0.182 (3.609)**	**0.392 (3.849)**	**0.422 (2.591)**	IV	1
Mauritania	**-0.101 (-4.261)**	**-0.098 (-2.828)**	-0.018 (-0.361)	0.022 (0.575)	IV	1
Rwanda	**0.416 (3.700)**	**0.465 (3.586)**	**0.327 (2.494)**	**0.622 (3.472)**	IV	1
Senegal	-0.025 (-1.444)	**-0.092 (-2.542)**	**-0.169 (-2.221)**	**-0.136 (-2.352)**	IV	2
Seychelles	**0.076 (2.408)**	**0.121 (3.239)**	-0.028 (-0.965)	-0.037 (-0.982)	IV	2
Sierra Leone	0.006 (0.312)	**0.085 (5.682)**	0.100 (0.903)	**0.250 (2.260)**	IV	2
Togo	**-0.016 (-4.251)**	**-0.014 (-2.801)**	**-0.037 (-6.007)**	**-0.056 (-5.182)**	IV	1
Uganda	**-0.071 (-6.910)**	**-0.055 (-5.780)**	**0.625 (3.790)**	**0.568 (4.493)**	IV	3

t-ratios are in parenthesis (Bold figures are significant at 5% level)

Table A9: Comparison of long-run impact of aid when the composition of tradable sector changes (GDP and Tradable output)

	Panel A		*Panel B*	
	Trad = Agr + Man		*Trad = Agr + Ind*	
Country	*gdp*	*trad*	*gdp*	*trad*
Madagascar			0.035 (1.705)	0.015 (1.494)
Botswana	**-0.190 (-2.147)**	**-0.207 (-2.342)**	-0.065 (-0.899)	**-0.200 (-2.137)**
Burundi			**-0.132 (-2.814)**	**-0.354 (-4.728)**
Central Africa	0.015 (0.590)	**-0.050 (-2.925)**	0.001 (0.045)	**-0.049 (-2.700)**
Ethiopia	-0.045 (-0.661)	**-0.207 (-3.616)**	-0.333 (-1.916)	**-0.343 (-2.032)**
Mali			-0.008 (-0.520)	**-0.049 (-2.673)**
Sudan	-0.002 (-0.070)	**-0.096 (-1.997)**	-0.004 (-0.405)	**-0.033 (-4.411)**
Benin	0.026 (0.585)	**-0.247 (-2.234)**	-0.033 (-1.667)	**-0.068 (-2.261)**
Burkina Faso	-0.002 (-0.029)	**-0.164 (-2.390)**	-0.003 (-0.191)	**-0.054 (-3.472)**
Cameroon	-0.003 (-0.357)	**-0.010 (-2.271)**	**-0.129 (-2.259)**	**-0.148 (-2.259)**
Cape Verde			**-0.099 (-2.241)**	-0.062 (-1.761)
Gambia	-0.005 (-0.612)	**0.050 (3.606)**	-0.006 (-0.661)	-0.001 (-0.075)
Kenya	**-0.118 (-2.894)**	**-0.085 (-2.106)**	**-0.140 (-3.191)**	**-0.131 (-2.760)**
Lesotho	**0.077 (2.241)**	**-0.104 (-2.366)**	0.004 (0.222)	**-0.061 (-3.493)**
Malawi	**0.073 (2.620)**	**0.181 (3.637)**	**0.073 (2.518)**	**0.182 (3.609)**
Mauritania			**-0.101 (-4.261)**	**-0.098 (-2.828)**
Rwanda	**0.383 (4.103)**	**0.403 (3.873)**	**0.416 (3.700)**	**0.465 (3.586)**
Senegal	**-0.019 (-3.725)**	**-0.066 (-6.135)**	-0.025 (-1.444)	**-0.092 (-2.542)**
Seychelles	**-0.060 (-2.860)**	**-0.085 (-2.984)**	**0.076 (2.408)**	**0.121 (3.239)**
Sierra Leone			0.006 (0.312)	**0.085 (5.682)**
Togo	**-0.030 (-5.702)**	**-0.024 (-3.025)**	**-0.016 (-4.251)**	**-0.014 (-2.801)**
Uganda	-0.021 (-1.242)	**-0.026 (-2.108)**	**-0.071 (-6.910)**	**-0.055 (-5.780)**

t-ratios are in parenthesis (Bold figures are significant)

Table A9 reports the long-run impact of aid on GDP and the tradable sector. Panel A shows the long-run impact of foreign aid on GDP and the tradable output, where the tradable output is composed of agricultural and manufacturing value-added outputs. While panel B shows the long long-run impact of foreign aid on GDP and the tradable output, where the latter is composed of agricultural and industrial value-added outputs.

The long-run effect of aid on GDP has changed in Botswana, Cameroon, Lesotho, Senegal, Seychelles, and Uganda. On the other hand, the long-run impact of aid on the tradable sector has only changed in the Gambia and Seychelles: the effect has changed from positive to no effect in the Gambia and from negative to positive in Seychelles. This robustness checking indicates that my result is robust regardless of the composition of the tradable sector.

Table A10: Comparison of long-run impact of aid when the composition of tradable sector changes (Tradable and non-tradable output)

	Panel A		*Panel B*	
	Trad = Agr + Man		*Trad = Agr + Ind*	
Country	*ntrad*	*trad*	*ntrad*	*trad*
Madagascar			-0.052 (1.319)	0.014 (1.390)
Botswana	**-0.191 (-1.968)**	**-0.191 (-2.120)**	-0.061 (-0.765)	**-0.372 (-3.057)**
Burundi			**0.408 (5.650)**	**-0.279 (-4.190)**
Central Africa	**0.104 (2.444)**	**-0.050 (-2.690)**	**0.082 (1.995)**	**-0.053 (-2.830)**
Ethiopia	0.127 (1.813)	**-0.214 (-4.656)**	-0.230 (-1.667)	**-0.277 (-2.222)**
Mali			**0.038 (2.300)**	**-0.049 (-2.551)**
Sudan	**0.075 (1.983)**	-0.089 (-1.915)	**0.035 (2.034)**	**-0.036 (-4.494)**
Benin	0.160 (1.824)	**-0.231 (-2.322)**	-0.001 (-0.019)	**-0.069 (-2.273)**
Burkina Faso	0.121 (1.426)	**-0.146 (-2.014)**	0.046 (1.841)	**-0.048 (-3.446)**
Cameroon	0.001 (0.004)	**-0.010 (-2.278)**	**-0.072 (-3.324)**	**-0.073 (-3.324)**
Cape Verde			**-0.163 (-2.098)**	-0.067 (-1.411)
Gambia	-0.005 (-0.612)	**0.050 (3.606)**	**-0.037 (-2.759)**	0.022 (1.459)
Kenya	**-0.146 (-2.883)**	**-0.090 (-2.229)**	**-0.150 (-2.867)**	**-0.077 (-2.032)**
Lesotho	**0.141 (2.605)**	**-0.108 (-2.385)**	0.049 (1.784)	**-0.072 (-3.197)**
Malawi	-0.010 (-0.276)	**0.181 (3.643)**	-0.023 (-0.630)	**0.183 (3.614)**
Mauritania			-0.037 (-1.571)	**-0.066 (-5.221)**
Rwanda	**0.373 (3.849)**	**0.406 (3.849)**	**0.376 (3.388)**	**0.468 (3.580)**
Senegal	0.002 (0.334)	**-0.066 (-6.172)**	0.012 (0.647)	**-0.093 (-2.653)**
Seychelles	**-0.056 (-2.306)**	**-0.085 (-2.970)**	0.048 (1.548)	**0.079 (2.143)**
Sierra Leone			-0.060 (-1.324)	**0.101 (3.977)**
Togo	**-0.033 (-3.691)**	**-0.020 (-2.889)**	**-0.025 (-2.886)**	**-0.014 (-2.469)**
Uganda	-0.036 (-1.364)	-0.021 (-1.673)	**-0.101 (-6.264)**	**-0.050 (-4.887)**

t-ratios are in parenthesis (Bold figures are significant)

Table A10 reports the long-run impact of foreign aid on the tradable and non-tradable sectors. The long-run impact of aid on the non-tradable sector changes in Botswana and Seychelles (In Panel A, the effect of aid on the non-tradable output is negative, while in Panel B, there is no effect). In Cameroon, the Gambia, and Uganda there is no effect of aid on the non-tradable output, where the tradable output is composed of agricultural and manufacturing value added outputs; however, a negative effect, when the manufacturing sector is replaced by industrial sector. Finally, in Lesotho, the result changes from positive effect to no effect. Concerning the effect of aid on the tradable sector, the results are similar to that in Table A9. The long-run impact of aid on the tradable sector has changed in the Gambia, Seychelles, and Uganda; the long-run effect of aid has been changed from positive to no effect in Gambia, from negative to positive in Seychelles, and from no effect to negative effect in Uganda.

Appendix B: One-sector DSGE Model

B.1- The Representative Agent's Optimization Problem

The representative agent maximizes his expected inter-temporal utility taking price sequences $\{w_t^h,\ r_t^k\}_{t=0}^{\infty}$ as given:

$$U = \sum_{t=0}^{\infty} \beta^t [log(C_t) + \gamma \log(L_t)] \quad \text{(B.1)}$$

Subject to:

$$L_t + N_t + S_t = 1 \quad \text{(B.2)}$$

$$C_t + I_t^k + I_t^h + T_t = r_t^k K_t + w_t^h N_t H_t + F * \exp(z_t^f) \quad \text{(B.3)}$$

$$K_{t+1} = I_t^k + (1\text{-}\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t \quad \text{(B.4)}$$

$$H_{t+1} = A_t^h S_t^{\theta_1} {I_t^h}^{\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} + (1\text{-}\delta_h) H_t \quad \text{(B.5)}$$

The Lagrangian function can be written as:

$$max_{\{C_t, N_t, S_t, I_t^h, K_{t+1}, H_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \{\log(C_t) + \gamma \log(1 - N_t - S_t)$$

$$+ \lambda_t (r_t^k K_t + w_t^h N_t H_t + F*\exp(z_t^f) - C_t - I_t^h - T_t - K_{t+1} + (1\text{-}\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t)$$

$$+ \mu_t (A_t^h S_t^{\theta_1} {I_t^h}^{\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} - H_{t+1} + (1\text{-}\delta_h) H_t)\}$$

Here, λ_t and μ_t are the Lagrange multipliers on the budget and transformations constraints.

First order conditions are as follows:

$$[C_t]: \frac{1}{C_t} = \lambda_t \quad \text{(B.6)}$$

$$[S_t]: \frac{\gamma}{1 - N_t - S_t} = \mu_t \theta_1 A_t^h S_t^{\theta_1 - 1} {I_t^h}^{\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} \quad \text{(B.7)}$$

$$[N_t]: \frac{\gamma}{1 - N_t - S_t} = \lambda_t w_t^h H_t \quad \text{(B.8)}$$

$$[I_t^h]: \lambda_t = \mu_t \theta_2 A_t^h S_t^{\theta_1} {I_t^h}^{\theta_2 - 1} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} \quad \text{(B.9)}$$

$$[K_{t+1}]: \lambda_t [1 + \emptyset(\frac{K_{t+1}}{K_t} - 1)] = \beta E_t [\lambda_{t+1} (r_{t+1}^k + (1\text{-}\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}} - 1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1} - 1)^2)] \quad \text{(B.10)}$$

$$[H_{t+1}]: \mu_t = \beta E_t [\lambda_{t+1} (w_{t+1}^h N_{t+1}) + \mu_{t+1} (1\text{-}\delta_h)] \quad \text{(B.11)}$$

The transversality conditions for physical and human capital are as follows:

$\lim_{t\to\infty} \beta^t \lambda_t K_{t+1} = 0$ and $\lim_{t\to\infty} \beta^t \mu_t H_{t+1} = 0$

Combining (B.6) and (B.8) to get:

$$\frac{\gamma C_t}{1-N_t-S_t} = w_t^h H_t \quad \text{(B.12)}$$

Equation (B.12) is the first intra-temporal Euler equation for leisure and consumption. It sets the marginal rate of substitution between consumption and leisure (LHS) equals to the relative price of leisure or the effective opportunity cost of leisure (RHS).

Combining equations (B.6), (B.7) and (B.9) to get:

$$\frac{\gamma C_t}{1-N_t-S_t} = \frac{\theta_1 I_t^h}{\theta_2 S_t} \quad \text{(B.13)}$$

Equation (B.13) is the second intra-temporal Euler equation that shows the relationship between consumption, private human capital investment, leisure time and time devoted to acquire human capital. It sets the marginal rate of substitution between consumption and leisure (LHS) equals to the marginal rate of substitution between private human investment and time allocated to study and this relationship holds every period.

Combing equations (B.6) and (B.10) to get:

$$\frac{1}{C_t}[1+\emptyset(\frac{K_{t+1}}{K_t}-1)] = \beta E_t[\frac{1}{C_{t+1}}(r_{t+1}^k + (1-\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}}-1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1}-1)^2)] \quad \text{(B.14)}$$

Equation (B.14) corresponds to the physical capital Euler equation that equalizes the marginal private cost (LHS) of sacrificing one unit of current consumption of physical good with the marginal private benefit (RHS) of allocating the extra savings into the aggregate physical capital.

Insert (B.7) and (B.8) into (B.11) to get:

$$\frac{\frac{\gamma}{1-N_t-S_t}}{\theta_1 A_t^h S_t^{\theta_1-1} I_t^{h\,\theta_2}(\exp(z_t^{gh})I_t^{gh})^{1-\theta_1-\theta_2}} = \beta E_t\{\frac{\gamma}{1-N_{t+1}-S_{t+1}}[\frac{N_{t+1}}{H_{t+1}} + \frac{1-\delta_h}{\theta_1 A_{t+1}^h S_{t+1}^{\theta_1-1} I_{t+1}^{h\ \theta_2}(\exp(z_{t+1}^{gh})I_{t+1}^{gh})^{1-\theta_1-\theta_2}}]\} \quad \text{(B.15)}$$

Equation (B.15) corresponds to the human capital Euler equation that equalizes the current marginal private cost (LHS) for an extra unit of time spending on education with the marginal private benefit (RHS) responses in the future.

B.2- Firm's Optimization Problem

The representative firm is owned by the representative agent and produces homogenous good. The firm operates in a competitive domestic market and the factor demands are determined in a competitive fashion. The representative firm chooses physical capital and effective labor[179] to maximize profits, taking prices as given each period.

The firm's maximization problem can be written as follows:

$$max_{\{K_t\,,\widetilde{H_t}\}} A_t \exp(z_t\,) K_t^{\alpha} (\widetilde{H_t})^{1-\alpha} - \; r_t^k K_t \; - w_t^h \widetilde{H_t} \tag{B.16}$$

The necessary first order conditions yield:

$$[K_t]\text{: } \alpha A_t \exp(z_t\,)(\frac{K_t}{\widetilde{H_t}})^{\alpha-1} = \quad r_t^k \tag{B.17}$$

$$[\widetilde{H_t}]\text{: } (1-\alpha) A_t^T \, \exp(z_t^T)\, (\frac{K_t}{\widetilde{H_t}})^{\alpha} = \; w_t^h \tag{B.18}$$

Equation (B.17) corresponds to the rate of return on physical capital and equation (B.18) is the wage rate per unit of effective labor.

Factors of production earn their marginal productivity since factor markets are competitive, and the standard zero-profits condition holds such that: $r_t^k K_t \; + w_t^h N_t\, H_t \; = Y_t$

B.3- The Equivalent Social Planner's Problem

The first and second welfare theorems state that the solution to the competitive equilibrium yields the same allocation as the solution to the social planner's problem; the social planner maximizes the following expected utility of the representative agent:

$$max_{\{C_t\,,\,S_t,N_t\,,I_t^h,K_{t+1}\,,\,H_{t+1}\,,\}} E_0 \sum_{t=0}^{\infty} \beta^t [log(C_t) + \; \gamma \log(L_t)] \quad \text{subject to} \tag{B.19}$$

---

[179] The effective labor: $\widetilde{H_t}$ = $N_t\, H_t$

$L_t + N_t + S_t = 1$ (B.20)

$C_t + I_t^k + I_t^h + I_t^{gh} + G_t = A_t \exp(z_t) K_t^{\alpha} (N_t H_t)^{1-\alpha} + F^* \exp(z_t^f)$ (B.21)

$K_{t+1} = I_t^k + (1-\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t$ (B.22)

$H_{t+1} = A_t^h S_t^{\theta_1} I_t^{h\,\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} + (1-\delta_h) H_t$ (B.23)

The government budget constraint:

$T_t = I_t^{gh} + G_t$

The Lagrangian function can be written as:

$max_{\{C_t,\, S_t, N_t, I_t^h, K_{t+1},\, H_{t+1},\}} E_0 \sum_{t=0}^{\infty} \beta^t \{[log(C_t) + \gamma \log(1 - N_t - S_t)]$

$+ \lambda_t (A_t \exp(z_t) K_t^{\alpha} (N_t H_t)^{1-\alpha} + F * \exp(z_t^f) - I_t^h - I_t^{gh} - G_t - C_t - K_{t+1} + (1-\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} -$

$1)^2 K_t) + \mu_t (A_t^h S_t^{\theta_1} I_t^{h\,\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} - H_{t+1} + (1-\delta_h) H_t)\}$

Here λ_t and μ_t are the Lagrange multiplier or the co-state variables to physical and human capital, respectively.

Necessary first order conditions associated with the social planner's problem are:

$[C_t]$: $\frac{1}{C_t} = \lambda_t$ (B.24)

$[S_t]$: $\frac{\gamma}{1-N_t - S_t} = \mu_t \theta_1 A_t^h S_t^{\theta_1 - 1} I_t^{h\,\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}$ (B.25)

$[N_t]$: $\frac{\gamma}{1-N_t - S_t} = \lambda_t (1-\alpha) A_t \exp(z_t) \left(\frac{K_t}{N_t H_t}\right)^{\alpha} H_t$ (B.26)

$[I_t^h]$: $\lambda_t = \mu_t \theta_2 A_t^h S_t^{\theta_1} I_t^{h\,\theta_2 - 1} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}$ (B.27)

$[K_{t+1}]$: $\lambda_t [1+\emptyset(\frac{K_{t+1}}{K_t} - 1)] = \beta E_t [\lambda_{t+1} (\alpha A_{t+1} \exp(z_{t+1}) \left(\frac{K_{t+1}}{N_{t+1} H_{t+1}}\right)^{\alpha-1} + (1-\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}} - 1) \frac{K_{t+2}}{K_{t+1}} -$
$\frac{\emptyset}{2}(\frac{K_{t+2}}{K_{t+1}} - 1)^2)]$ (B.28)

$[H_{t+1}]$: $\mu_t = \beta E_t [\lambda_{t+1} ((1-\alpha) A_{t+1} \exp(z_{t+1}) \left(\frac{K_{t+1}}{N_{t+1} H_{t+1}}\right)^{\alpha} N_{t+1}) + \mu_{t+1}(1-\delta_h)]$ (B.29)

The transversality conditions for physical and human capital are as follows:

$\lim_{t\to\infty} \beta^t \lambda_t K_{t+1} = 0$ and $\lim_{t\to\infty} \beta^t \mu_t H_{t+1} = 0$

Combining equations (B.24) and (B.26) to get:

$$\frac{\gamma C_t}{1-N_t-S_t} = (1-\alpha)A_t \exp(z_t)\left(\frac{K_t}{N_t H_t}\right)^{\alpha} H_t \quad \text{(B.30)}$$

Equation (B.30) is the intra-temporal Euler equation for leisure and consumption. It equates the effective opportunity cost of leisure to the marginal rate of substitution between leisure and consumption.

Combining equations (B.24), (B.25) and (B.27) to get:

$$\frac{\gamma C_t}{1-N_t-S_t} = \frac{\theta_1 I_t^h}{\theta_2 S_t} \quad \text{(B.31)}$$

Equation (B.31) is the intra-temporal Euler equation for consumption, education expenditures and time spent for acquiring human capital. It equates the marginal rate of substitution between leisure and consumption (LHS) to the marginal rate of substitution between education expenditure and time spent on education.

Combining equations (B.24) and (B.28) to get:

$$\frac{1}{C_t}\left[1 + \emptyset\left(\frac{K_{t+1}}{K_t} - 1\right)\right] = \beta E_t\left\{\frac{1}{C_{t+1}}\left(\alpha A_{t+1}\exp(z_{t+1})\left(\frac{K_{t+1}}{N_{t+1}H_{t+1}}\right)^{\alpha-1} + (1-\delta_k) + \emptyset\left(\frac{K_{t+2}}{K_{t+1}} - 1\right)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}\left(\frac{K_{t+2}}{K_{t+1}} - 1\right)^2\right)\right\} \quad \text{(B.32)}$$

Equation (B.32) corresponds to the intra-temporal Euler equation for consumption that equates the marginal social cost of giving up one unit of current consumption with the marginal social benefit of allocating extra savings into physical capital; i.e. Euler equation for physical capital.

From (B.25) and (B.26):

$$\lambda_t = \frac{\mu_t \theta_1 A_t^h S_t^{\theta_1 - 1} I_t^{h\,\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}}{(1-\alpha)A_t \exp(z_t)\left(\frac{K_t}{N_t H_t}\right)^{\alpha} H_t}$$

Insert λ_t back in equation in (B.29) and after some manipulation I get:

$$\frac{\frac{\gamma}{1-N_t-S_t}}{\theta_1 A_t^h S_t^{\theta_1-1} I_t^{h\,\theta_2}(\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}} = \beta E_t\left\{\frac{\gamma}{1-N_{t+1}-S_{t+1}}\left[\frac{N_{t+1}}{H_{t+1}} + \frac{1-\delta_h}{\theta_1 A_{t+1}^h S_{t+1}^{\theta_1-1} I_{t+1}^{h\,\theta_2}(\exp(z_{t+1}^{gh}) I_{t+1}^{gh})^{1-\theta_1-\theta_2}}\right]\right\} \quad \text{(B.33)}$$

Equation (B.33) corresponds to Euler equation for human capital that equates the current marginal social cost (LHS) for an extra unit of time spent on acquiring human capital with the marginal social benefit of the human capital in the future.

B.4- Steady State

In steady state, consumption, output, physical capital and human capital are all constant, i.e., X_t = X_{t+1} = X where X ∈ (C, L, N, S, I^k, I^h, K, H). The steady state equilibrium can be achieved when the technology, foreign aid, government expenditure, and human capital shocks are assumed to be constant; i.e. exp(z_t) = exp(z_t^f)= exp(z_t^g)= exp(z_t^{gh}) =1, ∀ t. The necessary first order conditions of the social planner problems become:

$$\frac{\gamma C^*}{1-N^*-S^*} = (1-\alpha)A\left(\frac{K^*}{N^*H^*}\right)^{\alpha} H^* \quad \text{(B.34)}$$

$$\frac{I^{h^*}}{C^*} = \frac{\gamma\theta_2 S^*}{\theta_1(1-N^*-S^*)} \quad \text{(B.35)}$$

$$\frac{1}{\beta} = \alpha A\left(\frac{K^*}{N^*H^*}\right)^{\alpha-1} + (1-\delta_k) \quad \text{(B.36)}$$

$$\frac{1}{\theta_1 S^{*(\theta_1-1)} I^{h^{*\theta_2}} I^{gh^{*(1-\theta_1-\theta_2)}}} = \beta\left(\frac{N^*}{H^*} + \frac{1-\delta_h}{\theta_1 S^{*(\theta_1-1)} I^{h^{*\theta_2}} I^{gh^{*(1-\theta_1-\theta_2)}}}\right) \quad \text{(B.37)}$$

$$L^* + N^* + S^* = 1 \quad \text{(B.38)}$$

$$C^* + I^{h^*} + I^{k^*} + I^{gh^*} + Gov^* = AK^{\alpha^*}(N^*H^*)^{1-\alpha} + F^* \quad \text{(B.39)}$$

$$I^{k^*} = \delta_k K^* \quad \text{(B.40)}$$

$$I^{h^*} = \left[\frac{\delta_h H^*}{S^{*\theta_1} I^{h^{*\theta_2}} I^{gh^{*(1-\theta_1-\theta_2)}}}\right]^{\frac{1}{\theta_2}} \quad \text{(B.41)}$$

Directly from (B.41) $H^* = \frac{S^{*\theta_1} I^{h^{*\theta_2}} I^{gh^{*(1-\theta_1-\theta_2)}}}{\delta_h}$

Insert H^* back in (B.37) and get the ratio of study time to work time in the steady state as follows:

$$\frac{S^*}{N^*} = \frac{\theta_1\delta_h}{\frac{1}{\beta}-(1-\delta_h)} \quad \text{(B.42)}$$

B.5- Balanced Growth Path

A balanced growth path (BGP) is the solution to the following equilibrium dynamic system:

$$\frac{\gamma C_t}{1-N_t-S_t} = (1-\alpha)A_t \exp(z_t)\left(\frac{K_t}{N_t H_t}\right)^{\alpha} H_t \quad \text{(B.43)}$$

$$\frac{\gamma C_t}{1-N_t-S_t} = \frac{\theta_1 I_t^h}{\theta_2 S_t} \quad \text{(B.44)}$$

$$\frac{1}{C_t}\left[1+\emptyset\left(\frac{K_{t+1}}{K_t}-1\right)\right]=\beta E_t\left\{\frac{1}{C_{t+1}}\left(\alpha A_{t+1}\exp(z_{t+1})\left(\frac{K_{t+1}}{N_{t+1}H_{t+1}}\right)^{\alpha-1} + (1-\delta_k) + \emptyset\left(\frac{K_{t+2}}{K_{t+1}}-1\right)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}\left(\frac{K_{t+2}}{K_{t+1}}-1\right)^2\right)\right\} \quad \text{(B.45)}$$

$$\frac{\frac{\gamma}{1-N_t-S_t}}{\theta_1 A_t^h S_t^{\theta_1-1} I_t^{h\,\theta_2}(\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}} =$$

$$\beta E_t\left\{\frac{\gamma}{1-N_{t+1}-S_{t+1}}\left[\frac{N_{t+1}}{H_{t+1}} + \frac{1-\delta_h}{\theta_1 A_{t+1}^h S_{t+1}^{\theta_1-1} I_{t+1}^{h\,\theta_2}(\exp(z_{t+1}^{gh}) I_{t+1}^{gh})^{1-\theta_1-\theta_2}}\right]\right\} \quad \text{(B.46)}$$

$$L_t + N_t + S_t = 1 \quad \text{(B.47)}$$

$$C_t + I_t^k + I_t^h + I_t^{gh} + G_t = Y_t + F{*}\exp(z_t^f) \quad \text{(B.48)}$$

$$Y_t = A_t \exp(z_t) K_t^{\alpha}(N_t H_t)^{1-\alpha} \quad \text{(B.49)}$$

$$K_{t+1} = I_t^k + (1-\delta_k)K_t - \frac{\emptyset}{2}\left(\frac{K_{t+1}}{K_t}-1\right)^2 K_t \quad \text{(B.50)}$$

$$H_{t+1} = A_t^h S_t^{\theta_1} I_t^{h\,\theta_2}(\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2} + (1-\delta_h)H_t \quad \text{(B.51)}$$

$$r_t^k = \alpha A_t \exp(z_t)\left(\frac{K_t}{N_t H_t}\right)^{\alpha-1} \quad \text{(B.52)}$$

$$w_t^h = (1-\alpha)A_t^T \exp(z_t^T)\left(\frac{K_t}{N_t H_t}\right)^{\alpha} \quad \text{(B.53)}$$

Let g_Y, g_C, g_{I^k}, g_{I^h}, g_L, g_N, g_S, g_K, and g_H be the growth rates of the variables Y_t, C_t, I_t^k, I_t^h, L_t, N_t, S_t, K_t, and H_t, respectively. Since L_t, N_t and S_t are bounded between 0 and 1 (equation B.47), this implies that their growth rate along the BGP is zero (i.e. $g_L = g_N = g_S = 0$). I need to show that in the present model with human capital all the other variables along the BGP should be stationary for an exogenous growth model. I_t^{gh}, Gov_t and F*exp(z_t^f) are exogenous variables and their growth rates are zeros in the model.

r_t^k and w_t^h are stationary along the BGP. From (B.52) and (B.53), $\frac{K_t}{H_t}$ should be constant, this implies that $g_K = g_H$.

In (B.43), $C_t = C_0(1+g_C)^t$ and $H_t = H_0(1+g_H)^t$ and to satisfy equation (43), thus $g_C = g_H$.

In (B.44), $C_t = C_0(1+g_C)^t$ and $I_t^h = I_0^h(1+g_{I^h})^t$ and to satisfy equation (44), thus $g_C = g_{I^h}$.

In (B.49), $Y_t = Y_0(1+g_Y)^t$, $K_t = (K_0(1+g_K)^t)^\alpha$ and $H_t = (H_0(1+g_H)^t)^{1-\alpha}$, since $g_K = g_H$ this implies that $g_K = g_H = g_Y$.

In (B.48), $C_t = C_0(1+g_C)^t$, $I_t^h = I_0^h(1+g_{I^h})^t$, $I_t^k = I_0^k(1+g_{I^k})^t$ and $Y_t = Y_0(1+g_Y)^t$ and to satisfy equation (B.48), thus $g_C = g_{I^h} = g_{I^k} = g_Y$.

Therefore, from equations (B.43), (B.44), (B.48), (B.49), (B.52) and (B.53) I conclude that $g_C = g_{I^h} = g_{I^k} = g_Y = g_K = g_H$.

From (B.46), $\theta_1 A_t^h S_t^{\theta_1 - 1} {I_t^h}^{\theta_2} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}$ is the marginal productivity of study hours and it is stationary along the BGP, similar to the marginal productivity of labor and physical capital. To satisfy condition (B.46), $\frac{N_{t+1}}{H_{t+1}}$ should be constant along BGP, thus $g_H = g_N = 0$.

Therefore, $g_C = g_{I^h} = g_{I^k} = g_Y = g_K = g_H = g_L = g_N = g_S = 0$.

To see if the zero growth rate of the variables satisfy equations (B.45), (B.50), and (B.51):

From (B.45), I get:

$$(1 + g_C)(1 + \emptyset(g_K)) = \beta(r_{t+1}^k + (1-\delta_k) + \emptyset(g_K)(1+g_K) - \frac{\emptyset}{2}(g_K)^2) \quad \text{(B.54)}$$

$$1 = \beta(r_{t+1}^k + (1-\delta_k)) \quad \text{(B.55)}$$

Condition (B.55) is equivalent to the steady state equation (B.36).

Divide (B.50) by K_t to get:

$$1 + g_K = \frac{I_t^k}{K_t} + (1 - \delta_k) - \frac{\emptyset}{2}(g_K)^2$$

$$g_K = \frac{I_t^k}{K_t} - \delta_k - \frac{\emptyset}{2}(g_K)^2 \quad \text{(B.56)}$$

$$\frac{I_t^k}{K_t} = \delta_k \quad \text{(B.57)}$$

Condition (B.57) is equivalent to steady state equation (B.40).

Divide (B.51) by H_t to get:

$$1 + g_H = \frac{A_t^h S_t^{\theta_1} I_t^{h^{\theta_2}} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}}{H_t} + (1 - \delta_h)$$

$$g_H = \frac{A_t^h S_t^{\theta_1} I_t^{h^{\theta_2}} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}}{H_t} - \delta_h \tag{B.58}$$

$$\frac{A_t^h S_t^{\theta_1} I_t^{h^{\theta_2}} (\exp(z_t^{gh}) I_t^{gh})^{1-\theta_1-\theta_2}}{H_t} = \delta_h \tag{B.59}$$

Condition (B.59) is equivalent to the steady state equation (B.41).

Thus, all the variables are stationary along the balanced growth path indicating that the present model exhibits an exogenous growth behavior.

B.6- Estimates of the Share of Households Human Capital Investment[180]

The University of Nairobi conducted a private survey in 2009[181] and it was published in 2013. This survey consists of 1942 households, in 17 Kenyan districts including both urban and rural areas. The households were distributed among three categories: households with international migrants, households with internal migrants, and households without migrants. One of the survey questions asks the households about their monthly expenditure on education as follows: "In the last six month how much you spend on education/apprenticeship (including tuition fees, tutor fees, school uniforms, books, and supplies)?" Their responses are presented as per the table below:

Table B1: Average monthly expenditure by households (%)

International migrant	Internal migrant	non-migrant
5.31%	3.03%	1.69%

[180] No time series data on private human capital investment are available.
[181] The name of the survey: Kenya - Migration Household Survey 2009. The report can be downloaded from: http://microdata.worldbank.org/index.php/catalog/94

Table B1 shows that households who have international migrant spend 5.31% of their monthly income on education, whereas the internal migrant and non-migrant households spend 3.03% and 1.69% of their monthly expenditure on education, respectively.

Table B2 below shows the weighted average of the total spending on education by the households.

Table B2: Distribution of households by type of migrant

	Number	Percentage	Weighted average
International migrant	713	36.71	1.949301
Internal migrant	557	28.68	0.869004
Non-migrant	672	34.6	0.58474
	1942	100	3.403045

Table B2 shows that on average Kenyan households spend 3.4% of their monthly expenditure (consumption) on education. That is $\frac{I^{h^*}}{C^*}$ = 3.4%.

B.7- World Bank Database Definition:

Agriculture is defined as:

"Agriculture corresponds to ISIC divisions 1-5 and includes forestry, hunting, and fishing, as well as cultivation of crops and livestock production. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Data are in current local currency."

Manufacturing is defined as:

"Manufacturing refers to industries belonging to ISIC divisions 15-37. Value added is the net output of a sector after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources. The origin of value added is determined by the International Standard Industrial Classification (ISIC), revision 3. Data are in current local currency."

Gross Domestic Product is defined as:

"GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in current Local Currency Unit."

Household final consumption expenditure defined as:

"Household final consumption expenditure (formerly private consumption) is the market value of all goods and services, including durable products (such as cars, washing machines, and home computers), purchased by households. It excludes purchases of dwellings but includes imputed rent for owner-occupied dwellings. It also includes payments and fees to governments to obtain permits and licenses. Here, household consumption expenditure includes the expenditures of nonprofit institutions serving households, even when reported separately by the country. Data are in constant local currency."

General government final consumption expenditure defined as:

"General government final consumption expenditure (formerly general government consumption) includes all government current expenditures for purchases of goods and services (including compensation of employees). It also includes most expenditures on national defense and security, but excludes government military expenditures that are part of government capital formation. Data are in constant local currency."

Gross capital formation (Investment) is defined as:

"Gross capital formation (formerly gross domestic investment) consists of outlays on additions to the fixed assets of the economy plus net changes in the level of inventories. Fixed assets include land improvements (fences, ditches, drains, and so on); plant, machinery, and equipment purchases; and the construction of roads, railways, and the like, including schools, offices, hospitals, private residential dwellings, and commercial and industrial buildings. Inventories are stocks of goods held by firms to meet temporary or unexpected fluctuations in production or sales, and "work in progress." According to the 1993 SNA, net acquisitions of valuables are also considered capital formation."

Government education expenditure is defined as:

"Education expenditure refers to the current operating expenditures in education, including wages and salaries and excluding capital investments in buildings and equipment."

Foreign aid is defined as:

"Net official development assistance (ODA) consists of disbursements of loans made on concessional terms (net of repayments of principal) and grants by official agencies of the members of the Development Assistance Committee (DAC), by multilateral institutions, and by non-DAC countries to promote economic development and welfare in countries and territories in the DAC list of ODA recipients. It includes loans with a grant element of at least 25 percent (calculated at a rate of discount of 10 percent)."

B.8- One-sided HP Filter versus Two-sided HP Filter

Regular HP filter (or two-sided) uses a full sample, leading to end-point sensitivity. However, one-sided HP filter (i.e. backward looking) uses data available at a given point of time. On the other hand, Hamilton (2017) argues that the HP filter is characterized by spurious dynamic as the filtered values in the middle of the sample are different from those at the end of it. He proposes an alternative filter called the Hamilton filter. Table B3.1 below compares the stylized business cycle facts for the Kenyan economy. The main differences between the filters are in standard deviations where one-sided HP filter variables' volatilities are lower than in two-sided HP filter and Hamilton filter. Concerning the correlations, no significant changes in signs, but the magnitude changes from one filter to another. For calibration purposes, I use one-sided HP filter.

Table B3.1: Kenyan data moments

Filter Type	HP 1 Sided	HP 2 Sided	Hamilton Filter
Standard Deviations			
GDP	0.0288	0.0352	0.0405
Consumption	0.0493	0.0658	0.0775
Physical capital investment	0.1025	0.1270	0.2088
Exogenous Variables			
Government expenditure	0.0686	0.0748	0.1095
Public human capital investment	0.0901	0.0989	0.1268
Aid	0.2080	0.2137	0.2961

Table B3.2: Kenyan data moments

Correlations with GDP			
Consumption	0.8337	0.8580	0.7297
Physical capital investment	0.4233	0.3632	0.5587
Public human capital investment	0.1812	0.1289	0.1826
Government expenditure	-0.0434	-0.0604	-0.0584

Table B3.3: Kenyan data moments

Correlations with Aid			
GDP	0.3508	0.2143	0.1483
Consumption	0.0931	0.0562	0.0347
Physical capital investment	-0.0652	-0.0512	0.0037
Public human capital investment	-0.1161	-0.1183	-0.1136
Government expenditure	-0.2946	-0.2431	-0.1067

Table B3.4: Kenyan data moments

Correlations with public human capital			
GDP	0.1812	0.1289	0.1826
Consumption	0.1857	0.1067	0.2239
Physical capital investment	0.1733	0.1385	0.1256

Table B3.5: Kenyan data moments

Correlations with government expenditure			
GDP	-0.0434	-0.0605	-0.0585
Aid	-0.2946	-0.2431	-0.1068
Consumption	0.0331	0.0473	-0.0662
Physical capital investment	0.1667	0.1381	0.1018

B.9- Technology and Government Expenditure Shocks

B.9.1- Technology Shock (TFP Shock)

Figure B1 shows the impacts of a positive one-standard technology shock for the corresponding responses. Higher productivity raises the marginal productivity in the goods sector, which induces the representative agent to increase his working hours and enjoy less leisure time. In addition, the TFP shock reduces the marginal cost of physical capital; this would lower the current marginal utility of consumption compared to the future. Thus, the representative agent smooths his consumption behavior and the balance is restored by investing in physical and human capitals. However, the response of physical capital investment is 4.8 times than that for the private human capital investment; this might be related to the reduction of the marginal cost of physical capital due to the TFP shock.

The positive reaction of consumption occurs in the period in which the TFP shock occurs and declines gradually in subsequent periods. Moreover, GDP increases on impact as a result of increasing labor hours supplied then declines and stays above the steady state for a long period of time. The dynamic effect of the TFP shock can also be felt in human capital accumulation. TFP shock increases the marginal cost of human capital relative to physical capital; the representative agent finds that human capital accumulation is expensive compared to physical capital and thus reduces the hours devoted to acquire skills. However, higher productivity in the goods sector increases private human capital investment on impact. The initial decline in study hours[182] and the initial increase in private human capital investment have a direct impact on the accumulation of human capital stock. Thus, human capital stock takes a humped shape that increases gradually and reaches its peak after 20 periods after the realization of the TFP shock. On the other hand, the response of physical capital stock is initially small on impact, increases in subsequent years after the shock showing a humped shape that reaches its peak in the 7th period, and then declines monotonically afterward.

The TFP shock increases both the marginal productivity of labor that stays above the steady state for a long period of time as well as the marginal productivity of physical capital. However, the marginal productivity of physical capital declines below the steady state and stays below it for a long period of time after 6 years of the shock. The marginal productivity of study hours increases

[182] TFP shock could increase the study hours if the cost adjustment in the physical capital law of motion exceeds 2.2 and in this case the result would be consistent with Sakellaris and Spilimbergo (2000) where they find that college enrollments in non-OECD countries is pro-cyclical.

on impact but declines gradually afterward. The rise in the marginal productivity of study hours emerges from the decline of studying hours, although the agent increases his own contribution to private human capital investment.

A positive TFP shock leads to a pro-cyclical behavior for employment, consumption, and physical and private human capital investment. The study time is found to be counter-cyclical and is consistent with Dejong and Ingram (2001).

B.9.2- Government Expenditure Shock

In this sub-section, I provide the impact of government expenditure shock to some selected stationary variables which are shown in Figure B2 below. An increase in government expenditure leads to an immediate increase in output. On the other hand, there is a reduction in consumption, private human capital investment, and physical capital investment.

Time allocated to work increases at the expense of study and leisure time, whom both decline. In addition, both forms of capital stocks decline as a result from the reduction in investment in both forms and due to the decline in study hours (for human capital accumulation). Real interest rate rises on impact, while the real wage declines and stays below its trend for a long period of time. Finally, the marginal productivity of study hours increases on impact and declines monotonically below the steady state in the 6^{th} period.

Figure B1: Impulse responses to a positive one-standard TFP shock

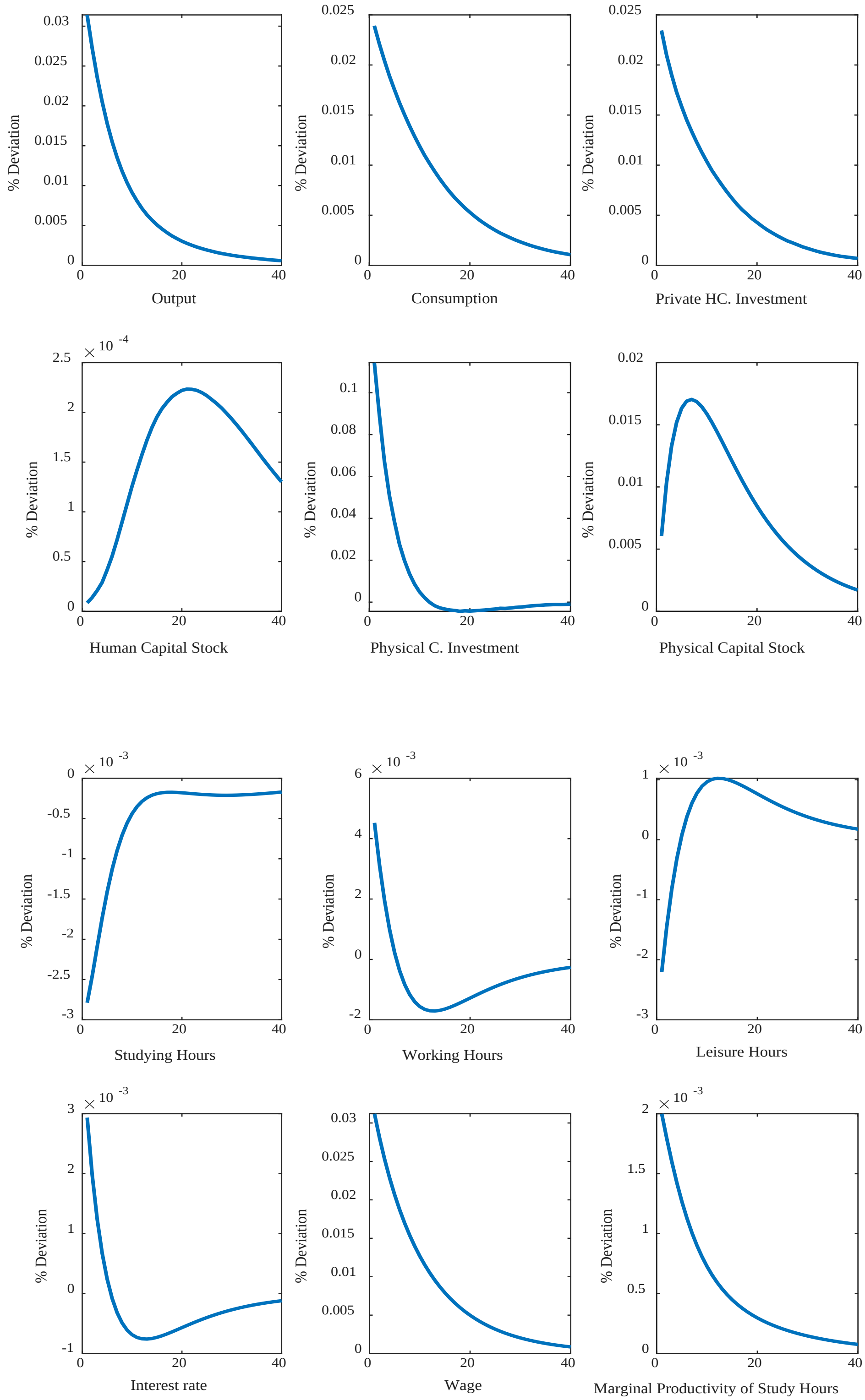
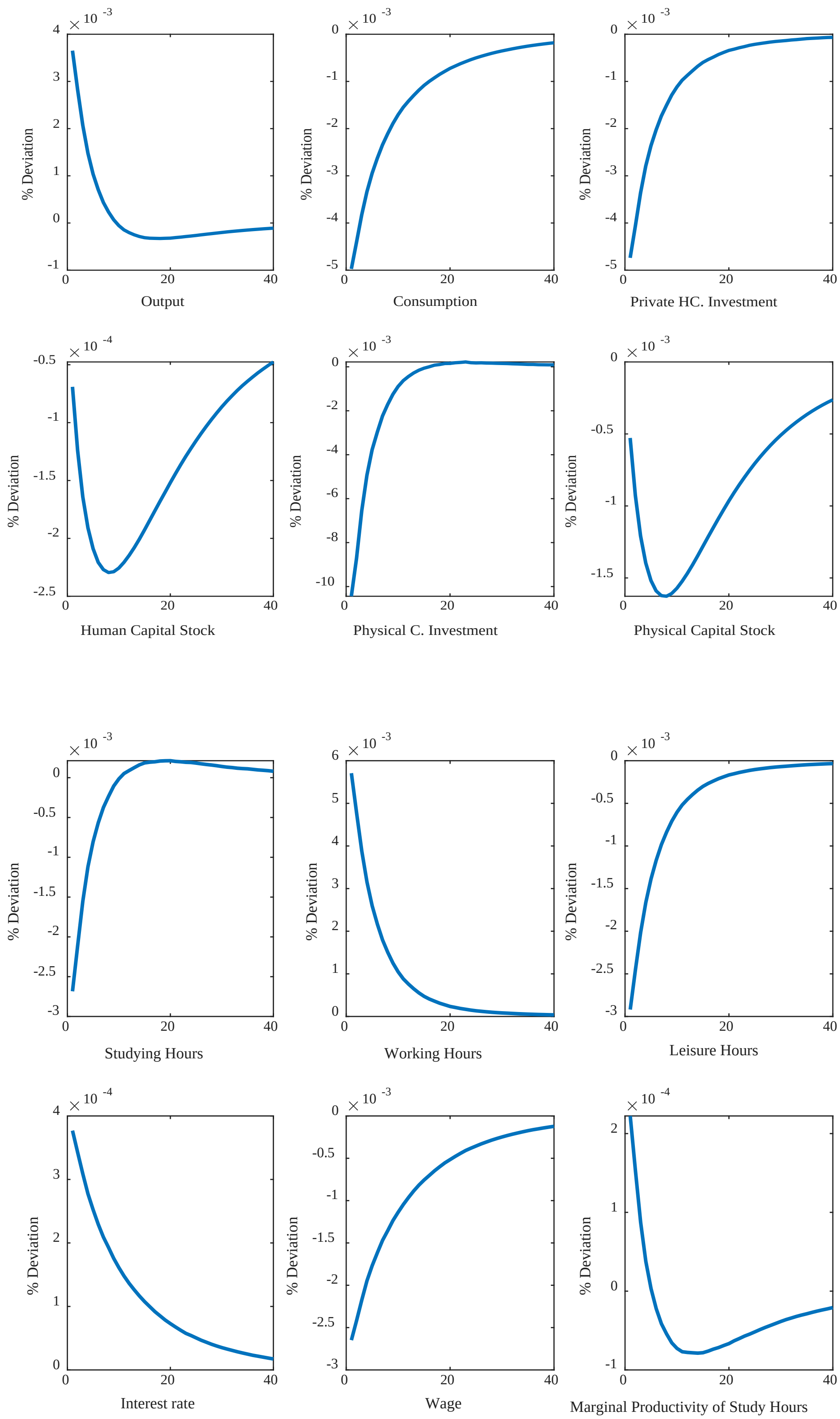


Figure B2: Impulse responses to a positive one-standard government expenditure shock



Appendix C: Two-sector DSGE Model

C.1- The Representative Agent's Optimization Problem

The representative agent maximizes his expected inter-temporal utility taking price sequences $\{P_t^N,\ w_t^h,\ r_t^k\}_{t=0}^{\infty}$ as given:

$$max_{\{C_t^T,C_t^N,C_t,N_t^T,N_t^N,S_t,L_t,I_t^h,K_{t+1},H_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \{logC_t + \gamma logL_t\} \qquad \textit{subject to} \tag{C.1}$$

$$S_t + N_t^T + N_t^N + L_t = 1 \tag{C.2}$$

$$C_t = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} \tag{C.3}$$

$$C_t^T + P_t^N C_t^N + I_t^h + I_t^k + T_t = w_t^h N_t H_t + r_t^k K_t + F_t \tag{C.4}$$

$$K_{t+1} = I_t^k + (1-\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t \tag{C.5}$$

$$H_{t+1} = A_t^h S_t^{\eta_1} I_t^{h\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} + (1\text{-}\delta_h) H_t \tag{C.6}$$

The government budget constraint:

$$T_t = P_t^N I_t^{gh} + P_t^N G_t$$

The Lagrangian function can be written as:

$$max_{\{C_t^T,C_t^N,C_t,N_t^T,N_t^N,S_t,\ I_t^h,K_{t+1},H_{t+1}\}} E_0 \sum_{t=0}^{\infty} \beta^t \{logC_t + \gamma\log(1 - N_t^T - N_t^N - S_t)\}$$

$$+ \lambda_{0t}([\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} - C_t)$$

$$+ \lambda_{1t} (w_t^h N_t H_t + r_t^k K_t + F_t - C_t^T - P_t^N C_t^N - K_{t+1} + (1\text{-}\delta_k)K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t - I_t^h - T_t)$$

$$+ \lambda_{2t}(A_t^h S_t^{\eta_1} I_t^{h\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} + (1\text{-}\delta_h) H_t - H_{t+1}) \tag{C.7}$$

Here, λ_{0t} - λ_{2t} are the Lagrange multipliers on the budget and transformations constraints.

First order conditions:

$$[C_t]: \frac{1}{C_t} = \lambda_{0t} \tag{C.8}$$

$$[C_t^T]: \lambda_{0t}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(1+\mu)} = \lambda_{1t} \tag{C.9}$$

$$[C_t^N]: \lambda_{0t}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} (1-\omega)(C_t^N)^{-(1+\mu)} = P_t^N \lambda_{1t} \quad \text{(C.10)}$$

$$[I_t^h]: \lambda_{1t} = \lambda_{2t}\eta_2 A_t^h S_t^{\eta_1} I_t^{h\,\eta_2-1}(\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} \quad \text{(C.11)}$$

$$[S_t]: \frac{\gamma}{1-N_t^T - N_t^N - S_t} = \lambda_{2t}\eta_1 A_t^h S_t^{\eta_1 - 1} I_t^{h\,\eta_2}(\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} \quad \text{(C.12)}$$

$$[N_t^T]: \frac{\gamma}{1-N_t^T - N_t^N - S_t} = \lambda_{1t}\, w_t^h H_t \quad \text{(C.13)}$$

$$[N_t^N]: \frac{\gamma}{1-N_t^T - N_t^N - S_t} = \lambda_{1t} w_t^h H_t \quad \text{(C.14)}$$

$$[K_{t+1}]: \lambda_{1t}[1 + \emptyset(\frac{K_{t+1}}{K_t} - 1)] = \beta E_t[\lambda_{1t+1}(r_{t+1}^k + (1\text{-}\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}} - 1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1} - 1)^2)]$$

(C.15)

$$[H_{t+1}]: \lambda_{2t} = \beta E_t[[\lambda_{1t+1}\left(w_{t+1}^h N_{t+1}\right) + \lambda_{2t+1}((1\text{-}\delta_h)] \quad \text{(C.16)}$$

The transversality conditions for physical and human capital are as follows:

$$\lim_{t\to\infty} \beta^t \lambda_{1t} K_{t+1} = 0 \text{ and } \lim_{t\to\infty} \beta^t \lambda_{2t} H_{t+1} = 0 \quad \text{(C.17)}$$

From equations (C.9) and (C.10), the relative price of non-tradable goods is derived:

$$P_t^N = (\frac{1-\omega}{\omega})(\frac{C_t^N}{C_t^T})^{-(1+\mu)} \quad \text{(C.18)}$$

Equation (C.18) equates the marginal rate of substitution between tradable good consumption C_t^T and non-tradable good consumption C_t^N to the relative price of non-tradable goods P_t^N each period.

Combining equations (C.8), (C.9), and (C.15) to get the Euler equation that equalizes the marginal private cost of sacrificing a unit of current tradable consumption good with the marginal private benefit of allocating the extra savings into aggregate physical capital:

$$\frac{1}{C_t}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(1+\mu)}[1 + \emptyset(\frac{K_{t+1}}{K_t} - 1)] = \beta E_t\{\frac{1}{C_{t+1}}[\omega(C_{t+1}^T)^{-\mu} + (1-\omega)(C_{t+1}^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_{t+1}^T)^{-(1+\mu)}(r_{t+1}^k + (1\text{-}\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}} - 1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1} - 1)^2)\} \quad \text{(C.19)}$$

Combining equations (C.8), (C.10), and (C.15) to get the Euler equation that equalizes the marginal private cost of sacrificing a unit of current non-tradable consumption good with the marginal private benefit of allocating the extra savings into aggregate physical capital:

$$\frac{1}{C_t}[\omega(C_t^T)^{-\mu}+(1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1}(1-\omega)(C_t^N)^{-(1+\mu)}[1+\emptyset(\frac{K_{t+1}}{K_t}-1)] =$$

$$\beta E_t\{\frac{1}{C_{t+1}}[\omega(C_{t+1}^T)^{-\mu}+(1-\omega)(C_{t+1}^N)^{-\mu}]^{-\frac{1}{\mu}-1}(1-\omega)(C_{t+1}^N)^{-(1+\mu)}(r_{t+1}^k+(1\text{-}\delta_k)+\emptyset(\frac{K_{t+2}}{K_{t+1}}-1)\frac{K_{t+2}}{K_{t+1}}-\frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1}-1)^2)\} \quad (C.20)$$

Equations (C.19) and (C.20) correspond to Euler equations that equalize the marginal private cost (LHS) of sacrificing one unit of current consumption of tradable and non-tradable good with marginal private benefit (RHS) of allocating the extra savings into the aggregate physical capital.

Combining equations (C.12), (C.13), and (C.16) to get:

$$\frac{\frac{\gamma}{(1-N_t^T-N_t^N-S_t)}}{\eta_1 A_t^h S_t^{\eta_1-1} I_t^{h^{\eta_2}}(\exp(z_t^h)I_t^{gh})^{1-\eta_1-\eta_2}}=\beta E_t\{\frac{\gamma}{1-N_{t+1}^T-N_{t+1}^N-S_{t+1}}[\frac{N_{t+1}}{H_{t+1}}+\frac{1-\delta_h}{\eta_1 A_{t+1}^h S_{t+1}^{\eta_1-1} I_{t+1}^{h^{\eta_2}}(\exp(z_{t+1}^h)I_{t+1}^{gh})^{1-\eta_1-\eta_2}}]\} \quad (C.21)$$

Equation (C.21) corresponds to the human capital Euler equation that equalizes the current marginal private cost (LHS) for an extra unit of time spending on education with the marginal private benefit (RHS) responses in the future.

Combining equations (C.8), (C.9), (C.11), and (C.12) to get:

$$\frac{\gamma C_t}{(1-N_t^T-N_t^N-S_t)([\omega(C_t^T)^{-\mu}+(1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1}\omega(C_t^T)^{-(1+\mu)})}=\frac{\eta_1 I_t^h}{\eta_2 S_t} \quad (C.22)$$

Equation (C.22) is the intra-temporal Euler equation that shows the relationship between consumption, private human capital investment, leisure time, and time devoted to acquire human capital. It sets the marginal rate of substitution between consumption and leisure (LHS) equals to the marginal rate of substitution between private human investment and time allocated to study; this relationship holds every period.

Combining equations (C.8), (C.9), and (C.13) to get:

$$\frac{\gamma C_t}{(1-N_t^T-N_t^N-S_t)}=[\omega(C_t^T)^{-\mu}+(1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1}\omega(C_t^T)^{-(1+\mu)}w_t^h H_t \quad (C.23)$$

Equation (C.23) is the intra-temporal Euler for leisure and consumption (tradable). It equates the effective opportunity cost of leisure to the marginal rate of substitution between leisure and consumption.

Combining equations (C.8), (C.10), and (C.14) to get:

$$\frac{\gamma C_t P_t^N}{1-N_t^T - N_t^N - S_t} = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1}(1-\omega)(C_t^N)^{-(1+\mu)} \, w_t^h H_t \tag{C.24}$$

Equation (C.24) is the intra-temporal Euler for leisure and consumption (non-tradable). It equates the effective opportunity cost of leisure to the marginal rate of substitution between leisure and consumption.

Definition. The consumption based CES price index P_t^C is the minimum expenditure I_t to consume $C_t = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}}$ such that, $I_t = P_t^C \, C_t$, given P_t^N. By duality theory, this is equivalent to maximize the representative agent's consumption subject to his consumption expenditure:

$$max_{\{C_t^T, C_t^N\}}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} \tag{C.25}$$

subject to

$$P_t^C \, C_t = C_t^T + P_t^N C_t^N \tag{C.26}$$

Set up the Lagrangian:

$$max_{\{C_t^T, C_t^N\}}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} + \lambda\,(P_t^C \, C_t - C_t^T - P_t^N C_t^N) \tag{C.27}$$

The necessary first order conditions:

$$[C_t^T]\text{: } [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(\mu+1)} = \lambda \tag{C.28}$$

$$[C_t^N]\text{: } [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} (1-\omega)(C_t^N)^{-(\mu+1)} = P_t^N \lambda \tag{C.29}$$

Combining equations (C.28) and (C.29) with (C.26) to derive the Marshallian demand functions for C_t^T and C_t^N as follows:

$$C_t^T = \frac{(1-\omega)^{-\frac{1}{1+\mu}} P_t^C \, C_t}{(1-\omega)^{-\frac{1}{1+\mu}} + (\omega)^{-\frac{1}{1+\mu}} P_t^{N\frac{\mu}{1+\mu}}} = \frac{(\omega)^{\frac{1}{1+\mu}} P_t^C \, C_t}{\omega^{\frac{1}{1+\mu}} + (1-\omega)^{\frac{1}{1+\mu}} P_t^{N\frac{\mu}{1+\mu}}} \tag{C.30}$$

$$C_t^N = \frac{(\omega)^{-\frac{1}{1+\mu}} P_t^C \, C_t \; P_t^{N^{-\frac{1}{1+\mu}}}}{(1-\omega)^{-\frac{1}{1+\mu}} + (\omega)^{-\frac{1}{1+\mu}} P_t^{N\frac{\mu}{1+\mu}}} = \frac{(1-\omega)^{\frac{1}{1+\mu}} P_t^C \, C_t \; P_t^{N^{-\frac{1}{1+\mu}}}}{\omega^{\frac{1}{1+\mu}} + (1-\omega)^{\frac{1}{1+\mu}} P_t^{N\frac{\mu}{1+\mu}}} \tag{C.31}$$

The CES price index is found by substituting the Marshallian demands equations (C.30) and (C.31) into equation (C.25):

$$C_t = [\omega\left(\frac{(\omega)^{\frac{1}{1+\mu}} P_t^C\, C_t}{\omega^{\frac{1}{1+\mu}} + (1-\omega)^{\frac{1}{1+\mu}} P_t^{N\frac{\mu}{1+\mu}}}\right)^{-\mu} + (1-\omega)\left(\frac{(1-\omega)^{\frac{1}{1+\mu}} P_t^C\, C_t\, P_t^{N^{-\frac{1}{1+\mu}}}}{\omega^{\frac{1}{1+\mu}} + (1-\omega)^{\frac{1}{1+\mu}} P_t^{N\frac{\mu}{1+\mu}}}\right)^{-\mu}]^{-\frac{1}{\mu}} \quad \text{(C.32)}$$

The solution for the CES price index P_t^C of equation (C.32) is:

$$P_t^C = [\omega^{\frac{1}{1+\mu}} + (1-\omega)^{\frac{1}{1+\mu}}(P_t^N)^{\frac{\mu}{1+\mu}}]^{\frac{1+\mu}{\mu}} \quad \text{(C.33)}$$

From equation (C.33), P_t^C is an increasing function of P_t^N.

The Euler equation of the physical capital and the composite good can be written by combining equations (C.17), (C.19), (C.25), (C.26), (C.30), and (C.31) as:

$$\frac{\frac{1}{C_t}[1+\emptyset(\frac{K_{t+1}}{K_t}-1)]}{P_t^C} = \beta E_t\{\frac{\frac{1}{C_{t+1}}}{P_{t+1}^C}(r_{t+1}^k + (1-\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}}-1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1}-1)^2)\} \quad \text{(C.34)}$$

Equilibrium equation (C.34) is the first Euler condition that equalizes the marginal private benefit (RHS) of allocating the extra savings into the aggregate physical capital with the marginal private cost (LHS) of sacrificing one unit of current consumption. In other words, the Euler equation equates marginal utility of consumption to the marginal utility of saving.

C.2- Firms' Optimization Problems

There are two types of representative firms owned by the representative agent: one produces a tradable good and the other produces a non-tradable good. Both firms operate in a competitive domestic market and the factor demands are determined in a perfective competitive fashion. The representative firm chooses physical capital and effective labor[183] to maximize profits taking prices as given each period.

The tradable good firm's maximization problem can be written as follows:

$$max_{\{K_t^T, \widetilde{H_t^T}\}}\ A_t^T \exp(z_t^T)\, K_t^{T\alpha}(\widetilde{H_t^T})^{1-\alpha} - r_t^T \kappa^k(K_t^T, K_t^N) - w_t^T \kappa^h(H_t^T, H_t^N) \quad \text{(C.35)}$$

The necessary first order conditions yield:

---

[183] Tradable effective labor: $\widetilde{H_t^T} = N_t^T H_t^T$ and non-tradable effective labor $\widetilde{H_t^N} = N_t^N H_t^N$.

$$[K_t^T]: \alpha A_t^T \exp(z_t^T)\,(\frac{K_t^T}{\widetilde{H_t^T}})^{\alpha-1} = r_t^T \kappa_T^k(K_t^T, K_t^N)^{184} \quad (C.36)$$

$$[\widetilde{H_t^T}]: (1-\alpha)A_t^T \exp(z_t^T)\,(\frac{K_t^T}{\widetilde{H_t^T}})^{\alpha} = w_t^T \kappa_T^h(H_t^T, H_t^N) \quad (C.37)$$

In (C.36) $\kappa_T^k(K_t^T, K_t^N) = [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}-1}(K_t^T)^{-(\nu_k+1)}$

In (C.37) $\kappa_T^h(H_t^T, H_t^N) = [(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}-1}(H_t^T)^{-(\nu_h+1)}/N_t^T$

Solving for the rate of return on physical capital:

$$r_t^T = \frac{\alpha A_t^T \exp(z_t^T)\,(\frac{K_t^T}{\widetilde{H_t^T}})^{\alpha-1}}{\kappa_T^k(K_t^T, K_t^N)} \quad (C.38)$$

and the wage rate per unit of effective labor:

$$w_t^T = \frac{(1-\alpha)A_t^T \exp(z_t^T)\,(\frac{K_t^T}{\widetilde{H_t^T}})^{\alpha}}{\kappa_T^h(H_t^T, H_t^N)} \quad (C.39)$$

The non-tradable firm’s maximization problem is written as follows:

$$max_{\{K_t^N, \widetilde{H_t^N}\}}\ P_t^N A_t^N \exp(z_t^N)\, K_t^{N\theta}(\widetilde{H_t^N})^{1-\theta} - r_t^N \kappa^k(K_t^T, K_t^N) - w_t^N \kappa^h(H_t^T, H_t^N) \quad (C.40)$$

The necessary first order conditions yield:

$$[K_t^N]: P_t^N \theta A_t^N \exp(z_t^N)\,(\frac{K_t^N}{\widetilde{H_t^N}})^{\theta-1} = r_t^N \kappa_N^k(K_t^T, K_t^N) \quad (C.41)$$

$$[\widetilde{H_t^N}]: P_t^N(1-\theta)A_t^N \exp(z_t^N)\,(\frac{K_t^N}{\widetilde{H_t^N}})^{\theta} N_t^N = w_t^N \kappa_N^h(H_t^T, H_t^N) \quad (C.42)$$

In (C.41), $\kappa_N^k(K_t^T, K_t^N) = [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}-1}(K_t^N)^{-(\nu_k+1)}$

In (C.42), $\kappa_N^h(H_t^T, H_t^N) = [(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}-1}(H_t^N)^{-(\nu_h+1)}/N_t^N$

Solving for the rate of return on physical capital:

[184] By implicit differentiation.

$$r_t^N = \frac{P_t^N \theta A_t^N \exp(z_t^N)\,(\frac{K_t^N}{\widetilde{H_t^N}})^{\theta-1}}{\kappa_N^k(K_t^T, K_t^N)} \quad (C.43)$$

and the wage rate per unit of effective labor:

$$w_t^N = \frac{P_t^N (1-\theta) A_t^N \exp(z_t^N)\,(\frac{K_t^N}{\widetilde{H_t^N}})^{\theta}}{\kappa_N^h(H_t^T, H_t^N)} \quad (C.44)$$

Factors of production earn their marginal productivities since factor markets are competitive and the standard zero-profits condition holds such that:

$$r_t^k K_t + w_t^h N_t H_t = Y_t^T + P_t^N Y_t^N \quad (C.45)$$

C.3- The Equivalent Social Planner's Problem

The first and second welfare theorems state that the solution to the competitive equilibrium yields the same allocation as the solution to the social planner's problem.

The social planner maximizes the following expected intertemporal utility of the representative agent:

$$max_{\{C_t^T, C_t^N, C_t, N_t^T, N_t^N, S_t, L_t, I_t^h, K_{t+1}, H_{t+1}, K_t^T, H_t^T, K_t^N, H_t^N\}} E_0 \sum_{t=0}^{\infty} \beta^t \{logC_t + \gamma logL_t\} \quad (C.46)$$

subject to

$$S_t + N_t^T + N_t^N + L_t = 1 \quad (C.47)$$

$$C_t = [\omega (C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} \quad (C.48)$$

$$C_t^T + I_t^k + I_t^h = A_t^T \exp(z_t^T)\, K_t^{T\alpha} (N_t^T H_t^T)^{1-\alpha} + \mathrm{F}\exp(z_t^F) \quad (C.49)$$

$$C_t^N + G_t + I_t^{gh} = A_t^N \exp(z_t^N)\, K_t^{N\theta} (N_t^N H_t^N)^{1-\theta} \quad (C.50)$$

$$K_{t+1} = I_t^k + (1-\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t \quad (C.51)$$

$$H_{t+1} = A_t^h S_t^{\eta_1} I_t^{h\,\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} + (1-\delta_h) H_t \quad (C.52)$$

$$K_t = [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}} \quad (C.53)$$

$$H_t = [(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}} \quad (C.54)$$

The Lagrangian function can be written as:

$$max_{\{C_t^T, C_t^N, C_t, N_t^T, N_t^N, S_t, I_t^h, K_{t+1}, H_{t+1}, K_t^T, H_t^T, K_t^N, H_t^N\}} E_0 \sum_{t=0}^{\infty} \beta^t \{logC_t + \gamma log(1 - N_t^T - N_t^N - S_t\}$$

$$+ \lambda_{0t}([\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} - C_t)$$

$$+ \lambda_{1t} (A_t^T \exp(z_t^T) K_t^{T\alpha} (N_t^T H_t^T)^{1-\alpha} + \text{F} \exp(z_t^F) - C_t^T - I_t^h - K_{t+1} + (1\text{-}\delta_k) K_t - \frac{\emptyset}{2}(\frac{K_{t+1}}{K_t} - 1)^2 K_t)$$

$$+ \lambda_{2t} (A_t^N \exp(z_t^N) K_t^{N\theta} (N_t^N H_t^N)^{1-\theta} - C_t^N - G_t - I_t^{gh})$$

$$+ \lambda_{3t}(K_t - [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}})$$

$$+ \lambda_{4t}(H_t - [(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}})$$

$$+ \lambda_{5t}(A_t^h S_t^{\eta_1} I_t^{h\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} + (1\text{-}\delta_h) H_t - H_{t+1}) \quad \text{(C.55)}$$

The necessary first order conditions associated with the social planner's problem are:

$$[C_t]: \frac{1}{C_t} = \lambda_{0t} \quad \text{(C.56)}$$

$$[C_t^T]: \lambda_{0t}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(1+\mu)} = \lambda_{1t} \quad \text{(C.57)}$$

$$[C_t^N]: \lambda_{0t}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} (1-\omega)(C_t^N)^{-(1+\mu)} = \lambda_{2t} \quad \text{(C.58)}$$

$$[I_t^h]: \lambda_{1t} = \lambda_{5t}\eta_2 A_t^h S_t^{\eta_1} I_t^{h\eta_2-1} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} \quad \text{(C.59)}$$

$$[S_t]: \frac{\gamma}{1-N_t^T-N_t^N-S_t} = \lambda_{5t}\eta_1 A_t^h S_t^{\eta_1-1} I_t^{h\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} \quad \text{(C.60)}$$

$$[N_t^T]: \frac{\gamma}{1-N_t^T-N_t^N-S_t} = \lambda_{1t} (1\text{-}\alpha) A_t^T \exp(z_t^T) K_t^{T\alpha} (N_t^T H_t^T)^{-\alpha} H_t^T \quad \text{(C.61)}$$

$$[N_t^N]: \frac{\gamma}{1-N_t^T-N_t^N-S_t} = \lambda_{2t} (1\text{-}\theta) A_t^N \exp(z_t^N) K_t^{N\theta} (N_t^N H_t^N)^{-\theta} H_t^N \quad \text{(C.62)}$$

$$[K_{t+1}]: \lambda_{1t}[1 + \emptyset(\frac{K_{t+1}}{K_t} - 1)] = \beta E_t[\lambda_{1t+1}((1\text{-}\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}} - 1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1} - 1)^2) + \lambda_{3t+1}]$$

(C.63)

$$[H_{t+1}]: \lambda_{5t} = \beta E_t[\lambda_{5t+1}((1\text{-}\delta_h) + \lambda_{4t+1}] \quad \text{(C.64)}$$

$$[K_t^T]: \lambda_{1t}\ (\alpha A_t^T\ \exp(z_t^T)\ \left(\frac{K_t^T}{N_t^T H_t^T}\right)^{\alpha-1}) = \lambda_{3t}[(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}-1}(K_t^T)^{-(\nu_k+1)} \tag{C.65}$$

$$[K_t^N]: \lambda_{2t}(\theta A_t^N\ \exp(z_t^N)\ \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta-1}) = \lambda_{3t}\ [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}-1}(K_t^N)^{-(\nu_k+1)} \tag{C.66}$$

$$[H_t^T]: \lambda_{1t}(1-\alpha)A_t^T \exp(z_t^T)\ (\frac{K_t^T}{N_t^T H_t^T})^{\alpha} N_t^T = \lambda_{4t}[(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}-1}(H_t^T)^{-(\nu_h+1)} \tag{C.67}$$

$$[H_t^N]: \lambda_{2t}(1-\theta)A_t^N \exp(z_t^N)\left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta} N_t^N = \lambda_{4t}[(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}-1}(H_t^N)^{-(\nu_h+1)} \tag{C.68}$$

The transversality conditions for physical and human capital are as follows:

$\lim_{t\to\infty} \beta^t\, \lambda_{1t} K_{t+1} = 0$ and $\lim_{t\to\infty} \beta^t\, \lambda_{5t} H_{t+1} = 0$

Combining equations (C.56), (C.57), (C.63), and (C.65) to get:

$$\frac{1}{C_t}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{\ -\frac{1}{\mu}-1}\ \omega(C_t^T)^{-(1+\mu)}\ \left[1 + \emptyset\left(\frac{K_{t+1}}{K_t} - 1\right)\right] =$$

$$\beta \mathrm{E_t}[\frac{1}{C_{t+1}}\ [\omega(C_{t+1}^T)^{-\mu} + (1-\omega)(C_{t+1}^N)^{-\mu}]^{\ -\frac{1}{\mu}-1}$$

$$\omega(C_{t+1}^T)^{-(1+\mu)}[(\frac{(\alpha A_{t+1}^T \exp(z_{t+1}^T)\left(\frac{K_{t+1}^T}{N_{t+1}^T H_{t+1}^T}\right)^{\alpha-1})}{\left[(K_{t+1}^T)^{-\nu_k} + (K_{t+1}^N)^{-\nu_k}\right]^{\frac{-1}{\nu_k}-1}(K_{t+1}^T)^{-(\nu_k+1)}} + \quad (1\text{-}\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}} - 1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1} -$$

$$1)^2)] \tag{C.69}$$

Equation (C.69) corresponds to the intra-temporal Euler equation for consumption that equates the marginal social cost of giving up one unit of current consumption with the marginal social benefit of allocating extra savings into aggregate physical capital; i.e. physical capital Euler equation.

Combining equations (C.60), (C.61), (C.64), and (C.67) to get:

$$\frac{\frac{\gamma}{(1-N_t^T - N_t^N - S_t)}}{\eta_1 A_t^h S_t^{\ \eta_1 - 1} I_t^{h\,\eta_2}(\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2}} = \beta \mathrm{E_t}\{\frac{\gamma}{1-N_{t+1}^T - N_{t+1}^N - S_{t+1}}($$

$$\frac{N_{t+1}^T}{H_{t+1}^T\left[(H_{t+1}^T)^{-\nu_h} + (H_{t+1}^N)^{-\nu_h}\right]^{\frac{-1}{\nu_h}-1}(H_{t+1}^T)^{-(\nu_h+1)}} + \frac{(1-\delta_h)}{\eta_1 A_{t+1}^h S_{t+1}^{\ \eta_1-1} I_{t+1}^{h\ \eta_2}(\exp(z_{t+1}^h) I_{t+1}^{gh})^{1-\eta_1-\eta_2}})\} \tag{C.70}$$

Equation (C.70) corresponds to the intra-temporal Euler equation for human capital; it equates the current marginal social cost (LHS) for an extra unit of time spent on acquiring human capital with the marginal social benefit of the human capital in the future.

Combining equations (C.57), (C.58), (C.65), and (C.66) to get:

$$\alpha A_t^T \exp(z_t^T) \left(\frac{K_t^T}{N_t^T H_t^T}\right)^{\alpha-1} = (\frac{1-\omega}{\omega}) (\frac{C_t^N}{C_t^T})^{-(1+\mu)} \theta A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta-1})(\frac{K_t^T}{K_t^N})^{-(\nu_k+1)} \quad \text{(C.71)}$$

Equation (C.71) equates the marginal productivity of physical capital across sectors.

Combining equations (C.57), (C.58), (C.67), and (C.68) to get:

$$(1-\alpha) A_t^T \exp(z_t^T) \left(\frac{K_t^T}{N_t^T H_t^T}\right)^{\alpha} N_t^T = (\frac{1-\omega}{\omega}) (\frac{C_t^N}{C_t^T})^{-(1+\mu)} (1-\theta) A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta} N_t^N (\frac{H_t^T}{H_t^N})^{-(\nu_h+1)} \quad \text{(C.72)}$$

Equation (C.72) equates the marginal productivity of human capital across sectors.

Combining equations (C.56), (C.57), and (C.61) to get:

$$\frac{\gamma C_t}{1-N_t^T - N_t^N - S_t} = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(1+\mu)}(1\text{-}\alpha) A_t^T \exp(z_t^T) (\frac{K_t^T}{N_t^T H_t^T})^{\alpha} H_t^T \quad \text{(C.73)}$$

Equation (C.73) is the intra-temporal Euler for leisure and consumption (tradable). It equates the effective opportunity cost of leisure to the marginal rate of substitution between leisure and consumption.

Combining equations (C.56), (C.57), and (C.62) to get:

$$\frac{\gamma C_t}{1-N_t^T - N_t^N - S_t} = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} (1-\omega)(C_t^N)^{-(1+\mu)}(1\text{-}\theta) A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta} H_t^N \quad \text{(C.74)}$$

Equation (C.74) is the intra-temporal Euler for leisure and consumption (non-tradable). It equates the effective opportunity cost of leisure to the marginal rate of substitution between leisure and consumption.

Combining (C.56), (C.58), (C.59), and (C.60) to get:

$$\frac{\gamma C_t}{(1-N_t^T - N_t^N - S_t)([\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(1+\mu)})} = \frac{\eta_1 I_t^h}{\eta_2 S_t} \quad \text{(C.75)}$$

Equation (C.75) is the intra-temporal Euler equation that shows the relationship between consumption, private human capital investment, leisure time, and time devoted to acquire human capital. It sets the marginal rate of substitution between consumption and leisure (LHS) equals to the marginal rate of substitution between private human investment and time allocated to study; this relationship holds every period.

C.4- Steady State

In steady state, consumption, tradable and non-tradable consumptions, output, tradable and non-tradable outputs, tradable and non-tradable physical capitals, and tradable and non-tradable human capital, investments in both form of capital are all constant; i.e. $X_t = X_{t+1} = X$, where $X \in (C, C^T, C^N\ L,\ N^T, N^N,\ S,\ I^k, I^h,\ K,\ H, K^T, K^N, H^T, H^N)$. The steady state equilibrium can be achieved when the technology, foreign aid, government expenditure, and public human capital shocks are assumed to be constant; i.e. $\exp(z_t^T) = \exp(z_t^N) = \exp(z_t^f) = \exp(z_t^g) = \exp(z_t^{gh}) = 1$, $\forall$ *t*. The necessary first order conditions of the social planner problems become:

$$\frac{1}{\beta} = \left[\frac{\alpha A^T (\frac{K^{*T}}{N^{*T} H^{*T}})^{\alpha-1}}{K^{*T^{-(\nu_k+1)}}\ [K^{*T^{-\nu_k}} + K^{*N^{-\nu_k}}]^{-\frac{(\nu_k+1)}{\nu_k}}} + (1-\delta_k)\right] \tag{C.76}$$

$$\frac{1}{\eta_1 A^h S^{*(\eta_1-1)} I^{h*\eta_2} I^{gh*(1-\eta_1-\eta_2)}} = \beta \left[\frac{N^{*T}}{H^{*T^{-(\nu_h)}}\ [H^{*T^{-\nu_h}} + H^{*N^{-\nu_h}}]^{-\frac{(\nu_h+1)}{\nu_h}}} + \frac{1-\delta_h}{\eta_1 A^h S^{*(\eta_1-1)} I^{h*\eta_2} I^{gh*(1-\eta_1-\eta_2)}}\right]$$

(C.77)

$$\alpha A^T (\frac{K^{*T}}{N^{*T} H^{*T}})^{\alpha-1} = (\frac{1-\omega}{\omega})\ (\frac{C^{*N}}{C^{*T}})^{-(1+\mu)}\ \theta A^N\ \left(\frac{K^{*N}}{N^{*N} H^{*N}}\right)^{\theta-1} (\frac{K^{*T}}{K^{*N}})^{-(\nu_k+1)} \tag{C.78}$$

$$(1-\alpha) A^T (\frac{K^{*T}}{N^{*T} H^{*T}})^{\alpha} N^{*T} (H^{*T})^{(\nu_h+1)} = (\frac{1-\omega}{\omega})\ (\frac{C^{*N}}{C^{*T}})^{-(1+\mu)}\ (1-\theta) A^N\ \left(\frac{K^{*N}}{N^{*N} H^{*N}}\right)^{\theta} N^{*N} (H^{*N})^{(\nu_h+1)}$$

(C.79)

$$\frac{\gamma C^*}{1-N^{*N}-N^{*T}-S^*} = [\omega (C^{*T})^{-\mu} + (1-\omega)(C^{*N})^{-\mu}]^{-\frac{1}{\mu}-1}\ \omega (C^{*T})^{-(1+\mu)} (1-\alpha) A^T (\frac{K^{*T}}{N^{*T} H^{*T}})^{\alpha} H^{*T}$$

(C.80)

$$\frac{\gamma C^*}{1-N^{*N}-N^{*T}-S^*} = [\omega (C^{*T})^{-\mu} + (1-\omega)(C^{*N})^{-\mu}]^{-\frac{1}{\mu}-1} (1-\omega)(C^{*N})^{-(1+\mu)} (1-\theta) A^N \left(\frac{K^{*N}}{N^{*N} H^{*N}}\right)^{\theta} H^{*N} \tag{C.81}$$

$$\frac{\gamma C^*}{(1-N^{*N}-N^{*T}-S^*)([\omega(C^{*T})^{-\mu}+(1-\omega)(C^{*N})^{-\mu}]^{-\frac{1}{\mu}-1}\omega(C^{*T})^{-(1+\mu)})}=\frac{\eta_1 I^{h^*}}{\eta_2 S^*} \quad \text{(C.82)}$$

$$L^* + N^{*T} + N^{*T} + S^* = 1 \quad \text{(C.83)}$$

$$C^{*T} + I^{h^*} + I^{k^*} = A^T K^{*T^{\alpha}} (N^{*T} H^{*T})^{1-\alpha} + F^* \quad \text{(C.84)}$$

$$C^{*N} + I^{gh^*} + G^* = A^N K^{*N^{\theta}} (N^{*N} H^{*N})^{1-\theta} \quad \text{(C.85)}$$

$$C^* = [\omega(C^{*T})^{-\mu} + (1-\omega)(C^{*N})^{-\mu}]^{-\frac{1}{\mu}} \quad \text{(C.86)}$$

$$I^{k^*} = \delta_k K^* \quad \text{(C.87)}$$

$$I^{h^*} = [\frac{\delta_h H^*}{S^{*\eta_1} I^{h^{*\eta_2}} I^{gh^{*(1-\eta_1-\eta_2)}}}]^{\frac{1}{\eta_2}} \quad \text{(C.88)}$$

$$K^* = [K^{*T^{-\nu_k}} + K^{*N^{-\nu_k}}]^{-\frac{1}{\nu_k}} \quad \text{(C.89)}$$

$$H^* = [H^{*T^{-\nu_h}} + H^{*N^{-\nu_h}}]^{-\frac{1}{\nu_h}} \quad \text{(C.90)}$$

C.5- Balanced Growth Path

A balanced growth path (BGP) is a solution to the following equilibrium dynamic system:

$$\frac{1}{C_t}[\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(1+\mu)} \left[1 + \emptyset\left(\frac{K_{t+1}}{K_t} - 1\right)\right] =$$

$$\beta \mathrm{E_t}[\frac{1}{C_{t+1}} [\omega(C_{t+1}^T)^{-\mu} + (1-\omega)(C_{t+1}^N)^{-\mu}]^{-\frac{1}{\mu}-1}$$

$$\omega(C_{t+1}^T)^{-(1+\mu)}[(\frac{(\alpha A_{t+1}^T \exp(z_{t+1}^T)\left(\frac{K_{t+1}^T}{N_{t+1}^T H_{t+1}^T}\right)^{\alpha-1})}{\left[(K_{t+1}^T)^{-\nu_k}+(K_{t+1}^N)^{-\nu_k}\right]^{\frac{-1}{\nu_k}-1}(K_{t+1}^T)^{-(\nu_k+1)}} + (1-\delta_k) + \emptyset(\frac{K_{t+2}}{K_{t+1}} - 1)\frac{K_{t+2}}{K_{t+1}} - \frac{\emptyset}{2}(\frac{K_{t+2}}{K_t+1} - 1)^2)] \quad \text{(C.91)}$$

$$\frac{\frac{\gamma}{(1-N_t^T - N_t^N - S_t)}}{\eta_1 A_t^h S_t^{\eta_1 - 1} I_t^{h^{\eta_2}} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2}} = \beta \mathrm{E_t}\{\frac{\gamma}{1-N_{t+1}^T - N_{t+1}^N - S_{t+1}}($$

$$\frac{N_{t+1}^T}{H_{t+1}^T\left[(H_{t+1}^T)^{-\nu_h}+(H_{t+1}^N)^{-\nu_h}\right]^{\frac{-1}{\nu_h}-1}(H_{t+1}^T)^{-(\nu_h+1)}} + \frac{(1-\delta_h)}{\eta_1 A_{t+1}^h S_{t+1}^{\eta_1-1} I_{t+1}^{h^{\eta_2}} (\exp(z_{t+1}^h) I_{t+1}^{gh})^{1-\eta_1-\eta_2}})\} \quad \text{(C.92)}$$

$$\alpha A_t^T \exp(z_t^T) \left(\frac{K_t^T}{N_t^T H_t^T}\right)^{\alpha-1} = (\frac{1-\omega}{\omega}) (\frac{C_t^N}{C_t^T})^{-(1+\mu)} \theta A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta-1})(\frac{K_t^T}{K_t^N})^{-(\nu_k+1)} \quad (C.93)$$

$$(1-\alpha) A_t^T \exp(z_t^T) \left(\frac{K_t^T}{N_t^T H_t^T}\right)^{\alpha} N_t^T = (\frac{1-\omega}{\omega}) (\frac{C_t^N}{C_t^T})^{-(1+\mu)} (1-\theta) A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta} N_t^N (\frac{H_t^T}{H_t^N})^{-(\nu_h+1)} \quad (C.94)$$

$$\frac{\gamma C_t}{1-N_t^T - N_t^N - S_t} = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(1+\mu)} (1-\alpha) A_t^T \exp(z_t^T) (\frac{K_t^T}{N_t^T H_t^T})^{\alpha} H_t^T \quad (C.95)$$

$$\frac{\gamma C_t}{1-N_t^T - N_t^N - S_t} = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} (1-\omega)(C_t^N)^{-(1+\mu)} (1-\theta) A_t^N \exp(z_t^N) \left(\frac{K_t^N}{N_t^N H_t^N}\right)^{\theta} H_t^N \quad (C.96)$$

$$\frac{\gamma C_t}{(1-N_t^T - N_t^N - S_t)([\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}-1} \omega(C_t^T)^{-(1+\mu)})} = \frac{\eta_1 I_t^h}{\eta_2 S_t} \quad (C.97)$$

$$S_t + N_t^T + N_t^N + L_t = 1 \quad (C.98)$$

$$C_t = [\omega(C_t^T)^{-\mu} + (1-\omega)(C_t^N)^{-\mu}]^{-\frac{1}{\mu}} \quad (C.99)$$

$$C_t^T + I_t^k + I_t^h = Y_t^T + F \exp(z_t^F) \quad (C.100)$$

$$C_t^N + G_t + I_t^{gh} = Y_t^N \quad (C.101)$$

$$K_{t+1} = I_t^k + (1-\delta_k) K_t - \frac{\emptyset}{2} (\frac{K_{t+1}}{K_t} - 1)^2 K_t \quad (C.102)$$

$$H_{t+1} = A_t^h S_t^{\eta_1} I_t^{h\,\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2} + (1-\delta_h) H_t \quad (C.103)$$

$$K_t = [(K_t^T)^{-\nu_k} + (K_t^N)^{-\nu_k}]^{\frac{-1}{\nu_k}} \quad (C.104)$$

$$H_t = [(H_t^T)^{-\nu_h} + (H_t^N)^{-\nu_h}]^{\frac{-1}{\nu_h}} \quad (C.105)$$

$$P_t^N = (\frac{1-\omega}{\omega}) (\frac{C_t^N}{C_t^T})^{-(1+\mu)} \quad (C.106)$$

$$Y_t^T = A_t^T \exp(z_t^T) K_t^{T\alpha} (N_t^T H_t^T)^{1-\alpha} \quad (C.107)$$

$$Y_t^N = A_t^N \exp(z_t^N) K_t^{N\theta} (N_t^N H_t^N)^{1-\theta} \quad (C.108)$$

$Y_t = Y_t^T + P_t^N Y_t^N$ (C.109)

Let $g_Y, g_{Y^T}, g_{Y^N}, g_C, g_{C^T}, g_{C^N}$ $g_{I^k}, g_{I^h}, g_L, g_{N^T}, g_{N^N}, g_S, g_K, g_{K^T}, g_{K^N}, g_H, g_{H^T}$, and g_{H^N} be the growth rates of the variables $Y_t, Y_t^T, Y_t^N, C_t, C_t^T, C_t^N$ $I_t^k, I_t^h, L_t, N_t^T, N_t^N, S_t, K_t, K_t^T, K_t^N, H_t, H_t^T$, and H_t^N, respectively. Since L_t, N_t^T, N_t^N, and S_t are bounded between 0 and 1 (equation C.98), this implies that their growth rate along the BGP is zero (i.e. $g_L = g_{N^T} = g_{N^N} = g_S = 0$). I need to show that in our model with human capital all the other variables along the BGP should be stationary for an exogenous growth model. I_t^{gh}, G_t , and F*exp(z_t^f) are exogenous variables and their growth rates are zeros in the model.

Marginal productivities of physical and human capital and relative price of non-tradable goods are stationary along the BGP. From (C.93), (C.94) and (C.106), $\frac{K_t^T}{N_t^T H_t^T}, \frac{K_t^N}{N_t^N H_t^N}, \frac{K_t^T}{K_t^N}, \frac{H_t^T}{H_t^N}$, and $\frac{C_t^N}{C_t^T}$ should be constant, this implies that:

$$g_{C^T} = g_{C^N} = g_{K^T} = g_{K^N} = g_{H^T} = g_{H^N}.$$

In (C.99), $C_t = C_0(1+g_C)^t$, $C_t^T = C_0^T(1+g_{C^T})^t$, and $C_t^N = C_0^N(1+g_{C^N})^t$ and to satisfy equation (C.99), thus $g_C = g_{C^T} = g_{C^N}$.

In (C.104), $K_t = K_0(1+g_K)^t$, $K_t^T = K_0^T(1+g_{K^T})^t$, and $K_t^N = K_0^N(1+g_{K^N})^t$ and to satisfy equation (C.104), thus $g_K = g_{K^T} = g_{K^N}$.

In (C.105), $H_t = H_0(1+g_H)^t$, $H_t^T = H_0^T(1+g_{H^T})^t$, and $H_t^N = H_0^N(1+g_{H^N})^t$ and to satisfy equation (C.104), thus $g_H = g_{H^T} = g_{H^N}$.

In (C.95), $C_t = C_0(1+g_C)^t$, $C_t^T = C_0^T(1+g_{C^T})^t$, $C_t^N = C_0^N(1+g_{C^N})^t$, and $H_t^T = H_0^T(1+g_{H^T})^t$ and to satisfy equation (C.95), thus $g_C = g_{C^T} = g_{C^N} = g_{H^T}$.

In (C.95), $C_t = C_0(1+g_C)^t$, $C_t^T = C_0^T(1+g_{C^T})^t$, $C_t^N = C_0^N(1+g_{C^N})^t$, and $H_t^N = H_0^N(1+g_{H^N})^t$ and to satisfy equation (C.95), thus $g_C = g_{C^T} = g_{C^N} = g_{H^N}$.

In (C.97), $C_t = C_0(1+g_C)^t$, $C_t^T = C_0^T(1+g_{C^T})^t$, $C_t^N = C_0^N(1+g_{C^N})^t$, and $I_t^h = I_0^h(1+g_{I^h})^t$ and to satisfy equation (C.97), thus $g_C = g_{C^T} = g_{C^N} = g_{I^h}$.

In (C.107), $Y_t^T = Y_0^T(1+g_{Y^T})^t$, $K_t^T = K_0^T(1+g_{K^T})^t$, and $H_t^T = H_0^T(1+g_{H^T})^t$, since $g_{K^T} = g_{H^T}$ this implies that $g_{K^T} = g_{H^T} = g_{Y^T}$.

In (C.108), $Y_t^N = Y_0^N(1+ g_{Y^N})^t$, $K_t^N = K_0^N(1+ g_{K^N})^t$, and $H_t^N = H_0^N(1+ g_{H^N})^t$, since $g_{K^N} = g_{H^N}$ this implies that $g_{K^N} = g_{H^N} = g_{Y^N}$.

In (C.109), $Y_t = Y_0(1+g_Y)^t$, $Y_t^T = Y_0^T(1+ g_{Y^T})^t$, and $Y_t^N = Y_0^N(1+ g_{Y^N})^t$ and to satisfy equation (C.109), thus $g_Y = g_{Y^T} = g_{Y^N}$.

In (C.100), $C_t^T = C_0^T(1+ g_{C^T})^t$, $I_t^k = I_0^k(1+g_{I^k})^t$, and $Y_t^T = Y_0^T(1+ g_{Y^T})^t$ and to satisfy equation (C.100), thus $g_{C^T} = g_{Y^T} = g_{I^k}$.

In (C.101), $C_t^N = C_0^N(1+ g_{C^N})^t$, $I_t^h = I_0^h(1+g_{I^h})^t$, and $Y_t^N = Y_0^N(1+ g_{Y^N})^t$ and to satisfy equation (C.101), thus $g_{C^N} = g_{Y^N} = g_{I^h}$.

In (C.92), $\eta_1 A_t^h {S_t}^{\eta_1 - 1} {I_t^h}^{\eta_2} (\exp(z_t^h) I_t^{gh})^{1-\eta_1-\eta_2}$ is the marginal productivity of study hours and it is stationary along the BGP. To satisfy equation (C.92),

$\frac{N_{t+1}^T}{H_{t+1}^T\left[(H_{t+1}^T)^{-\nu_h}+(H_{t+1}^N)^{-\nu_h}\right]^{\frac{-1}{\nu_h}-1}(H_{t+1}^T)^{-(\nu_h+1)}}$ should be constant along BGP, thus $g_{N^T} = g_{H^T} = g_{H^N} = 0$.

Therefore, $g_Y = g_{Y^T} = g_{Y^N} =$
$g_C = g_{C^T} = g_{C^N} = g_{I^k} = g_{I^h} = g_L = g_{N^T} = g_{N^N} = g_S = g_K = g_{K^T} = g_{K^N} = g_H = g_{H^T} = g_{H^N} = 0$.

Thus, all the variables are stationary along the balanced growth path, indicating that the present model exhibits an exogenous growth behavior.

C.6- Technology Parameters' Estimates

The technology parameters (α and θ) are estimated from the Kenyan national accounts data on production accounts by industry, sectoral factor payments, and GDP at factor cost for the period 1990–2014 (See Tables C1 and C2). The share of labor in the industry[185] and service sectors value added (treated as non-tradable output) is straight forward, and it is estimated at 1 - θ = 0.55. The computation of the share of labor in the agricultural sector (tradable sector) is not straight forward, due to the poor accounting system in the agricultural and forestry sectors. Odhiambo et al. (2004) estimate that around 70-75% of the total agricultural products are produced by small-scale farms, which are characterized by low productivity and the usage of primitive technologies. The data

[185] Manufacturing included.

available for the agricultural and forestry sectors compensation of employees represents 10-15% of the total value added of agricultural and forestry outputs; the rest goes to gross operating surplus and gross mixed income. Since it is hard to differentiate between gross operating surplus and gross mixed income in Kenyan national accounts data; I assume that 70% of the gross operating surplus and gross mixed income is the share of labor in the small-scale farms. Upon using this assumption, I estimate the share of income in the agricultural sector at $1 - \alpha = 0.65$[186].

The values of physical capital shares in the tradable and non-tradable sectors (α and θ) are estimated to be 0.35 and 0.45, respectively. These estimates show that the non-tradable sector is physical capital intensive and the tradable sector is human capital intensive.

Table C1: Estimates of labor and capital share in Kenyan agricultural output

year	Agr. lab	Agr. cap	Agr.	lab share	cap share
1990	21820	54330.4	76150.4	0.2865382	0.7134618
1991	23498.2	60277.2	83775.4	0.2804905	0.7195095
1992	25748.2	68627.6	94375.8	0.2728263	0.7271737
1993	28618.2	87030.4	115648.6	0.2474582	0.7525418
1994	33232.8	106597.8	139830.6	0.2376647	0.7623353
1995	39272.4	130551.4	169823.8	0.2312538	0.7687462
1996	46011.2	143874.2	189885.4	0.2423104	0.7576896
1997	53039.2	159214.8	212254	0.2498855	0.7501145
1998	64518.6	178727.8	243246.4	0.2652397	0.7347603
1999	69796.2	172144.94	241941.14	0.2884842	0.7115158
2000	77865.47	159509.02	237374.49	0.328028	0.671972
2001	72853	315964	388817	0.1873709	0.8126291
2002	77591	297059	374650	0.2071026	0.7928974
2003	84600	324605	409205	0.2067423	0.7932577
2004	92994	359408	452402	0.2055561	0.7944439
2005	101587	402570	504157	0.2014987	0.7985013
2006	116394	394239	510633	0.2279406	0.7720594
2007	121495	413929	535424	0.2269136	0.7730864
2008	126246	492699	618945	0.2039697	0.7960303
2009	146205	580655	726860	0.201146	0.798854
2010	181978	987678	1169656	0.1555825	0.8444175
2011	209361	1241054	1450415	0.1443456	0.8556544
2012	229942	1400048	1629990	0.1410696	0.8589304
2013	267389	1529897	1797286	0.1487738	0.8512262
2014	309065	1735112	2044177	0.1511929	0.8488071
Averages				0.2215754	0.7784246

[186] $1 - \alpha = (0.7*0.78) + 0.1 = 0.646$

Table C2: Estimates of labor and capital share in Kenyan industrial and services (I & S)sectors

year	(I&S) lab	(I&S) cap	(I&S)	lab share	cap share
1990	52958.136	41698.664	94656.8	0.55947524	0.440524759
1991	59089.876	53003.924	112093.8	0.52714669	0.472853307
1992	73281.132	64445.468	137726.6	0.53207682	0.467923175
1993	87010.264	67522.936	154533.2	0.56305224	0.436947763
1994	116348.184	69901.016	186249.2	0.62469092	0.375309081
1995	140174.728	79111.672	219286.4	0.63923129	0.360768712
1996	140931.144	118116.056	259047.2	0.54403655	0.455963454
1997	170019.756	132738.044	302757.8	0.56157019	0.438429808
1998	207359.656	159523.144	366882.8	0.56519318	0.434806821
1999	226270.134	153949.586	380219.72	0.59510363	0.404896373
2000	254068.525	180776.245	434844.77	0.58427407	0.415725926
2001	297795.68	219238.32	517034	0.57596924	0.42403076
2002	319487.08	213066.92	532554	0.5999149	0.400085099
2003	349148.34	257168.66	606317	0.57585115	0.424148853
2004	391246.54	307030.46	698277	0.56030277	0.439697226
2005	427278.26	363534.74	790813	0.54030252	0.459697476
2006	515704.82	514286.18	1029991	0.50068867	0.499311334
2007	577955.44	498316.56	1076272	0.53699756	0.463002438
2008	614613.2	619896.8	1234510	0.49786004	0.502139958
2009	685261.06	661391.94	1346653	0.50886239	0.491137613
2010	857762.58	800016.42	1657779	0.51741672	0.482583276
2011	951096.6	946483.4	1897580	0.50121555	0.498784452
2012	1062452.16	1136655.84	2199108	0.48312869	0.516871313
2013	1234473.22	1220887.78	2455361	0.50276649	0.497233515
2014	1400013.22	1393147.78	2793161	0.50122897	0.498771027
Averages				0.54793426	0.452065741

C.7- Technology and Government Expenditure Shocks

C.7.1- Technology Shocks[187] (TFP Shocks)

Figure C1 reports the impacts of a positive one-standard-deviation technology shock for the corresponding impulse response functions. Given that both shocks are perfectly correlated, the dynamics of the relative price of non-tradable goods is determined by physical capital investment. For instance, when a positive TFP shock hits the economy, the tradable and non-tradable outputs increase, causing total output to increase. Higher productivity declines the marginal cost of physical capital, inducing the representative agent to increase physical capital investment. Thus, the representative agent smooths his consumption behavior and the balance is restored by investing in physical and human capital. The response of physical capital investment is 3.6 times that of private human capital investment. Consequently, both the tradable and non-tradable consumptions increase and the relative price of non-tradable goods decline.

The decline in the relative price causes a reallocation of resources between sectors; the tradable labor, tradable physical capital, and tradable human capital increase on impact. On the other hand, the depreciation of the relative price of non-tradable goods causes non-tradable labor, non-tradable physical capital, and non-tradable human capital to decrease. However, total labor supply increases as a result of the TFP shocks due to higher marginal productivity of labor; time devoted to acquire new skills declines due to the high opportunity cost of studying. Furthermore, a TFP shock has a positive impact on the marginal productivity of study hours that increases on impact and stays above trend for a long period of time. The high marginal productivity of labor and the high marginal productivity of study hours are the two forces facing the representative agent in determining the optimal allocation of his time among labor, leisure, and study hours.

A positive TFP shock leads to a pro-cyclical behavior for employment, the tradable and non-tradable outputs, tradable and non-tradable consumptions, and physical and private human capital investment. The study time is found to be counter-cyclical which is consistent with Dejong and Ingram (2001).

[187] Tradable and non-tradable productivity shocks are perfectly correlated.

C.7.2- Government Expenditure Shock

In this sub-section, I provide the impact of a positive one-standard-deviation government expenditure shock to some selected stationary variables, which are shown in Figure C2 below. Government expenditure shock can easily alter the non-tradable consumption, causing the relative price of non-tradable goods to increase. The relative price appreciation reallocates the resources from the tradable sector to the more profitable sector, the non-tradable sector. Thus, non-tradable labor supply increases at the expense of tradable labor, causing the non-tradable output to increase and the tradable output to shrink. Total labor supply increases at the expense of study and leisure time, leading to an increase in total output. In addition, there is a reduction in total consumption, private human capital investment, and physical capital investment. Finally, the marginal productivity of study hours increases on impact.

Figure C1: Impulse responses to a positive one-standard-deviation TFP shock

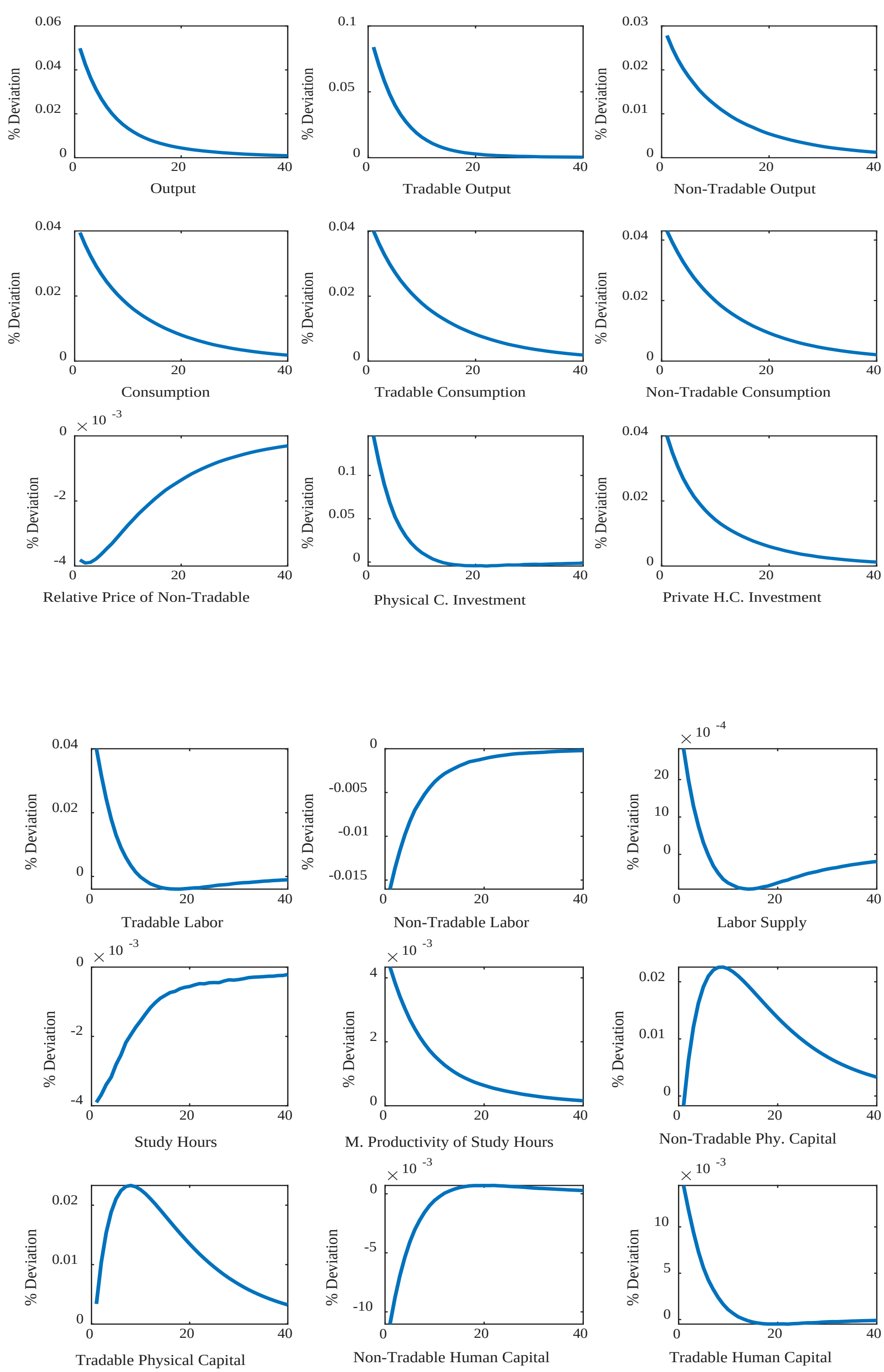
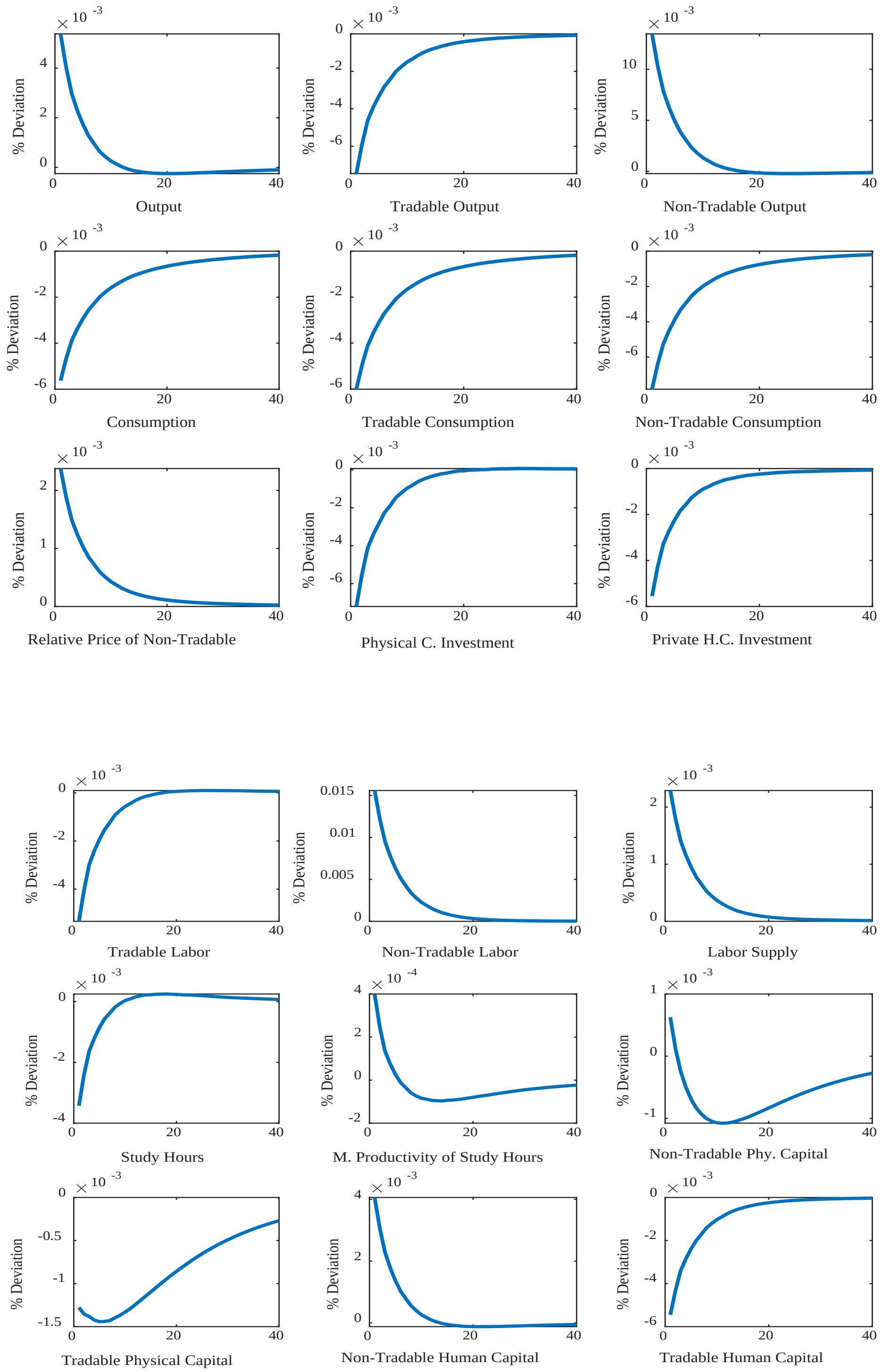


Figure C2: Impulse responses to a positive one-standard-deviation government expenditure shock



C.8- Stationarity and Rank Tests

Table C3.1: Augmented Dickey-Fuller unit root test

Variable	Level	I(1) vs I(0)	Lags		1st Diff	I(2) vs I(1)	Order
aid	-1.72	Don't reject	0	D+T	-7.41***	Reject	I(1)
gdp	-2.97	Don't reject	1	D+T	-6.05***	Reject	I(1)
trad	-2.05	Don't reject	0	D+T	-8.94***	Reject	I(1)
p^T	-2.78	Don't reject	1	D+T	-6.13***	Reject	I(1)
p^{NT}	-2.17	Don't reject	0	D+T	-4.49***	Reject	I(1)

***,**,* represent significant at 1, 5, and 10% respectively; D for drift, T for trend

Critical values (D+T): -4.178 (1%), -3.513 (5%) and -3.186 (10%)

Critical Values (D): -3.58 (1%), -2.930 (5%) and -2.603 (10%)

The ADF critical values are based on McKinnon (1991), optimal lag length (SIC)

Table C3.2: Phillips-Perron unit root test

Variable	Level	I(1) vs I(0)		1st Diff	I(2) vs I(1)		Order
aid	-1.83	Don't reject	D+T	-7.41***	Reject	D	I(1)
gdp	-2.37	Don't reject	D+T	-6.05***	Reject	D	I(1)
trad	-1.87	Don't reject	D+T	-8.82***	Reject	D	I(1)
P^T	-2.91	Don't reject	D+T	-6.26***	Reject	D	I(1)
P^{NT}	-2.83	Don't reject	D+T	-4.97***	Reject	D	I(1)

***,**,* represent significant at 1, 5, and 10% respectively; D denotes for drift and T for trend

Critical values (D+T): -4.178(1%), -3.513(5%) and -3.186(10%)

Critical Values (D): -3.58 (1%), -2.930 (5%) and -2.603 (10%)

Table C3.3: KPSS Unit Root Test Results

Variable	Level	I(0) vs I(1)		1st Diff	I(1) vs I(2)		Order
aid	0.152**	Reject	D+T	0.098	Don't reject	D	I(1)
gdp	0.193**	Reject	D+T	0.35	Rej at 10%	D	I(1)
trad	0.223***	Reject	D+T	0.345	Don't reject	D	I(1)
P^T	0.187**	Reject	D+T	0.202	Don't reject	D	I(1)
P^{NT}	0.194**	Reject	D+T	0.215	Don't reject	D	I(1)
Asymptotic critical values			D+T		D		
Level	1%		0.216		0.739		
	5%		0.146		0.463		
	10%		0.119		0.347		

***,**,* represent significant at 1, 5, and 10% respectively; D for drift and T for trend

Table C3.4: Perron test for exogenous structural break

Country	Variable	Break Type	Break Year	Outlier Type	t-statistics	Order
Kenya	*aid*	Intercept	1995	IO	-3.11 (0.87)	I(1)

p-value in parentheses and depends on the time of break

Table C3.5: Zivot-Andrews test for endogenous Structural Break

Country	Variable	Break Type	Break Year	t-statistics	Order
Kenya	*aid*	Intercept	1996	-4.62	I(1)
Critical	Intercept		Trend		Both
Value 5%	-4.8		-4.42		-5.08

Table C4: Trace test of cointegration rank

p-r	r	Eig.Value	Trace	Trace*	Frac95	P-Value	P-Value*
5	0	0.644	112.637	105.993	97.792	0.003	0.012
4	1	0.426	64.159	61.276	72.202	0.173	0.255
3	2	0.319	38.073	36.874	49.028	0.361	0.421
2	3	0.29	20.032	19.658	30.866	0.474	0.5
1	4	0.081	3.951	3.926	14.888	0.901	0.903

Trend assumption: Unrestricted constant and restricted linear deterministic trend;
*: the Bartlett small sample corrected test statistic
Frac95: 5% critical value of the test of H(r) against H(p)
The critical values and p-values are simulated under break
Proportion of the break differs from one country to another