Hacettepe University Graduate School Of Social Sciences

Faculty of Economics and Administrative Sciences

Department of Economics

ECONOMIC GROWTH IN SUB-SAHARAN AFRICA: A VIEW FROM UNIFIED GROWTH THEORY

Ataman İçer

Master’s Thesis

Ankara, 2017

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Bu çalışmadaki bütün bilgi ve belgeleri akademik kurallar çerçevesinde elde ettiğimi, görsel, işitsel ve yazılı tüm bilgi ve sonuçları bilimsel ahlak kurallarına uygun olarak sunduğumu, kullandığım verilerde herhangi bir tahrifat yapmadığımı, yararlandığım kaynaklara bilimsel normlara uygun olarak atıfta bulunduğumu, tezimin kaynak gösterilen durumlar dışında özgün olduğunu, Yard. Doç. Dr. Mustafa Aykut ATTAR danışmanlığında tarafımdan üretildiğini ve Hacettepe Üniversitesi Sosyal Bilimler Enstitüsü Tez Yazım Yönergesine göre yazıldığını beyan ederim.

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DEDICATION

I want to dedicate this thesis to my lovely students, who look after this study more than me, for being source of motivation of my life and for giving novel touches to my life.

ABSTRACT

İÇER, Ataman. *Economic Growth in Sub-Saharan Africa: A View From Unified Growth Theory,* Master's Thesis, Ankara, 2017

Economic growth in Sub-Saharan Africa (SSA) has been one of the main concerns of economic growth literature. There was no economic growth in SSA until several decades. This study attempts to explain the causes of earlier stagnation and recent growth in the region via households' decisions on the child quantity-quality (Q-Q) tradeoff. After reviewing the literature on growth economics, we show why Unified Growth Theory (UGT) is potentially useful to understand the experience of SSA economies. The canonical model of UGT defines modern growth as a regime where productivity growth and education has virtuous circle and where increases in education lead to decreases in fertility. To test whether SSA economies exhibit modern growth a la UGT, we use Ordinary Least Squares (OLS) and Instrumental Variables (IV). Our results verify that, for 27 countries in SSA and for the period of 1960-2010 education has a strong and causal negative effect on fertility. Besides, this result is robust to the addition of several controls. Another important result is on the threshold effects. When we divide our sample into low-education and high-education groups, the child Q-Q tradeoff is active in high-education group. Therefore, there perhaps exists a level of education above which fertility declines causally as a response to increasing educational attainment. Lastly, differenced and system Generalized Method of Moments (GMM) estimations show that high fertility rates are traditional in SSA as lagged fertility is positive and significant, but it does not remove the negative causal effect of education on fertility.

Keywords

Unified Growth Theory, Malthusian Regime, Post-Malthusian Regime, Modern Growth Regime, Sub-Saharan Africa, education, fertility, quantity-quality tradeoff, Instrumental Variable, Generalized Method of Moments

TABLE OF CONTENTS

ACCEPTANCE AND APPROVAL……………..……………………….……………i

DECLARATION………………………………………………………….……....ii

YAYINLAMA VE FİKRİ MÜLKİYET BEYANI…………………………….…iii

ETİK BEYAN……….…...………………………………………………….…iv

ACKNOWLEDGEMENT…………………….……………………………….……v

DEDICATION……………………………………………………………….....vi

ABSTRACT………………………………………….………..……………vii

TABLE OF CONTENTS……………………………………..………………...viii

LIST OF TABLES……………………………………………………..……………xi

LIST OF FIGURES……………………………………………………………...xii

CHAPTER 1: INTRODUCTION………………………………………………….…1

CHAPTER 2: THE RISE OF THE UNIFIED GROWTH THEORY…………..…4

2.1 Early Theories and Thoughts…………………….……………………..5

2.1.1 Smith……………………………………….…………........7

2.1.2 Malthus and Ricardo………...……………………….……………8

2.1.3 Marx……………………….………………………….……..10

2.1.4 Schumpeter……………………………………………………..10

2.2 The Genesis of the Modern Theories: The Harrod-Domar Model…….11

2.3 The Neoclassical Economic Growth Models………………………….....12

2.3.1 The Solow-Swan Model………………………..………………13

2.3.2 The Ramsey-Cass-Koopmans Model………………..……………14

2.4 Endogenous Growth Theory……………………………….……….…15

2.4.1 Marshallian Externalities…………………………………….…...15

2.4.2 Schumpeterian Innovations…………………………………….....16

2.5 Poverty Traps…...17

2.6 The Unified Growth Theory…………………………….…….….….20

CHAPTER 3: STAGNATION AND GROWTH IN THE UNIFIED GROWTH THEORY……………………………………………………………………...22

3.1. THE MODEL ENVIRONMENT…………………………..………23

3.1.1. Demographic Structure……………………………….…….24

3.1.2. Endowments…………………..……………………………24

3.1.3. Preferences……………………..…………………………24

3.1.4. Technologies……………………………….……………..…25

3.2. THE DECISION PROBLEM………………………..……………..26

3.3 THE THREE REGIMES…………………………..………..…28

3.3.1 The Malthusian Regime……………………………….……….28

3.3.2 The Post-Malthusian Regime……………………………......29

3.3.3 The Modern (or Sustained) Growth Regime………..……….…30

3.4. Other Unified Growth Dynamics……….………………………….31

CHAPTER 4: STAGNATION AND GROWTH IN SUB-SAHARAN ECONOMIES: MAIN PATTERNS AND REGULARITIES…………………..…..32

4.1 A Brief Review of the Literature………………………….………..…32

4.2 Estimates of Economic Growth and Stability……………………..………..35

4.3 The Dynamics of Education and Fertility…………………………..…39

4.4 A Concluding Remark………………………..……………………..42

CHAPTER 5: THE CHILD QUANTITY-QUALITY TRADEOFF IN SUB-SAHARAN AFRICA……………………………………..………………...44

5.1. INTRODUCTION…………………………………………….…………44

5.2 RELATED LITERATURE……………………………………...….48

5.3. EDUCATION AND FERTILITY IN SUB-SAHARAN AFRICA…….50

5.4 METHODOLOGY AND DATA………………………….……..……….53

5.4.1 Methodology……………………………………………….………..53

5.4.2 Data…………………………………………………………….……56

5.5 RESULTS………………...…………………………….…………….59

5.6. THRESHOLD EFFECTS……………………………….…………….....66

5.7 DYNAMICS MODEL OF FERTILITY AND EDUCATION……….....72

5.8 CONCLUDING REMARKS..76

CHAPTER 6: CONCLUSION…………..………………………………..……79

REFERENCES...82

APPENDIX 1: TEZ ÇALIŞMASI ORJİNALLİK RAPORU………………….……..92

APPENDIX 2: ETİK KURUL İZNİ MUAFİYET FORMU……………………….94

LIST OF TABLES

Table 1: Average Growth Rates in SSA……………………………..………………36

Table 2: Correlation Matrix of Variables……………………………….…………...50

Table 3: Summary Statistics……………………………………………….……...57

Table 4: OLS: The Effect of Education on Fertility……………………..……………..60

Table 5: First Stage of Random Effect IV Estimations for Whole SSA…….…………61

Table 6: Second Stage of Random Effect IV Estimations for Whole SSA………..…...62

Table 7: First Stage of Fixed Effect IV Estimations for Whole SSA………………..…64

Table 8: Second Stage of Fixed Effect IV Estimations for Whole SSA…………….....65

Table 9: First Stage of Random Effect IV Estimations for Low-Level Education Group……………………………………………………………….………………..67

Table 10: Second Stage of Random Effect IV Estimations for Low-Level Education Group…………………………………………………………………………...…68

Table 11: First Stage of Random Effect IV Estimations for High-Level Education Group…………………………………………………………………………...70

Table 12: Second Stage of Random Effect IV Estimations for High-Level Education Group………………………………………………………………...………71

Table 13: Difference GMM Estimations…………………………………………….…73

Table 14: System GMM Estimations………………………………………………..75

LIST OF FIGURES

Figure 1: The Patterns of GDP per capita in SSA ……………………………….…….38

Figure 2: The Patterns of Education in SSA……………………………….……....…..40

Figure 3: The Patterns of Fertility in SSA………………………………..…………41

Figure 4: Correlation among Variables…………………………….………….…….46

Figure 5: Bivariate Kernel Density of Education and Fertility for 1960……………......52

Figure 6: Bivariate Kernel Density of Education and Fertility for 1960……………......52

CHAPTER 1

INTRODUCTION

Economic growth in Africa is one of the most attractive issues in the literature. Economists have always been interested in why the African case is a growth tragedy. A set of early papers have investigated the causes of poverty and stagnation especially in Sub-Saharan Africa (SSA). This literature has largely focused on *geography and diseases*, on the one hand, and on *institutions and policies*, on the other hand. This literature has obtained mixed results but it is hard to diminish the roles of geography or institutions. A selective list of studies includes those of Sachs and Warner (1997), Easterly and Levine (1997), Gallup and Sachs (2001), Bertocchi and Canova (2002), and, the last but not the least, Acemoglu and Robinson (2010).

More recent discussion is centered on the case of growing economies in SSA. From one side of the discussion, Young's (2012) influential paper shows that real consumption growth rate is about 3.4% to 3.7% per annum for 29 SSA countries for the 1990-2006 period. This raises the question of whether African growth is tragedy or will be over. Rodrik (2014), on the other hand, argues that growth in SSA is not of a modern character because the fast growing economies in the recent decade do not support this growth via structural transformation.

This thesis answers the question of whether SSA is out of the poverty trap using Unified Growth Theory (UGT). While there are several models of economic growth in the literature, we argue why UGT first developed by Galor and Weil (2000) and then refined and extended by Galor (2005, 2011) is an appropriate framework for explaining stagnation and growth patterns in SSA. In the remainder of this chapter, we summarize the main contents of the thesis and the results we have obtained.

Chapter 2 summarizes the history of economic growth theory. Our aim in Chapter 2 is to show that why it is appropriate to use the UGT to explain Sub-Saharan economic growth and stagnation. Beginning with Aristotle and Plato, Chapter 2 clarifies the reasons behind why the UGT has become an influential theory of economic growth in the 21st century. This theory considers all phases of stagnation and growth and unifies them within a single framework. At the end of Chapter 2, we will have showed that how the literature on economic growth reaches the UGT both from an historical and from a methodological perspective.

Chapter 3 briefly summarizes the canonical UGT developed first by Galor and Weil (2000) and then refined by Galor (2005, 2011). In Chapter 3, we introduce the theory through individual preferences, endowments, and technologies. The analysis is therefore mathematical. The solution of the main optimization problem of interest shows us that there can be three different regimes at which the static equilibrium of the economy can be. Then, the sequence of all static equilibria defines the dynamic equilibrium of the model. Exactly which regime prevails depend on state variables that determine consumption, fertility, and education decisions. After introducing this canonical model, we discuss some other unified growth dynamics at the end of Chapter 3.

The objective of Chapter 4 is to summarize the main patterns and regularities of growth, education, and fertility in SSA. The case of SSA economies in terms of economic development has been tragic. However, there are now growing economies in SSA. Chapter 4 first presents a brief review of the literature on African economic growth and development. It then provides a specialized look on the dynamics in terms of how real GDP per capita, education, and fertility have changed. The end result is that the dynamics of growth, fertility, and education in SSA show that UGT is a highly relevant theoretical framework to understand stagnation, growth, and the transition from former to the latter in SSA.

Building on the notion that fertility decisions depend on educational investment on children, Chapter 5 investigates whether the quality-quantity (Q-Q) tradeoff is relevant in understanding the determinants of economic growth in SSA. Using total fertility rate (TFR) and average years of schooling (AYS) as proxies for fertility and education respectively, Chapter 5 estimates panel regressions for 27 countries for the period of 1960-2010. Results are as follow: First, education is an endogenous determinant of fertility. Second, Two Stage Least Squares estimations with education being instrumented with population density and years since independence indicate that education has a robust and causal negative impact on fertility. When the sample of countries is divided into low-education and high-education groups, the Q-Q tradeoff is much more effective in the high-education group, confirming that there exist threshold effects. Finally, Generalized Method of Moments (GMM) estimations of a dynamic model where lagged fertility positively affects current fertility through cultural persistence show that the causal negative effect is robust.

In Chapter 6 that concludes the thesis, we provide a brief summary of main messages and describe how the analysis presented in this thesis can be extended in different ways.

Chapter 2

THE RISE OF THE UNIFIED GROWTH THEORY

Early theories and thoughts regarding economic growth start in ancient times and cover Aristotle and Plato. Ibn Khaldun and David Hume are two other philosophers who have thought about growth and development. Economics under the name of political economy, on the other hand, has become a branch of science only with Adam Smith's ideas on the wealth of nations. After Adam Smith, David Ricardo, and Thomas Malthus, economic thought has become more systematic towards the end of the eighteenth century, and progress in the following decades has been impressive.

Political economists have been interested in the creation and distribution of wealth. But 1870s have witnessed the rise of neoclassical theory that emphasizes (Pareto) efficiency. Neoclassical economists have not pursued research programs dealing with economic growth problems. Growth has not been handled as a separate field of economics until the 20th century. In mid-1900s, Harrod (1939) and Domar (1946) have touched on this subject from a Keynesian perspective and with concerns on long-run stability of capitalist accumulation; they have led to a new and systematic analysis of economic growth.

Early growth literature, e.g., Solow's (1956, 1957) analysis, finds that the source of long-run economic growth is exogenous productivity growth. Searching for endogenous sources of economic growth has therefore been a priority for theorists. Romer (1986, 1990), Lucas (1988), Grossman and Helpman (1991), and Aghion and Howitt (1992) have proposed several mechanisms to make growth endogenous. On the other hand, some other economists have been trying to find out the reasons behind stagnation and poverty. Azariadis and Stachusrki's (2005) survey on poverty traps identify several such reasons including human capital trap. Becker et al. (1990) for example demonstrate that why high fertility and no education equilibrium is a poverty trap.

Unified growth theorists argue that it is problematic to explain economic growth and stagnation with different models. The convincing argument underlines the continuity in economic history; today's developed societies with sustained growth paths have been poor and stagnating economies of preindustrial times. Therefore, the task for the growth theorist must be to develop a unified model that predicts an endogenous transition from stagnation to growth. At the end of this chapter, we will have showed that the UGT fulfills this objective.

The remainder of this chapter is organized as follows: Section 2.1 summarizes early theories and thoughts. Section 2.2 presents a discussion of why the Harrod-Domar model is the genesis of modern growth theories. Section 2.3 introduces the neoclassical growth models. Sections 2.4 and 2.5 respectively summarize endogenous growth and poverty trap literatures. The last section of this chapter, Section 2.6, introduces UGT and concludes the chapter with some remarks on methodology.

2.1 EARLY THEORIES AND THOUGHTS

Economics has always been a matter of philosophy since ancient times. Most of the early philosophers have some ideas about economic progress. A selective list would include Aristotle, Plato, Ibn Khaldun, and Hume. The interesting thing is that even ancient philosophers were interested in and understood the importance of technology and demography.

Walford and Gillies (1853) explain Aristotle's views on economic phenomena. In his book *Oeconomica*, Aristotle describes the economy and gives some clues about population (Walford and Gillies, 1853). An economy consists of households, and the main producers in an economy are men. A man and his properties including his slaves form a household. Then, the man finds a wife where there are some duties for both husbands and wives. The man produces consumption goods in his land for sustaining the life of family members and also feeds his slaves. Meanwhile, the wife treats her husband with respect and helps him bear children. The man should have children to be taken care of when old. Furthermore, the husband and his wife should educate their children both about production and honor. This is the subject matter of economics. Thus, we can say that Aristotle was aware of the importance of fertility, education, and the old-age security. More importantly, he claims that sustained economic progress is possible with a nonnegative population growth rate.

Plato (2003) designs an ideal state in his books in a theatric way, and he argues for a class system in this ideal state. Specifically, there should be three classes; rulers, warriors, and workers. The most important class is the class of workers since they provide the needs of all the other classes. Plato (2003) is well aware of the importance of population. He claims that population growth rate must be at the replacement level for a stagnant economy. If all individuals have children, then these children pursue their fathers' job, and so there will be no scarcity in any sector or class. Even if there is a rigid class structure, an individual can transit from one class to another with a good education. Therefore, fertility and education are important issues in Plato's thought.

Ibn Khaldun is an important figure since he is the first thinker who considered technology, specialization, and foreign trade in a systematic way. Ali (2006) explains the economic thought of Khaldun. According to this account, Khaldun gives importance to the division of labor where labor force is the main factor of production in Khaldun's economics. An individual cannot produce all of his necessities by himself, and collective work can produce more output than the sum of output produced alone. This is of course possible with the division of labor. If every individual concentrates on one part of a work, then the productivity of them expands. On the other hand, Khaldun claims that the division of labor is limited with population size, the degree of civilization, and the wideness of market. International trade is important since the division of labor becomes more beneficial if the market size expands. Lastly, the division of labor remains limited in countries with low levels of population because of the lack of opportunity of dividing works between workers. Henceforth, Khaldun's claim is the division of labor is more possible and beneficial with high population growth rate.

Hume's ideas are also important for UGT. McGee (1989) briefly explains Hume's economic views. The source of value is labor according to Hume, and he rejects Montesquieu's (1989) claim that the world population had fallen since ancient times. Hume claims that factors such as poverty puts a pressure on population growth rate, and this idea is seen later in the view of other economists such as Malthus. McGee (1989) claims that Hume was interested in wealth rather than growth. Hume understands wealth as the consumption of different types of products. Because of difference in climate in different regions, it is not possible for a country to produce so many different products. Therefore, Hume refers to trade for wealth. He refutes the idea that trade increases the wealth of one of the trading parties and reduces the other; trade is a win-win situation. Henceforth, trade creates wealth and trading countries are wealthier than those who do not.

2.1.1 Smith

In Smithian economics, the volume of output is determined by the stock of capital, the labor force, and the level of technology. Capital is defined as a factor that increases the labor productivity. If one of these factors increases ceteris paribus, it leads to an increase in output. Colander and Landreth (1994) explain Smith's thought. According to Smith, as the population increase, it is possible to produce more output in an economy. We can see the importance of population in Smithian economics from this point of view.

The important aspect of Smithian economics is technology and the division of labor. If something is true for an individual, then it is also true for the whole economy (Colander and Landreth, 1994). In *The Wealth of Nations*, Smith suggests that there is less division of labor in a smaller household, and they can only produce their needs. However, as the division of labor accelerates, production increases beyond the *own consumption* level, and this creates savings in the economy. Furthermore, these savings are used for capital formation in the next term, and it is possible to achieve a more effective division of labor. Even if Smith sees the harmful effect of the division of labor, which is caused by repetitive works, it is important since it increases production and, hence, welfare. Lastly, the division of labor is limited by market tightness and capital stock in Smithian economics (Colander and Langreth 1994.) A large market increases the possibility of quantity sold in the economy, and it triggers the economy to produce more output.

2.1.2 Malthus and Ricardo

The economic views of Malthus (1798, 1806) mainly concentrate on population. His main argument is the inconsistency of the growth rates of population and output (Roncaglia, 2006). The total volume of goods to be consumed grows at an arithmetical fashion, but population growth is geometrical. This leads prices to increase, and, therefore, real wages to decrease. At this point, preventive check enters the picture as people delay marriage and/or having children. In other words, men prevent themselves from getting into a position where they do not have enough resources to feed and protect their wife and children. If preventive check does not operate and keep population limited, then positive (or natural) checks take a stage and cause population to decrease. Famine and disease are some examples of such positive checks. Preventive and positive checks explain why population growth rate is an increasing function of real wage. In the long run, the economy is always in a balanced equilibrium with fixed population and fixed real wage; there exists a unique level of real wage that makes population growth rate being exactly equal to zero.

What reinforces equilibrium in the long run is the diminishing returns with respect to labor which is implied by the fact that the production depends on non-reproducible input such as land. To understand this, suppose that the economy is initially in its long-run equilibrium. Now suppose that population level decreases for some reason. This increases the real wage because of diminishing returns, but it then also increases population growth rate. Increased population growth then eat up the gains enjoyed by favored generations until diminishing returns eventually lead the economy into its long-run equilibrium.

The last thing to say about the Malthusian view is that population stays stagnant if there is no change in technological capabilities or the availability of arable land (Galor and Weil, 1999; Ashraf and Galor, 2011). Therefore, a new production technology in use increases output and output per capita. The initial effect of this increase is an increase in population. In other words, increased income is offset by increased population. The argument is that countries with superior technologies have denser populations but not a larger standard of living.

Ricardian analysis is very similar as he is one of the co-founders of the law of diminishing returns. His analysis also starts with wages. Real wage is initially at its equilibrium level, and it does not change over time. This wage is equal to the Malthusian subsistence level. Economic growth is possible with capital accumulation in Ricardo's model (Roncaglia, 2006). Since the share of wage income does not depend on production, distributional conflict occurs only between rent and profit. As rents increase, the share of capital from production decreases, and this leads to decrease in profits. This situation decreases the rate of capital accumulation and hinders economic growth. On the other hand, if a capitalist adopts a labor-saving technology, the demand for labor decreases, and this causes wages to decrease (Humphrey, 2004). Even if this is a short-run effect of technological progress, in the long-run, workers decrease their desired wage rate to regain their job. Yet, since the new wage rate is below the subsistence level, population growth decreases. This situation continues until the wage rate returns to the subsistence level. In the new long-run equilibrium, there are fewer workers but more output. Because of expanded output, prices tend to decrease, and, therefore, real wages increase. This increases population growth rate, and the loop continues. Consequently, as in the Malthusian model, there is an inverse relationship between population level and output per capita in the short run as governed by diminishing marginal returns with respect to labor. In the long run, on the other hand, living standards are independent of the level of population.

2.1.3 Marx

Karl Marx does not have a theory of population change, but he and Engels (1993) criticize the Malthusian population theory in *Capital* (1876) and *The Condition of the Working Class in England* (1945). Both Marx and Engels accuse Malthus of being a slander against human beings and sinner against science (Hill, 2014). Even if Marx does not deal directly with population, he rejects the Malthusian idea of poverty being a destiny. Marx claims that poverty is a consequence of capitalist accumulation process.

Lucas (2002) states that we owe so much to Marx since he was the first to recognize the transformative role of entrepreneurial class. This awareness is critical because entrepreneurs create fundamental changes in production processes. Their aim is mainly finding new technologies that replace labor force with machines to decrease the share of labor compensation. These new technologies lead to increases in the total number of unemployed workers, i.e., the industrial reserve army (Petersen, 1988). Accordingly, new machines replace laborers. Furthermore, they replace older laborers with younger ones, males with females, and the skilled with the unskilled. Therefore, in Marxian economics, economic growth occurs through capital accumulation and productivity growth.

2.1.4 Schumpeter

Schumpeter is one of the most important growth economists. Even if his theory remains informal in terms of mathematical formality, his ideas have proved to be highly influential in growth and economic evolution literatures for many generations of economists. The 1934 English edition of his *The Theory of Economic Development* is a cornerstone of growth and development literature, and Colander and Landreth (1994) explain Schumpeter's theory by referring to this book as well.

In Schumpeter's (1934) thought, the main resource of economic growth is innovation. Any gain collected by an innovator is also a gain for the whole economy. Any finding regarding an innovation is copied and implemented by other producers in the economy, and this causes economic growth. Schumpeter (1934) claims that economic growth can be explained by discontinuous technical changes. Such changes include the introduction of a new good or of a new production technique, the discovery of new markets and new sources of supply, and, lastly, the changes in the structure and organization of the society. Briefly, economic growth is due to creative destruction of agents who respond to market incentives.

2.2 THE GENESIS OF THE MODERN THEORIES: THE HARROD-DOMAR MODEL

The Harrod-Domar model of Harrod (1939) and Domar (1946) is a benchmark for economic growth literature. The importance of this model comes from its mathematical originality and influence. The literature before Harrod (1939) and Domar (1946) lacks mathematical formality. Hence, the model is a genesis point for growth theorists who use mathematical tools such as calculus in dynamic economic analysis.

The model analyzes the Keynesian model in the long-run where the capital stock can be expanded. While Keynes restricts his analysis with short-run problems, Harrod (1939) and Domar (1946) study the long-run development of a capitalist economy under Keynesian assumptions.

The Harrod-Domar model explains growth through saving and investment. It considers a closed economy without government. Thus, saving is used entirely for investment. However, this transformation is subject to a friction where planned and unplanned investment may not always be equalized (Akyüz, 1980). There are two effects of investment in an economy. The first is to create income, which is a demand effect, and, secondly, it accumulates capacity by increasing capital stock, which is a supply effect.

The most important and debated assumption of the model is that it builds upon the Leontief production function which implies a fixed capital-output ratio. This means firms cannot substitute labor for capital or vice versa to produce the same level of output.

When planned investment expenditure is not exactly equal to actual investment that is determined by saving, then actual growth rate is different than the so-called warranted growth rate which is determined by saving rate and capital-output ratio. Specifically, when planned investment is larger than actual investment, this creates an excess demand in product markets and an unplanned decrease in inventories. Observing this excess demand, firms increase their planned investment but this creates an even larger excess demand since capital-output ratio is fixed. Put differently, increased investment expenditure will increase the initial difference between the actual and warranted growth rates. Thus, in the Harrod-Domar model, capitalist accumulation process is subject to knife-edge property. If the balance between actual and warranted rates is disturbed once, growth either implodes or explodes away from the warranted rate.

The model also studies how the long-run dynamic equilibrium in the labor market becomes unstable or stale. Although there can be a balance between product markets in a growing economy, the balance in the labor market at the same time is a coincidental. It is simply because fertility and population growth rate are considered as exogenous factors; one cannot ensure that the growth rate of labor supply determined by these exogenous rates is going to be equal to the growth rate of capital or output.

2.3 THE NEOCLASSICAL ECONOMIC GROWTH

The neoclassical models are originally due to Solow (1956, 1957) and Swan (1956). The main point of Solow (1956, 1957) is that the Harrod-Domar model features an unstable growth path only because it does not allow for factor substitution. Factor substitution is what changes all growth analyses radically. Then, Cass (1965) and Koopmans (1965) extend the Ramsey (1928) model and make the analysis intertemporal with endogenous savings.

The main quest of neoclassical models is what affects the long-run growth rate of an economy. This is what makes them classical models. The models assume there are three production factors, i.e., capital, labor, and productivity, and the elasticity of substitution is equal to unity, i.e., the production function is Cobb-Douglas. Another important assumption of the models is that technological progress that explains productivity growth is exogenous.

2.3.1 The Solow-Swan Model

As in the Harrod-Domar model, there exists an aggregate production function. Also, saving rate, depreciation rate, and population growth rate are exogenous and fixed. Most importantly, however, the Solow-Swan model allows for factor substitution and capital-output ratio is not fixed generally. This is what makes it different from the Harrod-Domar model. In fact, Solow's (1956) objective is not to develop an economic growth model but to show that the Harrod-Domar result crucially depends on the Leontief technology.

In the short-run, if capital stock per worker is less than its steady-state level, its marginal productivity is large due to Inada conditions, and this allows for growth through savings per worker being higher than depreciation and dilution. The converse is true if capital stock per worker is higher than its steady-state value.

In the version without technological progress and productivity growth, the model predicts a constant level of output per capita in the long run. This level is determined mainly by saving and population growth rates, increasing in the former and decreasing in the latter. Therefore, the model's message for development policy formation in poor countries is to increase savings and decrease fertility.

In the version with exogenous technological progress and productivity growth, the model has a unique steady-state similar to the one described above. The critical difference is the following: Productivity enters the model to increase effective working hours (in labor-augmenting Harrod-neutral form), and capital stock per effective worker and output per effective worker converge to constants in the long run. Thus, capital stock per worker and output per worker grow exactly at the rate of exogenous productivity growth.

Some implications of the model should be noted here. Firstly, the model suggests that the long-run growth rate of output is exogenous and is independent of saving and population growth rate. Secondly, if the saving rate increases or population growth rate decreases, these create only some level effects. Third, in the absence of technological progress, there is no long-run real GDP per capita growth in an economy. Lastly, this model predicts conditional convergence. In other words, countries that have identical saving, population growth and productivity growth rates will eventually converge to the same steady-state equilibrium.

2.3.2 The Ramsey-Cass-Koopmans Model

This model is originally due to Ramsey (1928). For most of early 20th century economists, however, it has been too difficult from a mathematical point of view. Its further development has therefore been proposed much later by Cass (1965) and Koopmans (1965).

The main advance of this model relative to the Solow-Swan model is that it endogenizes savings through intertemporal utility maximization. The rest of the analysis is almost identical since long-run economic growth is explained solely by exogenous productivity growth.

The model considers a decentralized economy in which individuals and firms maximize their utility and profits respectively through time. Individuals equalize the rate of return on current consumption and future consumption. If the rate of return to saving is higher than the rate of return of consumption, households are more willing to save and shift consumption into the future.

Firms on the other hand endeavor to maximize their profit by choosing optimal amounts of capital and labor. The maximization problem of a representative firm equalizes wage to the marginal product of labor and rent to the marginal product of capital as usual. In other words, the marginal return of each factor equals its associated marginal cost. At this point, firms maximize profit.

2.4 ENDOGENOUS GROWTH THEORY

Neoclassical theories take technological progress and productivity growth as exogenously determined processes. However, when the driver of economic growth in the long run is treated as an exogenous variable, this is neither useful to generate development recipes for the third world countries nor plausible from a methodological viewpoint.

After realizing these gaps in theory, economists have worked on endogenous growth models. These models are of different types: The early models focus on knowledge spillovers or innovation.

2.4.1. Marshallian Externalities

In general, there exist three types of knowledge spillover effects in economics. These are Marshall-Arrow-Romer (MAR) spillover (Marshall, 1890; Arrow, 1962; Romer, 1986), Porter (1990) Spillover, and Jacobs Spillover (Jacobs, 1969; Jackson, 1991). MAR Spillover suggests that firms in the same industry should be located closer to each other and manipulate the market by being local monopolies. Porter Spillover (1990) suggests that, like MAR, firms should be located closer, but, in contrast to MAR, they should be competitive instead of manipulating the industry through monopoly power. On the other hand, Jacobs Spillover offers a distinct idea; it suggests that firms in the same industry should be located far from each other. They should be located in such an area where there are many firms operating in different industries. Jacobs (1969) claims that firms should take advantage of accessing different types of knowledge related to their own production processes in such areas.

Growth models have focused on the first type of spillovers (Romer, 1986; Lucas, 1988). These are externality models where knowledge spillovers affect the growth process. Clearly, when there is new knowledge that increases productivity, e.g., a new technological development, a new machine, or a new labor-saving idea, all the firms in the market may start benefiting from it. This non-rivalry effect has not been dealt in dynamic general equilibrium models until 1980s.

Marshallian externalities simply originate from Marshall (1890), and the idea is developed in works of Arrow (1962) and Romer (1986) regarding physical capital and of Uzawa (1965) and Lucas (1988) regarding human capital. Marshallian externalities increase the productivity of production factors via positive externalities. Here, knowledge spillover from other firms' machinery or other workers' skills creates the externality through interactions among agents. Since knowledge is non-rival, all agents can take advantage of simultaneously using it. After noting the importance of knowledge spillover effects, economists clarified the role of deep parameters affecting the rate of economic growth in general equilibrium.

2.4.2 Schumpeterian Innovations

Although both Marshallian Externalities and Schumpeterian Innovations are regarded as an endogenous growth models, they have a critical difference: In Marshallian externality models, growth is endogenous but not the result of purposeful behavior. In Schumpeterian innovation models, growth is endogenous through profit-seeking actions of entrepreneurs and firms.

Romer (1990), Grossman and Helpman (1991), and Aghion and Howitt (1992) constitute the 1st generation Schumpeterian models. These economists try to endogenise technology in dynamic general equilibrium models where purposeful, profit-seeking behavior of firms and entrepreneurs is the engine of growth. These models show that policies are highly relevant in affecting growth in the long run. However, they also carry the scale effect problem; growth is increasing in population level which contradicts with the US data (Jones, 1995a).

To resolve the scale effect problem, economists are divided into two camps. One camp is called the semi-endogenous growth theory, and the other is the 2nd generation Schumpeterian literature. Jones (1995b) and Kortum (1997) are examples of semi-endogenous growth models. These models show that the growth rate of the economy in the long run is a function of the growth rate of population. Policies, therefore, become ineffective in affecting growth. On the other hand, Young (1998) and Peretto (1998) are two examples of the 2nd generation Schumpeterian models. These economists assume that there are two types of innovation, product and process innovations. These models solve the scale effect problem basically because increasing population spreads over increasing number of products and firms, and the scale effect is therefore sterilized.

2.5 POVERTY TRAPS

A poverty trap can be defined as an inefficient or undesired equilibrium where poverty persists because the mechanism that creates poverty is self-reinforcing. There could be many reasons that lead an economy into a poverty trap, and Azariadis and Stachurski (2005) present a survey of the literature on poverty traps. This survey emphasizes the reasons behind self-reinforcing traps and the reasons behind divergence between countries.

Not adopting (or not being able to adopt) efficient technologies by poor countries is one important reason. This trap occurs when traditional methods exhibit increasing returns. Another reason is the existence of financial constraints. In a poor economy with underdeveloped financial markets, it is hard to find necessary funds for investments with high sunk costs. Besides, for an entrepreneur, it is not a straightforward decision to invest in new technology if the economy is subject to wide fluctuations. Simply put, risk aversion limits the total volume of investments. Therefore, poor countries remain trapped with existing low-productivity methods for a variety of reasons. Several such mechanisms are proposed by countless papers in the related literature, but we here focus on a selective subset of such poverty traps.

The most striking and popular reason behind self-reinforcing poverty is perhaps the demographic or Malthusian one. As explained above with reference to the views of Malthus and Ricardo, a Malthusian trap occurs when population grows as a response to increasing living standards under diminishing marginal returns (Malthus, 1798). In the long run, an (agricultural) economy where land is fixed and there is no technological progress has fixed population and fixed living standards. If living standards increase above its long-run level of subsistence, this first leads to positive population growth but increasing population growth decreases average product in the long run.

Another type of poverty trap is due to human capital. The idea here is that underdeveloped countries cannot meet qualified workers' wage, and, therefore, the external effect of human capital accumulation does not take place in such countries. Put differently, underdeveloped countries do not provide sufficient compensation to people with higher levels of human capital, and they therefore migrate to developed countries to get a higher wage. In such a situation, underdeveloped countries cannot escape the poverty trap (Lucas, 1988). This situation is also an obstacle for countries to utilize learning-by-doing externalities. In underdeveloped countries, infant industries and firms are inexperienced, and they cannot afford to pay high wages to attract qualified workers from other sectors. Therefore, they cannot accumulate their experience and cannot exhibit progress. For this reason, there are several protection methods offered by economists, and the infant industry protection argument is one example for this (Krueger and Tuncer, 1982).

A poverty trap model that influenced UGT is due to Becker et al. (1990) and studies human capital and fertility. This model has two different steady-state equilibria. One of them is high fertility-no education equilibrium, and the other is low fertility-high education equilibrium. The paper shows that the rate of return on child quantity is greater than the rate of return on child quality in human-capital-scarce countries. Thus, decentralized equilibria of economies with sufficiently small initial stocks of human capital converge to the high fertility-no education steady-state. In this trap, parents do not educate their children, and human capital therefore remains at its initial level.

The size of the market and the division of labor can create a poverty trap. Smith (1817) claims that the division of labor is limited by the size of the market. Young (1928) on the other hand claims the opposite; the size of the market is limited by the division of labor. Both of them are true as causality runs both ways. Furthermore, Romer (1987) underlines the possibility of economic growth throughout the division of labor. The implications are not trivial, and the mutual reinforcement increases the rate of economic growth. As the division of labor intensifies, labor productivity grows faster, and, therefore, it increases the total quantity produced. After exceeding the subsistence level in the economy, entrepreneurs look for new markets to sell the surplus production. Therefore, the size of the market expands. On the other hand, as the market size expands, entrepreneurs intensify the division of labor to increase labor productivity. In this sense, underdeveloped countries cannot use this possibility of growth because of the vicious circle. Namely, for a small economy, there is no chance to intensify the division of labor, and entrepreneurs cannot expand market size. Conversely, since market size is narrow in a small economy, entrepreneurs do not need to increase the division of labor.

2.6 THE UNIFIED GROWTH THEORY

The success of UGT lies in its originality in explaining both stagnation and growth within a single framework. This is the reason why we rest on UGT to understand SSA. In the next chapter, we provide a formal introduction to UGT using Galor's (2005) formulation. However, for the integrity of this review, we briefly introduce UGT in this concluding section.

There are three distinct regimes an economy typically experiences throughout its historical development. These three regimes are the Malthusian, the Post-Malthusian, and, lastly, the modern or sustained growth regimes. All these regimes are determined as an outcome of causal relationships between education and fertility decisions of individuals and technological progress in the economy.

In the Malthusian regime, population growth rate responds positively to output per capita. Economic dynamics in this regime mainly follow the views of Malthus and Ricardo. Thus, consumption is at the subsistence level, and people do not invest in education. In the long run, this regime is almost identical to the no education steady-state of Becker et al. (1990).

But UGT's Malthusian regime differs from that of Becker et al. (1990) in a crucial way. In Becker et al. (1990), the economy cannot escape the Malthusian regime. In UGT, there are latent dynamics that eventually change the qualitative behavior of the dynamic system. The latent dynamic that explains the transition from the Malthusian to Post-Malthusian regime is the very slow and mutually reinforcing growth in population and productivity. Even if it takes thousands of years, the economy eventually becomes sufficiently populous and productive to leave the Malthusian trap.

In the Post-Malthusian regime, the economy grows at increasingly faster rates because population growth accelerates. However, educational investment is still zero. This, on the other hand, does not mean that it will remain so. The latent dynamics during the

Post-Malthusian regime eventually imply a sufficiently large return to human capital. At some endogenously determined date, it is optimal to decrease fertility and give children some education that they would need in a modernizing economy. Accordingly, then, the modern growth regime is almost identical to the low fertility-high education equilibrium of Becker et al. (1990).

As we see, UGT handles both stagnation and growth in a single framework. It is very important to note the following: The regime transitions occur at endogenously determined dates. The model does not require a sizable exogenous shock that triggers the transitions. Hence, the transitions are gradual and completely explained by the initial values and structural parameters of the model.

CHAPTER 3

STAGNATION AND GROWTH IN THE UNIFIED GROWTH THEORY

The UGT of Galor (2005, 2011) is fundamentally about the historical continuity of endogenous growth process in the very long run. The main purpose is to explain stagnation and growth within the same framework. After the publication of Galor and Weil's (2000) original formulation, there have been other unified growth models proposed, and most of growth economists admit the usefulness of such models.

Becker et al. (2010) and Fernihough (2017) are some examples of the studies that use this theory as a foundation to understand the child Q-Q tradeoff in Prussia and Ireland respectively. A quantitative analysis of the model in its original 2005 formulation is provided by Lagerlof (2006).

In Chapter 2, we have summarized theories and models developed to explain economic growth and stagnation. However, almost all of them explain one of them in their framework. Namely, these theories explain either economic growth or reasons behind stagnation. Historically, this is not a viable approach since today's developed economies are the stagnating economies of the past, and today's stagnating economies are expected to be developed economies in the very long run. The success of UGT is that it can explain both economic growth and stagnation in the same model, and theory becomes truly historical.

The theoretical discussion in this chapter follows directly from Galor (2005, 2011). The organization of the remainder of this chapter is as follows: Section 3.1 introduces model environment, Section 3.2 solves the model's main optimization problem, Section 3.3 analyzes the three regimes, and Section 3.4 presents a discussion of other unified growth dynamics.

3.1. THE MODEL ENVIRONMENT

The model time is discrete and extends to infinity: $t \in \{0,1,\ldots\}$. There is an overlapping-generations economy with children and adults, and, for the sake of simplicity, each generation produces a single homogenous good over time. The production technology uses an exogenously determined amount of land which is fixed over time, and efficiency units of labor. The mass of efficient units of labor is determined by the mass of workers and their human capital. The model also assumes that there is no government, and the economy is closed.

The population participates in the labor force in return for wage income. Producers use labor and land in the production process and pay a wage to the labor force. Since there is no property right over land in the model, wage is equal to the average product. The model can be extended with a landowner class without altering the main results.

The decision problem of individuals is about consumption, the number of children they have, and education investment each child receives. Education simply determines the children's human capital when they become adults. An adult individual use additional time input to educate her children, and this education should cover skill depreciation if technological progress is fast. Furthermore, education itself affects technological progress positively since educated generations are more innovative. In such an environment, adults who care about their own consumption and their children's quantity and quality maximize their lifetime utility, and their decision affect the whole economy.

3.1.1. Demographic Structure

There are two overlapping-generations in the economy. L_t identical adults participate in the labor force in every generation, and each has n_t children. Individuals live for two periods. In the first period, $t-1$, the individual is a child and consumes a proportion of parental time. For the sake of simplicity, every individual has one parent. In the second period, t, the individual become a parent and a part of the labor force. For analytical convenience, L_t and n_t are real numbers, and adult population grows at the rate n_t.

3.1.2. Endowments

Every individual has one unit of time in the model. Individuals have to take a decision on how to allocate their time between labor force activity, child bearing, and child educating. They choose an optimal level of quality and quantity of (surviving) children. After this decision is made, individuals allocate their remaining time to labor market activity to obtain wage income.

On the other hand, the economy as a whole has a land endowment of $X > 0$. Since the main concern of the model is not land ownership or inequality, land is assumed to be owned communally and enters the production function as a free input.

Lastly, every individual has a human capital determined by her parent's educational investment decision and depreciates with technological progress.

3.1.3. Preferences

Adult individuals obtain utility from consumption c_t, the quantity n_t of children, and the quality h_{t+1} of each child. The utility function of an adult individual is

$$u_t = (1-\gamma)\ln(c_t) + \gamma\ln(n_t h_{t+1}), \qquad \gamma \in (0,1) \tag{3.1}$$

The lifetime budget constraint of this adult is given by

$$z_t n_t(\tau + e_{t+1}) + c_t \leq z_t, \qquad \tau \in (0,1) \tag{3.2}$$

where z_t is real income (see below), τ is the time cost of a child to be taken care of, and e_{t+1} is the amount of time spent for each child in the form of educational investment.

3.1.4. Technologies

The final output is produced according to constant-returns-to-scale Cobb-Douglas type function. In period t, the total volume of production denoted by Y_t, is

$$Y_t = H_t^{\alpha}(A_t X)^{1-\alpha}, \qquad \alpha \in (0,1) \tag{3.3}$$

where H_t is effective labor input (or aggregate human capital), A_t is endogenously determined productivity variable, and X is the land endowment. $A_t X$ is, therefore, efficient units of natural resources used in production.

The following assumptions are imposed: First, there are no property rights over land as mentioned earlier. This implies that land rent is nil. Second, individuals are fully employed, and, for the sake of simplicity, there is only one good produced in the economy.

Human capital per worker is defined as in $h_t = H_t/L_t$. Human capital per worker in $t+1$ is a function of educational investment and the rate of technological progress g_{t+1}. The technology to produce human capital is implicitly defined as in

$$h_{t+1} = h(e_{t+1}, g_{t+1}) \tag{3.4}$$

We have, $\partial h_{t+1}/\partial e_{t+1} > 0$ and $\partial h_{t+1}/\partial g_{t+1} < 0$. Without any education and technological progress, every individual has a normalized level of human capital that is equal to 1. Namely, $h(0, g) = 1$ for all g.

Since children become adults at the end of childhood and adults leave the scene at the end of adulthood, the law of motion for adult population L_{t+1} is

$$L_{t+1} = n_t L_t \tag{3.5}$$

where $L_0 > 0$ is an exogenous given.

Finally, there exists an aggregate technology that implicitly determines the growth rate of productivity g_{t+1}.

$$g_{t+1} \equiv \frac{A_{t+1} - A_t}{A_t} = g(e_t, L_t) \tag{3.6}$$

The conjecture here is that educated individuals are more innovative so that we have $\partial g_{t+1}/\partial e_t > 0$. On the other hand, population level also increases productivity growth because of the Boserup effect. That is, when population level gets larger, agricultural economies try to find new and more efficient ways of production to alleviate the population pressure. Therefore, we have $\partial g_{t+1}/\partial L_t > 0$. Moreover, since the Boserup effects apply to pre-modern economies with $e_t = 0$, the model assumes that $g(0, L_t) > 0$ for all t.

3.2. THE DECISION PROBLEM

Given production function in (3.3), output per worker, y_t, becomes

$$y_t = h_t^{\alpha} x_t^{1-\alpha} \tag{3.7}$$

where $y_t \equiv Y_t/L_t$, $h_t \equiv H_t/L_t$ and $x_t \equiv (A_t X)/L_t$. It is clearly the case that the growth of output per capita depends on the growth rates of human capital (h_t) and effective resources per capita (x_t). Since every worker obtains the average product as income, z_t simply satisfies

$$z_t = y_t = w_t h_t \tag{3.8}$$

where w_t denotes the real wage. The problem of individuals is to maximize u_t by choosing c_t, n_t, and e_{t+1}. Formally, we have the following:

$$\max_{n_t, e_{t+1}} (1-\gamma) \ln\{z_t[1 - n_t(\tau + e_{t+1})]\} + \gamma \ln\{n_t h(e_{t+1}, g_{t+1})\}$$

Subject to:

$$\begin{aligned} & z_t[1 - n_t(\tau + e_{t+1})] \geq \tilde{c} \, ; \\ & (n_t, e_{t+1}) \geq 0 \end{aligned} \tag{3.9}$$

where $\tilde{c} > 0$ is the subsistence consumption level.

The solution of this problem is unique but described by piecewise functions that define the three regimes of stagnation and growth.

Because of the Cobb-Douglas form, the total amount of time that is spent on children satisfies the following:

$$n_t(\tau + e_{t+1}) = \begin{cases} \gamma, & if \; z_t \geq \tilde{z} \\ 1 - (\tilde{c}/z_t), & if \; z_t \leq \tilde{z} \end{cases} \tag{3.10}$$

Here, $\tilde{z} \equiv \tilde{c}/(1-\gamma)$ is the critical level of income below which the subsistence consumption restriction is just binding. If $z_t \leq \tilde{z}$ holds, consumption remains at the subsistence level and income increases are allocated to children. Otherwise, a constant fraction of time is allocated to children and consumption increases.

The solution of the problem is piecewise for educational investment as well. At the optimal point, e_{t+1} is an increasing, implicitly defined function of the rate of technological progress. More specifically, there is a critical level of g_t denoted by $\hat{g} > 0$ such that

$$e_{t+1} = e(g_{t+1}) \begin{cases} = 0, if\ g_{t+1} \leq \hat{g} \\ > 0, if\ g_{t+1} \geq \hat{g} \end{cases} \tag{3.11}$$

where $e'(g_{t+1}) > 0$. This characterization of the unique solution of the problem tells us that adults do not find it optimal to give their children some education if technological progress is not sufficiently fast.

3.3 THE THREE REGIMES

Since education and fertility take different values in equilibrium according to the conditions of technological progress and real income per worker respectively, these conditions create different regimes in the economy.

3.3.1 The Malthusian Regime

First, consider the case where technological progress is not fast enough $(g_{t+1} \leq \hat{g})$ and real income per worker is below the subsistence level $(z_t \leq \tilde{z})$. Optimization results in

$$e_{t+1} = 0, \qquad c_t = \tilde{c}, \qquad \text{and} \qquad n_t = (1-\tilde{c}/z)/\tau \tag{3.12}$$

This situation is simply named as the Malthusian regime. Since technological progress is sufficiently slow, there is no incentive for educational investment and no increase in per capita GDP. Therefore, households spend their income on consumption, which is only at the subsistence level, and then they spend their remaining income on the quantity of children. Therefore, fertility is in a positive relationship with real income and consumption per worker, but not with education. For this reason, this regime is called the Malthusian regime.

Population growth in this regime is slow because the economy is poor. However, the virtuous circle between population growth and productivity growth slowly increases the pace of population and productivity growth. Put differently, both $g(0, L_t)$ and n_t slowly increase along with increases in A_t, x_t, z_t, and y_t.

3.3.2 The Post-Malthusian Regime

In the Post-Malthusian regime, consumption is larger than the subsistence level but educational investment is still equal to zero.

$$e_{t+1} = 0, \qquad c_t > \tilde{c}, \qquad \text{and} \qquad n_t = \gamma / \tau \tag{3.13}$$

The economy enters this regime when A_t, x_t, z_t, and y_t are sufficiently large to imply $z_t \geq \tilde{z}$ but technological progress is still sufficiently slow ($g_{t+1} \leq \hat{g}$).

In this regime, productivity growth continues and increasing real incomes are directed to increasing real consumption. As long as $\tau < \gamma$, that is, the cost of child bearing is sufficiently small given the preference parameter that increases the marginal utility of fertility, population grows ($n_t > 1$). In this regime, γ parameter implies that the value attributed to a child increases the chosen number of children.

3.3.3 The Modern (or Sustained) Growth Regime

Since $g(0, L_t)$ keeps increasing in both the Malthusian and the Post-Malthusian regimes, the economy has to eventually enter a regime with $e_{t+1} > 0$ when technological progress is sufficiently fast ($g_{t+1} \geq \hat{g}$). This regime is then characterized by

$$e_{t+1} > 0, \qquad c_t > \tilde{c}, \qquad \text{and} \qquad n_t = \frac{\gamma}{\tau + e(g_{t+1})} \tag{3.14}$$

Two dynamics in the modern growth regime should be emphasized. First, technological progress and educational investment create a virtuous circle through the equations

$$g_{t+1} = g(e_t, L_t) \tag{3.15}$$

$$e_{t+1} = e(g_{t+1})$$

as increasing education and fastening technological progress converges to a steady-state where $e^* > 0$ and $g^* > 0$. Throughout this convergence, g_t and e_t increase in a self-equilibrating way as ensured by functional forms.

The other dynamic that should be emphasized is that the increase in educational investment explains the decrease in fertility in advanced stages of economic development. Since the total fraction of time spent to children is equal to γ, adult individuals start investing in child quality and therefore decrease child quantity. In other words, the child Q-Q tradeoff becomes active.

3.4. OTHER UNIFIED GROWTH DYNAMICS

Even if Galor's (2005, 2011) canonical theory analyzed above focuses on education and fertility, there exist some other dynamics centrally associated with economic growth and development in the very long run. Four variables are of particular interest; these are urbanization rate, the share of labor employed in agriculture, life expectancy, and export of manufactured goods. In the course of economic development, urbanization rate increases, agriculture's labor share decreases, life expectancy increases, and the economy starts exporting manufactured products.

It is important to understand how these dynamics interact with education and fertility. First, agricultural societies have low education and high fertility because agricultural production does not require (formal) education and child labor is an important input in agriculture. Second, industrial and service sectors are historically located in urban areas, and it is usually not appropriate or legal to employ child labor in these nonagricultural sectors. Finally, increased life expectancy is causally related (i) to increased education because people have a longer expected life during which they benefit from their educational investment and (ii) to fertility decline because people who care about the surviving number of children decrease gross fertility as mortality decreases. Finally, economies that export primary (agricultural) products do not find an incentive to invest in education because education is not relevant in this type of specialization. But in a developing economy, industrialization eventually leads to increases in manufactured exports, and this strengthens the Q-Q tradeoff.

CHAPTER 4

STAGNATION AND GROWTH IN SUB-SAHARAN ECONOMIES: MAIN PATTERNS AND REGULARITIES

4.1 A BRIEF REVIEW OF THE LITERATURE

The case of African economies in terms of economic development has been tragic. Africa has suffered from different obstacles, and these have dragged African economies in economic development.

Africa has suffered from the common diseases, such as HIV and Malaria (Gallup and Sachs, 2001), civil wars (Easterly and Levine, 1997) and colonization (Bertocchi and Canova, 2002). Gallup and Sachs (2001) show how poverty and malaria are correlated. They claim a region being affected by malaria tends to have a lower level of income. Malaria is specific for Africa, and working to destroy malaria in tropical regions is mostly ineffective. The effect of malaria for intensively affected countries is 1.3% slower per capita growth. On the other hand, Gallup and Sachs (2001) also claim that 10% decline in malaria causes 0.3% increase in the rate of economic growth.

Easterly and Levine (1997) claim that policies, schooling, financial system, foreign exchange market, government deficits, and infrastructure affect the growth rate of an economy. However, all these policies worked against the economic growth rate of Africa since African economies have not developed these policies properly. Easterly and Levine (1997) argue that ethnic diversity is the main reason why these policies did not affect African economies in a positive way.

Bertocchi and Canova (2002) explain the underdevelopment of African economies through colonial heritages. The study claims that European colonization in Africa had a negative effect on African economies. Therefore, decolonization has a positive effect on economic growth performance.

There is a larger literature on economic growth and stagnation in SSA, and they use different approaches to identify the factors of growth and stagnation. Bloom and Sachs (1998) find complex correlations among demography, geography, health, and economic conditions. The importance of this paper comes from the fact that it identifies many of the factors that contribute to Africa's economic trap. It measures convergence to the steady-state level of income per worker by defining the steady-state level as a function of human capital, health status, natural resource abundance, and sound economic policy. It suggests that the relationship between physical environment and the social outcomes is undeniable. Therefore, linkages among demography, geography, health, and economic performance ought to be examined more intensively.

Savvides (1995) looks for factors that trigger African economic growth and reasons for the difference in GDP per capita growth rate across Africa. This study applies Mankiw et al. (1992) methodology and finds that initial conditions, investment share, and population growth rate affect economic growth rate positively. The latter is at odds with the modern growth regime of UGT, but the study also finds that human capital is not significant in explaining growth. Furthermore, political freedom is another factor contributing positively to economic growth. Adams (2009) searches for variables that cause economic growth in SSA. The study finds that domestic investment triggers economic growth as indicated by both OLS and fixed effect estimations while foreign direct investment has a significant and positive effect only in OLS estimation. Wilson and Gyimah-Brempong (2004) investigate the growth effects on health-based human capital. To do so, they use an extended Solow model and panel data estimation methods. This study shows that economic growth in SSA is affected by health conditions. This study however is subject to a biased sample since almost all SSA countries considered in this study are growing countries. Plessis and Smit (2006) investigate the growth path of South African economy between 1994 and 2004. They claim that the democratic transition created an expectation of the return of economic growth in South Africa. For this reason, they look for realized economic performance by using different instruments. The study finds that there is about 3% average growth rate for this decade where the dominant factor that contributed to growth is total factor productivity. But this study does not investigate the factors that affect total factor productivity. Arora and Vamvakidis (2005) make an analysis for 47 African countries between 1960 and 1999 and find that economic growth rate of South Africa affects the rest of African economies positively. They use real GDP per capita growth rate of South Africa as an independent variable and the growth rate of real GDP per capita of an African country as a dependent variable as well as other control variables such as demographic variables, other countries' GDP per capita growth rate, and trade openness. The study finds that 1% increase in South African economic growth rate yields an increase in the growth rate of other African countries in the range of 0.5% and 0.75% percent.

Acemoglu and Robinson (2010) claim that African economic tragedy is caused mainly by their political regimes rather than their geography. Most of the countries in the world undergone some endogenous regime changes, but this is not the case for Africa. They argue that slave trade, colonization, the relative delay in state formation compared to Eurasia, and, finally, that states are usually absolutist and patrimonial are the main factors that resulted in an institutional framework that is responsible for economic tragedy. Building on these notions, Acemoglu and Robinson (2010) emphasize that the public lacks the necessary economic incentives to save and invest and that the political elite does not have an incentive to provide public goods. Poverty, therefore, is reinforcing.

Wheeler's (1984) study analyzes the effects of both the geographical conditions and the policy variables on economic growth, once separately and then jointly for African states during 1970s. The study also looks for different geographical and policy variables in isolation to identify the particular effect of variables. The main finding is that geographical variables as a group have more impact on economic growth rather than policy variables.

Sachs and Warner (1997) try to explain the source of slow growth in SSA in a multi-country panel data framework for the period of 1965-1990. They show that policy variables such as openness to international trade have a large positive impact on economic growth. However, they also find that Africa's geographical conditions are also affecting the growth prospects negatively. Being landlocked and having a tropical climate are foremost geographical attributes that are associated with lower growth rate of real GDP per capita.

Temple (1998) searches for the growth effects of initial conditions, social capital, and policies for Africa. He also takes into account the effect of ethnic diversity on economic growth and obtains interesting findings. Even if policies are good, growth can be low because of different reasons. Temple (1998) shows that more than half of the variation in developing country growth can be explained by observed variables including the initial conditions. Another important finding of the study is that a country which has a lower level of social capital at the initial date tends to have bad policy outcomes and a lower growth rate. This study is important since it controls for endogeneity. It does not ignore the causality between economic growth and social norms and claims that a developing country which has a higher level of social capital relative to another developing country tends to have a higher rate of schooling, a better financial system, and more effective fiscal policy. Such a country then tends to have a higher average growth rate.

4.2 ESTIMATES OF ECONOMIC GROWTH AND STABILITY

While SSA has stayed stagnant for decades, there are now growing economies. Table 1 shows the estimated growth rates of real GDP per capita for some SSA economies for the years between 1960 and 2010. The very simple structural framework we build upon to come up with these estimates is as follows.

Suppose that real GDP per capita y_t grows at a fixed rate g and is subject to stochastic

Table 1: Average Growth Rates in SSA

Country	Avg. Growth Rate	Initial GDP p. c.	Instability
Botswana	8.322	366.828	0.168
Mauritius	3.814	678.063	0.372
Zimbabwe	2.471	1.592.101	0.474
Mali	2.306	354.787	0.135
Lesotho	2.224	799.467	0.118
Gabon	1.562	6,405.178	0.298
Cameroon	1.462	1,201,512	0.153
Congo, Republic	1.066	1,604.933	0.269
Mauritania	1.035	1,463.249	0.202
Mozambique	0.981	392.403	0.195
South Africa	0.899	5.797.216	0.201
Benin	0.642	639.074	0.138
Namibia	0.488	4,226.925	0.107
Uganda	0.469	777.888	0.469
Kenya	0.448	1,373.037	0.074
Malawi	0.397	678.063	0.146
Gambia, The	0.263	1,426.652	0.090
Senegal	0.138	1,625.984	0.082
Burundi	0.124	1,084.759	0.136
Rwanda	0.099	904.901	0.001
Ghana	-0.181	2,195.678	0.250
Tanzania, United Rep.	-0.290	1,082.984	0.238
Zambia	-0.795	1,819.043	0.281
Central African Rep	-0.975	1,169.699	0.052
Niger	-1.882	1,521.614	0.114
Liberia	-3.028	1,827.666	0.431
Congo, Democratic Rep.	-3.106	1,395.256	0.213

Data Source: Penn World Table (Feenstra et al., 2013) GDP per capita is in purchasing power parity corrected terms.

disturbances represented by $\varepsilon_t \sim N(0, \sigma^2)$:

$$y_t = y_0\,(1+g)^t e^{\varepsilon_t} \tag{4.1}$$

Then, taking the natural logarithm of both sides of this equation yields

$$\ln y_t = \ln(y_0) + \ln(1+g) * t + \varepsilon_t \tag{4.2}$$

Notice that OLS estimation of (4.2) yields the estimates of $\boldsymbol{\hat{g}}$ and $\boldsymbol{\hat{\sigma}^2}$. The coefficient of $\boldsymbol{t}$ is the natural logarithm of the gross growth rate, and the variance of error terms is an indicator of the instability of the growth path. Therefore, $\boldsymbol{e^{\hat{\beta}_1} - 1}$ is the percentage growth rate of real GDP per capita. The growth rate is higher and the growth path is more stable in some countries according to the Table 1. The most outstanding is the case of Botswana. The growth rate estimate for Botswana is 8.32 % for the period between 1960 and 2011, and it is relatively stable.

We can also observe this dynamic from Figure 1. This figure shows the evolution of the natural logarithms of real GDP per capita for SSA economies considered here. There is a reference line in the graphs, and this line shows the initial level of real GDP per capita for these economies. Accordingly, some countries exceed these levels at the end of sample, some fall far behind this level, and some stay the same level after several decades of fluctuations. Botswana, located in the top panel of the figure, clearly has a highly stable growth path. As the figure shows, Botswana reaches the highest level of real GDP per capita among these countries. Some other countries have similar performances. Mauritius, Zimbabwe, Mali, and Lesotho are some of the other fast-growing countries according to Table 1.

However, their initial levels of real GDP per capita and stability levels are not equal to Botswana's. Mauritius has a higher initial level than Botswana, but it has not reached the same level as Botswana reaches at the end. This is also true for Zimbabwe, Mali, and Lesotho. In particular, the graph of Zimbabwe suggests that this economy has survived crises, and it shows rapid growth after 2005. On the other hand, despite

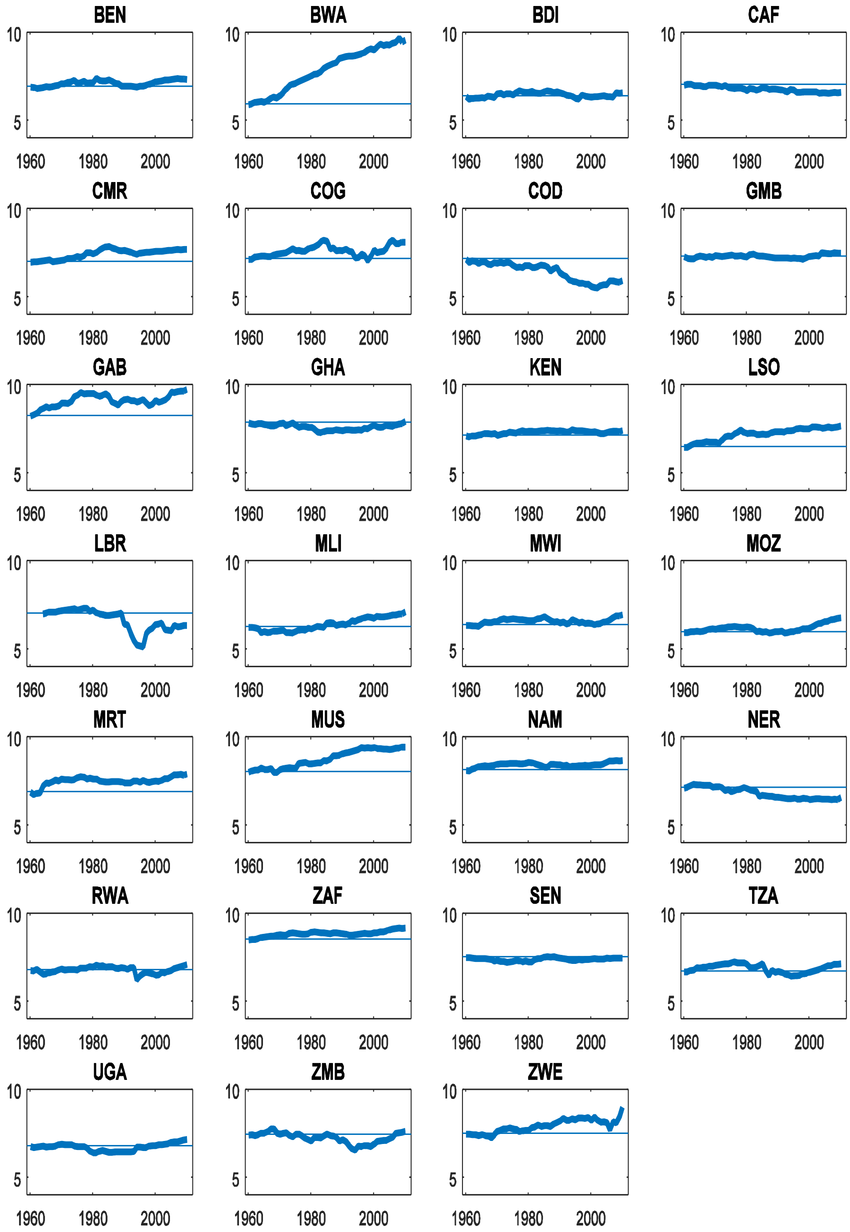

Figure 1: The Patterns of GDP per capita in SSA

BEN: Benin, BWA: Botswana, BDI: Burundi, CAF: Central African Republic, CMR: Cameroon, COG: Congo,COD:Congo, the Democratic Republic of, GMB: Gambia, GAB: Gabon, GHA: Ghana, KEN: Kenya, LSO: Lesotho, LBR: Liberia, MLI: Mali, MWI: Malawi, MOZ: Mozambique, MRT: Mauritania, MUS: Mauritius, NAM: Namibia, NER: Niger, RWA: Rwanda, ZAF:South Africa, SEN: Senegal, TZA:Tanzania, UGA: Uganda, ZMB: Zambia, ZMB: Zimbabwe
Source: Introduced in Sevtion 5.4.2

growth, Mali is not very rich at the end of the sample. Table 1 also shows negative growth rate estimates for some countries such as Niger, Liberia, and the Democratic Republic of Congo. The growth path of Liberia is one of the most unstable paths among all countries considered. This shows that Liberia might be in the Malthusian trap as Malthusian economies usually exhibitlarge fluctuations due to mortality shocks such as wars and diseases. Figure 1 suggests that those economies have a lower real GDP per capita at the end of the period than at the initial point. The situation for Ghana and Senegal is also remarkable. These two economies exhibit fluctuations. They record a lower and a lower and a higher GDP per capita level in different years, but, at the end, they reach almost the same level as they have initially.

4.3 THE DYNAMICS OF EDUCATION AND FERTILITY

Although Table 1 and Figure 1 give us some idea about the growth paths of SSA economies, we should check whether these paths are in line with UGT. Figure 2 and 3 show the patterns of education and fertility respectively for the same economies. There is a reference line in Figure 3 which shows the replacement level of fertility. The AYS of the population aged over 15 and the TFR[1] (i.e., births per woman) are used as proxies for education and fertility. Not surprisingly, the most outstanding figures again belong to Botswana. The AYS are increasing at a modest pace for years between 1960 and 1980, and then its growth remarkably accelerates after 1980. TFR exhibits an expected pattern, showing a modest decrease in the period of 1960-1980 with a remarkable acceleration after 1980. Furthermore, the fertility behavior of Botswana converges to replacement level year by year. Considering these two figures with the evolution of real GDP per capita, Botswana seems to have undergone a demographic transition exactly as described by UGT, and this country most probably is in the modern growth regime.

[1] "Total fertility rate represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with age-specific fertility rates of the specified year." World Bank, World Development Indicators.
http://databank.worldbank.org/data/reports.aspx?source=world-development-indicators#

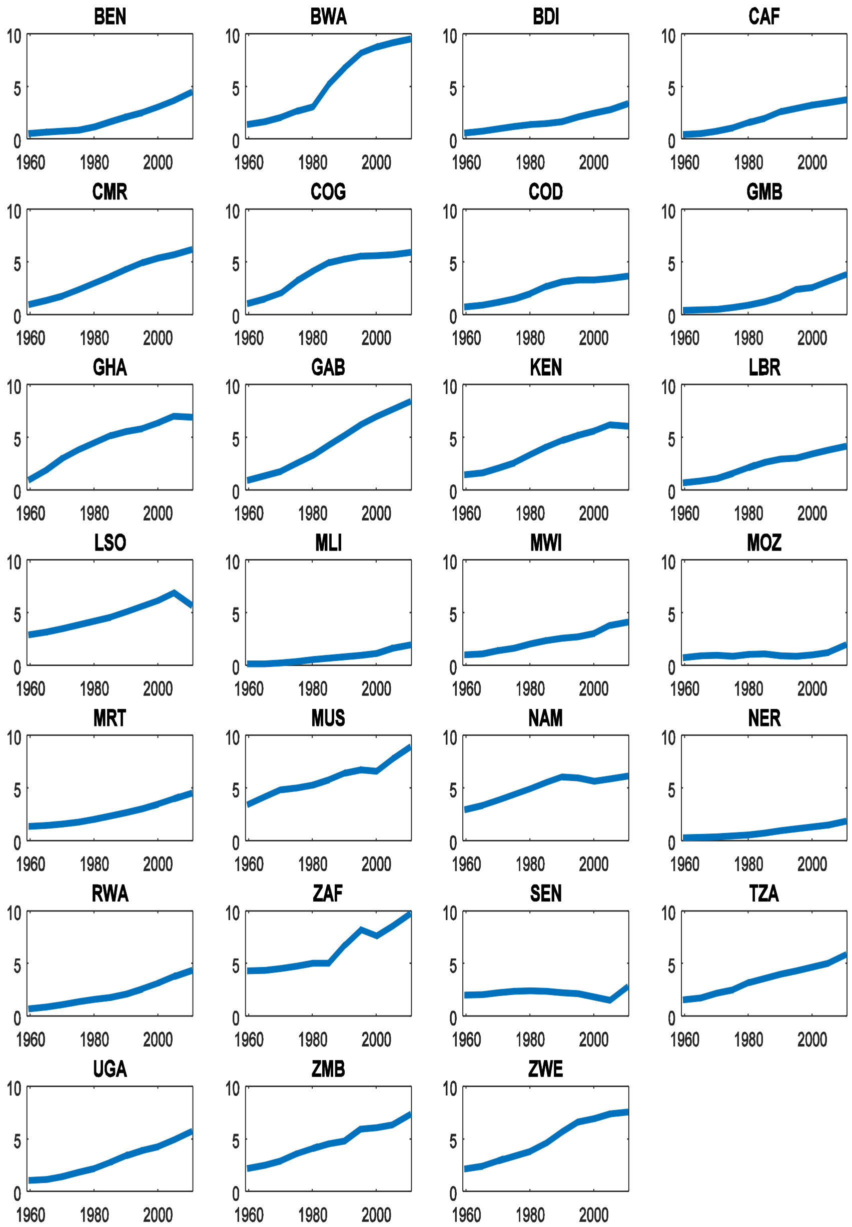

Figure 2: The Patterns of Education in SSA

BEN: Benin, BWA: Botswana, BDI: Burundi, CAF: Central African Republic, CMR: Cameroon, COG: Congo,COD:Congo, the Democratic Republic of, GMB: Gambia, GAB: Gabon, GHA: Ghana, KEN: Kenya, LSO: Lesotho, LBR: Liberia, MLI: Mali, MWI: Malawi, MOZ: Mozambique, MRT: Mauritania, MUS: Mauritius, NAM: Namibia, NER: Niger, RWA: Rwanda, ZAF:South Africa, SEN: Senegal, TZA:Tanzania, UGA: Uganda, ZMB: Zambia, ZMB: Zimbabwe.
Source: Introduced in Section 5.4.2

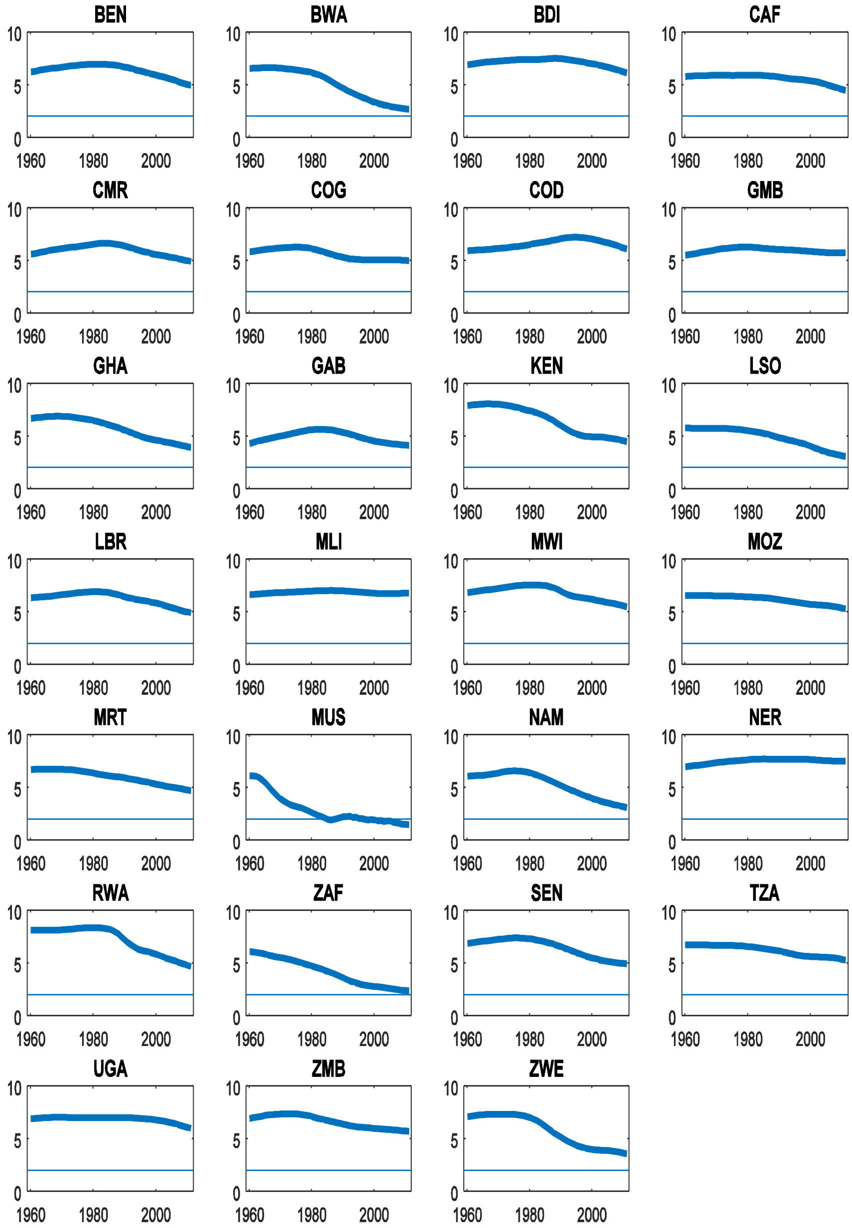

Figure 3: The Patterns of Fertility in SSA

BEN: Benin, BWA: Botswana, BDI: Burundi, CAF: Central African Republic, CMR: Cameroon, COG: Congo,COD:Congo, the Democratic Republic of, GMB: Gambia, GAB: Gabon, GHA: Ghana, KEN: Kenya, LSO: Lesotho, LBR: Liberia, MLI: Mali, MWI: Malawi, MOZ: Mozambique, MRT: Mauritania, MUS: Mauritius, NAM: Namibia, NER: Niger, RWA: Rwanda, ZAF:South Africa, SEN: Senegal, TZA:Tanzania, UGA: Uganda, ZMB: Zambia, ZMB: Zimbabwe.
Source: Introduced in Section 5.4.2

The evolution of education figures for Gabon, Mauritius, and Zimbabwe are also remarkable. However, situations of these countries are slightly different than each other. The education pattern of Zimbabwe is similar to Botswana. It also shows a modest increase between 1960-1980 years, and it then accelerates. This acceleration however is not as fast as Botswana's. Similarly, the fertility behavior in Zimbabwe does not dramatically change for the years between 1960 and 1980, and then it shows a decrease. But the fertility rate in Zimbabwe is still far from the replacement level. This indicates that this country might be in the Post-Malthusian epoch or is undergoing a demographic transition right now. The situation for Mauritius is almost identical to that of Zimbabwe except for the timing of events. Mauritius might be very close to entering the modern growth regime if it is not already in it. This country reaches one of the highest education levels at the end of the period, and the lowest fertility rate among the countries considered here. Furthermore, the fertility rate decreases to a level that is below replacement. The situation for Gabon, however, is different. According to Table 1, Gabon has the highest initial real GDP per capita level. This can also be observed from Figure 1. The growth path of education of Gabon is also in line with UGT. However, Figure 3 says that demographic transition started long after the acceleration in educational investment. TFR increases between 1960 and 1982, and then it decreases in Gabon. This shows that Gabon is most probably in a Malthusian regime. Burundi, Mali, Mozambique, and Niger are some of the examples for the Malthusian countries. AYS are too low in these countries, and TFR is remarkably higher than the replacement level. Real GDP per capita in Mozambique and Mali increase after mid-1980s but remain at comparatively low levels. On the other hand, real GDP per capita in Niger decreased far behind the initial level, and Burundi exhibited large fluctuations during the period under consideration.

4.4 A CONCLUDING REMARK

Despite the fact that Africa has suffered from different handicaps regarding economic growth, there are growing countries in SSA right now. Furthermore, some countries are either in modern growth regime or very close to entering it. The reason why some countries still do not converge to modern growth regime is simply that they are in their Malthusian regimes. To go beyond the graphical inspection presented here, we need to devise formal testing procedures that would show us that whether economic growth in SSA is of modern character in the terminology of UGT. The following chapter provides a formal econometric analysis that finds some answers.

CHAPTER 5

THE CHILD QUANTITY-QUALITY TRADEOFF IN SUB-SAHARAN AFRICA

5.1. INTRODUCTION

SSA is the poorest region in the world. No country in SSA has a level of GDP per capita that is larger than 17,128 US dollars in 2010. The statistical figures regarding poverty, disease, conflicts, and corruption, among other ills, describe the African economic tragedy.

Africa's stagnation and its lack of bright development prospects in the future have been much debated issues in the literature. There have been efforts to identify the causes of the African economic tragedy. Harrison et al. (2013), for example, analyzes Africa's advantages and disadvantages in production. The study finds that firms in Africa have advantages in low-tech production, with wage and productivity growth rates being significantly lower compared to firms located in other regions of the world. Financial constraints, the lack of infrastructure, and political monopolies for instance are the factors partially determining the low productivity performance of African economies. Some economists further claim that Africa's underdevelopment is a destiny and those African economies will not able to escape from Malthusian trap in foreseeable future. Korotayev and Zinkina (2015) is one example for this claim. This study looks population, GDP, and GDP per capita dynamics of Uganda, Kenya and Tanzania and compares them with dynamics of Bangladesh. It concludes that because of high fertility rates, lack of family planning, and low marriage age these countries will not succeed to escape from Malthusian trap. However, not all economists share this pessimism. Young (2012) is a good example to those who do not share this pessimism. The study shows that real consumption growth rate based on owning of durable good, housing quality, child health, mortality, and education, is about 3.4-3.7 for 29 Sub-Saharan countries for 1990-2006 period. Kenny (2010) on the other hand gives assertive claims about Malthusian trap and concludes that with exceptional cases in Africa, there is no country in the world that has not escape from Malthusian trap. Especially in recent decades, some African countries such as Gabon and Zambia have exhibited an impressive economic growth record. For these two countries, for instance, the average rates of growth from 2000 to 2011 are respectively 8.46 % and 7.38% per annum. This chapter studies growth and stagnation in SSA from the viewpoint of the UGT. The UGT has been proposed by Galor and Weil (2000) and Galor (2005, 2011, and 2012) and is a theory that attempts to understand all the regimes an economy transits through in the course of its entire economic development. Three regimes that characterize the path of economic development of an economy according to the UGT are the Malthusian, the Post-Malthusian, and the Modern Growth regimes. In the first regime, subsistence constraints are binding, and stagnation is due to the population pressure a la Malthus. In time, miniscule rates of productivity growth depending on the level of population positively leads to the relaxation of subsistence constraints, and the economy enters the second regime. In this Post-Malthusian stage, increasing prosperity leads to increasing population growth because individuals invest only in the quantity of children. But, in time, the latent dynamics in the model, mainly the return to human capital in the form of skills, result in the activation of the Q-Q tradeoff as individuals find optimal to decrease the number of children they have but increase the educational investment each child receives. The economy at this date enters the final regime of modern growth where increased education of the workforce accelerates productivity growth. Figure 4 visualizes these complex relationships where a bi-directional arrow implies two-way causation.

We argue in this chapter that the dynamics of fertility and education in SSA provide information on whether or not SSA countries that exhibit faster-than-ever growth in recent decades are economies that truly experience modern growth. This is an

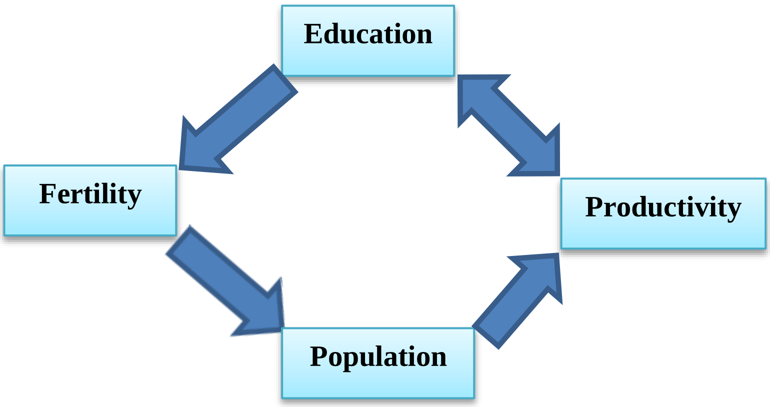

Figure 4: Correlation among Variables

interesting research avenue since Rodrik (2014), for example, argues that the fast growth performance in some of the African growth miracles do not really represent a secular shift to a stage of modern growth. This is because the growth record in SSA is not supported by structural transformation and a sustainable rise in manufacturing industries.

This chapter basically tests the validity of the child Q-Q tradeoff in SSA since the UGT as a theoretical foundation builds on the notion that the transition to modern growth occurs when the Q-Q tradeoff is deliberately activated; if parents choose to have fewer children and to increase the level of educational investment for each child, then this indicates that SSA economies evolve from stagnation to modern economic growth (Galor and Weil, 2000; Galor, 2005, 2011).To alleviate the problem of endogeneity between education and fertility, we use the method of instrumental variables (IV). We first estimate a simple OLS model for 27 countries with quinquennial data from 1960 to 2010. This OLS model where fertility is the dependent variable indicates that fertility and education has a strong inverse relationship. But hypothesis tests confirm our presumption that education is an endogenous covariate. For this reason, we implement a 2SLS procedure to estimate the causal effect of education on fertility. In the first stage of this analysis, we run a random and a fixed effects GLS regression for the panel with two instruments for education. These are the population density and the years since independence in country i at time t. The former instrument receives theoretical support from the theory of school formation developed by de la Croix et al. (2007). Since the average cost of establishing schools in more densely populated areas is lower. The other instrument is basically motivated by the notion that independent countries must have more focused development strategies and planning visions given an urgent and strong need to pursue national interests. The anecdotal evidence proposed by Dahlstrom (1995) and Kreienbaum et al. (2002) regarding the independence-education nexus respectively for Namibia and Zambia support such a view.

Our results verify that education affects fertility negatively in SSA, and this is robust to different specifications and control variables. Classifying countries according to their education level indicates that the causal effect of education on fertility is stronger in high education group and barely significant in the low education one. Furthermore, our results confirm that the instruments are valid, and additional controls do not change the magnitude and the significance of the causal inverse relationship between education and fertility.

Then, we make dynamic estimation by using difference and system GMM. This method allows us to see whether lagged fertility has an effect on current realization of fertility. GMM also allow us to use lagged value of the fertility as an instrument. Therefore, this method solves the endogeneity problem in itself. Results confirms that lagged fertility has a high positive and significant effect on fertility, but it does not release the negative and significant effect of education on fertility.

The outline of the chapter is as follows: Section 5.2 presents a short review of the literature. Section 5.3 summarizes the main patterns of fertility decline and the rise of education in SSA. Section 5.4 introduces the IV methodology and describes the data used. Section 5.5 presents the main results. Section 5.6 extends the analysis with the threshold effects. Finally, Section 5.7 concludes with some remarks.

5.2 RELATED LITERATURE

This chapter is related with a number of recent papers that study the relationship between education and fertility for SSA. Garenne (2012) looks at the relation between fertility and education in SSA for the years between 1900 and 1985. The analysis takes into account 34 countries and uses a longitudinal approach to identify the causal relationship. Garenne (2012) finds a weak but a complex relationship between education and fertility. Countries with a higher level of education in SSA have an earlier onset of the fertility transition, but the speed of the transition is not correlated with the level of education. Moreover, years during which fertility decline decelerates are associated with a slower rate of increase in education, but years during which education increase loses its momentum does not affect the fertility trend. Lastly, education has a weak but positive association with GDP per capita, and it fluctuates with factors such as religion and colonization. Being a Muslim country has a negative effect on education, and British colonial heritage corresponds to a higher level of education. In another similar study, Chisadza and Bittencourt (2015) looks at the relationship between education and fertility for 48 SSA economies for the 1970-2010 period. Their results suggest that the relation is significant for countries which have a high level of education. Chisadza and Bittencourt's (2015) results also support the notion that increases in the level of education lead to fertility decreases, and, hence, cause the demographic transition. Some countries in SSA, according to their results, are in a stage leading to modern or sustained growth with increased urbanization rates being the main driver of increased levels of educational attainment. Bittencourt's (2014) analysis on the other hand focuses on the case of South African for the period of 1980-2009. Also using a longitudinal approach to identify heterogeneity and to alleviate the endogeneity bias, the analysis takes primary education completion as an endogenous variable and confirms that education has a negative and significant effect on fertility. By identifying this effect, Bittencourt (2014) claims that South African escaped the Malthusian trap. Bongaarts (2010) estimates the effects of differences in education levels on fertility in SSA. Results show that the level of education is positively related to the demand for and the usage of contraception, implying an inverse relationship fertility. The study also examines the relationships between education level and fertility for given levels of contraceptive usage, of the demand for contraceptives, and of the desired family size. It finds a negative relationship in all cases. Caldwell and Caldwell (1987) focus on the cultural determinants of fertility in SSA. Their results indicate that Africans do not control fertility to have moderate family size. The only control of fertility in Africa seems to be the sexual abstinence of females, and this channel is usually ignored in empirical work. Lastly, Caldwell and Caldwell (1987) claim that high fertility in Africa is not an outcome of the erosion of preexisting constraints.

This chapter is most directly related with those of Becker et al. (2010) who try to identify the links of causation between education and fertility in Prussian counties before the Industrial Revolution and of Fernihough (2017) who does the same thing for Ireland. Becker et al. (2010) conclude that the Q-Q tradeoff existed in preindustrial Prussia. Based on detailed data for 334 Prussian counties for the period of 1816-1849, they claim that fertility and education affected each other. They use the method of instrumental variables (IVs) and use the school enrollment rate and child-women ratio as proxies for education and fertility, respectively. Their instruments are landownership inequality and the distance to Wittenberg for education and adult sex ratio for fertility. Fernihough's (2017) results are based on 1911 Irish census and tests for the causality between education and fertility. The estimations of this study verify the negative relation between education and fertility and it is robust with different estimation methods and controls. While we also estimate a model of the Q-Q tradeoff, we utilize a panel dataset and exploit both cross-section and time variation. Besides, our framework strongly builds upon the UGT and our focus is the causal effect of education on fertility as dictated by the UGT.

While the directly related theoretical literature is that of the unified growth models, a few papers that develop poverty trap models with fertility and/or education deserve credit here. These are Azariadis and Drazen (1990), Becker et al. (1990), Galor (1996), and Lucas (1998), and all of these models show that economies may be trapped in the long run at a steady-state equilibrium with low human capital and low education (and

Table 2: Correlation Matrix of Variables

	Total fertility rate	Avg. years of schooling	GDP per capita
Total fertility rate	1.0000		
Avg. years of schooling	−0.7461	1.0000	
GDP per capita	−0.6464	0.6558	1.0000

Data Source: Total Fertility Rate – World Bank (2012)

Average Years of Schooling – Barro and Lee (2013)

GDP per capita – Penn World Table 8.0

hence with high fertility).[2] For instance, Becker et al. (1990) study a model that predicts the existence of two different steady-state equilibria. One of them has a low level of human capital and a high level of fertility, and the other has the opposite. This study, serving as one of the foundations for the UGT, asserts that fertility is endogenous to the return on human capital because of parental preferences and the intertemporal budget constraint. Most importantly, the initial level of human capital determines the fate of the economy as it determines whether the economy converges to low-fertility or high-fertility steady-state; when an economy has a sufficiently large level of human capital, namely if human capital is abundant, then households in this economy choose to invest in the education of their children. In contrast, if an economy has a sufficiently low level of human capital, then choosing to have more children and a lower level of investment is the long-run outcome.

5.3. EDUCATION AND FERTILITY IN SUB-SAHARAN AFRICA

There is a sizable literature that documents the dynamics of education and fertility in SSA. Two remarkable reviews should be mentioned here. Majgaard and Mingat (2012)

[2] The major deficiency of these poverty trap models is that they cannot explain how an economy endogenously and gradually transits from low education equilibrium to high education in the long-run.

studies the education system in SSA. This study looks several different indicators such as educational attainment, the relevance of education to work and life, and the quality of education. The study argues there is no equal opportunity for all SSA citizens to obtain education. There are different reasons for this, but the most important reason seems to be living in rural areas. On the other hand, educational investments are insufficient both at the individual level and at the country level. Foote et al. (1993) analyze demographical changes in SSA and find different reasons behind the fertility decline. Using the data from Demographic and Health Surveys (DHS), they conclude that fertility decline is a widespread phenomenon in SSA. Another interesting finding is that the changes in marriage patterns of SSA communities explain the declines in fertility levels as marriage ages are increasing because of increasing educationalattainment.[3] Table 2 shows the cross correlation matrix for fertility, education, and GDP per capita for the pooled data of 27 SSA African countries.[4] Accordingly, education and fertility are highly correlated and negatively related. As the table suggests, the correlation coefficient between them is −0.7461 which is in line with the claim of UGT. Second, the correlation between fertility and GDP per capita is negative with a coefficient of −0.6464. Lastly, we observe a positive correlation coefficient between education and GDP per capita; it is equal to 0.6588. These statistically significant correlation coefficients are in line with the main predictions of the UGT for economies in the modern growth regime.

Figures 5 and 6 show bivariate kernel density estimates of TFR and AYS for the years 1960 and 2010 respectively. From these nonparametric estimates, we can easily observe the scope and pace of the demographic transition in SSA. In 1960, most of the countries have a very low level of education and a very high level of fertility. But, in 2010, situation is much different with many countries being in the middle of their demographic transition. Figure 5 suggests that that TFR is mostly around six and seven while AYS is between zero and two in SSA as a whole. These figures suggest that most **o**f SSA economies had not passed the subsistence level of income, and the critical level of technology had not been achieved yet in 1960 according to the UGT. Figure 6 on the other hand clearly shows that TFR is lower and AYS is higher on average in 2010. But

[3] The study also finds that decreases in child mortality have significant effects on population growth.
[4] See Section 5.4.2 for the list of these countries.

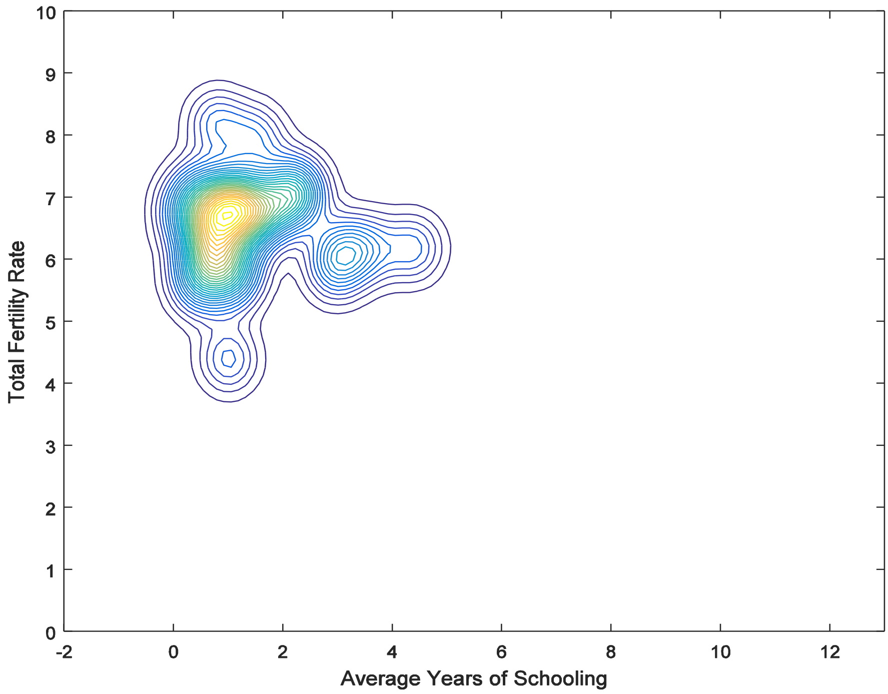

Figure 5: Bivariate Kernel Density of Education and Fertility for 1960

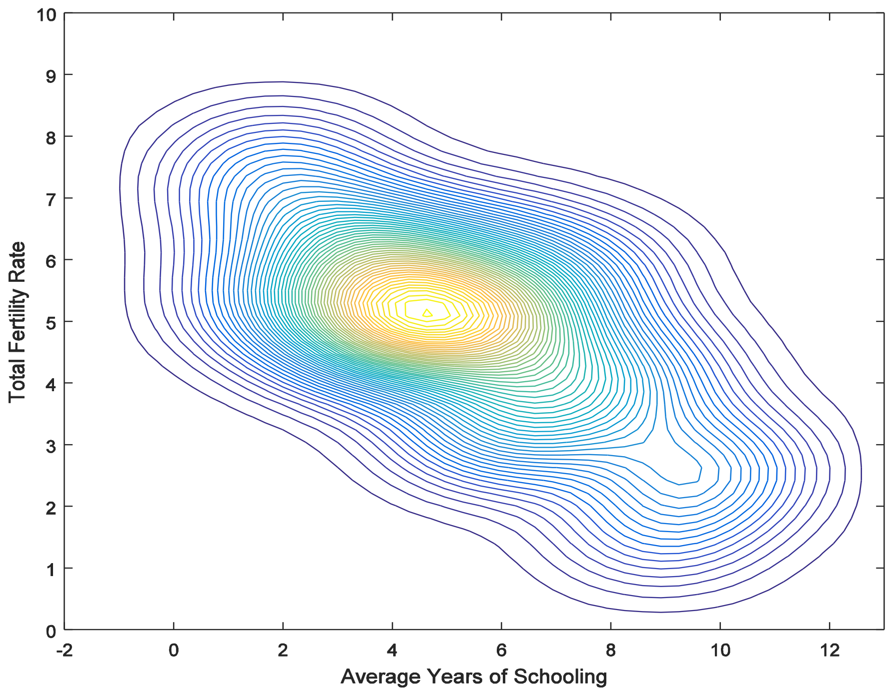

Figure 6: Bivariate Kernel Density of Education and Fertility for 2010

this figure also indicates that large ranges of values for TFR and AYS exist. Therefore, the joint distribution of fertility and education, while single-peaked, reflects the experience of countries that look very different in terms of fertility and education in 2010. There are both *low-education with high-fertility* countries and *high-education with low-fertility* ones and most of the countries are located in between. This implies that most countries are in the middle of their demographic transitions. While one group seems to have left the Malthusian trap via the Q-Q tradeoff, another group fails to experience such a transition.

5.4 METHODOLOGY AND DATA

5.4.1 Methodology

The linear regression equation we estimate first with OLS (without controlling for the endogeneity of education) and, then, with IV to alleviate the endogeneity bias has the following simple form:

$$Fertility_{i.t} = \gamma_i + \alpha \times Education_{i,t} + \boldsymbol{X_{i,t}} \times \boldsymbol{\beta} + e_{i,t} \tag{5.1}$$

Here, $(i.t)$ indexes a country-time pair where i indexes $N = 27$ SSA countries and t indexes $T = 11$ 5-year episodes from 1960 to 2010. The parameter we are mainly interested in is $\alpha \in \mathbb{R}$ that simply measures how education affects fertility. $\boldsymbol{X_{i,t}}$ is a matrix of control variables and $e_{i,t}$ is residual term. The null hypothesis we are to test is $H_0: \alpha = 0$, i.e., whether parents' fertility decision is affected by educational investment on children.

When fertility and education decisions affect each other, estimating (1) with OLS is subject to endogeneity bias, i.e., $E\left[Education_{i,t} \middle| e_{i,t}\right] \neq 0$. The UGT provides an explanation that motivates such an endogeneity assumption. The latent variables in an economy lead to (endogenous) changes in observed variables. An increase in the return to human capital, for instance, leads to an increase in education investment of parents. Education increases are also associated with decreases in fertility rates.

IV estimation removes the endogeneity bias by instrumenting education with variables that are not correlated with the error term $e_{i,t}$. Specifically, good instruments for education have to be highly correlated with education without being correlated with other things that have an effect on $Fertility_{i.t}$. But if the correlation between the IV, say $Z_{i,t}$, and $Education_{i,t}$ is weak, then parameter estimates can still be biased (Staiger and Stock, 1994) and OLS results and IV results tend to be close to each other, making IV estimation redundant (Bound et al., 1995). Therefore, we should find such instruments that their effects are highly and statistically significant. Besides, by construction, instruments must be affecting the dependent variable $Fertility_{i.t}$ only through $Education_{i,t}$. In other words, effects of instruments on dependent variable must be indirect, and their effect must reach the dependent variable via the independent variable (Pearl, 2003).

There is another problem causing results to be potentially inconsistent. When the model is exactly identified, the case of one IV in our example, the correlation between the instrument and the error term is not testable. Henceforth, we cannot say with confidence that the model gives unbiased and consistent results. A remedy for this problem is to use more than one IV for $Education_{i,t}$. Accordingly, the linear first-stage regression we estimate reads

$$Education_{i,t} = \theta_i + \mu Density_{i,t} + \rho Independence_{i,t} + \boldsymbol{X_{i,t}\omega} + \varepsilon_{i,t} \quad (5.2)$$

where $Density_{i,t}$ denotes the population density of country i at time t, and $Independence_{i,t}$ denotes the number of years since country i has been an independent country (with a sovereign state) at time t. $\boldsymbol{X_{i,t}}$ is the vector of control variables as in (1).

We believe that $Density_{i,t}$ and $Independence_{i,t}$ explain the variation in $Education_{i,t}$ and have an indirect effect on $Fertility_{i.t}$. Furthermore, we believe that these two variables are uncorrelated with residuals in (1). The reason why we use population density as an instrument is that, in the theory proposed by de la Croix et al. (2007), population density decreases the cost of school establishment. Governments or municipalities do not generally establish a new school in rarely populated regions since the demand for education stays low given the low level of population in the region. A low level of population basically increases the average cost by requiring a larger fixed cost of buildings and a larger variable cost of teacher salaries. Therefore, schools are usually established in highly populated regions. In the model proposed by de la Croix et al. (2007), households' educational investment decisions depend on the distance to the nearest school, and longer distances simply imply more expensive education. We naturally assume that $Density_{i,t}$ has no direct effect on fertility, and it is uncorrelated with the error terms in (1).

The motivation for our second instrument $Independence_{i,t}$ is basically the transformative role of becoming an independent country. Intuition suggests that independent countries more enthusiastically and more easily pursue developmental policies and planning. In this respect, education takes a central functioning. In an example for how becoming an independent economy affected the system of education, Kreienbaum et al. (2002) explains the situation in Zambia. Before independence and under 75 years of colonial administration, missionaries largely controlled education, and their approach. This means that there were two types of education in Zambia. One is the European education system that did not truly build on Zambia's national interest and long-term needs. It was more appealing to foreigners with better facilities. The African schools naturally had poorer opportunities. After independence, Zambians' expectations from independence made the Zambian government create a new educational system that resulted in increases in enrollment rates. In another example, Dahlstrom (1995) explains the changes in the educational system in Namibia after independence. He also underlines the racist and elite educational system under colonial administration. Accordingly, the new government after independence gave priority on changing the educational system, reflected in the slogan *Education for all*.

It should be noted that we use four control variables that are surely endogenous to the dynamics of transition from stagnation to growth. These are urbanization rate, real GDP per capita, life expectancy, and infant mortality rate. We associate these variables as additional controls to see whether the relationship between education and fertility is somehow masked by the relationships of education and fertility with these endogenous covariates.

5.4.2 Data

There exist 48 countries in SSA, but data availability necessitates the inclusion of 27 SSA countries in the analysis. These countries are Benin, Botswana, Burundi, Cameroon, Central African Republic, Congo, Democratic Republic of the Congo, Gabon, Gambia, Ghana, Kenya, Lesotho, Liberia, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Republic of South Africa, Rwanda, Senegal, Tanzania, Uganda, Zambia, and Zimbabwe. We use several data sources. The main variables of interest are education and fertility in this study. We use the *Average Years of Schooling* (AYS) as a proxy for Education. The data source for this variable is Barro and Lee’s (2013) celebrated dataset in which quinquennial data between 1950 and 2010 is available for each country. The other variable of interest, the proxy for Fertility, is the *Total Fertility Rate* (TFR). TFR is available at the World Bank website for the period of 1960-2010. Other variables are either controls or instruments. We construct two types of control variables. These are historical controls and geographical controls. Historical controls include religions, colonial dummies, and ethnolinguistic fractionalization.

The three proxies for religion, i.e., *Catholic, Protestant, and Muslim*, are the percentages of population belonging to Roman Catholic, Protestant, and Muslim beliefs respectively in 1980, and the source of this data is La Porta et al. (1999).

We have two colonial dummies, one for British and another for French colonial heritage. The colonial dummy *England* (respectively *France*) takes a value of one instead of zero if this country was a British (respectively French) in the past.

Table 3: Summary Statistics

	Observation	Mean	Std. Dev.	Min.	Max.
Year 1960					
Avg. years of schooling	27	1.448	1.041	0.2000	4.390
Total fertility rate	27	6.510	0.760	4.384	8.187
Urbanization rate	27	14.122	10.960	2.100	46.600
GDP per capita	26	1,535.377	1,158.979	376.467	5,063.655
Life Expectancy	27	42.265	6.671	28.212	58.745
Infant mortality rate	24	135.214	25.122	92.6	186.9
Population Density(*1965*)	27	36.168	74.235	0.829	370.936
Year 2010					
Avg. years of schooling	27	5.367	2.251	1.880	9.690
Total fertility rate	27	4.838	1.374	1.570	7.584
Urbanization rate	27	39.737	17.436	10.600	85.700
GDP per capita	27	3,782.139	4,661.263	382.932	17,127.770
Life Expectancy	27	58.045	5.360	47.483	72.967
Infant mortality rate	24	58.029	17.384	37.5	101.7
Population Density	27	97.758	146.179	2.664	65.691
Control Variables					
Muslim	27	25.426	34.173	0.000	100.000
Protestant	27	20.919	23.495	0.000	75.900
Catholic	27	18.367	19.499	0.000	62.100
Elevation	27	0.744	0.501	0.034	2.161
Ethnoling. fraction.	27	0.633	0.270	0.013	0.890
Being colony of France	8				
Being colony of England	10				

Average Years of schooling is the education attainment aged over 15. Total fertility rate is the number of children can be born by a woman if she would live until end of childbearing age. Urbanization rate is the percantage of population that lives in urban areas. GDP per capita is Expenditure-side real GDP in PPP corrcted and divided by population. Life expectancy is expectation of the number of years that a newborn infant would live. Infant mortality is the number of infants out of 1000 infants that die before they reach one year of age. Population Density is the level of midyear population divided by the land area in square kilometer. Muslim, Protestant, and Catholic are the percantage of people that belongs to that religion. Elevation is mean elevation kilometers above see level. Ethnolingustic fractionalization is an index for the events that whether two randomly selected induvidial belongs to same ethnolinguistic group, whether they speaks the same language or different, and whether they belongs to the same religion. Being Colony of France and Being Colony of England are whether a country was a colony of France and England respectively. Data sources are introduced in 4.2.

Ethnolinguistic fractionalization is the average of five different indices and ranges from zero to one as a normalization. The five indices measure the following: (1) the probability of the event that two randomly selected individuals are not members of the same ethnolinguistic group in 1960, (2) the probability of the event that two randomly selected individuals speak different languages, (3) the probability of the event that two randomly selected individuals do not speak the same language, (4) the percentage of population that cannot speak the official language, and (5) the percentage of population that do not speak the widely used language in the country. Since we do not have annual or quinquennial data here, the value of Ethnolinguistic Fractionalization is fixed for each country in the sample. This data is available for 1960.

Geographical controls used in the study are *Elevation* and a dummy for being *Landlocked*. We obtain the information of the status of being landlocked from Sachs et al. (2004). The variable *Landlocked* takes a value of one if it is a landlocked country and zero otherwise. The source of the elevation data[5] is the website of the College of Urban and Public Affairs at Portland State University.

The two IVs we use for education are *Population Density* and *Years Since Independence* as discussed above. We obtain the former from the World Bank's World Development indicators (WDI) for the years between 1961 and 2010. It basically measures the level of midyear population divided by the land area in square kilometers.[6] For years since independence, we normalize the first year of independence to zero, and $Independence_{i,t}$ therefore increases over the years, being equal to negative values if a country gains independence after 1960. Lastly, for additional control variables, we use the WDI and the Penn World Tables (PWT) data. The urbanization rate and life expectancy respectively identify the percentage of the population of each country that lives in urban areas and how many years a randomly selected newborn infant would live without any change in the pattern of mortality. These two variables are constructed

[5] Elevation data for Congo and Democratic Republic of the Congo is counted jointly in data source. Furthermore, elevation data of Mauritius is not available on this data source. Therefore, we used Ministry of Energy and Public Utilities data source for Mauritius.

[6] The land area does not include inland water bodies, continental shelf, and exclusive economic zones, and midyear population does not cover the refugee population.

using WDI data. Real GDP per capita in purchasing power parity corrected terms is available in Feenstra et al. (2013), also known as the Penn World Tables (PWT). Infant mortality data is also obtained from WDI, and it shows the number of infants that die before they reach one year age. This variable shows mortality for per 1,000 live births.

Table 3 summarizes the descriptive statistics for our variables. The outstanding thing to note is the evolution of TFR. The average TFR fell from 6.51 in 1960 to 4.83 in 2010. The other remarkable thing is the evolution of AYS. Its average across countries is equal to 1.44 for 1960 and 5.36 for 2010. The strong inverse relationship between the two is reflected in these numbers. The question is simply whether it is due to the Q-Q tradeoff.

Table 3 also gives information about control variables. The average urbanization rate increased from 14.12 % to 39.73 % for years between 1960 and 2010 in SSA, GDP per capita increased from 1,535$ to 3,782$, life expectancy increased from 42.26 years to 58.04 years, and lastly infant mortality rate decreased from135.21 to 58.03 on average.

5.5 RESULTS

The objective of this section is to summarize the main results. Table 4 collects the results of the OLS estimation of (1). The dependent variable is TFR and the main independent variable of interest is of course AYS. In the first column, we see the pure effect of education on fertility. This estimate suggests that a unit of increase in AYS decreases TFR by 0.429 units at 1% significance level. This result is not surprising for us; as the UGT suggests, this relation must be strong and negative. On the other hand, we add some control variables with results being showed in the second column. The addition of control variables does not change the sign, the magnitude, and the significance of this effect.

Table 4: OLS: The Effect of Education on Fertility

Dependent Variable: Total fertility rate			
	(1)	(2)	(3)
Avg. years of schooling	−0.429***	−0.431***	−0.522***
	(0.023)	(0.024)	(0.029)
Muslim		0.004	0.003
		(0.008)	(0.009)
Protestant		0.001	0.003
		(0.012)	(0.013)
Catholic		0.006	0.007
		(0.011)	(0.012)
Ethnoling. Fraction.		0.349	0.429
		(0.615)	(0.683)
France		−0.141	−0.065
		(0.404)	(0.449)
England		0.260	0.408
		(0.361)	(0.402)
Landlocked		0.322	0.220
		(0.369)	(0.410)
Elevation		0.270	0.297
		(0.416)	(0.463)
Residuals			0.163***
			(0.049)
Constant	7.452***	6.579***	6.772***
	(0.127)	(0.859)	(0.955)
Observation	297	297	270
R^2	0.5555	0.6110	0.5822
Durbin-Wu-Hausman Test			0.0009

*Random effect GLS regression. Dependent variable: Total Fertility Rate. Standart errors in parentheses. ***p<0.01, **p<0.05, *p<0.10. Total fertility rate is the number of children can be born by a woman if she would live until end of childbearing age. Average Years of schooling is the education attainment aged over 15.*
Source: Introduced in 4.2

The major problem here is, of course, the endogeneity of education. The Durbin-Wu-Hausman (DWH) test indicates that there is an endogenous relation in the second specification. In the third column of Table 4, we have another set of regression results. In this regression, we first run a regression such that education is the dependent

Table 5: First Stage of Random Effect IV Estimations for Whole SSA

Dependent Variable: Average years of schooling					
	(1)	(2)	(3)	(4)	(5)
Population density	0.020***		0.000	0.003**	0.005***
	(0.002)		(0.002)	(0.002)	(0.001)
Years since independence		0.071***	0.080***	0.073***	0.041***
		(0.004)	(0.005)	(0.005)	(0.005)
Urbanization Rate					0.073***
					(0.009)
Life expectancy					−0.045***
					(0.010)
Log of GDP per capita					0.517***
					(0.121)
Share of Muslims				−0.001	−0.003
				(0.017)	(0.010)
Share of Protestants				0.038**	0.015
				(0.018)	(0.015)
Share of Catholics				0.020	0.002
				(0.027)	(0.014)
Ethnoling. Fractionalization				0.714	0.338
				(0.940)	(0.704)
Being colony of France				1.453*	0.145
				(0.737)	(0.542)
Being colony of England				2.411***	1.411**
				(0.653)	(0.552)
Being landlocked				−1.515**	−0.448
				(0.589)	(0.510)
Mean elevation				1.709***	1.951***
				(0.648)	(0.571)
Constant	2.262***	1.447***	1.172***	−2.451	−3.952**
	(0.743)	(0.186)	(0.348)	(2.090)	(1.570)
Observation	270	297	270	270	270
F – Statistic	100.05	704.05	378.67	78.29	120.14

*2SLS random effect regression. Dependent variable: Average years of Schooling First-stage estimates in columns (1), (2), (3), (4), (5). Robust standard errors in parentheses. *** p<0.01, **p<0.05, * p<0.10. . Average Years of schooling is the education attainment aged over 15. Population Density is the level of midyear population divided by the land area in square kilometer. Years since independence is the number of years after a country gains the independence.*
Source: Introduced in 4.2

Table 6: Second Stage of Random Effect IV Estimations for Whole SSA

Dependent Variable: Total fertility rate					
	(6)	(7)	(8)	(9)	(10)
Average Years of Schooling	−0.650***	−0.464***	0.524***	−0.528***	−0.855***
	(0.112)	(0.070)	(0.071)	(0.073)	(0.175)
Urbanization Rate					0.050*
					(0.026)
Life Expectancy					0.005
					(0.017)
Log of GDP per capita					−0.086
					(0.184)
Share of Muslims				0.003	−0.002
				(0.007)	(0.010)
Share of Protestants				0.003	−0.004
				(0.011)	(0.015)
Share of Catholics				0.007	0.000
				(0.007)	(0.011)
Ethnoling. Fractionalization				0.429	0.254
				(0.368)	(0.498)
Being colony of France				−0.061	−0.479
				(0.329)	(0.536)
Being colony of England				0.415	0.540
				(0.363)	(0.468)
Being landlocked				0.210	0.302
				(0.350)	(0.471)
Mean elevation				0.304	−1.063
				(0.436)	(0.657)
Constant	8.255***	7.567***	7.815***	6.793***	6.870***
	(0.409)	(0.263)	(0.279)	(0.786)	(1.506)
Observation	270	297	270	270	270
R^2	0.5867	0.5555	0.5867	0.6443	0.5505
F- Statistic	33.61	43.47	54.51	13.24	18.76
Sargan-Hansen *p*-value			0.2127	0.1669	0.4393
Hansen Specification Test (Efficient Estimate)	RE	RE	FE	FE	RE

*2SLS random effect regression. Dependent variable: Total Fertility Rate. Second-stage estimates in columns (6), (7), (8), (9), (10) correspond to first-stage estimates displayed in columns (1), (2), (3), (4), and (5) respectively. Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.10. Total fertility rate is the number of children can be born by a woman if she would live until end of childbearing age. Average Years of schooling is the education attainment aged over 15.*

variable. Then we get the estimated residual term from this regression, and we add this as an independent variable into the second specification. With this residual term being a statistically significant explanatory variable indicates that there really exists an endogeneity bias. Accordingly, the DWH test rejects the null hypothesis of OLS estimators being consistent.

Tables 5 and 6 present the results of IV estimations. In Table 5, we present the first stage results indicating the effects of IVs on AYS, and Table 6 presents the second stage results on TFR. In the first stage regression, we firstly add IVs separately, in columns 1 and 2 respectively, and then jointly include them in column 3. We add historical and geographical controls in column 4 to see whether the magnitude, the sign, and the significance of parameter estimates change, and, lastly, we add additional controls in column 5 to check whether their endogeneity would have any effect. All specifications are estimated with random effects, but we also compared them with fixed effect estimation results.

According to the first specification, a unit of increase in population density increases AYS by 0.02 years. If we take into account that population density has increased almost 60 units on average between 1960 and 2010, we can say this variable has to be effective enough on education. The second specification suggests that years since independence is strongly associated with AYS. Accordingly, one year passed after independence increases AYS by 0.07 years. Its significance does not change even we add different control variables, and its coefficient does not differ so much in different specifications.

On the other hand, we do not see significant effects of geographical and historical variables on education except mean elevation. Accordingly, one kilometer increase in elevation increase education by 1.70 units and the positive effect of mean elevation is robust with additional controls. Even if the fourth specification suggests that being a former colony of England in the past affects AYS positively, its significance is not so robust to the addition of other controls.

The corresponding second-stages of the IV estimations appear in Table 6, and these

Table 7: First Stage of Fixed Effect IV Estimations for Whole SSA

Dependent Variable: Average years of schooling				
	(1)	(2)	(3)	(4)
Population density	0.022***		−0.002	0.002
	(0.005)		(0.003)	(0.002)
Years since independence		0.082***	0.087***	0.064
		(0.008)	(0.012)	(0.010)
Urbanization Rate				0.056***
				(0.017)
Log of GDP per capita				0.470**
				(0.168)
Life Expectancy				−0.061***
				(0.016)
Constant	2.136***	1.155	1.124***	−0.423
	(0.289)	(0.208)	(0.188)	(1.429)
Observation	270	297	270	270
F- Statistic	22.22	107.38	112.59	81.20

*2SLS fixed effect regression. Dependent variable: Average years of Schooling First-stage estimates in columns (1), (2), (3), (4), (5). Robust standard errors in parentheses. *** p<0.01, **p<0.05, * p<0.10. Average Years of schooling is the education attainment aged over 15. Population Density is the level of midyear population divided by the land area in square kilometer. Years since independence is the number of years after a country gains the independence.*
Source: Introduced in 4.2

results are our main results of interest. In this table, results suggest that AYS has a statistically significant and large negative effect on TFR even after controlling for historical, geographical, and additional controls. Furthermore, IV estimates qualitatively confirm that the OLS estimates are subject to endogeneity bias and suggest notably larger effects than the OLS estimates of Table 4. In other words, OLS estimates are biased downwards.

IV results suggest that one unit of an increase in AYS causes 0.65 unit of a decrease in TFR in the first specification, and 0.434 unit of a decrease in the second specification. However, since these specifications are exactly identified, our preferred model is shown in the third specification. Accordingly, one unit of an increase in AYS causes a 0.524 unit of a decrease in TFR in SSA as a whole.

Table 8: Second Stage of Fixed Effect IV Estimations for Whole SSA

Dependent Variable: Total fertility rate				
	(1)	(2)	(3)	(4)
Avg. years of schooling	−0.639***	−0.462***	−0.518***	−0.827***
	(0.111)	(0.070)	(0.071)	(0.161)
Urbanization Rate				0.048*
				(0.026)
Log of GDP per capita				−0.091
				(0.184)
Life Expectancy				0.004
				(0.017)
Constant	8.221***	7.561***	7.796***	7.953***
	(0.388)	(0.230)	(0.247)	(1.341)
Observation	270	297	270	270
R^2	0.5867	0.5555	0.5867	0.3812
F- Statistic	33.19	44.13	54.11	27.58
Sargan-Hansen *p*-value			0.2347	0.6300

*2SLS fixed effect regression. Dependent variable: Average years of Schooling First-stage estimates in columns (1), (2), (3), (4), (5). Robust standard errors in parentheses. *** p<0.01, **p<0.05, * p<0.10. Average Years of schooling is the education attainment aged over 15. Population Density is the level of midyear population divided by the land area in square kilometer. Years since independence is the number of years after a country gains the independence.*
Source: Introduced in 4.2

This result is robust since we get almost the same result after adding historical and geographical controls in the fourth specification. When both IVs are included, the Sargan-Hansen over-identification test statistic suggests that our instruments are valid. In other words, it indicates that population density is a good instrument to explain variations in years since independence as long as years since independence explain the same variation. The reverse argument is also true.

Lastly, we add additional controls to obtain the fifth specification in the first-stage analysis. Even if we do not expect these controls to have significant effects onTFR at the second stage basically because these additional controls are endogenous variables in the UGT, they have highly significant effects on education. Both urbanization rate and GDP per capita affect education positively while the effect of life expectancy is negative. The last column in Table 6 confirms our expectation that these endogenous covariates have an insignificant effect on TFR as the causal effect of AYS basically carries the entire economic effect of modernization on TFR. In short, neither historical and geographical controls nor the endogenous covariates other than education have a causal effect on TFR.

When we use Hausman specification test, results are inconclusive to choose between random or fixed estimation. Therefore, we also get estimation IV estimation results with fixed effect. Table 7 and 8 present the estimation results when country effects are assumed to be fixed effects. Here, time-invariant geographical and historical controls are omitted. The results for the first stage do not change dramatically. This is also true for the second stage results. In the third column, we use both IVs and corresponding seventh column suggests that a unit increase in AYS causes a 0.518 unit of a decrease in TFR. This is extremely close to random effect GLS results reported in Table 6. Besides, over-identification test results still indicate that the instruments are valid. Therefore, we can say that our results are robust with different specifications, and the Q-Q tradeoff is active in SSA. The magnitude, the sign, and the significance of the causal effect of education on fertility are not sensitive to alternative specifications.

5.6. THRESHOLD EFFECTS

The main results reported above clearly show that the Q-Q tradeoff is robustly active in SSA as a whole. Besides, the availability of panel data allows us to resolve unobserved heterogeneity at least partially. But equally important is the possible sensitivity of the results with respect to estimating the model for the entire set of countries. What if the Q-Q tradeoff is active in some countries but not (yet) active in some others? What if there are threshold effects exactly as dictated by the UGT? We argue that some countries in SSA might have exceeded a threshold level of education. If this is true, the threshold effects should be identified through where the Q-Q tradeoff is active and where it is not.

Table 9: First Stage of Random Effect IV Estimations for Low-Level Education Economies

Dependent Variable: Average years of schooling					
	(1)	(2)	(3)	(4)	(5)
Population density	0.017***		0.007***	0.006***	0.006***
	(0.002)		(0.001)	(0.001)	(0.001)
Years since independence		0.044***	0.039***	0.044***	0.040***
		(0.003)	(0.003)	(0.004)	(0.007)
Urbanization Rate					0.030***
					(0.008)
Life Expectancy					−0.025**
					(0.012)
Log of GDP per capita					−0.185
					(0.131)
Share of Muslims				0.022**	0.019
				(0.009)	(0.012)
Share of Protestants				0.024*	−0.012
				(0.014)	(0.018)
Share of Catholics				0.078***	0.076***
				(0.015)	(0.019)
Ethnoling. Fractionalization				−0.884	−1.339
				(0.897)	(1.125)
Being colony of France				2.500***	2.462***
				(0.656)	(0.886)
Being colony of England				1.931**	1.977**
				(0.747)	(0.980)
Being landlocked				−0.997**	−0.703
				(0.461)	(0.644)
Mean elevation				−1.369	−1.425
				(0.979)	(1.226)
Constant	1.036***	0.625***	0.370**	−2.545*	−0.260
	(0.551)	(0.147)	(0.173)	(1.403)	(2.102)
Observation	140	154	140	140	140
F- Statistic	124.63	376.75	225.58	66.46	50.73

*2SLS random effect regression. Dependent variable: Average years of Schooling First-stage estimates in columns (1), (2), (3), (4), (5). Robust standard errors in parentheses. *** p<0.01, **p<0.05, * p<0.10. Average Years of schooling is the education attainment aged over 15. Population Density is the level of midyear population divided by the land area in square kilometer. Years since independence is the number of years after a country gains the independence.*
Source: Introduced in 4.2

Table 10: Second Stage of Random IV Effect Estimations for Low-Level Education Economies

Dependent Variable: Total fertility rate					
	(6)	(7)	(8)	(9)	(10)
Average years of schooling	−0.579***	−0.378***	−0.480***	−0.469***	−0.537*
	(0.189)	(0.124)	(0.138)	(0.139)	(0.256)
Urbanization Rate					0.005
					(0.023)
Life Expectancy					0.002
					(0.029)
Log of GDP per capita					−0.289
					(0.310)
Share of Muslims				−0.003	−0.003
				(0.006)	(0.007)
Share of Protestants				−0.016	−0.018
				(0.010)	(0.014)
Share of Catholics				0.002	0.004
				(0.010)	(0.011)
Ethnoling. Fractionalization				−0.473	−0.663
				(0.423)	(0.515)
Being colony of France				−0.135	0.061
				(0.361)	(0.455)
Being colony of England				0.037	0.273
				(0.522)	(0.548)
Being landlocked				0.490	0.395
				(0.351)	(0.453)
Mean elevation				−0.108	−0.084
				(0.487)	(0.497)
Constant	7.810***	7.350	7.602***	7.935***	9.827***
	(0.450)	(0.296)	(0.340)	(0.673)	(1.836)
Observation	140	154	140	140	140
R^2	0.2021	0.1694	0.2021	0.4123	0.3894
F- Statistic	9.40	9.29	12.06	6.75	5.92
Sargan-Hansen *p*-value			0.5267	0.2449	0.3070

*2SLS random effect regression. Dependent variable: Total Fertility Rate. Second-stage estimates in columns (6), (7), (8), (9), (10) correspond to first-stage estimates displayed in columns (1), (2), (3), (4), and (5) respectively. Robust standard errors in parentheses. *** p<0.01, **p<0.05, * p<0.10. Total fertility rate is the number of children can be born by a woman if she would live until end of childbearing age. Average Years of schooling is the education attainment aged over 15.*
Source: Introduced in 4.2

To this end, we estimate the very same IV regressions for two different panels by classifying countries into high-education and low-education groups. We divide them according to their fifty-year average education data. The countries that have lower average AYS are included in the first group of low-education countries. The second group covers the high-education countries.

In the low-education group, we have 14 economies; Burundi, Benin, Central African Republic, The Democratic Republic of the Congo, Gambia, Liberia, Malawi, Mali, Mozambique, Mauritania, Niger, Rwanda, Senegal, and Uganda. The members of the second group, which is high-education group, are Botswana, Cameroon, Congo, Gabon, Kenya, Lesotho, Mauritius, Namibia, United Republic of Tanzania, South Africa, Zambia, and Zimbabwe.

Table 9 shows the first-stage results for the first group economies, and Table 10 shows the corresponding second-stage results. For all specifications effect of education on fertility is much lower than its effect for whole Africa. According to the eighth column in Table 10 one-year increase AYS decreases TFR by 0.48 units and this is much smaller than the results reported in Table 6. Adding control variables decreases this coefficient more, but it still is significant with control variables and the relation is still negative. The additional controls again create too much variation in the parameters. In the tenth column, we see the same model estimation with additional control and it suggests that one unit increase in AYS causes 0.537 unit decrease in fertility rate. However, because of the endogeneity of these additional controls, the significance of education decreases. Finally, the Sargan-Hansen test verifies that our instruments are valid for all specifications. Consequently, there is no strong education-fertility relation for low-education countries. Therefore, we can say those countries have not succeeded to escape from the Malthusian regime, and Q-Q tradeoff is not active in that countries.

We see the results for high-education group economies in Table 11 and Table 12. We intuitively think that these group economies have passed the threshold level of education. Therefore, we expect a stronger relation between education and fertility. Table 12 shows the second stage estimation results. Accordingly, education effect on

Table 11: First Stage of Random Effect IV Estimation for High-Level Education Economies

Dependent Variable: Average years of schooling

	(1)	(2)	(3)	(4)	(5)
Population density	0.018***		−0.001	0.001	0.000
	(0.004)		(0.001)	(0.001)	(0.001)
Years since independence		0.105***	0.111***	0.095***	0.074***
		(0.004)	(0.005)	(0.005)	(0.008)
Urbanization Rate					0.021*
					(0.013)
Life Expectancy					0.010
					(0.020)
Log of GDP per capita					0.361**
					(0.169)
Share of Muslims				−0.111***	−0.066**
				(0.020)	(0.027)
Share of Protestants				0.011	0.010
				(0.012)	(0.013)
Share of Catholics				0.001	0.004
				(0.014)	(0.014)
Ethnoling. Fractionalization				−2.469***	−2.265***
				(0.705)	(0.642)
Being colony of France				−3.761***	−3.373***
				(0.930)	(0.999)
Being colony of England				−2.730***	−1.860***
				(0.429)	(0.526)
Being landlocked				1.292***	1.145***
				(0.222)	(0.364)
Mean elevation				−1.669***	−1.011**
				(0.357)	(0.502)
Constant	3.923***	2.492***	2.391***	8.023***	2.786
	(0.819)	(0.236)	(0.370)	(1.422)	(2.548)
Observation	130	143	130	130	130
F- Statistic	60.45	1157.83	451.57	456.55	396.90

*2SLS random effect regression. Dependent variable: Average years of Schooling First-stage estimates in columns (1), (2), (3), (4), (5). Robust standard errors in parentheses. *** p<0.01, **p<0.05, * p<0.10. Average Years of schooling is the education attainment aged over 15. Population Density is the level of midyear population divided by the land area in square kilometer. Years since independence is the number of years after a country gains the independence.*

Source: Introduced in 4.2

Table 12: Second Stage of Random Effect IV Estimations for High-Level Education Economies

Dependent Variable: Total fertility rate					
	(6)	(7)	(8)	(9)	(10)
Average years of schooling	−0.813***	−0.511***	−0.556***	−0.638***	−0.857***
	(0.107)	(0.083)	(0.081)	(0.100)	(0.173)
Urbanization Rate					0.036
					(0.030)
Life Expectancy					0.047*
					(0.023)
Log of GDP per capita					−0.409
					(0.279)
Share of Muslims				0.059**	0.053
				(0.023)	(0.034)
Share of Protestants				0.043***	0.042**
				(0.012)	(0.018)
Share of Catholics				0.007	0.003
				(0.011)	(0.016)
Ethnoling. Fractionalization				2.328***	2.198**
				(0.476)	(0.836)
Being colony of France				1.102	0.641
				(0.705)	(1.032)
Being colony of England				1.140***	1.124**
				(0.289)	(0.415)
Being landlocked				1.394***	1.343*
				(0.520)	(0.718)
Mean elevation				−0.324	0.096
				(0.370)	(0.640)
Constant	9.394***	7.840***	8.106	4.213***	4.766*
	(0.455)	(0.428)	(0.453)	(0.898)	(2.206)
Observation	130	143	130	130	130
R^2	0.5917	0.5599	0.5917	0.7808	0.7720
F- Statistic	57.33	38.09	46.92	37.09	1358.78
Sargan-Hansen *p*-value			0.2024	0.0328	

*2SLS random effect regression. Dependent variable: Total Fertility Rate. Second-stage estimates in columns (6), (7), (8), (9), (10) correspond to first-stage estimates displayed in columns (1), (2), (3), (4), and (5) respectively. Robust standard errors in parentheses. *** p<0.01, **p<0.05, * p<0.10. Total fertility rate is the number of children can be born by a woman if she would live until end of childbearing age. Average Years of schooling is the education attainment aged over 15.*
Source: Introduced in 4.2

fertility is much higher than its effect on SSA as whole for all specifications. These results meet our intuitive expectations. Since education-fertility relation takes a stage in both Post-Malthusian and the modern growth regime according to UGT, the estimation results verify that the relation is stronger for high-education group of economies. The eighth column suggest that one unit increase in AYS causes 0.556 units decrease in fertility rate. Control variables increase this parameter much more. Therefore, we can confidently say that Q-Q tradeoff active in high-education countries. Namely, households' decision on the child quantity depends on child quality. On the other hand, control variables have significant effects on fertility. Accordingly, percentage of population that belongs to either religion, ethnolinguistic fractionalization, being colony of England formerly, and being landlocked have a positive effect on fertility, but parameters of percentage of people that belongs to Muslim is not so robust with additional controls.

5.7. DYNAMIC MODELS OF FERTILITY AND EDUCATION

The main point of our investigation is the causal effect of education on fertility. Random and fixed effects estimations indicate that the effect is negative and statistically significant. Besides, Sargan test indicates that IVs are jointly valid.

One important problem with these static panel estimations is the following: They assume that there is no persistence in fertility, i.e., the lagged value of fertility does not affect current fertility. Besides, the static models also assume that lagged education has no effect on current fertility which, however, may be through in reality.

If such effects are indeed present, then dynamic panel estimation methods should be followed. Here, since education is an endogenous determinant of fertility, we rest on GMM estimates of the causal effect. The first model we estimate is specified as follows:

Table 13: Difference GMM Estimations

Dependent Variable: Total fertility rate						
	(1)	(2)	(3)	(4)	(5)	(6)
Lag of Fertility	0.702^{***}	0.678^{***}	0.716^{***}	0.731^{***}	0.701^{***}	0.676^{***}
	(0.081)	(0.092)	(0.108)	(0.068)	(0.101)	(0.133)
Education	-0.225^{***}	-0.290^{***}	-0.248	-0.204^{***}	-0.214^{***}	-0.473^{***}
	(0.044)	(0.065)	(0.149)	(0.045)	(0.069)	(0.099)
Log of GDP p.c.		0.443^{**}				0.418^{**}
		(0.205)				(0.195)
Urbanization Rate			0.005			0.040^{*}
			(0.024)			(0.021)
Life Expectancy				-0.004		-0.007
				(0.007)		(0.023)
Mortality Rate					0.001	0.001
					(0.002)	(0.008)
F statistics	172.11	120.78	110.64	154.96	124.75	33.84
# of observation	216	216	216	216	206	206
# of instruments	18	18	18	18	18	18
p-value of Hansen overidentification	0.330	0.272	0.341	0.278	0.317	0.464
AR(1)	0.006	0.010	0.014	0.004	0.008	0.042
AR(2)	0.226	0.342	0.320	0.202	0.246	0.873

Two-step difference GMM regressions. Robust standard errors in parentheses. Dependent variable: Total Fertility Rate. *** *p<0.01,* ***p<0.05,* * *p<0.10. Total fertility rate is the number of children can be born by a woman if she would live until end of childbearing age. Average Years of schooling is the education attainment aged over 15.*

$$Fertility_{i.t} = \gamma_i + \delta Fertility_{i.t-1} + \alpha Education_{i,t} + \boldsymbol{X_{i,t}\beta} + e_{i,t} \qquad (5.3)$$

Here δ shows the effect of fertility at time $t-1$ on fertility at time t. It basically measures the cultural persistence of high fertility. The other variables and parameters are as the same as introduced in equation (5.1). Since the lagged term and education are now endogenous, they need to be instrumented in one way or another. In what follows, we mainly follow Roodman (2006) and apply difference and system GMM to equation (5.3).

The first-differenced version of (5.3) removes the individual effects as in

$$\Delta Fertility_{i.t} = \delta \Delta Fertility_{i.t-1} + \alpha \Delta Education_{i,t} + \Delta \boldsymbol{X_{i,t}} \boldsymbol{\beta} + \Delta e_{i,t} \quad (5.4)$$

In difference GMM estimation, (5.4) is estimated via GMM where lagged levels are used as instruments. In system GMM estimation, on the other hand, not only lagged levels but also lagged differences are used as IVs. The main reason is that lagged levels are not proper instruments if variables are highly persistent. In both type of estimations, two-step efficient GMM estimations are reported.

Table 13 reports the results of difference GMM estimations. The maximum lag of IVs is restricted to "1" because of the instrument proliferation problem that magnifies Hansen p values. Difference GMM results that use 18 levels IVs in total indicate the following results.

First, lagged fertility is moderately persistent and statistically significant with a positive coefficient at all specifications. This means that cultural effects that imply high fertility are not trivial. Second, and more importantly for our investigation, education remains to have a causal negative impact on fertility. Besides, the magnitude of this effect is now much lower and more meaningful from a structural viewpoint. Third, IVs clearly pass the validity restriction as Hansen J statistic does not allow to reject the null of joint validity. The p values are neither too low nor too large. Finally, the model performs well on error autocorrelation statistics as well. While the errors exhibit autocorrelation at the first-lag as expected by construction, they are free of autocorrelation problem at the second lag as the null hypothesis of no autocorrelation at the second lag cannot be rejected.

When we return to system GMM results shown in Table 14, results are overall similar to difference GMM results except for the cases where the inclusion of infant mortality as an explanatory variable affects the significance of education. In columns (5) and (6), the magnitude of the point estimate of lagged fertility parameter is larger. Other than

Table 14: System GMM Estimations

Dependent Variable: Total fertility rate						
	(1)	(2)	(3)	(4)	(5)	(6)
Lag of Fertility	0.829***	0.843***	0.843***	0.882***	0.937***	0.927***
	(0.056)	(0.072)	(0.070)	(0.053)	(0.061)	(0.077)
Education	−0.158***	−0.183***	−0.193***	−0.117***	−0.053	−0.103
	(0.021)	(0.030)	(0.038)	(0.025)	(0.031)	(0.066)
Log of GDP p.c.		0.151*				0.100
		(0.077)				(0.079)
Urbanization Rate			0.009			0.009
			(0.006)			(0.010)
Life Expectancy				-0.010		0.009
				(0.006)		(0.018)
Mortality Rate					0.005***	0.007
					(0.002)	(0.007)
Constant	1.430***	0.302	1.238***	1.476**	−0.024	−1.451
	(0.401)	(0.783)	(0.491)	(0.400)	(0.530)	(1.786)
F statistics	626.28	441.04	408.29	368.58	395.56	190.15
Observation	240	240	240	240	230	230
# of instruments	38	38	38	38	38	38
p-value of Hansen overidentification test	0.979	0.988	0.986	0.972	0.986	0.929
p-value of Hansen group exclusion test	0.419	0.289	0.434	0.256	0.504	0.547
AR(1)	0.002	0.003	0.002	0.002	0.002	0.034
AR(2)	0.106	0.111	0.157	0.124	0.073	0.083

Two-step system GMM regressions. Robust standard errors in parentheses. Dependent variable: Total Fertility Rate. *** *p<0.01,* ***p<0.05,* * *p<0.10. Total fertility rate is the number of children can be born by a woman if she would live until end of childbearing age. Average Years of schooling is the education attainment aged over 15.*

this change, the results on instrument validity and autocorrelation are similar even though the larger number of instruments potentially weakens the Hansen overidentification and difference-in-Hansen (group exclusion of GMM-style instruments) test results.

In other estimations not reported, the dynamic panel data model where education affects fertility not only contemporaneously but also with a lag is found to be insignificant whether it is estimated with difference GMM or system GMM.

To conclude this section, we believe that the most satisfactory model of dynamic fertility behavior for economies in SSA is the parsimonious model (5.3) where instruments are limited to level instruments. Since education and fertility are not random walks but seem to be described best as mean-reverting processes, difference GMM results should not be problematic. Besides, it is important to note that, when the dynamic model with lagged fertility and contemporaneous education is taken as the true model, then the magnitude of the coefficient of education decreases from very high values obtained under static mode to some plausible values. In difference GMM model, for example, one year of additional schooling is associated with a decrease in fertility corresponding to 0.2 to 0.47 children.

Finally, it is plausible to choose difference GMM over system GMM as the former uses fewer instruments than the latter even if we limit the maximum lag structure to unity. Thus, the reported p values for various Hansen tests are not very close to unity in difference GMM, and the tests are therefore not as weakened as in system GMM.

5.8. CONCLUDING REMARKS

In this chapter, we investigate whether the increasing pace of economic growth in SSA is of modern type as described by the UGT. The relationship between education and fertility has a key role in understanding this as the theory predicts that the child Q-Q tradeoff must be active in economies under the regime of modern growth: If the decline in fertility levels are causally associated with increases in education, then economic growth has a modern character according to the UGT.

We estimate a two-equation structural model with panel data where education is explained in the first-stage and fertility in the second-stage with the main explanatory variable being education. The main results are the following: OLS estimates suggest that there is a strong inverse relationship between education and fertility in SSA as a whole. But hypothesis tests indicate that education is an endogenous explanatory variable for fertility. When education is instrumented with population density and years since independence to alleviate the endogeneity bias, the 2SLS random effects estimates suggest that the negative effect of education on fertility is indeed causal and stronger than predicted by OLS estimates. Results also indicate that the instruments for education are valid instruments, and the causal effect is robust to historical and geographical controls. The causal effect of education on fertility is also robust to the change of country effects from random to fixed effects.

As an exploratory exercise, we also check the robustness of the causal effect with respect to three additional controls that are surely endogenous to the process of economic development. These are real GDP per capita, urbanization rate, and life expectancy that are highly correlated both with education and fertility. In line with our expectations, these variables do not have any effect on fertility when education is present as a right-hand side variable.

Lastly, we use dynamic panel data estimation where lagged fertility rate affects current realization. Both difference and system GMM results show that lagged fertility has significant and positive effect on fertility, and the magnitude is not negligible. Thus, we could say high fertility rates are traditional, but it does not veil the negative causal effect of education on fertility.

Our results are in line with some of the results proposed earlier. The claim of Savvides (1995) is political freedom affect economic growth. We did not look direct effect of political freedom on economic growth, but since our assumption is years since independence affects economic growth via education level, our results are in line with Savvides (1995). Furthermore, our results are compatible with Acemoglu and Robinson (2010). The claim in that study is cause of underdevelopment of Africa is their regime rather than their geographical conditions. We find similar results. Accordingly, geographical condition has no effect on both education and fertility while regime effect, which is proxied by years since independence, has a significant effect on education. On the other hand, our estimation results suggest opposite claim of Wheeler (1984). The claim in that study is geographical conditions has a significant effect on economic situation of Africa rather than political variables**.**

An important result originates from the extended analysis of the model when countries are separated into two groups depending on whether they have low- or high-education. We estimate the very same model with the same IVs for the two groups separately. Results indicate that the threshold effects are indeed significant, as the Q-Q tradeoff is statistically significant for the high-education group. In contrast with the theory where what matters is the absolute level of educational investment however small it is, this result indicates that the size of educational investment does actually matter to affect whether the fertility decline starts.

Lastly, the other important results are gotten from dynamic analyze. Difference and system GMM results allow us to see whether fertility is traditional in SSA. Using lagged fertility to explain current realized fertility shows that high fertility rates in SSA is persistent and traditional. Lagged fertility explains the high fertility rates, and the volume of the effect is so high. However, this positive effect does not suppress the negative and significant effect of education on fertility.

This chapter leaves several important issues related with the growth and stagnation experience of the countries in SSA. We focus entirely on the theoretical mechanism proposed as decisive in the UGT, i.e., the child Q-Q tradeoff, and other cultural, geographical, institutional, and traditional determinants of economic growth and stagnation enter the picture only in the form of control variables. In this way, these deep determinants of economic growth do not seem to have any direct and significant effect on the way the child Q-Q tradeoff works, but an analysis of economic growth or relative prosperity would unmask the role of such fundamental causes as usually documented in the related literature on comparative economic development.

CHAPTER 6

CONCLUSION

It has been controversial whether persistent poverty in SSA is associated mainly with geography or institutions. But newer literature focuses on whether growing economies in SSA give us some hopes about the future of economic growth in SSA. While some authors easily talk about an African growth miracle, some others claim that the recent growth experience of some fast-growing SSA economies is not of modern or sustained character.

This thesis attempts to develop a new approach to African economic history. It takes UGT as its foundation and applies its definition of modern growth to SSA.

The historical review of growth theories shows us that UGT is a methodologically refined and inclusive version of earlier economic growth models. After economic growth becomes a sub-discipline in economics, economists have started looking at reasons behind stagnation and growth. Early theories, such as those Harrod (1939) and Domar (1946) and those of Solow (1956) and Swan (1956), claim economic growth is an exogenous process. In these theorists' thought, neither demography nor technology plays a distinctive role. But others have taken demography and/or technology seriously. Arrow (1962), Uzawa (1965), Romer (1986, 1990), Lucas (1988), Becker et al. (1990), and Aghion and Howitt (1992) are some of these economists. They develop models that explain stagnation/poverty or growth. Therefore, one can say that creativity eventually appreciates the right course of thought.

This certainly applies to UGT because economists cited above have not developed models that explain the unique historical development of a typical developed economy from past to present. These models explain either growth or poverty trap, but what is essential and innovative is to develop the model that explains growth and development in its entirety. Furthermore, the model should achieve explaining the transition from poverty to growth endogenously where the transition is gradual.

The canonical model of UGT defines modern growth as a process where educational attainment increases and fertility decreases. Our elementary analysis in Chapter 4 indicates that economic stagnation and growth in SSA economies can be analyzed from the perspective of UGT.

Chapter 5 verifies that, for 27 countries in SSA and for the period of 1960-2010, education has a strong and causal negative effect on fertility. This child Q-Q tradeoff effect has been confirmed both via OLS and IV methods. Besides, this result is robust to the addition of controls.

Another important result is on the threshold effects. When we divide our sample into low-education and high-education groups, the child Q-Q tradeoff is much effective in high-education group. Therefore, there perhaps exists a level of education above which fertility declines causally as a response to increasing educational attainment.

Furthermore, when we add the lagged value of fertility to look whether there is a traditional persistency in fertility behavior, we see that education have a lesser effect on fertility. Yet, this effect still significant and negative. This result is also robust to control variables. Dynamic estimation allowed us to see whether predetermined fertility rates affect current situation, and we can confidently say that, high fertility rates are traditional heritage in SSA.

Two messages originating from this thesis are the following. First, UGT is a candidate for being a new grand theory that explains why and how economies develop and get rich or remain stagnant and poor. UGT has strong microeconomic foundations, and it easily lends itself to econometric and quantitative analysis. Second, the postwar economic history of SSA can be understood using UGT. The data we used in the quantitative analysis exhibit patterns that are in line with the main tenets of UGT. The countries in which individuals invest on their child quality seem to have escaped the Malthusian trap.

One type of task that we have not attempted here would be to develop Structural Equation Models and estimate its parameters via likelihood methods. In such a model, some of the variables that are endogenous to the transition to modern growth, such as urbanization, real GDP per capita, life expectancy, and infant mortality rates can be included. Another task would be to develop a fully structured UGT model with all the necessary elements and provide a quantitative analysis of it based on calibration and simulation exercises. We leave these two tasks to future research.

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92

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95

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