EDUCATION AND FERTILITY RATES: SOME EVIDENCE FROM AFRICA

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Contents

Abstract

This research report aims to investigate the impact of both primary and secondary school enrolment on fertility rates. This analysis is taken across 47 sub-Saharan African countries over the period 1975 to 2015. A panel time series analysis is used in this report to which fixed effects and pooled OLS models are considered. From the results, it is concluded that at lower educational levels such as primary school, fertility decision-making is scarcely affected. The results from secondary school enrolment are, however, significant and do have an impact on fertility decision-making. Based on Galor's unified growth theory and the data analysed, it is concluded that sub-Saharan Africa is departing from the Malthusian stagnation epoch towards a modern growth regime as there is evidence of a child quality over quantity trade-off. Fertility reduction suggests that there are greater costs in bearing children, whilst, at the same time, implying greater productivity and human capital accumulation. In the long run, this results in economic growth and sustainable development.

This research report, confide to sub-Saharan Africa, takes into consideration previous literature over a different time period, makes use of panel time series. This period is an interesting one, as it incorporates the change in democracy for many African nations along with a number of structural changes unfolding on the continent, both socio-economic and political. There are very few previous literature studies in the sub-Saharan African context that have exposed such findings. This research takes into consideration an identification strategy borrowed primarily from the works of Chisadza and Bittencourt, (2015) as well as Bittencourt (2016), testing the most accepted estimates from the literature. This research does not look at the causality between fertility (along with the explanatory and control variables assessed and discussed) and education, but rather at the strength of the correlations.[1]

Keywords: Education, Fertility, sub-Saharan Africa.
JEL Classification Codes: I20, J13, N3, O55.

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Introduction

Education and Fertility Rates: Some Evidence from Africa: The purpose of this research report is to demonstrate the impact of education enrolment on fertility rates in sub-Saharan Africa, by taking into account pooled ordinary least squares (POLS) and fixed effects as the main estimators. The data analysed in this research endeavour is drawn from 47 African nations from the World Bank, World Development Indicators, the UN Population Division and Gapminder databases during the period 1975 to 2015.

Fertility rates have become a central study within many social sciences. Indeed, they are a major focus in both developed and developing nations. Historically, as the Industrial Revolution progressed, it spread across Europe and the Americas. The demand for an educated labour force resulted in higher skilled employment as human capital and labour required greater technological skills (Galor and Weil, 2000).

This research report assesses sub-Saharan African countries following the demographic transformation subsequent to independence in these countries in conjunction with Galor's unified growth theory.[2] From this hypothesis, conclusions have been drawn on the basis of a child quality over quantity trade-off. This ultimately led to demographic transformations within these countries. Such transformations have over time resulted in a reduction in fertility rates along with greater levels of productivity due to accrued human capital and sustainable development (Chisadza and Bittencourt, 2015).

As there were inadequate skills during the Industrial Revolution, premia were applied to incentivise the acquisition of higher-level, enhanced, skills within the labour force (Galor and Weil, 2000). As demand for education and skills increased, the demand for children decreased as child care and education for children became too costly. This resulted in a child quality over quantity trade-off.

The foundation of this research report focuses on unified growth theory by setting the context in assessing the relationship of both primary and secondary education, mortality rates, GDP per capita, gender equality, urbanisation and agricultural factors on fertility rates. Unified growth theory examines three stages, namely the Malthusian stagnation epoch regime, the post-Malthusian regime and the modern growth regime. The main purpose of this research report is

[2] The majority of African countries attained independence in the 1960s and 1970s, the last being Djibouti in 1977.

to ascertain how sub-Saharan Africa has progressed in terms of development, and at which of the three stages the region is situated over the period.

Along with unified growth theory, other theories have been hypothesised further contributing to the reasoning behind the decline in fertility rates. Firstly, unified growth theory suggests that greater advances in technology trigger greater investment in education for children. The second notion is the reduction in mortality rates which, in the process, reduces the incentive to bear more children (Chisadza and Bittencourt, 2015). Thirdly, greater GDP per capita impacts the trade-off of child quality over quantity as suggested by Barro and Becker (1988, 1989).

The first section of this research report discusses theories and hypotheses proposed by various researchers. The research examines unified growth theory and the relationship between fertility and education enrolment, mortality rates, GDP per capita, gender equality as well as the control variables of urbanisation and agriculture which influence fertility over the designated period. The second section of the report reviews the data in detail and provides results depicting the relationship between fertility and the selected variables. Furthermore, this section discusses the methodologies applied and analyses the POLS and fixed effects estimates along with the robust estimate of common correlated effects (CCE). Six regressions have been conducted in this research report. The first regression starts with education enrolment (primary and secondary) on fertility. In the second to sixth regressions, a single new explanatory variable is introduced, one at a time. In all six cases for the POLS and fixed effects estimates, the results depict a positive relationship between primary school enrolment and fertility rates, while the coefficients for secondary school enrolment are negative and significant in all cases. The test for robustness takes into consideration the CCE estimates in which primary school enrolment in most cases is positive, but not significant. Secondary school enrolment depicts a negative and significant relationship in some cases. The final section of the report is followed by conclusions and final remarks.

This research report, examines sub-Saharan Africa by taking into consideration previous literature over a different time period, and by making use of panel time series. This period is an important time period as it encapsulates the demographic transformations within many African nations, coupled with a number of structural changes developing on the continent, both socio-economic and political. There are very few previous literature studies that have exposed such findings, in the sub-Saharan African context. This research, therefore, takes into consideration an identification strategy borrowed primarily from the works of Chisadza and

Bittencourt, (2015) and Bittencourt (2016), and test the most accepted estimates from the literature. Causality between fertility (along with the explanatory and control variables assessed) and education are not the primary focus in this research report. The focus is rather on the strength of the correlations.

Figure 1 below depicts declining fertility rates[3] across all 47 sub-Saharan African countries. Over the entire sample, Mauritius, Seychelles and South Africa had the lowest fertility in 2015, whilst the Democratic Republic of the Congo, Niger and Somalia had the highest. Looking at Angola and Somalia, fertility has stagnated over the period, while Mauritius has succeeded in the reduction of fertility rates. It must be noted that some of these countries in the sample underwent different forms of development, securing advancements earlier than others. The more developed countries "have earlier take-offs" in the reduction of fertility compared to their poorer counterparts. There is, therefore, a delayed process of demographic transformation (Chisadza and Bittencourt, 2015:3). Whilst these countries have institutional discrepancies, they have experienced demographic transformations at different times (Chisadza and Bittencourt, 2015). This hypothesis is in line with the theories presented by Galor (2011), in that many countries in Europe experienced very similar consequences during the Industrial Revolution.

Figure 1: Fertility rates across sub-Saharan Africa (Source: World Bank, 1975-2015)

[3] Note that fertility has been linearised.

Figure 2[4] below depicts a graphical representation of average fertility rates and secondary school enrolment between 1975 and 2015 from an international perspective. Although fertility rates in all continents have been declining over the period, Africa depicts the highest figures, while Europe depicts the lowest in the order of almost half the amount. While this decline is significant for fertility rates across the globe, secondary school enrolment has positive trends and depicts a direct opposite result to that of fertility rates. Overall, Africa depicts the lowest figure while Europe depicts the highest by a magnitude approximately quadrupling the amount to that of Africa. Although Africa has experienced a delayed demographic transformation, there is an increase in human capital, but at a much slower rate compared to the rest of the world, specifically the developed economies. Since Africa is still lagging behind the rest of the world in terms of fertility decline, this research report aims to investigate the effectiveness of the opportunity cost between education enrolment and fertility rates within sub-Saharan Africa as suggested by unified growth theory. In addition, the research report aims to determine the level of economic development and at what stage of development sub-Saharan Africa is located in terms of the regimes suggested by unified growth theory.

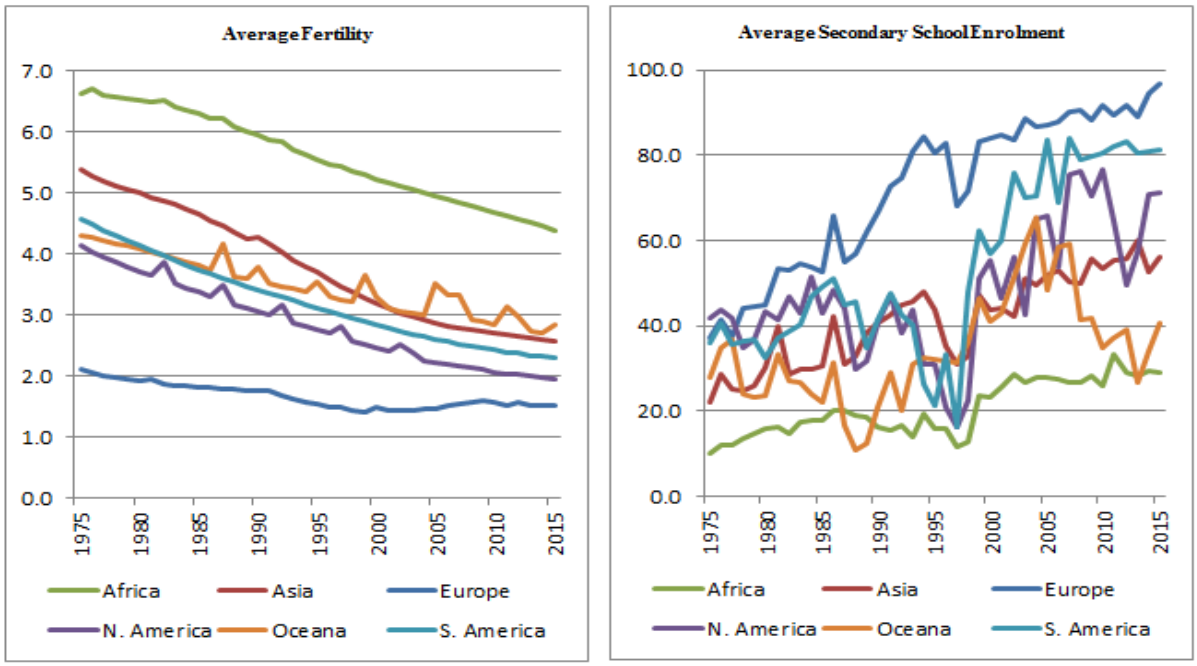

Figure 2: Average International Education and Fertility Rates (Source: World Bank, 1975-2015)

[4] Note that secondary school enrolment is considered here rather than primary school enrolment as secondary school has a greater (negative) impact on fertility rates, whereas primary school enrolment tends to have a positive impact on fertility. This will be discussed later in more detail in the data and methodology sections of this research report.

Literature Review

The research report assesses unified growth theory in sub-Saharan Africa by evaluating the child quality over quantity trade-off as well as the impact of education enrolment on fertility. The mortality rates, GDP per capita, gender equality and control variables such as urbanisation and agriculture are also considered. Aside from the importance of the study to assess the developmental stage within sub-Saharan Africa, the test of whether the data is robust and in line with the theories proposed is also of considerable significance.

Unified Growth Theory

Unified growth theory assesses the conversion from economic stagnation to growth due to accumulated development within a nation. It assesses how population composition magnitudes have resulted in technological acceleration and considers the importance of education as a contributing factor in a dynamic technological environment. From this, it also evaluates how the demand for education towards technological advancements can result in a reduction in fertility rates. The rise in educational levels has brought about greater human capital enhancement, hence higher productivity levels and GDP or income per capita. Furthermore, this has resulted in sustainable economic growth over time. A perpetual increase in the investment in human capital results in a greater outcome of reduced fertility rates over time (Conley et al. 2007). Based on this theory, both economic and human population growth comprise three regimes, namely the Malthusian stagnation epoch regime, the post-Malthusian regime and the modern growth regime (Galor, 2005a).

Historically, the Malthusian epoch regime has experienced ever-long stagnant income per capita and population growth, as well as inadequate technology and low education investment returns. This, notwithstanding, population growth and income per capita had a positive relationship. The post-Malthusian regime passed through advances in technology in which the demand for skills within the labour force rose. This led to increases in human capital returns and incentives for citizens to invest in education, particularly for their own children. This, in turn resulted in fewer children being born as the notion of child quantity versus quality trade-offs emerged. This allowed for increases in household incomes influenced by a demographic transformation. Following such a transformation, the modern growth regime defined stability within population growth as fertility rates decreased along with better skills within the labour

force, productivity and higher incomes per capita (Galor and Weil, 2000; Galor and Moav 2002).

According to Galor and Weil (2000), the unified growth model considers two major aspects:

1. The behaviour of income per capita.
2. The relationship between income per capita and population growth rates.

The sustained growth or modern growth regime considers the interpretation of an ending to an ever-long period of steady state equilibria. Here, the population was able to break the shackles of stagnation and function in a society with rapid and sustainable economic growth. It has been found that higher population growth rates tend to occur within developing nations. In contrast, the more developed nations experience near zero population growth rates (Galor and Weil, 1993, 1996).

According to Malthusian theory, living standards are inversely related to population size. Higher living standards result in lower population sizes and lower living standards result in higher population sizes. Galor and Weil (2000), consider the transition from the Malthusian regime via the post-Malthusian regime along with a demographic transformation leading to the modern growth regime. Since this demographic transformation focuses on the trade-off between income levels and the quantity of children, it also involves technological advancements rather than income alone. These advancements manifest in the rise of human capital return rates, contributing further to the child quality over quantity trade-off. Greater advances in technology bring about higher demands for an educated and appropriately trained labour force, with greater enrolments in education. The pace of technological advancements provides parents with the choice of educational investment for their children. This, in the long run, enhances human capital and skills. This advancement in technological human capital subsequently leads to a demographic transformation in that "wages and the return to child quality continues to rise, shifting away from child quantity, as population growth tends to decrease" (Galor and Weil, 2000:810).

During the formative phases of the Industrial Revolution, labour forces were characterised by unskilled (rather than so-called skilled, craft) employees. The notion of human capital played a minor role in production during the early part of the Industrial Revolution. As the Industrial Revolution evolved, the demand for higher skills (and, therefore, higher education) increased. In the process, the educational requirements for human capital were shaped (Galor, 2005a). In

other words, as the progression and advancement in technology was taking place, the increase in the demand for education resulted in a demographic transformation at the turn of the 19th century, as the Industrial Revolution began to mature (Galor 2005b).

Education Enrolment

Since education enrolment has an inverse relationship with fertility (particularly in terms of female enrolment), it also suggests that contraception techniques result in a negative relationship with fertility rates (Ainsworth et al. 1996). According to Ainsworth et al. (1996), there are four approaches to explain this phenomenon. The first is the wage effect. Here, there is a trade-off between the wages earned by women in the labour force and those who are childbearing. In other words, there is an opportunity cost of raising a child. According to Becker and Lewis (1973), a trade-off tends to occur for every additional child that is born, provided that child quality is constant. It is also on the basis that the benefit of earning wages can entice more women to invest more in child education, thereby postponing childbearing and, hence, lowering fertility.

The second approach deals with the demand for child education. This theorises the notion that the more educated women are, there are potentially higher aspirations that they may provide for their own children in the same or similar manner. This in turn could result in the probability that women with fewer children may invest greater financial allocations to their offspring than women with more children, resulting in a quality over quantity trade-off.

The third approach looks at infant and child mortality. Here, higher the level of education of a woman, the lower the mortality rates, in that healthier children are born. The discrepancy between surviving children and live births is reduced, as more precautions are considered in fertility decision-making.

The final approach delves into the application of contraception. The higher the education of a woman, the greater the tendency to apply contraceptive techniques more effectively than that of a woman with a lower education level. The magnitude of unexpected births is, therefore, reduced. Bivariate studies were conducted during the 1960s, which established that greater levels of education in both men and women resulted in greater contraceptive applications, with resultant lower birth rates (Ainsworth et al., 1996).

According to Bittencourt (2016), and in line with unified growth theory, secondary school enrolment has both a negative and significant effect on fertility rates. Secondary school enrolment over time leads to rises in capital per worker along with increases in production levels, economic growth and changes in population compositions such as age and gender characteristics.

Galor and Moav (2002) point out that a larger investment in education, as well as a proportional increase in technological advancements, will give rise to sustainable economic growth. This, in essence, summarises the impact of investment in education on fertility rates and sustainability within developing economies.

Bittencourt (2016) provided a study within the sub-Saharan region by analysing the rise in demand for education associated with decreasing fertility rates and increasing democratisation. The study focused on the transition of economic development and growth by applying unified growth theory to developing nations after independence from colonial powers. This theory examines the opportunity cost between child quantity and child quality and the expected formation of a democratised state with lower fertility rates. It has been found that lower rates in education (mainly at secondary school level) inversely impact fertility decisions (Chisadza and Bittencourt, 2015).

Mortality Rates and Life Expectancy

As mortality rates tend to be relatively high in Africa due to underdevelopment and insufficient or poor health conditions, societies in these circumstances, generally, tend to undergo a replacement effect for deceased children. Parents will tend to have an additional child to counterbalance the death of another. This is also to satisfy parental utility contributing towards the quality over quantity trade-off (Angeles, 2010).

According to Klemp and Weisdorf (2012), as more children enter a family, there is a greater possibility of them being unskilled and illiterate; this was evident during the 18th and 19th centuries in Europe. Along with such studies, research conducted by Conley et al. (2007), suggests that child mortality is often influenced by greater fertility which results in tension on household income and lower parental care as more children enter a family. Dreze and Murthi (2001), suggest that greater child mortality rates could potentially lead to rises in fertility rates, as parents may be enticed to replace the death of a child. It is also possible that greater fertility

rates may result in greater mortality rates, due to behavioural consequences such as cultural preferences or biological consequences. This is particularly notable at the age at which a female bears a child. Cultural preferences, on the other hand, could include preferences of sons over daughters. A family could increase the size of a family until a son is born, in the process increasing the probability of death (infant mortality) within a household. Biological consequences could be that a woman delivers a child at a very young age, in which an infant could be born prematurely with deformities and various illnesses (Dreze and Murthi, 2001). This leads to Becker's (1960) argument, where he posits that people are more interested in the survival of children and not necessarily the number of births in a family. In other words, greater child mortality rates may lead to greater fertility rates as parents are encouraged to replace lost children.

According to Galor (2011), evidence from the Industrial Revolution in Europe showed that greater life expectancies resulted in greater fertility rates. This was due to the "precautionary demand for children during that transitional period" (Bittencourt, 2016:6). From this source of evidence, life expectancy can be associated with fertility in that, as life expectancies increase, there is an expectation that fertility rates will also increase.

In developing regions such as sub-Saharan Africa, life expectancies are relatively low compared to that of the developed world. This is potentially due to diseases such as HIV/AIDS and insufficient healthcare services in developing societies, where the child survival rates are highly uncertain. This holds true, specifically in sub-Saharan Africa, as the correlation between life expectancies and fertility rates have a negative and significant relationship. This supports the notion that greater life expectancies could potentially lower the uncertainty of child survival rates. Subsequently, this raises the scope of human capital investment, further reducing fertility and enhanced development in terms of sustainability and technological advancements (Bittencourt, 2016). Although life expectancies have been low in Africa compared to those of the developed world, there have over the past two decades been increasing trends in life expectancies in Africa.

Income

There is more control over the number of birth rates in a more educated society in that there is better fertility decision-making. These decision-making processes consider the cost implications of having more children, in which societies will bear fewer children. In this

context. this generally results in greater quality investment in children rather than accumulating the costs of having more children. An increase in income ought to result in both an increase in quality over quantity of children, but the elasticity of quality should be larger compared to quantity (Becker, 1960).

According to Malthusian theory, increases in family sizes are based on increases in income. Two major aspects are highlighted in this theory. Firstly, child mortality rates tend to decrease as income levels rise, thereby increasing infancy and childhood survival rates. This is potentially on the basis that child healthcare becomes more affordable. Secondly, the Barro-Becker theory (1988, 1989) highlights the opportunity cost of rising income per capita which, in turn, encourages parents to substitute the quantity of children for higher quality. This results in an income effect. Based on research conducted by Schultz (2008), women with greater ownership and accessibility of assets such as property and finances have a greater stake of wealth in which they tend to invest in the quality over quantity of children. Families with higher income levels have better choices and options than families with lower income levels.

As choices are influenced by income levels, higher income earners sometimes experience "social pressures" in which they are obligated to invest more in their children, accumulating greater costs. Greater cost accumulation is, therefore, a reason for families to bear fewer children. Income elasticity of demand rather than the price (cost) elasticity of demand for children is, therefore, influenced by these "social pressures."[5] Income elasticity of demand in terms of quantity becomes smaller over time whilst the income elasticity of demand in terms of quality is increasing. Here, "social pressures" play a major role in the trade-off (Becker, 1960:215). According to Herzer, Strulik and Vollmer (2012), the rises in income levels act as a substitute for technological advancements as this raises the incentive to bear fewer children since the expenses relating to child needs are high.

Gender Equality

Having previously discussed education as an important factor for human capital development and economic growth, another important consideration is heterogeneity amongst society. This

[5] It should be noted that the propensity to produce children has an influence on family sizes along with prices (costs) and income levels. Desirability also plays a role, in that families may only be able produce one child as opposed to their desired preference of having two children, whilst a family can desire having three children, but could end up having five children (Becker, 1960).

provides a more diverse human capital pool within the employing firm, with greater innovation and creativity in the labour force. This diversity element generally entails gender, ethnicity, variances amongst age groups and levels of work experience. On the topic of gender (by today's standards in many countries across the globe), women have taken on leadership responsibilities at very senior roles within the labour force. They have accomplished equality with men on many levels. Over several decades, the study between the relationship of fertility rates and gender equality has been considered in developed nations such as Sweden and Finland. These countries are renowned for high female employment rates within the labour force as well as high fertility rates in comparison to the rest of Europe. Fertility decision-making is primarily based on three main fundamentals: employment, infancy and child care. Financial security for both men and women, also serves as a factor. By incorporating these fundamentals, it is on the basis of steady employment that provides financial security and greater household sustainability in which women will bear a child in the short term (Galor and Weil, 1993, 1996).

The rate of population growth influences capital levels per worker in the labour force. The lower the population growth, the higher the capital levels are per worker. This in turn affects relative wages for both men and women. As capital levels increase, so do relative wages. These increases in relative wages increase household incomes as well as the cost of bearing children. This is, therefore, a substitution effect on the demand of child bearing and career development for women. Higher relative wages for women results in a greater effect on economic growth. If women do not participate in the labour force, economic growth declines as outputs decline. In the process, fertility rates increase. As women become empowered, the higher their chances of career development. It is, therefore, imperative for both men and women to participate in the labour force to induce higher productivity and output, thereby reducing fertility rates (Galor and Weil, 1993, 1996).

Urbanisation and Agriculture

In terms of urbanisation, studies conducted in Africa have shown that fertility rates are significantly lower in urban regions in comparison to those of rural regions. This differentiation is predominantly due to the greater accessibility of education, healthcare and employment. Greater accessibility provides greater applications of contraception techniques lowering fertility rates in the process.

In countries such as Kenya and Nigeria, women having completed basic primary school levels have resulted in considerably lower fertility rates than women with no education at all. This also applies to women educated within urban regions than those women educated, residing in rural regions (Ainsworth et al. 1996). From this analysis, there is the anticipation for urbanisation to be negatively related to fertility rates.

Based on the hypothesis presented by Galor (2005a), the 19th century saw acceleration in both industrialisation and urbanisation in Europe along with rises in demand for human capital. This resulted in lower fertility rates. With urbanisation on the rise in many African nations, particularly due to rapid rises in industrialisation and the demand for skills, there is a negative relationship between urbanisation and fertility rates. As regions become more advanced technologically, the focus is shifted from child quantity to child quality. This substitution effect in accordance with the unified framework, implies that there is a transformation from a Malthusian stagnation epoch to a modern growth regime. This is due to higher levels of industrialisation, accessibility to greater employment, education and health services (Galor and Weil, 2000).

During the Industrial Revolution, the east and west regions of Prussia experienced high fertility rates, particularly as many countries were undergoing demographic transformations. As time has progressed, and with improvements in data reporting, research has indicated that as industrialisation has risen, the quantum of agriculture has decreased. This rise in industrialisation positively impacts education, while a reduction in agriculture negatively impacts education. This ultimately leads to lower fertility levels (Becker, Cinnirella and Woessmann, 2010). The agricultural sector plays a large role within sub-Saharan Africa in that subsistence farming is a key player. In this context, family sizes tend to be of great significance. Here, it is not about the quality of children, but rather the quantity. As agricultural share of GDP increases, fertility rates also increase.

There is often an inverse relationship between urbanisation and agricultural share of GDP in that, as urbanisation rises, agricultural share of GDP decreases. The opposite tends to occur as urbanisation decreases (Bittencourt, 2016). The agricultural-urban ratio or process is based on exogenous shocks such as droughts within rural areas and job market failure within urban regions that influence decision-making. “Economic growth mostly affects the urbanisation rate through a sector shift out of agriculture” (Brückner, 2011:13). As there are variations between the agricultural-urban ratios, there is a significant impact on fertility rates.

The increasing rate of urbanisation results in the substitution for quality over quantity due to advancements in technology within sub-Saharan African nations as they undergo rapid industrialisation. Urbanisation tends to focus on the basis of higher educational requirements in which innovation and technological advancements are built. This leads to lower fertility rates (Chisadza and Bittencourt, 2015).

The following section of this research report, applies the theories of unified growth theory and the hypotheses of the variables discussed in the literature review. Data models are analysed by applying a panel time-series approach, allowing for an empirical study accounting for fixed effects, heterogeneity and cross-sectional dependency of variables. This provides a more informative view and tests the viability of the various hypotheses presented in this research report.

Data and Methodology

Data

The data are taken from the World Bank, World Development Indicators, the UN Population Division and Gapminder databases. This data have been analysed over 47 African nations from 1975 to 2015. A series of datasets have been used to compile the analysis.[6]

With fertility, *fertility*, and education (primary and secondary school enrolment, *primeduc* and *seceduc* respectively), being the major variables throughout this research report, mortality rates, GDP per capita, gender equality and the control variables, urbanisation and agricultural share of GDP are also examined. Total fertility rates defined by the World Bank are the total births per woman. This is indicated by 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." The primary school enrolment variable is taken from the World Development Indicators. It is defined as the number of pupils of the "school-age group" enrolled at primary school level and is taken as a percentage over the total population within that specific age group. The figures are reported as an adjusted net enrolment number. Secondary school enrolment is defined as the gross enrolment ratio which is the total

[6] With such datasets combined to form a panel, some counties had missing information in some years forming an unbalanced panel time-series dataset.

enrolment irrespective of age, to the population of the age group that parallels the level of education illustrated.

Firstly, mortality, *mort*, is extracted from the World Bank database and is based on infancy per 1000 live births. This is the number of new-born deaths before the age of one year, per 1000 live births in a given year. Based on theories suggested by Gries and Grundmann (2014), child mortality has a major influence on fertility, particularly within less developed countries. Where there are decreases in mortality rates, there is a strong likelihood for fertility rate reduction to follow. This is because there is less of an incentive to invest in child quantity, but rather child quality. As there is a co-linearity between mortality and life expectancy, Galor (2011), suggests that greater life expectancies could potentially result in increases in fertility. As for sub-Saharan Africa, where all nations are in developing phases, there are greater uncertainties about the survival of children.

Secondly, GDP per capita, *GDP*, in the form of income is taken from the Gapminder database. GDP per capita is considered by taking into account purchasing power parities and is reported in US dollars fixed at 2011 prices. Inflation rates and cost of living expenses tend to vary across different countries and are also taken into consideration. In line with Becker (1960), higher incomes, considering the heterogeneity in terms of development within the various sub-Saharan African countries, potentially leads to lower fertility. This is possibly due to greater opportunity costs of bearing many children, in which fertility rate reduction generally occurs at a certain stage of development. This reduction in fertility tends to often be associated with higher household incomes (Galor and Weil, 1993, 1996).

Thirdly, gender equality, *gen*, is considered and is taken from the Gapminder database. Gender equality is calculated as the "primary completion rate percentage of female students completing the last year of primary school by taking the total number of female students in the last grade of primary school, minus the number of repeaters in that grade, divided by the total number of children of official graduation age. The ratio can exceed 100 percent due to over-aged and under-aged children who enter primary school late/early and/or repeat grades." It is acknowledged that the variable for gender equality is not necessarily a robust indication of gender equality in that it does not imply a comparison between male and female outcomes. The data in this report for gender equality is, however, a more utilised set of information in that there is sufficient data, with the highest number of data points. According to Galor and Weil (1993, 1996), a lower gender gap ratio tends to lead to lower fertility rates. The higher the

participation rate in the labour force for women, the greater the wage rate. Here, the costs of raising children generally outweighs increases in household income. This impacts on fertility decision-making which, in the process, decreases family sizes as fewer children are born (Galor and Weil, 1993, 1996).

Fourthly, urbanisation, *urb*, is a control variable considered in which the data has been extracted from the World Bank. Urbanisation is calculated as a percentage of urban residents over the total population by country. From the theory explained earlier, there is an anticipation that greater urbanisation yields lower fertility rates. Based on Ainsworth et al. (1996), the greater the migration of a population from rural to urban areas, the lower the fertility rate. This goes back to the child quality over quantity trade-off, in which more industrialised areas demand greater skills.

Finally, agricultural share of GDP, *agric*, is also a control variable and is taken from the World Bank database. Agriculture is based on the International Standard Industrial Classification (ISIC) divisions 1-5 which entails hunting, fishing, forestry, crop cultivation as well as the production of livestock. This indicator is in the form of a value-added figure and is expressed as a percentage of GDP. This value-added figure is the "net output of a sector after aggregating all outputs and subtracting intermediate inputs." It is "calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources." Countries with a higher share in agriculture undergo a greater child quantity over quality trade-off, since these societies depend on subsistence farming and require larger families as a form of aid for survival. Theoretically, it is expected that greater agricultural dependency is associated with greater fertility rates, indicating that the agricultural share depicts a positive correlation with fertility (Bittencourt, 2016). According to Becker, Cinnirella and Woessmann (2010:14), "the level of industrialisation is positively and the incidence of agriculture negatively associated with education, possibly mirroring corresponding demand for education linked to the economic structure." This relates to the notion that the more developed areas have greater access to healthcare and education, which in turn lowers fertility rates.

Discussion

Based on the primary objective of this research, it is proposed that as secondary enrolment rises, there is an association with lower fertility rates across the sample. A lower fertility rate postulates a behaviour of positive growth, greater productivity and output as this is triggered

by increases in capital per worker (Galor, 2011). As several African nations within the sub-Saharan region are undergoing greater progressions of development, notably through investment and greater technological intake, it can be said that several regions are not exactly in a status of Malthusian stagnation. These nations are rather encountering a post-Malthusian regime (Bittencourt, 2016).

By complementing the main variables in the analysis as well as the literature and data, the mean data across the 47 sub-Saharan countries is depicted in figure 3[7]. Panel a illustrates that over time, fertility rates have decreased on average in sub-Saharan Africa, with an approximate figure of six to seven children in the mid-1970s to roughly four to five children in 2015. Panel b depicts an opposite picture to that of fertility rates whereby primary school enrolment has fluctuated over the period with a positive trend. Primary school enrolment has increased from approximately 60 percent to 72 percent. In panel c, secondary education enrolment has increased significantly over the period. It depicts that approximately on average 15 percent of residents within sub-Saharan Africa enrolled in secondary education in 1975 rising to an estimated 50 percent in 2015.

Panel d shows a similar relationship to fertility and depicts a significant drop in mortality rates over the period. This depicts a drop from approximately 120 to 35 new-born deaths before the age of one year, per 1000 live births in a given year. It is, therefore, safe to assume that mortality usually experiences a significant relationship with fertility. For mortality rate reduction, imported medical remedies such as antiretrovirals and vaccinations, media and government awareness of health issues, have made significant strides in this regard over the period analysed. From the graph below, it should be noted that mortality rates decreased earlier in the period than fertility rates suggesting that imported medical remedies have played a rather momentous part in sub-Saharan Africa since the late 1970s (Chisadza and Bittencourt, 2015).

In panel e, a fluctuating, but steady rise in GDP per capita is depicted since income per worker plays a contributing role in GDP, and the income effect has played a dominant role (Chisadza and Bittencourt, 2015). GDP per capita has risen from approximately $2,800 to $5,000 over the period analysed. Based on theories advanced by Dreze and Murthi (2001:7), children are either considered an economic liability or an advantage which in turn has an impact on the income effect of households. Within developed countries where fertility rates are much lower,

[7] For a similar analysis for the control variables, refer to Appendix A

children are often considered a "consumption good" in which greater investment is relayed on them. This in turn increases the child quality over quantity trade-off as parents have larger income levels. In contrast, in developing countries, where fertility rates are much higher, children are often considered a "productive asset" and they are utilised as a source of labour and a contributor to security as parents become older. Based on this security, it is highly likely that sub-Saharan Africa experiences greater incentives to bear more children as income levels increase.

In support of the data, 19th century Western Europe underwent very similar circumstances as experienced in sub-Saharan Africa advancing toward a post-Malthusian regime in that income levels are rising with fertility rates. This is also likely to occur via early marriages (Chisadza and Bittencourt, 2015; Galor and Weil, 1999).

Gender equality has increased steadily over the period as depicted in panel f, as international sponsors and benefactors have contributed towards education, whilst at the same time, endorsing gender equality within developing countries (Chisadza and Bittencourt, 2015). The female completion rates at primary school have risen with ratios from approximately 7.4 to 9.3 over the period.

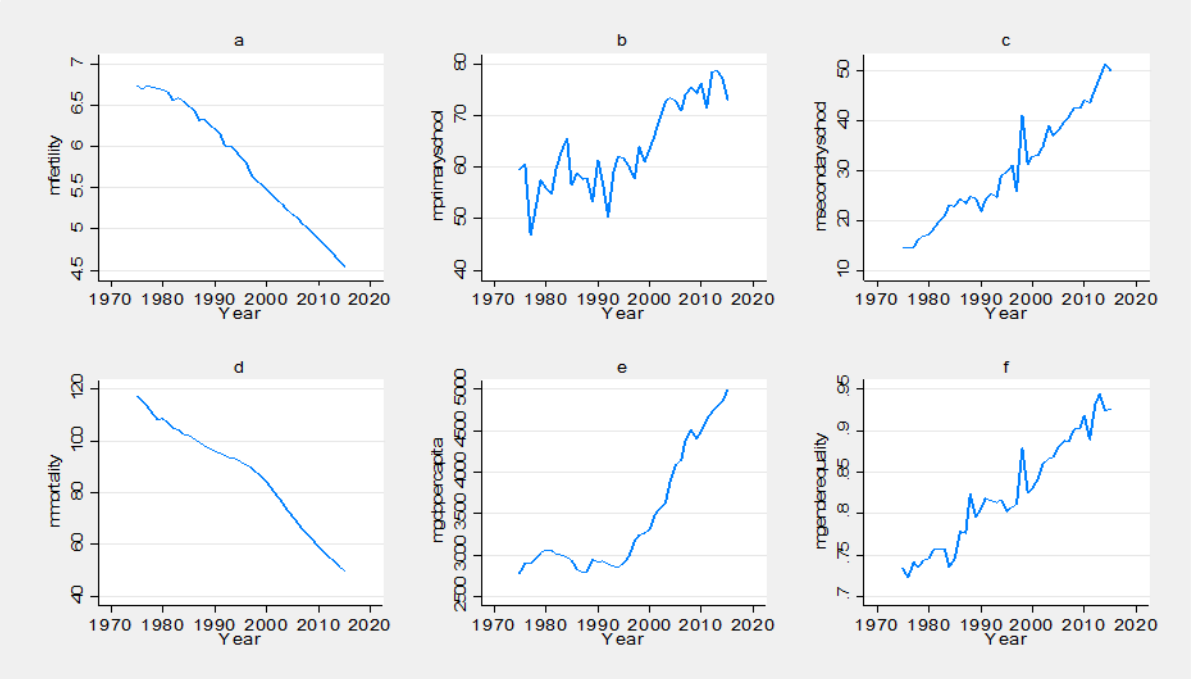

Figure 3: Mean fertility rates, primary school enrolment, secondary school enrolment, mortality rates, GDP per capita and gender equality in sub-Saharan Africa over time (Source: World Bank and Gapminder, 1975-2015).

Summary Statistics

The summary statistics in this next section interrogates the data. Scatterplots are used in the analysis; figure 4 depicts the mean relationships between fertility and the explanatory variables education enrolment (both primary and secondary), mortality rates, GDP per capita and gender equality.[8]

Figure 4 depicts a downward trend in both primary and secondary school enrolment. This is in line with unified growth theory in that higher attainments in education result in lower fertility rates. Employment, therefore, requires greater skills, hence greater enrolment in schools.

Africa is on the brink of becoming more developed[9], partly due to technological advancements and investor confidence from abroad. This graphical representation is aligned to the theory of child quality versus quantity trade-offs as well as the demographic transformation within sub-Saharan Africa (Chisadza and Bittencourt, 2015). Due to the continued development in sub-Saharan Africa, demand for greater skills is on the rise. With greater demand for more educated employees across various industries in the labour force, secondary school enrolment tends to result in greater investment in quality over quantity trade-offs. Hence, this leads to fertility rate reduction and greater secondary school enrolment (Bittencourt, 2016).

In addition, the graph presented in figure 4 depicts a consistent and informative, but intriguing, correlation that is positive between mortality and fertility rates, suggesting that there

[8] For further information regarding this data broken down by intergovernmental organisations, refer to Appendix B.

[9] According to Gries and Grundmann (2014), more developed countries with higher industrialisation have more developed manufacturing sectors and are predominantly capital intensive. In contrast, more developing countries are more dependent on primary sectors in which there is lower skilled labour. The discrepancy in sectors within both types of countries effects parental decision-making on education for children. There is little or no incentive to invest in children in a low skilled labour primary sector economy, but there is for a higher skilled manufacturing economy. This presents the child quality over quantity rationale between these types of economies. Manufacturing sectors export lower levels of fertility while primary sectors have the opposite or no effect, where education levels are likely to be lower. Based on their findings, economic development is frequently negatively affected by high levels of fertility. Trade can have an impact on fertility, in that trade integration provides sustenance in fertility rate reduction within developing nations with high fertility rates. This can be achieved by the transformation from a primary sector to a manufacturing sector economy. Bittencourt et al. (2017), proposes that the relationship between education as well as openness of trade is non-linear and that the initial influence of education is able to drive lower contraception levels and increase fertility, but once a threshold is encountered, the opposite effect tends to occur. In many cases in Africa, manufacturing goods are being imported and agricultural goods (low-skilled products) are being exported. This openness of trade tends to have a positive effect on fertility (Gries and Grundmann, 2014). In a nutshell, countries that export agricultural-type products tend to experience higher levels of fertility.

is a replacement effect as pointed out by Angeles (2010). As there are infant deaths in a household, women will tend to compensate by having a new-born child.[10]

A negative relationship between GDP per capita and fertility rates prevails. In line with Becker (1960), this suggests that, as a nation becomes more developed, the lower its population growth and hence the lower its fertility rates. On the other hand, the less developed a nation becomes, the higher its fertility rates. Gender equality is depicted by a negative trend and suggests that as more women enter the labour force, human capital rises resulting in higher economic growth. Interestingly, this is negatively correlated with fertility. Women undergo a substitution effect and, therefore, become career-driven rather than bearing the cost of remaining at home to provide care for too many children (Galor and Weil, 1993, 1996).

Figure 4,[11] depicts the mean education levels, gender equality, mortality rates and GDP per capita versus the mean fertility rates. The variables align to the theories presented in the literature review and the correlation matrices presented later in this research report.

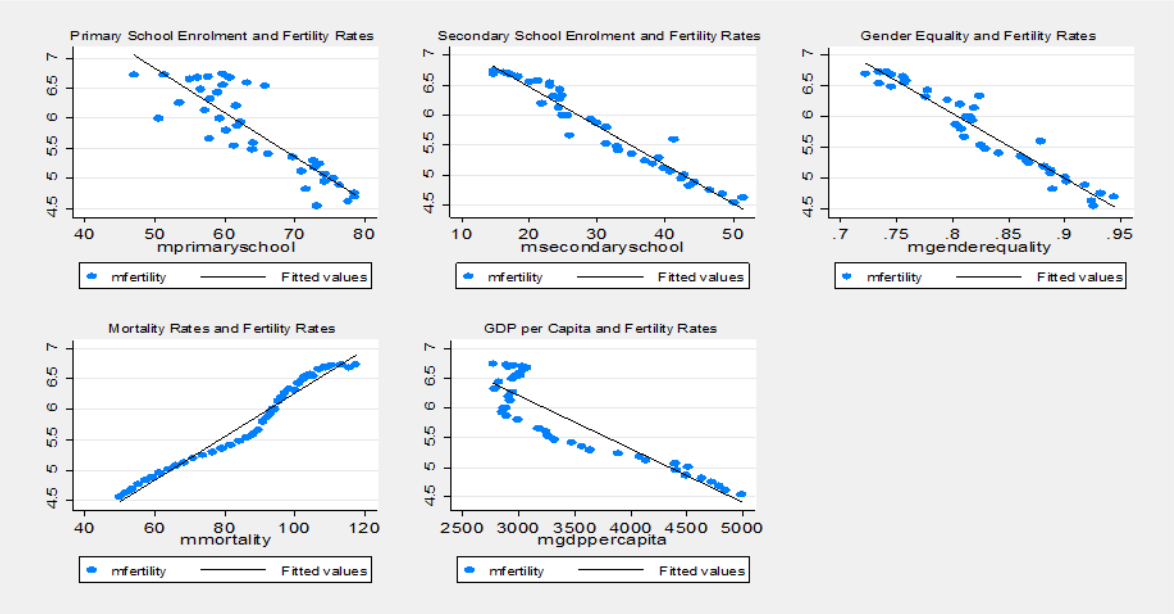

Figure 4: Mean Education, Gender Equality, Mortality Rates, GDP per Capita and Fertility Rates in sub-Saharan Africa (Source: World Bank, 1975-2015)

[10] Life expectancy is calculated as if mortality rates are fixed over time and considers the average number of years of a new-born infant if they were to live in such a time period. Empirically, there is often a negative relationship between life expectancy and fertility rates. This corroborates the theories proposed by Galor (2011) in that countries with developing economies are expected to encounter greater uncertainties about the future existence of children.

[11] For a similar analysis for the control variables, refer to Appendix A

Descriptive Statistics

This section provides the means, standard deviations minima, maxima statistics as well as graphical representations. In table 1[12], the descriptive statistics display the main variables analysed, namely fertility and secondary school enrolment. The variables have been linearised and display a negative and significant correlation with one another. This is consistent with the theory advanced in the literature. The data has shown a gradual decline in fertility rates towards the second half of the period analysed. This is potentially due to the evolution from a demographic transformation, where potentially greater investment in education as well as a quality over quantity trade-off, has lowered fertility rates.

By looking at the data in detail, fertility rates are the highest in Rwanda and the lowest in Mauritius with figures of 8.46 and 1.36 respectively.[13] As Mauritius tends to be a more developed country and in line with findings by Chisadza and Bittencourt (2015), fertility rates are under greater control. Primary school enrolment is the highest in Mauritius and the lowest in Burkina Faso with figures of 99.91 and 12.56. Secondary school enrolment is the highest in Seychelles and the lowest in Niger with figures of 115.99 and 1.62 respectively. According to Chisadza and Bittencourt (2015), both Mauritius and Seychelles undergo the greatest education enrolments as they have more developed economies.

Mortality rates are the highest in Guinea and the lowest in Seychelles with figures of 181.8 and 11.9 respectively. This aligns with Bittencourt (2016) in that diseases and inadequate healthcare within developing countries experience uncertain child survival rates.[14] According to Chisadza and Bittencourt (2015), the more developed a nation, the lower its fertility rate and the less developed a nation, the higher its fertility rate. GDP per capita is the highest in Equatorial Guinea and the lowest in Liberia with figures of $40,143.00[15] and $142.00 respectively. These incomes per worker are associated with fertility rates of 5.36 and 6.16 respectively. This aligns to research by Becker (1960), in that there is a child quality over quantity trade-off based on the income elasticity of demand.

[12] For further information regarding this data by intergovernmental organisations, refer to Appendix C.
[13] Please note that these figures are not the averages, but are rather the actual figures reported some time in the designated period of this research report.
[14] Life expectancy is the highest in Mauritius and the lowest in Ethiopia with figures of 74.5 and 35.43 respectively. Life expectancy over the period is the highest on average in the Seychelles and the lowest in the Central African Republic with figures of 70.41 and 47.94 respectively.
[15] It should be noted that Equatorial Guinea has a population of approximately 1.2 million people and is one of sub-Saharan Africa's largest oil producers making GDP per capita a rather inflated figure. The same outcome should be noted for Gabon which has a population of approximately 2 million people.

Gender equality is the highest in Lesotho and the lowest in Chad with figures of 1.45 and 0.35 respectively. As societies become more developed, women will undergo a substitution effect in which they will be more career focused, rather than living a lifestyle at the expense of bearing too many children (Galor and Weil, 1993, 1996).

There is evidence as depicted below, that supports the theory that as more people reside in urban areas, the lower the fertility rate, and, conversely, the more people that reside in rural areas, the greater the fertility rate. There is, therefore, an inverse relationship between the two variables (Ainsworth et al. 1996). By looking at these control variables in more detail, urbanisation is the highest in Gabon and the lowest in Burundi with figures of 86.15 and 3.22 respectively. Agricultural share of GDP is the highest in Uganda and the lowest in Botswana with figures of 74.27 and 1.82 respectively. This reveals that areas undergoing greater urbanisation are typically more developed as greater skills from education are demanded than areas highly dependent on agriculture. This impacts the agricultural-urban ratio.

Table 1: Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max	Source
Fertility Rate	1909	5.79	1.32	1.36	8.46	World Bank
Primary School Enrolment	849	65.72	22.11	12.56	99.91	WDI
Secondary School Enrolment	1207	29.62	22.99	1.62	115.99	World Bank
Mortality Rate	1887	86.27	36.47	11.90	181.80	World Bank
GDP per Capita	1927	3,457.18	4,822.77	142.00	40,143.00	Gapminder
Gender Equality	1047	0.83	0.19	0.35	1.45	World Bank
Urbanisation	1739	31.78	16.05	3.22	86.15	World Bank
Agriculture	1416	28.51	16.61	1.82	74.27	World Bank

A series of correlation coefficients are depicted in the correlation matrix in Table 2 below between fertility rates and the given explanatory and control variables across the 47 sub-Saharan African countries. Between primary school and secondary school enrolment and fertility there is a negative correlation depicted, indicating a trade-off. As expected, the remaining variables are aligned with the theory statistically. Mortality and agriculture depict consistencies in the data, where a positive correlation exists with fertility. Greater mortality rates suggest that diseases and the lack of healthcare still exists in many regions, resulting in a replacement effect for deceased children (Angeles, 2010).

In terms of agriculture, societies in several regions are highly dependent on larger families, as they rely on subsistence cultivation as a basis of survival (Bittencourt, 2016). GDP per capita,

gender equality and urbanisation depict negative correlations on fertility. This suggests that there are areas within the sample that are becoming more developed as there is a greater demand for education and skills (Chisadza and Bittencourt, 2015). By taking a closer look at the variables on fertility in table 2, primary and secondary school enrolment, mortality rates, gender equality and agricultural share of GDP have the strongest correlations.

Table 2: Correlation matrix between Fertility and variables across sub-Saharan Africa (47 countries).[16]

	Fertility	Primary School	Secondary School	Mortality	GDP per Capita	Gender Equlity	Urbanisation	Agriculture
Fertility	1.0000							
Primary School	-0.6057	1.0000						
Secondary School	-0.8315	0.7191	1.0000					
Mortality	0.7329	-0.6695	-0.7546	1.0000				
GDP per Capita	-0.4866	0.3309	0.6201	-0.4253	1.0000			
Gender Equlity	-0.6164	0.6435	0.5710	-0.6711	0.3778	1.0000		
Urbanisation	-0.5334	0.3099	0.5192	-0.4190	0.4885	0.1874	1.0000	
Agriculture	0.6062	-0.5174	-0.6161	0.6474	-0.5953	-0.5224	-0.6042	1.0000

Figure 5 depicts a worldwide geographical distribution of fertility rates as well as secondary school enrolment ratios for 1975 and 2013[17]. There are major contrasts between the two years compared from a global perspective. Internationally, the more developed countries such as Australia, Canada, the United Kingdom and the United States tend to reflect higher enrolments in secondary schools and lower fertility rates oppose to the underdeveloped regions such as Africa and Asia (particularly the Middle East). From a sub-Saharan African perspective, the Southern African countries (the SADC region) have advanced significantly in terms of increasing enrolment rates and reducing fertility rates in comparison to many other countries on the continent. As the years have progressed, the quality of data has improved dramatically, suggesting that there is better precision within the distributions of data, enabling one to interpret the results more accurately.

[16] For further information regarding this data broken down by intergovernmental organisations, refer to Appendix D

[17] Since the period analysed in this research is from 1975 to 2015, the latest data for the shapefile was best for 2013, as data for 2015 was insufficient.

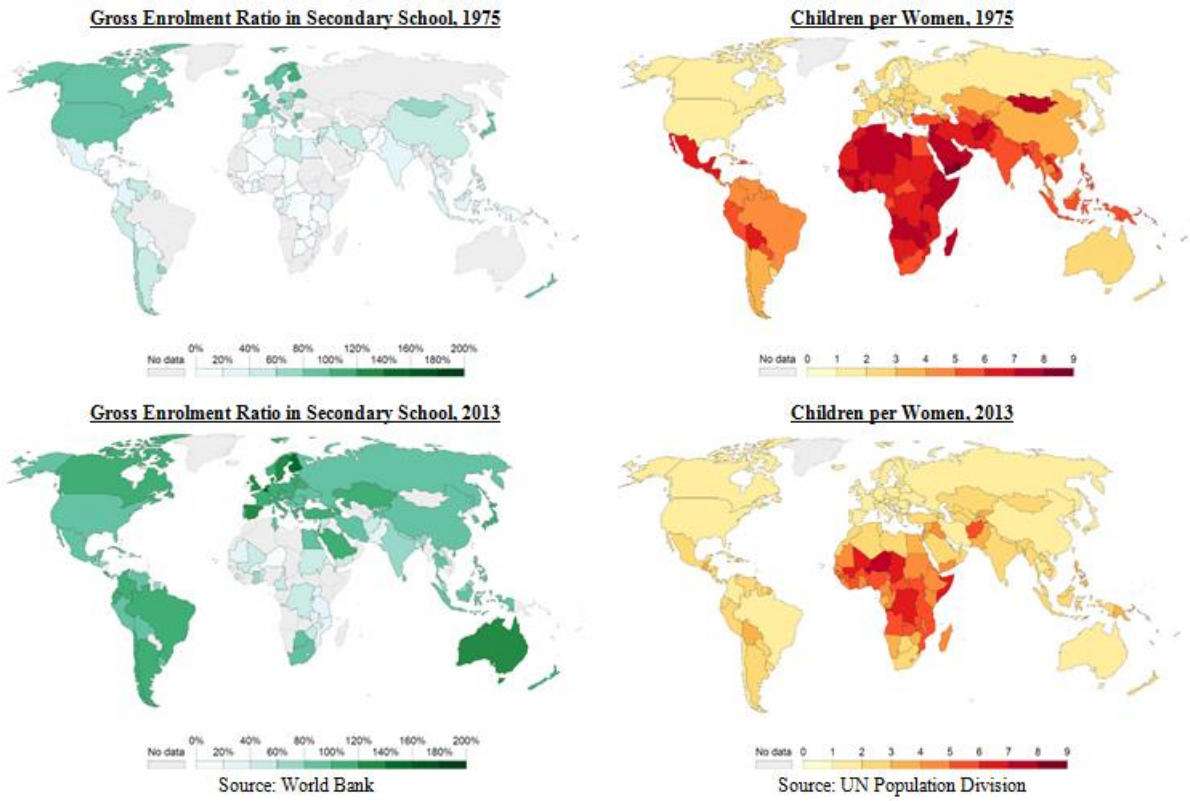

Figure 5: Worldwide Fertility Rates and Secondary School Enrolment Ratios (Source: World Bank and UN Population Division)

Methodology

Panel time series, also known as longitudinal time series data, is a set of observations on cross-section units. Units examined in this research report are countries across a time period, expressed as $i = 1, 2, \ldots, N$ over repeated time periods, $t = 1, 2, \ldots, T$. The purpose of this research report is to measure the effect on a scalar dependent variable, $fertility_{it}$, of a set of exogenous variables, $primeduc_{it}$, $seceduc_{it}$, $mort_{it}$, GDP_{it} and gen_{it}. The research also considers a k x 1 vector X_{it}, of control variables. Panel time series data is advantageous over single cross-sections $T = 1$; or single time series $N = 1$, by considering instances where both N and T are both large. Panels account for greater samples which can help enhance the efficiency of the data as well as alleviating multicollinearity. By allowing for more heterogenous variables in the process, this accounts for unobserved variable identification that impact all countries (Smith and Fuertes, 2010).

A panel data econometric analysis using POLS and fixed effects estimates have been conducted in this research report. Education is the main variable studied together with the explanatory and control variables which are used to determine fertility rates within the sample of sub-Saharan

African countries. A further analysis of common correlated effects (CCE) is taken into consideration to test the robustness of the data. The CCE approach is a technique applied in order to analyse the influence of cross-sectional dependence, and to determine heterogeneity within the slopes and fixed effects. Due to the differences in the levels of sustainable development in sub-Saharan Africa, the impact of idiosyncratic shocks such as education enrolment, mortality and the influx of urbanisation on fertility can vary across countries (Chudik and Pesaran, 2015). Pesaran's (2006) CCE estimator focuses on dealing with dependencies across countries in panels with heterogeneity amongst the data. It is useful in estimating β, as it takes into consideration common factors, such as spill-overs between countries, as well as idiosyncratic variations within the data. The CCE estimator is very similar to ordinary least squares estimate as it applies an auxiliary regression augmented methodology within the panel of the variables (Fuleky, Ventura and Zhao, 2017).

Pooled data is a collection of data across the units (countries) and the time period examined. POLS intersect the data between countries and time forming a "country-time" collective unit. Pooling data is a beneficial method in analysing the variations of the data and the number of observations easily and more accurately (Hicks, 1994). This research report estimates a baseline POLS model taking into consideration homogeneity between the countries, as they all share common intercepts and slopes. It should be noted that countries such as South Africa and Burkina Faso will differ in features such as trade policies, fiscal and monetary policies, political barriers, growth in population, geographic positioning or technological accessibility. The fixed effects i is able to capture heterogeneity present within the model by considering these discrepancies and including "individual specific effects, allowing for more efficient estimates" (Chisadza and Bittencourt, 2015:11). By accounting for these differences, as well as considering specific experiences encountered by the various countries, this analysis provides for estimations that are more consistent and unbiased. The application of a fixed effects model allows one to determine the impact analysis of the regressed variables over time. It also examines the correlations between the explanatory and control variables as well as the dependent variable within the system of countries analysed. There are assumptions in terms of impact or bias within the number of countries analysed, in that the residuals are correlated with the explanatory variables. The idea of a fixed effects model is to eliminate all time-invariant factors, thereby analysing the net effects of the explanatory or control variables on the dependent variable, *fertility*.

Using fertility as the dependent variable, the following equation in the cross-section of countries is estimated by:

$$fertilty_{it} = \alpha_i + \omega_i primeduc_{it} + \beta_i seceduc_{it} + \pi_i mort_{it} + \gamma_i GDP_{it} + \theta_i gen_{it} + \rho_i \boldsymbol{X}_{it} + \mu_{it}$$

Here, the dependent variable *fertility* denotes the fertility rate, and the explanatory variable, *primeduc* and *seceduc* denote primary and secondary education enrolment respectively. X_{it} is a vector of the control variables. The explanatory variables, *mort*, *GDP* and *gen* denote mortality rates, GDP per capita and gender equality respectively.

The main underlying theory is that the higher the enrolment in secondary school, the lower the impact on fertility rates. In other words, the relationship between fertility and secondary school enrolment is negative ($\beta < 0$). For each country *i*, the exogenous control variables are estimated as:

$$X_{it} = \alpha_i + \phi_i urb_{it} + \xi_i agric_{it} + \epsilon_{it}$$

The control variables *urb* and *agric* denote urbanisation and agriculture respectively. Different countries i, represent levels of heterogeneity within the panel. By applying the panel data scenario, heterogeneity can be taken into consideration and is able to test for the behaviour of the variables, rather than analysing the data individually as a single time series analysis. The panel analysis is able to provide a more holistic analysis of the sub-Saharan African data (Chisadza and Bittencourt, 2015).

Results

The regression results for both estimates align to the literature in that there is an incentive for people to invest in the quality of their children. This suggests a child quality over quantity trade-off. As in table 3 below, both estimates depict a negative and significant relationship between secondary school enrolment and fertility rates in all instances. As heterogeneity is introduced and more control variables are added to the regressions, the POLS regressions provide a positive relationship between primary school enrolment and fertility rates. Although

all cases depict a positive relationship, there are less significant outcomes as depicted in columns 1 and 6.

A 10 percent rise in secondary school enrolment results in a range from 0.6 percent to 3.1 percent decrease in fertility rates, while primary school enrolment results in a range from 0.19 percent to 0.53 percent increase in fertility rates. This creates the impression that the investment in secondary education has a stronger effect on fertility rates than at primary school level. These outcomes are, therefore, aligned to Chisadza and Bittencourt (2015), as there is a negative relationship between secondary school enrolment and fertility rates. According to research initiated by Lehr (2009), primary school education tends to have more of a positive relationship with fertility, and typically in less developed countries that have not undergone any form of demographic transformation.

In all cases for both estimates, the results depict a positive relationship between primary school enrolment and fertility rates, while the coefficients for secondary school enrolment are negative. Higher levels of education (secondary school) may imply that women have greater awareness of the burden of bearing many children at a young age (Chisadza and Bittencourt, 2015). This positive relationship at primary school level is possibly due to young women abandoning their education as they fall pregnant, thus only achieving fewer years of education. This potentially hinders their options of attaining a higher level of education. Due to these circumstances, parents may propose the conception of marriage as it may be deemed as a source of income for young women in terms of financial security and child support. Higher education attainment most likely results in women marrying at a later age and, in the process, enticing them to invest in the education of their children (Dreze and Murthi, 2001). The more women who progress at schooling, even at primary school level, the better their decision-making in terms of bearing children (Ainsworth et al. 1996). This research shows that secondary schooling results in lower fertility rates of a greater order than at primary school level (Chisadza and Bittencourt, 2015).

By examining both estimates, the gender equality variable under the POLS estimate are negative and significant in most cases, while the fixed effects estimates are positive and significant in most cases. As women become more educated, there is an increased tendency to delay marrying at a young age. In the process, they are enticed to invest in fewer children of their own. Their decision-making around contraceptive techniques and practices are also applied via education (Ainsworth et al. 1996). As more educated women enter the labour force,

their income levels rise which, in hindsight, contributes greatly towards the child quality over quantity trade-off (Galor and Weil, 1993, 1996).

In the past, sub-Saharan Africa experienced extremely poor health conditions and facilities together with diseases and various epidemics. As a result, the lives of infants were considerably shortened. This contributed to high levels of mortality. While this situation still exists, there have been significant improvements in that there is a positive relationship between mortality and fertility. With such an issue under the control of women, there is a sharp tendency to replace deceased infants. As there have been improvements in female healthcare on the one hand, there have been greater enrolments in higher education for women on the other. Over time, fertility as well as mortality rates have declined (Reher, 2011). According to Conley et al. (2007), from a global perspective, infant mortality is considered to be a great contributor towards fertility.

For both estimates in table 3, mortality rates provide a positive and significant relationship with fertility rates in all cases. The intensity of the replacement effect is therefore prevalent in times of poor health conditions imposed on infants. The timing of the demographic transformation plays a significant role in mortality rates. The sooner a country undergoes this transformation, the greater the impact it has on fertility rate reduction. This transformation can be a relatively lengthy process in which this delay can hinder the course of reducing fertility rates (Montgomery, 2000). According to Galor and Moav (2002), sustained economic growth generally results in greater survival rates and enhances human capital within the labour force. This is plausible, particularly after positive shocks such as a demographic transformation can result in a strong association between human capital and technological advancements. Negative shocks such as diseases (HIV/AIDS) generally lead to an opposite occurrence in that there are lower survival rates and a weak association between human capital and technological advancements. This results in a negative impact on sustained economic growth.

In the majority of cases, there is a negative and significant relationship between GDP per capita and fertility rates. According to Galor and Weil (1999), advances in technology and human capital has increased the demand for enhanced skillsets and led to associated rises in income levels. This, in essence, increases the child quality over quantity trade-off in which there is an investment in a child, thus reducing fertility rates.

From these results, it is evident that the greater the urbanisation rate, the lower the fertility rate. It is also evident that there is an inverse relationship between urbanisation and agricultural share of GDP. In most cases across both the POLS and fixed effects estimates, the results are

significant and reflect the theories proposed by Ainsworth et al. (1996). Urban areas in Africa tend to be undergoing a transformation from Malthusian stagnation towards a modern growth regime as theorised by Galor and Weil (2000, 2002). Urban areas become more secure in terms of finance and job opportunities with associated greater accessibility to educational facilities that incentivise people to relocate from rural areas is reinforced.

Table 3: Pooled OLS and Fixed Effects estimates, sub-Saharan Africa, 1975-2015.

	1	2	3	4	5	6
FERTILITY	POLS	POLS	POLS	POLS	POLS	POLS
Primary School	0.053	0.052	0.05	0.082	0.074	0.019
	(1.62)	(2.05)*	(2.04)*	(2.78)**	(2.53)*	(0.56)
Secondary School	-0.309	-0.109	-0.08	-0.089	-0.064	-0.06
	(18.78)**	(7.10)**	(5.13)**	(5.31)**	(3.57)**	(2.97)**
Mortality		0.441	0.388	0.348	0.386	0.403
		(22.28)**	(18.75)**	(15.63)**	(16.73)**	(17.23)**
GDP per Capita			-0.08	-0.089	-0.048	0.015
			(6.84)**	(7.20)**	(3.50)**	(0.93)
Gender Equality				-0.128	-0.163	-0.069
				(3.06)**	(3.84)**	(1.52)
Urbanisation					-0.047	-0.01
					(2.65)**	(0.49)
Agriculture						0.096
						(5.75)**
R-squared	0.53	0.73	0.75	0.75	0.77	0.8
	1	2	3	4	5	6
FERTILITY	FE	FE	FE	FE	FE	FE
Primary School	0.196	0.235	0.184	0.122	0.153	0.148
	(7.59)**	(9.34)**	(7.15)**	(4.11)**	(5.26)**	(4.91)**
Secondary School	-0.312	-0.235	-0.199	-0.202	-0.148	-0.121
	(22.68)**	(14.14)**	(11.62)**	(11.24)**	(6.76)**	(5.45)**
Mortality		0.227	0.179	0.218	0.243	0.185
		(7.96)**	(6.21)**	(6.66)**	(7.36)**	(5.22)**
GDP per Capita			-0.117	-0.087	-0.056	-0.01
			(6.25)**	(4.33)**	(2.79)**	(0.41)
Gender Equality				0.253	0.195	0.045
				(4.52)**	(3.55)**	(0.78)
Urbanisation					-0.171	-0.157
					(5.79)**	(4.94)**
Agriculture						0.117
						(5.99)**
R-squared	0.55	0.6	0.62	0.63	0.66	0.71
Observations	677	668	668	617	546	484

Coefficients reported. Robust standard errors in parenthesis. ***p<0.01, **p<0.05, * p<0.1

Robustness

Following on from the above analysis, the tests for robustness are considered by analysing the CCE estimator. Table 4 below depicts the CCE estimates per variable. Primary school

enrolment in most cases is positive, but not significant. Secondary school enrolment is negative and significant in panels 1 and 4. By taking panels 1 and 4 into consideration, a one-unit percentage increase in primary school yields a 0.04 percent and 0.067 percent increase in fertility rates respectively, while a one-unit percentage increase in secondary school yields a 0.126 percent and 0.116 percent decrease in fertility rates respectively. From the robust test, there is confirmation with the POLS and fixed effects estimates that both primary and secondary school enrolment have a positive and negative relationship with fertility rates respectively. There is evidence to suggest that there is cross sectional dependency and spill-overs in terms of common correlated effects. However, these results are, overall, relatively weak.

Mortality rates in most cases align with the other estimates, depicting, a positive relationship with agricultural share of GDP. In panels 3 and 5, the results for mortality are positive and significant. A one-unit percentage increase in mortality rates yield a 0.131 percent and 0.161 percent increase in fertility rates in panels 3 and 5 respectively.

GDP per capita, in some cases, depicts a negative but not significant relationship. As technology advances, so does the income per worker, as well as demand for skilled labour. As a country enters a stage of further development, the child quality over quantity trade-off increases and, in the process, leads to a reduction in fertility rates. Greater accessibility to income and finances reduces financial limitations, and can benefit poor societies in terms of educational investment (Galor and Moav 2004).

Gender equality in most cases depicts a negative but not significant relationship with fertility rates. Galor and Weil (1993, 1996), suggest that income earned by women in the labour force will undergo the trade-off of bearing children.

Furthermore, the fertility average depicts significant results in panels 1, 3 and 6, indicating that there are unforeseen common factors amongst the data. In panel 6, the results robustly propose that the sub-Saharan African region, is experiencing a child quality over quantity trade-off. Here, there is greater demand for educated and skilled human capital. The incentive for child quality is clearly suggested by this demand for human capital via increases in educational return. Such investments in education are great contributors, shifting from the Malthusian stagnation towards a modern growth regime (Becker, Cinnirella and Woessmann, 2010).

Table 4: Common Correlated Effects (CCE), sub-Saharan Africa, 1975-2015.

	1	2	3	4	5	6
FERTILITY	CCE	CCE	CCE	CCE	CCE	CCE
Primary School	0.04	0.123	-0.34	0.067	0.022	-0.085
	(0.46)	(1.03)	(1.10)	(0.88)	(0.21)	(0.75)
Secondary School	-0.126	-0.085	-0.031	-0.116	-0.034	0.105
	(3.12)**	(0.6)	(0.34)	(2.29)*	(0.80)	(1.45)
Mortality		-0.484	0.131	0.315	0.161	0.381
		(0.91)	(2.28)*	(1.86)	(1.97)*	(1.16)
GDP per Capita			-0.086	0.076	0.008	-0.058
			(0.66)	(1.55)	(0.22)	(1.24)
Gender Equality				0.115	-0.039	-0.112
				(1.28)	(0.38)	(0.42)
Urbanisation					0.642	0.188
					(1.00)	(0.42)
Agriculture						-0.056
						(1.15)
Fertility ave	0.181	0.614	0.254	0.152	0.03	-0.081
	(2.67)**	(1.10)	(2.91)**	(1.66)	(0.85)	(2.67)**
Observations	666	638	633	572	484	383

Coefficients reported. Robust standard errors in parenthesis. ***p<0.01, **p<0.05, * p<0.1

Conclusion

From an overall perspective, the results from the sample of data over the period under review indicate that development is unquestionably ongoing within the sub-Saharan African region. This is borne out of technological advancements flowing into the region as well as innovation via educational inputs. This in turn has led over time to a reduction in fertility rates in the region. This suggests that there are rises in capital per worker in which there are greater outcomes of economic sustainability and output from productivity levels. Based on the findings in the literature review, the results are associated with unified growth theory in that the child quality over quantity trade-off is present in the data. This trade-off has resulted in lower fertility in which positive strides have been made towards a modern growth regime. The data and the analysis thereof also suggest that rising mortality rates coincide with increasing fertility rates via a replacement effect (Chisadza and Bittencourt, 2015).

According to Jones and Romer (2010), the rise in technology and innovation, growth, commodities, incomes and financial sustainability by means of urbanisation and globalisation has given rise to market accessibility to both consumers and suppliers. With such market accessibility available, the sub-Saharan region has over the latter 25 years of the reporting

period seen consumption levels rise in terms of educational, health and housing investments (Young, 2012). The more educated a society is, the greater the level of innovation adjustable to increased technological advances. This in turn strengthens knowledge and skills as well as greater sustainable development (Nelson and Phelps, 1966). In terms of the POLS, fixed effects and CCE results as well as findings by Galor and Weil (1999), the relationship between GDP per capita and fertility rates in most cases is negative. From the results analysed, fixed effects are the preferred method in analysing the data as they account for heterogeneity within the data.

The results contained in this research report have shown that greater urban migration has led to a reduction in fertility rates, further contributing to the child quality over quantity trade-off. This influx of urbanisation is a strong indicator, meaning that there are increasing advancements in technology requiring greater skills in the region. This has further contributed to fertility rate reduction in that there are greater investments in a child's education, contributing further to sustainable development and growth. There are continuous transformations supporting the notion that sub-Saharan Africa is shifting away from the Malthusian stagnation epoch to a post-Malthusian regime (Chisadza and Bittencourt, 2015).

This research report has proposed prospective future research by opening up new investigative studies by applying micro data such as literacy rates on fertility rates. This type of investigative study can be applied in a more targeted way in a South African context. Prior to democracy in 1994, South African non-white citizens received very limited access to modern education. This potentially explains the higher levels of fertility rates, during the apartheid era. Subsequent to 1994, there were major structural changes and improved accessibility to modern education and labour. This provided better fertility decision-making. Since the advent of democracy in South Africa, citizens (particularly non-white citizens) have had improved access to employment opportunities and prospects. From an overall perspective, research endeavours can be improved in the future, by focusing on the investigation of the effects aggregate school enrolments. This can be conducted by considering both male and female enrolment rather than asserting a primary focus on female school enrolments only. Such research can be further strengthened by taking into consideration instrumental variables as well as how the impact that endogeneity can influence the relationship between education and fertility.

This research report has made use of fixed effects, by dealing with statistical endogeneity, through demeaning the data. Although the data analysed focuses on the strength of the correlations rather than the causality between fertility and education, it has, however, provided

an interesting insight overall. The introduction of compelling instrumental variables would strengthen the results, resulting in causal relationships between the variables studied and fertility rates. This will provide a more accurate and clearer observation in terms of the impact that these variables can have on fertility rates.

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Appendices

Appendix A

Figure A1 depicts the mean relationships between fertility and the control variables, urbanisation and agricultural share of GDP. Figure A1 below depicts a downward trend between urbanisation and fertility. The data presented in the graphs aligns to the child quality over quantity trade-off, in which urban areas tend to be more developed regions, incurring greater demands for skills (Chisadza and Bittencourt, 2015). There is a positive correlation between agriculture share of GDP and fertility rates, indicating consistency amongst the data and theories proposed in the literature. The graphs are in line with Bittencourt (2016), in that greater agricultural reliance is associated with higher levels of fertility.

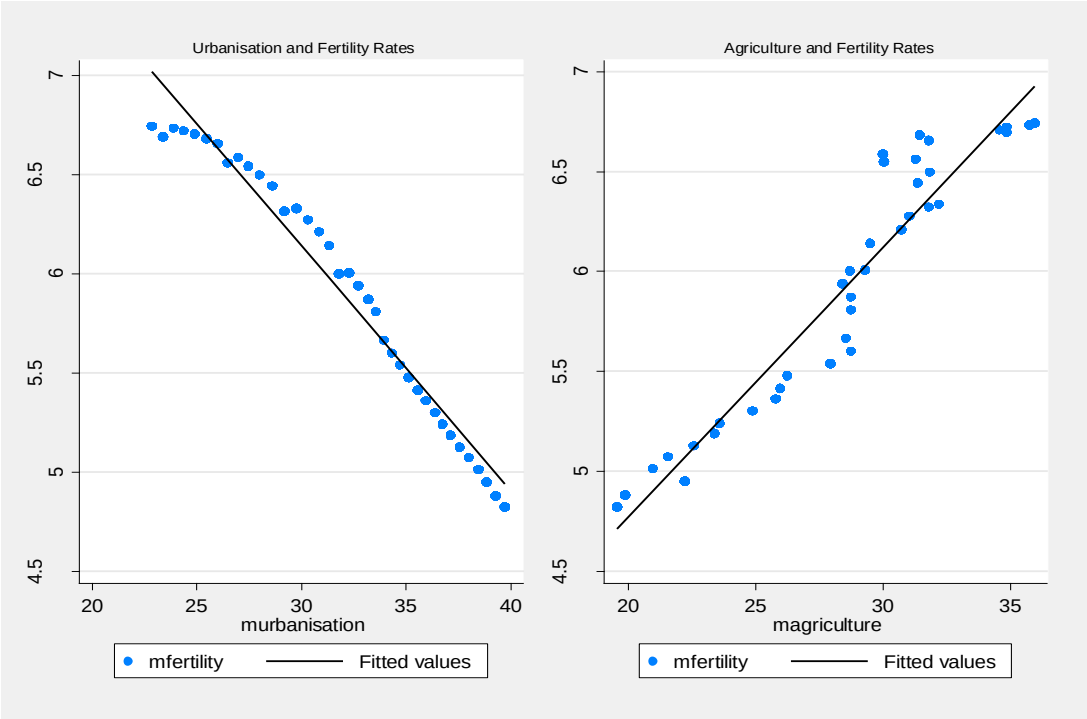

Figure A1: Mean Urbanisation and Agricultural share of GDP and Fertility Rates in sub-Saharan Africa (Source: World Bank, 1975-2015)

There is a significant rise in urbanisation depicted in in figure A2 below, whilst agricultural share of GDP has declined over the period. It can be seen that urbanisation has risen on average from roughly 23 percent to almost 40 percent in 2015, while agriculture has dropped on average from a little more than 35 percent to just less than 20 percent in 2015. This is mainly determined by the agricultural-urban decision-making process, in which urban regions become a pull factor

as there is a better quality of life in the city. This picture clearly depicts the inverse relationship between urbanisation and agricultural share of GDP as pointed out by Bittencourt (2016). The increase in urbanisation tends to have a decrease in fertility rates.

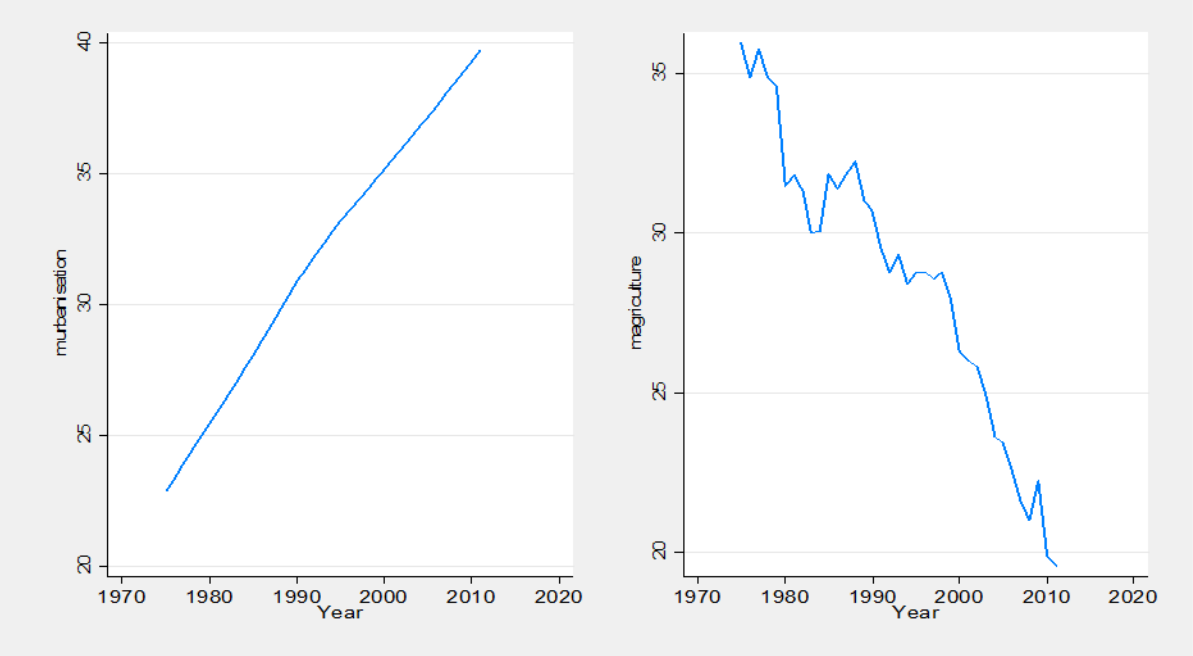

Figure A2: Mean Urbanisation and Agricultural share of GDP in sub-Saharan Africa over time (Source: World Bank, 1975-2015).

Appendix B

The summary of statistics below depicts all of the variables selected in this research report by intergovernmental agreement (region). The intergovernmental agreements are listed as follows:

- Economic and Monetary Community of Central Africa (CEMAC)
- Economic Community of Central African States (ECCAS)
- Economic Community of West African States (ECOWAS)
- Intergovernmental Authority on Development (IGAD)
- Southern African Development Community (SADC)

Each graph depicts the mean relationships between fertility and the explanatory variable education enrolment (both primary and secondary), mortality rates, GDP per capita, gender equality, urbanisation and agricultural share of GDP.

Figures B1 and B2 below depict the impact of primary and secondary school enrolment respectively on fertility rates. Similar to the analysis on the overall sample, namely, sub-Saharan Africa, a downward trend is presented in each region for both primary and secondary school enrolment. This corroborates unified growth theory supporting the notion that attainments in higher education (secondary school) results in lower fertility rates. Technological advancements, therefore, require greater knowledge and skills which impact on fertility decisions, contributing towards the child quality versus quantity trade-off within sub-Saharan Africa (Chisadza and Bittencourt, 2015).

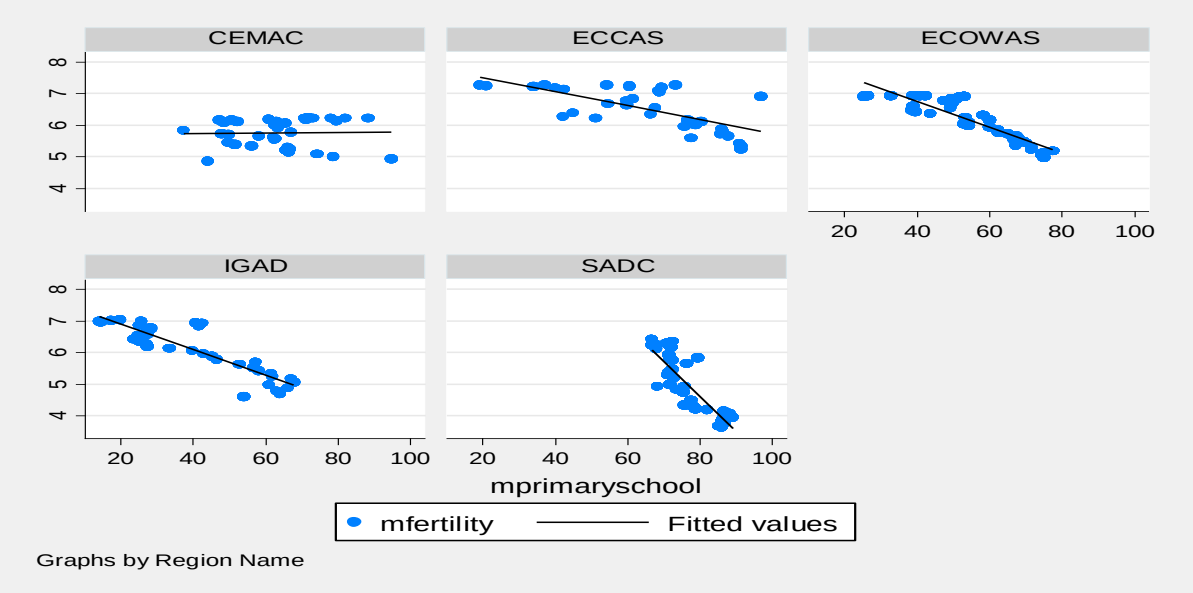

Figure B1: The Impact of Primary School Enrolment on Fertility Rates (Source: World Development Indicators, 1975-2015)

In figure B2, the SADC region expresses the strongest elasticity, as a large secondary education enrolment yields a larger reduction in fertility rates in comparison to the other regions. The CEMAC region depicts a flatter, but relatively stagnant trend. Although secondary school enrolment depicts a negative trend, it is not significant, suggesting that secondary school enrolment in the CEMAC region has very little impact on fertility rates.

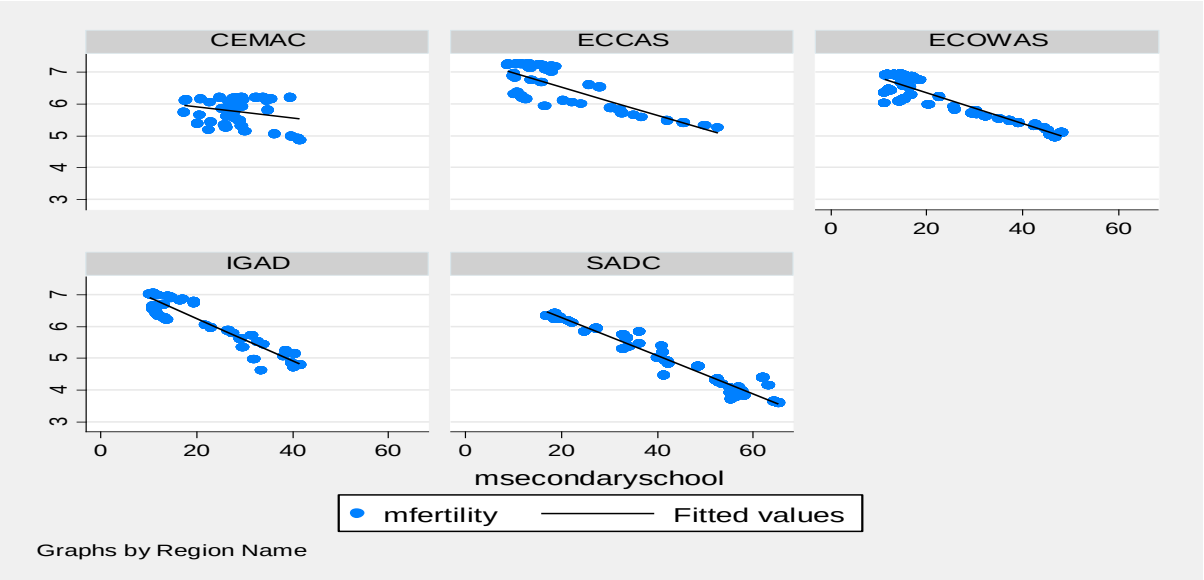

Figure B2: The Impact of Secondary School Enrolment on Fertility Rates (Source: World Bank, 1975-2015)

Figure B3 below depicts the impact of mortality rates on fertility rates. There is a positive trend between mortality and fertility rates, suggesting that there is a replacement effect on deceased children (Angeles, 2010). As there are infant deaths in a household, women will tend to compensate by having a new-born child. Out of all of the intergovernmental regions, the SADC region expresses a fairly steady elasticity between mortality and fertility rates, suggesting that an increase in mortality rates yields a steady rise in fertility rates.

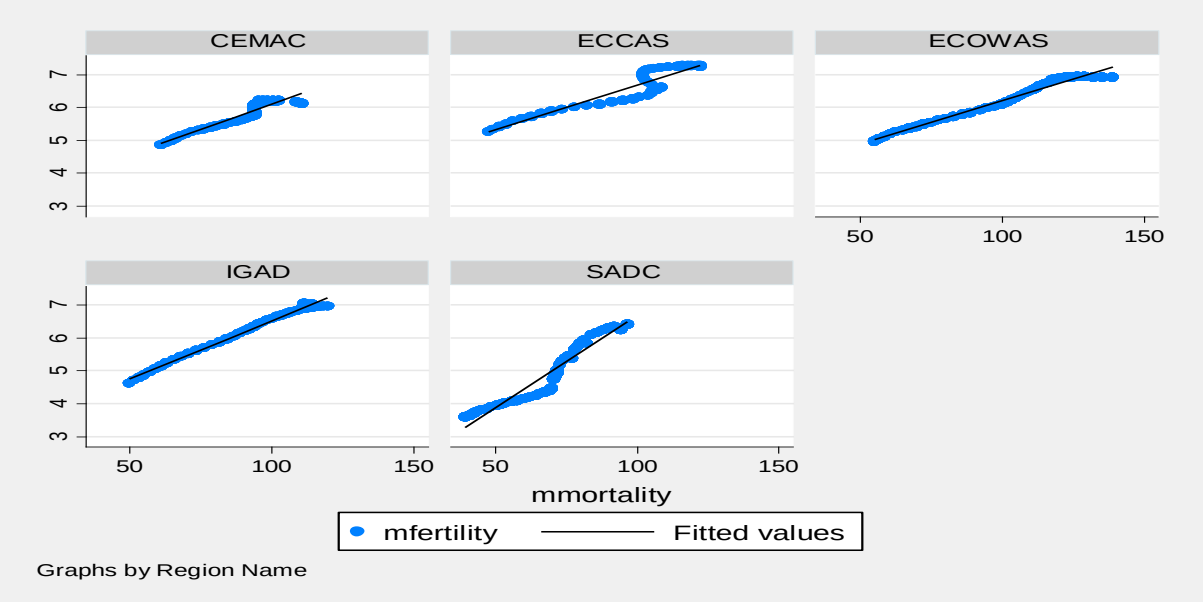

Figure B3: The Impact of Mortality Rates on Fertility Rates (Source: World Bank, 1975-2015)

According to figure B4, there is a negative trend between GDP per capita and fertility rates. This suggests that greater development within a country results in lower population sizes and greater fertility reduction. The ECOWAS and IGAD regions express the strongest elasticities, suggesting that there is underdevelopment and impoverishment associated with high fertility rates within these regions.

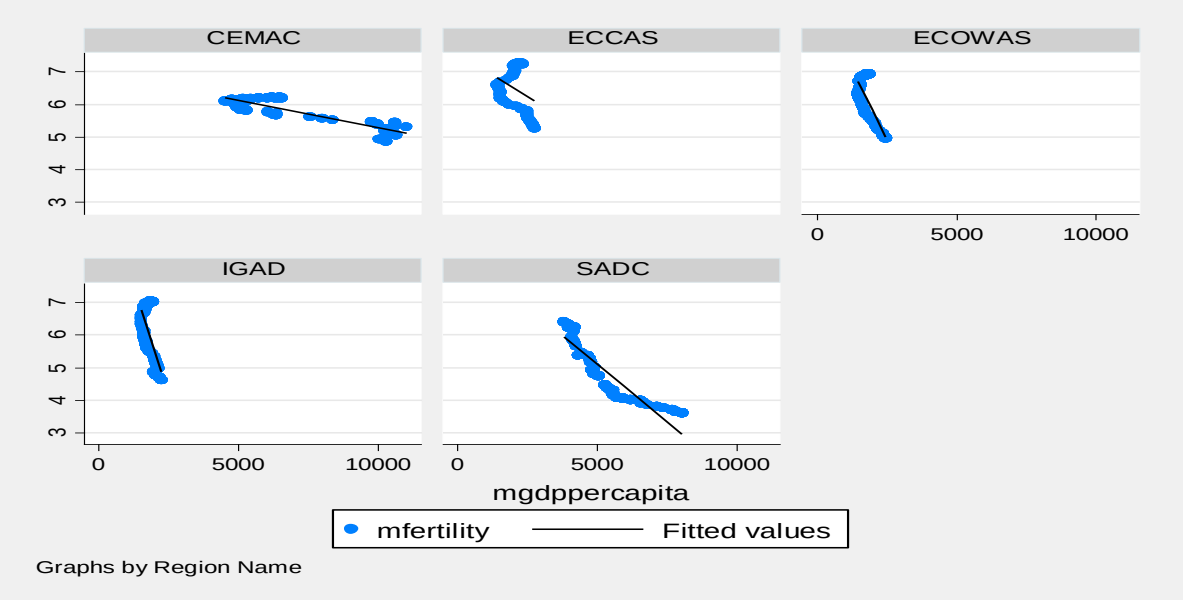

Figure B4: The Impact of GDP per Capita on Fertility Rates (Source: Gapminder, 1975-2015)

Figure B5 below depicts the impact of gender equality on fertility rates. Gender equality is depicted by a negative trend. As more and more women are entering the labour force due to acquired skills and competencies, the quality in human capital is increasing with associated increases in greater economic growth. The rise in economic growth and sustainable development is negatively correlated with fertility, depicting an informative and consistent outcome. There is a substitution effect in which women become more focused on a selected career path instead of bearing high costs for their children in terms of healthcare and education (Galor and Weil, 1993, 1996). Out of all of the intergovernmental regions, the SADC region expresses the strongest elasticity between gender equality and fertility rates. A small increase in gender equality yields a large decrease in fertility rates.

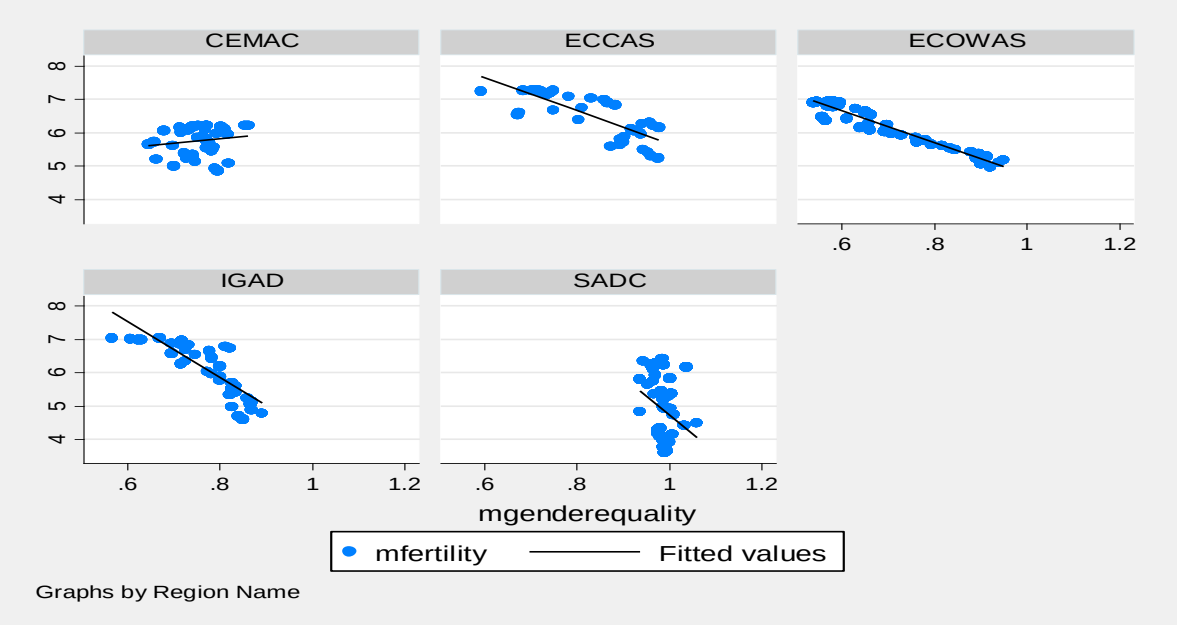

Figure B5: The Impact of Gender Equality on Fertility Rates (Source: Gapminder, 1975-2015)

Figures B6 and B7 below depict the multiple impact of urbanisation and agricultural share of GDP on fertility rates. Within sub-Saharan Africa, urbanisation has experienced a positive trend while the agricultural share of GDP expresses an opposite result. The impact of agriculture on fertility is associated with the theories suggested by Becker, Cinnirella and Woessmann (2010), in that the quality of children and unskilled commodities (agricultural goods) do not exactly complement one another. As economies enter a stage of development, the reduction in fertility is enhanced by secondary school enrolment. Out of all of the intergovernmental regions, the SADC region expresses the strongest elasticity between urbanisation and fertility rates as well as the agricultural share of GDP and fertility rates.

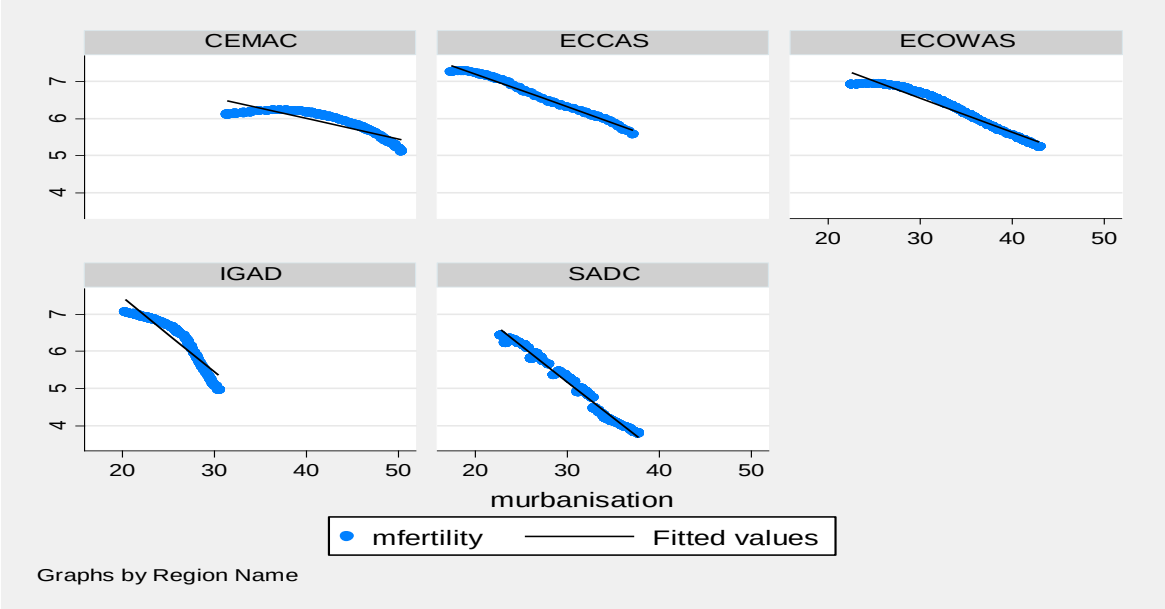

Figure B6: The Impact of Urbanisation on Fertility Rates (Source: World Bank, 1975-2015)

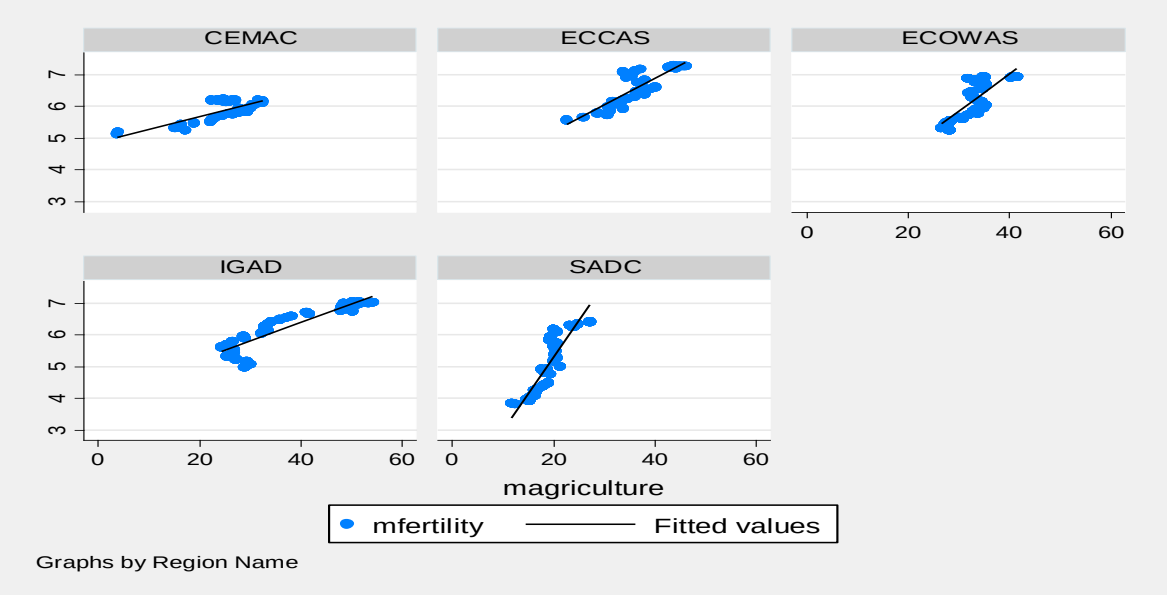

Figure B7: The Impact of Agriculture on Fertility Rates (Source: World Bank, 1975-2015)

Since GDP per capita over the period is on the rise, it is safe to assume that the sub-Saharan region is steering away from the Malthusian epoch towards a modern growth regime. This is particularly evident within the SADC region, where the substitution effect is prevalent, superseding the income effect (Becker, 1960). The decrease in fertility rates, triggered by secondary school enrolment, results in increases in urbanisation, simultaneously reducing agricultural share of GDP. This implies that the SADC region is clearly moving towards the

post-Malthusian regime at a faster rate in comparison with the rest of the intergovernmental regions (Bittencourt, 2016).

Appendix C

Table C below depicts the data for all 47 sub-Saharan African countries and is broken down by intergovernmental organisations (regions). Fertility rates in the ECCAS region has experienced the highest levels whilst the SADC region has experienced the lowest levels, with figures of 6.5 and 4.86 respectively. As the SADC tends to be a more developed region, fertility rates are under greater control within this region.

In terms of education enrolment, primary school enrolment over the period is the highest on average in the SADC and the lowest in the IGAD region, with figures of 78.1 percent and 46.81 percent respectively. Secondary School enrolment over the period is the highest on average in the SADC region with figures of 42.59 percent. The ECCAS region has the lowest, with figures of 21.75 percent. In line with Chisadza and Bittencourt (2015), the SADC region experiences the greatest education enrolments as these countries tend to have more developed economies than that of the rest of the sub-Saharan African regions.

Mortality rates over the period are the highest on average in the ECOWAS region whilst the SADC region has experienced the lowest, with figures of 97.93 and 68.36 respectively. This aligns to Bittencourt (2016), in that there are more sophisticated healthcare facilities in the SADC region compared to the ECOWAS region. The ECOWAS region is in all likelihood undergoing inadequate healthcare where there are uncertain child survival rates.

GDP per capita over the period is the highest on average in the CEMAC region whilst the IGAD region has experienced the lowest, with figures of $7,130.92 and $1,752.58 respectively. As suggested by Chisadza and Bittencourt (2015), the more developed a nation is the lower its fertility rate and the less developed a nation the higher its fertility rate. Incomes per worker are associated with fertility rates. This aligns to Becker (1960), in that there is a child quality over quantity trade-off based on the income elasticity of demand.

Gender Equality over the period is the highest on average in the SADC region whilst the ECOWAS region has experienced the lowest, with ratios of 0.98 and 0.71 respectively. As societies become more developed, women tend to undergo a substitution effect in which they will be more career focused, rather than spend the costs of bearing too many children (Galor and Weil, 1993, 1996).

Urbanisation over the period is the highest on average in the CEMAC region whilst the IGAD region has experienced the lowest, with figures of 42.93 and 25.82 respectively. Agricultural

share of GDP over the period is the highest on average in the IGAD region whilst the SADC region has experienced the lowest, with figures of 37.60 and 18.64 respectively. A greater influx of people into urban areas results in a reduction in fertility rates. The opposite effect tends to occur for greater residence within agricultural areas (Ainsworth et al. 1996). Areas with greater urbanisation are typically more developed than areas highly dependent on agriculture which impacts on the agricultural-urban ratio.

Table C: Descriptive Statistics by Intergovernmental Agreements

CEMAC Region

Variable	Obs	Mean	Std. Dev.	Min	Max	Source
Fertility Rate	246	5.76	0.81	3.85	7.43	World Bank
Primary School Enrolment	71	64.41	18.15	24.18	99.25	WDI
Secondary School Enrolment	145	28.02	17.16	2.38	70.89	World Bank
Mortality Rate	235	88.28	26.48	35.80	146.60	World Bank
GDP per Capita	246	7,130.92	9,298.37	578.00	40,143.00	Gapminder
Gender Equality	124	0.76	0.16	0.35	1.00	World Bank
Urbanisation	222	42.93	17.30	15.57	86.15	World Bank
Agriculture	201	24.99	18.10	2.00	68.86	World Bank

ECCAS Region

Variable	Obs	Mean	Std. Dev.	Min	Max	Source
Fertility Rate	205	6.50	0.97	3.97	8.46	World Bank
Primary School Enrolment	63	67.68	23.35	17.42	98.99	WDI
Secondary School Enrolment	137	21.75	15.84	2.13	82.03	World Bank
Mortality Rate	200	93.10	32.76	27.10	148.20	World Bank
GDP per Capita	205	2,008.84	1,645.22	506.00	7,615.00	Gapminder
Gender Equality	113	0.83	0.14	0.58	1.04	World Bank
Urbanisation	185	26.55	17.65	3.22	62.65	World Bank
Agriculture	140	36.38	16.31	5.66	65.67	World Bank

ECOWAS Region

Variable	Obs	Mean	Std. Dev.	Min	Max	Source
Fertility Rate	615	6.16	1.00	2.37	7.91	World Bank
Primary School Enrolment	303	59.22	22.17	12.56	99.80	WDI
Secondary School Enrolment	391	23.45	17.91	1.62	89.35	World Bank
Mortality Rate	605	97.93	36.22	18.90	181.80	World Bank
GDP per Capita	615	1,792.14	1,087.08	142.00	6,514.00	Gapminder
Gender Equality	335	0.71	0.17	0.41	1.07	World Bank
Urbanisation	555	33.02	11.03	6.35	62.58	World Bank
Agriculture	432	33.72	12.54	6.39	65.05	World Bank

IGAD Region

Variable	Obs	Mean	Std. Dev.	Min	Max	Source
Fertility Rate	328	6.14	1.08	2.91	7.84	World Bank
Primary School Enrolment	101	46.81	20.76	14.22	91.00	WDI
Secondary School Enrolment	160	22.58	13.84	2.93	57.84	World Bank
Mortality Rate	314	88.36	31.09	33.80	176.80	World Bank
GDP per Capita	328	1,752.58	949.80	516.00	4,538.00	Gapminder
Gender Equality	138	0.78	0.12	0.51	0.98	World Bank
Urbanisation	296	25.82	20.00	7.04	77.08	World Bank
Agriculture	195	37.60	18.32	3.06	74.27	World Bank

SADC Region

Variable	Obs	Mean	Std. Dev.	Min	Max	Source
Fertility Rate	515	4.86	1.59	1.36	7.64	World Bank
Primary School Enrolment	311	78.10	14.96	34.46	99.91	WDI
Secondary School Enrolment	374	42.59	28.88	2.64	115.99	World Bank
Mortality Rate	533	68.36	38.06	11.90	178.90	World Bank
GDP per Capita	533	5,288.84	5,101.45	379.00	25,684.00	Gapminder
Gender Equality	337	0.98	0.14	0.64	1.45	World Bank
Urbanisation	481	30.87	14.01	7.65	61.99	World Bank
Agriculture	448	18.64	12.74	1.82	55.20	World Bank

Appendix D

A series of correlation coefficients by intergovernmental organisations (regions) are depicted in the correlation matrices in table D below. The figures in all regions depict similar outcomes to the overall sample (sub-Saharan Africa), between fertility rates and the given explanatory and control variables. These are consistent results, in that there is a negative correlation between primary school and secondary school enrolment and fertility rates indicating a child quality over quantity trade-off. As expected statistically, the remaining variables line up with the theories proposed in the literature review. Mortality and agriculture display a positive correlation with fertility, consistent with Angeles (2010). Greater mortality rates suggest that diseases and the lack of healthcare still exists in many regions resulting in a replacement effect for deceased children (Angeles, 2010). In terms of agriculture, people in several regions are highly dependent on larger families in agricultural areas for subsistence cultivation as a source of survival (Bittencourt, 2016). GDP per capita, gender equality and urbanisation depict negative correlations consistent with Chisadza and Bittencourt (2015). This suggests that there are areas within the sample that are becoming more developed than others and, in the process, lowering fertility rates at a faster pace.

Table D: Correlation matrix between Fertility and variables across inter-governmental organisations

CEMAC Region

-	Fertility	Primary School	Secondary School	Mortality	GDP per Capita	Gender Equality	Urbanisation	Agriculture
Fertility	1.0000							
Primary School	-0.3004	1.0000						
Secondary School	-0.5685	0.8509	1.0000					
Mortality	0.6500	-0.6097	-0.8668	1.0000				
GDP per Capita	-0.4455	-0.0990	0.3105	-0.4821	1.0000			
Gender Equality	-0.6715	0.8905	0.7521	-0.7467	0.5635	1.0000		
Urbanisation	-0.8499	0.6455	0.7525	-0.8358	0.5171	0.8249	1.0000	
Agriculture	0.4314	-0.5566	-0.7249	0.8541	-0.6562	-0.7353	-0.6518	1.0000

ECCAS Region

-	Fertility	Primary School	Secondary School	Mortality	GDP per Capita	Gender Equality	Urbanisation	Agriculture
Fertility	1.0000							
Primary School	-0.7983	1.0000						
Secondary School	-0.7144	0.7487	1.0000					
Mortality	0.7575	-0.7414	-0.7602	1.0000				
GDP per Capita	-0.0960	0.2878	0.0695	-0.1134	1.0000			
Gender Equality	-0.5383	0.7564	0.4572	-0.7498	0.0182	1.0000		
Urbanisation	-0.5679	0.6260	0.6657	-0.3892	0.6275	0.1246	1.0000	
Agriculture	0.3206	-0.6974	-0.4018	0.0662	-0.7860	-0.2724	-0.7845	1.0000

ECOWAS Region

-	Fertility	Primary School	Secondary School	Mortality	GDP per Capita	Gender Equality	Urbanisation	Agriculture
Fertility	1.0000							
Primary School	-0.7220	1.0000						
Secondary School	-0.8520	0.7568	1.0000					
Mortality	0.6798	-0.7230	-0.6612	1.0000				
GDP per Capita	-0.4277	0.4615	0.6481	-0.3297	1.0000			
Gender Equality	-0.7366	0.6938	0.7609	-0.8033	0.5654	1.0000		
Urbanisation	-0.7533	0.6912	0.8086	-0.4932	0.4977	0.7109	1.0000	
Agriculture	0.3774	-0.4257	-0.2920	0.5825	-0.3740	-0.3783	-0.4299	1.0000

IGAD Region

-	Fertility	Primary School	Secondary School	Mortality	GDP per Capita	Gender Equality	Urbanisation	Agriculture
Fertility	1.0000							
Primary School	-0.3912	1.0000						
Secondary School	-0.6445	0.8356	1.0000					
Mortality	0.7084	-0.6142	-0.8570	1.0000				
GDP per Capita	-0.4466	0.0162	0.2916	-0.2530	1.0000			
Gender Equality	-0.4629	0.8003	0.8055	-0.6904	0.2783	1.0000		
Urbanisation	-0.4264	-0.3720	-0.1443	-0.1676	0.4638	-0.1589	1.0000	
Agriculture	0.6950	0.0183	-0.3890	0.6477	-0.6582	-0.4299	-0.6177	1.0000

SADC Region

-	Fertility	Primary School	Secondary School	Mortality	GDP per Capita	Gender Equality	Urbanisation	Agriculture
Fertility	1.0000							
Primary School	-0.6340	1.0000						
Secondary School	-0.8751	0.7267	1.0000					
Mortality	0.7598	-0.8408	-0.7720	1.0000				
GDP per Capita	-0.7256	0.5910	0.8398	-0.6877	1.0000			
Gender Equality	-0.3552	0.1627	0.2402	-0.4858	0.2267	1.0000		
Urbanisation	-0.7188	0.6145	0.7947	-0.6729	0.7873	0.1239	1.0000	
Agriculture	0.7067	-0.6891	-0.7590	0.7740	-0.7723	-0.3368	-0.7502	1.0000

Appendix E

According to the panel data in this analysis, fertility rates over the period are the highest on average in Niger and the lowest in Mauritius with figures of 7.68 and 2.12 respectively. Primary school enrolment over the period is the highest on average in Malawi and the lowest in Somalia with figures of 95.97 percent and 16 percent respectively. Secondary school enrolment over the period is the highest on average in South Africa and the lowest in Tanzania with figures of 86.48 percent and 7.4 percent respectively.

Mortality rates have shown to be lower in more developed countries and higher in less developed countries. Mortality rates over the period are the highest on average in Sierra Leone and the lowest in the Seychelles with figures of 142.85 and 16.63 respectively.

Gabon, Equatorial Guinea, Seychelles and South Africa are considered to be greater in terms of development by looking at GDP per capita with figures on average of $19,515.20, $13,300.59, $15,758.39 and $10,923.27 respectively. This corresponds to fertility rates of 4.91, 5.7, 2.4 and 3.49 respectively. In contrast, Liberia, Mozambique, Malawi and Somalia are considered to be lower in terms of development with figures on average of $751.17, $626.44, $634.05 and $757.71 respectively. This corresponds to fertility rates of 6.08, 6.01, 6.48, 7.2 respectively. This aligns to Becker (1960), in that an increase in income results in an increase in the child quality over quantity trade-off.

Gender Equality over the period, is on average, the highest in Lesotho and the lowest in Guinea-Bissau, with ratios of 1.21 and 0.49 respectively.

Urbanisation over the period, on average, is the highest in Djibouti and the lowest in Burundi with figures of 74.85 and 6.91 respectively. Agricultural share of GDP over the period is the highest on average in Somalia and the lowest in Djibouti with figures of 63.97 and 3.48 respectively.

Table E below depicts the mean figures for each variable for each country. Intergovernmental agreements (regions) are also depicted.

Table E: Mean variables by each sub-Saharan African country and Intergovernmental agreement over the period 1975-2015

Country	Region	Fertility Rate	Primary School	Secondary School	Mortality Rate	GDP per Capita	Gender Equality	Urbanisation	Agriculture
Angola	**ECCAS**	6.88	61.47	12.54	112.93	4,705.51	0.77	40.14	10.67
Burundi	**ECCAS**	7.02	51.52	11.56	96.68	841.37	0.76	6.91	51.19
Benin	**ECOWAS**	6.25	69.58	24.08	98.87	1,475.66	0.64	34.78	34.39
Burkina Faso	**ECOWAS**	6.62	36.76	10.90	93.21	1,028.66	0.73	15.40	32.07
Botswana	**SADC**	4.26	81.62	47.55	47.32	9,105.02	1.09	40.63	7.44
Central African Republic	**CEMAC**	5.61	56.57	12.26	111.34	926.54	0.58	36.42	47.81
Cote d'Ivoire	**ECOWAS**	6.33	58.48	20.52	99.28	3,321.41	0.71	41.30	26.01
Cameroon	**CEMAC**	5.92	77.31	28.74	91.35	2,679.88	0.82	40.83	24.84
Congo, Dem. Rep.	**ECCAS**	6.62	64.03	29.60	110.10	1,022.63	0.70	29.44	39.13
Congo, Rep.	**CEMAC**	5.40	82.96	54.08	61.53	5,031.78	0.87	55.02	9.10
Cabo Verde	**ECOWAS**	4.53	92.71	56.12	42.65	3,064.78	1.02	43.45	12.16
Djibouti	**IGAD**	5.10	34.82	17.49	86.83	2,911.85	0.74	74.85	3.48
Eritrea	**IGAD**	5.73	41.41	28.29	76.17	1,142.44	0.79	16.69	20.28
Ethiopia	**IGAD**	6.47	52.53	20.62	100.53	770.32	0.76	13.23	53.08
Gabon	**CEMAC**	4.91	95.26	37.36	55.57	19,515.20	0.93	70.23	6.70
Ghana	**ECOWAS**	5.31	72.51	41.56	74.38	2,376.22	0.85	39.38	44.93
Guinea	**ECOWAS**	6.11	51.60	20.10	119.24	1,144.76	0.55	28.57	21.49
Gambia, The	**ECOWAS**	6.01	59.75	21.40	75.26	1,586.37	0.63	41.30	27.34
Guinea-Bissau	**ECOWAS**	5.97	48.92	10.47	102.43	1,522.12	0.49	29.75	52.13
Equatorial Guinea	**CEMAC**	5.70	55.48	19.69	106.58	13,300.59	0.84	34.73	31.62
Kenya	**IGAD**	5.77	71.87	37.95	59.61	2,286.88	0.93	18.23	31.01
Liberia	**ECOWAS**	6.08	40.27	28.51	129.79	751.17	0.65	41.21	No data
Lesotho	**SADC**	4.47	72.46	31.14	82.55	1,564.98	1.21	16.96	20.23
Madagascar	**SADC**	5.76	65.23	27.14	78.49	1,602.22	0.96	24.35	30.66

Country	Region	Fertility Rate	Primary School	Secondary School	Mortality Rate	GDP per Capita	Gender Equality	Urbanisation	Agriculture
Mali	**ECOWAS**	6.92	56.76	17.06	121.55	1,255.80	0.66	24.97	45.94
Mozambique	**SADC**	6.01	59.79	12.44	130.97	626.44	0.78	22.47	33.79
Mauritius	**SADC**	2.12	92.95	67.61	21.25	9,778.41	0.99	42.73	11.10
Malawi	**SADC**	6.48	95.97	23.20	110.61	634.05	0.85	12.26	39.08
Namibia	**SADC**	4.82	86.69	53.16	49.90	6,861.32	1.03	29.85	10.72
Niger	**ECOWAS**	7.68	36.91	7.98	105.34	945.56	0.63	15.27	40.96
Nigeria	**ECOWAS**	6.29	66.96	28.69	111.96	3,706.95	0.82	37.47	37.16
Rwanda	**ECCAS**	6.43	69.08	18.01	95.01	963.34	0.96	9.77	40.03
Sudan	**IGAD**	5.82	57.69	39.15	72.47	2,480.20	0.89	27.95	36.92
Senegal	**ECOWAS**	6.09	54.47	20.99	70.45	1,958.24	0.80	38.84	19.28
Sierra Leone	**ECOWAS**	6.21	82.62	20.59	142.85	1,340.59	0.70	33.57	44.70
Somalia	**IGAD**	7.20	16.00	7.66	104.26	757.71	0.54	31.02	63.97
South Sudan	**IGAD**	6.28	36.53	9.48	119.91	2,624.98	0.67	13.60	No data
Sao Tome and Principe	**ECCAS**	5.56	93.00	44.94	53.20	2,511.34	0.99	46.48	20.01
Swaziland	**SADC**	4.99	73.03	46.42	68.96	5,240.05	0.94	21.03	15.94
Seychelles	**SADC**	2.40	92.05	83.50	16.63	15,758.39	1.04	50.00	4.72
Chad	**CEMAC**	7.02	47.68	13.26	104.49	1,331.56	0.56	20.37	33.94
Togo	**ECOWAS**	5.94	76.57	28.22	82.74	1,403.78	0.61	30.07	35.11
Tanzania	**SADC**	5.99	63.31	7.40	86.55	1,665.37	0.93	19.60	37.07
Uganda	**IGAD**	6.78	67.19	9.40	94.02	1,046.29	0.78	10.97	46.45
South Africa	**SADC**	3.49	91.53	86.48	50.12	10,923.27	1.01	53.87	4.52
Zambia	**SADC**	6.24	79.85	17.32	87.21	2,797.73	0.86	37.76	19.00
Zimbabwe	**SADC**	5.09	89.48	34.48	58.08	2,197.71	0.92	29.82	16.96