Examining Fertility from a Development Perspective: An Empirical Study of 20 Countries in 40 Years

LIN QIU

Fall 2011
Senior Research Seminar
Department of Economics
American University

I. Introduction

Since the beginning of human race, population growth was close to zero. It was not until the development of agriculture, which changed people from subsistence foragers to cultivators, that a dramatic increase in population growth rate occurred (Gillian R. Bentley et al., 1993). Agriculture greatly increased the fertility rate of the human race because food supply became sustainable, and agriculture work was extremely labor intensive. Anthropological demography views the fertility of foraging groups as relatively low and that of agriculture groups as much higher and more variable. This model is supported by contemporary ethnographic evidence that agriculture tends to lead to high fertility rate. However, the binary social structure categorization of pre and post-agriculture was broken by industrialization. Societies are divided into "pre-industrial" "industrial" and "post-industrial." This requires the examination of fertility rate to include other social factors that influence people's decision making process such as economic growth and level of education in addition to agriculture.

Low population growth imposes stress on the younger generation and the labor force. High population growth may cause shortages of resources and social problems such as unemployment. What influences people's decision of the number of children to have? Experiences of developed countries indicate a negative relationship between economic development and fertility rate. This is because with more wealth, people do not need children as help to work on farms or help with domestic chores; richer people can afford education, which in turn qualifies them for jobs and causes delays in marriages; and developed countries have transitioned away from the traditional agriculture production model that relies heavily on labor to a modern version that is of large scales, mechanized, and commoditized (Bruce L. Gardner, 2002), so there is no demand for a large quantity of children.

The developing country scenario is quite the opposite. Agriculture sectors are usually composed of smallholder producers. Small productions are not only labor intensive but also inefficient, because of lack of technology, and risky, because of low safety standards (IFAD, 2011). As of 2002, three out of four poor people in developing countries live in rural areas, and most of them depend on agriculture for their livelihoods (World Bank, 2008). As a result, agriculture has important implications for fertility rates in developing countries.

This paper analyzes the fertility rates in developing countries by investigating the impact of economic development, education, and agriculture. Economic development and education are found to be positively associated with fertility rates, and value added agriculture has a negative relationship with fertility rates. These conclusions are tested using the fixed effect model. The implications of the results are that developing countries could effectively control population growth, especially in the rural areas, by promoting agriculture productivity, providing universal education, and facilitating agricultural business opportunities.

II. Literature Review

Having children involves costs. Parents have to spare time and money to care for them and send them to school. People have children because they are also a form of investment. Children provide short-term economic benefits by working at home. When parents get old, children's support is a form of reward for parent's long-term investments (Assaf Razin and Efraim Sadka, 1995) . The decision to have kids is a complex one that involves many more social and economic factors than the ones mentions above. It is a micro decision that involves household economics but also a macro one, because fertility rate is highly interrelated with a national economy's well-being.

An overwhelming number of studies have shown that the relationship between fertility and GDP growth is negative. Avner Ahituv develops and estimates an empirical model of the interplay between fertility and economic development by using data from 141 countries. He uses panel data to find that a 1% decrease in population growth increases GDP per capita growth by more than 3%. In addition, because families with low levels of human capital choose to have more children, income per capita grows faster in developed countries than in developing countries. He states the following as reasons for his findings: (1) children consume resources, but do not produce, implying that in countries with high fertility, a smaller share of the population works; (2) parents spend time taking care of their children, implying an additional negative impact on the labor supply; (3) the classical physical capital dilution; and (d) reverse causality, meaning that income influences fertility behavior(Avner Ahituv, 2001).

Similarly, Galor and Weil find that a rapid decline in fertility is accompanied by accelerated output growth. Their model has 3 components: (1) increases in capital per worker raise women's relative wages, since capital is more complementary to women's labor input than to men's; (2) increasing women's relative wages reduces fertility by raising the cost of children more than household income; and (3) lower fertility raises the level of capital per worker (Oded Galor and David N. Weil, 1996).

Robert Barro examines how education impacts growth, but he also examines fertility. He uses about 100 countries in his analysis, and looks at a range of developed and developing countries. His estimates indicate that economic growth is significantly negatively related to the total fertility rate; thus, the choice to have more children per adult comes at the expense of growth in output per person (Robert J. Barro, 2001).

Another angle to look at the dynamics between fertility and GDP growth is the effects of population maturity on labor supply. A lowered fertility rate means less abundant labor supply. China's population will contract as a result of its One Child Policy, but the population growth of India is ambivalent since it could either further expand or slow down like elsewhere in Asia. The implications of China's lowered fertility rate and India's continued high rate is that more FDI will go to India, and capital returns will be higher. However, this comes at the cost of per capita income because both countries' GDPs depend positively on fertility rate but negatively per capita income. Consequently, India faces the difficult choice of sustaining overall GDP growth with robust population increase or improving per capita income by reducing its fertility (R. Tyers et al., 2007). However, the "more people, more GDP" model only occurs under specific situations. Bloom and Williamson introduced demographic variables into an empirical model of economic growth and discovers changes in mortality and fertility rates contributed to the economic miracle in Asia. The changes of fertility rates led to a much faster growth in Asia's working-age population than its dependent population during 1965-90, so the per capita productive capacity was largely improved. The growth was sustained by a friendly environment provided by East Asian countries' economic, social, and political institutions. Yet population growth's effects on economic development are purely transitional, which means economic expansion happens only when the growth rates of the dependent population diverges from that of the working-age (David E. Bloom and Jeffrey G. Williamson, 1998).

Julian Simon observed that two-variable correlations between the rate of population growth and the rate of growth per capita income usually show no significant relationship, contradictory to most findings by other scholars (Julian L. Simon, 1989). He used both cross-sectional and time-series analyses to obtain this result and was criticized by some people who argued that two-variable analyses of this type are too primitive to justify the conclusion that changes in population growth rates have no effect on economic growth. Justifying his research, Simon contended the absence of correlation between two variables is a strong indication that neither variable influences the other. In his case, slower population growth does not cause faster economic development. He invited his critic to find specific variables that were omitted in his research and to include them to see if there really is a negative partial relationship between population growth and economic development. To respond to Simon's challenge to his critics, Robin Barlow identified lagged fertility as one variable omitted by Simon. His justification was that this variable could serve as a predictor of current per capita income growth because it disentangled short run and long run effects of population growth. He offered four reasons: (1) fertility tends to have negative impacts on per capita income growth in the short run; (2) in the long run, fertility's partial effects tend to be positive; (3) due to the high correlation of past and current fertilities, current population growth rates capture both the short-run negative and the long-run positive effects; (4) hence, current population growth appears to have no impact on current per capita income growth in Simon's research because the positive and negative effects are neutralized when there really is a negative short-run effect on per capita income growth by population growth (Robin Barlow, 1994).

Barlow's argument is further reinforced by Brander and Dowrick's earlier finding on the role of fertility and population in economic development. They used two improved sets of 107 cross-country panel data covering 1960-85 to re-examine the effects. Their finding concurs with Barlow's and the majority of scholars' conclusions, which is that high birth rates appear to reduce economic growth. This negative relationship is caused by investment effects and "capital dilution," although not evident in the data (James A. Brander and Steve Dowrick, 1994). Having more people means less capital per person, which is why the declines of birth rate have a strong positive impact on per capita income through labor supply or dependency effects.

Besides economic development, the changes in fertility rate can also be interpreted from a different angel. Barro looked at the effects of government policies on fertility rates. The indicator he chose was human capital. Among the many components of human capital, i.e. education, health, and social capital, Barro mainly studied education. He stressed the differences in the quantity of education, measured by years of attainment at various levels, and the quality, gauged by internationally comparable exams. His findings show a positive relationship between the average years of school attainment of adult male at the secondary and higher levels and growth, meaning the more adult male receive school education, the faster the growth rate will be. For girls, this finding does not stand. Barro argues this is because women are not well utilized in the labor markets of many countries (Robert J. Barro, 2001). I do not intend to include gender disparity in the research; however, Barro's conclusion implies an indirect influence of fertility rate over growth because the more children poor people have, the lower the mean of the number of people attending school gets.

Similarly, instead of studying the direct relationships between GDP growth rate and fertility rate, De La Croix and Doepke assume fertility and education are interdependent and study the effect of education on growth. In their opinion, when poor parents decide to have more children, they are unable to put every child at school. As children from rich families receive education and have better careers, the disparity between rich and poor grow bigger. When the number of children born in poor households exceeds that of rich households, social wealth gap widens, which lowers average education and consequently, growth (David De La Croix and Matthias Doepke, 2003). This is a theoretical framework between inequality and growth, but the fundamental cause of inequality is population growth.

An addition to the above body of literature is Carmen, Aguayo and Exposito's reemphasis on the importance of education on sustained development using econometric models. They studied three cross-sector relations: the diminution of excessively high fertility rates with increases in the education level of population; value-added services sector with the internal production of industry and agriculture with foreign trade and changes in population; and the industrial development with the educative level of population and foreign trade, the first one is of special relevance to my study. They found that higher level of education contributes to the decrease in fertility. In other words, families with higher levels of education usually have lower fertility rates on average. Lower fertility results in higher per capita income that usually increases the level of education (Guisan Carmen et al., 2001). Part of the reason for the decrease in fertility rate with higher education is that women's education attainment raises the costs of house work, as women's productivity outside the households becomes higher. This in turn decreases the demand for fertility. Parents view human capital as a replacement for the quantity of children. When people realize education brings higher wage rates, the demand for school would increase, and hence indirectly decreases the need for birth (T. Paul Schultz, 2007a). This implies that education and fertility reinforce the influence over each other, and an economy benefits from this cycle.

Women's education, especially, has significant impact on a country's fertility rate. In an analysis of the data from the Demographic and Health Surveys for 26 countries, the negative relationship between women's education and fertility rate is confirmed (Teresa Castro Martin, 1995). A special case is when an illiterate woman gains primary education, fertility increases. Yet education's fertility-enhancing effect is limited. Although a gap exists between people with higher and lower education, and the strength of the negative relationship, women's education has generally lowered fertility rates in all countries. The fertility trend from 1980 to 1990 in America shows that women with college degrees dramatically shifted the childbearing age to later. With the availability of different child care services, education attainment gives women more opportunities to pursue career first and decreased the number of children to have in their twentieth (Ronald Rindfuss et al., 1996). An analysis of 11 developing countries' cumulative marital fertility of education women yields similar results. The similarity in the relationship between fertility and education across different national, societal, and cultural settings implies that advancement in female education can be expected to change fertility behavior without simultaneous changes in other aspects (Anrudh Jain, 1981). The depressing effect education has on fertility rate is reinforced by another study using 22 Sub-Saharan African countries as targets. This study goes one step further and studies the community education level's effect on individual women's decision to have kids. The simulation returns that fertility rates would be 1 percent lower if the current communal education level were elevated to the higher level in Kenya (Øystein Kravdal, 2002). Education, especially women's education, has serious implication for fertility rates across countries in all levels of development.

Agriculture, as the major source of income and employment in most developing countries, is tightly related to people's lives. Technology advancement will force people to change production strategies and household behavior. It also brings increased productivity and higher income. Fertility, as an important household decision, is unavoidably affected by household behavioral change. A study has shown that the adoption of agricultural technology has both a direct and indirect negative effect on fertility rate. Mechanical technologies, as opposed to biochemical technologies, have a larger influence on transforming labor demand patterns and production techniques (Sharmistha Self, 2008). Agricultural machines are oftentimes technically complex and requires training and certain level of education to handle. Children are not fit for this task. The adoption of agricultural machinery in turn changes people's preference of gaining skills and education, which decreases the demand of children (Sharmistha Self, 2008). Market wages are the opportunity costs of the time women spend on children. With the adoption of agricultural technology, the example of India shows that agriculture productivity increases. The price of women bearing and nurturing children increases relative to men's. In this situation, it is more likely that couples both agree to have fewer children and spend more time working (Sudhin K. Mukhopadhyay, 1994). However, there is an opposite argument that if expansion of agriculture occurs, it creates more opportunities for men than for women, which decreases women's status and the opportunity costs of bearing children. Fertility increases.

There is much more research on the relationships between fertility rates and various indicators. Unfortunately, so far, the conclusions have not been unanimous. The goal for this research is contributing to the literature on fertility rates by focusing specifically on developing countries' cases and analyzing the dynamics between fertility rates, GDP per capita, literacy rate, and value added agriculture. Given the very different situations between developed and developing countries, I argue that it is valuable to study developing countries separately from a development prospective that taken into consideration the extra needs and obstacles people from developing countries face.

III. Economic Model

Adam Smith noted that in areas where labor is scarce, family sizes tend to be larger. The function of children as extra cheap labor has existed since the 18th century, especially in North America where land was abundant. People tend to have more children because they are potential help. Thomas Malthus, however, did not view fertility as a personal choice but as outcome of social institutions. Fertility was determined by the economic requirements society place on a couple before they were allowed to get married. (T. Paul Schultz, 2007a). This pre-industrial model is one of the earliest behavioral models on fertility. Many economists after Malthus have built on this work and developed new models to accommodate the real increase in wages after the Industrial Revolution and situations in low-income countries.

The Malthusian model states that population growth depends on the economy's material condition, in particular food supply. Without restraints, the world's population increases geometrically. As Malthus assumes the human being's biological capacity to produce exceeds that of physical capacity, food production only increases arithmetically (graph 1). Human survival requires the consumption of a minimum amount of food every day, if per capita consumption falls to a low enough level, population growth would cease. This is the "Malthusian trap," which states that per capita income tends to stay at the subsistence level because population always grows at the allowed maximum rate. Graphically, Malthusian population supply in the long run is indefinitely elastic at an arbitrary low wage level, w* (graph 2). Population demand, measured by labor productivity at food production with fixed natural resources, is an inverted U-shape curve that intersects population supply twice. Equilibrium is reached at N* where demand intersects supply from above. Between N* and point A, where demand first crosses supply, wage is above the subsistence level, and hence there is a tendency to produce more children. Any wage level below w* would not trigger population growth because people cannot live under subsistence level for long (Isaac Ehrlich and Francis Lui, 1997, T. Paul Schultz, 2007b). In Malthus' framework, fertility has a negative externality on society, but since people are self-interest seekers, they ignore the negative externalities and continue to have children (T. Paul Schultz, 2007b). Malthus proposes a cycle where high fertility leads to lower wages, which in turn discourages early marriage and decrease the number of children each women have (T. Paul Schultz, 2007a). In the Malthusian model, population growth is constrained by economic resource and the productivity of a society.

What Malthus did not articulate was why food production only increases arithmetically. The eighteenth century political economist, David Ricardo, attribute this to the scarcity of land and the classical economics concept of the law of diminishing returns to labor farming, with land fixed. As long as the marginal product of labor on fixed land is above the labor's subsistence pay, the residual profits of capitalists remain positive, and population continues to expand (Isaac Ehrlich and Francis Lui, 1997). This is why the population demand curve in Malthus' model is inverted U shaped. Food productivity will increase as long as there is land and tools for extra labor. The absolute total output increases with more labor, but the marginal returns is constantly declining. The point where marginal returns to labor become zero indicates that labor has become abundant. Instead of generating output, labor is hindering it. As a result, food production increases arithmetically, at a much slower rate than population increase.

Technology was an important element missing in both Malthus and Ricardo's analysis. Although Ricardo recognized the possible role technology might have in shifting the labor demand upward, he complies with Malthus' model where workers would not accept payment below the subsistence wage. Malthus and Ricardo both assumed population growth to be endogenous to the economy (Isaac Ehrlich and Francis Lui, 1997). The incentive of having children for them is that children are potential labor that will earn economic benefits. As a result, the force of population growth comes from people as opposed to external factors such as national policy or parental pressure.

Divergent from the classical population growth model is the neoclassical model of growth that has technology with constant returns to scale for labor and capital inputs. Even with population growing geometrically, technology can help increase productivity to a level that natural resource and capital constraint no longer hold. People's incentive to save secures a rate of capital formation, which could match or even surpass the rate of population growth (Isaac Ehrlich and Francis Lui, 1997). When the rate of capital formation balances with that of population growth, a steady state is achieved, which means technology, physical capital, and population will grow at the same rates.

Other economists such as Gary Becker reformatted the neoclassical theory of population by adding that children are "consumption goods" of parents despite exhibiting characteristics of producer goods, which contributes to production output of household chores or agriculture. He contends that the quantity of children compete with other commodities in parents' utility function (Gary Stanley Becker, 1960). Children bring parents joy and fun, just like commodities such as clothes, food, and drinks. However, Becker recognizes the quality of children is also important to parents, which is determined by economic resources parents have (Gary Stanley Becker, 1960). Through education, nurturing, and disciplining, a child develops "qualities," or human capital, that are valuable to a society and the children himself. These qualities enable a child to find jobs when he grows up. They can also be passed down to future generations as human capital. Per Becker's argument, the decision of the quantity of children is affected by parents' ability to exercise birth control, which is determined by their level of education and economic strength. According to Becker, the demand of fertility is a function of family income, costs of children, and parental education.

The above classical and neoclassical population growth theories link economic development, or per capita income, with fertility decisions. Yet the late Julian Simon was doubtful of the causal relations between population growth and economic development and argues the key conclusion of existing population studies is actually the absence rather than the presence of causality (Julian L. Simon, 1989). As opposed to Malthus' contention that fertility is resistant to exogenous forces, a national report concurs with Simon and criticizes the academic studies of fertility that ignore the 20th century policy-driven fertility decline (1986). In cases of less-developed countries (LDCs), data do not show a higher rate of population growth with a decreased rate of economic development. Additional children influence the LDC economy by inducing people to work longer hours and invest more, which causes improvements in social and physical infrastructure (Julian L. Simon, 1981). Simon's model contradicts both classical and neoclassical conclusions and posits that in LDCs, moderate population growth, rather than zero or negative growth, could lead to better standard of living and economic development.

My research builds upon both the classical, neoclassical, and Julian Simon's population growth models and re-examines the influence of per capita income and educational level on fertility in developing countries. A third factor, value added agriculture, measured by the percentage share of agriculture in GDP, is added to the analysis. Previous studies have established a relationship between fertility rates and agriculture development. Developed countries use advanced technologies in agricultural production, which improves productivity and releases labor from the agriculture sector to other economic activities. Developing countries, however, still lags in terms of agriculture technology and productivity. As agriculture remains the major employment and source of income for most developing countries, I hypothesize that the larger agriculture's share in a country's GDP is, the more responsive fertility rate is to changes in the agriculture sector. Increases in GDP per capita and literacy rate tend to decrease fertility rate because more employment opportunities and life choices people will have as alternatives to having children.

IV. Empirical Strategy

a. Econometric Model

For this research, I use the Fixed Effect (FE) Model. The FE model explores the relationship between the dependent and independent variables within an entity, such as country, person, company, and etc. in a set of panel data. It is an econometric model used to control for omitted variables that differ among entities but are constant over time. The omitted variables are characteristics that are unique to individual entities which may or may not influence the dependent variable. These include but are not limited to history, culture, initial wealth, gender, race, ethnicity, climate, and geography. The FE model assumes that the time-invariant characteristics are unique to individual entities and hence should not be correlated with other individual characteristics. Similarly, each entity's error term and constant should not be correlated with those of the other entities.

In my analysis, I look at how fertility (fertility) in developing countries is affected by GDP per capita (gdpperca), literacy rate (schen), and agriculture's percentage in national GDP (ag). As fertility is highly responsive to a country's social institutions such as traditional views of women's role, the responsibility to produce heirs, and sanctions against single women, if they are not controlled for, the error terms will correlate with the dependent variable. Using FE model removes the time-invariant characteristics and eliminates the correlation between the error terms and the dependent variable, so I can assess the independent variables impact on fertility.

The FE model is represented as follows:

$$fertility_{i,t} = \alpha * ag_{i,t} + \beta * gdpperca_{i,t} + \gamma * schen_{i,t} + \varepsilon_i + \mu_{i,t}$$

$$(i = 1, 2, \dots, 20; t = 1970, 1971, \dots, 2009)$$

Each variable is subscripted "i, t." "i" is the country identification number. There are 20 developing countries in my data. "t" stands for year. "i, t" represents the value of a variable in country i, year t. ε_i captures the time-invariant characteristics. The error term, $\mu_{i,t}$, accounts for the unobserved factors in individual countries. Based on the literature review and economic models, I hypothesize that the signs of the coefficients for per capita income and education are negative, and the sign for the coefficient for value added agriculture is positive.

b. Description of Data

The data for my analysis comes from the World Bank Data files online in the Data Bank (see Table 1 for descriptive statistics). They came from the World Bank's "World Development Indicators" catalog.

The fertility data, total fertility rate (births per women), is under category "Gender" and represents the number of children that would be born to a woman if she were to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates (graph 3) (2010).

The agriculture data, value added agriculture, is under category "Agriculture and Rural Development" (graph 4). It represents the net output of the agriculture sector, including forestry, hunting, and fishing, as well as cultivation of crops and livestock production, after adding up all outputs and subtracting intermediate inputs. It is calculated without making deductions for depreciation of fabricated assets or depletion and degradation of natural resources (2010).

The GDP per capita data, GDP per capita, is under category "Economic Policy and External Debt" and is gross domestic product divided by midyear population (graph 5) (2010). It is in current U.S. dollars.

The literacy rate data, percentage of gross school enrollment, is under category "Education" and is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown (graph 6) (2010).

The limitation of the data is that ideally I would like to use the percent of agriculture employment in all employment. However, almost all sample countries' data are missing, so it is replaced with value added agriculture as I see it to be the closest fit. There are also missing variables in other variables, but they do not interfere significantly with the statistical analysis.

c. Results of Statistical Analysis

The FE model returns the following result (Table 2):

$$\widehat{fertility}_{i,t} = 4.887678 + 0.0691428 * ag_{i,t} - 0.0001736 * gdpperca_{i,t} - 0.0216559 * schen_{i,t}$$

(0.0044669) (0.0000237) (0.0023512)

According Table 2, all p values are smaller than 5%. As a result, the coefficients are statistically significant. The result has the following implications. Holding GDP per capita and school enrollment constant, a unit increase in value added agriculture results in 0.0691428 unit increase in fertility. Holding value added agriculture and school enrollment constant, a unit increase in GDP per capita results in a 0.0001736 unit decrease in fertility. Holding value added agriculture and GDP per capita constant, a unit increase in percentage of gross school enrollment leads to 0.0216559 decrease in fertility. The $R^2$of the regression using within estimator is 0.578. It means 57.8% of the variation in fertility is explained by the regression line.

d. Interpretation

The equation in section c indicates fertility rate has a positive relationship with agriculture value added and a negative relationship with GDP per capita and percentage of gross school enrollment. The findings concur with my hypothesis that in developing countries, agriculture influences people's decision of fertility. Personal income and educational level also play a role in fertility decisions. Given that developing countries' political environment, social welfare, child care services, and labor laws are different from those of developed countries, the results need to be interpreted in the appropriate context where poor people's resources and rationales are studied. Rural and urban cases are also studied separately.

As of 2010, 49.15 percent of the world's population lives in rural areas (2010). Although manufacture and non-agriculture related employment has risen significantly in developing countries over the past few decades, agriculture-related work still takes up the majority of rural population's lives. Agriculture in developed countries is highly mechanized. One person could work on acres of land on a tractor. However, in developing countries where people still plow land manually, the same amount of land will need many more workers than in developed ones. Most agricultural sectors of developing countries still operate in the model of family farm. As a result, family members become an important, if not the only, source of labor for agriculture production. In many cases, agriculture is the single most important source of income and food for people. Anything that will enhance agriculture production is given priority. The demand of children in development countries comes largely from the need to help with farm work. If there is an expansion in agriculture, rural people will address the increased labor demand by having more children. The implications of an agriculture expansion for urban people in developing countries is that rural families with migrant workers will also have to produce children to make up for the loss of labor to urban areas. It is unlikely that they will make migrant workers return from cities to help with agriculture work because the opportunity costs of migrant workers are high. Consequently, holding technology constant, if the share of agriculture expands in an economy, it is likely that the country will exhibit a period of population growth.

Increased per capita income influences developing countries' people by offering them more options of life satisfaction, better healthcare, longer life-expectancy, improved child quality, and most importantly, education. Urban residents may choose to pursue careers or dreams in their twenties instead of getting married. As people get married at a later age, the number of children they can have in their life decreases. In both urban and rural settings, better economic conditions enable people to raise the quality of their children, which in turn increases the cost of each child and decreases the total number of children people can have in their entire life. Another important purpose of having children used to be providing security when parents get old (Øystein Kravdal, 2002)Øystein Kravdal, 2002). With increased per capita income and national development, social welfare programs tend to get better, and parents depend less on children. The demand of children decreases.

The reasons for fertility to be inversely related to education in developing countries are not too different from cases in developed countries, as education brings better and more economic opportunities and lowers the dependency on children when parents get old. Most female in urban areas are literate to some extent. People with education are more productive, which increases the opportunity costs of staying home and nurturing children. In addition, all African countries with a few exceptions, most countries in Asia and Oceana, a majority of Western Asia, and Latin America and Caribbean have population policies that facilitate family planning and the distribution of contraceptives to help prevent excessively high fertility rate (2003). These policies are most likely to reach and be accepted by the educated population, and hence fertility is controlled. In rural areas, educated women can also participate more in productive activities outside of the household. This increases household income, which enables a family to send its children to school. Yet sending children to school makes having an extra child more expensive. Children in school are not available for domestic and agriculture work (Øystein Kravdal, 2002). As a result, families that can afford to send children to school usually have a smaller number of children than those whose children do not go to school because the cost of having children becomes higher, and the short-term economic benefits decreases.

V. Conclusion and Directions for Further Research

This study of the relationship between fertility and agriculture, GDP per capita, and education provides a development perspective of population growth in the developing world. The incorporation of agriculture in the model and the positive relationship it has with fertility indicate the distinctive conditions associated with developing countries as opposed to the developed world. Lack of technology and low productivity heavily burdens the low-income people, who use children as manpower for help. Excessive fertility not only catches people in a poverty trap by producing children who will continue to be poor but also creates child labor which is extremely dangerous to the physical and psychological development of children.

Economic development and education are revealed to be negatively associated with population growth, but neither of them occurs without proper government involvement, support, and facilitation. Education empowers people for better economic opportunities and health measures that alleviates poverty and reduces incidental pregnancy. When household income rises, parents can send children to school, and the quality of children increases. The time parents want to spend with individual children goes up as they can talk about school, career goal, and enjoy leisure activities together. Quality takes over quantity, and the number of children each family can have is likely to decrease due to the increased quality time that is spent together. Education and economic development create a positive cycle that eliminates social issues such as child labor caused by economic hardship. One important step towards achieving this is that government provides universal education programs that equip people with basic skills and knowledge. Only with basic literacy can farmers learn how to use agricultural machines to help increase productivity. With increased productivity, they will be able to release the dependence on children's help with work, and children will have time to go to school.

Developing countries need the international society's assistance with setting appropriate policies to guide population growth and facilitate economic expansion. Oftentimes it is neglected that lessons learned from developed countries may not be applicable to every developing country in the world. Future research on fertility should include more indicators that are relevant to developing countries' conditions, for example poor infrastructure, inefficient health system, and corruption. It is only when research efforts are carefully tailored for developing countries that they can possibly yield maximum benefits and contribute to international development efforts.

VI. References

2003. "Fertility, Contraception, and Population Policies," New York: United Nations Secretariat,
1986. "Population Growth and Economic Development: Policy Questions," Washington, DC: National Research Council, Committee on Population,
2010. "World Development Indicators," Washington, DC: The World Bank,

Ahituv, Avner. 2001. "Be Fruitful or Multiply: On the Interplay between Fertility and Economic Development." *Journal of Population Economics*, (15), 51-71.

Bank, World. 2008. "World Development Report 2008 Agriculture for Development," Washington, DC: The World Bank,

Barlow, Robin. 1994. "Population Growth and Economic Growth: Some More Correlations." *Population and Development Review*, 20(1), 153-65.

Barro, Robert J. 2001. "Education and Economic Growth," *OECD.*

Becker, Gary Stanley. 1960. "An Economic Analysis of Fertility," *Demographic and Economic Change in Developed Countries.* Princeton, NJ: Princeton University Press,

Bentley, Gillian R.; Tony Goldberg and Grazyna Jasienska. 1993. "The Fertility of Agricultural and Non-Agricultural Traditional Societies." *Population Studies*, 47(2), 269-81.

Bloom, David E. and Jeffrey G. Williamson. 1998. "Demographic Transitions and Economic Miracles in Emerging Asia." *The World Bank Economic Review*, 12(3), 419-55.

Brander, James A. and Steve Dowrick. 1994. "The Role of Fertility and Population in Economic Growth." *Journal of Population Economics*, 7(1), 1-25.

Carmen, Guisan; Eva Aguayo and Pilar Exposito. 2001. "Economic Growth and Cycles: Cross-Country Models of Education, Industry and Fertility and International Comparisons." *Applied Econometrics and International Development*, 1(1), 9-37.

De La Croix, David and Matthias Doepke. 2003. "Inequality and Growth: Why Differential Fertility Matters." *The American Economic Review*, (93), 1091-113.

Ehrlich, Isaac and Francis Lui. 1997. "The Problem of Population and Growth: A Review of the Literature from Malthus to Contemporary Models of Endogenous Population and Endogenous Growth." *Journal of Economic Dynamics and Control*, 21(1), 205-42.

Galor, Oded and David N. Weil. 1996. "The Gender Gap, Fertility, and Growth." *The American Economic Review*, 86(3), 374-87.

Gardner, Bruce L. . 2002. *American Agriculture in the Twentieth Century: How It Flourished and What It Cost*. Cambridge: Harvard University Press.

IFAD. 2011. "Rural Poverty Report 2011," Rome: International Fund for Agricultural Development IFAD,

Jain, Anrudh. 1981. "The Effect of Female Education on Fertility: A Simple Explanation." *Demography*, 18(4), 577-95.

Kravdal, Øystein. 2002. "Education and Fertility in Sub-Saharan Africa: Individual and Community Effects." *Demography*, 39(2), 233-50.

Martin, Teresa Castro. 1995. "Women's Education and Fertility: Results from 26 Demographic and Health Surveys." *Studies in Family Planning*, 26(4), 187-202.

Mukhopadhyay, Sudhin K. 1994. "Adapting Household Behavior to Agricultural Technology in West Bengal, India: Wage Labor, Fertility, and Child Schooling Determinants." *Economic Development and Cultural Change*, 43(1).

Razin, Assaf and Efraim Sadka. 1995. *Population Economics*. Cambridge: MIT Press.

Rindfuss, Ronald; S. Morgan and Kate Offutt. 1996. "Education and the Changing Age Pattern of American Fertility: 1963–1989." *Demography*, 33(3), 277-90.

Schultz, T. Paul. 2007a. "Fertility in Developing Countries." *Yale University Economic Growth Center Discussion Paper*, (No. 953).
____. 2007b. "Population Policies, Fertility, Women's Human Capital, and Child Quality." *Yale University Economic Growth Center Discussion Paper*, (No. 954).
Self, Sharmistha. 2008. "Developing Countries and Fertility: Role of Agricultural Technology." *International Journal of Development Issues*, 7(1), 62-75.
Simon, Julian L. 1989. "On Aggregate Empirical Studies Relating Population Variables to Economic Development." *Population and Development Review*, 15(2), 323-32.
____. 1981. *The Ultimate Resource*. Princeton: Princeton University Press.
Tyers, R.; J. Golley and I. Bain. 2007. "Projected Economic Growth in China and India: The Role of Demographic Change." *Australian National University, College of Business and Economics, School of Economics, ANUCBE School of Economics Working Papers*, (31).

VII. Tables

Table 1: Descriptive Statistics

```
. summarize  fertility ag gdpperca schen
```

Variable	Obs	Mean	Std. Dev.	Min	Max
fertility	800	4.512116	1.710516	1.598	7.817
ag	691	23.80542	13.57904	3.698673	68.87998
gdpperca	758	1302.362	1638.718	78.56181	10297.51
schen	671	88.3049	29.89908	11.75582	129.7153

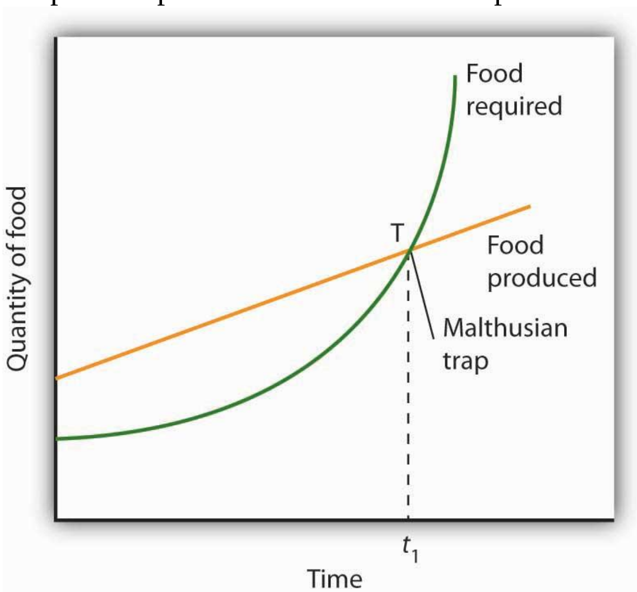
.

Table 2: Results of the FE model

```
. xtreg  fertility ag gdpperca schen, fe

Fixed-effects (within) regression               Number of obs      =       588
Group variable: countryid                       Number of groups   =        19

R-sq:  within  = 0.5780                         Obs per group: min =         6
       between = 0.5515                                        avg =      30.9
       overall = 0.5631                                        max =        40

                                                F(3,566)           =    258.39
corr(u_i, Xb)  = -0.2810                        Prob > F           =    0.0000

------------------------------------------------------------------------------
  fertility |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
------------+-----------------------------------------------------------------
         ag |   .0691428   .0044669    15.48   0.000     .0603691    .0779165
   gdpperca |  -.0001736   .0000237    -7.31   0.000    -.0002203    -.000127
      schen |  -.0216559   .0023512    -9.21   0.000     -.026274   -.0170378
      _cons |   4.887678   .2721258    17.96   0.000     4.353179    5.422178
------------+-----------------------------------------------------------------
    sigma_u |  1.1115597
    sigma_e |  .54590404
        rho |  .80567562   (fraction of variance due to u_i)
------------------------------------------------------------------------------
F test that all u_i=0:     F(18, 566) =    89.25             Prob > F = 0.0000

.
```

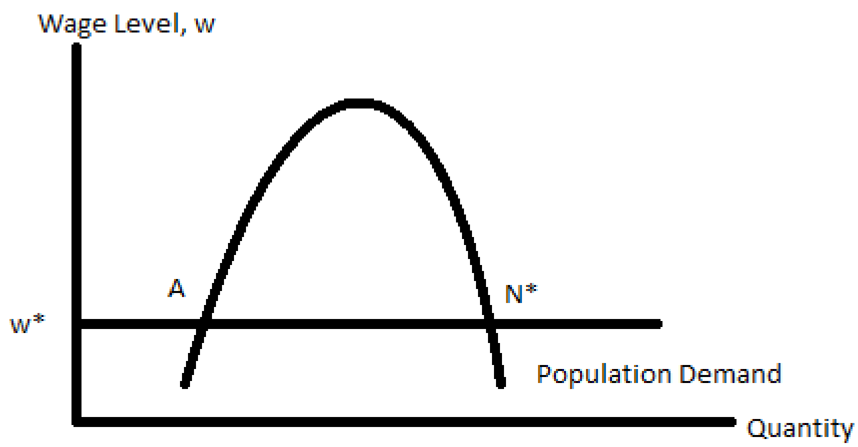
VIII. Figures

Graph 1: Population Growth vs. Food production

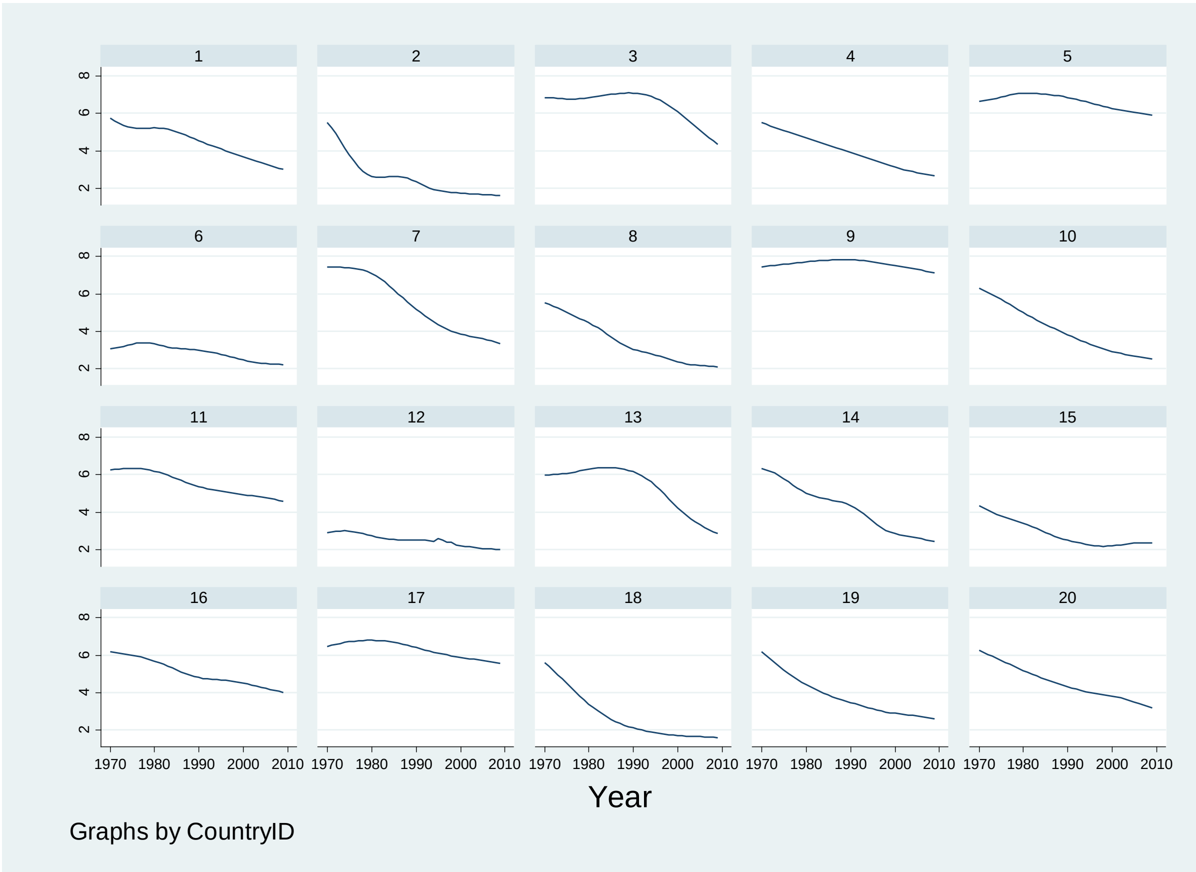


Source: Phillip Appleman, ed., *Thomas Robert Malthus: An Essay on the Principle of Population—Text, Sources and Background, Criticism* (New York: Norton, 1976), xi.

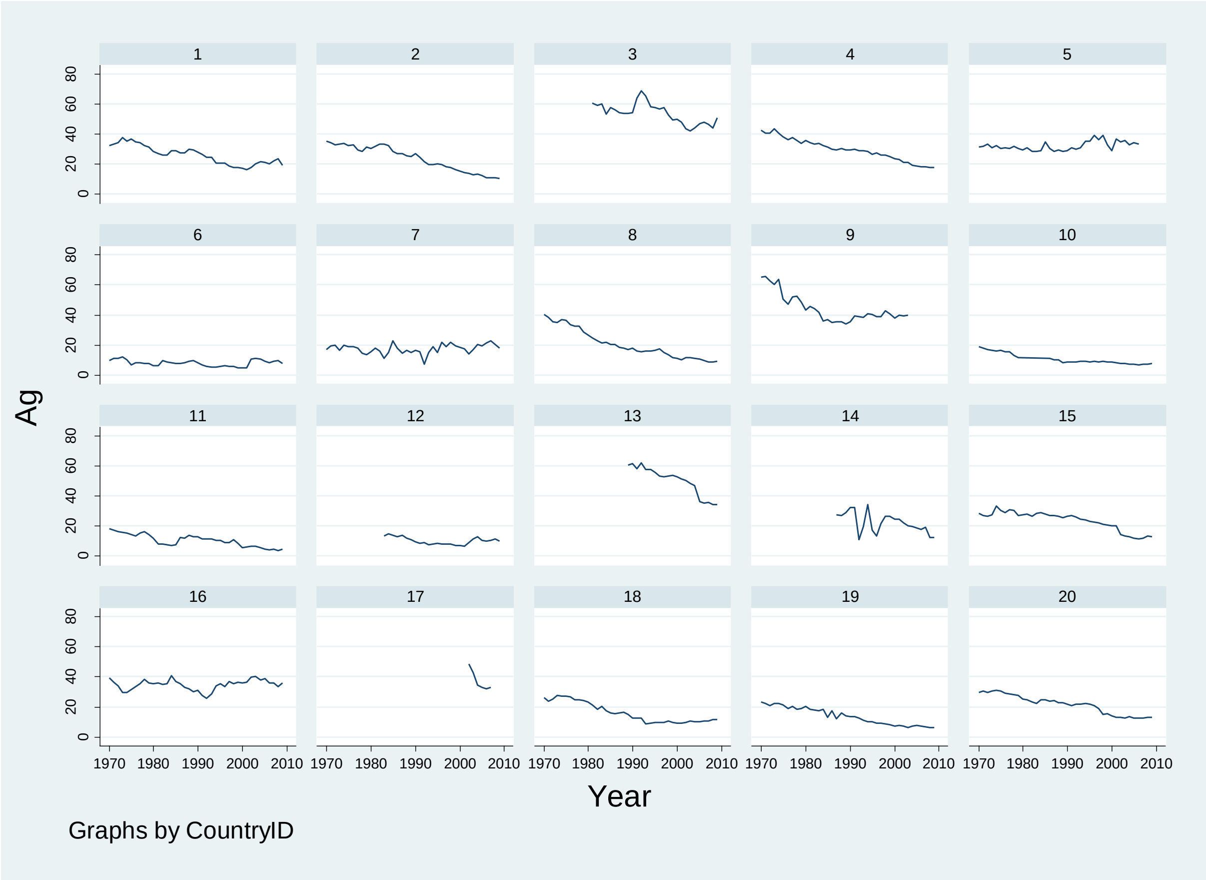
Graph 2: Malthusian Population Model



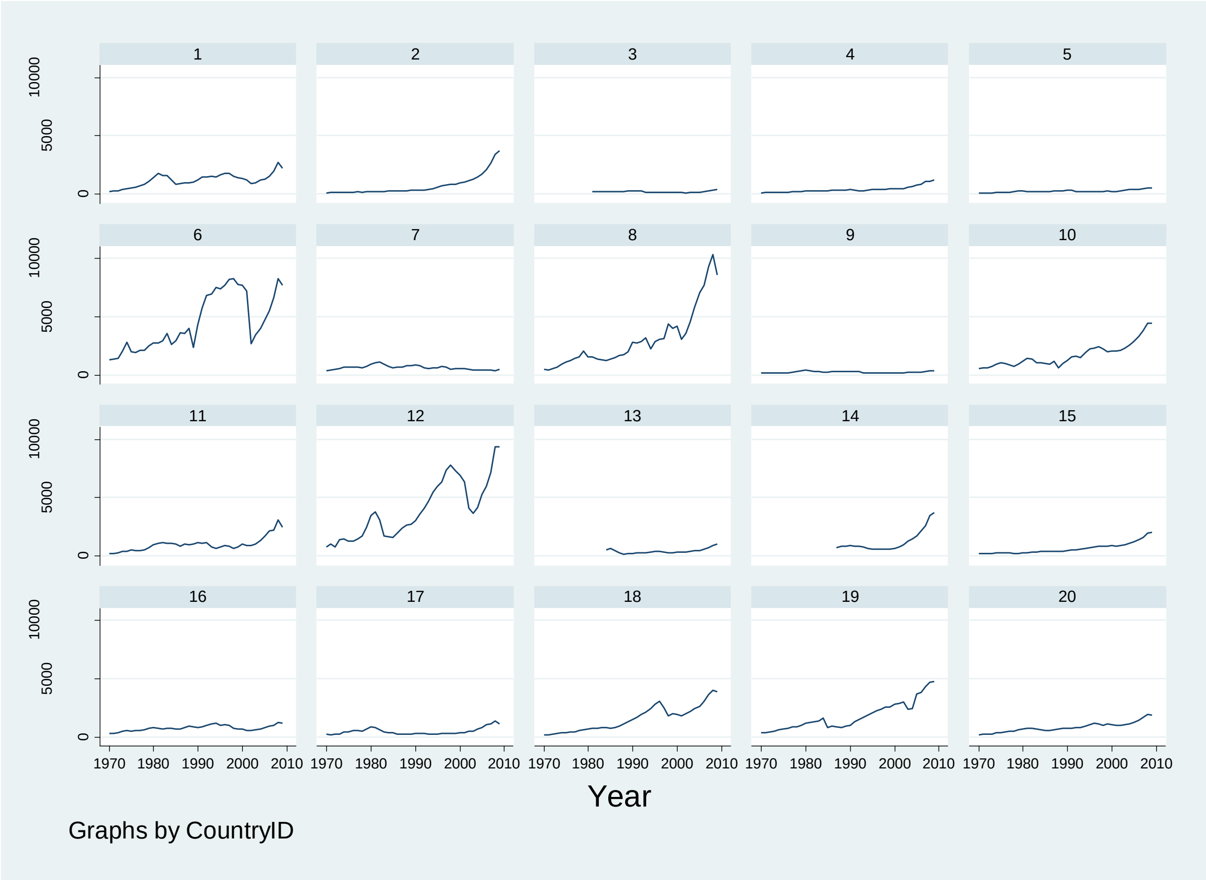
Graph 3: Total Fertility Rate (birth per women)



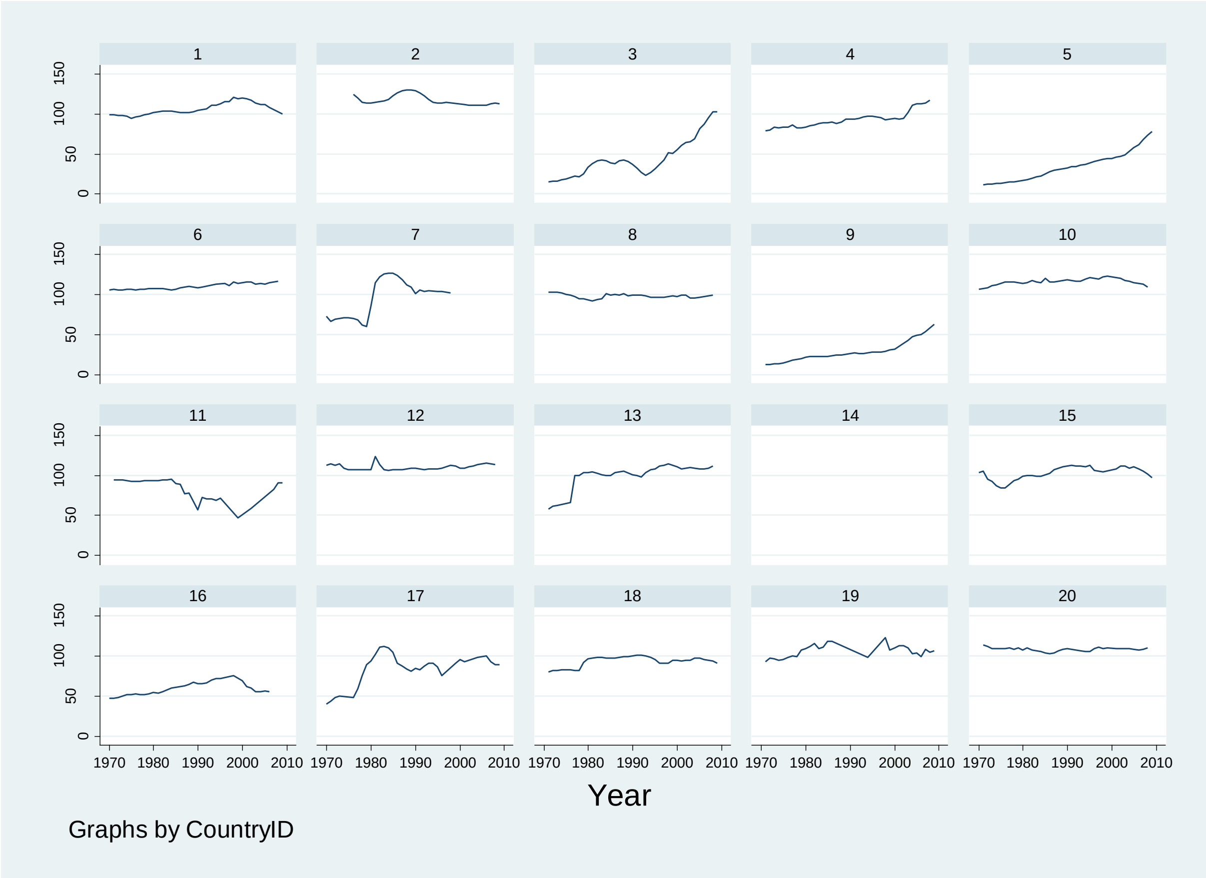
Graph 4: Value Added Agriculture



Graph 5: GDP per Capita (current US$)



Graph 6: Percentage of Gross School Enrollment



Graph 7: World Rural Population (percentage)