EXAMINING CAUSES OF POVERTY IN LATIN AMERICA

AND SUB-SAHARAN AFRICA

A Thesis

by

GARNETT MURPHY ANDERSON II

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

August 2007

Major Subject: Agricultural Economics

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Approved by:

Chair of Committee,	David A. Bessler
Committee Members,	James W. Mjelde
	Theodore L. Turocy
Head of Department,	John P. Nichols

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ABSTRACT

Examining Causes of Poverty in Latin America

and Sub-Saharan Africa. (August 2007)

Garnett Murphy Anderson II, B.S., University of Louisiana at Lafayette

Chair of Advisory Committee: Dr. David A. Bessler

This thesis assesses causality among fourteen economic variables as they relate to world poverty. If we know what influences poverty, we may be able to take steps to eliminate it. The measure of poverty used in this study is the World Bank's measure of the percent of a country's population living on less than $2.00 a day. Data from countries in Latin America and Sub-Saharan Africa were gathered and tested to determine if poverty is caused by child mortality, international trade, agricultural income, life expectancy, birth rate, relative size of rural population, gross domestic product (GDP) per capita, foreign aid, under-nourishment, health, crop index, illiteracy, income inequality, or political freedom.

Peter-Clark (PC) search algorithm for graph construction was applied throughout the study. Two separate causal graphs were built from the Latin American data. One graph was built under the assumption that we have prior knowledge about the temporal order of the events represented by each variable. These assumptions were not used in building the second graph. In both cases, a significance level of .20 was used for hypothesis testing, a level suggested by the authors of PC algorithm for data sets of our size. Two graphs were also built from the Sub-Saharan African data using the same

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algorithm, assumptions, and significance level. In addition, two graphs were built from a combination of the data from Latin America and Sub-Saharan Africa.

Results show only one variable (birth rate), out of a possible fourteen, to be a possible cause of poverty. This possible causal relationship showed up four times out of the six graphs built. Poverty was actually shown to be a cause of birth rates in two of the graphs that were built. These results also show that the poor do not necessarily benefit from an increase in GDP or an influx of foreign aid as is commonly thought.

DEDICATION

This thesis is dedicated to my parents, Bill and Tina Anderson. It is also dedicated to Glenn, Sallie, Bill, and Sylvia Cochran, who made me feel a part of their family during my time at Texas A&M.

ACKNOWLEDGEMENTS

NOMENCLATURE

2da	percentage of population living on $2.00 or less per day
gin	gini index
fre	freedom index
agi	agricultural income
lfe	life expectancy
rur	percent of population which is rural
imo	child mortality
gdp	gross domestic product
ill	illiteracy
aid	foreign aid
nrs	percent of under-nourished
brt	birth rate
hlt	health
trd	international trade
cin	crop index

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CHAPTER I

INTRODUCTION

Objective

The objective of this thesis effort is to explore economic and social variables that may be influential in causing poverty, particularly in the regions of Sub-Saharan Africa and Latin America. Theories and thoughts abound on what exactly causes poverty. Obviously, the answer has not been found. If poverty could be eliminated, it would be perhaps the greatest triumph mankind has ever known. To cure poverty, we need to know what causes it. Essentially, if we know what causes poverty, we can then take steps to eliminate it. By using real world data and econometric methods, this thesis will attempt to provide a map showing the start of the path to poverty. If this path is accurate, it will also be a potential path to recovery.

Justification

The subject of poverty has been studied for years. Indeed, organizations such as the World Bank have employed some of the best economic minds of our time strictly for this purpose. One need not be well versed in international political or social conditions to know that poverty exists in regions such as Africa and Latin America. Poverty is often the first thing that comes to mind when we think of Africa and Latin America. Looking at the percentage of people living on less than $2.00 a day provides a glimpse of poverty in these two regions. Several Latin American countries show high percentages of people

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This thesis follows the style of the *American Journal of Agricultural Economics.*

living in poverty: Bolivia (51.4 percent), Ecuador (52.3 percent), El Salvador (54.0 percent), Honduras (68.8 percent), and Paraguay (49.3 percent). The numbers for countries in Africa are even more staggering: Niger (85.3 percent), Rwanda (84.6 percent), the Central African Republic (84.0 percent), Mali (90.6 percent), and Zambia (87.4 percent) (see World Bank Development Report, 2000/2001, Box 1.2, p. 17 and Table 4, pp. 280 - 281). Recently, a new method has become available to take another look at the poverty question using the artificial intelligence algorithms of Pearl (2000). These help us study causal relationships among a set of variables. These methods define "cause" to be the ability to change or influence one variable by changing or manipulating another variable. The methods exploit asymmetric relationships between cause and effect among three or more variables. Thus, they are a "break though" relative to correlation-based models, which cannot go beyond the statement, "correlation does not imply causation." So while correlation-based models are helpful, and will be used in this thesis, these new methods allow us to go a step further. Results show not only that certain variables may be related but also how they influence one another as well. This will ultimately strengthen our results.

Organization

In the chapters that follow, the following descriptions will be presented. Chapter II provides a review of the literature relative to the topic of study. Chapter III will provide a background and definition of directed acyclic graphs, as well as a description of the software used. Chapter IV presents statistics and measures of poverty relative to the regions studied and compares them to other parts of the world. This chapter will also

provide information on the data that is used. Chapter V will show the results of the directed acyclic graphs and provide relevant regression equations. Chapter VI will offer an intuitive discussion of the links between all the variables studied, as well as thoughts on poverty as a whole. A summary of the findings will be presented in Chapter VII, along with concluding remarks.

CHAPTER II

LITERATURE REVIEW

Certain parts of the world have experienced steady economic growth, while others have not. Some wonder if it is reasonable to suggest that Latin America and Sub-Saharan Africa could one day resemble the United States or Europe in terms of economic prosperity. An important question for this thesis was what economic and/or social variables should be considered for study? In attempting to identify what may cause or influence poverty, it is difficult to know exactly what variables might play a role. However, the literature on potential causes is rich and allowed me to choose variables that are commonly thought to influence poverty.

To fight poverty we must understand why a region such as Africa has not experienced noticeable growth rates. Possible explanations for slow growth in Africa that are both external and internal are discussed by Collier and Gunning (1999). They suggest that Africa's problems might be rooted in its tropical location. It has been suggested that the climate is one that fosters diseases and creates hostile conditions for agriculture. This can lead to higher human fertility and lower life expectancy. The soil quality is poor, which is very concerning knowing that agriculture typically accounts for 25.0 percent of GDP in this region (see Loper and Bessler, 2001). The role of agriculture is paramount in many studies. Rosenzweig writes: " . . . one important and pervasive characteristic of low-income countries is the large proportion of the labor force in agriculture" (Rosenzweig 1988, p. 714). As Nobel Laureate T.W. Schultz summarized so well:

Most of the people in the world are poor, so if we knew the economics of being poor, we would know much of the economics that really matters. Most of the world's poor people earn their living from agriculture, so if we knew the economics of agriculture, we would know much of the economics of the poor (Shultz 1980, p. 639).

It's troubling to know that, although many lesser developed countries are rooted in agriculture, their agricultural productivity is severely lacking. Ehui and Pender write: "Despite the fact that two thirds of the 627 million people living in Sub-Saharan Africa depend on agriculture or agriculture-related activities for their livelihoods, the region has the lowest agricultural productivity in the world" (Ehui and Pender 2005, p. 238). Although agricultural output as a whole has grown, agricultural productivity has not. The authors note that food production per capita has declined by 17% in Sub-Saharan Africa since 1970 (Ehui and Pender 2005). This is not good for the region for obvious reasons. Ehui and Pender write: "Low productivity has eroded the competitiveness of African agriculture in the world market; as a result most countries in the region have become net importers of food commodities" (Ehui and Pender 2005, p. 225).

Other possible causes include factors such as low population density, which possibly leads to higher costs of transport, poor market integration, high natural resource endowments per capita, and higher ethno-linguistic diversity. The colonial heritage of the region results in smaller countries, which are in turn riskier and slower in the area of technological innovation (Collier and Gunning 1999).

Collier and Gunning (1999) also explain how leadership in the region has evolved from an autocracy to dictatorship in some cases. These undemocratic governments, captured by urban residents, often have few commercial and agricultural-

related interests. In the 1970s, several of these economies became statist and reduced exports. The crucial role of government and democracy is a leading topic for many researchers. Amartya Sen states succinctly, "Developing and strengthening a democratic system is an essential component of the process of development" (Sen 1999, p. 157).

Yet, another possible explanation touched on by Collier and Gunning (1999) is the fact that exports are concentrated in a narrow range of commodities. Deaton (1999) explores in further detail the role of commodity prices in economic growth. African countries primarily export commodities so their link to economic growth must be better understood. Deaton (1999) argues that rising commodity prices will not solve poverty; only the end to tropical poverty will bring increases in commodity prices. Deaton (1999) notes that real commodity prices show a distinct lack of a positive upward trend so owners of a primary commodity would not have seen much growth in real income. Sometimes there are shocks in commodity prices, but they do not have long-run effects. In fact, long-run real commodity prices revert back to a long-run unchanging average. Deaton (1999) argues that governments must better understand price swings, but that it will be difficult to construct good policy rules because price forecasting models are inadequate for the most part. Yields of crops grown in other countries are higher as workers in Africa do not benefit from technological innovation. Finally, Deaton (1999) argues that real prices can not rise as long as there is an unlimited supply of labor at a subsistent wage level.

Relative size of the population that is rural is one of the variables studied in this thesis. Since a large population of Sub-Saharan Africa lives in a rural setting, it makes

sense to include this variable as a possible cause of poverty. At the close of the last century, the African rural population was at least 450 million, of whom about 270 million lived in absolute poverty, accounting for nearly 85.0 percent of the poor (Mwabu and Thorbecke 2004). Because most of these rural inhabitants are small farmers, we need to know if increasing the agricultural income these people receive would somehow spur the rest of the economy in Africa. Regrettably, agriculture has performed poorly in Africa in recent years. Over the last half century, the poor performance of the agricultural sector, and by extension, of the rural areas, has been generally considered the Achilles' heel of Africa's overall growth and development performance (Mwabu and Thorbecke 2004). However, many believe that although agriculture has performed poorly, it is nevertheless the starting point for jump starting the economy. We have learned that many other poor developing countries that were successful in achieving growth and poverty alleviation (particularly in parts of Asia) emphasized agriculture at an early stage of development (Mwabu and Thorbecke 2004).

It seems that some of us in America have a tendency to take a rather cynical approach when it comes to those who are in poverty and, even worse, those who are on some sort of assistance. It is rather easy to tap into the common rally cry that those who are without should somehow rise above it. Indeed, we seem to take pride in those that are somehow able to pull themselves out of poverty. We have eerily simple solutions. We say that folks should simply get a job. But what about those living in rural areas where the job prospects are not abundant? What are we to say to those who are tied to the land in rural Africa? Studies in our own country show that just because policies are

being created to spur those who are on assistance to find work does not mean that those policies will have the desired effect for those living in rural areas. Swaminathan and Findeis write:

> A key question for rural areas was whether changes in policy that sought to put poor people on welfare assistance to work was whether this policy change could reduce poverty rates in rural areas, due to the weak job prospects there. For rural areas, it appears that the answer to this important question is no. This effect is only found for metro areas (Swaminathan and Findeis 2004, p. 1294).

The fact that a policy or practice put into place may affect people in certain regions differently or not at all is humbling and probably not altogether surprising. We may think that we have a solution that can easily be applied to all people in all circumstances when even in our own country that is shown perhaps not to be the case. We know now that, even if rich countries somehow decide to invest money in places like Africa and Latin America, not everyone will be positively affected by it. That does not mean that investment and aid should not reach these countries, but rather it means we must be mindful that those who live in extreme poverty often live in rural areas. We need to be aware that they may not be touched by foreign investment and aid like those living in metro areas.

The variable of income inequality is also studied in this thesis. If we see a large disparity among incomes in certain countries or regions of the world, we wonder how much it makes sense to redistribute income. Some argue how effective or fair redistribution is for the purpose of reducing income inequality and poverty as a whole. Agenor writes:

> Theory and facts suggest that the relationship between growth and inequality is ambiguous, and reducing inequality may have adverse effects on growth. For

instance, lower inequality may reduce the propensity to save and invest of capitalists, thereby reducing growth rates and hurting the poor indirectly. This implies that the emphasis on redistributive policies as an attempt to reduce poverty may be misplaced, particularly in low-income countries. In the long run, growth is essential for alleviating poverty. It tends to reduce poverty through rising employment, increased labor productivity, and higher real wages. It creates the resources to raise incomes and increase public investment, and even if 'trickle down' is insufficient to bring the benefits of growth to the poor, governments will have scope for stronger redistributive measures when income is higher and growing faster (Agenor 2005, p. 426).

Certain countries in Latin America and Sub-Saharan Africa have been endowed with an abundance of natural resources. One might think that these would help in increasing overall growth rates in GDP. However, some believe that these resources may actually end up being harmful for development. This "problem" is referred to as "Dutch Disease." Loper and Bessler write:

Yet, abundance of natural resources may depress investment in other sectors of the economy, leading to retarded development. The latter is illustrated by Holland's experience in the Groningen gas fields, where gas discovery led to a decline in the Netherlands' export competitiveness in other sectors of its economy -- thus the name 'Dutch Disease' attributed to the decline in other sectors of the economy 'caused' by high exports of natural resources (Loper and Bessler 2001, p. 463).

Again, the connection between governance and growth in Sub-Saharan Africa is discussed by Ndulu and O'Connell (1999). They show that real GDP growth is distinctly related to political structure. Real GDP experienced greater growth in multi-party political systems followed by a one-party system and then military oligarchies. It is difficult to ignore the role government plays and easy to see that good governance leads to growth. The authors note that in choosing state-led and inward-looking industrialization, leaders were captive to ideas rather than interests. Ndulu and

O'Connell (1999) cite a quote from Robert Bates (1983) to describe Africa's post-

independence agricultural policies in eight countries that he analyzed:

> Leaders engage in bureaucratic accumulation and act so as to enhance the wealth and power of those who derive their incomes from the public sector; they also act on behalf of private factions, be they social classes, military cliques, or ethnic groups. They engage in economic redistribution, often from the poor to the rich and at the expense of economic growth. These are the central themes in policy formation in Africa and their prominence serves to discredit any approach based on a conviction that governments are agents of the public interests (Bates 1983, p. 165).

> Sachs et al. (1995) write:

> In many parts of the developing world, especially Latin America and Africa, political power has been disproportionately concentrated in urban areas, thereby adding to the political weight of labor relative to landowners and turning the trade regime more protectionist (Sachs et al. 1995, p. 21).

The role of health and schooling investments in Africa is discussed by Schultz

(1999). He argues that poor health and education lead to low productivity, which leads to

slow growth. Education does much more than expand one's horizons and job prospects.

An additional year of schooling for a mother in a low-income country is associated with

a 5.0-10.0 percent reduction in her child's likelihood of dying in its first five years.

Although it's difficult to know the magnitude of growth returns to schooling, it can be

argued that higher initial levels of education tend to be associated with more rapid

subsequent growth. Schultz (1999) also argues that if one were to single out the human

capital constraint that has slowed development in Africa, it would appear to be low

levels of health. Also, given the competitive private wage returns to schooling, the

economic case for additional investments in education is unambiguous. He also notes

that cultural heterogeneity of Africa may help explain why mass education, which forges

common means of communication and competition in the labor market, is associated with such large percentage gains in productivity.

Literacy rates are commonly used as a way to measure education. Proponents of literacy programs argue that reading and writing skills improve individuals' chances of increasing their earnings. While it is difficult to determine causality, a growing body of evidence suggests that literacy increases the productivity and earning potential of a population (Verner 2005). In his World Bank policy research paper, Verner (2005) uses an example of a farmer in Thailand. Verner (2005) notes that farmers with four years of schooling are three times more likely to adopt new fertilizers and other inputs than farmers with one to three years of schooling (World Bank 1991). The difference appears to be attributable to the fact that better educated farmers absorb new information more quickly and are more innovative than less educated farmers (Verner 2005).

The role of health in development has gained greater attention in recent years. We seem to think that having good health is a starting point to having a better life. Bloom and Canning (2004) note the importance by highlighting that three of the eight Millennium Development Goals adopted by the United Nations are directly related to health. The primary aim of these goals is to eradicate poverty on a global basis. The fact that three of the goals are related to health speaks volumes to the importance the international development community places on health. Bloom and Canning (2004) note a report from the Commission on Macroeconomics and Health, which the World Health Organization set up to determine the place of health in global economic development:

> In a recent report the commission notes that as well as saving millions of lives every year, improving the poor's access to health services could 'reduce poverty,

spur economic development, and promote global security.' The report adds that 'the burden of disease in some low-income regions, especially sub-Saharan Africa, stands as a stark barrier to economic growth,' and therefore any comprehensive development strategy must address health head on (Bloom and Canning 2004, p. 61).

Another variable that is used in this study is international trade. Seemingly, few would argue that increasing a country's capacity to trade would have a negative effect on economic growth, and the literature appears to support that as well. Lewer and Van den Berg write:

> A one percentage point increase in the growth of exports is associated with a one-fifth percentage point increase in economic growth. Given the power of compounding, the effect on growth is very important for human welfare (Lewer and Van den Berg 2003, p. 363).

The area of population growth is a topic that often comes up as it concerns economic development in lesser developed countries. Although conditions may not be ideal for raising children in some of these countries, we often find that birth rates are alarmingly high. The affects of this population growth may have a devastating effect. Young writes:

> Agricultural and rural development efforts are being checked, and in some countries nullified or reversed, by the effects of population increase; and that unless greater efforts are made to reduce rates of population growth, then hunger, poverty, and the suffering which these cause will continue (Young 2004, p. 83).

Young (2004) highlights the importance of understanding the relationship between population growth and poverty in his discussion of the Sub-Saharan African country of Malawi. Young (2004) notes that Malawi remains one of the world's poorest countries, has a low life expectancy among its population, has a high infant mortality rate, and more than a third of the population is undernourished. These problems remain

despite the fact that Malawi has enjoyed a relatively stable government and absence of civil unrest, while being favored by aid agencies (Young 2004). An alarming statistic pointed out is the massive population increase Malawi has seen over the years. The 1960 population of Malawi was three-and-a-half million. It has since risen steadily to twelve million in 2004. And, sadly, the only apparent check in the population growth was in the early 1990s by the onset of AIDS (Young 2004). Young (2004) argues that the proportion of development aid directed towards population-related aims, and in particular towards family planning services, should be much higher.

Although some might argue that the efforts of institutions like the World Bank have been negligible in fighting poverty, Sender (1999) gives some encouraging statistics that indicate that some progress is being made. Sender (1999) notes that Sub-Saharan Africa's performance is superior to many developing countries with respect to certain improvements in female welfare. For example, the following are percentages of literate females in 1995: Sub-Saharan Africa (48.0 percent), Asia (36.0 percent), and Pakistan (24.0 percent) (Sender 1999). He also notes that a positive trend in expansion of secondary school provision is that secondary schooling for girls appears to have powerful effects in reducing both infant mortality rates and fertility. Another positive effort is sanitation. One-third of the total population of Sub-Saharan Africa has access to safe water and sanitation. That number of the total population of Sub-Saharan Africa that had access to safe water and sanitation was below 10 percent in 1970. Sender (1999) also says the picture of economic growth in Africa is more complex than suggested by the commonly quoted GDP variable. He also notes the importance of agriculture in the

region. Agriculture is the sector where 70 percent of Africans live and women account for more than half of employment. Agriculture accounted for 50 percent of total exports in recent years in 20 Sub-Saharan African countries. However, growth trends are down, performance has been unsatisfactory, and technological change has been minimal.

Much has also been written about the role of economic aid in developing countries. William Easterly (2001) gives reasons why the countries in the tropics have continuously struggled in their quest for economic development. Even though countries in these regions have received enormous amounts of aid from institutions around the world, they continue to be mired in poverty. Easterly (2001) argues that although these countries have received aid, they have not made the internal changes necessary to continue on the path to recovery. Simply put, Easterly (2001) writes that countries, like people, respond to incentives. Before aid is awarded, governments must demonstrate that they are willing to put in place policies that will help the cause. Otherwise, the cycle of poverty will continue. Easterly writes

> 'Filling the financing gap' implies giving more concessional aid to countries with higher trade deficits, higher current debt, and lower private lending. This perversely rewards the 'irresponsible governments,' whose policies scare away private lenders and lead to higher trade deficits and higher debt. Filling the financing gap pours good money after bad, creating an official debt spiral in which the inability of countries to service their existing debt is the reason that they are granted new official loans (Easterly 2001, p. 133).

Indeed, prior research using directed acyclic graphs supports Easterly's argument. Bessler writes: "the evidence is rather strong that Foreign Aid is not a major player in the poverty chain." (Bessler 2003, p. 33). This study will be similar to Bessler (2003); however, he did not offer a separate analysis of Latin American poverty and

African poverty. A criticism of his work is that the model generating poverty is not the same throughout the world.

Although this thesis examines several economic and social variables that might be causes of poverty on an individual basis, it is highly likely that several of these variables may be correlated. Thus the answer to solving the problem of poverty may include policies that affect several different variables. It is not surprising to learn that previous studies show several variables to be related. Life expectancy is highly correlated with investment, probably due to the positive effect of public health programs on health (Hoeffler 2002). In addition, life expectancy is influenced by other determinants such as female education and infrastructure; in particular sanitation, and access to safe water (Hoeffler 2002). Knowing that there is a linkage between variables, we can easily surmise that isolating one particular variable as a cause of poverty is not very probable. Nevertheless, we need to study and examine which variables may influence or cause poverty so we can begin to at least have the pieces of what is sure to be a complex puzzle.

Not everyone agrees on the best way to address the problem of poverty. While some groups claim that the actions of the World Bank have significantly reduced the number of people living in poverty other groups say the numbers are distorted. Critics also make strong arguments about the validity of the data used. Robert Wade (2004) questions the World Bank's claim that over the past 20 years the number of people living on less than $1.00 a day has fallen by 200 million, after rising steadily for 200 years. Indeed, he notes that other experts say the 1980s and 1990s were decades of declining

global inequality and reductions in the proportion of the world's population in extreme poverty. Some parties champion globalization while others decry it. The core of Wade's argument is that he questions the empirical basis of the World Bank's argument. Wade (2004) points out that there is a large margin of error with the numbers used to determine the poverty headcount. Specifically, the poverty headcount is very sensitive to the reliability of household surveys of income and expenditure. The available surveys are of widely varying quality and many do not follow a standard template. Some sources of error are well known, such as the exclusion of most of the benefits that people receive from publicly provided goods and services. The governments of India and China chose not to participate. So, for example, in China, the purchasing power parity exchange rate is based on guestimates from small, ad hoc price surveys in a few cities, adjusted by rules of thumb to take account of huge prices difference between urban and rural areas. Wade (2004) even notes that a comparison of two recent World Bank publications suggests how the World Bank's statements about poverty are affected by its tactics and the ideological predispositions of those in the ideas controlling positions. In conclusion, Wade (2004) says that the population living in extreme poverty has probably fallen the past two decades or so, having been rising for decades before then. Beyond this we cannot be confident because the World Bank's poverty numbers are subject to a large margin of error, are probably biased downward, and probably make the trend look rosier than it really is.

In summary, there have been a number of articles and studies on world poverty. The literature shows that opinions vary on not only what influences poverty in these

regions of the world, but also the best methods to use in addressing this problem. This

study will attempt to use recent methods to explore whether commonly thought of

influential variables of poverty can be statistically shown to cause poverty.

CHAPTER III

AREAS STUDIED AND DATA DESCRIPTION

Variable Definitions and Descriptive Statistics

This chapter provides definitions on the variables that are used, accompanied

with statistics from selected countries, including countries outside the areas of study.

These numbers reaffirm what most already know to be true; that several countries in

Africa and Latin America are severely lacking in the area of development. The data used

for the study comes from the World Bank, the Food and Agricultural Organization of the

United Nations (FAO), and the Heritage Foundation. The countries studied in Latin

America can be found in Appendix Table 1 and the countries studied in Sub-Saharan

Africa can be found in Appendix Table 2. The variables discussed can also be found in

Appendix Tables 1 and 2. The following variables were studied:

$2.00/Day Measure of Poverty. The World Bank's 1993 measure of the percent

of each country's population living on $2.00 or less per day is a less exclusive measure

of economic poverty (less exclusive than the $1/day measure). The average value of the

countries studied in Latin America is 35.5 percent. Honduras shows the highest value at

68.8 percent and Uruguay shows the lowest at only 6.6 percent. Other countries in Latin

America with greater than 50.0 percent of the population living on less than $2.00 per

day include Bolivia (51.4 percent) and Ecuador (52.3 percent). The countries in Sub-

Saharan Africa present even more sobering statistics. The average value is 72.3 percent.

Nigeria shows the highest value at 90.8 percent with South Africa showing the lowest at

35.8 percent. Only one of the 22 countries studied in Sub-Saharan Africa shows less than

half of the population living on less than $2.00 per day. Some of the higher percentage countries are: Mali (90.6 percent), Zambia (87.4 percent), Rwanda (84.6 percent), Mozambique (78.4 percent), and Ethiopia (76.4 percent).

Undernourishment. The FAO measure of undernourishment is based on discrepancies between the minimum calories required for a population versus the calories available from local food consumption, trade, and stocks (see FAO 2000, p. 6 and Table 1). The measure is the percentage of a country's population whose food intake falls below the minimum requirement. The data are for years 1996 – 1998. The average value of the countries studied in Latin America is 13.4 percent. The Dominican Republic shows the highest value at 28.0 percent, with Chile and Uruguay both showing the lowest value at 4.0 percent. The average value of the African countries studied is 31.5 percent. Mozambique shows the highest value at 58.0 percent and Nigeria shows the lowest at 8.0 percent. Other countries in Sub-Saharan Africa with a percentage greater than 40 include: the Central African Republic (50.0 percent), Ethiopia (49.0 percent), Niger (46.0 percent), Zambia (45.0 percent), Sierra Leone (43.0 percent), and Tanzania (41.0 percent).

Gini Index. This is the World Bank's estimate of the extent to which the distribution of income among individuals or households within a country deviates from equality. A value of 0 indicates equality across individuals or households. A value of 100 indicates the extreme of inequality (see World Development Report 2000/2001, p. 320 and Table 5, pp. 282 - 283). The average value of the countries studied in Latin America is 50.36 percent. The highest value of income inequality is Brazil at 63.4

percent and the lowest value is Trinidad at 40.3 percent. For the African countries, the average value is 44.4 percent. The highest value is South Africa at 58.4 percent and the lowest is Rwanda at 28.9 percent.

Freedom Index. The Heritage Foundation's Index of Freedom is used as a measure of overall freedoms for 2001. The index gives a rating of each country on nine aspects (categories) of freedom: International Trade, Fiscal Burden, Government Intervention, Monetary Policy, Foreign Investment, Banking and Finance, Wages and Prices, Property Rights, and Regulation. Each country is provided a discrete measure of 1, 2, 3, 4, or 5 on each of these categories of freedom. The integer 1 indicates freedom with respect to a measure; a measure of 5 indicates no freedom with respect to a measure. The index is found online at http://cf.heritage.org. The average measure of freedom in Latin America is 2.9. The country in Latin America enjoying the most freedom is El Salvador with a low measure of 2.4. Brazil has the highest measure, and the lowest amount of freedom, with 3.5. Other countries with a measure greater than 3 include: Venezuela (3.4), Honduras (3.3), the Dominican Republic (3.2), Mexico (3.1), Ecuador (3.1), and Columbia (3.0). The average measure of freedom in Sub-Saharan Africa is 3.5. Zambia and Namibia have the most freedom with a low measure of 2.9. Rwanda has the least amount of freedom with a measure of 4.3. Every country studied in Sub-Saharan Africa, with the exception of Zambia, has a measure of freedom that is equal to or greater than 3.0.

Agricultural Value Added Per Worker. This is the World Bank's measure of the output of the agricultural sector less the value of the intermediate inputs. Agriculture

includes values from forestry, fishing and hunting, cultivation of crops, and livestock production. Data are in constant 1995 U.S. dollars. The average value in Latin America is $2,907.83. The highest value belongs to Uruguay at $6,657.00, and the lowest belongs to Honduras at $1,018.00. The average value in Sub-Saharan Africa is $530.41. South Africa has the highest value at $3,486.00 and the lowest is Mozambique at $121.00. Only two other countries have values greater than $1,000.00; Namibia has a value of $1,063.00 and Cote d'Ivoire has a value of $1,004.00.

Illiteracy Rate. Here we use the World Bank's 1999 measure of the percentage of people ages 15 and older that cannot, with understanding, read and write a short straightforward declaration on their daily life. The average value in Latin America is 13.9 percent. Guatemala has the highest percentage of illiteracy at 35.6 percent and Uruguay has the lowest percentage at 2.8 percent. El Salvador, with a percentage of 24.6 percent, is the only other country with an illiteracy rate greater than 20.0 percent. The average value in Sub-Saharan Africa is 46.16 percent. The highest percentage is Niger at 87.1 percent and the lowest is Zimbabwe at 16.0 percent. Other countries with an illiteracy rate greater than 50.0 percent include: Gambia (69.5 percent), Mali (68.4 percent), Senegal (68.1 percent), Ethiopia (67.8 percent), Mozambique (62.4 percent), the Central African Republic (61.4 percent), Mauritania (61.2 percent), Cote d'Ivoire (60.6 percent), and Sierra Leone (60.0 percent).

Life Expectancy. This is the World Bank's 1999 measure of the number of years a newborn child would live if current patterns of mortality at the time of birth remain fixed throughout her/his life. The average life expectancy of the countries studied in

Latin America is 70.3 years. Costa Rica claims the highest life expectancy at 76.5 years

and Bolivia has the lowest at 61.5 years. Other countries with a life expectancy greater

than 70 years include: Chile (75.2 years), Jamaica (74.4 years), Panama (74.0 years),

Venezuela (72.8 years), Uruguay (72.6 years), Trinidad (71.6 years), Mexico (71.5

years), and the Dominican Republic (70.4 years). These compare favorably to other

countries around the world such as: Japan (80.4 years), Australia (78.2 years), United

Kingdom (77.1 years), and Canada (78.9 years). The average life expectancy of the

countries studied in Sub-Saharan Africa is only 50.7 years. The country with the highest

life expectancy is South Africa at 62.9 years and the lowest is Sierra Leone, with a life

expectancy of only 35.2 years. Other countries with low life expectancies include: Niger

(45.5 years), Mozambique (44.6 years), Ethiopia (44.1 years), Mali (44.0 years), and

Zambia (43.10 years).

Rural Population Percentage. This is the World Bank's 1999 measure of the

percentage of a country's population living in rural areas. It is calculated from the

difference between the total population and the urban population. The average measure

of the population living in rural areas in Latin America is 36.2 percent. The country with

the highest percentage of people living in rural areas is El Salvador at 55.0 percent. The

country with the lowest percentage is Uruguay at 10.0 percent. The average measure of

the population living in rural areas in the countries studied in Sub-Saharan Africa is 68.3

percent. The country with the highest percentage is Rwanda at 94.3 percent and the

lowest is Mauritania at 48.8 percent. The percentage of the population living in rural

areas in other parts of the world: Egypt (55.8 percent), Switzerland (32.3 percent),

France (24.9 percent), USA (23.5 percent), Canada (23.1 percent), and Saudi Arabia (16.0 percent).

Child Mortality. We use the World Bank's 1999 measure of the probability that a newborn person will die before reaching age five if subject to current age-specific mortality rates. The number is expressed as a rate per 1,000 people. The average measure of the countries studied in Latin America is 36.2. The highest measure of the countries studied is Bolivia at 85.0 and the lowest is Chile at 13.0. The average measure of the countries studied in Sub-Saharan Africa is 156.3. The highest measure is Sierra Leone with 286.0 and the lowest is Botswana with 62.0. Measures of other countries outside the areas of study include: Egypt (51.0), Saudi Arabia (20.0), USA (7.2), United Kingdom (5.9), Canada (5.5), Australia (5.3), Switzerland (4.8), France (4.7), and Japan (3.7).

Foreign Aid. This is measured as official development assistance and net official aid record of international transfer of financial resources of goods and services. This World Bank measure is expressed as a percentage of gross national income for 1995. The average measure of aid as a percentage of gross national income of the countries studied in Latin America is 22.7 percent. The country with the highest measure is Bolivia at 78.6 percent and the smallest percentage is Venezuela at 1.2 percent. The average measure of aid as a percentage of gross national income of the countries studied in Sub-Saharan Africa is 57.6 percent. The country with the highest measure is Mauritania at 117.9 percent and the lowest is Nigeria at 1.8 percent. Other countries receiving large amounts of aid include: Rwanda (114.6 percent), Namibia (91.2 percent),

Zambia (82.2 percent), Senegal (78.9 percent), Mozambique (77.8 percent), Gambia (64.7 percent), Sierra Leone (62.6 percent), Lesotho (61.5 percent), and Botswana (60.1 percent).

International Trade as a Percentage of GDP. This World Bank measure uses the sum of exports and imports of goods and services as a share of gross domestic product for the year 1995. The average measure of the countries studied in Latin America is 61.4 percent. The highest measure is Jamaica at 108.2 percent and the lowest is Brazil at 16.3 percent. The average measure of the countries studied in Sub-Saharan Africa is Lesotho at 143.5 percent and the lowest is Rwanda at 31.7 percent. The percentage of trade for other countries include: Canada (78.2 percent), Saudi Arabia (76.5 percent), Switzerland (75.1 percent), United Kingdom (56.9 percent), France (48.0 percent), USA (24.6 percent), and Japan 21.6 percent.

Birth Rate. This World Bank measure is the number of live births occurring during the year 1995, per 1,000 population estimated at midyear. The average measure of birth rate of the countries studied in Latin America is 26.1. The highest is Guatemala at 36.7 and the lowest is Trinidad at 14.9. The average measure of birth rate of the countries studied in Sub-Saharan Africa is 40.4. The highest is Niger at 52.3 and the lowest is South Africa at 28.7. Birth rates in other countries include: Saudi Arabia (34.5), USA (14.6), Australia (13.7), France (12.4), Switzerland (11.4), and Japan (9.5).

GDP Per Capita. The World Bank's measure is defined as the domestic product divided by mid-year population in constant 1995 U.S. dollars. GDP is the sum of gross value added by all resident producers in the economy, plus any product taxes and minus

any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. The average measure of GDP per capita of the countries studied in Latin America is $2,728.07. The country with the highest measure is Uruguay at $5,975.21 and the lowest is Bolivia at $919.80. The average measure of GDP per capita of the countries studied in Sub-Saharan Africa is only $732.91. The country with the highest measure is South Africa at $3,943.33 and the lowest is Ethiopia at $109.78. Other countries in Sub-Saharan Africa with a GDP per capita of less than $250.00 include: Madagascar ($235.30), Rwanda ($221.37), Niger ($205.40), Sierra Leone ($196.37), and Tanzania ($180.21). GDP per capita of other countries around the world include: Switzerland ($44,217.15), Japan ($43,483.32), USA ($29,230.86), France ($27,489.07), and Canada ($20,472.18).

Crop Production Index. This World Bank index shows agricultural production for each year relative to the base period 1989-91. It includes all crops except fodder crops. Regional and income group aggregates for the FAO's production indexes are calculated from the underlying values in international dollars, normalized to the base period 1989-91. The average measure of the countries studied in Latin America is 115. The country with the highest measure is Bolivia at 150 and the country with the lowest is Panama at 73. The average measure of the countries studied in Sub-Saharan Africa is 105. The country with the highest measure is Ghana at 167 and the country with the lowest is Botswana at 68.

Total Health Expenditure. This 2000 World Bank measure is the sum of public and private health expenditures as a ratio of total population. It covers the provision of health services (preventive and curative), family planning activities, nutrition activities, and emergency aid designated for health, but does not include provision of water and sanitation. Data are in current international dollars. The average measure of health expenditure of the countries studied in Latin America is $299.33. Uruguay has the highest measure at $740.00 and Guatemala has the lowest at $92.00. The average measure of health expenditure of the countries studied in Sub-Saharan Africa is $93.18. South Africa has the highest measure at $574.00 and Tanzania has the lowest measure at $14.00. Measures of health expenditure in other countries outside the area of study include: USA ($3,983.00), Switzerland ($2,624.00), Canada ($2,197.00), France ($2,064.00), Australia ($1,866.00), Japan ($1,807.00), and United Kingdom ($1,391.00).

CHAPTER IV

DIRECTED GRAPHS

The econometric methods used for this study are based on directed acyclic graphs. In this chapter, these methods are explained and the software used for the study will be discussed. At the heart of this study is the question of what exactly may cause or influence poverty. If we are able to build a model showing causality among variables, we can then make better decisions on which policies should be implemented to help our ultimate cause; in this case, reducing poverty. In essence, we can then predict the consequences of changing a variable that affects another. We can represent a causal model as A $\rightarrow$ B. In studying causal models, we can predict what might happen by changing the effect variable (B) by changing the cause variable (A). Hausman (1998, p. 7) writes: "Causation seems connected to intervention and manipulation: one can use causes to 'wiggle' their effects." Being able to predict this 'wiggling' effect is what can lead us to the goal of reducing world poverty.

Intervention, not just predictability, is important in defining causation. Bunge (1959) says that causality requires a productive or genetic principle that models how something comes into being. In other words, A causes B if A is productive of B. More recent definitions of causality have tended to focus more on predictability instead of a change-based or intervening definition. An example of this is Granger-type causality (Granger 1980). Granger-type causality does not consider intervention or change and instead focuses on predictability alone. Definitions that focus on prediction alone, without distinguishing between intervention and subsequent realization, may mistakenly

label as cause variables that are associated only through an omitted variable (Bessler 2003). The caveat of focusing on prediction alone is that you may attempt to change policies on the wrong set of variables.

Researchers have often used correlation or partial correlation on observational data. Indeed, many students and researchers are familiar with correlation in applied studies and often use least squares regressions in building forecasting models. When studying data, it is usually of great interest as to whether variables can be shown to be correlated with one another. If two variables are highly correlated, we know that both variables are somehow connected. However, we also know that although variables may be correlated or partially correlated, we can not say with confidence that one variable in fact causes or influences another because correlation in itself does not imply causation. Yet, as researchers, we still rely heavily on these models to help predict what will happen in the future based on past observational data.

An essential message from recent work on directed acyclic graphs for applied studies is that under certain well-defined conditions it is possible to offer causal interpretations to observed correlation structures (Bessler 2003). In a sense, directed graphs will allow us to build off of these already-observed correlation structures and allow us to take a step further in identifying causation. Our results can then be interpreted as causal. When we find a directed path (defined below) we are implying that we can make changes in one variable to change another. For example, the directed path below shows a connection between three variables: Health, Child Mortality, and Poverty (those living on $2.00 or less per day).

Health → Child Mortality → Poverty

We are implying by the arrows that Health causes Child Mortality, which in turn causes Poverty. We can then make changes towards Health which will ultimately change Poverty.

A directed graph is a picture representing the causal flow among a set of variables. A graph is an ordered triple <**V,M,E**>, where **V** is a non-empty set of vertices (variables), **M** is a non-empty set of marks (symbols attached to the end of undirected edges), and **E** is a set of ordered pairs. Each member of **E** is called an edge. Vertices connected by an edge are said to be adjacent. If we have a set of vertices {A,B,C,D}, the undirected graph contains only undirected edges (e.g., A — B). A directed graph contains only directed edges (e.g., C → D). A directed acyclic graph is a directed graph that contains no directed cyclic paths. An acyclic graph has no path that leads away from a variable only to return to that same variable. (The path A → B → C → A is labeled "cyclic" as here we move from A to B, but then return to A by way of C.) Only acyclic graphs are used in this study.

These graphs are pictures (illustrations) for representing conditional independence as given by the recursive decomposition:

$$\Pr(v_1, v_2, v_3, \ldots, v_n) \ = \ \prod_{i=1}^{n} \Pr(v_i \mid pa_i)$$

where Pr is the probability of vertices (variables) v_1, v_2, v_3, ...,v_n, pa_i the realization of some subset of the variables that precede (come before in a causal sense) v_i in order (v_1, v_2, v_3, ...,v_n), and the symbol $\prod$ represents the product operation, with index of operation

denoted below (start) and above (finish) the symbol. Pearl (1995) proposes d-separation as a graphical characterization of conditional independence. That is, d-separation characterizes the conditional independence relations given by the above product (Π Pr). If we formulate a directed acyclic graph in which the variables corresponding to pa$_i$ are represented as the parents (direct causes) of v_i, then the independencies implied by the product given above can be read off the graph using the notion of d-separation as defined in Pearl (1995):

> Definition: *Let X, Y and Z be three disjoint subsets of vertices [variables] in a directed acylic graph G, and let p be any path between a vertex [variable] in X and a vertex [variable] in Y, where by 'path' we mean any succession of edges, regardless of their directions. Z is said to block p if there is a vertex w on p satisfying one of the following: (i) w has converging arrows along p, and neither w nor any of its descendants are on Z or (ii) w does not have converging arrows along p, and w is in Z. Furthermore, Z is said to d-separate X from Y on graph G, written (X ⊥ Y | Z)$_G$ if and only if Z blocks every path from a vertex [variable] in X to a vertex [variable] in Y.*

Geiger, Verma, and Pearl (1990) show that there is a one-to-one correspondence between the set of conditional independencies, X ⊥ Y | Z, implied by the above factorization and the set of triples, X, Y, Z, that satisfy the d-separation criterion in graph G. If G is a directed acyclic graph with vertex set V, if A and B are in V, and if H is also

in V, then G linearly implies the correlation between A and B conditional on H is zero if and only if A and B are d-separated given H.

The notion of d-separation (directional separation) can be illustrated further. Consider three variables (vertices): A, B and C. A variable is a *collider* if arrows converge on it: A → B ← C. The vertex B is a collider, A and C are d-separated, given the null set. However, if we condition on B, we open-up the information flow from A to C. Conditioning on B makes A and C d-connected (directionally connected). Amend the graph given above to include variable D, as a child of B, such that:

$$A \rightarrow B \leftarrow C$$
$$\downarrow$$
$$D.$$

If we condition on D rather than B, we, as well, open up the flow between A and C (Pearl 2000, p. 17). This illustrates the (i) component of the definition given above.

If converging arrows do not characterize our information flow, as illustrated above, but instead information flow is characterized by diverging arrows, then the d-separation condition is different. This is given by the (ii) component of the definition above. Say we have three vertices K, L, and M, described by the following graph: K ← L → M. Here L is a common cause of K and M. The unconditional association (correlation) between K and M will be non-zero, as they have a common cause L. If we condition on L (know the value of L), the association between K and M disappears (Pearl 2000, p. 17). Conditioning on common causes blocks the flow of information between common effects. In an unconditional sense, K and M are d-connected (as they have a common cause); while conditioning on L, variables K and M are d-separated.

Finally, if our causal path is one of a chain (causal chain), condition (ii) in the above definition again applies. If D causes E and E causes F, we have the representational flow: D→ E→ F. The unconditional association (correlation) between D and F will be non-zero, but the association (correlation) between D and F conditional on E will be zero. For causal chains, the end points (D and F) are not d-separated, while conditioning on the middle vertex (E) makes the end points d-separated (Pearl 2000).

Spirtes, et al. (1999) examine the relationship between directed graphs and the counterfactual random variable model (the random assignment experimental model) of Holland (1986). For one (causal relationships shown via directed graphs on observational data) to imply the other (causal relationships revealed in a random assignment experiment), three conditions are needed. First, one should focus on a causally sufficient set of variables. This implies that no omitted variables cause any two of the included variables under study. If variable A causes both B and C and we exclude A from the study, then an apparent causal flow from B to C (or vice versa) may be due to the fact that A causes both B and C, so the causal flow identified as running from B to C would be spurious (Suppes 1970). Second, one needs to constrain themselves to causal flows that respect a causal Markov condition. That is to say, if A causes B and B causes C, we can factor the underlying probability distribution on A, B, and C as Pr(A,B,C) = Pr(A)Pr(B|A)Pr(C|B). Finally, the probabilities, Pr, we attempt to capture by graph G are faithful to G if A and B are dependent if and only if there is an edge between A and B.

Causal sufficiency suggests that one has captured a sufficient set of variables, which are related theoretically, that can be used to conduct analysis. If one fails to

include a relevant variable, one runs the risk of putting a line between two variables that are actually effects of an omitted third variable. Spirtes, Glymour, and Scheines (2000) note that the Markov condition has been questioned in quantium mechanical experiments. Failure to require the condition would require us to ignore statistical dependency even in experimental designs. Lastly, the faithfulness condition may not hold if parameter values cancel one another. As an example, the following two equations explain the underlying model that generates X, Y, and Z:

$$X = 20Y + 2Z + \varepsilon_X$$

$$Z = -10Y + \varepsilon_Z$$

where ε_X and ε_Z are uncorrelated noise terms, each not correlated with its associated right-hand side variables (ε_X is not correlated with Y or Z and ε_Z is not correlated with Y). If this is the "true" generating process on X, Y, and Z, it has a Directed Acyclic Graphical representation with no conditional independence relations (dropping the noise terms):
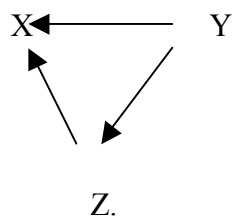
Yet, X and Y are uncorrelated. If we rely on correlation and partial correlation stucture based on observational data on X, Y, and Z to remove edges between variables, we would mistakenly remove the edge between X and Y, even though the data generating

process requires it to be present. However, slight variations in any of the linear

coefficients show X and Y to be correlated, so that the correlation structure in the model

is unstable (Glymour 1997, p. 209).

Researchers at Carnegie Mellon University have developed computer software

for carrying-out causal inference using the correlation matrix associated with a set of

variables (Bessler 2003). The software is called TETRAD IV. The first step is to

generate a correlation matrix from the variables studied, which are then loaded as a file

into TETRAD IV. TETRAD IV then begins with a complete undirected graph; all

variables are connected to one another by an edge (line). If correlations or partial

correlations among variables are not significantly different from zero, then the edges are

removed based on a pre-determined level of significance. This study uses significance

levels of .20. The following z-statistic is used to test whether a correlation or partial

correlation is statistically zero:

$$z_{i,j|k} = \frac{\sqrt{T - N_k}}{2} \ln(\frac{1 + r_{i,j|k}}{1 - r_{i,j|k}}),$$

where T is the number of observations used to estimate the correlations, $r_{i,j|k}$ is the

estimated correlation between variables i and j given k, and N_k is the number of variables

in k (N_k is zero for unconditional correlations). If variables i, j and k are normally

distributed, then $z_{i,j|k}$ follows a standard normal distribution. Edges (lines) surviving all

correlation and partial correlation tests are then directed (assigned arrows "X→Y or

Y→X") by applying conditions (i) and (ii) of the d-separation definition given above

(Bessler 2003). PC algorithm will be used in TETRAD IV. With PC algorithm, three

sets of data (Latin America, Sub-Saharan Africa and Latin America, and Sub-Saharan

Africa countries combined) and a .20 level of significance, a total of six graphs will be

generated. The algorithm rests on three assumptions: (1) there are no hidden common

causes between any pair of observed variables; (2) with continuous variables, the direct

causal effect of a variable into another is linear and the distribution is normal; and (3) the

(unknown) graph representing the population causal relationships should be acyclic

(Scheines et al., 1994).

PC algorithm has been studied extensively in Monte Carlo simulations in Spirtes,

Glymour, and Scheines (2000) and Demiralp and Hoover (2003). This thesis uses a

sample size of less than 100. With a sample size of less than 100, PC algorithm may

make two mistakes. The results may mistakenly include or exclude edges and may also

mistake the direction of the edge. The mistake of the direction of the edge appears to be

more likely than the exclusion or inclusion of edges. Spirtes, Glymour, and Scheines

write:

> In order for the methods to converge to correct decisions with probability 1, the
> significance level used in making decisions should decrease as the sample size
> increases and the use of higher significance levels (e.g., .2 at sample sizes less
> than 100, and .1 at sample sizes between 100 and 300) may improve performance
> at small sample sizes. (Spirtes, Glymour, and Scheines p. 116).

The results presented below should be viewed cautiously with this knowledge in mind.

CHAPTER V

RESULTS

Results are presented for a total of six different models. Each group of data

(Latin America, Sub-Saharan Africa, and a combination of Latin America and Sub-

Saharan Africa) were tested with PC algorithm at a significance level of .20. In addition,

each group of data were tested with PC algorithm assuming prior knowledge about the

temporal order of the events represented by each variable. TETRAD IV allowed us to set

the order of events in a tier format. Events happening earlier in time were placed in

lower numbered tiers. For example, we could add the information that freedom precedes

illiteracy in time. This constraint could be used by PC algorithm to direct the edge

between freedom and illiteracy with an arrow pointing to illiteracy. If we do not have

any information about the temporal order of events, they are placed in the same tier. In

this analysis, the following tier structure was used: Tier 0: freedom and gini index; Tier

1: illiteracy, birth rates, child mortality, life expectancy, rural percentage, and under-

nourished; Tier 2: agricultural income, gdp, health, foreign aid, trade, and crop index;

Tier 3: poverty. The idea is that it may take longer for freedom and the gini index to

occur, and therefore they should be ordered first so that we can see the results of doing

so. Our analysis begins with the correlation matrix on the variables discussed earlier.

The correlation matrix is the unconditional correlation between all 15 variables. The

order in which the variables are listed is given across the top of the matrix using the

abbreviations as follows: 2da = percentage of population living on $2.00 or less per day;

gin = gini index; fre = freedom index; agi = agricultural income; lfe = life expectancy;

rur = percent of population which is rural; imo = child mortality; gdp = gross domestic product; ill = illiteracy; aid = foreign aid; nrs = percent of under-nourished; brt = birth rate; hlt = health; trd = international trade; and cin = crop index. The actual variable definitions are given above. A negative sign before a number represents a negative correlation. Figure 1 below shows the correlation matrix for Latin America.

	2da	gin	fre	agi	lfe	rur	imo	gdp	ill	aid	nrs	brt	hlt	trd	cin
2da	1														
gin	.12	1													
fre	-.25	-.48	1												
agi	-.48	.25	-.09	1											
lfe	-.52	.26	-.17	.57	1										
rur	.50	-.17	-.01	-.66	-.47	1									
imo	.63	-.08	-.07	-.62	-.88	.52	1								
gdp	-.41	.31	-.39	.71	.53	-.71	-.50	1							
ill	.54	-.11	-.02	-.57	-.68	.70	.78	-.47	1						
aid	.36	-.12	-.18	-.28	-.19	.32	.29	-.44	.11	1					
nrs	.42	-.07	.28	-.51	-.56	.52	.61	-.61	.49	.20	1				
brt	.60	.42	-.37	-.49	-.43	.51	.65	-.38	.57	.25	.32	1			
hlt	-.46	.24	-.32	.73	.51	-.62	-.49	.87	-.46	-.32	-.65	-.35	1		
trd	-.17	-.28	.13	-.08	.49	.11	-.51	-.18	-.36	.27	-.13	-.29	-.18	1	
cin	.37	.20	-.46	.03	-.11	-.08	.34	.08	.14	.36	-.21	.37	.00	-.24	1

Figure 1. Correlation Matrix - Latin America.
Please refer to page vii for a list of acronym definitions.

When considering poverty, there are modestly strong positive relationships found between $2.00/day and Child Mortality (imo) (.63) and Birth Rate (brt) (.60). There are also modestly strong negative relationships found between $2.00/day and Life Expectancy (lfe) (-.52), Agricultural Income (agi) (-.48), Health (hlt) (-.46), and GDP (gdp) (-.41). We see several large correlations outside of column 1, so we should expect

to see causal flows among these variables. For example, we would expect to see a causal

flow between Life Expectancy (lfe) and Child Mortality (imo), with a negative

correlation of

-.88.

As mentioned previously, TETRAD IV takes the correlation matrix as input and

begins with a complete undirected graph. Every variable is connected to every other

variable without direction. Lines are removed by way of tests that the correlation

(covariance) between any two variables is not different from zero. If we cannot reject the

hypothesis that a particular correlation (covariance) at some pre-determined significance

level, we remove the line connecting the two variables. Edges that remain are said to

survive zero-order conditioning (as we conditioned on no other variable to remove edges

at this stage). Edges (lines connecting variables) surviving these zero-order tests are

subjected to a series of first-order conditioning tests. Here, we condition edges between

two variables on a third variable. If the conditional correlation between any two

variables is not significantly different from zero we remove that edge, just as we did at

zero-order conditioning. Continuing on, edges surviving tests of first order conditioning

are subjected to tests of second-order conditioning. Lastly, TETRAD IV directs edges

using d-separation arguments discussed above. The results are shown below in figure 2:

Figure 2. Directed Graph - Latin America - .20 Significance Level.
Please refer to page vii for a list of acronym definitions.

Figure 2 represents the graph generated from the Latin American data at a

significance level of .20 with no events ordered. We see that none of the variables cause

or influence poverty. We do, however, see certain causal flows that we expected to see

based on initial strong correlations. We see that Life Expectancy (lfe) and Child

Mortality (imo) do in fact have a causal flow. In this case, because they are negatively

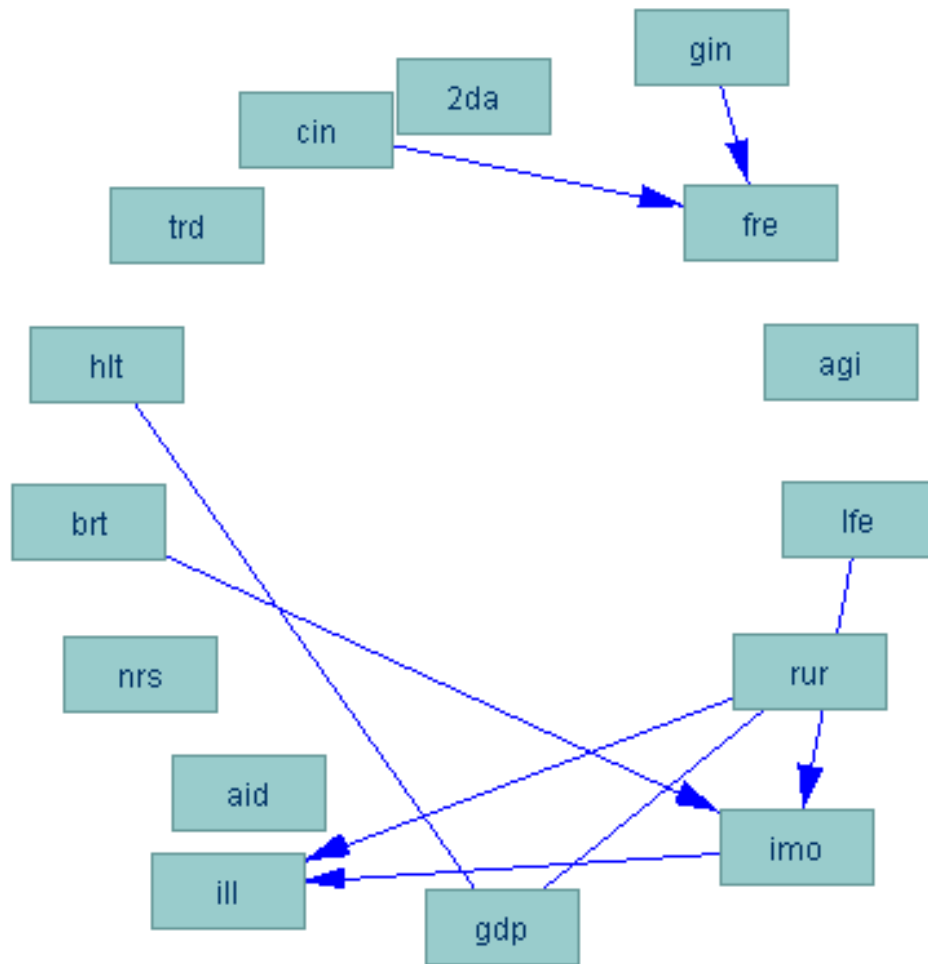correlated, an increase in Life Expectancy (lfe) causes Child Mortality (imo) to decline.
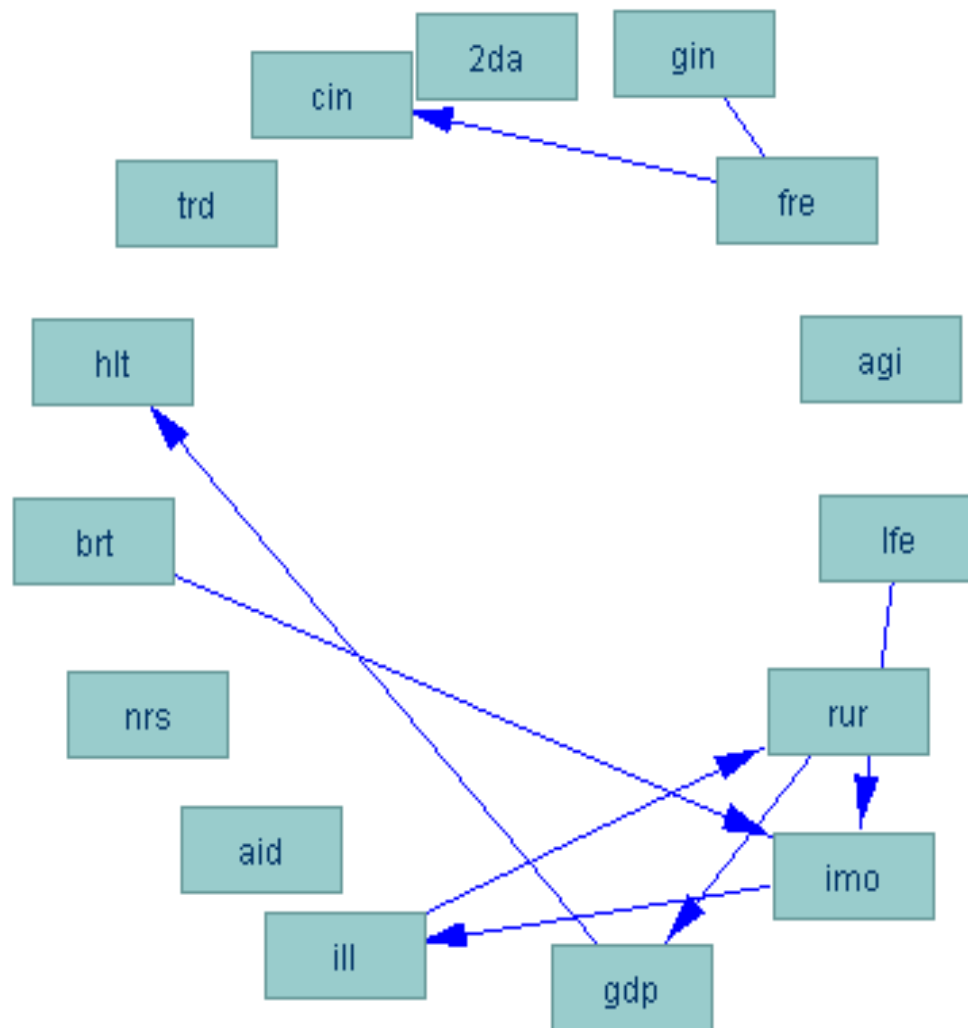

Figure 3. Directed Graph - Latin America – Events Ordered.
Please refer to page vii for a list of acronym definitions.

Figure 3 represents the graph generated from the Latin American data with a

significance level of .20 and an ordering of the events. Once again, we see that none of

the variables studied can be shown to cause or influence poverty. It's interesting to note

that variables commonly thought to help reduce poverty (gdp/per capita, foreign aid,

etc.), do not prove to be true.

The next step is to see if the pattern shown resulting from the Latin American

data holds for other parts of the world. In our case, it will be useful to learn whether

these causes might be isolated to a particular region of the world. As we study the results

from Sub-Saharan Africa, we once again begin our analysis with the correlation matrix

shown in figure 4.

	2da	gin	fre	agi	lfe	rur	imo	gdp	ill	aid	nrs	brt	hlt	trd	cin
2da	1														
gin	.12	1													
fre	-.25	-.48	1												
agi	-.48	.25	-.09	1											
lfe	-.52	.26	-.17	.57	1										
rur	.50	-.17	-.01	-.66	-.47	1									
imo	.63	-.08	-.07	-.62	-.88	.52	1								
gdp	-.41	.31	-.39	.71	.53	-.71	-.50	1							
ill	.54	-.11	-.02	-.57	-.68	.70	.78	-.47	1						
aid	.36	-.12	-.18	-.28	-.19	.32	.29	-.44	.11	1					
nrs	.42	-.07	.28	-.51	-.56	.52	.61	-.61	.49	.20	1				
brt	.60	.42	-.37	-.49	-.43	.51	.65	-.38	.57	.25	.32	1			
hlt	-.46	.24	-.32	.73	.51	-.62	-.49	.87	-.46	-.32	-.65	-.35	1		
trd	-.29	.33	-.24	.04	.47	-.22	-.44	.20	-.30	.31	-.44	-.36	.20	1	
cin	.37	.20	-.46	.03	-.11	-.08	.34	.08	.14	.36	-.21	.37	.00	-.24	1

Figure 4. Correlation Matrix – Sub-Saharan Africa.
Please refer to page vii for a list of acronym definitions.

From the matrix, there is a modestly strong positive relationship found between

$2.00/day and Birth Rate (brt) (.70). There are also modestly strong negative

relationships found between $2/day and Health (hlt) (.70), Agricultural Income (agi) (-

.67), and GDP (gdp) (-.67). Once again, we would also expect to see a causal flow

between Life Expectancy (lfe) and Child Mortality (imo) with a negative correlation of -

.90. It is often thought that increasing GDP/Per Capita is the best method for helping the

poor. The negative correlation makes sense. One might assume that as GDP/Per Capita

increases, Poverty would decrease. This may make sense logically, but the directed

graphs tell a different story as shown in figure 5.
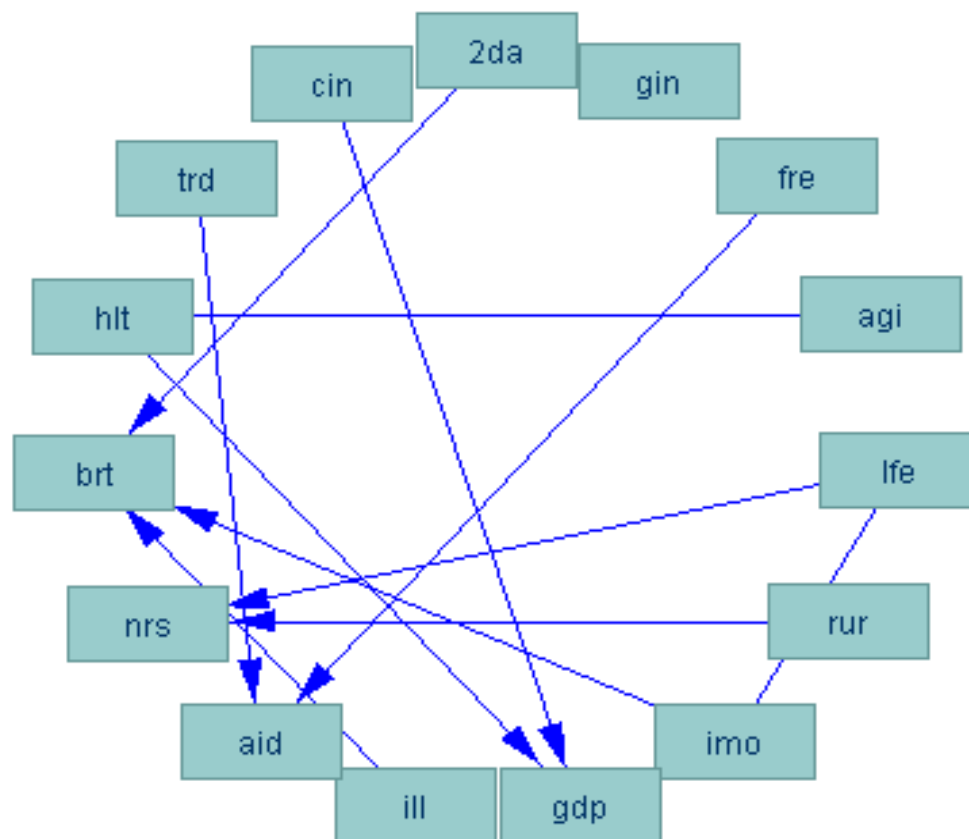
Figure 5. Directed Graph - Sub-Saharan Africa - .20 Significance Level.
Please refer to page vii for a list of acronym definitions.

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We see that GDP/Per Capita, as well as Agricultural Income, do not cause or influence poverty as the initial correlations might have suggested. However, we do see a causal flow between Poverty and Birth Rates as Poverty is shown to cause Birth Rates. However, when we order the events, we see that Birth Rates cause Poverty as shown in figure 6. Based on our assumptions of prior knowledge of the ordering of events, we expect this to be the case.
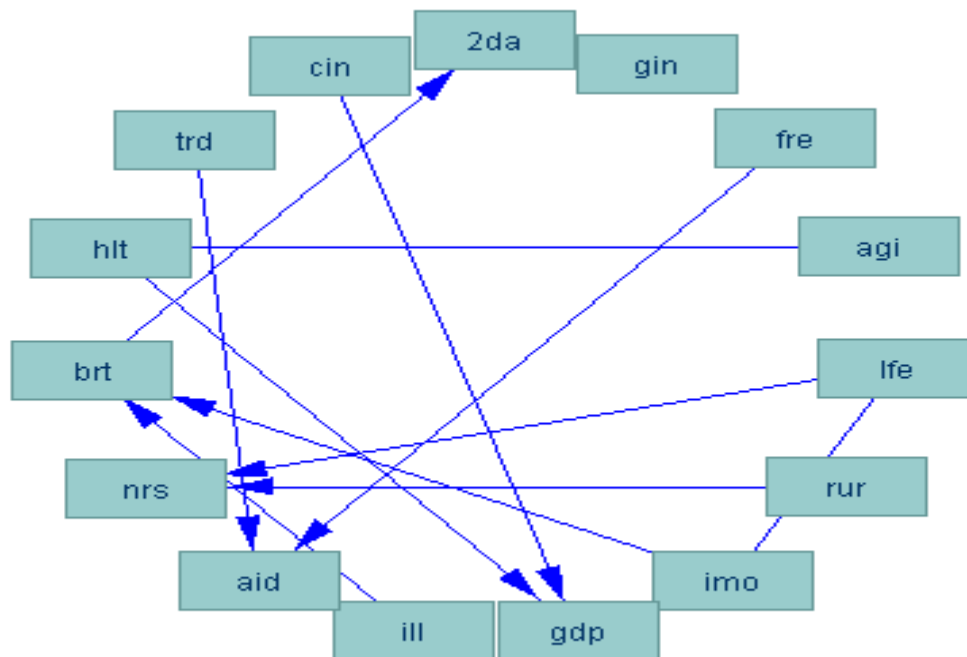

Figure 6. Directed Graph - Sub-Saharan Africa - Events Ordered.
Please refer to page vii for a list of acronym definitions.

It may be troubling to some that the graphs do not show GDP/Per Capita to be a cause or influence of poverty. After all, it is commonly thought among development

economists to be the variable that should require the most attention. However, Ordinary Least Squares Regression techniques provide additional evidence and strengthen the argument that increasing GDP/Per Capita does not necessarily benefit the poor. Consider the following regressions. Using the Sub-Saharan African data, equation (1) is a regression with the dependent variable being the percentage living on $2.00/day or less, and the independent variable being GDP/Per Capita. The estimated coefficients and standard errors are given:

(1) $2.00/day = 54.837 - 0.007(GDP/Per Capita).
           (6.305)   (0.002)

Here, the estimated coefficient associated with GDP/Per Capita is large relative to its estimated standard error, a t-statistic of 3.5, suggesting that at a low level of significance, GDP/Per Capita is an important variable in understanding our measure of Poverty. The negative sign on the coefficient lends itself to the thought that an increase in GDP/Per Capita decreases Poverty. However, as equation (2) below shows, it would be premature to assume that a policy solely directed towards increasing GDP/Per Capita would be the best way to help the poor. This is similar to the regression in equation (1), but instead we also include Birth Rate on the right-hand side of the equation:

(2) $2.00/day = 33.964 - 0.005(GDP/Per Capita) + 0.595(Birth Rate).
           (31.644)   (0.004)   (0.883)

Looking at the estimated coefficient on GDP/Per Capita and its standard error, we see that the value of the coefficient decreases relative to the corresponding coefficient in equation (1). Also, the t-statistic of 1.25 suggests that at usual levels of

significance the coefficient is not different from zero. Based on the results from equation (2), we can conclude, along with the directed graph, that Poverty will not be changed solely on a change in GDP/Per Capita.

When combing data from the two regions, we get the resulting correlation matrix to begin our analysis shown in figure 7.

	2da	gin	fre	agi	lfe	rur	imo	gdp	ill	aid	nrs	brt	hlt	trd	cin
2da	1														
gin	-.14	1													
fre	.21	-.43	1												
agi	-.75	.27	-.34	1											
lfe	-.81	.27	-.41	.73	1										
rur	.76	-.24	.34	-.79	-.74	1									
imo	.80	-.27	.39	-.68	-.96	.73	1								
gdp	-.68	.36	-.51	.80	.69	-.72	-.66	1							
ill	.73	-.28	.36	-.66	-.81	.67	.82	-.63	1						
aid	.47	-.22	.26	-.48	-.54	.46	.54	-.45	.45	1					
nrs	.62	-.17	.41	-.64	-.71	.68	.69	-.63	.53	.35	1				
brt	.85	-.06	.21	-.74	-.87	.78	.88	-.66	.81	.50	.63	1			
hlt	-.70	.32	-.47	.80	.68	-.67	-.65	.90	-.64	-.40	-.64	-.64	1		
trd	-.04	.00	.02	-.11	.13	.08	-.14	-.08	-.15	.32	-.20	-.09	-.06	1	
cin	.08	-.03	-.23	.08	.07	-.20	-.01	-.02	.06	.02	-.25	.03	-.04	-.19	1

Figure 7. Correlation Matrix – Combined.
Please refer to page vii for a list of acronym definitions.

From the matrix, there are strong positive relationships found between $2.00/day and Birth Rate (brt) (.85), Child Mortality (imo) (.80), Rural percentage (rur) (.76), and Illiteracy (ill) (.73). There are also strong negative relationships found between $2/day and Life Expectancy (lfe) (-.81), Agricultural Income (agi) (-.75), and Health (hlt) (-.70).

Once again, we also see a modestly strong negative relationship with GDP/Per Capita

(gdp) (-.68).
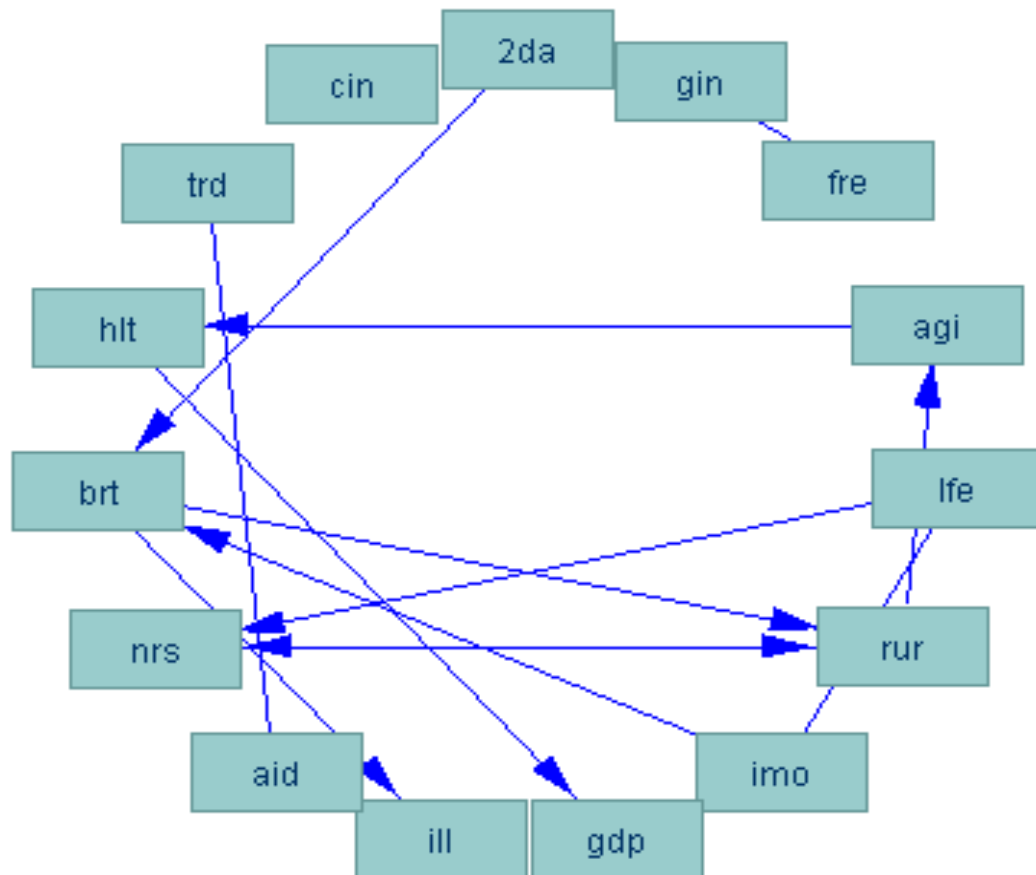
Figure 8. Directed Graph - Combined - .20 Significance Level.
Please refer to page vii for a list of acronym definitions.

In figure 8 above, the graph generated from the combined data at a .20

significance level shows, as was the case with the Sub-Saharan African data, that Birth

Rates influence Poverty.
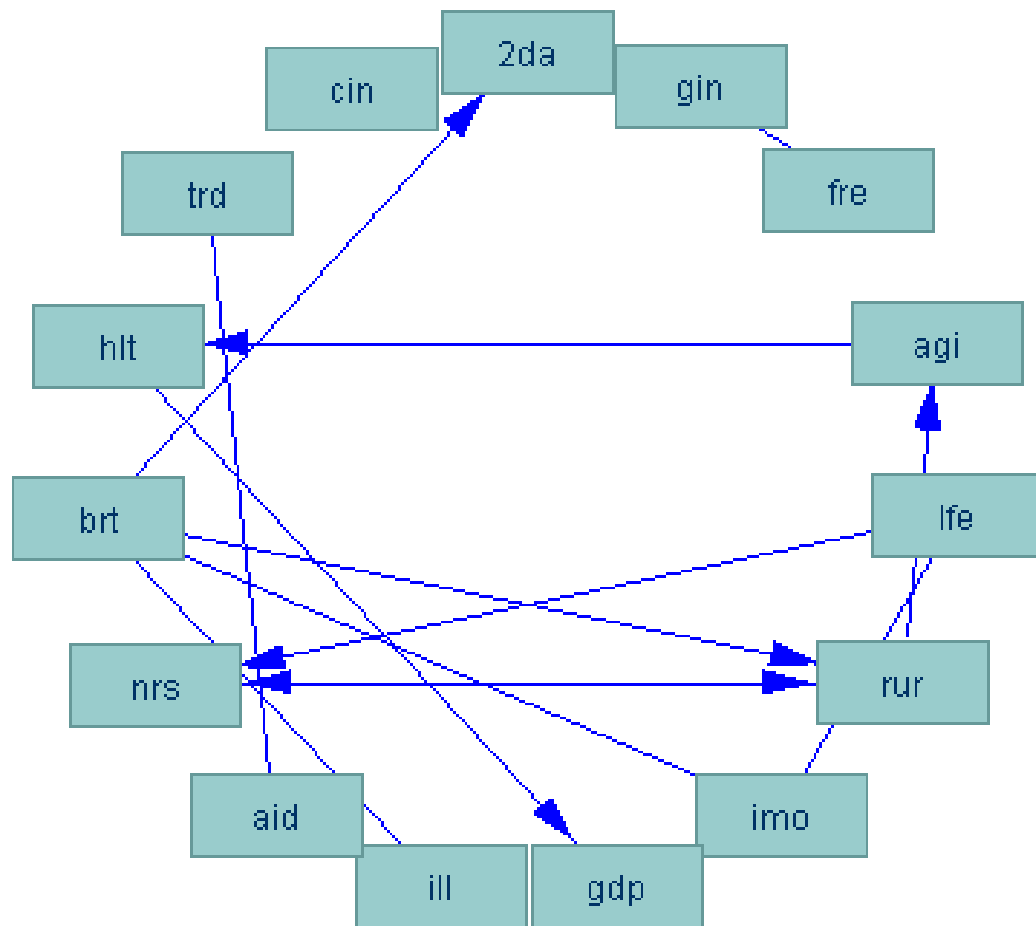
Figure 9. Directed Graph - Combined – Events Ordered.
Please refer to page vii for a list of acronym definitions.

Once again, in figure 9, we see a causal flow among Birth Rates and Poverty.

The only difference being that TETRAD IV showed Birth Rates to cause Poverty when

the events were ordered. For all six graphs, we see that increases in money and income

(Agricultural Income, GDP/Per Capita, and Foreign Aid) do not benefit the poor as a

whole, as is commonly thought.

CHAPTER VI

INTUITIVE DISCUSSION

This chapter offers a brief, intuitive discussion on the results of the graphs generated from the study, as well as an overall subjective opinion on the study of poverty as a whole. The graphs and subsequent figures that are referred to are found in Chapter V. This discussion tries to combine the objective results of the data with a subjective interpretation.

In the interest of maintaining clarity, this discussion on the results of the graphs generated from the study will focus on the results obtained with temporal ordering. This is the group of data that was generated with the assumption that we had prior knowledge about the order of events. A discussion will be offered on each variable, whether or not it was found to be a cause of another variable or variables, or if instead it was shown to be caused by another variable or variables.

The first variable to be discussed is the gini index. The gini index is the World Bank's estimate of the extent to which the distribution of income among individuals or households within a country deviates from equality. The graph resulting from the Latin American data found in figure 3 shows that there is an undirected edge between the gini index and the freedom index, which is used as a measure of overall freedoms. This edge is not found in the data from Sub-Saharan Africa. The edge between these two variables may by explained by higher income inequality relating to less freedoms. In addition, the relationship between the two indices may be because they use the same or similar data to generate the indices. The country with the highest value of income inequality in Latin

America is Brazil at 63.4. In addition, Brazil also has the highest measure of un-freedom in Latin America at a value of 3.5. Perhaps because there is less freedom in Brazil, there is a higher concentration of wealth among those who are in government or among those who receive favorable treatment from the government. The lack of freedom may cause the wealth to be concentrated in the hands of a select few.

The freedom index has some interesting results. In the graph resulting from the Sub-Saharan African data, shown in figure 6, the freedom index is shown to be a cause of foreign aid, while it is shown to be a cause of the crop production index in Latin America. Foreign aid is the average measure of aid as a percentage of gross national income and aid is defined as official development assistance and net official aid record of international transfer of financial resources of goods and services. That foreign aid seems to be rewarded based on un-freedom is worth noting because it would seem to be rather inconsistent to reward a country with aid if they were guilty of being less free. It's as if they are being rewarded aid based on bad behavior. Rwanda has the highest measure of un-freedom in Sub-Saharan Africa with an enormous value of 4.5, one of only two countries with a measure above 4.0. At the same time, Rwanda's aid as a percentage of gross national income is a staggering 114.0 percent. Oddly, it seems that countries with less freedom receive more aid. Perhaps their lack of freedom is a major cause of the poverty they suffer from, and in turn the international community rewards them with aid. Perhaps a better method would be to reward these countries with aid based on the policies of economic and social freedom they are willing to implement. In Latin America we see the freedom index being a cause of the crop production index. It

appears that the more freedom a country has, the smaller their agricultural production will be. El Salvador is the most free with a freedom index measure of 2.4. Their agricultural production is only higher than Panama's. This may mean that the more freedom a country has, the better they are at developing job opportunities outside of agriculture. A country would probably be more likely to invest in a country that has more freedom and a stable government than in one that has less freedom and a less stable government. More foreign investment means more jobs, and those jobs would most likely not be in the agricultural setting.

In the African data, we see an undirected edge between the agricultural value added per worker and total health expenditure. The agricultural value added per worker is the output of the agricultural sector less the value of the intermediate inputs while total health expenditure is the sum of public and private health expenditures as a ratio of total population. The data combined from the two regions, shown in figure 9, shows that the agricultural value added per worker is a cause of total health expenditure. There appears to be a correlation between someone's health and how much value they add as a worker. In short, the healthier they are the more they can produce. South Africa has the highest agricultural value added per worker at $3,486.00. South Africa also has the highest total health expenditure at $574.00.

Concerning life expectancy, which is the number of years a newborn child would live if current patterns of mortality at the time of birth remain fixed throughout her/his life, both sets of regional data show an edge between life expectancy and infant mortality. Infant mortality is a measure of the probability that a newborn child will die

before reaching age five if subject to current age-specific mortality rates. The number is expressed as a rate per 1,000 people. The Latin American data show life expectancy to be a cause of infant mortality. Among these two variables there is a strong negative correlation of (-.88), which can be found in figure 1and should be expected. If infant mortality rates are low in a particular country, we might assume that is due to things like good health care and education concerning health. These same things might logically cause life expectancy to be higher as well. If a country is experiencing high infant mortality rates, then we know that we can expect life expectancy rates to decrease just by the law of averages. In the African data, life expectancy is also shown to be a cause of undernourishment. There is once again a negative correlation. So, if life expectancy is higher, we know that there is a greater availability from local food consumption, trade, and stocks to meet the minimum calories required. In other words, the population of people that are undernourished is lower when life expectancy is higher.

Rural population percentage is the World Bank's measure of the percentage of a country's population living in rural areas. It is calculated from the difference between the total population and the urban population. From the Latin American data, we can see that rural population percentage is a cause of both infant mortality, as well as GDP per capita. Rural population percentage is positively correlated with infant mortality and negatively correlated with GDP per capita. We might assume that those living in rural areas do not have access to adequate health care as might be found in an urban environment, which leads to an increase in infant mortality rates. In addition, it's plausible that most living in these rural areas make their living from agriculture,

probably from subsistence farming. As a result, their income levels would expectedly be much lower than say a professional living in an urban area of Latin America. From the Latin American data we also see illiteracy rates to be a cause of the rural population percentage. These two variables are strongly, positively correlated. It's interesting that illiteracy causes the rural population percentage to increase. We might expect this to be the other way around. Just like a lack of adequate health care facilities causes an increase in infant mortality, we might expect a lack of educational resources in rural areas to cause the illiteracy rate to increase. However, it's the other way around with illiteracy rates causing an increase in rural population percentage. Perhaps the reasoning is because those who may have lived in urban areas at one time, and were unable to develop reading skills, were ultimately relegated to pursuing a life in agriculture found in rural areas. It seems that if a country's population is largely illiterate, we can expect to see a large portion of the population living in rural areas. In the African data, we see that rural population percentage causes undernourishment. A lack of adequate nourishment would not be unexpected in a rural area, perhaps because they do not have access to the availability of food that is required for the minimum number of calories necessary. Or, the food may be available, but it is possible those in rural areas are not in a position to afford it as they have a lower GDP per capita than those living in urban areas.

Moving on to the variable of infant mortality, we see that it is a cause of illiteracy in the Latin American data, while it is a cause of birth rates in the African data. Although babies may be dying, this does not stop women from continuing to have babies. Children may be needed in order to help care for the parents and they may be needed to help

provide for the family as well. Having children is obviously important. As more babies die, more births will take place since children are a vital part of each family's existence. In the Latin American data, with an increase in illiteracy from infant mortality, perhaps this is because those having children who die as infants are uneducated and illiterate. And, as they continue to have children, infants who survive to adulthood may likely end up being illiterate like their parents.

Next we move on to the variable of GDP per capita. The Latin American data shows GDP to be a cause of health expenditure. There is a very positive strong correlation between two variables. This is somewhat encouraging to know that the more money a person or country has, the more they will be willing to spend on health care. It's also a telling sign of the importance of health care. If GDP per capita is somehow increased, then it appears that the health of the population will increase as well. However, the African data show a reversal of cause. Instead, it shows health care expenditures to be a cause of GDP per capita. Maybe this is because the healthier the person, the more work they are able to do and the more money they are able to earn for themselves and their family. This causal flow also showed up when the data were combined. This may discreetly say something about the government as well. The aid given to these regions is possibly being spent differently. Perhaps GDP per capita does not cause health care expenditures in Sub-Saharan Africa to increase because the governments that receive the aid are electing not to spend it on health care as much as they are in Latin American countries. However, the data does show that the healthier people are in Sub-Saharan Africa, the more money they will be able to make for

themselves. This seems rather obvious, but it does not seem obvious that enough money is being spent on health care. Another interesting connection with the variable of GDP in the Sub-Saharan African data is the connection with the crop production index. The crop production index is shown to be a cause of GDP per capita, but the two variables are negatively correlated. Even though crop production may be increasing, this may actually cause GDP per capita to fall because the wages associated with crop production are much lower than they would be for a job that is found outside of crop production and agriculture.

Illiteracy is shown to be a cause of birth rates in the Sub-Saharan African data. There is a strong, positive correlation. It would seem that if someone is illiterate, that would cause them to have more children than if they were literate. Perhaps this goes along with some of the other connections we have previously discussed. It is not unlikely that those who are illiterate live in rural areas and their livelihoods center around agriculture. And, the more children that someone has in this environment can be seen as beneficial. More children mean more help with the work that has to be done and also more bodies that are able to earn money.

In the African data, foreign aid is shown to be caused by international trade, which is a measure that uses the sum of exports and imports of goods and services as a share of GDP. It is a positive correlation although not too terribly strong. This may be an indication of relations between donor countries and those receiving aid. If countries have the structure and willingness to trade internationally, it seems that they are more likely to receive foreign aid.

Birth rates are shown to cause infant mortality in the Latin American data, while birth rates are shown to be a cause of those living on less than $2.00/day in Sub-Saharan Africa. The relationships between both sets of variables are positively correlated. In the Latin American data, it seems that as birth rates increase so does the infant mortality rate. This may have to do with simple averages. In other words, if more children are born, then we can expect to see a higher rate of infant mortality simply because the chances increase with each additional birth. But, we may want to know why more children are being born in the first place. Is it because more people are living in rural areas, which causes families to rely more on agriculture? And, does that cause them to want to have more children to help out with the work? Whatever the reason for birth rates increasing, we see that it can have the terrible result of increasing infant mortality. That the Sub-Saharan African data show an increase in people living on less than $2/day is at the heart of this thesis. Ultimately, we are concerned with variables that influence poverty. And, birth rates are shown in the Sub-Saharan African data to be a cause of poverty. Although it's not likely that this variable is the single cause of poverty, it is nevertheless an indication that we may at least be in the neighborhood of where to start. It seems logical that in a region of the world where poverty is already rampant, that adding more people to the region through birth rates would not end up helping matters. But, as discussed previously, the fact that people are in poverty may cause them to have more children. However, it's difficult to believe that if people in Sub-Saharan Africa were somehow not allowed to have anymore children that poverty would somehow be eradicated. If someone is poor before they start having children, they are only going to

be poorer after having children. That does not mean that not having children will cause them somehow to leap out of the cycle of poverty. But we must start somewhere, and perhaps the logical starting point is educating people on the effects of adding children to an already deplorable environment. It may be too extreme to ask that a government implement a law like the one found in China where couples are only allowed by law to have one child in their family. But, driving home the importance of not exacerbating the problem of poverty by adding to it is well worth it.

Concerning the study of poverty as a whole, the belief that one theory or group of theories would somehow be able to wrap their collective arms around the subject of poverty and its causes is a bold one; but, most would agree that it is worth pursuing, even if there are no clear signs of a breakthrough in significantly reducing world poverty. We see how humbling a task it is to come up with an answer if we merely try to understand why poverty occurs in a particular neighborhood in our own country. Why do people have markedly different incomes even though they may only live blocks apart? Maybe if we can break it down, we will somehow stumble upon where the root of the problem lies.

We know that the main problem is poverty and that there are too many people in the world that are living in it. This causes them to live a life that those of us who are not in poverty might describe as unfair. Living in poverty categorizes them as poor. People are considered poor if they have a small amount of money or, even worse, no money at all. So, we need to get money into the hands of those that are poor. How do we do that? Most people receive money through the work they do. They have work to do because a

business or person provides a job. A business or person is able to provide that job because they have a need for labor. They have a need for labor because the market demands the services and products their business provides. People in the market demand services and products because they have a need for them and/or because they have a desire for them. The money they have earned allows them to purchase and consume those products and services. It's a cycle that has moved along nicely for many years. But, it all starts with people having money in their pocket (which they earn from work) to demand that the market create jobs to produce those goods and services. So, the solution to getting money into people's pockets and allowing them to climb out of poverty is rooted in having a way to earn money. There seem to be plenty of jobs in America (as of the writing of this paper, the current rate of unemployment in the United States in less than 5 percent). But, in South Africa, the unemployment rate was greater than 20 percent in 2005. There seems to be an ample number of jobs in the United States, while there is a less than sufficient amount in places like Africa. Maybe it has to do with the political environment. Perhaps a company is not comfortable investing their money in places where governments are not stable, even though they could pay wages that are significantly less than they would have to pay in their own country. Maybe companies are worried about the stranglehold AIDS has on this region. Maybe they are worried about the productivity levels of the workforce and whether or not they would embrace work environments such as call centers which have been popularly outsourced to India. Would they embrace them in Africa or Latin America? One can spend an entire lifetime trying to come up with ways to stimulate an economy and to pull other countries

out of poverty. Many variables can be studied and multiple models can be produced through analysis. However, I think most would agree that one single variable is not the cause of poverty. Most would probably also agree that having a democratic system of government in place that is friendly to business would be a good first step. When we look at all the foreign aid that has been poured into these regions of poverty over the years and admit that the problem is still largely there, we can see why William Easterly might be right in wanting to reward aid based on a country's willingness to adapt policies that would help them ultimately help themselves.

Perhaps we might view the idea as a parent views their child in school. If a parent is willing to reward a child with five dollars for every 'A' received in their schoolwork, the child has an incentive to study harder. The child may indeed be willing to sacrifice some time spent playing video games and instead spend his time studying. Money is a strong incentive, whether it's in the case of a child or in the case of a country. But, parents should not be willing to give out their money until the actual result has been achieved. In other words, if a child typically makes 'C's in class, if for no other reason than they are a bit lazy when it comes to studying, then a parent might expect that same behavior from the child if the reward comes before the work. For example, if the parent gives the child $25.00 at the start of the semester (the child is taking 5 classes, hence five 'A's multiplied by $5.00 an 'A' returns $25.00), and tells the child, "I am giving this money to you in advance and I expect you to have five 'A's at the end of the semester." The intent is good on the parent's part, but the child receives the $25.00 no matter the outcome. The child may in fact promise his parents that he will work hard and

make five 'A's. But, if the child was a bit lazy in his approach to schoolwork before the agreement, chances are he will revert to his old ways since he already has the money in his hand. Truly, what is the child's incentive not to play video games and instead study if he already has the money? At the end of the semester, the child will more than likely come up with some excuse as to why he did not receive all 'A's.

But, if the child is given money only after his grades have been finalized and the report card is in the hands of the parents, perhaps then we will see the true measure of the incentive. The incentive will start to reveal how strong it was to begin with. If the child receives three 'A's, and the resulting $15.00 that goes along with that, he has direct evidence that his parents meant what they said about rewarding him based on the grades he made. He is in no position to ask them or negotiate for more because the rules were explained to him ahead of time. Now, going forward, the child not only has $15.00 to spend as he chooses, but he also knows that he will be eligible to receive the same amount next semester, or perhaps even more. He may realize that he is more than capable of attaining good grades if he simply applies himself a bit more. Now, his decisions about how to spend his free time will be influenced by his desire for money. He knows that the more time he devotes to his studies, the more money he is likely to get. And, not only does he get the money from his parents, but he also receives praise for his efforts from both his parents and his teachers. His pocket increases and so does his self esteem. In essence, it's a win-win situation for everyone involved.

Admittedly, there is a big difference between a child being able to work hard for good grades and an entire country that is trying to put into practice economic policies.

However, the incentive structure is the same. If countries can show that they are willing to make the necessary changes, which will benefit them more than anyone, they will be rewarded with more aid. Obviously, the practices that have been put in place do not seem to have worked out thus far. It's a difficult balance for sure. Countries want to help and do, and then they find themselves being criticized for their methods of help. Those that criticize often preach about debt forgiveness and seem to vilify nations that want to collect what belongs to them – their own money that they lent out in the first place.

Most of us know what it's like to have credit card debt and can relate to wanting that debt to go away. We "know" that once the debt is wiped out, we will surely act more prudently in our spending the next time around, or so we tell ourselves. But the debt does not simply disappear. We have to make decisions on how we spend our income in order to satisfy that debt. In fact, we are required to make a minimum payment each month. If we do not make the monthly payment, that missed payment shows up on our credit report, which ultimately affects our credit score. That credit score allows banks to determine what interest rate they will apply to loans we seek or if they will even extend us a loan at all. On an individual level, if we borrow money, we can expect to pay it back with interest or be prepared to deal with the penalties that go along with not paying it back. Should the rules that apply to individuals also apply to countries? It would seem so. However, when we see pictures or read about the conditions in some of these countries, asking for the money back with interest is not a popular platform on which to stand. You can not expect to be well received when others announce that you are making money on the backs of the poor.

Continuing with the credit card example on an individual level, suppose I have lost my job, I have children that are sick and in need of extended hospital visits, and that my car and home have been repossessed by the bank. Because I have no money, I use my credit card even more than I did before. Now I'm really in a difficult situation concerning my debt. The debt has not only piled up, but I don't have the means to pay it back. Perhaps others have heard of my predicament and approach the credit card companies on my behalf, even though I have been appealing to them for relief, but with no such luck. Maybe the credit card company decides that I will not have to pay the interest back, only the principle of my outstanding debt. That's good news, but there's still a problem; I can not pay that back either. I have no income and I purchased some things with my credit card that I thought might be able to help me make money, but they have proven to be poor investments (some get-rich-quick real estate program I saw on a late night infomercial and some old coins purchased on the internet that turned out to be bogus). My living conditions have not changed. The kids are still sick, I'm living with relatives, and I'm using a bicycle for my primary mode of transportation instead of a car. On top of that I am still burdened with an outstanding credit card balance, and although the amount I owe is no longer increasing since the interest has been forgiven, the amount I owe is still large. Once again, others appeal to the credit card companies on my behalf. They let the public know that I am in dire straits financially and that the big, bad, evil credit card company is demanding its money back. Money I asked them to loan me for assistance in the first place. The credit card company relents because they do not want the bad publicity. They decide to forgive my debt altogether so I am no longer saddled

with the weight of outstanding debt around my neck. In addition, they have wiped my failure to repay the debt off my credit history. In other words, if I ever need a loan again the lender will not be able to take into account my previous credit history when I was not able to make payments. Things worked out remarkably well.

However, there's still a problem; the kids are still sick, I'm still living with relatives, and I'm still using a bicycle for my primary mode of transportation. I need money to get the kids medical help, I need money so I no longer have to live with relatives, and I need money to get a car. An even bigger problem is I'm not sure where I'll get the money. Those that appealed to the credit card companies on my behalf (I'll call them the "appealers") do not have enough money individually to support me and they have no way of providing a job for me. They are able to help me buy medicine for my children for a week, but that's the extent of the help they are able to provide. However, the appealers say they can help in other ways. They do not have the money to help me, and I do not have the money to help myself, but they say they will appeal to those that do have the money and demand that they help me. The appealers say that those with the money have an obligation to help those that do not. I agree with them. I know that I would be willing to help someone if they needed it and I was able to. The only problem is I'm not able to, at least not right now. I need somebody to help me get started and the appealers seem to know who to ask. The appealers tell me that they have some good news and some bad news. The good news is that they have found somebody to loan me some money. The bad news is that it's once again the credit card company. How could that be I ask? They tell me that the credit card company is the only one that

has the means and the willingness to help. The credit card company has reservations because they know what happened with me last time. However, they decided previously to ignore my credit history so that did not work against me. And, they also had take into account the loud cries of the appealers. The appealers were able to pressure the credit card company into coming to the table in the first place. Once again, the credit card company did not want any bad publicity and they did not appreciate the appealers painting a picture that this was a case of the "haves" and the "have nots." The credit card company told the appealers that they would be willing to provide me a loan, with a minimal interest rate, but only on one condition. The condition is that the advisors of the credit card company must be able to work with me in order to set up a budget and advise me on the best ways to invest and spend my money. In other words, I would not be able to invest in any get-rich-quick schemes shown on late night infomercials and I would no longer be able to surf the internet looking for products like coins and collectibles. In fact, I won't be able to visit any casinos and I will no longer be allowed to give any money to my older cousin just because he threatens me like he did in the past. In short, if I once again borrow money from the credit card company, I will only be allowed to spend money that directly benefits me or my family.

The appealers were not too happy when they heard about this. In their minds, the credit card company should not be able to tell me how to spend the money I have in my possession. They even used the term slave as if the credit card company is the master and I am the lowly servant. But, at the end of the day, it is the credit card company that is supplying me the money. And, after all, they want to receive their money back (and

not have to lose their money by forgiving the debt like they did before) so it would seem like they have my best interest in mind when it comes to how the money they loan me is managed. Granted, I may not be thrilled with the idea of someone telling me what to do with the money I have in my pocket. But, if it is in fact their money, I suppose I can see why they have such a vested interest. As another incentive for me to go along with their policies, the credit card company has told me that they would also be willing to give me more money in the future if I prove to be a good steward with the money that they are planning to give me. But first, I must prove to them that I can pay my bills on time and that I can spend and invest the money wisely. The appealers are not too happy with this idea either. In their minds, the credit card company should give me as much money as possible and they should not be able to hold back any until I can show good behavior. In their minds it is cruel to deny me any money when I so desperately need it. The credit card company is arguing that this method will force me to think about my spending habits and that I will now have a strong incentive to be a better steward of the money in my pocket. The credit card company also says that if I am now able to buy a vehicle with the money they lend me, then I must use that vehicle part of the time to drive around to different employment agencies in order to look for long-term employment. They are not saying that I can not use the vehicle to drive my children to the doctor or to search for a place to live, only that I must spend part of the time I spend driving on seeking employment. The appealers are not happy about this stipulation as well. Their thought is that if I own the car, then I should be able to drive it when and where I want to. However, the credit card company says that if part of my time is spent looking for a job,

then I will not need to come to the credit card company in the future to borrow money. But, if I decide to borrow money in the future, I will be in a much better position to pay the debt off once I have steady employment. And, the credit card company will feel more comfortable loaning me more money as well since they will be able to charge me interest and make money themselves, which they can ultimately use to help someone else.

Once again, in the fictional example above, I tried to put the process of loaning foreign aid in rather simplistic terms and was able to do so when relating it to an individual, somewhat personal level that most of us can relate to with our experiences with credit cards. I'm not trying to imply that the factors that allow an individual to get credit and pay it off are the same as a third-world country trying to receive a loan from an agency like the World Bank. However, I think when we can put it on a personal or individual level, we can get a better sense of what the different parties involved are saying. And, since countries that need aid are made up of millions of individuals, perhaps it is not a stretch to try and understand how the psychology of an individual might apply to a country as a whole.

I think we must recognize that countries that are mired in poverty seemingly have no chance to recover from it unless they have help from wealthy countries. And, perhaps the wealthy countries should recognize the bountiful resources they have been given and establish an even greater push to help those that were not given as much. Surprisingly, it's not a popular stance to demand accountability from those that need help, but we must recognize that those countries that are in such bad shape want things to change.

They want things to be different and we want that for them, so much so that we are willing to give enormous amounts of aid. And, what are the results of all this aid? Are things really any better? They do not appear to be. So, we can all agree that the methods of the past have not yet achieved their desired results. Perhaps they never will. Countries that are willing to give up some of their own resources to help another should recognize their duty to continue to do so. At the same time, they should require change if they expect to see any. It makes no sense to continue to pour money into a government that is not willing to make any lasting changes. Just like it makes no sense for a parent to give a child money for grades they have not yet earned. Earn the grades first before the reward is given. But, also help the child develop better study habits along the way and encourage their diligence. And, as a country is extended a line of credit they should know that their ability to receive an increase in their line of credit will be determined by their history of payments. If they make payments on time they can expect to receive more aid. But, also help them to understand how their money is being spent and guide them in their approach to investing in their future.

The end result is that all parties have a responsibility. We all have a responsibility to help others and others have a responsibility to help others help themselves. The World Bank can give needy countries aid and advice on policy, but until the country receiving aid is able to make changes internally, we may expect to see that they will continue to struggle in their fight against poverty. Perhaps the best way to inspire them to change internally is to give them an incentive to change internally. They need to welcome the spirit of change before they are indeed able to change. It is our

responsibility to offer assistance and plant the seeds of change. We can then hope that

those seeds ultimately take root and become the foundation of the first step out of

poverty.

CHAPTER VII

SUMMARY AND CONCLUDING REMARKS

The objective of this thesis was to explore economic and social variables that may be influential in causing poverty, particularly in the regions of Sub-Saharan Africa and Latin America. Recent methods of Directed Acyclic Graphs were used to build six models using data from countries in Latin America and Sub-Saharan Africa. The principle findings from the analysis are as follows.

Of the two separate causal graphs that were built from the Latin American data, none of the fourteen variables were found to be causes or influences of poverty, although several causal flows among variables were identified. For the graphs that were built from the Sub-Saharan African data, both graphs showed a causal flow between birth rates and poverty. The graph built on the assumption of ordered events showed birth rates to be a cause of poverty from the Sub-Saharan African data. The graph without events ordered from the Sub-Saharan African data showed poverty to be a cause of birth rates. This lends itself to the importance of having prior knowledge on the temporal ordering of events. Several other causal flows were identified as well. Two graphs were also built after combining the data from the two regions. As with the Sub-Saharan African data, we see a causal flow among poverty and birth rates. One graph showed poverty to be a cause of birth rates when the events were not ordered and the other showed birth rates to be a cause of poverty when we inserted ordering of events. Interestingly, the results also showed that the poor do not necessarily benefit from an increase in GDP or an influx of foreign aid as is commonly thought.

An essential point to the results of this thesis is that, although our results do not necessarily shed light on causes of poverty, that does not mean policies should not be directed towards certain economic or social variables simply because they have not been shown to influence poverty. As an example, both directed graphs generated from the Latin American data show a causal flow among GDP/per capita and health. Both also show a causal flow between the crop index and freedom. Although none of these variables were shown to be a cause of poverty, most would agree that it would still be beneficial to set policy around one variable if it is shown to influence another in a positive way. In other words, if Latin America can experience more freedom by the generation and production of more crops, then steps should be taken to do just that. If we know that health and GDP are strongly correlated, then efforts should be taken to improve at least one knowing it will positively affect the other.

The area of world poverty is one that will always require future research. A viable extension of this work is to replicate the analysis for other parts of the world to better discern geographic differences in what variables may influence poverty. Another extension of this work is to use different algorithms through TETRAD IV, as well as different ordering of events. It would also be useful to include additional economic and social variables in the analysis.

It is perhaps too much to ask if it would be possible to actually identify what causes poverty. Being able to decrease poverty on a local level is often difficult, let alone a global level. The idea of how to "best handle" the problem of reducing world poverty can often seem overwhelming and even impossible. However, that does not mean that it

is not a worthy cause to study and to try and help with. Indeed, those of us who are

fortunate enough not to live in poverty should be more inclined to think about this

problem than those who do actually live in it. Why? Because our thoughts, ideas, and

help are perhaps the beginning to the pathway out of poverty for those mired in it. The

best route to mark out is a subjective one, but the biggest mistake would be not taking

that first step down the path.

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APPENDIX

Table 1. Data - Latin America.
Please refer to page vii for a list of acronym definitions.

Country	2da	gin	fre	agi	lfe	rur	imo
Bolivia	51.4	42.0	2.7	1072.0	61.5	39.3	85.0
Brazil	25.4	63.4	3.5	4099.0	67.0	20.4	44.0
Chile	18.4	56.5	2.5	5658.0	75.2	15.6	13.0
Columbia	28.7	51.3	3.1	3426.0	69.8	28.2	30.0
Costa Rica	23.3	46.1	2.9	4733.0	76.5	53.2	14.8
Domin Rep	16.0	50.5	3.2	2472.0	70.4	38.2	47.0
Ecuador	52.3	46.6	3.1	1710.0	68.1	39.7	39.0
El Salvador	54.0	50.8	2.4	1690.0	69.4	55.0	39.0
Guatemala	33.8	59.6	2.7	2111.0	64.2	61.4	57.0
Honduras	68.8	52.7	3.3	1018.0	68.7	52.5	48.0
Jamaica	25.2	41.1	2.8	1426.0	74.4	46.3	26.0
Mexico	34.8	50.3	3.1	1705.0	71.5	26.6	38.4
Panama	25.1	56.6	2.5	2475.0	74.0	45.0	25.7
Paraguay	49.3	57.7	2.8	3484.0	69.7	47.6	28.0
Peru	41.4	44.9	2.9	1465.0	67.8	29.1	52.0
Trinidad	39.0	40.3	2.6	2057.0	71.6	28.3	19.4
Uruguay	6.6	42.3	2.8	6657.0	72.6	10.0	19.8
Venezuela	44.6	53.8	3.4	5083.0	72.8	14.5	25.2
Country	gdp	ill	aid	nrs	brt	trd	hlt
Bolivia	919.8	18.4	78.6	23.0	34.2	49.9	120.0
Brazil	4482.7	17.2	1.6	10.0	20.3	16.3	462.0
Chile	4858.3	5.2	10.8	4.0	19.7	59.6	423.0
Columbia	2403.1	10.0	2.0	13.0	25.5	36.0	410.0
Costa Rica	3419.7	5.3	22.5	6.0	24.1	83.0	428.0
Domin Rep	1607.9	18.8	7.9	28.0	26.2	66.2	206.0
Ecuador	1563.9	10.9	18.9	5.0	26.3	53.9	151.0
El Salvador	1669.4	24.6	54.9	11.0	28.5	55.0	270.0
Guatemala	1473.2	35.6	22.4	24.0	36.7	40.4	92.0
Honduras	705.6	29.0	53.4	22.0	34.9	99.1	198.0
Jamaica	1782.7	15.9	43.7	10.0	23.3	108.2	162.0
Mexico	3250.6	10.6	4.7	5.0	30.8	62.3	354.0
Panama	3039.8	9.7	11.8	16.0	23.5	78.9	390.0
Paraguay	1842.7	8.4	19.8	13.0	31.8	73.9	225.0
Peru	2293.1	12.5	14.5	18.0	27.0	31.2	246.0
Trinidad	4356.3	7.6	16.9	13.0	14.9	92.9	270.0
Uruguay	5975.2	2.8	23.3	4.0	17.8	39.6	740.0
Venezuela	3461.8	9.4	1.3	16.0	25.5	57.8	241.0

Table 1. Data - Latin America – Continued.

Country	cin
Bolivia	150.0
Brazil	119.00
Chile	123.0
Columbia	100.0
Costa Rica	125.0
Domin Rep	95.0
Ecuador	129.0
El Salvador	99.0
Guatemala	120.0
Honduras	120.0
Jamaica	134.0
Mexico	120.0
Panama	73.0
Paraguay	107.0
Peru	140.0
Trinidad	103.0
Uruguay	109.0
Venezuela	111.0

Table 2. Data - Sub-Saharan Africa.
Please refer to page vii for a list of acronym definitions.

Country	2da	gin	fre	Agi	lfe	rur	imo
Botswana	61.4	50.0	3.3	473.0	60.8	71.5	62.0
C. Afr.Rep.	84.0	40.9	3.3	380.0	47.6	60.9	157.0
Cote Divor	49.4	36.9	3.5	1004.0	47.6	56.7	180.6
Ethiopia	76.4	40.0	3.6	136.0	44.1	84.6	175.0
Gambia	84.0	47.8	3.4	233.0	50.8	71.0	127.0
Ghana	74.6	33.9	3.2	554.0	60.0	64.1	104.0
Kenya	62.3	57.5	3.4	222.0	52.6	71.4	112.0
Lesotho	65.7	56.0	3.7	516.0	58.3	76.0	137.0
Madagascar	89.0	43.4	3.3	187.0	53.5	73.5	158.0
Mali	90.6	50.5	3.3	261.0	44.0	73.2	238.0
Mauritania	68.7	42.4	3.8	444.0	52.7	48.8	149.0
Mozambique	78.4	39.6	4.1	121.0	44.6	66.2	201.0
Namibia	55.8	40.9	2.9	1062.0	58.5	71.4	100.5
Niger	85.3	36.1	4.0	194.0	45.5	81.8	260.0
Nigeria	90.8	37.5	3.3	629.0	50.1	60.5	147.0
Rwanda	84.6	28.9	4.3	326.0	47.5	94.3	202.0
Senegal	67.8	54.1	3.7	317.0	51.5	56.2	130.0
Sierra Leon	74.5	40.9	3.5	426.0	35.2	66.7	286.0
So Africa	35.8	58.4	3.0	3486.0	62.9	50.7	70.0
Tanzania	59.7	38.1	3.5	176.0	49.4	73.1	147.0
Zambia	87.4	46.2	2.9	210.0	43.1	60.8	188.5
Zimbabwe	64.2	56.8	3.8	312.0	56.1	68.2	107.7
Country	gdp	ill	aid	nrs	brt	trd	hlt
Botswana	3502.1	28.1	60.1	27.0	35.1	90.6	205.0
C. Afr.Rep.	321.1	61.4	51.3	50.0	37.9	38.4	30.0
Cote Divor	746.9	60.6	118.4	14.0	38.0	86.0	50.0
Ethiopia	109.8	67.8	19.5	49.0	47.1	40.5	21.0
Gambia	340.7	69.5	64.7	16.0	43.2	113.0	62.0
Ghana	385.8	36.2	32.8	10.0	33.2	71.6	66.0
Kenya	342.1	24.0	25.7	43.0	35.2	69.4	79.0
Lesotho	521.2	19.7	61.5	29.0	35.7	143.5	30.0
Madagascar	235.3	38.5	22.4	40.0	43.6	46.3	17.0
Mali	258.4	68.4	46.9	32.0	48.8	55.8	21.0
Mauritania	470.9	61.2	117.9	13.0	41.4	103.0	78.0
Mozambique	157.9	62.4	77.8	58.0	42.3	46.6	23.0
Namibia	2080.3	22.2	91.2	31.0	36.9	123.4	428.0
Niger	205.4	87.1	42.6	46.0	52.3	40.4	23.0
Nigeria	256.1	45.1	1.8	8.0	41.6	75.6	21.0
Rwanda	221.4	43.5	114.6	39.0	43.5	31.7	32.0
Senegal	549.7	68.1	78.9	23.0	39.8	73.9	59.0
Sierra Leon	196.4	60.0	62.6	43.0	47.1	49.6	31.0
So Africa	3943.3	17.0	7.7	0.0	28.7	47.7	574.0
Tanzania	180.2	31.1	33.5	41.0	41.8	51.9	14.0
Zambia	401.5	27.7	82.2	45.0	43.2	70.2	39.0
Zimbabwe	697.6	16.00	52.00	37.00	33.04	72.00	147.00

Table 2. Data - Sub-Saharan Africa – Continued.

Country	cin
Botswana	68.0
C. Afr.Rep.	97.0
Cote Divor	116.0
Ethiopia	111.0
Gambia	69.0
Ghana	167.0
Kenya	109.0
Lesotho	90.0
Madagascar	105.0
Mali	115.0
Mauritania	149.0
Mozambique	130.0
Namibia	88.0
Niger	98.0
Nigeria	135.0
Rwanda	96.0
Senegal	110.0
Sierra Leon	101.0
So Africa	93.0
Tanzania	94.0
Zambia	81.0
Zimbabwe	100.0

VITA

Garnett Murphy Anderson II

Permanent Address

Garnett Murphy Anderson II
Department of Agricultural Economics
Texas A&M University
2124 TAMU
College Station, TX 77843-2124

Educational Background

University of Louisiana at Lafayette
B.S. Professional Land and Resource Management
December 1996

Texas A&M University
M.S., Agricultural Economics
August 2007