MODELLING THE KEY DETERMINANTS OF CHILD LABOUR IN SOMALIA

BY

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A Research Project Submitted to the school of Mathematics, University of Nairobi, in Partial Fulfillment for the requirements of the Award of the Degree of Master of Science in Social Statistics

JUNE 2014
DECLARATION

Declaration by student

This research project is my original work and has not been submitted for a degree in any other university.

Signature ………………………………………. Date …………………………………………..

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(I56/79298/2012)

Declaration by Supervisor

This project has been submitted for examination with my approval as University supervisor.

Signature ………………………………………. Date …………………………………………..

Dr. N. Owuor Onyango

SCHOOL OF MATHEMATICS
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I am greatly indebted to my dear parents, brothers and sisters for their prayers. Last but not least, my word of thanks goes to my classmates for their fruitful comments and encouragement: especially David Gitahi, Andrew Wachira, Mary Mwangi, Sheilla Otieno, Mike Okal.
DEDICATION

TO

My beloved wife, Amina Ali Gedi

And to

My kids, Abdilwadud, Nabila and Abdirra’uf
# Table of Contents

DECLARATION ................................................................................................................................. ii

ACKNOWLEDGEMENT ................................................................................................................... iii

DEDICATION ................................................................................................................................. iv

LIST OF TABLES ........................................................................................................................... vii

LIST OF FIGURES ........................................................................................................................ viii

LIST OF ACRONYMS ...................................................................................................................... ix

ABSTRACT ...................................................................................................................................... x

CHAPTER ONE: INTRODUCTION ................................................................................................... 1

1.0 Introduction ................................................................................................................................. 1

1.1 BACKGROUND OF THE STUDY ............................................................................................... 2

1.1.1 The ILO Concept and Definition of Child Labour ................................................................. 2

1.1.2 The UNICEF Concept and Definition of Child Labour ......................................................... 4

1.1.3 Child labour and the MDGs .................................................................................................. 5

1.2 Problem Statement ..................................................................................................................... 11

1.3 Objectives of the study ............................................................................................................ 12

1.4 Research Questions ................................................................................................................ 12

1.5 Justification of the study .......................................................................................................... 12

1.6 Scope of the study .................................................................................................................. 13

1.7 Organization of the study ....................................................................................................... 13

CHAPTER TWO: LITERATURE REVIEW ......................................................................................... 14

2.0 Introduction ............................................................................................................................... 14

2.1 Literature review .................................................................................................................... 14

2.2 Conceptual framework ........................................................................................................... 18

2.3 Summary of the Literature Review ......................................................................................... 21

CHAPTER THREE: METHODOLOGY ............................................................................................... 22

3.0 Introduction ............................................................................................................................... 22

3.1 Theoretical Model ................................................................................................................... 22

3.2 Model Specification ................................................................................................................ 27

3.3 Estimation Method .................................................................................................................. 29

3.4 Variable Definition ............................................................................................................... 33
LIST OF TABLES

Table 1.1: Child labour and its sex distribution in 2012 ....................................................... 8

Table 1.2: Net Primary School enrolment (%) ........................................................................ 10

Table 3.1: Definition of variables used in the study ................................................................. 33

Table 4.1: Number of Children Who Work by Working Status .............................................. 37

Table 4.2: Descriptive Statistics by Working Status .............................................................. 38

Table 4.3: Wealth quintiles by child work status ................................................................. 39

Table 4.4: Binary Logistic Regression Results ..................................................................... 42
LIST OF FIGURES

Figure 2.1: Conceptual Framework ......................................................... 20
<table>
<thead>
<tr>
<th>ACRONYM</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSFR</td>
<td>Constitution of Somalia Federal Republic</td>
</tr>
<tr>
<td>EC</td>
<td>European Commission</td>
</tr>
<tr>
<td>GDP</td>
<td>Gross Domestic Product</td>
</tr>
<tr>
<td>GER</td>
<td>Gross Enrolment Rate</td>
</tr>
<tr>
<td>GLM</td>
<td>Generalized Linear Models</td>
</tr>
<tr>
<td>HH</td>
<td>Household</td>
</tr>
<tr>
<td>LPM</td>
<td>Linear Probability Model</td>
</tr>
<tr>
<td>MDGs</td>
<td>Millennium Development Goals</td>
</tr>
<tr>
<td>MICS</td>
<td>Multiple Indicator Cluster Survey</td>
</tr>
<tr>
<td>MLE</td>
<td>Maximum Likelihood Estimates</td>
</tr>
<tr>
<td>MoEHE</td>
<td>Ministry of Education and Higher Education</td>
</tr>
<tr>
<td>PAPFAM</td>
<td>Pan Arab Project for Family</td>
</tr>
<tr>
<td>PRSP</td>
<td>Poverty Reduction Strategy Paper</td>
</tr>
<tr>
<td>UN</td>
<td>United Nations</td>
</tr>
<tr>
<td>UNDP</td>
<td>United Nations Development Programme</td>
</tr>
<tr>
<td>UNESCO</td>
<td>United Nations Educational, Scientific and Cultural Organization</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
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</table>
ABSTRACT

Child labour is an effect of many factors that are addressed in the Millennium Development Goals (MDGs). Historically, programmes and policies have not been rolled out to address child labour owing to the fact that this has not been adequately captured or analysed in national data and statistics.

The main objective of this study was to investigate the key determinants of child labour in Somalia. The study focused on children aged between 5 and 14 years using the Somalia 2006 Multiple Indicator Cluster Survey (MICS) Data. Binary logistic regression was conducted to analyse the data. The explanatory variables are: child age and gender, parental education, family size, wealth, regions, and area of residence.

The logistic results show that the child’s age and gender, parent’s education, wealth, regions and area of residence are important determinants of child labour in Somalia. The findings indicate that the chance for child to be engaged in work increases with age. The boys had less chance to work compared to the girls. Wealth has negative influence on the chance for child labour. The results show that the literacy of father and mother decreases the chance of sending child to work. The logistic results also found regional disparities in child labour. Children from North West and North East had lower chance to be engaged in work than children from South central.

Policy interventions focusing on increasing adult literacy and income of households in rural and urban areas of Somalia have potential to decrease child labour. Targeting of educational resources allocation to the regions with high child labour rates should be enhanced.
CHAPTER ONE: INTRODUCTION

1.0 Introduction

High level of child labour phenomenon is considered to be a major obstacle to Millennium Development Goals (MDGs) and Poverty Reduction Strategy Paper (PRSP) (Global March Against Child Labour, 2013). The child labour problem is a major concern in conflict and post conflict situations like Somalia aiming to revive their human capital development. This study focuses on the key determinants of child labour in Somalia.

Before gaining independence in 1961, Somalia was colonized by both British and Italian. British colonized North West regions (current Somaliland), while Italian colonized the other regions (current Puntland and South Central Somalia). Somalia’s population was estimated to be around 4.12 million from its first census in 1975. This population grew to about 6.28 million before the ousting of Siad Barre’s government in 1991 (UNDP, 1997). In 2012 the population was estimated to be about 10.1 million in which 37% lived in the urban areas (World Bank, 2012).

Households in Somalia engage in different economic activities in order to generate income (World Bank, 2012). 50% of the population generates their income from self employment while 14% generate income from wage employment. 22.5% rely on remittances while the remaining 13.5% collects rent and receive aid as their sources of income (World Bank, 2006).

The state of Somalia currently is broken out into three zones brought about by the civil war. The three zones are the Central South Regions, Somaliland in Northwest, and Puntland in Northeast. Puntland and Somaliland have functional democracies leading to gain in education access (UNESCO, 2011). This study will focus attention on key determinants of child labour in Somalia.
1.1 BACKGROUND OF THE STUDY

Child labour doesn’t have a universally accepted definition. In most cases it is difficult to differentiate between the concept and definition of child labour. It has been argued by some authors that it is impossible to come up with a definition of child labour that captures all its features due to the complexity of child labour phenomenon. Weston (2005) equates child labour to social construct which differs by actors, history, context and purpose.

Different organizations dealing with issues of child labour differ in the concept and definition of child labour. World Bank, for instance, from its observation of the kind of destruction child labour has on long term investment, described it as a serious threat (Weston, 2005). On the other hand, ILO views child labour from the point of view of the long run effect it has on children in their day to day participation in income generating activities in the household while UNICEF looks beyond investment and economic activity, and incorporates work done domestically and not to the interest of the child (Huebler, 2006). This notwithstanding, there is need to agree on a universal definition for the purpose of policy making. The following subsection considers both ILO and UNICEF definitions.

1.1.1 The ILO Concept and Definition of Child Labour

ILO draws its concept of child labour from the ILO Minimum Age Convention No. 138 of 1973. The convention sets the minimum age which a child should engage in any form of employment as 15 years. *Any form of work that in violation of Convention No. 138 is considered child labour and illegal and should therefore be stopped.* ILO went ahead and introduced child work and child labour. According to ILO child work may be acceptable while child labour should be eliminated.
Four groups of children engaged in work or labour are identified below:

- Working children
  - Children who are economically active aged between 5 to 11 years are considered to be engaged in child labour. Also children aged between 12 to 14 years and are economically active are considered to be engaged in child labour except if they engage in light work for less than 14 hours per week.

- Children in hazardous work. Hazardous work is any form of work likely to cause harm to the health, safety and moral development of a child. This group involves children working in mines, construction or other hazardous activities and includes children aged 18 years and below and working 43 hours or more per week.

- The last group is those children involved in the worst forms of labour as defined by ILO Convention No. 182. It includes children in forced or bonded labour, armed conflict, prostitution and pornography, and illicit activities.

The “worst forms of child labour” comprise: (a) slavery and forced labour, including child trafficking and forced recruitment for armed conflict; (b) the use of children in prostitution and pornography; (c) the use of children in illicit activities; and (d) any activity or work by children that, by its nature or conditions, is likely to harm or jeopardize their health, safety or morals – often referred to as “hazardous work” (ILO, 2013).

Two points come out from this view of ILO. Firstly, from the four groups we see the first group covering all activities which seem to right according to ILO, while the second and third groups cover activities of child labour which needs to be eliminated and the fourth group gives a picture that needs an urgent action for elimination.
ILO does not include children under the age of 5 since they are considered too young to be working. The second point is that this definition only considers work that can generate income such as production of goods and services. There is no mention of household chores such as cooking, cleaning or taking care of young ones. Gibbons, Huebler & Loaiza (2005) in criticizing the ILO definition, argue that it is too narrow since it underrates the harm that work has on children especially girls who mostly perform household work compared to boys.

1.1.2 The UNICEF Concept and Definition of Child Labour

The ILO definition of child labour has been expanded by UNICEF by considering the domestic work done by children apart from the economic work. Child labour is defined by UNICEF as follows:

- Children 5 -11 years engaged in any economic activity, or 28 hours or more domestic work per week;
- Children 12-14 years engaged in any economic activity (except light work for less than 14 hours per week), or 28 hours or more domestic work per week;
- Children 15-17 years engaged in any hazardous work.

The goodness with the UNICEF definition is that it captures all work done by children. This definition also gives an indication of child labour which is harmful to children’s physical or mental development. However, it is of limited value for an analysis of the trade-off between work and school attendance.
1.1.3 Child labour and the MDGs

Child labour is linked to MDGs through their cause and effect. The relationship between child labour and MDGs is that the problems that MDGs seek to address are what cause child labour. The major problem among them is poverty covered under MDG 1 together with reducing people who suffer from hunger. Low levels of primary school enrolment especially for girls (MDG 2 & 3). There were also limited or no basic services covered under MDG 4, 5, 6 & 7 that would reduce child mortality, improve maternal health, combat HIV/AIDS, malaria and other major diseases and ensure environmental sustainability. Finally, there was a problem related to poor public policy covered under MDG 8. Further, child labour makes achievement of MDGs difficult due to the invisibility of children engaged in child labour from the national statistics and plans making them to be left out of the programs and policies.

It is widely known that there are young people who work in the labour market for wages while others work in the family without pay. In the recent past there has been a growing interest on the part of international organizations, researchers and governments to understand the factors that determine both supply and demand of child labour.

The 18th century ushered the Industrial Revolution in Great Britain. It is during this revolution that child labour which was a social problem associated with industrial production and capitalism, and accepted in agricultural societies in the early ages start to be opposed. The opposition of child labour became enormous in other countries that were industrializing in the following century (Shahrokhi, 1996).
As of 2013, ILO estimated the number of children in the ages of 5 – 17 years who were engaged in employment to be 264 million worldwide. 11 per cent of this age group (168 million) was child labourers. Of this 168 million, about half (85 million) were engaged in hazardous work which directly endangers their health, safety and moral development (ILO, 2013).

Children who are actively engaged in economic activities worldwide can be disaggregated as follows: 2.5 million are found in developed countries while transition economies account for 2.4 million children. Asia and Pacific has the highest number of children in employment at 127.3 million while Latin America and the Caribbean has 17.4 million. Sub-Saharan Africa together with Middle East and North Africa account for the remaining 48 million and 13.4 million child labourers respectively.

Studies have found out those employees who are aged below 18 years to be vulnerable to particular hazards. For instance, a study conducted by ILO in the US finds that the rate at which children and adolescent children are injured per an hour worked was twice that of adults. A similar study in Denmark, Finland, Norway and Sweden in 1998-99 among working children at the ages of 13 – 17 years found an injury rate of between 3 to 19 percent of children working before and after school. In developing countries, the rate of injury and illness per 100 children was found to range from a low of 12% in agriculture for boys to a high of 35% in construction for girls (ILO, 2002).

Since Africa has the highest incidence of economically active children with 41 per cent of the children involved in work, the dominant work engaged in is agriculture where more than 30 per cent of children aged between 10 and 14 years are engaged in.
Despite the high rates of child labour, there has been a fall in the incidence of child labour especially for girls in the period from 2000 – 2012 by a whopping 40 per cent compared to a reduction of 25 per cent for boys. This reduction in girls’ employment is attributed to the campaign on girl child education as well as gender equality progress. The number of children in employment in the age group of 5 – 17 years in 2012 is high for boys compared to girl; that is 99.8 million boys versus 68.2 million girls. Although there is a little difference by sex in the number of child labourers aged between 5 – 14 years in table 1.1 (51% are boys and 49% are girls), the gender gap between the ages group of 15 – 17 years (81% boys and 19% girls) is considerable while about 52.3% of child labourers in the 12 – 14 years category are boys (ILO, 2013).
Table 1.1: Child labour and its sex distribution in 2012

<table>
<thead>
<tr>
<th>Sex and age group</th>
<th>Number of child Labourers (,000)</th>
<th>Distribution by Sex (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5-11</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>73072</td>
<td>100</td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>12-14</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>47381</td>
<td>100</td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total 5-14</strong></td>
<td><strong>120453</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>Boys</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total 15-17</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boys</td>
<td>47503</td>
<td>100</td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total 5-17</strong></td>
<td><strong>167956</strong></td>
<td><strong>100</strong></td>
</tr>
<tr>
<td>Boys</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: ILO, 2013

The above statistics indicate the intensity of child labour and the need to address it, in order to eliminate its adverse effects on human capital development and the future growth potential of developing countries.
The literature distinguishes *child labour* and *child work*, where the latter is the more unharmful and probably healthy kind, and includes helping household in various chores and household activity.

Children engage in child labour activities mostly after school hours or when they are on holidays and it is almost impossible not to engage in child labour if the child is from rural areas. Children who are above the ages of 12 or 13 years are allowed by ILO Minimum Age Convention to participate in light work such distributing newspapers given certain conditions (ILO, 1995).

Somalia has not taken into consideration the issue of child labour for some time. This can be attributed to the civil conflict which afflicted the country for the last two decades which forced children to engage in labour activities. Also there is almost no data that can be used to address child labour problem in Somalia. It is argued that most children in the labour market find themselves there due to the high levels of poverty and unemployment in the country. The worst form of child labour is urban child labour that is driven by rising number of street children as well as displaced families who find haven in the city streets.

It is believed that children ought to work to help their families. This is derived from the fact that the country has high levels of poverty as well as unemployment rates hence necessitating the need to have children generate income for the families through working. This is usually due to lack of other alternatives of family income.

Lack of human capital development has been the main challenge affecting Somalia’s growth prospects. This is due to high non-school attendance rate worsened by wide gender disparities.

Ministry of Education and Higher Education estimates that among 10 school aged children in Somalia only 4 attend school. Further, it is estimated that only 710,860 children in Somalia out
of 1.7 million primary age children are enrolled to school despite a significant increase in school enrolment in the previous eight years. According to 2011 data collected by MoEHE, 42 per cent of school aged children are enrolled to school (MoEHE, 2011).

School enrollment is not the only issue in Somalia, but also gender inequalities. It is reported that among the teachers employed in Somalia, only 15 per cent are females who are mainly unqualified.

Somalia is divided into three zones namely; Puntland (PL), Somaliland (SL) and South Central (SC) zones. This division was brought by the collapse of the government in 1991. Table 1.2 below illustrates the primary school net enrollment in the three zones in 2007. Primary school net enrollment rate for Somalia in 2007 was reported as 32 per cent.

Table 1.2: Net Primary School enrolment (%)

<table>
<thead>
<tr>
<th>Region/Zone</th>
<th>Female</th>
<th>Male</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Central</td>
<td>17.41</td>
<td>18.33</td>
<td>17.87</td>
</tr>
<tr>
<td>Somaliland</td>
<td>41.89</td>
<td>54.61</td>
<td>48.25</td>
</tr>
<tr>
<td>Puntland</td>
<td>29.82</td>
<td>31.56</td>
<td>30.69</td>
</tr>
<tr>
<td>Total</td>
<td>29.71</td>
<td>34.82</td>
<td>32.27</td>
</tr>
</tbody>
</table>

Source: European Commission, 2009

In table 1.2 obviously these enrolment rates correlate with zonal political stability. Somaliland and Puntland are politically stable unlike South and Central zone which has been politically unstable a longer duration of time.
1.2 Problem Statement

The development of any nation depends on its human resource but child labour hinders human resource development (JAMON, 2010). Child labour greatly contributes to the poverty rate among the community as it increases the dropouts of children from schools; it also decreases the school enrollment rate. In contrast, education equips one with life skills which enables him/her to move from poverty to prosperity, it is a part of any solution of eliminating /reducing the child labour. Despite the potential disadvantages and hardships for children engaged in child labour, school enrollment and attendance rates are very low in Somalia (MoEHE, 2011). The child labourers are almost 50% of all the children in Somalia (UNICEF, 2007).

It is not clear what explains the high child labour rate in Somalia, as very few studies have been conducted about the problem of child labour. In order to address the key determinants of child labour, there is a need to have a clear understanding of the nature and causes of child labour in Somalia. Without this knowledge, it would be difficult to formulate policies and interventions to eliminate/reduce the phenomenon of child labour across the country.

This study examines the factors influencing the family’s decision to subject the child to work in both conflict and non-conflict areas in Somalia with especial attention to gender, regions, and residence differences. Being binary response variable, logistic model is used to analyse and estimate the determinants of child labour in Somalia.
1.3 Objectives of the study

The general objective of this study is to investigate and identify the key determinants of child labour in Somalia by employing Mathematical regression.

The specific objectives of the study include:

a) To identify factors influencing family’s decision to send the child to work in Somalia using the Binary logistic model.

b) To draw policy implications based on findings of the study to minimize the activities of child labour.

1.4 Research Questions

This study attempts to answer the following questions:

a) Which factors influence family’s decision to send the child to work?

b) How can the problem be addressed by different stakeholders?

1.5 Justification of the study

The future of every nation lies in her children and this can only be realized if the children are well equipped with the necessary skills to enable them take over from the aging population. Child labour from literature available indicates that it depends to a great extent on the income of the family and the educational level of parents concerned. This study is expected to throw more light into the “problem” of child labour in the region especially in the study area. It also seeks to bring awareness of the issues to the local community and how to address them. The findings from the study will help authorities concerned to know the magnitude of the problem in the study area. The recommendations if implemented can help minimize the effects of the problem of child
labour in the study area. The research findings will also add to the existing literature of knowledge. The research findings and recommendations will stimulate interest in the area and call for further research in future.

1.6 Scope of the study

Geographically, the study will cover three zones in Somalia (Somaliland, Puntland, and South Central). There are disparities in terms of political stability and population density among the zones.

The study focus on the determinants of child labour in Somalia for children aged 5 to 14 years. The study uses household survey data comprises of all the three zones.

1.7 Organization of the study

The research has been organized into five chapters. The first chapter introduces the research, identifies the key problem under investigation and states the specific objectives for the research. It further, asks the relevant research questions, gives a justification for the topic, and defines its scope. The second chapter presents a review of relevant literature on child labour and the framework of relevant variables. Chapter Three contains the data source, explains the methods and procedures used in the study, and defines the key data variables.

The results are presented in chapter four. This is a very important chapter in the research because it provides the information to answer the research questions raised. The findings are based on the data analysed in this chapter. Chapter five contains conclusion and policy implications.
CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

In this chapter, we review literature on how other researchers have applied determinants of child labour in analyzing similar data as used in this study. The section on literature review focuses on the objectives of the studies, the methods of data collection, data analysis techniques, the variables used in the study, and results of the data analysis. The other section examines the conceptual framework of the study. The chapter ends with a summary of the reviewed literature.

2.1 Literature review

Laurent and Sébastien (2010) investigated characteristics and determinants of child labour in Cameroon, using data from the Cameroonian survey on employment and informal sector. In this study, Binary probit and Tobit models were estimated using child time of work as the dependent variable. Independent variables used were grouped into: individual’s characteristics which are: the sex, the age; the relationship with the household (biological child of the household head). Household environment: the household income, the residence, the size and the composition of household. Finally, household head’s characteristics: the level of education, the type of employment, the age and sex. They found in the estimated models, an increase in income together with increase in household size resulted to a reduction in the time that a child spent on work. Also their study found that an increase in the place of residence together with an increase in the level of education of household head could result to a reduction in the time spent by children working. All the variables in the study were found to be statistically significant except the level of education of the household head which was statistically insignificant. This implies that an increase in adults’ income by 1 per cent would result to a decrease in time spent by
children to work by more than 2 hours. The reduction tends to favor girls since their working time reduces by 3 hours compared to boys’ 1 hour 30 minutes. Time of work is more sensitive in urban areas compared to rural areas in regards to household income variations. Additionally, when the household size increases by one person, the study found that it results in reduction of time spent by children working by 0.6 per cent in favor of boys (-0.64%) than girls (-0.55%). In terms of residential areas, children in urban areas tend to benefit more compared to their counterparts in the rural areas.

Age of a child also has a significant effect on the time spent on work by a child. Older children allocate more time to economic work. Being a child of the household head reduces time in hours that young boys are allocated to work in economic activities by 0.33%. Also children living with their parents in the urban areas were found to allocate 0.69% less time for work. Households headed by females were found to allocate less time to work for their children compared with those headed by males. In addition households headed by females allocated more time domestic works so as to enable their children spend time studying. These households have higher and significant probability of sending children to school.

Moyi (2011) examined the causes and magnitude of child labour in Kenya. The data used for this study was drawn from the second round (2000) of the Multiple Indicator Cluster Survey (MICS). Multinomial logistic regression was used in this paper. The variables used in this study were classified as to the children, household, and community characteristics that influence child labour and school participation. Age, gender, and the relationship to the head of household and the children’s number of siblings, gender of the head of household, and education of the head of household, have impact on school and/or work participation. The income of the household,
employment status of the mother, and the place of residence are some household characteristics that may impact school and/or work participation.

This study hypothesized that the socioeconomic status and structure of the household would a strong effect on child labour as well as many children who were working to be attending school. The study found children’s activities to affected by their age and gender, how they are related to the household head, education level of the household head, wealth of the household and the children present in the household. Although the study found that children of the household head were less likely to be working only and attending neither school nor work; however, they had a higher probability of combining both school and work. Urban children were found to combine school and work four times less likely compared to their rural counterparts. The study recommended that policy makers formulate policies which would factor education inequality dimension between children who combine work and school and those who do not combine if the effect of working is going to hinder children from attaining education.

Rubkwan (2008) investigated the various factors that influence a household's decision of sending a child to work. This presented a detailed empirical analysis of the determinants of child labour in Thailand. Econometric analysis is carried out using data from the Thailand labour force survey (National Statistic Office Thailand, 2003). Multiple regression model was estimated using number of hours children worked in the last 7 days before the survey (child time of work) as the response variable. The explanatory variables in this paper were classified as: The ‘children’ characteristics that are age and wage. The ‘household’ characteristics which are the household’s monthly income, region of residence, number of children, gender of household head, age of household head, parental education, and occupation of household head.
However, the ‘school’ and ‘community’ characteristics were not incorporated due to the limitation of the dataset.

The estimates of the model indicated that wage impacted significantly on the time that children allocate to work. Age had significant effect on boys but insignificant on girls. This implied that the older the boy became, the more time he would be allocated to work. Boys and girls in urban areas were found to work fewer hours compared to their counterparts in the rural areas. The effect was more on boys than in girls. The size of the household affected the working time of children positively. This implies that households that had more members had their children working more hours. Girls tend to benefit from household’s head age. This implies the more the age, the more the time boys are allocated work compared to girls. Educated parents were found to allocate fewer working hours for their children. The occupation of the household head was also found to affect the working time of children. Children from households in which occupation of the household head is related to agriculture were found to be involved in some form of work.

Jay, Mima, Nadine, George and Noreen (2007) had identified and examined the relationship of child labour with a large set of possible factors with the UNICEF data for analysis on 175 countries. Regression model was conducted using total child labour (the ratio of children employed in their total population) as dependent variable. The explanatory factors used in the study were: female literacy in the country (mother’s education), economic growth rate (GDP growth rate) and the proportion of population with income less than dollar a day (poverty).

The results were found, showed that a 1 percentage point rise in female literacy can reduce total child labour in a country by 25 percent. Similarly, a 1 per cent point reduction in population
below dollar a day can reduce 21 per cent point in total child labour. Economic growth is quite an effective factor, especially in reducing female child work.

### 2.2 Conceptual framework

A household decision to either send or not to send a child to work is usually a function of a number of factors. As child labour has enormously adverse effects on human capital development, researchers have investigated the factors that influence child labour using quantitative methods.

The frequently used variables in previous literature review about child labour can be classified into 4 groups: children, household, school, and community characteristics. ‘Children’ characteristics include gender, age, wage, relationship with the household, and birth order. ‘Household’ characteristics are household income, parental education, occupation, household head, gender of household head and the number of children and/or household size. ‘School’ characteristics are the distance from home to school and the quality of school. Finally, ‘community’ characteristics are the location, infrastructure, and neighborhood.

In conclusion, the successful answers of these factors eliminate/reduce the child labour while the existence of those factors contributes the child labour phenomenon as in Figure 2.1.
Figure 2.1: Conceptual Framework

Determinants of Child Labour

Individual/Child Characteristics
- Age
- Gender
- Birth Order
- Relationship with HH
- etc

Household Characteristics
- Household Income
- Parental Education
- Household Size
- Gender/Age of HHH
- Type of ‘Occupation
- etc

Community Characteristics
- Location
- Infrastructure
- Neighborhood
- etc

School Characteristics
- Distance from home to school
- Quality of School
- etc

Child at Work
Unsuccessful Elimination of Child Labour

Child at School
Successful Elimination of Child Labour

Source: Author, 2014
2.3 Summary of the Literature Review

The issue of child labour is evident from the reviewed literature, but the big problem with Somalia (and Africa in general), is the lack of reliable data capturing the magnitude of the problem. Several factors influencing child labour are: poverty; single parenting; ignorance of the parents; and strong socio-cultural beliefs. Poverty has come out as a major determinant of child labour in developing countries, with the vast majority of the children engaged in agricultural activities. A common socio-cultural belief common among rural dwellers is that child labour is part of a training program, and therefore considers them as essential contributors to household incomes.

Laws are important in fighting this vice, but if enforcement is patchy the situation is not helped - this is the case (as observed in the literature) beyond the formal sector where children get involved in agricultural and domestic chores.

For the purpose of this study, child labour is defined as any activity, economic or non-economic, performed by a child, that is either too dangerous or hazardous and/or for which the child is too small to perform and that has the potential to negatively affect his/her health, education, moral and normal development.

The legal definition of a child in Somalia is anyone who has not reached the age of maturity, which is 18 years (CSFR, 2012). It is accepted that children under 5 years are not physically capable of undertaking work of any significance, whether economic or non-economic. The target group for the study, therefore, comprised all children aged 5 to 14 years, engaged in economic or non-economic activities (including housekeeping/household chores in their own parent'/guardians’ household).
CHAPTER THREE: METHODOLOGY

3.0 Introduction

This chapter discusses the methodology employed in the study. The methods and the procedures discussed have been motivated by the reviewed literature in the previous chapter and the type of data available.

3.1 Theoretical Model

Binary Logit Model or Logistic Regression model is most useful when the response variable is not continuous but instead has only two possible outcomes (two dummy coded), 1 or 0. This model is typically used when predicting an event which has two possible outcomes.

Since the probability of an event must lie between 0 and 1, it is impractical to model probabilities with linear regression techniques, because the linear regression model allows the dependent variable to take values greater than 1 or less than 0. The logistic regression model is a type of generalized linear model that extends the linear regression model by linking the range of real numbers to the 0-1 range.

The binary response variable can be defined as

\[ Y = \begin{cases} 1, & \text{if child labour} \\ 0, & \text{if not child labour} \end{cases} \]

with \( Pr(Y = 1) = \pi \) and \( Pr(Y = 0) = 1 - \pi \); \( E[Y] = \pi \). \( Y \) is known as a Bernoulli random variable.

If the binomial variable \( Y \) with parameters \( n \) trials and \( \pi \) (probability of child labour in each trial) has a mean \( E(Y) = n\pi \) and variance \( \sigma^2 = n\pi(1 - \pi) \), Then the density is

\[ f(y) = \binom{n}{y} \pi^y (1 - \pi)^{n-y}, y = 1,2,3,\ldots,n \]
\[
= \binom{n}{y} \left(\frac{\pi}{[1 - \pi]}\right)^y (1 - \pi)^n
\]
\[
= \exp\left\{y \log\left(\frac{\pi}{[1 - \pi]}\right) + n \log(1 - \pi) + \log\left(\binom{n}{y}\right)\right\}
\]
which is in the form of exponential family of distributions (as indicated in the appendix I) with \(\theta = \log\left(\frac{\pi}{[1 - \pi]}\right)\) and hence \(\pi = \frac{e^\theta}{1 + e^\theta}\), \(a(\phi) = 1\), \(b(\theta) = n \log(1 + e^\theta)\), \(c(y, \phi) = \log\left(\binom{n}{y}\right)\).
Hence \(b'(\theta) = \frac{ne^\theta}{1 + e^\theta} = n\pi\) and \(b''(\theta) = \frac{ne^\theta}{(1 + e^\theta)^2} = n\pi(1 - \pi)\), so that \(E(Y) = n\pi\) and \(\text{var}(Y) = n\pi(1 - \pi)\) as required.

Logistic regression, like ordinary regression, can have multiple explanatory variables. Some or all of those predictors can be a dummy variable, rather than continuous measurement.

If more than one predictor variable is used to explain the response variable then the model becomes

\[
\text{logit}(\pi_i) = \ln\left(\frac{\pi_i}{1 - \pi_i}\right) = \sum_{j=0}^{p} x_{ij} \beta_j \text{for} i = 1, 2, \ldots, n.
\]
where \(x_{ij}\) is a matrix of the predictor variables, and \(\beta\) is a vector of the unknown regression parameters. A fixed change in \(x_i\) may have less impact when \(\pi_i\) is near 0 or 1 than when \(\pi_i\) is near the middle of its range. In this model the response and explanatory variables are linearly related since the range of the probability (0-1) is extended to real numbers by transformation of link function logit.

After exponentiating both sides of the model and simple algebraic calculations, the model is equivalent to \(\pi_i = \frac{e^{\sum_{j=0}^{p} x_{ij} \beta_j}}{1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j}}\) which gives a logistic curve.
Interpretation of the model parameters
The predictor variable \( x \) can either be a continuous measurement or a dummy variable corresponding to a categorical variable as both continuous and/or categorical predictor variables can be included in the logistic regression model. \( \beta_0 \) and \( \beta_i \) are unknown regression coefficients to be estimated.

(i) If the predictor is a continuous variable; for any two values of predictor \( X = k \) and \( X = k + 1 \) where \( k \) is a constant

\[
\frac{\pi_i}{1 - \pi_i} = e^{\beta_0 + \beta_1 k}
\]

Thus

\[
\text{Odds Ratio} = \frac{e^{\beta_0 + \beta_1 (k+1)}}{e^{\beta_0 + \beta_1 k}} = e^{\beta_1}
\]

\( e^{\beta_1} \) is the change in likelihood of event occurring for every additional measure of the predictor variable.

If \( \beta_1 = 0 \), then \( e^{\beta_1} = 1 \). The implication of this is that the predictor variable is not significant in predicting the response variable. Another interpretation is that if odds ratio is 1, then the odds of the event occurring for both groups is the same. Thus the value 1 for odds ratio used as a reference point for interpretation of odds ratio.

If \( \beta_1 < 0 \), then \( e^{\beta_1} < 1 \). The event is \( e^{\beta_1} \) times less likely to occur for every unit increase in predictor. Alternatively, the event is \( 100(1 - e^{\beta_1})\% \) less likely to occur for every unit increase in predictor.
If $\beta_1 > 0$, then $e^{\beta_1} > 1$. The event is $e^{\beta_1}$ times more likely to occur for every unit increase in predictor. Alternatively, if $1 < e^{\beta_1} < 2$, the event is $100(e^{\beta_1} - 1)\%$ more likely to occur for every unit increase in predictor.

(ii) If the predictor is a categorical variable, first select one level of the variable as a reference group and then create a dummy variable. For the dummy variable, for the reference group $X = 0$ and for the other level $X = 1$

$$\left( \text{odds when } X = 0 \right) = \frac{\pi_i}{1 - \pi_i} = e^{\beta_0 + \beta_1(0)}$$

$$\left( \text{odds when } X = 1 \right) = \frac{\pi_i}{1 - \pi_i} = e^{\beta_0 + \beta_1(1)}$$

Thus $O.R = \frac{e^{\beta_0 + \beta_1(1)}}{e^{\beta_0 + \beta_1(0)}} = e^{\beta_1}$

If $\beta_1 < 0$, the event is $e^{\beta_1}$ times less likely to occur for other group compared to the reference group. Alternatively, the event is $100(1 - e^{\beta_1})\%$ less likely to occur for other group compared to the reference group.

If $\beta_1 > 0$, the event is $e^{\beta_1}$ times more likely to occur for other group compared to the reference group. Alternatively, if $1 < e^{\beta_1} < 2$ the event is $100(e^{\beta_1} - 1)\%$ more likely to occur for other group compared to the reference group.

**STATISTICAL INFERENCE AND MODEL CHECKING**

The process by which coefficients are tested for significance for inclusion or elimination from the model involves several different techniques. The maximum likelihood estimators (MLE) are approximately normally distributed for large samples. Statistical inference based on the Wald statistic is simplest, but likelihood-ratio inference is more trustworthy (Alan, A., 2007).
**Inference about Model Parameters**

A $100(1 - \alpha)\%$ confidence interval for a model parameter $\beta$ equals $\hat{\beta} \pm z_{\alpha/2}SE(\hat{\beta})$, where $SE$ is the standard error of $\hat{\beta}$. The Wald test statistic $z = \frac{\hat{\beta}}{SE}$ has an approximate standard normal distribution when $\beta = 0$. Equivalently, $z^2$ has an approximate chi-squared distribution with $df = 1$. The 95% C.I for $OR = e^\beta$ is $\exp(\hat{\beta} \pm z_{0.025}SE(\hat{\beta}))$.

**Hypothesis testing:**

To test $H_0: \beta = 0$, vs. $H_1: \beta \neq 0$, we use Wald’s test statistic $\left(\frac{\hat{\beta}}{SE}\right)^2 \sim X^2(1)$ or P-value test statistic $p-value = 2 \times prob(Z > |z|)$. Reject $H_0$ if the p-value is less than $\alpha$.

To test $H_0: OR = 1$, vs. $OR \neq 1$, we reject $H_0$ at $\alpha$ level of significance if the 100(1-$\alpha$)% C.I for O.R does not contain 1.

**Goodness of model fit**

Let $L_M$ denote the maximized log-likelihood value for a model $M$ of interest. Let $L_S$ denote the maximized log-likelihood value for the most complex model possible. This model has a separate parameter for each observation, and it provides a perfect fit to the data. The model is said to be saturated. Because the saturated model has additional parameters, its maximized log likelihood $L_S$ is at least as large as the maximized log likelihood $L_M$ for a simpler model $M$. The deviance of a GLM is defined as

$$Deviance = -2\log\left(\frac{L_M}{L_S}\right) = -2(\log L_M - \log L_S)$$

For further details go to Appendix II.

The deviance is the log-likelihood ratio statistic for comparing model $M$ to the saturated model $S$. It is a test statistic for the hypothesis that all parameters that are in the saturated model but not in model $M$ equal zero. GLM software provides the deviance, so it is not necessary to calculate $L_M$ or $L_S$. For some GLMs, the deviance has approximately a chi-squared distribution.
\[ D = x^2(n - p) \]

Where \( n \) is the number of observations and \( p \) is the number of parameters estimated. The deviance statistic \( D \) describes a lack of fit in this case, the larger the value, the poorer the fit. A significant fit is one where the test gives a non significant result. Alternatively, one can use the null model (i.e. model with intercept only) to test for adequacy of the fitted model. In this case, the hypotheses are:

\( H_0: \) the null model is better fit vs. \( H_1: \) the fitted model is a better fit

The deviance statistic describes goodness of fit, i.e. a significant fit is one where the test gives a significant result.

### 3.2 Model Specification

Modeling child labour supply depends on the perception of child labour decision making process. Two aspects related to the process is whether the options are considered sequential or simultaneous. With sequential decision making process, the household head makes the first decision, that is, whether to send the child to school. Once this decision has been made, then the second decision is made, that is, whether to send the child to work. With simultaneous decision making, a choice is made by the household head from a pool of decisions on whether to send the child to school or work (Moyi, 2011).

Multinomial logit model is used in modeling simultaneous decision making while sequential logit model is used for sequential decision making process. The current study has assumed sequential decision making process and will use binary logistic model. Two options are contrasted in this study. The household face two discrete options in which they try to maximize utility. The households choose from the following two mutually exclusive activities:
1. Child works

2. Child does not work

Child does not work is the reference for this model.

The probability of a child engaging in work is given as:

$$\text{Prob}[Y_i = 1| i = 1,2,\ldots,n] = \pi_i = \frac{e^{\sum_{j=0}^{P}X_{ij}\beta_j}}{1 + e^{\sum_{j=0}^{P}X_{ij}\beta_j}}$$

Where $\beta = (\beta_1, \beta_2, \ldots, \beta_p)^T$ and $X_{ij} = (X_{i1}, X_{i2}, \ldots, X_{ip})$. The independent variables in vector $X$ include individual, household and community characteristics.

Individual child characteristics are age of child and gender of child. This study will take the children aged 5 to 14 years. The study expects that the older child age, the higher the probability that the child being engaged in work because the older the child the higher probability of assisting family. The study, however, expects female children labourers to be more likely to engage compared to boys due to cultural background of the community.

Household characteristics include household size, household wealth (asset ownership) and parent’s education. This study expects both education of the parents and wealth of the household to negatively influence probability of child labour. This implies that households with educated parents are more likely to withdraw their children from work as well as those households with higher wealth index, because of negative relationship of household wealth and child labour. The size of the household is expected to affect child engagement of work either positively or negatively, because of luxury and substitution axioms. These axioms are defined as follows:

Luxury Axiom: A family sends the children to the labour market only if the family’s income
from non-child labour sources drops below the subsistence level. Substitution Axiom: Child labour and adult labour are substitutes from a firm’s point of view.

Community characteristics include regions, and the type of residence. Households located in rural areas are expected to have high engagement of work compared to their counterparts in the urban areas, because in rural areas human capital development services are limited.

### 3.3 Estimation Method

Since the engagement of children in work is a discrete variable then binary choice model becomes appropriate for this study. The dependent variable takes the value of 1 or 0 (i.e. 1 if child works and 0 if child attends school). The objective of this study therefore is to estimate the relationship between the probability of a child working given the individual, household and community characteristics. Linear probability model (LPM), probit model and logit model are the three estimations approaches that are employed when dealing with binary dependent variables (Gujarati, 2007).

Although LPM is the simplest method of the three approaches, it violates the normality assumption as well as its probability estimates usually lie outside the 0-1 bound. An S-shaped probability model is needed for the study. What is chosen in practice is either probit or logit model because they not only correct the problem on non-normality but also their dependent variable tend to lie within the 0-1 range (Gujarati, 2007).

In the **probit model**, the link function for the model, called the **probit link**, transforms probabilities to $z$-scores from the standard normal distribution. When both models fit well, parameter estimates in probit models have smaller magnitude than those in logistic regression.
models. This is because their link functions transform probabilities to scores from standard versions of the normal and logistic distribution, but those two distributions have different spread. The standard normal distribution has a mean of 0 and standard deviation of 1. The standard logistic distribution has a mean of 0 and standard deviation of 1.8. When both models fit well, parameter estimates in logistic regression models are approximately 1.8 times those in probit models. The parameters of the model will be estimated using a MLE technique. The likelihood function for the model is specified as follows:

\[ L(\beta / y) = \prod_{i=1}^{n} e^{y_i \log \left( \frac{\pi_i}{1-\pi_i} \right) + n \log (1 - \pi_i) + \log \left( \frac{n}{y} \right)} \] ... (3.1)

Since the logarithm is a monotonic function, any maximum of the likelihood function will also be a maximum of the log likelihood function and vice versa. Thus, taking the natural log of Eq. 1 yields the log likelihood function:

\[ l(\beta) = \sum_{i=1}^{n} \left( y_i \log \left( \frac{\pi_i}{1-\pi_i} \right) + n \log (1 - \pi_i) + \log \left( \frac{n}{y} \right) \right) \] ... (3.2)

The maximum likelihood/ log likelihood estimates are the values of \( \beta \) that maximize the likelihood/ log likelihood function. The critical points of a function (maxima and minima) occur when the first derivative equals 0. If the second derivative evaluated at that point is less than zero, then the critical point is a maximum. Thus, finding the maximum likelihood estimates requires the first and second derivatives of the likelihood function. Knowing \( \log \left( \frac{\pi_i}{1-\pi_i} \right) = \sum_{j=0}^{p} x_{ij} \beta_j \) and after solving for \( \pi_i \) becomes \( \pi_i = \frac{e^{\sum_{j=0}^{p} x_{ij} \beta_j}}{1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j}} \). Then the log likelihood equation can be considerably simplified to;
To find the critical points of the log likelihood function, set the first derivative with respect to each $\beta$ equal to zero. Thus,

$$
\frac{\partial l(\beta)}{\partial \beta_j} = \sum_{i=1}^{n} \left( y_i x_{ij} - n \cdot \frac{e^{\sum_{j=0}^{p} x_{ij} \beta_j}}{1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j}} \cdot e^{\sum_{j=0}^{p} x_{ij} \beta_j} \cdot \frac{\partial}{\partial \beta_j} \left( \sum_{j=0}^{p} x_{ij} \beta_j \right) \right)
$$

$$
= \sum_{i=1}^{n} \left( y_i x_{ij} - n \cdot \frac{e^{\sum_{j=0}^{p} x_{ij} \beta_j}}{1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j}} \cdot x_{ij} \right)
$$

$$
= \sum_{i=1}^{n} (y_i x_{ij} - nx_{ij} \pi_i) \quad \text{.................................................. (3.3)}
$$

The maximum likelihood estimates for $\beta$ can be found by setting each of the $p+1$ equations in Eq. 3 equal to zero and solving for each $\beta_j$.

To evaluate whether the critical points of the function are maximum or minimum, set the second derivative with respect to each $\beta$ equal to zero.

Thus,
\[
\frac{\partial^2 l(\beta)}{\partial \beta_j \partial \beta_{j'}} = \frac{\partial}{\partial \beta_j} \sum_{i=1}^{n} \left( y_i x_{ij} - n x_{ij} \frac{e^{\sum_{j=0}^{p} x_{ij} \beta_j}}{1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j}} \right)
\]

\[
= - \sum_{i=1}^{n} n x_{ij} \left[ x_{ij} e^{\sum_{j=0}^{p} x_{ij} \beta_j} \left( 1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j} \right) - x_{ij} e^{\sum_{j=0}^{p} x_{ij} \beta_j} e^{\sum_{j=0}^{p} x_{ij} \beta_j} \right] \left( 1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j} \right)^{-2}
\]

\[
= - \sum_{i=1}^{n} n x_{ij} \left[ \frac{x_{ij} e^{\sum_{j=0}^{p} x_{ij} \beta_j}}{\left( 1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j} \right)^2} \right]
\]

\[
= - \sum_{i=1}^{n} n x_{ij} \left[ \frac{e^{\sum_{j=0}^{p} x_{ij} \beta_j}}{1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j}} \cdot \frac{1}{1 + e^{\sum_{j=0}^{p} x_{ij} \beta_j}} \cdot x_{ij} \right]
\]

\[
= - \sum_{i=1}^{n} n x_{ij} \pi_i (1 - \pi_i) x_{ij}^T \text{ ................................................................. (3.4)}
\]

Eq. 3.4 is the variance covariance matrix of the parameter estimates. The equations (3.3) and (3.4) in general require numerical iterative techniques for their solution, since they are nonlinear equations. Perhaps, the most popular method for solving systems of nonlinear equations in practice is Newton’s method, also called the Newton- Raphson method (Scott).

The MLE has the desirable statistical properties of normality, efficiency and consistency asymptotically (Long, 1997). This implies that the said properties hold as the study sample size increases. We can only interpret the sign and significance of the coefficients when we use the logit model.
### 3.4 Variable Definition

Table 3.1: Presents Definition of variables used in the study.

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Child Labour</td>
<td>Equals 1 if child works, 0 otherwise</td>
</tr>
</tbody>
</table>

#### Explanatory variables

<table>
<thead>
<tr>
<th>Individual /Child Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age</strong></td>
<td>Age of child in year (5-14 years)</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td>Boy = 1 if a child is a boy, 0 otherwise</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Household Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Household Size</strong></td>
<td>Refers to the number of regular household members</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Education level of the father and mother</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>None =1 if No education, 0 otherwise</td>
<td></td>
</tr>
<tr>
<td>Non curriculum =1 if Non curriculum, 0 otherwise</td>
<td></td>
</tr>
<tr>
<td>Primary =1 if Primary, 0 otherwise</td>
<td></td>
</tr>
<tr>
<td>Secondary = 1 if Secondary, 0 otherwise</td>
<td></td>
</tr>
<tr>
<td>Tertiary = 1 if Tertiary, 0 otherwise</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wealth Index</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Refers to household’s ownership asset such, Number of rooms in house, Land owned by household, and it measures household’s cumulative living standard</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Community Characteristics</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Residence</strong></td>
<td>Urban=1if Household reside in urban areas, 0 otherwise</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Zone</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>North west=1 if Household reside in North west regions (Somaliland), 0 otherwise. North east = 1 if Household reside in North east regions (Puntland), 0 otherwise.</td>
<td></td>
</tr>
</tbody>
</table>
3.5 Data Source

The Multiple Indicator Cluster Survey (MICS) is a household survey program developed by UNICEF to assist member states with a general framework for collecting data to monitor the condition of children and women. The 2006 MICS data for Somalia will be used in this study to extract the key determinants of child labour in Somalia.

This data, the Somali 2006 MICS, is from the third round of MICS conducted between 2005 and 2006 by UNICEF Somalia in collaboration with the Pan-Arab Project for Family Health (PAPFAM) project of the League of Arab States and was intended for monitoring progress towards the Millennium Development Goals (MDGs) by assessing the Health and Education situation of children and women. The previous MICS covered only Somaliland (this is the first one, conducted in 1995) and the second was conducted in 1999. It was also a nationally representative sample survey covering 5,969 households.

The sample was selected in four stages:

1. A predetermined number of clusters were selected in each zone: for Somaliland and Puntland, 60 clusters each; and 130 clusters for Central South Somalia.

2. Districts were selected in each zone using proportional probability to size and the various types of settlements selected from them.

3. Clusters were selected within the settlements.

4. Finally, households were randomly selected.

The questionnaires captured information on the household, from guardians and the eligible children in order to assess factors influencing households to send their children into work.
A child is considered to be involved in child labour activities at the moment of the survey if during the week preceding the survey:

Ages 5-11: at least one hour of economic work or 28 hours of domestic work per week

Ages 12-14: at least 14 hours of economic work or 28 hours of domestic work per week

The MICS questionnaire had a number of questions addressing child labour, such as: (UNICEF, 2007)

- During the past week, did (name) do any kind of work for someone who is not a member of the household?
- During the past week, did (name) help with housekeeping chores such as cooking, shopping, cleaning, washing clothes, fetching water, or caring for children?
- During the past week, did (name) do any other family work (on the farm or in a business)?

These questions reduce but do not eliminate the likelihood of underestimating the extent of work because child work is not always recognized as work.
Chapter 4: Data Analysis and Results

4.0 Introduction

This chapter presents the results of the study. The first section presents descriptive statistics of the variables included in the study. The second section presents the logistic regression results, and the last is discussion of the results.

4.1 Descriptive Analysis

There are a total of 9,961 children between the ages of 5 to 14 years old from the selected dataset. Out of these, 4,962 children were working during the last 7 days before the survey, or approximately half (50%) of the observations. This is an indication of how serious the situation of child labour in Somalia is. In this section the characteristics of the sample used in the study are presented. This study has focused on the effects of individual, household and community characteristics on child labourers. The unit of analysis is boys and girls of child labourers aged (5-14years).

Similar to other developing countries, the majority of child laborers in Somalia work without earning wages. Table 4.1 classifies children who are working according to their working status. Only some children appear to be engaged in work outside the household whether paid or unpaid (9 percent). About 23 percent of children aged 5-14 perform more than 28 hours of household chores per week and just about one in two children aged 5-14 (43 percent) are working for the family business. Very few child labourers are engaging in working both outside household and family business (1.2 percent). Just under a quarter (24 percent) of children aged 5-14 present together more than 28 hours of household chores per week and family business.
Table 4.1: *Number of Children Who Work by Working Status*

<table>
<thead>
<tr>
<th>Type of Work</th>
<th>Frequency</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Working Outside Household</td>
<td>458</td>
<td>9.2</td>
</tr>
<tr>
<td>Household Chores for 28+ hours/week</td>
<td>1,116</td>
<td>22.5</td>
</tr>
<tr>
<td>Working for family business</td>
<td>2,123</td>
<td>42.8</td>
</tr>
<tr>
<td>Outside household and Household Chores</td>
<td>60</td>
<td>1.2</td>
</tr>
<tr>
<td>Household Chores and family business</td>
<td>1,205</td>
<td>24.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>4,962</strong></td>
<td><strong>100.0</strong></td>
</tr>
</tbody>
</table>

*Source:* Computed from the 2006 MICS Data in Somalia

It was compared in Table 4.2, the key characteristics of children who work and those who do not work by looking at sample proportions in the categorical characteristics and sample means in continuous characteristics. The percentage of children aged (5-11) years who work (45.5%) is less than those who do not (54.5%), while differently that of children aged (12-14) years who work (62.7%) are more than those do not (37.3%). That is as the child age increases as s/he engages in work. Most children in the sample were 5-11 years old. According to the gender of the child, the percentage of working boys and girls stood at 45.1%, 54.6% respectively compared to those who do not work 54.9%, 45.4 respectively. That is, girls are more likely to work.

45% of father in the sample had no education, 25% had primary education, 16% had secondary education, and 12% had tertiary education, and also 2% had non curriculum education (non formal education). A different pattern is observed among mothers. Majority of the mother (63%) had no education, 17% had primary education, 13% had secondary education, and only 4% had
tertiary education, while 3% had non curriculum education. This shows that Education attainment is very low among mothers compared to fathers.

Table 4.2: Descriptive Statistics by Working Status

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Working Children</th>
<th>Not Working Children</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Boy</td>
<td>2281 (45.1%)</td>
<td>2772 (54.9%)</td>
<td>5053 (100.0%)</td>
</tr>
<tr>
<td>Girl</td>
<td>2681 (54.6%)</td>
<td>2227 (45.4%)</td>
<td>4908 (100.0%)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5-11 years</td>
<td>3389 (45.5%)</td>
<td>4064 (54.5%)</td>
<td>7453 (100.0%)</td>
</tr>
<tr>
<td>12-14 years</td>
<td>1573 (62.7%)</td>
<td>935 (37.3%)</td>
<td>2508 (100.0%)</td>
</tr>
<tr>
<td><strong>Household Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household Size</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Father’s level of Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>2021 (44.4%)</td>
<td>2330 (46.6%)</td>
<td>4531 (45.5%)</td>
</tr>
<tr>
<td>Primary</td>
<td>1450 (29.2%)</td>
<td>1037 (20.7%)</td>
<td>2487 (25.0%)</td>
</tr>
<tr>
<td>Secondary</td>
<td>750 (15.1%)</td>
<td>824 (16.5%)</td>
<td>1574 (15.8%)</td>
</tr>
<tr>
<td>Tertiary+</td>
<td>456 (9.2%)</td>
<td>715 (14.3%)</td>
<td>1171 (11.8%)</td>
</tr>
<tr>
<td>Non Standard Curriculum</td>
<td>105 (2.1%)</td>
<td>93 (1.9%)</td>
<td>198 (2.0%)</td>
</tr>
<tr>
<td>Mother’s level of Education</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>3235 (65.2%)</td>
<td>3057 (61.2%)</td>
<td>6292 (63.2%)</td>
</tr>
<tr>
<td>Primary</td>
<td>927 (18.7%)</td>
<td>763 (15.3%)</td>
<td>1690 (17.0%)</td>
</tr>
<tr>
<td>Secondary</td>
<td>51 (10.3%)</td>
<td>791 (15.8%)</td>
<td>1302 (13.1%)</td>
</tr>
<tr>
<td>Tertiary+</td>
<td>157 (3.2%)</td>
<td>267 (5.3%)</td>
<td>424 (4.3%)</td>
</tr>
<tr>
<td>Non Standard Curriculum</td>
<td>132 (2.7%)</td>
<td>121 (2.4%)</td>
<td>253 (2.5%)</td>
</tr>
<tr>
<td>Wealth Index</td>
<td>-0.21 (mean)</td>
<td>0.24 (mean)</td>
<td></td>
</tr>
<tr>
<td><strong>Community Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>1431 (37.7%)</td>
<td>2367 (62.3%)</td>
<td>3798 (100.0%)</td>
</tr>
<tr>
<td>Rural</td>
<td>3531 (57.3%)</td>
<td>2632 (42.7%)</td>
<td>6163 (100.0%)</td>
</tr>
<tr>
<td>Zone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North West</td>
<td>988 (38.4%)</td>
<td>1583 (61.6%)</td>
<td>2571 (100.0%)</td>
</tr>
<tr>
<td>North East</td>
<td>1083 (47.7%)</td>
<td>1189 (52.3%)</td>
<td>2272 (100.0%)</td>
</tr>
<tr>
<td>Central Southern</td>
<td>2891 (56.5%)</td>
<td>2227 (43.5%)</td>
<td>5118 (100.0%)</td>
</tr>
<tr>
<td><strong>Total number of observations</strong></td>
<td>4962 (49.8%)</td>
<td>4999 (50.2%)</td>
<td>9961 (100.0%)</td>
</tr>
</tbody>
</table>

*Source*: Computed from the 2006 MICS Data in Somalia
On the other hand, the table indicates that the child labour decreases with the increase of mother’s or father’s level of education. On average, households that need assistance from their children have about 0.2 less members in their family than households that do not need child laborers. The average wealth score of the households whose children are working is substantially lower than that of households whose children are not working.

The largest difference of sample means between these two groups of children was found in household locations. The majority (62%) of the Somali children were from rural areas compared to 38% who were from the urban areas. 57% of the children who live in rural areas are working while 62% of the children that live in urban areas are not working. The most (51%) of children in the sample used for the study was from South Central regions, 26% were from North West regions (Somaliland), and 23% were from North east regions (Puntland). The descriptive statistics shows that 56%, 47% and 38% of the children who live in Central Southern regions, Puntland, and Somaliland respectively are child labourers.

### Table 4.3: Wealth quintiles by child work status

<table>
<thead>
<tr>
<th>Wealth index quintiles</th>
<th>Total children aged 5-14 years</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Working children</td>
<td>Not Working children</td>
<td>Total</td>
</tr>
<tr>
<td>Poorest</td>
<td>1276 (25.7%)</td>
<td>749 (15.0%)</td>
<td>2025 (20.3%)</td>
</tr>
<tr>
<td>Second</td>
<td>1162 (23.4%)</td>
<td>742 (14.8%)</td>
<td>1904 (19.1%)</td>
</tr>
<tr>
<td>Middle</td>
<td>1002 (20.2%)</td>
<td>935 (18.7%)</td>
<td>1937 (19.4%)</td>
</tr>
<tr>
<td>Fourth</td>
<td>845 (17.0%)</td>
<td>1246 (24.9%)</td>
<td>2091 (21.0%)</td>
</tr>
<tr>
<td>Richest</td>
<td>677 (13.6%)</td>
<td>1327 (26.5%)</td>
<td>2004 (20.1%)</td>
</tr>
<tr>
<td>Total</td>
<td>4962 (100.0%)</td>
<td>4999 (100.0%)</td>
<td>9961 (100.0%)</td>
</tr>
</tbody>
</table>

*Source: Computed from the 2006 MICS Data in Somalia*
Table 4.3 indicates that the poorest households have an incentive to send their children to work to provide additional income. In contrast, the richest households do not need income from their children. This is consistence with the luxury axiom which states that when a family is below the poverty line, then they will need income from child labour.

4.2 The logistic Results

The study tested whether the fitted model adequately describes the data. The null hypotheses are:

\[ H_0: \beta_1 = \beta_2 = \cdots = \beta_{15} = 0, \]

alternatively \( H_1: \) the fitted model is a better fit \( (\beta_i \neq 0, \forall i = 1, 2, \ldots, 15) \). The value of Deviance based on the difference between the null deviance and residual deviance is 1368.410 with 15 degrees of freedom, the p-value is 0.0000. The null hypothesis is rejected. Thus the model is significant. This implies that the model fits the data well.

To answer the primary objective of the study, the study hypothesizes that the explanatory variables have no influence to family’s decision of sending the children to work in Somalia. Table 4.4 reports the logistic regression results to estimate the determinants of child labour in Somalia. The dependent variable is coded 1 if a child is labourer and 0 otherwise. In order to interpret the quantitative implications of the results we have to compute the odds ratio of the coefficients for continuous / dummy predictor variables. Therefore, Table 4.4 presents estimated coefficients and odds ratio of the logistic regression of child labour in Somalia.

4.3 Discussion of the logistic results

The study found different important findings. Starting with individual characteristics, the study showed that a year increase in child age increases child labour by 20.5% and it is statistically significant at 0.1% level. This result indicates that as the age of the child increases the
probability of child labour would also increase. The study also found that boys are 39% less likely to work relative to their counterparts (girls) and statistically significant at 0.1% level. This is that the girls have higher probability of being engaged in work than boys. These results are similar to other studies such as Moyi (2011), and Laurent & Sebastien (2010).

Household size was also used to determine child labour in the study. It is negatively related to child labour. However, it was found to be statistically insignificant at 5%. Its effect on working children was found to be very low. This implies that an increase in household size by one person would decrease the probability of being engaged in work by 0.3%. This is consistent with the substitution axiom which states that the adult labour replaces child labour. Thus the probability of child labours decreases when a family has more adult members, and also the domestic work is distributed among children of the household. This result is similar to those of Laurent & Sebastien (2010).

Parental education is another explanatory variable that was considered to determine the family’s decision of sending child to work.

The Father’s education level with primary for children aged 5-14 years has negative relationship to the working children and statistically insignificant at 5% level. This implies that children aged 5-14 whose father has primary education are 19.7 percentage points less likely to work than those whose father has none education. Children whose fathers have secondary, tertiary and high education are 1.4, 8, 1.5 percentage points respectively less likely to be engaged in work compared to those whose fathers have none education. However, the effect of fathers’ secondary, tertiary and high education is statistically insignificant at 5% level.
### Table 4.4: Binary Logistic Regression Results

<table>
<thead>
<tr>
<th>Explanatory Variables</th>
<th>Estimate(B)</th>
<th>S.E.</th>
<th>Wald</th>
<th>Df</th>
<th>P-value</th>
<th>Exp(B) (Odds Ratio)</th>
<th>95.0% C.I. for EXP(B)</th>
<th>Lower</th>
<th>Upper</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Children Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.187</td>
<td>0.008</td>
<td>561.611</td>
<td>1</td>
<td>0.000***</td>
<td>1.205</td>
<td>1.187</td>
<td>1.224</td>
<td></td>
</tr>
<tr>
<td>Boy^b</td>
<td>-0.415</td>
<td>0.043</td>
<td>91.148</td>
<td>1</td>
<td>0.000***</td>
<td>0.661</td>
<td>0.607</td>
<td>0.719</td>
<td></td>
</tr>
<tr>
<td><strong>Household Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household Size</td>
<td>-0.003</td>
<td>0.003</td>
<td>0.890</td>
<td>1</td>
<td>0.346</td>
<td>0.997</td>
<td>0.991</td>
<td>1.003</td>
<td></td>
</tr>
<tr>
<td>Father's education primary^c</td>
<td>-0.220</td>
<td>0.160</td>
<td>1.890</td>
<td>1</td>
<td>0.169</td>
<td>0.803</td>
<td>0.587</td>
<td>1.098</td>
<td></td>
</tr>
<tr>
<td>Father's education secondary</td>
<td>-0.014</td>
<td>0.163</td>
<td>0.008</td>
<td>1</td>
<td>0.929</td>
<td>0.986</td>
<td>0.716</td>
<td>1.357</td>
<td></td>
</tr>
<tr>
<td>Father's education high</td>
<td>-0.083</td>
<td>0.166</td>
<td>0.250</td>
<td>1</td>
<td>0.617</td>
<td>0.920</td>
<td>0.665</td>
<td>1.274</td>
<td></td>
</tr>
<tr>
<td>Father's education non curriculum</td>
<td>-0.015</td>
<td>0.172</td>
<td>0.008</td>
<td>1</td>
<td>0.930</td>
<td>0.985</td>
<td>0.704</td>
<td>1.379</td>
<td></td>
</tr>
<tr>
<td>Mother's education primary^d</td>
<td>-0.229</td>
<td>0.140</td>
<td>2.679</td>
<td>1</td>
<td>0.102</td>
<td>0.795</td>
<td>0.604</td>
<td>1.046</td>
<td></td>
</tr>
<tr>
<td>Mother's education secondary</td>
<td>-0.056</td>
<td>0.147</td>
<td>0.145</td>
<td>1</td>
<td>0.703</td>
<td>0.946</td>
<td>0.710</td>
<td>1.260</td>
<td></td>
</tr>
<tr>
<td>Mother's education high</td>
<td>-0.279</td>
<td>0.150</td>
<td>3.455</td>
<td>1</td>
<td>0.063*</td>
<td>0.756</td>
<td>0.563</td>
<td>1.015</td>
<td></td>
</tr>
<tr>
<td>Mother's education non curriculum</td>
<td>-0.106</td>
<td>0.178</td>
<td>0.355</td>
<td>1</td>
<td>0.551</td>
<td>0.899</td>
<td>0.634</td>
<td>1.275</td>
<td></td>
</tr>
<tr>
<td>Wealth index</td>
<td>-0.354</td>
<td>0.034</td>
<td>108.039</td>
<td>1</td>
<td>0.000***</td>
<td>0.702</td>
<td>0.657</td>
<td>0.750</td>
<td></td>
</tr>
<tr>
<td><strong>Community Characteristics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Urban^e</td>
<td>-0.310</td>
<td>0.064</td>
<td>23.466</td>
<td>1</td>
<td>0.000***</td>
<td>0.733</td>
<td>0.647</td>
<td>0.831</td>
<td></td>
</tr>
<tr>
<td>North west^f</td>
<td>-0.603</td>
<td>0.055</td>
<td>120.525</td>
<td>1</td>
<td>0.000***</td>
<td>0.547</td>
<td>0.491</td>
<td>0.609</td>
<td></td>
</tr>
<tr>
<td>North east</td>
<td>-0.272</td>
<td>0.055</td>
<td>24.690</td>
<td>1</td>
<td>0.000***</td>
<td>0.762</td>
<td>0.684</td>
<td>0.848</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>-0.798</td>
<td>0.211</td>
<td>14.345</td>
<td>1</td>
<td>0.000***</td>
<td>0.450</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Deviance ~ $X^2(15)$ = 1368.410 ($p$-value = 0.0000)

---

a. 10% Significant, ** 5% Significant, *** 0.1% Significant.
b. Reference group of gender = girl
c. Reference group of father’s education level = none
d. Reference group of mother’s education level = none
e. Refer group of residence = rural areas
f. Refer group of zone = South Central zone
The children aged 5-14 years whose mother has primary education are 20.5 percentage points less likely to be engaged in work than those whose mothers have none education and statistically insignificant at 5% level. However, children whose mother has secondary education are 5.4 percentage points less likely to work than those whose mother has none education. It does not have a statistically significant relationship with the working children at 5% level of significant. Children whose mothers have tertiary and non curriculum education are 24.4%, 10.1% respectively less likely to be involved in work than those whose mother has none education. However, the effect of mother’s tertiary and non curriculum education for children is statistically insignificant at 5% level of significant. These results are similar to those by Jay, et al (2007) who found mother’s education decreasing the probability of sending a child to work.

The economic situation of a household was found to determine children involvement in work. The indicator of economic situation (wealth index) was found to exert a positive and statistically significant at 0.1% level effect for children. This implies that households that are wealthy have higher chance of withdrawing their children from the work, i.e., any unit increase in the household wealthy, household is 0.702 times (30%) more likely to withdraw their children from the work compared to the children from poor households. This result is in line with other studies that posit a negative relationship between child labour and household income (Moyi, 2011, Laurent & Sebastien, 2010, Rubwkan, 2008, & Jay, et al, 2007).

The area of residence has negative and statistically significant (p-value<0.01) effect on probability of being child labour. This implies that children live in urban areas are 27 percentage points less likely to work than rural children. This result is similar to those by (Moyi, 2011, Laurent & Sebastien, 2010, and Rubwkan, 2008).
This study also sought to know whether children from a particular region in Somalia had higher probability of child labour than the other regions. The study found that the region is key determinant of the probability of a child being engaged in work in Somalia. The children from North East and North West regions have negative relations with working children. This implies that children from North West and North East regions are 45 and 24 percentage points respectively less likely to work than those in South Central regions.
Chapter 5: Conclusion and Recommendation

5.1 Summary and Conclusion

This study examines key factors and characteristics determining child labour in Somalia using UNICEF data – 2006 MICS data. To attain the Millennium Development Goals (MDGs) for Somalia, knowledge of child labour and its impact is critical, yet complex hindrances make it difficult to define and examine. The UNICEF proposed expanded definition of child labour is important to this study because most working children participate in household chores (Reynolds, 1991).

Children between the ages of 5 to 14 years were sampled; descriptive statistics applied to characterize child labour; and a binary logistic model fitted to estimate the determinants. The fitted logistic model showed that a child’s age and gender, household size, parent’s education, wealth, regions and area of residence are some of the factors influencing child labour. Higher child labour rates were also detected by the model among older children, and that boys were less susceptible to child labour than girls.

Those coming from wealthy households were also less likely to be engaged in child labour than their counterparts from poorer households.

Parental education levels also indicated significance in that those children whose parents had some form of education were less likely to be involved in child labour than their peers whose parents had none – parental literacy levels therefore affects the probability that a child will be involved in child labour.

Considering the region factor, the model indicated that children in rural areas were more likely to be child labourers than their counterparts who dwelled in urban areas. Also, fairly stable regions
such as North West Somalia (Somaliland) and North East Somalia (Puntland) were indicated as regions where children had lower chances of being sent to work compared to other less stable regions such as Central South Somalia. However the model indicated that children from North East Somalia (Puntland) were more likely to work compared to those in North West Somalia (Somaliland).

### 5.2 Policy Recommendations

From the results, policies to be pursued are those that:

- Raise adult literacy levels by strengthening such existing programmes and creating new ones throughout Somalia.
- Improve living conditions of households
- Enhance the education level of the girl child
- Address regional disparities in probability of child labour by allocating more educational resources to regions with high child labour probability, while at the same time taking into account gender effects.

### 5.3 Areas of further research

A census would be required to provide more information in order to arrive at a more complete list of determinants of child labour in Somalia. Moreover, more factors such as school and community characteristics, such as, schooling access, school’s quality, neighbourhood and infrastructure, should be incorporated into the model since they may contribute to the unexplained effects – so far, little effort has been applied in investigating them. National primary data could be used in future since this would be more current.
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APPENDIXES

Appendix I

Generalized linear models

The general linear model is of the form

\[ y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} + e_i \]

The response variable \( y_i; i = 1, 2, \ldots, n \) is modeled a linear function of predictor variables \( x_j; j = 1, 2, \ldots, k \) plus an error term. The response variable is a continuous variable that has normal distribution.

Also the expected value of response variable is

\[ E[y_i | x_1, x_2, \ldots, x_k] = \mu_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} \]

The general linear model has the following assumptions

(i) The \( Y_i \) are mutually independent normal random variables, having mean \( \mu_i \) and constant variance \( \sigma^2 \), i.e., \( Y_i \sim N(\mu_i, \sigma^2) \) for \( i = 1, \ldots, n \).

(ii) The explanatory variables provide a set of linear predictors \( \eta_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} \) for \( i = 1, \ldots, n \).

(iii) The link between (i) and (ii) is that \( \mu_i = \eta_i \), i.e., the mean of the dependent variable for any observation is the linear predictor formed from that observation’s values on the explanatory variables.

There are two main ways in which this model may be unsatisfactory in a given practical situation:

(a) The distribution of the dependent variable may not be normal.

(b) The mean of the dependent variable may be a function of the linear predictor, rather than just the linear predictor itself.

To overcome objections (a) and (b) above, Nelder and Wedderburn introduced in 1972 the class of the generalized linear models. Generalized Linear Models (glm) go beyond this in two major respects:

(i) The response variables can have a distribution other than normal; i.e., any distribution within a class of distributions known as “exponential family of distributions”.

(ii) Instead of having \( \mu_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} \), we can allow for transformations \( g(\mu_i) = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_k x_{ik} \).
The exponential family

A random variable Y has a distribution within the exponential family if its probability density (or mass) function \( f(y) \) can be written in the canonical form

\[
f(y, \theta, \phi) = \exp\left\{ \frac{y \theta - b(\theta)}{a(\phi)} + c(y, \phi) \right\}
\]

(1) for some specific functions \( a(\cdot), b(\cdot), \) and \( c(\cdot) \) and parameters \( \theta \) and \( \phi \).

Since \( f(y, \theta, \phi) \) is a density, then

\[
\int \exp\left\{ \frac{y \theta - b(\theta)}{a(\phi)} + c(y, \phi) \right\} dy = 1
\]

Differentiating both sides with respect to \( \theta \) yields

\[
\int \frac{y - b'(\theta)}{a(\phi)} \exp\left\{ \frac{y \theta - b(\theta)}{a(\phi)} + c(y, \phi) \right\} dy = 0
\]

\[
\int y \exp\left\{ \frac{y \theta - b(\theta)}{a(\phi)} + c(y, \phi) \right\} dy = b'(\theta) \int \exp\left\{ \frac{y \theta - b(\theta)}{a(\phi)} + c(y, \phi) \right\} dy
\]

Hence it follows that

\[
E(Y) = b'(\theta)
\]

(2)

Differentiating a second time with respect to \( \theta \) yields

\[
- \frac{b''(\theta)}{a(\phi)} \int \exp\left\{ \frac{y \theta - b(\theta)}{a(\phi)} + c(y, \phi) \right\} dy +
\]

\[
\int \frac{(y - b'(\theta))^2}{a^2(\phi)} \exp\left\{ \frac{y \theta - b(\theta)}{a(\phi)} + c(y, \phi) \right\} dy = 0
\]

This gives

\[
\frac{1}{a^2(\phi)} \text{var}(Y) = \frac{b''(\theta)}{a(\phi)}
\]

i.e.

\[
\text{var}(Y) = a(\phi) b''(\theta)
\]

(3)
Appendix II

Generalized likelihood ratio test statistic

It is given from Eq(3.1) by

\[ \Lambda = \frac{L_R}{L_S} = \frac{\prod_{i=1}^{n} \exp\left\{\left[y\theta_i - b(\tilde{\theta}_i)\right]/a(\emptyset) + c(y, \emptyset)\right\}}{\prod_{i=1}^{n} \exp\left\{\left[y\tilde{\theta}_i - b(\tilde{\theta}_i)\right]/a(\emptyset) + c(y, \emptyset)\right\}} \]

Where

- \( L_R \) and \( L_S \) are maximum likelihoods for the reduced and saturated models respectively.
- \( \theta_i \) and \( \tilde{\theta}_i \) are the estimates of \( i \)th canonical parameter under the reduced and saturated models respectively and \( a(\emptyset) = \emptyset = 1 \).

Therefore \( \Lambda = \exp \sum_{i=1}^{n} \left[ y(\theta_i - \tilde{\theta}_i) - b(\theta_i) + b(\tilde{\theta}_i) \right] \)

Thus \( -2 \log \Lambda = 2 \sum_{i=1}^{n} \left[ y(\theta_i - \tilde{\theta}_i) + b(\theta_i) - b(\tilde{\theta}_i) \right] \)

So that \( D = -2 \log \Lambda \) where \( D = 2 \sum_{i=1}^{n} \left[ y(\theta_i - \tilde{\theta}_i) + b(\theta_i) - b(\tilde{\theta}_i) \right] \)

\( D \) is known as Deviance of the model but as indicated in Eq(3.1)

\[ \theta_i = \log \left( \frac{\pi_i}{1-\pi_i} \right) = \sum_{j=0}^{p} x_{ij} \beta_j \] and \( b(\theta_i) = -n \log(1 - \pi_i) \) where \( \pi_i = \frac{\sum_{j=0}^{p} x_{ij} \beta_j}{1 + \sum_{j=0}^{p} x_{ij} \beta_j} \)

So Deviance is the generalized likelihood ratio test statistic for comparing reduced model \( L_R \) to the saturated model \( L_S \).