UNIVERSITY OF NAIROBI

COLLEGE OF BIOLOGICAL AND PYSICAL SCIENCES

SCHOOL OF MATHEMATICS

TOPIC: MODELING LABOR MARKET PERFORMANCE IN SUB-SAHARA AFRICA USING CONVEX OPTIMIZATION TECHNIQUES

BY

MARY MUKUHI MWANGI

A RESEARCH PROJECT SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTERS OF SCIENCE IN SOCIAL STATISTICS OF THE UNIVERSITY OF NAIROBI

June 2014

DECLARATION

This project is my original work and has never been submitted for a degree in any other university.

Sign: …….Date: …….

Mary Mukuhi Mwangi

Reg. No.: I56/79346/2012

This project has been submitted for examination with our approval as university of Nairobi supervisors

Sign:……Date:……...

Prof. Moses M. Manene

Professor of Statistics,

School of Mathematics, University of Nairobi.

Sign: …….Date: …….

Prof. G. P. Pokhariyal,

Professor of Applied Mathematics,

School of Mathematics, University of Nairobi.

DEDICATION

First, I dedicate this work to Almighty God for guidance and protection. Second, to my Husband Geoffrey Kanyi for the support he accorded me through the journey. His constant reassurance through out the MSc program was my key drive. Third, to my son Aquilla Kiarie Junior, for remaining my greatest inspiration in achieving greater heights in all spheres of life. Finally yet importantly to my entire family for their encouragement, support and prayers while undertaking this course.

ACKNOWLEDGEMENT

I am grateful to University of Nairobi, particularly to my supervisors Prof. Moses M. Manene and Prof. G. P. Polkhariyal for guiding me through the project. Their tireless contribution aided me in bringing out the idea as I had earlier planned. I also want to pass my regards to my colleagues and discussion group members Sheilla Otieno, Sellessor Odipo, David Gitahi, and Abass Tifow for their tireless support whenever I needed them during the course. My gratitude also goes to my Cousin Antony Ndichu for editing my work.

ABSTRACT

In this project, we have modeled labor market performance in Sub-Sahara Africa using convex optimization. Labor market indicators were adopted as a reliable source of information capable of describing Sub-Sahara Africa labor market condition. We aimed at investigating a set of measures that could explain a maximum performance in the labor market using a set of variables categorized as independent, moderating, intervening, and dependent variables to labor market performance. Using linear programming, each category was considered as a constraint to labor market performance. Four constraint equations were constructed using factor analysis conducted on a set of variables in each category. The equations were named as employment by sector, labor force participation rate, status on employment, and working poverty. The objective function was constructed by fitting a multiple linear regression equation to a set of factors in the constraint equation. Using simplex method of solving linear programming problems, the solution revealed that out of the nine selected indicators, only four could explain Sub-Sahara Africa labor market performance. These were unemployment rate, labor force participation rate, labor productivity, and working poverty. This predictive model advises anybody concerned with Sub-Sahara Africa labor market on the areas that need more emphasis for a maximum performance to be realized.

Key words: Labor market indicators, labor market performance, Sub-Sahara Africa, labor force.

LIST OF ABBREVIATIONS

Abbreviation	Indicator
LFPR	Labor force participation rate
EPR	Employment to population ratio
SE	Status on employment
ES	Employment by sector
TUR	Total unemployment
YUR	Youth unemployment
AUR	Ratio of youth unemployment to adult employment
LP	Labor productivity
WP	Working poverty
ILO	International Labor Organization
KILM	Key Indicators of the Labor Market
WSWE_P	Percentage of waged and salaried workers
EMPL_P	Percentage of employers
OAW_P	Percentage of own account workers
PVE_P	Percentage of producer cooperative workers
CFW_P	Percentage of contributing family workers
AGR_P	Percentage of workers in agriculture sector
IND_P	Percentage of workers in industrial sector
SERV_P	Percentage of workers in the service sector
MRLS	Mozambique Rural Market Survey
OECD	Organization for Economic Co-operation and Development
EUROSTAT	Statistical office of the European Communities

Table of Contents

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

This chapter captures the background of the project, the research problem, objectives, and justifications of the study.

1.1 Background

The background of this project captures the principles of employment and unemployment in the general labor market, developed countries labor market, developing countries labor market, and Sub-Sahara Africa labor market.

a) Labor Market in General

Generally, labor market is affected by supply and demand for labor. It is a component of availability of labor force to serve the demands of the labor market in the production process. The characteristic features of a labor market comprise of rate of employment, extent of unemployment, and availability of vacancies. The whole concept is about employee-employer match (defined by skills, experience and education level of the human capital), earnings distributions, and employment class size description. Labor market performance is thus a product of the effect of skills level of the workforce in relation to the employers needs.

Efficient utilization of the accumulated human capital drives economic growth (Topel, 1999). For example, when advanced knowledge in technology is utilized in a country, the country finds it easy to adapt to modern ways of production as compared to the less advanced countries in technology. New technologies have been proven to increase productivity, which in turn accelerates economic growth. This further implies that the wealth of a given society is defined by its accumulated stock of human capital associated with productivity (Behrman, 1999).

With the advanced technology, job creation has remained a problem for many countries. This is because; many jobs have been mechanized meaning low demand for human capital, and labor force dynamics affecting job specifications, wages distribution, employee-employer benefits, work place locations, hiring trends, and job seeker-employer expectations have experienced significant growth (Stevens, 2002). The changes in technology and labor force dynamics have affected the job concept either due to worker migration in search for better employment terms or change of workstation within the same firm. There is therefore a continued exit and entry to employment in search for job satisfaction for the worker and value for money for the employer. The ripple effect to the firms is that hiring rates suffer instabilities as levels of job retention become inconsistent due to employer-employee expectation.

Job concept revolves around three levels; job entry, retention, and job exit. The three levels are facilitated by models of labor market behavior influenced by availability of vacancies, inventory cost, and demand for production, employment duration, wages, and employee-employer benefits (Chesher and Lancaster, 1983). The specific around job concept is a multi-level structure demonstrated in the figure below.

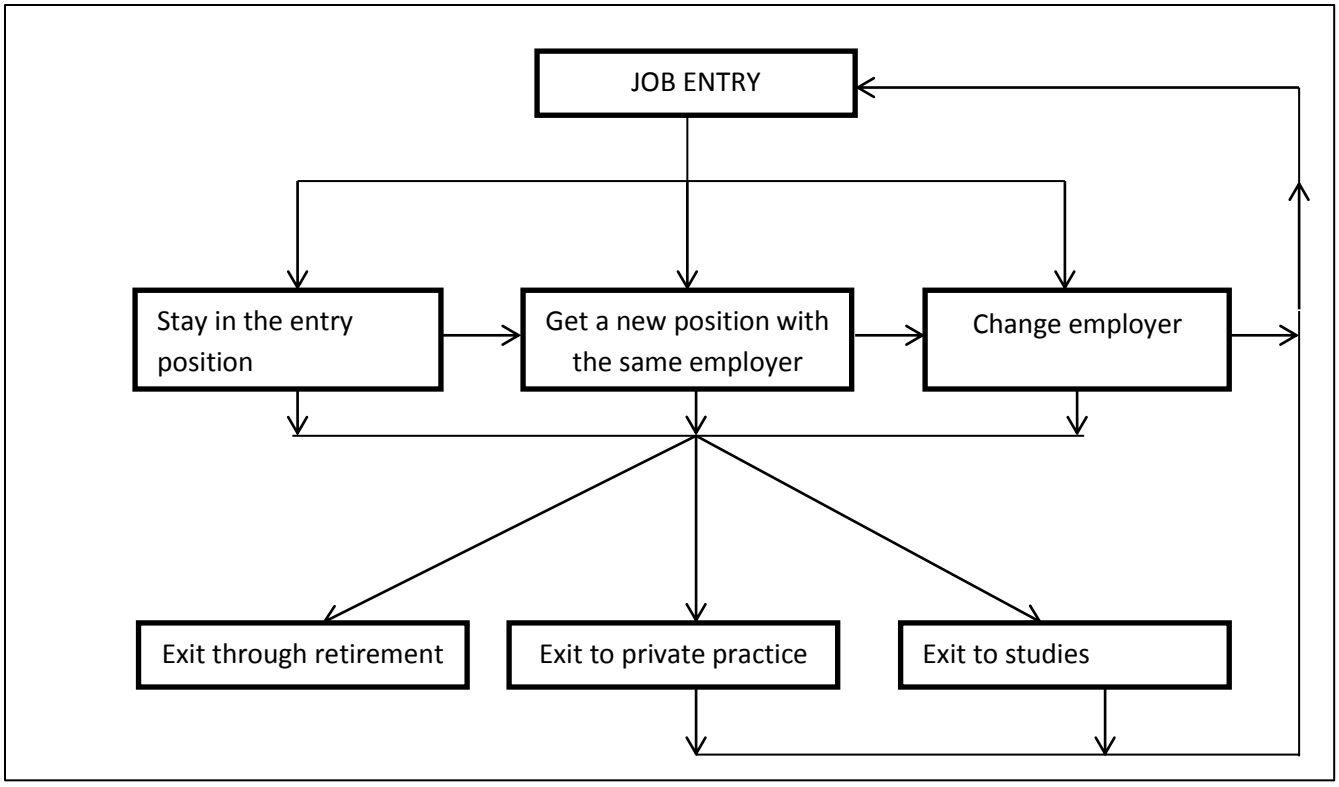


Figure 1: Job concept from entry to exit in the labor market

Source (Author, 2014)

Modeling is the technique of representing reality within a concept. An ideal model for the job market would be one that considers entry to the job market as a youth and exit as an elder. Unfortunately, the ideal never happens since the youths who should be entering the job market and the elders who should be exiting the market face particular challenges one of them being low labor force participation rates. Youths in particular have to face a period of unemployment when transiting from education life to working life. However, the periods differ depending on availability of vacancies and individual youth academic qualifications as required by different entry levels in the labor market. On the other hand, older people rarely are employed. Their

period of unemployment is much longer since the employment class considers them less productive especially when new skills are a requirement.

Conversely, an ideal job market concept is a product of vacancies and work force availability. The concept is unique for different occupations, industries, job locations, and salary scales (Toft, 2004). The uniqueness of a job market concept thus influences decisions made by both employees and employers on hiring trends per age category. For example, the upcoming technology market prefers employing young people willing to keep abreast with new skills. Consequently, any youth trained or willing to learn new skills will experience shorter unemployment periods as compared to the non-skilled youth. Nevertheless, the elder work force is considered for senior management positions requiring vast experience in the field.

The knowledge on youth and elder population employment trends is important to every government as the main employer. Individual governments take note of labor market evolution trends by age categories when planning on public sector management. Therefore, a single action by public sector employment trends advice private sector decision on labor market entry and intervention. For example, while experience remains a mandatory requirement to senior management positions in the public sector, ability to apply proper management skills is essential to being considered for senior management positions in private sector. It is then highly probable that private sector employs more young people compared to the public sector.

b) Labor market in developed countries

Developed countries like the G8 (US, France, Russia, Canada, Italy, Great Britain, Japan, and Germany) have dynamic labor market that change with every change in labor demand. The market is characterized by high employment rates motivated by production demands and

sustainable social security systems like elderly care, health, and pension schemes (Toft, 2004). Developed countries have had a stable economic growth and reduced working poverty over a long period (Topel, 1999). This is considered as an effect of capital output ration across an economic zone. In developed countries, human capital has been an unobserved factor due to the inevitable merge between technical and knowledge advancement (Topel, 1999). Both are functions of time devoted to develop a unit of human capital.

The adoption of innovation and technology has spurred a new wave of intense pressure on resource allocation as more resources are allocated to profitable production in developed countries (Sofia, 2011). For example, US industries facing stiff international competition experience production displacement that leads to change of production line or industry closure. The employees thus become jobless for a period before re-employment. Nonetheless, compared to developing countries, developed countries re-employment period after termination of employment contract happens within 2 years (Ruffer & Knight, 2007). Skilled laborers in developed countries have therefore opted for a change in job contracts from permanent to out sourcing services.

c) Labor market in developing countries

Labor market in developing economies is split into urban and rural labor market. According to Behrman (1999), urban labor market is characterized by

- Diversified production, labor demand and wage variation
- Higher return to education and skills
- Less seasonality dependency
- Higher unemployment due to higher labor migrations from rural to urban market

- Higher policy regulations and union activities due to greater worker diversity

The urban labor market is faced by the highest unemployment rate due to continued population growth. Many workers in urban labor market are forced to participate in low-wage and less productive occupations in the informal sector. The informal sector is characterized by ease of entry, production from locally available resources, small-scale production, ease of bypassing set regulations like taxes, ease of applying skills learned from school, and household can manage the business (Ruffer & Knight, 2007). It is therefore difficult to distinguish between a household and a firm in the informal sector since changes in household welfare directly affects firm production (Ruffer & Knight, 2007).

Rural labor market comprises of both agricultural and non-farm activities like mining and quarrying with agriculture dominating the market. Workers are majorly hired on short wage contracts for normal agriculture tasks like plowing, planting, weeding, and harvesting. The market faces wage rigidities that force many workers out of employments to subsistence farming for those who can access farming land. The rest of the human capital is thus underutilized if they cannot put up with the low wages in the market.

A case in point on India, where wage rigidities have been observed to lower employment rates especially in the poorest villages. As total labor use is reduced from formal employment, labor supply is channeled to individual farms and businesses. Nevertheless, the channeled labor force faces external pressures from rainfall seasonality and work moderation. The seasons affect labor demands for both dry and wet seasons. During wet season, cropping attracts a higher demand for labor as compared to harvesting and tilling periods that can be mechanized in the dry season.

This affects total labor performance when a large number of the Indian workers are left unutilized.

d) Labor Market In Sub-Sahara Africa

Sub-Sahara Africa, where Kenya is among the countries in Sub-Sahara Africa, faces a very dynamic labor market. Just like every other developing economy, its labor market is split into urban and rural labor market where rural market dominates. The agriculture industry has been growing faster in Sub-Sahara Africa than in any other part of the world. However, labor productivity has highly decreased due to unpredictable weather conditions thus increasing poverty levels in both rural and urban labor markets.

Labor force distribution and labor market production affect economic growth in a country regardless of class (Tope, 1999). Nevertheless, both distribution and production are a function of population size of which Sub-Sahara Africa has high population growth, but less labor force utilization. Underutilization of labor force facilitates continued labor migration between rural and urban markets. Although both markets create resources, the distribution to the two markets has been a challenge in Sub-Sahara Africa since more resources are channeled towards infrastructure and urban development. The level of efficiency and economic growth observed in the urban market thus presents urban market as a better performer than the rural market (Prskawetz et al., 2005). The growing rural urban inequality in resources distribution leads to a continued labor force migration to the urban market thus causing over population in urban markets and under population in the rural markets. The urban market thus has a surplus of human capital while the rural market suffers a shortage for labor (Bigsten and Horton, 1997).

1.2 Measurement of labor market performance

The above labor markets have brought out labor market performance as being measured by two main principles; employment and unemployment rates. The overall growth in employment based on long-term state of the labor market is driven by job concept cycles. These cycles are highly affected by population size, size of the employable class, and market absorption rates. Thus using employment as the only measure of labor market performance is misleading since employment rate only cannot capture the changes in the source population. On the other hand, unemployment rate when used alone creates an unjustifiably positive image of the market especially during recession. Unemployment rate also fails to account for people working part-time but preferring to work full-time. Employment rate covers the inadequacies experienced when only employment and unemployment rate are used as measures of labor market performance. Labor force participation rate measures the labor supply from the sum of employable population. It is a percentage of the total working population. This works as a good measure of the job opportunities available in labor market.

For this project, employment rate is grouped into labor force participation rate, employment to population ratio, status on employment, and employment by sector. Unemployment rate can be measured as total unemployment, which is a function of youth unemployment, and adult unemployment. This project is motivated by such principles and their application to labor market effect on productivity and reduction of working poverty in sub-Sahara Africa.

A neoclassical approach to explanation of labor market performance in Sub-Sahara Africa would be sufficient when a number of indicators will be considered for the study. This project used a different approach in describing labor market performance. It sought to use nine labor market indicators summarizing the above principles as given by international labor organization (ILO) to

model labor market performance. A description of the nine variables considered and how they were measured is provided in Table 1 below (International Labor Organization, 2014).

Table 1: Labor Market Indicators

	Indicator	**Abbreviation**	**How it is measured**	
1	Labor force participation rate	LFPR	Expressed as a percentage of the total population	
2	Employment to population ratio	EPR	Expressed as percentage of the total population	
3	Status on employment	SE	WSWE_P	Waged and Salaried employment as a percentage of the total employed
			EMPL_P	Employers as a percentage of the total employed
			OAW_ P	Own account workers as a percentage of total employed
			PVE_P	Member of producer corporation as a percentage of the total employed
			CFW_P	Contributing family worker as a percentage of the total employed
4	Employment by sector	ES	AGR_P	Employment in Agriculture as a percentage of the total employed
			IND_P	Industrial employment as a percentage of the total employed
			SERV_P	Service employment as a percentage of the total employed
5	Total unemployment rate	TU	Unemployment as a percentage of the total labor force	
6	Youth unemployment	YU	Youth unemployment as a percentage of the youth labor force	
7	Ration of youth unemployment to adult unemployment	RYUAU	Ratio of youth unemployment to adult unemployment	
8	Labor productivity	LP	GDP per person engaged	
9	Working poverty	WP	Percentage of the population living below international poverty line of US$ 1.25 Percentage of the persons living below nationally defined poverty lines	

Source: ILO (2014).

1.3 Objective of the study

Main objective of the study is to construct labor market performance model using statistical and mathematical concepts.

Specific objectives

The specific objectives are to:

- Use the knowledge of linear optimization in constructing convex optimization problem that could be solved using linear programming techniques.
- Test the linear optimization problem for convexity
- Obtain an optimal solution of the labor market performance.

1.4 Research Problem

Previous studies on labor market have shown that several indicators can describe Sub-Sahara Africa market. International Labor Organization picked 18 as the key indicators (Refer to appendix 1) but 9 as the most effective. This project therefore investigates the contribution of each of the nine most effective identified indicators (shown in Table 1 above) to the total labor market performance. The project also sorts to find among the nine indicators, which ones would describe Sub-Sahara Africa labor market performance better.

1.5 Justification of the study

Models can be reliably used in setting priorities in areas of interest in a statistics environment. The measurements in a model are more objective thus making it an effective method of understanding the relationship between concepts like convex optimization and labor market analysis. The best model should therefore be able to capture such associations with the least number of variables. This project therefore aimed at finding a set of measures on labor market

indicators that could define labor market performance using convex optimization techniques through linear programming. The project will be of importance to academicians and students who intend to venture into labor market statistics and optimization models at the same time.

1.6 Project Outline

The organization of this project is such that the introduction takes chapter 1 followed by literature review (chapter 2) that highlights the evidence of labor market performance in Sub-Sahara Africa. Chapter 3 presents the methodology that describes the research design used, the study population, models used, how the model was formulated, how the model was validated, and the proposed data analysis. Chapter 4 presents data analysis and finally Chapter 5 concludes the project with a couple of recommendations.

CHAPTER 2: LITERATURE REVIEW

A number of studies have been conducted on developing countries and Sub-Sahara Africa labor market. This chapter explore on both the theoretical and empirical literature on Sub-Sahara Africa labor market.

2.1 Theoretical literature review

According to Topel (1999), average productivity depends on the accumulated physical and human capital applied in the production process. The accumulation process is aided by time spent in school, apprenticeship programs or training. The process facilitates economic and human capital growth at the same rate under stable equilibrium. However, Sub-Sahara Africa accumulation process takes longer due to delayed entry into formal education and incomplete schooling for a bigger population. The delayed employment schedules affected by derailed economic growth in formal sector result in a bigger portion of the market choosing employment in the informal sector of the economy.

According to Fields (2011), developing countries include middle-income countries like South Africa, Brazil, and Thailand as well as low-income countries like Kenya, Tanzania, Pakistan, and Haiti. These countries experience a unique labor market with the following features compared to developed countries.

i. Relatively lower unemployment rates
ii. Low wages and long working hours
iii. Irregular working trends
iv. Men dominated labor market

v. Less workers on white-collar jobs as majority takes up self-employment, agriculture, and unpaid family assignments.
vi. Majority of workers work in private sector compared to developed countries where formal sectors employs the majority.
vii. High preference for regular wage jobs compared to casual wage jobs
viii. Limited on job skills by some regular wage job seekers
ix. The labor market is segmented into rural and urban where rural market dominates. Rural market is split into farm and nonfarm markets while urban market is split into formal and informal markets.
x. High preference for micro enterprises compared to employment.
xi. Low social protections
xii. The population consists of a big percentage of working poor. That is, about 1.3 billion people in families spend less than two dollars a day and thus they belong to the working poor class (Fields, 2011).

According to Bigsten and Horton (1997), Sub-Sahara Africa has the highest working poverty measured through economic growth though it is the richest in both human capital and resources. Structural changes and labor relocation between rural and urban labor market have enhanced labor inequality to 68% of the Sub-Sahara Africa population engage in agriculture either in family farms or on waged contracts (Bigsten and Horton, 1997). Although urban areas labor market is divided into formal and informal employment, informal employment accounts for 60% in urban employment and the rest remain in formal employment (Bigsten and Horton, 1997).

Oya (2010) further conducted a research on the unreported source of inequality and poverty in the rural labor markets in Africa. The researcher identified that there are wrong assumptions

made on the labor market where inexistence of rural wage employment is one of them. This could be due to African rural economies that are based on imbalanced societies inherited from colonialist. Thus, the assumption has stirred inequalities between labor and capital markets across Sub-Sahara Africa yet rural wage employment is the major source of class differentiation, variation, and privation. Another underreported area according to Oya (2011) is in change from small-scale farming to waged labor necessitated by low yields when applying traditional export crop. Labor migration and its consequences have also been highly underreported. For example, reporting on seasonal waged workers who move from disadvantaged parts of the country during different seasons has been under looked. These workers encounter poor pay and poor working conditions than homegrown workers who have already established terms for their wages (Oya, 2011). Such oversights could miss direct rural wage policies.

Cramer, *et al*. (2008), indicates that policy debate on labor performance supported by development, employment, and poverty reduction in Sub-Sahara Africa needs more attention. This is because, a number of surveys indicate that poverty reduction to rural African is depended on the labor market performance. However, there are great diversities not captured in many surveys especially on employment in rural labor markets. This was evidenced from Mozambique Rural Market Survey (MRLS) that captured a wide range of occupations among others being farming, bar and hotel service and market stalls, export and imports of goods. The oversight in capturing every aspect of the labor market leads to simplistic theoretical models that do not account for the power practiced in labor relations. Cramer, *et al.* (2008) thus recommends employment of research tools capable of capturing information on job quality, gender dimensions, and social status. For example, inclusion of gender dimension in MRLS was able to

capture that women participate in rural labor market unlike in standard surveys that indicate that women are either unpaid or self-employed workers.

Theoretical literature review summary

It is evident from literature that the five researchers identified some aspects of Sub-Sahara labor market performance. In summary, the market has a higher accumulated human capital and resources but inconsistent in average productivity due to lengthened accumulation periods. The increased poverty index in Sub-Sahara Africa is a product of poor reporting on labor market issues. The imbalance has caused performance inequality between rural and urban employment in terms of wage gaps and skills allocation. Thus, attention to reporting on labor market performance supported by existence of both rural and urban employment and labor migration could lift the mistake of generalizing the labor market as characterized by unemployment. The inclusion of all other indicators and their contribution to labor market performance in Sub-Sahara Africa could advice policy makers on the relevance of each indicator in the market.

2.2 Empirical Literature review

As mentioned above, the role of labor market indicators in describing the situation of labor market in Sub-Sahara Africa is very important. However, the empirical questions remain on the magnitude of an indicator in describing the market; does investment on human capital as advised by policies improve the state of poverty in Sub-Sahara Africa?

Gray *et. al.* (1996) studied labor market signals and indicators in Zimbabwe, Costa Rica, Bangladesh, and Cambodia. By use of case studies, the researchers were able to identify signals and indicators as labor market information components. The results recommended use of accuracy when estimating signals and indicators of the labor market in the current economic

environment. Informal local systems were identified to be the most effective measures of the labor market. They help in bridging the gap between employers and education systems on matters concerning training and technology changes. Therefore, labor market information is appropriate when used to study long-term labor market trends as well as advice government and training organizations.

Paula *et. al.* (2005) accessed social security coverage and labor market in developing countries by considering the reasons behind the low uptake of social security programs. Using standard normal distribution, the analysis of household surveys from Latin America showed that contribution is highly depended on education, earnings, employer size, age, and household characteristics. This was regardless of whether one is in self or waged employment. Old age pension programs were examined using voluntary, binding minimum wage, and compulsory participation. Pension uptake was affected by imperfect competition in the labor market.

Prskawetz *et. al.* (2005) explored the changes in size and composition of crude labor force over time. Using a Vaupel and Canudas Romo new decomposition method, the investigation was applied on five OECD (Organization for Economic Co-operation and Development) countries (France, United Kingdom, Germany, Spain, and United States of America) where crude labor force rate and mean age of the labor force were investigated. The aging rates of a country were divided into fast and slow aging countries and crude labor force was based on gender. The results showed that mean age of the labor force for male is depended on the population composition while for females it varied. Any changes in the crude labor force rate were directly related to change in age-specific labor force participation rates.

Satchi and Temple (2006) investigated labor market contribution to economic growth. Using data from Mexico, a general equilibrium model was used to investigate labor migration, chances of self-employment and effects of growth on wages in the informal sector, and matching friction of urban labor market. Labor productivity was measured on individual parameters of labor market. The results showed that there exists a sizeable informal sector, which contributes to a sizeable effect to the total labor performance. Changes in labor market parameters also had an effect on wage, which attracted rural-urban migration.

Dubra (2007) lead a team of researchers to study the labor force and the labor market in sectors of national economy. Labor force demand and supply on different sectors of economy in Latvian were investigated. The results showed that there was an imbalanced demand and supply of labor force by sectors. This was attached to low prestige of some jobs affected by low wages and society acceptance of the profession. Demographic processes that affect labor force migration also influence balance in the labor market. Strategy and policy planning should therefore be advised by labor market analysis that assists in labor allocation based on evidence.

Winters *et. al.* (2008) investigated rural wage employment in developing countries using 14 developing countries. To analyze the determinates of labor market participation differences, the researchers applied probit regression analysis where productivity was measured as either high or low based on labor force participation in waged employment. The analysis showed that poverty reduction is not entirely depended on sector employment or overall household livelihood strategy. Instead, education and infrastructure investment contribute to opportunity creations that are of higher wages thus help in fighting poverty. Gender differences in the labor market were explored where analysis suggested that gender participation and wages earned need to be given extraordinary attention in that women participation should be encouraged.

The empirical literature review thus presents a case where some components of the labor market are dependent on others while some are entirely independent. The conceptual framework in Figure 2 below explains how those components relate to each other.

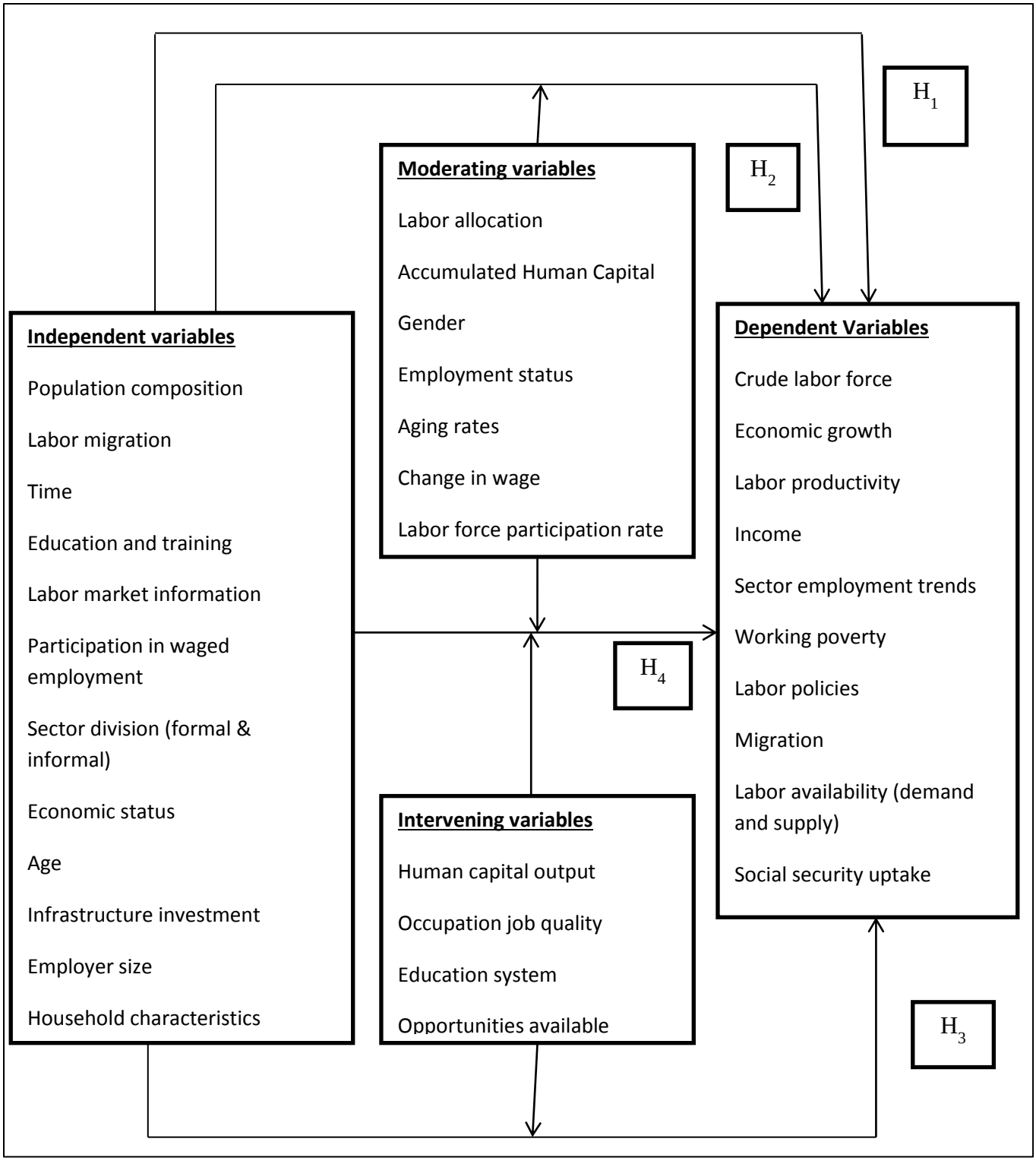


Figure 2: Labor market conceptual framework

Source (Author, 2014)

CHAPTER 3: RESEARCH METHODOLOGY

This chapter focuses on the research design, the study population, how labor market performance model was constructed using statistical models, model formulation, how the model was validated and the proposed analysis.

3.1.Research Design

The study adopted International Labor Organization research design since the data was collected from the organization's website. The research design is based on availability of data from given countries. An ideal situation is where by for an indicator like employment, the totals of employed persons across all countries is summed up. However, this rarely happen since countries report data in an inconsistent manner. International Labor Organization (ILO) therefore applies econometric models that assist in producing estimates of labor market indicators in the countries and years where real data is not available (ILO, 2014). Among the models are Global Employment Trends Model (GET Model) that gives estimates in terms of age and sex for indicators 2, 3, 4,9,10, and 17(refer to Appendix 1) . There is a new model for indicator 18 that gives estimates on employment by economic class and Trends Labor Force Model (TLF model) give estimates on indicator 1 and 13. According to International Labor Organization (2014) report, the models use multivariate regression to assign missing values. They use country specific information on "per capita income, GDP growth rates, demographic trends, country membership in the highly indebted poor country initiative (HIPC), geographic indicators, and country and time dummy variables" (ILO, 2014). The information is relevant in capturing the interdependency between labor market indicators and microeconomic variables.

3.2.Study population

Sub-Sahara Africa faces social economic problems related to labor market performance. The growth of poverty index could be due to low performance caused by inadequate labor capacity and ill interpretation of policies in the specific countries. This calls for well-documented data that can be used to develop policies applicable to Sub-Sahara Africa labor market performance. The population under study is therefore made up of 70 countries that submitted annual labor market data to ILO in the period between 1991 and 2012.

3.3.Modeling labor market indicators

This project modeled labor market indicators using convex optimization. The variables considered in the modeling were nine indicators summarized as LFPR, EPR, SE, ES, ES, TU, YU, RYUAE, LP, and WP with SE having WSWE_P, EMPL_P, OAW_P, PVE_P, and CFW_P. ES was split into AGR_P, IND_P, and SERV_P (Refer to Table 1).

3.3. 1 The problem to be solved

Labor market performance has been known to be measurable by a set of indicators, which are affected by employment, unemployment, and vacancy availability. Therefore, 18 indicators, as stipulated by ILO define the state of a labor market. However, not all indicators were used for this study, only the nine indicators that best explains labor market conditions were used. The study adopted an optimization problem described below:

A well performing labor market is made up of nine indicators (given in Table 1) each being achieved at 100%. We can construct such a labor market problem by considering nonnegative quantities x_j where j=1,……..n of n different factors that contribute to the definition of the indicators. A unit of quantity x_j contains an amount a_j of factor j and has an overall effect b_i to

the labor market performance. The problem is to determine feasible measures of the factors to a linear programing problem (Source, Author, 2014).

The canonical form of the linear programming problem was

$$\max\ Z = B^T x$$

Subject to

$$Ax \leq\ 100$$

$$x \geq 0$$

3.4.Background of the model used

This section describes the background of the model used in solving the above problem.

3.4.1 Convex Optimization

Convex optimization is the study of how one can make the best choice from a set of possible choices when faced by some requirements. To be able to solve convex optimization problems, one needs to be well versed with the knowledge of convex set and convex functions.

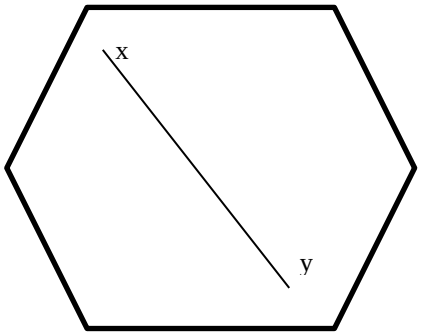
Convex Sets

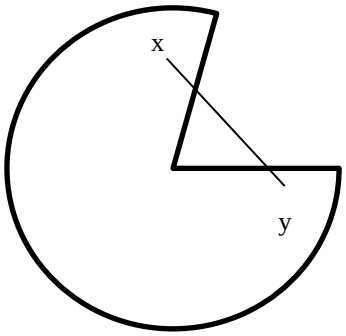
Definition 1.1

A set C is convex if for any two points $x, y\ \in C$, the line segment connecting them is contained in C. That is, if $x, y\ \in C\ and\ \lambda\ \in\ \mathbb{R}$ with $0 \leq \lambda \leq 1$,

$$\lambda x\ + (1 -\ \lambda) y \in\ C$$

Point $\lambda x + (1 - \lambda)y$ is called a convex combination of the points $x \; and \; y$. A good example is a polyhedron.





Convex set Not convex set

Convex functions

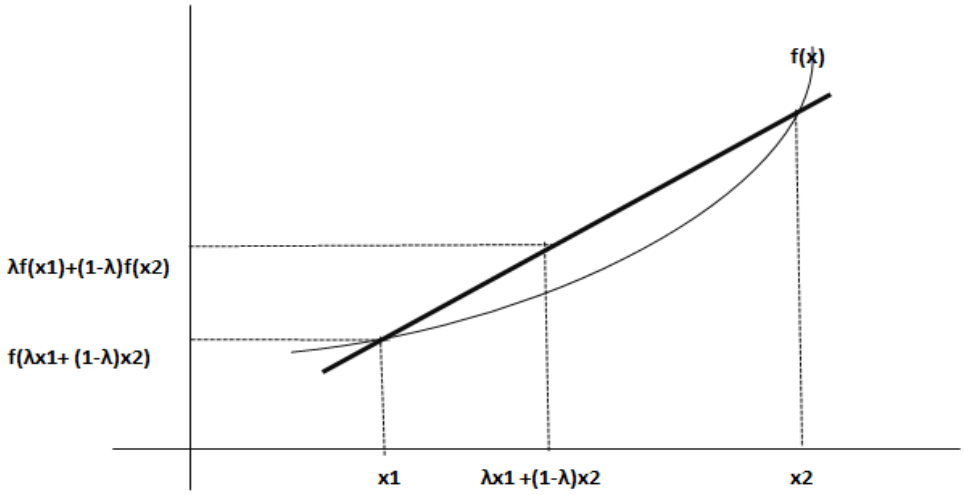
Definition 1.2

A function $f : \mathbb{R}^n \rightarrow \mathbb{R}$, is convex if its domain denoted as *D(f)* is a convex set, and if for all $x, y \in D(f)$ and $\lambda \in \mathbb{R}$ and $0 \leq \lambda \leq 1$

$$f(\lambda x + (1 - \lambda)y) \leq \lambda f(x) + (1 - \lambda) f(y)$$

This means that if one picks any two points on the graph of a convex function and draw a straight line between them, then the portion of the function between these two points will lie

below the straight line.



Graph of a convex function

3.4.2 How to identify convexity in a function

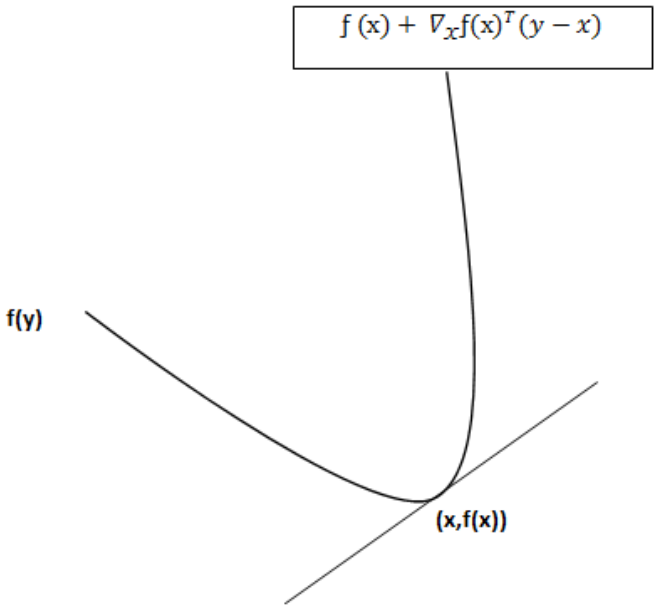
First Order Conditions for Convexity

It says that f is convex if and only if the tangent line is a global under estimator of the function f.

Suppose $\mathrm{f}: \mathbb{R}^n \rightarrow \mathbb{R}$ is differentiable (That is, a gradient $\nabla_x \mathrm{f}(\mathrm{x})$ exist at all points $x \in D$ *(f)*, then f is convex if and only if *D (f)* is a convex set and for all $x, y \in D(f)$,

$$\mathrm{f}(\mathrm{y}) \geq \mathrm{f}(\mathrm{x}) + \nabla_x \mathrm{f}(\mathrm{x})^T (y - x).$$

Where $\mathrm{f}(\mathrm{x}) + \nabla_x \mathrm{f}(\mathrm{x})^T (y - x)$ is the first order approximation to the function f at a point. This means that f is approximated by its tangent line at the point *i.e,*. if one takes the function f, every point of the tangent line will lie below the corresponding point on f.



The inequality $f(y) \geq f(x) + \nabla_x f(x)^T (y - x)$ shows that from local information about a convex function (i.e., its value and derivative at a point) we can derive global information (i.e., a global under estimator of it). This is the most important property of convex function where a local optimum is a global optimum. A simple example, if $\nabla f(x) = 0$, then for all $y \in D(f)$ $f(y) \geq f(x)$, i.e., x is a global minimizer of the function f.

Strict convexity can also be characterized by a first-order condition: f is strictly convex if and only if $D(f)$ is convex and for $x, y \in D(f)$, $x \neq y$, we have $f(y) > f(x) + \nabla_x f(x)^T (y - x)$.

Second Order Condition for Convexity

Suppose $f : \mathbb{R}^n \to \mathbb{R}$ is twice differentiable (That is, a Hessian $\nabla_x^2 f(x)$ exist for all points x in $D(f)$, then f is convex if and only if $D(f)$ is a convex set and its Hessian is positive semi definite: That is, for any $x \in D(f)$,

$$\nabla_x^2 f(x) \geq 0$$

This means that the second derivative of the function f is always non-negative for convexity to hold.

3.4.3 Convex Optimization problems

From the illustration of convex sets and convex functions, it is now certain that one can handle optimization problems. A convex optimization problem is of the form

$$minimize\ f_0(x)$$

$$subject\ to\ f_i(x)\ < 0, \qquad \mathrm{i} = 1, \ldots, m$$

$$\mathcal{k}_{\mathrm{i}} = 0, \qquad \mathrm{i} = 1, \ldots, \mathcal{p}$$

Where $f_0(x)$ and $f_i(x)$ are convex functions, and $\mathcal{k}_{\mathrm{i}}$ are affine functions, and x is the optimization variable.

The optimal value of an approximation problem is given as $\mathcal{P}^*$. This optimal value is equal to the least possible value of the objective function *f (x)*.

$$\mathcal{P}^* = \min\{\, f_0(x) : f_i(x) \leq\ 0, i =\ 1, \ldots, m, \mathcal{k}_{\mathrm{i}}(x) =\ 0, \mathrm{i} = 1, \ldots, \mathcal{p}\}$$

x^* is an optimal point if $f(x^*) = \mathcal{P}^*$

3.4.4 Linear Programming

Linear programming problem is a special case of convex optimization problem. The optimization technique has a linear objective function subject to linear equality and inequality constraints. Its feasible solutions fall in a convex polyhedron. The linear objective function of a linear optimization problem is an affine function with real values defined on the convex polyhedron. By definition, an affine function is an example of a convex optimization function, i.e.

Let $f : \mathbb{R}^n \rightarrow \mathbb{R}, f(x) = B^T x + c$ for some $B \in \mathbb{R}^n$, $c \in \mathbb{R}$. In this, case the Hessian $\nabla_X^2 f(x) = 0$ is for all x. The Hessian is a zero matrix thus making the function both positive and negative semi definite.

A linear programming solution will thus be a point in the polyhedron where the function is maximum or minimum. Linear programming problem is written as

$$minimize\ C^T x$$

$$subject\ to\ Ax \leq b$$

$$x \geq 0$$

x is the vector of variables to be determined

C and b are known vectors of coefficients

A is a known matrix of coefficients

$C^T x$ Which is the objective function of the transpose of C and the vector x.

n should be substantially smaller than *p*.

3.5.Model formulation

The constraint equations were formulated by conducting factor analysis on the variable in the four categories (dependent, moderating, intervening, and independent variables given in figure 2). Factor analysis is a technique of multivariate analysis. The technique describes correlations between a set of observed variables through linear combinations with a few unknown number of latent random factors (Timm, 2002). That is, if the observed variables $x_1, x_2, \ldots, x_p$ are at least

moderately correlated, the dimension of the system will thus be less than p. Therefore, factor analysis reduces redundancy among variables by use of smaller number of factors.

3.5.1 Background of Factor analysis

The random sample of observed variables $x_1, x_2, \ldots, x_p$ is from a homogeneous population with mean vector **μ** and covariance matrix **Σ**.

The factor analysis model expresses each variable as a linear combination of common factors $f_1, f_2, \ldots, f_n$ with an accompanying error term to account for the unique part in a variable (Rencher, 2008). The model is as follows:

$$\begin{aligned} x_1 - \mu_1 &= \lambda_{11} f_1 + \lambda_{12} f_2 + \cdots + \lambda_{1n} f_n + \varepsilon_1 \\ x_2 - \mu_2 &= \lambda_{21} f_1 + \lambda_{22} f_2 + \cdots + \lambda_{2n} f_n + \varepsilon_2 \\ &\vdots \\ x_p - \mu_p &= \lambda_{p1} f_1 + \lambda_{p2} f_2 + \cdots + \lambda_{pn} f_n + \varepsilon_p \end{aligned}$$

With

x_i are the test scores

*f'*s are the random variables that produce the *x'*s

λ_{ij} are the factor loadings (or weights). They show how individual *x* depends on *f*. That is, λ_{ij} specifies the significance of the *j*th factors to the *i*th variable.

ε_i are the residuals also known as unique or specific factors.

n should be substantially smaller than *p*.

Hence each test score about a mean is represented as two parts, a common part and a unique part

$$x_i - \mu_i = c_i + \varepsilon_i$$

Factor analysis investigates the common part

$$c_i = \lambda_{i1} f_1 + \lambda_{i2} f_2 + \cdots + \lambda_{in} f_n$$

$cov(\varepsilon_i, \varepsilon_j) = 0$ for $i \neq j$ and the λ_{ij} are the regression coefficients.

In matrix notation, the model can be written as

$$\boldsymbol{X - \mu = \lambda f + \varepsilon}$$

Where $X = (x_1, x_2, \ldots x_p)'$, $\mu = (\mu_1, \mu_2, \ldots \mu_p)'$, $f = (f_1, f_2, \ldots f_p)'$, $\varepsilon = (\varepsilon_1, \varepsilon_2, \ldots \varepsilon_p)'$, and

$$\lambda = \begin{pmatrix} \lambda_{11} & \lambda_{12} & . & . & . & \lambda_{1n} \\ \lambda_{21} & \lambda_{22} & . & . & . & \lambda_{2n} \\ . & . & & & & . \\ . & . & & & & . \\ . & . & & & & . \\ \lambda_{p1} & \lambda_{p2} & . & . & . & \lambda_{pn} \end{pmatrix}$$

Assumptions in factor analysis basic model

1. It is assumed that for $j = 1, 2, \ldots, n$, $E(f_j) = 0$, $\text{var}(f_j) = 1$ and $\text{cov}(f_j, f_k) = 0$, where $j \neq k$.
2. The assumptions for $\mathcal{E}_i$, $i = 1, 2, \ldots, p$, are similar except that the variance is unique for each residual part of each variable. Thus $E(\mathcal{E}_i) = 0$, $\text{var}(\mathcal{E}_i) = \psi_i$ and $\text{cov}(\mathcal{E}_i, \mathcal{E}_j) = 0$, where $i \neq k$
3. In addition $\text{cov}(\mathcal{E}_i, f_j) = 0$ for all i and j.

The constraint equation parameters

As explained earlier, constraint equations were constructed using factor analysis of the four variable categories (dependent, moderating, intervening, and independent variables) in SPSS version 20.1. However, not all variables in the four categories were fitted since the data available did not contain all variables highlighted in the conceptual framework. The available independent variables were time measured in years, participation in waged employment measured as a percentage of total waged and salaried workers, and employer size measured as percentage of the total employers. Sector division was divided into agriculture, industrial and service sectors. The three divisions were measured as a percentage of the total employed. On running the factor analysis, the correlation matrix showed that all the variables were sufficiently correlated but waged and salaried workers, employment in industrial sector and total employers had a correlation of 1. To remove redundancy waged and salaried workers variable was dropped and the analysis was run again. The independent variables yielded two factors namely, production and service sector factors whose equation was named as employment by sector. A well performing labor market has all laborers absorbed in any of the sectors. This implied that employment by sector should account for 100% absorption. Thus, the constraint was estimated not exceed 100% absorption.

The moderating variables available included labor allocation divided into rural (agriculture sector employment) and urban employment (service sector employment). Accumulated human capital was measured by status on employment, which comprised of self employed, own account workers, waged and salaried workers, contributing family workers and members of producer cooperatives. The other variables were gender measured as male and female, labor force participation rate and aging rates measured as a ratio of youth unemployment to adult

unemployment. The correlation matrix in the analysis showed that all the variables were sufficiently correlated but contributing family worker was highly correlated with waged and salaried workers, employers, and members of producer cooperatives. Employers were highly correlated with own account workers. Contributing family workers and own account workers were dropped from the analysis as a way of reducing redundancy. After a second run, the moderating variables yielded two factors namely employment and unemployment rate whose equation can be named as labor force participation rate. The estimation is that a well performing labor market has 100% LFPR.

The intervening variables available included human capital measured in terms of labor productivity, job quality measured as a function of status in employment (divided into self employed, own account workers, waged and salaried workers, contributing family workers and members of producer cooperatives. Opportunities available were measured in terms of employment to population ratio. The correlation matrix in the analysis showed that all the variables were sufficiently correlated but employers, members of producer society and contributing family workers were highly correlated with waged and salaried employers. Thus, employers, members of producer society and contributing family workers were dropped from this analysis. The intervening variables thus yielded one factors namely status on employment. The estimation is that at least all employable persons should belong to any of the highlighted employment status. Thus, the constraint should not exceed 100%.

The dependent variables available include crude labor force measured in terms of total participants, labor productivity and working poverty measured as a percentage of the population living below international poverty standards. Labor availability measured in terms of total unemployed was also available for the analysis. The dependent variable yielded two factors

namely labor utilization and unemployment rate. The equation was named as working poverty. This constraint was measured, as a percentage thus the constraint should not exceed 100%.

3.5.2 Model used in constructing the objective function: Multiple Linear Regression

This technique allows additional variables to enter the analysis separately so that the effect of each can be estimated on the independent variable. A linear model relating to the response variable *y* to several predictors has the form

$$y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \cdots + \beta_k x_k + \varepsilon$$

The parameter $\beta_0, \beta_1, \ldots \beta_k$ are the regression coefficients

$x_1, x_2, \ldots, x_k$ are the model predictors

ε is the error term providing information on the random variation in *y* not explained by the *x* variables. The variation could be due to other variables not known.

Construction of the objective function

The objective function of labor performance measured by labor productivity was fitted as a function of all factors. These are production and service for the first constraint, employment rate, and unemployment rate for the second constraint, status on employment for constraint three, labor utilization, and unemployment rate for constraint four. The objective function is thus a function of production sector, service sector, employment rate, total unemployment rate, status on employment, and labor utilization.

3.5.3 Labor market performance model

The fitted model was

$$Maximize\ Z = -0.336x_1 - 0.46x_2 + 1.97x_3 + 1.173x_4 - 2.092x_5 + 0.323x_6$$

Subject to

Employment by sector $3.12x_1 + 1.68x_2 \leq 100$

Labor force participation rate $4.8x_3 + 1.75x_4 \leq 100$

Status on employment $3.23x_5 \leq 100$

Working poverty $2.45x_6 + 1.24x_4 \leq 100$

$x_i \geq 0, i = 1, \ldots\ldots, 6$

Where

x_1 is production sector

$x_2$is service sector

x_3 is employment rate

x_4 is unemployment rate

x_5 is status on employment

x_6 is labor utilization

3.6.Validating the model

Linear programming models can be validated by either construct or by results. Validation by construct involves ascertaining that the modeling approach used was consistent with the industrial results or previous research findings. The model is thus deduced from real world observations and it is assumed valid based on the procedure followed. According to McCarl and Apland (1986), validation of linear programming models by results involves

1. Setting a real world outcome and gathering data causing the outcome.
2. Selecting a validation experiment
3. Performing the experiment and generating solutions
4. Testing for degree of association between the model output and the real world outcome
5. Making a decision regarding model validity

A number of validation experiments that a modeler can use on linear programming include feasibility experiment, quantity experiment, price experiment, prediction experiment, change experiment, tracking experiment and partial tests. This project chose to validate the model using prediction experiment since the model formulated was a prediction model. Prediction experiment involves fixing problem parameters at existing real world levels (McCarl and Apland, 1986). The solution to the model is sought and solutions are compared to the observed values. The aim of the experiment is to investigate if the linear programming model can reproduce reality. Its main limitation is that it does not consider the use of linear programming models in comparative static analysis.

The variables x_1 to x_6 were freshly determined using the original data set collected with minimal adjustments using factor analysis. The adjustments were as follows:

x_1 production was redefined by performing factor analysis on employment in agriculture and industrial sectors

x_2 service remained as employment in the service industry

x_3 a factor analysis on employment rate was refitted using employment in agriculture, industrial and service industry the resultant factor was renamed employment rate

x_4 unemployment rate used the collected data on unemployment rate

x_5 a factor analysis of status in employment was refitted again using information on waged and salaried workers, employers, own account workers, contributing family workers, and members of producers' cooperatives. Employers and contributing family workers had a higher correlation with the rest of the variables and were thus removed.

x_6 labor utilization remained as it was since there was no additional information to the variable.

After obtaining the variables, the constraint equations were obtained by fitting regression equations. The results were as follows

Labor productivity $0.509x_1 - 0.081x_2 = 6.209$

Labor force participation rate $1.677x_3 + 10.296x_4 = -12.54$

Employment to population ratio $5.837x_5 = -64.37$

Working poverty $3.727x_4 + 5.509x_6 = 22.247$

From the above constraints, labor productivity is below a hundred percent.

Labor force participation rate and employment to population ration have registered a negative figure. This could be due to LFPR and EPR being dependent on population size. From literature, it was highlighted that Sub-Sahara Africa population has been increasing despite the decreasing job creation initiatives. The increase has caused a higher population of the employable class that is not absorbed by the market. The inverse relationship between the population size and employment rate has cause a negative effect to labor market performance. However, the absolute values of the two constraints are still below 100% threshold.

Working poverty also registered a below a 100% effect on labor market performance. Previously, the formulated model had all the constraints given as less than or equal to a hundred. The observed model agrees that all the parameters are less than 100% since none of the parameters is equal to a value greater than a hundred. This model is thus valid and can be used for any analysis of labor market performance using labor market indicators.

3.7.Proposed analysis

This project used simplex method to solve the linear programming problem.

CHAPTER 4: DATA ANALYSIS

4.1 Description of the data

The data used for this project contained indicators on annual unemployment flow for 70 countries. International labor organization input the data into the calculations of unemployment rate. Majority of the data are from labor force survey datasets in OECD database (2013), EUROSTAT (Statistical office of the European Communities) (2013) and national statistical officers (2013), which often provide detailed and standardized data across countries on unemployment duration and labor market status (ILO, 2014). Unemployment by duration determined the country coverage for unemployment indicators.

4.2 Results

The formulated model was

$$Maximize\ Z = -0.336x_1 - 0.46x_2 + 1.97x_3 + 1.173x_4 - 2.092x_5 + 0.323x_6$$

Subject to

$$3.12x_1 + 1.68x_2 \leq 100$$

$$4.8x_3 + 1.75x_4 \leq 100$$

$$3.23x_5 \leq 100$$

$$2.45x_6 + 1.24x_4 \leq 100$$

$$x_i \geq 0, i = 1, \ldots\ldots, 6$$

Test for convexity

1st order condition: When first order conditions are applied, all the functions (objective function and the constraint functions) are found to be differentiable. That is the gradients exist at all points for both the objective function and the constraint equations. The domains of the functions are also convex sets.

2nd order condition: All the functions are twice differentiable. The second order conditions for all the functions are equal to zero. This implies that the Hessian matrix is positive semi definite.

From the test of convexity theory provided in Chapter 3, the formulated linear programming problem therefore qualifies to be a convex optimization problem since it meets both first and second order conditions.

Solution to the problem

To solve this problem, the project used simplex method

The standard form of the problem was

$$Maximize\ Z = -0.336x_1 - 0.46x_2 + 1.97x_3 + 1.173x_4 - 2.092x_5 + 0.323x_6$$

Subject to

$$3.12x_1 + 1.68x_2 = 100$$

$$4.8x_3 + 1.75x_4 = 100$$

$$3.23x_5 = 100$$

$$2.45x_6 + 1.24x_4 = 100$$

$$x_i \geq 0, i = 1, \ldots\ldots, 6$$

After adding the slack variables

$$Maximize\ Z = -0.336x_1 - 0.46x_2 + 1.97x_3 + 1.173x_4 - 2.092x_5 + 0.323x_6$$

Subject to

$$3.12x_1 + 1.68x_2 + s_1 = 100$$

$$4.8x_3 + 1.75x_4 + s_2 = 100$$

$$3.23x_5 + s_3 = 100$$

$$2.45x_6 + 1.24x_4 + s_4 = 100$$

$$x_i \geq 0, i = 1, \ldots\ldots, 6$$

The simplex tables were as below

Table 2: Simplex table 1

x_1	x_2	x_3	x_4	x_5	x_6	s_1	s_2	s_3	s_4	Z	
3.12	1.68	0	0	0	0	1	0	0	0	0	100
0	0	4.8	1.75	0	0	0	1	0	0	0	100
0	0	0	0	3.23	0	0	0	1	0	0	100
0	0	0	1.24	0	2.45	0	0	0	1	0	100
0.336	0.46	−1.97	−1.17	2.09	−0.323	0	0	0	0	1	0

Table 3: Simplex table 2

x_1	x_2	x_3	x_4	x_5	x_6	s_1	s_2	s_3	s_4	Z	
3.12	1.68	0	0	0	0	1	0	0	0	0	100
0	0	1	0.363	0	0	0	0.208	0	0	0	20.8
0	0	0	0	3.23	0	0	0	1	0	0	100
0	0	0	1.24	0	2.45	0	0	0	1	0	100
0.336	0.46	0	−0.455	2.09	−0.323	0	0.41	0	0	1	41

Table 4: Simplex table 3

x_1	x_2	x_3	x_4	x_5	x_6	s_1	s_2	s_3	s_4	Z	
3.12	1.68	0	0	0	0	1	0	0	0	0	100
0	0	2.74	1	0	0	0	0.571	0	0	0	57.1
0	0	0	0	3.23	0	0	0	1	0	0	100
0	0	−3.4	0	0	2.45	0	−0.709	0	1	0	29.1
0.336	0.46	1.25	0	2.09	−0.323	0	0.67	0	0	1	67

Table 5: Simplex table 5

x_1	x_2	x_3	x_4	x_5	x_6	s_1	s_2	s_3	s_4	Z	
3.12	1.68	0	0	0	0	1	0	0	0	0	100
0	0	2.74	1	0	0	0	0.571	0	0	0	57.1
0	0	0	0	3.23	0	0	0	1	0	0	100
0	0	−1.39	0	0	1	0	−0.289	0	0.408	0	11.9
0.336	0.46	0.799	0	2.09	0	0	0.577	0	0.132	1	70.9

The solutions were

$(x_1, x_2, x_3, x_4, x_5, x_6, s_1, s_2, s_3, s_4)$ = (0, 0, 0, 57.1, 0, 11.9, 100, 0, 100, 0)

And

Z= 66.84

4.3 Interpretation

The results from the above calculations indicate that the overall labor market performance in Sub-Sahara Africa is at 66.84 percent. This is measured by two main factors unemployment rate, which is at 57.1 percent and labor utilization, which is at 11.9 percent of the total population. The results thus indicate that of the nine labor market indicators, labor market performance is determined by four indicators namely unemployment rate, and labor utilization defined by labor force participation rate, labor productivity, and working poverty.

Compared to other labor market performance surveys done, the general results are realistic for Sub-Sahara Africa. For example, Mexico being a developing country like many of Sub-Sahara Africa countries registered a performance of 60.1 percent in 2011 and Canada being a developed country performed at 80.6 percent in 2011. Sub-Sahara Africa having a performance of 66.84 is in between the two economies. However, the greatest contributor to the performance is unemployment rate. This raises the question of the effect of unemployment rate to labor market performance. Compared to developed countries, literature exposed the market as having prolonged unemployment durations since job creation rates do not match up to the current global trends. This means that the market's ability to react to external pressures on unemployment contribute to performance.

CHAPTER 5: CONCLUSION AND RECOMMENDATION

Labor market performance can be termed as a function of all the labor market indicators with employment and unemployment trends acting supreme in the definition. However, the indicators vary in effect on market performance in different countries. For Sub-Sahara Africa, not all indicators of labor market conditions define labor performance. This could be a product of indicator measurements that make some of them highly correlated thus having a chance of higher elimination due to redundancy. For example, employment by sector was nested in total employment, youth unemployment was nested in total unemployment, and ratio of youth unemployment to adult unemployment was nested in employment to population ration. The three indicators thus lacked cognizable values in defining labor market performance. There is therefore need to consider cases of redundancy when projecting outcome based on a set of measures.

Nonetheless, the results above portray Sub-Sahara Africa labor market as a good performer. 66.84% performance is above average though with 57.1% unemployment rate. The confusion in the two figures paves way for several questions. Among the questions are the direct effect of unemployment rate in Sub-Sahara Africa and the effect of such a higher performance to economic growth. Such a higher performance when distributed among all the countries will be expected to reduce poverty and mortality rates in the region. However, the region is still rated as developing. The disagreement between results and reality could have been caused by the collective effect of data from many countries. The individual differences in country's performance and delivery of data thus caused neutralizing effect on Sub-Sahara Africa performance.

Recommendations

1. Labor market performance data in Sub-Sahara Africa should be country based. Such customized data will account for the changes that happen in the labor market structures that need to be studied as a trend. There is need for availability of data that can guide Sub-Sahara Africa in the adjustment process if labor performance has to be measured effectively.
2. Further research should be conducted on the direct effect of unemployment rate in Sub-Sahara Africa and the effect of such a higher labor market performance to economic growth.

REFERENCE LIST

Anand, Supreet Kaur. (2012). Essays on labor market in developing countries. *Digital Access to Scholarships at Harvard*. Accessed 25 February 2014 from: http://nrs.harvard.edu/urn-3:HUL.InstRepos:9284829.

Behrman Jere R. (1999). Labor Markets in Developing Countries. *Handbook of Labor Economics*, Vol.3. 2859-2939.

Bigsten Arne and Horton Sue. (1997). *Labor market in Sub-Sahara Africa to be included in Poverty Sub-Sahara Africa*. Accessed on 25 February 2014 from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.203.4263&rep=rep1&type=pdf

Chesher Andrew and Lancaster Tony. (1983). The Estimation of Models of Labor Market Behavior. *The review of economic studies*, Vol. 50 (4). Pp. 609-624.

Cramer Christopher, Oya Carlos, and Sender John. (2008). Rural Labor Markets in Sub-Sahara Africa: A New View of Poverty, Power, and Policy. *Centre for Development for Policy and Research*. Accessed on 25 Feb 2014 from: http://digitalcommons.ilr.cornell.edu/cgi/viewcontent.cgi?article=1156&context=workingprojects

Dubra Elena. (2007). Detailed Study of the labor Force and the Labor Market in Sectors of National Economy. *National Program of the European Union Structural Funds*. Accessed on 27 February 2014 from: http://www.lm.gov.lv/upload/darba_tirgus/darba_tirgus/petijumi/1._labour_force_en.pdf

Fields Gary S. (2011). Labor market Analysis for Developing Countries. *Official Journal of the European Association of Labor Economics*, Vol.18 (2011).S16-S22.

Gray L., Warrender, A. M., Davies, P., Hurley, C. & Manton, C. (1996). Labor market signals and indicators. *Overseas Development Administration*. Series 15, p.107.

International Labor Organization. (2014). Key Indicators of the Labor Market, 8th ed. *International Labor Office-GENEVA*. Accessed on 14 February 2014 from: http://kilm.ilo.org/2011/download/kilmcompleteEN.pdf

McCarl, Bruce A. and Apland Jeffrey. (1986). Validation of Linear Programming Models. *Southern Journal of Agricultural Economics*.Vol. 18 (2).p155- 164.

Oya Carlos. (2010). Rural Labor Markets in Africa: The unreported Source of Inequality and Poverty. *Centre for Development Policy and Research, number 57*. Accessed 27 February 2014 from: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCgQFjAA&url=http%3A%2F%2Fwww.soas.ac.uk%2Fcdpr%2Fpublications%2Fdv%2Ffile63653.pdf&ei=v0IQU4rJDqbT7AaQkYCgBA&usg=AFQjCNHuDNMtn5AupYAKT3RLLH0tj_z_ZQ&sig2=WwGlol6NDhomT4Q6FQKd6A&bvm=bv.61965928,d.ZGU

Paula Auerbach et al. (2005). Social Security Coverage and the Labor Market in Developing Countries. *Inter-American Development Bank*. Accessed on 25 February 2014 from: Felipe Herrera Library.

Prskawetz Alexia et al. (2005.). Decomposing the change in labor force indicators over time. Accessed 18 February 2014 from: http://www.demographic-research.org/volumes/vol13/7/13-7.pdf

Rencher Alvin C. (2008). *Methods of Multivariate Analysis*, 2 ed. New York, NY; A John Wiley & Sons, Inc. Publisher.

Ruffer Tim & Knight John. (2007). Informal Sector Labor Markets in Developing Countries. OX, United Kingdom.*Oxford Policy Management*. Accessed on 25 February 2014 from: http://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CDMQFjAB&url=http%3A%2F%2Fwww.opml.co.uk%2Fsites%2Fopml%2Ffiles%2FInformal%2520sector%2520labor%2520markets%2520in%2520developing%2520countries_0.pdf&ei=zkIQU-HnCa_07Aam44Fg&usg=AFQjCNExaGNqBPhnODyZfxuz_G8k3gdoxw&sig2=FdmPUew2ce6v5NZD65l5kg

Satchi Mathan & Temple Jonathan. (2006). Growth and Labor Markets in Developing Countries. Accessed on 25 February 2014 from: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.216.9256&rep=rep1&type=pdf

Sofia. (2011). Analysis on The Challenges Facing Labor Markets Within the Europe 2020 Strategy. *Republic of Bulgaria Economic and Social Council. ESC/2/030/2011 Commission on Labor, Income, Living Standards, and Industrial Relations*.

Stevens David W. (2002). Labor Market Dynamics: One Component of an Integrated System of Labor Market Information. *Workforce Information Council c/o Bureau of Labor Statistics*. Accessed on 18 February 2014 from: http://www.google.co.ke/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&ved=0CCoQFjAA&url=http%3A%2F%2Fwww.workforceinfocouncil.org%2Fdocuments%2FLaborMarketDynamicsConceptProject.doc&ei=9Q1sU-qyK6_y7AbkiYGAAg&usg=AFQjCNF5lp2J7xoMHXy561F1504wdhWR2Q&sig2=WYJQQ5f0SO8VBm8UoWvhfA&cad=rja

Timm, Neil H. (2002). *Applied Multivariate Analysis*. New York, NY: Springer-Verlag New York, Inc.

Toft Christian. (2004). *Essay on Segmentation, cross-national variation and European Union Regulations*. International labor market and social policy analysis. Sessel University Press.

Topel Robert. (1999). Labor Markets and Economic Growth. *Handbook of Labor Economics.*Vol. 3.2944-84.

Winters Paul et al. (2008).Rural Wage Employment in Developing Countries. Accessed on 27 February 2014 from: http://plagiarism.repec.org/jatta/jatta3.pdf

APPENDICES

Appendix 1: Labor market Indicators.

Indicator Number	Indicator
1	labor force participation rate
2	employment to population ratio
3	status in employment
4	employment by sectors
5	employment by occupation
6	part time workers
7	employment by hours worked
8	employment in the informal economy
9	total unemployment
10	youth unemployment
11	long term unemployment
12	time related to unemployment
13	Inactivity
14	labor force by level of education
15	skills mismatch
16	wages and compensation cost
17	labor productivity
18	working poverty

(ILO, 2014)