

**DETERMINANTS OF LABOUR PRODUCTIVITY IN ZAMBIA'S MANUFACTURING
FIRMS**

BY

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A dissertation submitted to the University of Zambia in partial fulfillment of the requirements of
the Degree of Master of Arts in Economics

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ABSTRACT

This paper investigates the determinants of labour productivity at firm level in Zambia's manufacturing sector, using panel data for the period 2006 to 2010 for 324 firms. The study is worth undertaking because labour productivity (LP) is a determinant of firm competitiveness and profitability. The study uses Hausman-Taylor technique to estimate a modified Cobb-Douglas production function, as in the study by Corvers F. (1997), for each category of firms; micro, small, medium and large. Stata Version 11 is used to analyze the data. The study results show that firm size, skill and education, capital and wage have a positive influence on LP across all firm categories. The results further show that employment growth in a firm reduces LP across all firm categories. Finally, foreign ownership, export orientation, industry age, research and development are all insignificant across all firm categories, and therefore do not influence LP in Zambia's manufacturing firms. The study concludes that human capital variables (skill and education), firm size, capital and wage are key drivers of labour productivity in Zambia's manufacturing firms and hence policies aimed at improving the sector's productivity and competitiveness should be aligned to target relevant variables identified in the study.

DEDICATION

To my parents Pastor and Mrs. Charles Ngombo Chikote.

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LIST OF ABBREVIATIONS AND ACRONYMS

ALP	-	Average Labour Productivity
BoZ	-	Bank of Zambia
CSO	-	Central Statistical Office
FEM	-	Fixed Effects Model
GCI	-	Global Competitiveness Index
GLS	-	Generalized Least Squares
INDECO	-	Industrial Development Corporation
HT	-	Hausman-Taylor Estimator
FNDP	-	Fifth National Development Plan
LP	-	Labour Productivity
MSMEs	-	Micro, Small and Medium Enterprises
MCTI	-	Ministry of Commerce, Trade and Industry
MNCs	-	Multinational Corporations
MISS	-	Manufacturing Industry Sector Survey
MP_L	-	Marginal Product of Labour
MP_K	-	Marginal Product of Capital
MRTS	-	Marginal Rate of Technical Substitution
NP	-	Net Profit
OECD	-	Organization for Economic Cooperation and Development
OLS	-	Ordinary Least Squares

PPPs	-	Public Private Partnerships
PSDRP	-	Private Sector Development Reform Programme
REM	-	Random Effects Model
R&D	-	Research and Development
SE	-	Standard Errors
SNDP	-	Sixth National Development Plan
UNDP	-	United Nations Development Programme
UNIDO	-	United Nations Industrial Development Organization
2SLS	-	Two Stage Least Squares

CHAPTER ONE

INTRODUCTION

Labour productivity is a very important determinant of a country's per capita income over a longer term as it determines competitiveness¹ of industrial products and thus profitability of industries in both domestic and foreign markets. High labour productivity means high utilization of capital and thus lower per unit cost of goods and services. Measured as the ratio of total output value or profit or stock price to total labour employed in producing the output, labour productivity draws a wedge between firms, as those that are innovative record high levels of profits.

Romer (1996) observes that the reason why firms are able to produce more output today from a given quantity of capital and labour than could be produced a century or two ago is because labour productivity has grown due to technological progress arising from research and development (R&D). He further observes that only growth in the effectiveness of labour can lead to permanent growth in output per worker. He apportions the differences in output (wealth) across time and space to differences in the effectiveness of labour and notes that for some reasonable cases, the impact of changes in capital per worker on output is modest.

Attention should therefore be paid to determinants of labour productivity at firm level in the manufacturing sector. This entails that analyses of determinants of labour productivity should not only address the question of changes in output based on quantity of labour employed in isolation but also output changes relative to the characteristics of the quality of labour employed in producing the output.

In Africa, labour productivity has not only been trailing Southeast Asia, but in fact the productivity gap widened between 1960 and 2000 as depicted in Figure 1.1 below. The slight recovery in productivity seen since the early 2000s indicates that economic growth is increasingly driven by rising labour productivity in some African countries. According to Africa Competitiveness Report 2013, the International Monetary Fund (IMF) examined productivity

¹ Definition of competitiveness are based on a variety of indicators such as profitability, cost advantages, product quality, or export or import ratios (Francis and Tharakan, 1989; and Niosi, 1991)

figures at a disaggregate level for the period 1995 to 2010, analyzing the extent to which structural transformation, defined as the shift of workers from low to high-average productivity activities, occurred in sub-Saharan Africa. The findings show that structural transformation has seen some countries such as Ethiopia, Kenya, Mozambique, and Tanzania, developing a manufacturing sector, and Kenya and Mauritius developing a service sector, although the report notes that the remaining African economies have registered only slow growth in labour productivity. The same report ranks Zambia’s pay and labour productivity efficiencies in the manufacturing sector behind Botswana, Egypt, Kenya, Namibia, Mozambique, South Africa and Tanzania (Global Competitive Report 2013).

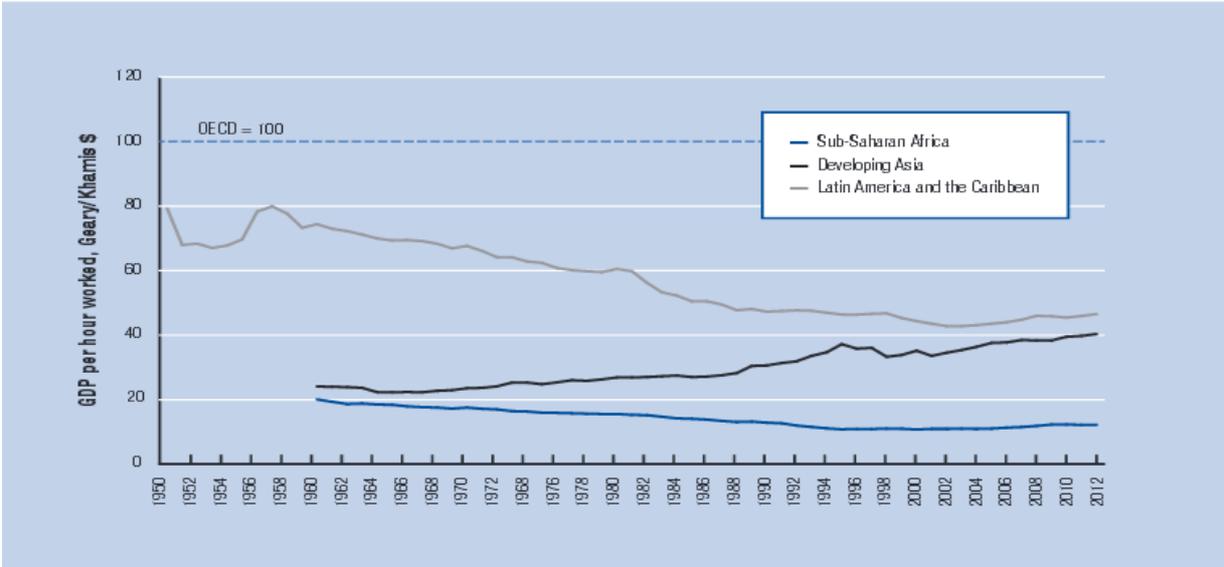


Figure 1.1: Labour Productivity in Manufacturing Sector by Region

Source: Africa Competitive Report 2013-World Economic Forum & World Bank

In an attempt to understand factors that influence labour productivity in manufacturing firms, a number of studies have been undertaken world over. Factors that have come out significant to influence labour productivity are net fixed assets per employee, export orientation, R&D activity of the firm, skill, education, firm ownership (private or public), wage and firm size. Of these factors most studies identify wage as the most significant factor in determining labour productivity at firm level (Papadagonas et al., 2005; and Niringiye et al., 2011).

In Zambia, the necessity to promote industrial competitiveness require an understanding of the determinants of labour productivity. However, there is no study that has addressed this issue. The purpose of this study is to investigate factors affecting labour productivity among industrial firms in Zambia. For this purpose, using statistical data from Manufacturing Industry Sector Survey (MISS) conducted in 2011 on 324 firms, the study analyzes the major factors affecting labour productivity in a firm. The magnitude of influence of each variable is also measured.

1.1.Problem Statement

Industrial competitiveness and growth of the manufacturing sector has a lot of positive benefits that accrue to an economy such as job creation, increase of per capita incomes as well as improved balance of payment accounts arising from value addition to a country's exports. However, for Zambia, during the Fifth National Development Plan (FNDP) period (2006 to 2010), the manufacturing sector had recorded slow growth rate averaging 3.3 percent against the projected growth rate of 7.5 percent.² At the same time, the Labour Force Survey Report³ show that labour productivity for the sector had declined by 25 percent during the period 2006 to 2009.⁴ An increase in labour productivity could have increased the manufacturing sector growth rate to the projected target and could have contributed significantly to Zambia's industrial competitiveness. This creates the need to investigate and understand determinants of labour productivity in Zambia's manufacturing sector.

1.2.General Objective

To investigate the determinants of labour productivity in Zambia's manufacturing sector at firm level.

1.3.Specific Objectives

- i) To examine the effect of human capital (i.e. education and skills) on labour productivity;
- ii) To investigate the effect of firm size on labour productivity;

² Sixth National Development Plan, 2011.

³Central Statistical Office (2012).

⁴ The annual decrease can be calculated by geometric mean; $(1 + r)^5 = 1.25$; $\bar{x} = 1 + r = (1.25)^{1/5} = 1.046$. Hence the growth rate is -4.6 percent per annum.

- iii) To determine the magnitude of influence of capital on labour productivity; and
- iv) To examine the magnitude of influence of wages on labour productivity.

1.4.Hypothesis

- i) Human capital has no effect on labour productivity in a firm;
- ii) Firm size has no effect on labour productivity in a firm;
- iii) Capital has no effect on labour productivity in a firm; and
- iv) Wage has no influence on labour productivity in a firm.

1.5.Significance

To my knowledge, there is no study that has been undertaken yet to specifically look at the determinants of labour productivity in the Zambia's manufacturing sector. Studies conducted in other countries cannot be generalized to Zambia as factors that affect labour productivity could be heterogeneous across countries. The use of panel data in this study creates unmatched impetus to observe the dynamics of variables otherwise difficult to observe when using time series or cross section data in isolation. Finally the study could appraise stakeholders on key drivers of labour productivity so as to increase the manufacturing sector's competitiveness.

1.6.Organization of the Study

The study is divided into six chapters. Chapter two provides an overview and structure of the manufacturing sector in Zambia. Chapter three discusses the literature from both theoretical and empirical standpoint. Chapter four presents the methodology and chapter five presents empirical results and discussions. Finally, chapter six presents the recommendations, proposed areas of future research, study limitations and conclusion.

CHAPTER TWO

OVERVIEW AND STRUCTURE OF THE MANUFACTURING SECTOR IN ZAMBIA

2.1. Introduction

The previous chapter introduced, in brief, the relevance of labour productivity at firm level and also presented a synopsis of labour productivity drivers. The chapter went further to present the ranking of the labour productivity in Zambia's manufacturing sector relative to some African countries. This chapter presents an overview, structure and characteristics of the manufacturing sector in Zambia.

2.2. Evolution of Manufacturing Industry in Zambia

Since independence, successive Zambian governments have attached great importance to improving the manufacturing sector's productivity so as to create employment and increase its competitiveness. Between 1960 and 1980s, many manufacturing companies were established across the country there by providing employment, with each region specialized in certain sub-sectors. For example, in the west, cashew and other foods as well as fertilizer and its by-products and in the northwest, there was the Mwinilunga Pineapple Industry. In the central-west region, textiles and blankets were produced. In the south, there were car and radio assembly plants. In the northern region, there was Mansa batteries, while the east had a thriving bicycle industry (UNIDO Report 2013).

To revitalize the manufacturing sector's productivity, the immediate post-independence government introduced the 1968 Mulungushi Reforms. The objective of the reforms, among others, were to acquire majority shareholding in a number of mostly resident expatriate manufacturing firms. Apart from political reasons, it was envisaged that state enterprise in manufacturing would promote industries which were import-substituting, export oriented, and employment generating, relying as far as possible on local resources.

To coordinate the industrial reforms was Industrial Development Corporation (INDECO) whose mandate was to establish, coordinate and run the industrialization process. These efforts, however, fell short in meeting the government's objectives. Much of manufacturing development by INDECO was judged to have been capital-intensive, urban based and directed towards

consumer goods requiring importation of considerable volumes of raw materials and intermediate products (Tangri, 1999). This coupled with the fall of copper prices and a rise in oil prices in the mid-1970s adversely affected the sector's performance. The knock-on effects were also felt by the sub-sectors that were linked to copper mining such as chemicals, rubber, basic metals and metal products. This led to most of the projects undertaken by INDECO to be unprofitable rather than improve labour productivity. Furthermore, shortages of imported inputs and protectionist measures led to inadequate competition. This coupled with inefficiencies in the management of the manufacturing industry led to many industries to close down during the 1980s.

In 1994, the Zambian Government embarked on a comprehensive economic reform programme to structurally adjust the economy aimed at ensuring dynamism, efficiency and competitiveness through a private sector led economy. There was a *vote face* from import substitution, protectionism and heavy public sector involvement towards the promotion of a private sector led market oriented economy.

The results of this policy shift have been judged differently by commentators, with some questioning the haste manner in which the process was undertaken resulting in undesired outcomes. For example, the United Nations Development Report (2007) states that the privatization of Zambia's State Owned Enterprises (SOEs) was executed in a haphazard manner, such that, with the exception of the countries in transition from central planning, it may be the case that no other country passed through economic liberalization so radical and rapid as Zambia did during the first half of the 1990s. In addition, an independent UNIDO Country Evaluation Report (2013) highlights that the ensuing period witnessed rampant corruption, capital flight acceleration and the decimation of Zambia's relatively strong industrial base.

National statistical records show that Zambia's total manufacturing index rose by 25 percent through the 1980s, but fell by 30 percent following privatization in the 1990s with industry showing negative growth over the 10year period, reversing significant gains in the previous decade and in the period since independence. Figure 2.1 below illustrates the Manufacturing Sector's performance from 1964 to 2010 and it can be observed that between 1964 and 1989 the Sector performed well but fell sharply after 1991.

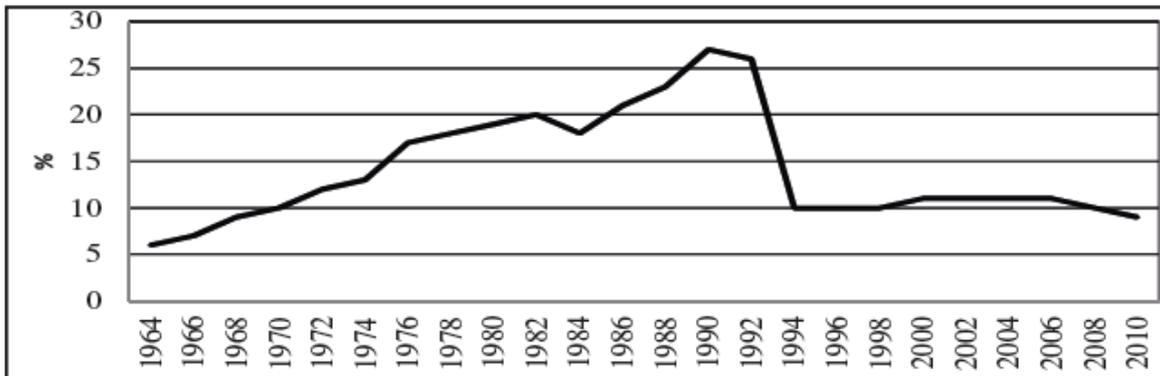


Figure 2.1: Share of Manufacturing Sector to GDP (1964-2010)

Source: UNIDO 2013 Report

Despite the afore mentioned challenges, and in line with strategies contained in the National Development Plans, the manufacturing sector continued to receive government support. For instance, in 2004 the Zambian government established the Private Sector Development Reform Programme (PSDRP) whose aim was to facilitate the development of a competitive business environment in Zambia so as to create jobs and wealth. The PSDRP was to be implemented in two phases, PSDRP I running 2006-2008 and PSDRP II running 2009-2014. The former focused on laying the foundation to foster sustainable private sector led growth by improving the investment climate while the latter focuses on improving increased access to financial services, infrastructure, regional and international markets, skills training and business development services among others.

An evaluation of PSDRP I indicated the need for improving competitiveness for the private sector and therefore PSDRP II listed, among others, the following priority reforms: micro, small and medium enterprise (MSME) development; Labour and labour productivity reform; Public Private Partnership (PPP) development; and trade expansion. These priority reforms are aligned to Vision 2030's and the FNDP objectives of developing a sustainable, diversified and competitive export led and value adding manufacturing sector. Therefore increase in sector competitiveness should be accompanied by improvement in labour productivity (Romer, 1996).

2.3. Characteristics of the Manufacturing Sector

2.3.1. Categorization of Sector by Product

Zambia's Commercial, Trade and Industrial (CTI) Policy of 2008 categorises the manufacturing sector into eight sub-sectors. The largest proportion of the sampled manufacturing firms by sub-sector is the Food, Beverages and Tobacco comprising 37 percent followed by Wood and Wood Products at 23 percent. Textiles, Clothing and Leather sub-sector is third at 12 percent. Fabricated Metal Products; and Chemicals, Rubber and Plastic Products in fourth and fifth positions representing 10 and 9 percent respectively as depicted in Table 2.1.below:

Table 2.1: Distribution of Firms by Sector

Sub-sector	Dominance (%)
Food, Beverages & Tobacco	34
Wood & Wood Products	20
Textiles, Clothing & Leather Products	12
Fabricated Metals	10
Chemicals, Rubber & Plastic	9
Metal Products	7
Paper, Printing & Publishing Products	5
Other Products	2
Non-Metallic & Mineral Products	1

Source: Author's illustration based on MISS 2011 data

2.3.2. Geographical Distribution of Manufacturing Firms

The sampled manufacturing firms are geographically concentrated in the two most urbanised provinces of Lusaka and Copperbelt with a total of 67 percent. North-Western and Luapula Provinces have the least concentration of manufacturing enterprises accounting for only 6 percent. Table 2.2 below provides a detailed geographic presentation:

Table 2.2: Distribution of Manufacturing Firms by Province

Province	Dominance (%)
Lusaka	42
Copperbelt	25
Southern	7
Central	6
Northern	6
Western	4
Eastern	4
North Western	3
Luapula	3

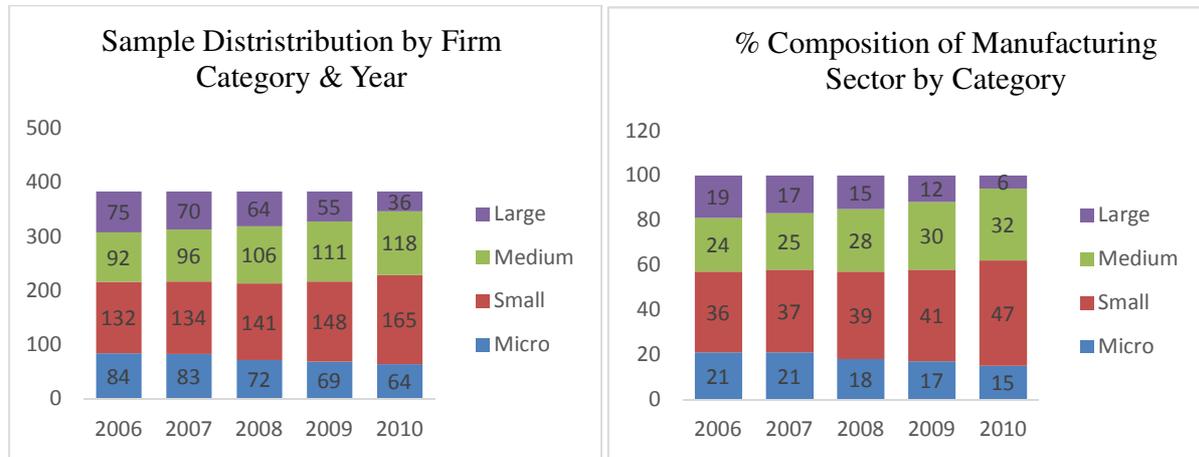
Source: Author's illustration based on MISS 2011 data

2.5. Sample Distribution by Category and Year

The total sample is 383 firms⁵ as indicated in Figure 2.2 Panel A below. Panel B presents firm composition by percentage points and year. Small firms had dominated the sector at an average of 40 percent and the least were large firms at 13.8 percent. Small and medium firms had been growing over FNDP period. This suggests that a number of micro firms grew into small; and large firms regressed to medium firms. This suggests that large firms have been substituting labour for capital leading them to being capital intensive.⁶

⁵ Out of the 383 firms the final sample size is 324. Firms that changed from one firm category to another are dropped from the sample in order to avert biased estimators (refer to Chapter 4, Section 4.3).

⁶Change in firm category suggest an increase or decrease in firm employee size. If output has to be held constant during transition, given a certain level of technology, then labour should be substituted for capital.



Panel A

Panel B

Figure 2.2: Firm Composition by Category and Percentage

Source: Author's illustration based on MISS 2011 data

2.3.4. Labour Force Analysis

During the FNDP period, firm employment growth averaged 20 percent in both micro and small firms. Medium and large firms had 43.6 percent and 57 percent respectively. The average employment growth rate for the sector was 35.25 percent, as illustrated in Figure 2.3 below:

Table 2.3: Average Employment Growth Rate by Firm Size (2006-2010)

Category	Average Employment Growth (%)
Micro	20
Small	20.2
Medium	43.6
Large	57.2
<i>Average Employment Growth</i>	<i>35.25</i>

Source: Author's illustration based on MISS 2011 data

Despite ranking last in terms of employment levels, micro firms have the highest labour productivity, followed by large firms with small firms last as indicated in Figure 2.4 below:

2.4. Labour Productivity (AP_L) by Firm Category (2006-2010)⁷

Firm Category	Net Profit	Total No. of Employees	AP_L
Micro	650,910,148,142	757	859,854,885
Small	-210,210,284,292,736	12,643	-16,626,614,276
Medium	-1,813,500,261,600	36,878	-49,175,667
Large	381,165,000,000	25,784	14,783,005

Source: Author's illustration based on MISS 2011 data

2.6.1. Marginal Productivity Analysis⁸

Economic theory attaches great importance to marginal analysis as observed by Nicholson (1998). This enables firms to analyze the effect of hiring an additional unit of input/s on total output. As such the study presents the findings of the Marginal Analysis in Table 2.5 below as calculated at Appendix A.

Table 2.5: Marginal Productivity Analysis by Firm Category

FIRM/YEAR	2006-2010 ⁹
Micro	$MP_L > AP_L$
Small	$MP_L > AP_L$
Medium	$MP_L > AP_L$
Large	$MP_L > AP_L$

Source: Author's illustration based on MISS 2011 data

Table 2.5 above shows that all firm categories operated below optimal levels (employment of labour) since $MP_L > AP_L$ and hence the optimal condition $MP_L = AP_L$ was not satisfied. Additional workers employed would have led to an increase in employment and increased output. It is worth noting that labour's total contribution to output is 80 percent while capital is 20 percent as depicted at Appendix A, equation (A6). The low capitalization levels can be traced through the low $MRTS_{K,L}$ in mostly micro and small firms. Medium and large firms seem to be indifferent in hiring either of the two inputs.

⁷ Currency figures are in unrebased Kwacha. Net Profit figures are for the sample and DONOT reflect the profitability of the entire sector by category in Zambia. Therefore inference should solely be by AP_L .

⁸ See detailed analysis at Appendix A.

⁹ Overall outlook of the aggregates of MP_L and AP_L for the FNDP period as calculated at Appendix A.

This Chapter looked at an overview, structure and evolution of manufacturing sector in Zambia. Descriptive statistics was also presented and concluded with the marginal productivity analysis by firm category.

CHAPTER THREE

LITERATURE REVIEW

3.1. Introduction

This chapter explores factors that are perceived to influence labour productivity at the firm level from both the theoretical and empirical standpoint. The chapter further contrasts and compares various studies conducted on determinants of labour productivity in manufacturing firms.

3.2. Theoretical Literature Review

3.2.1. Education, Abilities, Knowledge and Skill (Human Capital)

According to the human capital theory, human capital contributes to output just like other factors of production and also through technological change by driving both innovation and imitation (Schultz, 1961; Becker, 1964; Welch, 1970; and Mincer, 1974). Corvers (1997) discusses four effects of human capital on labour productivity: worker effect, allocative effect, diffusion effect, and research effect. He argues that human capital contributes to productivity level through allocative and worker effect, and productivity growth through diffusion and research effects. Corvers (1997) introduces the above effects as follow:

- a) The worker effect or 'own productivity' effect: - this effect as explained by Welch (1970) assumes that firms produce only one good with the production factor- education, and that other resources are given. The worker effect refers to the positive marginal productivity of education with respect to that particular good. Workers with a higher level of education are assumed to be more efficient in working with the resources at hand, i.e. these workers produce more physical output. In other words, education increases the effective labour input from the hours worked. Therefore a better educated labour force shifts the production possibility curve outwards.

- b) The allocative effect:- points to the greater (allocative) efficiency of better educated workers in allocating all input factors to the production process (including education itself) between the alternative uses. Welch (1970) gives two examples of the allocative effect. If there is one fixed input factor to produce two goods, education may improve the

total revenues of firms by means of a better allocation of the input factor between the alternative outputs. Although the production process is technically efficient because the firm produces on the production possibility curve (expressed in physical units), workers have more knowledge of how to maximize the marginal value product (expressed in money units) of the input factor. Total revenues are maximized if the marginal value product of the input factor is equalized for all goods. Another allocative effect is present if, in addition to education as an input factor, two (or more) other inputs are included in the production function. If just one good is produced with two inputs, education may also help to select the efficient quantities of inputs. In equilibrium, the marginal value product of the inputs should equal the price of the inputs. In fact, education seems to provide the skills to make better decisions based upon the available information. As a result of the allocative effect, an increase in the relative proportions of intermediate and highly-skilled is expected to lead to a higher productivity level in money units.

- c) Diffusion effect: - stresses that better educated workers have more ability to adapt to technological change and will introduce new production techniques more quickly. Nelson and Phelps (1966) state that "educated people make good innovators, so that education speeds the process of technological diffusion" (Bartel and Lichtenberg, 1987). Moreover, Nelson and Phelps (1966) stress the role of receiving, decoding and understanding information in performing a job. A higher level of education increases the ability to discriminate between more and less profitable innovations and reduces the uncertainty about investment decisions with regard to new processes and products. Therefore education increases the probability of successful and early adoption of innovations. Higher proportions of intermediate and highly-skilled workers, relative to low skilled workers, would be expected to lead to more rapid and successful adoption of innovations and higher productivity growth.

- d) Research effect:-refers to the role of higher education as an important input factor in research and development (R&D) activities, which is in turn, a key factor for technological progress and productivity growth (see, e.g., the endogenous growth models in Romer, 1990 and Grossman and Helpman, 1992). Since R&D activities are very

complex, a relatively large proportion of intermediate and highly-skilled workers are a prerequisite to increase technological knowledge and achieve productivity growth.

3.2.2. Firm size

Industrial organization literature as well as relative theory support the view that small and medium sized-enterprises (SMEs) are less cost efficient than the larger ones. This is due to economies of scale and product differentiation enjoyed by large firms. Lack of R&D expenditures and vertical integration increase cost for SMEs. Another reason for the lower efficiency is the large capital requirements in certain industrial sectors. Papadogonas et al., (2005) notes that since small firms have insufficient financing, they cannot grow to a large size firm and benefit from economies of scale.

3.2.3. Wage

According to the theory of efficiency wages, the wage rate above the market clearing level will increase labour productivity, through:-

- i) Improved worker health; better paid workers have a higher likelihood to eat a more nutritious diet, and workers who eat a better diet are healthier and more productive.
- ii) Reduced worker turn over; better paid workers are easy to retain hence retention of skill and experience (institutional memory).
- iii) Worker quality; highly skilled workers are attracted to better wages.
- iv) Worker effort; highly paid workers are more likely to possess a high level of motivation and bond to the firm.

The above effects can be summed up under the following two models:

- i) Incentives-driven model otherwise known as the Shirking model (Stiglitz et al., 1984); according to this model, as wage level increases, labour force will be more motivated to keep their jobs and will therefore try to increase level of their productivity to avoid being sacked (Griliches, 1986; Hall and Mairesse, 1995; Lööf and Heshmati, 2002).
- ii) Gift exchange model is based on the assumption that high wages change the relationship between employer and employee. An employee will be more attached to employer and try to increase his own productivity (Mühlau and Lindenberg, 2003). Many empirical studies

confirming the wage-efficiency phenomenon, including Huang et al., (1998) for the industrial sector in China have shown that productivity change is affected by wage more than human capital. The study of Romaguera et al., (1991) in Chile shows validity of the theory of efficiency wages. Mühlau and Lindenberg (2003), using statistical data in Japan and the United States have confirmed the validity of this theory. In line with the theory of efficiency wages, it is therefore plausible for firms to keep wages high even in the presence of surplus labour in order to maintain high levels of labour productivity.

3.2.4. Employment Growth

According to the law of diminishing marginal productivity, as more of the variable factor (labour) is added to the fixed factor, output tends to increase at a decreasing rate (Nicholson, 1998). What could have been expected is that as more labour is hired, output growth should equally rise. This could be true up to a certain level of output though, of which beyond this point, output tends to decline as more labour is hired. Papadogonas et al., (2005) and Fiouz et al., (2011) confirms this relationship as their study established a negative relationship between labour productivity and employment growth.

3.2.5. Industry Age

Industry age, denoting product innovation, is expected to correlate negatively with labour productivity of firms. According to theory and empirical findings (Karlsson and Nystrom, 2003), young industry sectors are characterized by new entrants which are usually very small (micro), small and medium size firms, knowledge intensive with highly skilled labour and new technology investments. As such these firms are more labour productive versus mature capital intensive firms, which usually are concentrated in capital intensive oligopolistic markets. In the early stages of product life cycle, competition is intense and firms are usually small. The capital intensity in production is low and a lot of resources are instead devoted to R&D, customer contact, marketing and design improvement. The intensity of labour is of great importance during this stage. Demand in this stage tends to be both price and income inelastic in connection with the presence of substitutes, implying that firms in this stage can benefit from market power and monopoly profits. During the later stage of the product life cycle, the presence of economies of scale tends to result in larger firms, higher capital intensity and a more concentrated industry structure. Since process innovations often result in production techniques that can be operated by less skilled labour, knowledge intensity decreases over the production cycle.

3.2.6. Foreign Ownership

According Salvatore (2004), the basic reason for the existence of Multi-National Corporations (MNCs) is the competitive advantage of global network of production and distribution. This competitive advantage arises in part from vertical and horizontal integration with foreign affiliates. By vertical integration most MNCs can ensure their supply of foreign raw materials and intermediate products and circumvent the imperfections often found in foreign markets. By horizontal integration through foreign affiliates, MNCs can better protect and exploit their monopoly power, adapt their products to local conditions and tastes and ensure consistent product quality. The large output of MNCs allows them to carry division of labour and specialization in production much further than smaller national firms. Foreign affiliates funnel information from around the world to the parent firm, placing it in a better position than national firms in evaluating, anticipating and taking advantage of changes in comparative costs, consumers' tastes and market conditions generally. All these ensure that firms that are foreign owned have a higher LP compared to local national firms.

3.2.7. Capital Stock

As suggested in growth models that support the view that greater capital accumulation leads to greater variety of capital goods and thus greater capital quality (Solow, 1960; Romer, 1987). In these models, technological change is embodied in new capital goods. Capital accumulation is perceived to increase firm productivity when combined with the right mix of effective labour. Macroeconomic theory thus attaches great importance to investment demand i.e. demand for plant and equipment. It is envisaged that a profit maximizing firm facing a perfectly competitive rental market for capital will hire additional capital input to the point at which its marginal revenue product (MRP_K) is equal to the market rental rate v (Nicholson, 1998).

3.3. Empirical Literature Review

A number of studies have attempted to investigate the factors that affect labour productivity in manufacturing industry, for example, Papadogonas et al., (2005) and Niringiye (2010), adopting labour productivity as the dependent variable, and the independent variables being physical capital, wage, firm size, foreign ownership, R&D, export orientation of firm, employment growth, education of employees, skill and industry age.

Fiouz et al., (2011) investigated determinants of labour productivity at the firm level in the Iran's manufacturing sector. The analysis was based on descriptive statistics and cross sectional regression models on a sample of 12,299 industrial firms. Results from the study show that among the explanatory variables, wage came out to be the most significant and important factor influencing labour productivity in line with the wage efficiency hypothesis among the industrial enterprises.

Other results from the study indicate that employees with college or higher degree were more productive as compared to their counterparts with less education. Capital intensity and firm size had a positive effect on labour productivity. Ownership of the firm had a bearing on productivity of firms, with those privately owned recording higher labour productivity levels compared to state owned firms. Furthermore, R&D played a positive role in labour productivity. Export status of the firm was positive with labour productivity signifying the importance of exports to international markets and new business development in technology improvement that results in labour productivity increase.

Papadogonas and Voulgaris (2005) conducted a study to investigate determinants of labour productivity growth in Greek manufacturing firms. They used regression models on a longitudinal sample of 3035 firms. The study revealed that labour productivity growth is positively related to growth of net fixed assets per employee, export orientation and R&D activity of the firm. Expenditures on R&D is used as a proxy of knowledge capital of firms. It is evident that as technology improves, the level of per worker output will increase, so any factor like R&D expenditures that causes technology improvement will increase labour productivity. The study found firm size, employment growth, and industry age to be negatively correlated with labour productivity growth.

A study to investigate the effect of human capital on labour productivity in East African manufacturing firms was undertaken by Niringiye et al., (2010). The study used Generalized Least Squares (GLS) to estimate the human capital model on longitudinal data from Kenya, Tanzania and Uganda. Results indicate that proportion of skilled workers and average education in Uganda, training, proportion of skilled workers and education of the manager in Tanzania and average education and training in Kenya were positively associated with labour productivity.

As much as the three studies by Fiouz, Papadogonas and Niringiye agree on factors such as capital intensity, export orientation and R&D to influence labour productivity, some differences can be observed in their studies. Fiouz emphasizes the importance of firm size on labour productivity and also in line with the study of labour productivity of developing countries conducted by Snodgrass and Biggs (1995) and Biesebroeck (2005), Papadogonas, however, down plays the role of firm size indicating that it reduces labour productivity growth. In further confirmation of the relevance of firm size to labour productivity, a survey conducted in Latin America in 2010 by Biesebroeck show that large manufacturing firms have higher levels of labour productivity on average of about 44 percent higher than the labour productivity of medium firms and 115 percent higher than that of small firms.

Geroski (1998) and Tybout (2000) at the other extreme, show that the flexible, non-hierarchical structure of small firms can give these firms a productivity advantage over large firms. Indeed several studies have shown a decrease in labour productivity as firm size increases.

The difference in the findings of the studies conducted on labour productivity could be explained by the differences in the type of data and methodology used. For Example, Fiouz et al., (2011) used cross section data while Papadogonas et al., (2005) used longitudinal data. Secondly, the use of the log of firm's annual sales as a proxy for firm size could also hold an explanation for the differences. Papadogonas uses weighted lagged differences in the log of annual sales (to capture labour productivity growth) while Fiouz used the absolute log of annual sales as a proxy for firm size. However, it is important to note that all the studies attach great importance to factors such as education and skill, capital, wage, foreign ownership status and export status of a firm and we therefore examine the factors below:

3.3.1. Education and Skill

Most of empirical studies in the field of education and its effect on labour productivity have been conducted at industry level, for instance Tan and Batra (1995), have used industry data of several developing countries and shown that level of education and firm training have positive and significant effect on productivity. In another study Corvers (1997), discussed the effects of human capital on both the level and growth of labour productivity in manufacturing sectors in

seven member states of the European Union (EU). The results of this study show that both intermediate and highly-skilled labour had a positive effect on the sectorial labour productivity level.

Bishop (1991), Bartel (1994), Hozler et al., (1993), Huselid (1995), Almeida and Carneiro (2008), show that firm trainings have positive and significant effect on labour productivity. Black and Lynch (1996), used the data of more than 3000 private establishments with more than 20 employees in the United States. Their findings show that the level of education has a positive and significant effect on labour productivity. Also the results indicated that the effect of labour trainings provided by the firm was positive and significant on labour productivity, and according to results, this effect was stronger than education effect. Turcotte and Rennison's (2004) study on industrial firms of Canada had the same results.

3.3.2. Firm export status

Based on existing studies there are two major reasons for a positive influence of firm export status on labour productivity:

Firstly, firms that export their products due to transport costs, marketing, distribution etc, must have lower domestic price in order to determine a price commensurate with their costs and willingness to pay of foreign buyers for their exporting products, (Salvatore, 2004). Extra cost for sales in export markets acts as a barrier to prevent non-efficient firms' entry. Therefore, firms that export their products are expected to be more efficient and have more labour productivity than the firms that sell their products only in domestic markets. Secondly, firms that are attempting to export, enter into unwanted territory and compete with other countries and can achieve a higher level of production knowledge through Learning-by-exporting process and improve their productivity (Wagner, 2005). Many firm level empirical studies in different countries indicate that being an exporter firm, has a positive effect on labour productivity, for instance: Bernard (1995), conducted his study for Mexico; Clerides et al., (1998) got the same result for Morocco as well as studies of Lin et al., (1999), Aw and Hwang (1995) and Tsou et al., (2002) in Taiwan, and the study of Van B. (2005) for nine African countries, confirm this idea. Moreover, the studies of Farinas and Martin-Marcos (2003) in Spain, Greenaway et al., (2003),

Hansson and Lundin (2004) for Sweden, and Girma et al., (2004) in England and finally Papadogonas et al., (2005) among industrial firms in Greece have indicated that the labour productivity in exporter firms is more than non-exporter firms.

3.3.3. Research and Development (R&D)

In most studies, R&D expenses are used as a proxy of accumulated R&D, due to lack of data. According to Wakelin (2001), R&D expenditure is the most common choice. Rogers and Tseng (2000) use R&D as a dummy variable to proxy which of the firms have higher levels of such capital. However questions concerning the time lag of R&D expenditures' effect on firm productivity arise. Lagged R&D expenditure is used in many studies, with no agreement on the correct length of the lag. Mairesse and Sassenou (1991) point out the stability of firm R&D over time for France, United States of America (U.S.A) and Germany and the insensitivity of the results to the choice of lag. Generally studies find that R&D has a positive and significant effect on productivity (Cohen,1995; Griliches, 1995; Wakelin, 2001). It was also found that there is an implicit time lag between R&D effort and its benefits. Studies suggest that the lag structure is bell shaped with a mean time lag of between 4 and 6 years. This means that ideally, a long time series R&D firm level data should be available (Rogers and Tseng, 2000).

CHAPTER FOUR

METHODOLOGY

4.1. Introduction

Chapter three reviewed studies conducted on labour productivity drivers from the theoretical and empirical perspectives. This chapter outlines the type of data and sample used, defines the independent variable and dependent variables. The theoretical and empirical model, estimation technique and the equation to be estimated are also presented.

4.2. Data and Sample Size

Secondary panel data from the Ministry of Commerce, Trade and Industry for 324 active manufacturing firms for the period 2006 to 2010 is used in the study. Firms established after 2006 and those that changed status in terms of firm category (in transition) during the FNDP period are dropped from the sample¹⁰. This is to avoid biased results. The MSME Policy has three classification criteria of firms namely, annual turnover, number of employees, and value of assets. The number of employees had remained stable over the period under review and hence the study adopts this method of classification as depicted in Table 4.1. Panels A and B below. The data are analyzed using Stata Version 11.

Table 4.1: Sample Distribution by Firm Category, Year and Firm Classification

Panel A						Panel B		
Sample Distribution						Firm Classification		
Category/Year	2006	2007	2008	2009	2010	category	No. of	employees
Micro	64	64	64	64	64	Micro	<=20	
Small	132	132	132	132	132	Small	[21 to 50]	
Medium	92	92	92	92	92	Medium	[51 to 100]	
Large	36	36	36	36	36	Large	>100	
Total	324	324	324	324	324			

Source: Author's illustration based on MISS data

Source: MCTI

¹⁰ Refer to Chapter 2, Section 2.3.3.

4.4. Theoretical Model

4.4.1. Cobb Douglas Production Function

To study the relationship between output and labour productivity, we begin our analyses with a Cobb-Douglas (1928) production function of the form:

$$Y = AK^\alpha L^\beta ; \frac{\partial y}{\partial L} > 0 \quad (1)$$

Where Y, K, L is output, capital and labour, respectively, and α and β are elasticity parameters expressing substitutability of inputs for each other.

We have the following:

$$AP_L = \frac{y}{L} = AK^\alpha L^{\beta-1} \quad (2)$$

$$\frac{\partial y}{\partial L} = A\beta K^\alpha L^{\beta-1} = MP_L; \text{ and} \quad (3)$$

$$\frac{\partial y}{\partial K} = A\alpha K^{\alpha-1} L^\beta = MP_K \quad (4)$$

Dividing equation (3) by equation (4) we have:

$$\frac{\beta K}{\alpha L} = MRTS_{K,L} \quad (5)$$

Equation (5) shows that substitutability of inputs depends solely on elasticity parameters α and β and the optimal point of production point will be

$$AP_L = MP_L; A\beta K^\alpha L^{\beta-1} = A\alpha K^{\alpha-1} L^\beta \quad (6)$$

4.4.2. Human Capital Augmenting Model

As in the study of Nelson-Phelps (1966), Lucas (1988), Corvers (1997) and Niringiye et al., (2010), extending and modifying equation (1) to incorporate individual i and longitudinal effects t , we have the following:

$$Y_{it} = AK_{it}^\alpha L_{it}^{*\beta} \quad (7)$$

Where Y, K are defined as before in (1) and L^* represents efficient units of effective labour.

We can then write an efficiency units of labour equation as follows:

$$L_{it}^* = L_{it} L_{1it}^{\theta_1} L_{2it}^{\theta_2} L_{3it}^{\theta_3} \quad (8)$$

Where L_i is the number of employees in firm i and $L_r^{\theta_r}$ is the number of employees with education level $r = 1, 2$ and 3 being lower, intermediate and higher education levels respectively. The parameter θ_r reflect the contribution of the respective education levels to efficiency units of labour.

Substituting equation (8) into (7) and dividing by labour (L) yields;

$$\frac{Y_{it}}{L_{it}} = A \left(\frac{K}{L} \right)_{it}^{\alpha} L_{it}^{\alpha + \beta - 1} (1 - L_2 - L_3)^{\beta(1 - \theta_2 - \theta_3)} L_{2it}^{\beta\theta_2} L_{3it}^{\beta\theta_3} \quad (9)$$

According to equation (9), the level of labour productivity depends on relative shares of the three educational levels in the labour force of the firm.

Equation (9) can be used to calculate the dynamic effects of human capital on labour productivity. We modify and extend Corvers (1997) model by including more additional human capital variables to minimize the over estimation of the relative significance of human capital components that were originally specified in the original model. We therefore include weighted average education and skill intensity. Thus we have the following model:

$$\frac{Y_{it}}{L_{it}} = A \left(\frac{K}{L} \right)_{it}^{\alpha} L_{it}^{\alpha + \beta - 1} L_{1,it}^{\beta\theta_1} L_{2,it}^{\beta\theta_2} L_{3,it}^{\beta\theta_3} L_{4,it}^{\beta\theta_4} \quad (10)$$

Taking logs to equation (10) yields the following;

$$\ln \frac{Y_{it}}{L_{it}} = \ln A + \alpha \ln \left(\frac{K_{it}}{L_{it}} \right) + (\alpha + \beta - 1) \ln L_{it} + \ln \beta \theta_1 L_{1,it} + \dots + \ln \beta \theta_4 L_{4,it} + u_i + \varepsilon_{it} \quad (11)$$

Where;

L_1, L_2, L_3 and L_4 are average weighted education level and proportion of skilled workers.

The basic framework of equation (11) relies on a modified Cobb-Douglas production function whose residual include the effect of numerous omitted variables. Such factors are well documented in literature and include; ownership structure (Soderblom and Teal, 2003) and sector specific variation in technologies (Lundavall, 1999). To control for effects of these factors, the LP equation is extended to include foreign ownership and sector dummies. Some studies include

a lagged dependent variable to in the production function to capture the fact that, whenever factors of production are changed, it may take time for output to reach its new long run level (Nickell, 1996). In this study, however, the inclusion of sector dummies did not change the results and they were all insignificant. Secondly the inclusion of a lagged dependent variable introduces a Nickell bias. To deal with the bias, the lagged dependent variable is treated as endogeneous but that would reduce tremendously our sample size. As a consequence the study estimates the production function without the lagged dependent variable and sector dummies to avoid the Nickell bias.

4.5. Empirical Model

The study adopts empirical models as in the study by Papadogonas et al., (2005) and Niringiye et al (2010). To extend this model to be conformable with panel data, we incorporate the longitudinal dimension. Secondly, our model uses log of annual net profit¹¹ divided by firm's total labour employed as the dependent variable so as to capture competitiveness¹² of firms. Extending equation (11) and adding variables of interest and in line with economic theory and empirical studies we have the following final model for estimation:

$$\left(\ln \frac{NP_{it}}{L_{it}}\right)_{HR} = \beta_0 + \beta_1 \ln \frac{K_{it}}{L_{it}} + \beta_2 \ln \frac{W_{it}}{L_{it}} + \beta_3 \ln skill_{it} + \beta_4 RD_i + \beta_5 \ln S_{it} + \beta_6 X_i + \beta_7 FO_i + \beta_8 IndusAge_{it} + \beta_9 Employgrow_{it} + \beta_{10} \ln naveduca_{it} + u_i + \varepsilon_{it} ; \quad (N = 324; T = 5)(12)$$

Whereas variables are defined in the Table 4.2.

A priori on the expected signs of the independent variables and justification thereof is as follows:

- **Capital** is expected to correlate positively with labour productivity as suggested by the Solow growth model (Solow, 1960; and Romer, 1987).
- **Wage** is expected to correlate positively with labour productivity as suggested by theory of efficiency wages (Stiglitz et al., 1984).
- **Skill** is expected to correlate positively with labour productivity as suggested by human capital theories (Berker, 1964; and Covers, 1997).

¹¹ Papadogonas et al (2005) and Niringiye et al (2010) uses log of annual firm sales divided by employment.

¹² As in the study by Francis and Tharakan, (1989) and Niosi, (1991), where profitability is used to capture competitiveness.

- **R&D** is expected to correlate positively with labour productivity due to technological progress as observed in endogenous growth models (Romer, 1990).
- **Firm Size** is expected to correlate positively with labour productivity as suggested by relative theory that support the view that SMEs are less cost efficient than large firms (Papadogonas et al., 2005).
- **Export Status** is expected to have a positive relationship with labour productivity because of high competitiveness accompanied by lower production cost (Bernard 1995; and Biesebroeck, 2005).
- **Foreign Ownership** is expected have a positive relationship with LP arising from the competitive advantage of global network of production and distribution enjoyed by MNCs (Salvatore, 2004).
- **Industry Age** is expected to correlate negatively with labour productivity of firms. Karlsson and Nystrom (2003) posit that young industry sectors are characterized by new entrants which are usually very small (micro), small and medium size firms, knowledge intensive with highly skilled labour and new technology investments.
- **Employment Growth** is expected to correlate negatively with labour productivity of firms, if unaccompanied by an equal or greater increase in capital stock. This is in support of the law of diminishing marginal productivity, Nicholson (1998), Papadogonas et al. (2005) and Fiouz et al.(2011) confirms this relationship.
- **Education** is expected to correlate positively with labour productivity of firms in support of the human capital theories (Berker, 1964; and Covers, 1997) and studies conducted by Tan and Batra (1995).

Table 4.2: Definition of variables

Variable	Assumptions and calculations
Explanatory	
$\ln \frac{K_{it}}{L_{it}}$	Log of firm's annual value of net fixed assets per firm's total labour employed ¹³
$\ln \frac{W_{it}}{L_{it}}$	Log of firm's annual wage per firm's total labour employed
$\ln S_{it}$	Log of total assets
$\ln skill_{it}$	Log of total No. of Diploma and Degree holders per firm's total labour employed
$\ln naveduca_{it}$	Log of average schooling years of firm's total labour ¹⁴
$IndustryAge_i$	2010 minus establishment year
RD_i	Dummy (1=firm has R&D; 0=otherwise) ¹⁵
FO_i	Dummy (1=firm is foreign owned; 0=otherwise)
X_i	Dummy (1=firm is an exporter; 0=otherwise)
$Employgrow_{it}$	Employment rate of growth (2006-2010) ¹⁶
$u_i + \varepsilon_{it}$	Within and between Error terms respectively
Dependent	
$\ln \frac{NP_{it}}{L_{it}}$	Log of firm's annual net profit divided by total number of employees

Source: Author's illustration

4.6. Estimation Technique

4.6.1. Diagnostic Tests

4.6.1.1. Cross-Sectional Dependency and Serial Correlation

Cross sectional dependency also known as contemporaneous correlation occurs when residuals are correlated across entities. Secondly, the presence of serial correlation causes the standard errors of the coefficients to be smaller than they actually are and leads to a higher R-squared

¹³Data on R&D firm expenses was unavailable, the answer to the question as to whether a firm undertook R&D activities or not was used to create the R&D dummy as in the study by Papadogonas et al. (2005) and Fiouz et al. (2011).

¹⁴ Weights are as follows (equivalent to No. of years spent acquiring the qualification apart from Grade 12 Certificate): Master's degree=3; Bachelor's degree=5; Diploma=3; and Trade Certificate=2; Grade 12 Certificate=1.

¹⁵ Capital has been adjusted at 4.5 percent depreciation rate (per annum) as recommended in empirical studies (Chapelle and Plane, 2005 and Niringiye et al., 2010).

¹⁶ Measured using $\frac{L_{it} - L_{i(t-1)}}{L_{i(t-1)}}$

(Reyna, 2010). The two problems, if not corrected, lead to biased results. According to Baltagi, (2003), cross-sectional dependency and serial correlation is a problem in macro panels with long time series (over 20-30 years). This is not much of a problem in micro panels (few years and large cases). Since our time series component is small ($T=5$), these two problems did not affect our study results.

4.6.1. 2. Hausman Test

The study ran a Hausman Test¹⁷ to determine the model that would yield consistent and most efficient estimators between fixed effects and random effects. If $H_0: \text{Cov}(u_i, X_{it}) = 0$ is true, then $\widehat{\beta}_{RE}$ and $\widehat{\beta}_{FE}$ are both consistent, but $\widehat{\beta}_{RE}$ will be more efficient since $SE(\widehat{\beta}_{RE}) < SE(\widehat{\beta}_{FE})$. But if instead $\text{Cov}(u_i, X_{it}) \neq 0$, then $\widehat{\beta}_{FE}$ is more efficient. Based on the above criteria the test statistic obtained is 28.20 which is greater than the critical value of a Chi-square (6 df, 5%) = 12.59. The study rejected the null hypothesis. Given such result, the preferred model is the fixed effects.

4.6.2. Fixed Effects (FE) Model

The FE model measures the association between individual-specific deviations of regressors from their time-averaged values and individual-specific deviations of the dependent variable from its time-averaged value. The model allows endogeneity of all regressors and individual effects. However the Fixed Effects model suffers one major setback when estimating time-invariant and slow-changing variables over time. Because of averaging variables over time T , all the time-invariant variables are eliminated. This renders the FE model less effective when dealing with time-invariant data. This all (Fixed Effects) or nothing (Random Effects) choice between individual effects and the regressors prompted Hausman and Taylor (1981) to propose a model where some of the regressors are correlated with the individual effects. The resulting estimator is called the Hausman-Taylor estimator.

¹⁷Results of the first and second Hausman Tests are at Appendix B

4.6.3. Pretest Estimator

Suggested by Baltagi et al., (2003), the pretest estimator guides in the choice between the Fixed Effects and Hausman-Taylor estimators. This pretest estimator reverts to the Hausman-Taylor estimator if the choice of strict exogenous regressors is not rejected by a second Hausman test based on the difference between the Fixed Effects and Hausman-Taylor estimators. Based on the above criteria, the study ran the second Hausman test between the FE and HT estimators and a tests statistic obtained is 1.26 which is less than the critical value of a Chi-square (6 df, 5%) = 12.59 and this led to the non-rejection of the null hypothesis. The study therefore settled for the Hausman Taylor estimator.¹⁸

4.6.4. Hausman - Taylor (HT) Estimator

Consider the Hausman and Taylor (1981) model which can be written as follows:

$$y_{it} = X_{it}\beta + Z_i\eta + \alpha_i + u_{it} \quad (25)$$

Where $i=1, 2, \dots, N$ and $t=1, 2, \dots, T$. The Z_i are individual time-invariant variables. α_i is IID(0, σ_α^2) whereas u_{it} is IID(0, σ_u^2) both independent of each other and among themselves. Hausman and Taylor (1981) split $X = [X_1, X_2]$ and $Z = [Z_1, Z_2]$ into two sets of variables such that X_1 is $n \times k_1$, X_2 is $n \times k_2$, Z_1 is $n \times g_1$, Z_2 is $n \times g_2$ and $n=NT$. X_1 and Z_1 are assumed exogenous and not correlated with α_i and u_{it} , while X_2 and Z_2 are endogenous due to their correlation with α_i but not with u_{it} . It is clear that in this model Ordinary Least Squares (OLS) is biased and inconsistent, while the FE estimator which wipes out the α_i using the within transformation is consistent. The latter estimator also wipes out the Z_i and as a consequence cannot yield estimates of η . The RE estimator which is GLS on (25) ignoring the endogeneity due to α_i will also yield biased and consistent estimates of the regression coefficients. Hausman and Taylor (1981) suggest an instrumental variable estimator which pre-multiplies (25) by $\Omega^{-\frac{1}{2}}$ where Ω is the variance covariance term of the error component $\alpha_i + u_{it}$, and then performs Two Stage Least Squares (2SLS) using as instruments $[Q, X_1, Z_1]$. Q is the within transformation matrix with $\hat{y} = Qy$

¹⁸ Second Hausman Test output Table at Appendix B

having a typical element $\hat{y}_{it} = y_{it} - \bar{y}_l$ and \bar{y}_l is the individual mean. This turns out to be equivalent to running 2SLS with $[\hat{X}, \bar{X}_1, Z_1]$ as the set of instruments. This clearly shows that the HT estimator is more efficient than the FE model as it enable us to estimate time invariant variables.

We therefore stack and partition our variables in matrix form in conformity with equation (26) as follows:

$$\mathbf{x}_{1i,t} = \begin{bmatrix} \ln K_{i,t} \\ \ln WG_{i,t} \\ \ln S_{i,t} \\ \text{employgrowth}_{i,t} \end{bmatrix}, \mathbf{x}_{2i,t} = \begin{bmatrix} \ln \text{skill}_{i,t} \\ \ln \text{aveduca}_{i,t} \end{bmatrix}, \mathbf{z}_{1i,t} = \begin{bmatrix} \text{IndustAge}_i \\ R\&D_i \end{bmatrix}, \mathbf{z}_{2i,t} = \begin{bmatrix} FO_i \\ X_i \end{bmatrix}$$

$n \times k_1 \quad n \times k_2 \qquad n \times g_1 \quad n \times g_2$

$$\mathbf{y}_{it} = \mathbf{X}'_{1it}\beta_1 + \mathbf{X}'_{2it}\beta_2 + \mathbf{Z}'_{1i}\eta_1 + \mathbf{Z}'_{2i}\eta_2 + \varepsilon_{it} + u_i \quad (26)$$

[Note: Equation 26 incorporates the time dynamics and is therefore an extension equation (25)]

Where: \mathbf{X}_{1it} is \mathbf{K}_1 variables that are time varying and uncorrelated with u_i ;

\mathbf{Z}_{1i} is \mathbf{L}_1 variables that are time-invariant and uncorrelated with u_i ;

\mathbf{X}_{2it} is \mathbf{K}_2 variables that are time varying and correlated with u_i ;

\mathbf{Z}_{2i} is \mathbf{L}_2 variables that are time-invariant and correlated with u_i .

Where the following assumptions should hold:

$$\begin{aligned} E[u_i | \mathbf{x}_{1it}, \mathbf{z}_{1i}] &= 0 \text{ though } E[u_i | \mathbf{x}_{2it}, \mathbf{z}_{2i}] \neq 0, \\ \text{Var}[u_i | \mathbf{x}_{1it}, \mathbf{z}_{1i}, \mathbf{x}_{2it}, \mathbf{z}_{2i}] &= \sigma_u^2, \\ \text{Cov}[\varepsilon_{it}, u_i | \mathbf{x}_{1it}, \mathbf{z}_{1i}, \mathbf{x}_{2it}, \mathbf{z}_{2i}] &= 0 \quad (27) \\ \text{Var}[\varepsilon_{it} + u_i | \mathbf{x}_{1it}, \mathbf{z}_{1i}, \mathbf{x}_{2it}, \mathbf{z}_{2i}] &= \sigma^2 = \sigma_\varepsilon^2 + \sigma_u^2, \\ \text{Corr}[\varepsilon_{it} + u_i, \varepsilon_{is} + u_i | \mathbf{x}_{1it}, \mathbf{z}_{1i}, \mathbf{x}_{2it}, \mathbf{z}_{2i}] &= \rho = \sigma_u^2 / \sigma^2, \end{aligned}$$

Furthermore we don't need instruments for \mathbf{z}_{1i} as it is uncorrelated with u_i and accordingly $\bar{\mathbf{x}}_{1i}$ is a valid instrument for \mathbf{z}_{2i} . Therefore K_1 should be greater or equal to L_2 .¹⁹

We therefore estimate equation (12) using the Hausman-Taylor estimation technique and get consistent and efficient estimators.

¹⁹ As recommended by Greene W. (2008), for the model to be identified K_1 must be greater than or equal to L_2

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1. Introduction

This chapter presents empirical results of the Hausman-Taylor estimators and a discussion of results is presented thereafter.

Table 5.1: Determinants of LP: Hausman-Taylor Estimates (Within Effects) with Standard Errors

Dependent Variable: Log of Value Added Annual Net Profit per Worker				
Independent Variable	Category of Manufacturing Firm			
	Micro	Small	Medium	Large
lnK/L	0.134* (0.0744)	0.127** (0.0716)	0.0942* (0.0551)	0.262** (0.138)
lnS	1.077*** (0.0543)	1.115*** (0.0206)	1.618*** (0.0158)	2.152*** (0.213)
lnSkill	2.732*** (0.0907)	0.241*** (0.432)	0.430*** (0.25)	2.906*** (0.758)
lnaveduca	1.717* (0.979)	0.0587* (0.0449)	0.00679** (0.00737)	0.141* (0.0625)
lnWG/L	5.585*** (0.102)	0.176** (0.018175)	0.0126** (0.0229)	0.704*** (0.314)
lnemploygrowth	-0.00121* (0.00067)	-0.00487* (0.00303)	-0.00127* (0.00858)	-0.00143* (0.1223)
lnIndustryAge	0.00836 (2.672)	0.0905 (0.215)	0.0597 (0.469)	3.3 (5.575)
FO	-0.718 (6.697)	-0.207 (1.602)	0.611 (0.1.120)	6.318 (6.689)
X	42.23 (37.38)	-1.127 (2.239)	-3.255 (3.943)	3.71 (7.011)
RD	3.508 (5.65)	0.327 (4.073)	-1.901272 (11.54891)	-7.43 (6.532)
_cons	-93.06*** (8.655)	-11.00* (6.001)	-18.27*** (3.774)	-44.96*** (14.37)
sigma_u	4.5464094	1.5167979	3.239877	5.9270382
sigma_e	0.01551589	0.79412998	0.52760576	0.25268509
Rho	.99998835 ^a	.78486047 ^a	.97416581 ^a	.99818576 ^a

*(**) *** indicates significance at 10%, 5% and 1% respectively.

a. fraction of variance due to u_i

As results in Table 5.1 show, firm size positively influence labour productivity across all the firms. The elasticity of labour productivity with respect to firm size is 1.077, 1.115, 1.618 and 2.152 for micro, small, medium and large firms, respectively. This suggests that if labour productivity increases by 1 percent on average, across all firm categories, total assets will have to go up by 1.077 percent, 1.115 percent, 1.618 percent and 2.152 percent respectively across all firm categories. This shows that labour productivity is highly responsive to changes in total assets of a firm.

Wage appears to be the most important factor in influencing labour productivity in micro firms as can be observed in its higher t value of 54.59 at 1 percent²⁰ level of significance. The elasticity of labour productivity with respect to wage per labour employed is 5.585, 0.176, 0.0126 and 0.704 for micro, small, medium and large firms respectively. This suggests that if labour productivity goes up by 1 percent, on average, wage of labour employed goes up by 5.585percent, 0.176 percent, 0.0126 percent and 0.704 percent in micro, small, medium and large firms respectively. This suggests that labour productivity in micro firms is highly responsive to changes in wage compared to other firm categories due to labour intensive production techniques.

The elasticity of labour productivity with respect to skill is 2.732, 0.241, 0.43 and 2.906 for micro, small, medium and large firms respectively. This suggests that a 1 percent increase in labour productivity will be accompanied by an increase in skill of 2.732 percent and 0.241 percent in small and micro firms respectively, and a rise of about 0.4 percent and 2.906 percent in medium and large firms respectively. The t statistic of 30.11 and 15.21 for micro and medium firms, respectively, could be attributed to the demand for skilled manpower when a firm is in infancy (micro) and medium status-when the firm is about to mature into a large firm.

It can further be observed that the elasticity of labour productivity with respect to education of labour employed is 1.717, 0.0587, 0.00679 and 0.141 for micro, small, medium and large firms respectively. This suggests that a 1 percent increase in labour productivity, on average, will be accompanied by an increase in average schooling years of employees by 1.717 percent and 0.0587 percent in micro and small firms respectively and a 0.00679 percent and 0.141 percent in medium and large firms respectively. This demonstrates that labour productivity is highly

²⁰ See Appendix C for all t statistic.

responsive to changes in average schooling years in micro as compared to the other firm categories. This could be attributed to low capitalization for micro firms. The t statistic of 5.36 and 3.27 for small and medium firms, respectively, suggests the importance of recruitment of qualified and educated personnel for the two firm categories if productivity has to be enhanced.

In small, micro, medium and large firms, the elasticity of labour productivity with respect to capital is 0.134, 0.127, 0.09 and 0.262 respectively. This suggests that if labour productivity goes up by 1 percent, on average, the capital goes up by 0.134 percent, 0.127 percent, 0.09 percent and 0.262 percent in micro, small, medium and large firms respectively. This shows that labour productivity in large firms is more responsive to changes in capital compared to other firm categories. Demand for capitalization becomes critical at micro and large levels as indicated by the t statistic of 1.80 and 1.90 for micro and large firms, respectively.

The elasticity of labour productivity with respect to employment growth in micro, small, medium and large firms is -0.00121, -0.00487, -0.00127 and -0.00143 respectively. This suggests that if labour productivity goes up by 1 percent, on average, employment growth falls by -0.00121 percent, -0.00487 percent, -0.00127 percent and -0.00143 percent respectively. The magnitude of the trade off is more profound in medium firms with a t of 2.81. This suggests that at this stage the firm should prioritize capitalization.

The elasticity of the constant coefficient in micro, small, medium and large firms is -93.06, -11, -18.27, -44.96 respectively. This suggests that if all the factors in our model were to collapse to 0, *ceteris paribus*, labour productivity in the firms would fall by 93.06 percent, 11 percent, 18.27 percent and 44.96 percent for micro, small, medium and large firms respectively. This demonstrates the relevance of the variables included in our model to labour productivity across different firm categories. Finally, the elasticities of coefficients for industry age, foreign ownership status, export orientation, research and development are all insignificant across all firm categories.

The standard deviation of residuals within groups u_i (σ_u) is 4.54644094, 1.5167979, 3.239877 and 5.9270382 for micro, small, medium and large firms respectively. The standard deviation of residuals, i.e. the overall error term, ε_i (σ_e) is 0.01551589, 0.79412998,

0.52760576 and 0.25268509 for micro, small, medium and large firms respectively. This clearly indicates that our model is significant across all firm categories.²¹

5.2. Discussion

This study attempted to investigate determinants of labour productivity in Zambia's manufacturing firms. It therefore tested the following hypotheses; human capital; firm size; capital; and wage have no influence on labour productivity in a firm. Below is the discussion of empirical results and findings:-

Consistent with the findings of the study conducted by Papadagonas et al., (2005), Fouzi et al., (2010) and Niringiye et al., (2011), the results show that education of the employees is positively correlated with LP across all firm categories. This is in support of the human capital theory that suggest that education may improve the total revenues of firms by means of a better allocation of the input factor between the alternative outputs. Workers will have more knowledge of how to maximize the marginal value product (expressed in money units) of the input factor. Furthermore, better educated workers have more ability to adapt to technological change and will introduce new production techniques more quickly. Nelson and Phelps (1966) state that educated people make good innovators, so that education speeds the process of technological diffusion. A higher level of education increases the ability to discriminate between more and less profitable innovations and reduces the uncertainty about investment decisions with regard to new processes and products. In this study, the greatest impact of education on labour productivity is in micro firms followed by large firms. This result suggests that the responsiveness of additional average schooling years has more bearing in micro and large firms as compared to other firm categories.

Skill is positively correlated with LP across all firm categories. The influence of skill on LP is more profound in large firms followed by micro firms. This suggests that LP is highly responsive to skill in large and micro firms as compared to the other firm categories. This result supports the human capital theory that emphasizes that human capital contributes to output just like other factors of production and also through technological change by driving both innovation and imitation Schultz (1961), Becker (1964) Welch, (1970), Mincer (1974), Corvers (1997) and Niringiye et al. (2011) had similar findings.

²¹ Reyna (2010) recommends that ε_i should be less than 1 for a model to be significant.

As in the study by Snodgrass et al., (1995), Baldwin and Gu (2003) and Fiouz. et al., (2011) and consistent with the theory of economies of scale, firm size has positive correlation with labour productivity for all firm categories. This suggests that firms should grow their assets so as to increase productivity. This result however contradicts the findings by Papadagonas and Voulgaris (2005) in their study in Greece that demonstrated a negative relationship.

Consistent with the study by Papadagonas et al., (2005) and Fiouz et al., (2011) that capital intensity has a positive effect on LP at firm level, the study has shown that capital has positive effect on LP across all firm categories. This result is in line with growth theories that emphasize the importance of capital intensity and accumulation. The results show that large firms are more capital intensive as compared to other firm categories.

Consistent with the theory of efficiency wages that posit that the wage rate above the market clearing level will increase labour productivity, the results of this study show that wage is positively correlated with labour productivity across all firm categories with wage coming out as the most important factor influencing LP in micro firms.²² The theory of efficiency wages explains that as wage level increases, the labour force will be more motivated to keep their jobs and will therefore try to increase their level of productivity to avoid being sacked. This has been supported by Griliches (1986); Hall and Mairesse (1995); Crépon et al., (1998); Lööf and Heshmati (2002). Secondly high wages change the relationship between employer and employee. An employee will be more attached to the employer and try to increase his own productivity (Mühlau and Lindenberg, 2003).

Employment growth in the manufacturing sector negatively affects LP for all firm categories. This result suggests that policy makers are confronted with a trade-off problem. Employment creation leads to losses in labour productivity in all firm categories. This is especially true with new technology and capital intensive industry sectors (large firms), which are the ones that show the highest net employment growth of 57.2 percent in Zambia (refer to Table 2.1). This has a twofold explanation. First the law of variable proportions that state that as the variable factor

²² Refer to Appendix C

(labour) is added to the fixed factor capital (in the short run), marginal physical product increases at a decreasing rate until it turns negative. In this study, this explanation could be plausible given the time dimension of the panel being short ($T=5$ years). Secondly, the theory of efficient wages could offer an alternative explanation. As wages rise above market clearing, costs of the firm rise too. This could lead firms to employing less manpower so as to pay a wage above the market clearing in order to retain and attract skilled workers (with high LP) and this would eventually lead to a rise in unemployment. Employment creation therefore should be accompanied by large capital investments in order to overcome this disadvantage. This is very true for Zambia that has put employment creation high on its agenda.

Finally, foreign ownership, export orientation, industry age, research and development are all insignificant across all firm categories, and therefore do not influence LP in Zambia's manufacturing firms. Papadogonas et al., (2005) found foreign ownership to be insignificant in Greece and Fiouz et al., (2011) found R&D to be insignificant in Iran. Niringiye et al., (2010) in their study in East Africa (Kenya, Tanzania and Uganda) found foreign ownership to be insignificant in Kenya and Uganda with an exception of Tanzania.

5.3. Summary of Results

The study show that firm size influence LP across all firm categories. This is consistent with the theory of economies of scale and also in support of the findings of studies conducted by Niringiye et al., (2010) in East Africa and Fiouz et al., (2011) in Iran. The results further show that the influence of firm size on LP is much higher in large firms followed by medium firms. Skill and education have a positive influence on LP, clearly demonstrating the relevance of human capital theory on LP and in tandem with findings of Schultz (1961), Becker (1964) and Niringiye et al., (2010). The influence of skill on LP is more profound in large firms followed by micro firms, suggests that LP is highly responsive to skill in large and micro firms as compared to the other firm categories.

Consistent with growth theories, capital has a positive influence on LP with large firms recording the highest responsiveness followed by micro firms. This is in line with the findings of studies conducted by Papadogonas et al., (2005), Niringiye (2010) and Fiouz et al., (2011). The study further demonstrates that wage has a positive influence on LP with the highest responsiveness

being in micro firms followed large firms. These findings support the theory of efficiency wages and also in line with other studies conducted²³. Employment growth negatively affects LP across all firm categories supporting the law of variable proportions and the theory of efficiency wage. This result is also consistent with findings of Niringiye et al., (2010) and Fiouz et al., (2011). Foreign ownership, export orientation, industry age, research and development are all insignificant, and therefore do not influence LP in Zambia's manufacturing firms. The study rejects the null hypotheses that; human capital; firm size; capital; and wage have no influence on labour productivity in Zambia's manufacturing firms and the alternative hypotheses proving otherwise are upheld.

²³ *ibid*

CHAPTER SIX

RECOMMENDATIONS, LIMITATIONS AND CONCLUSION

6.1. Introduction

This chapter presents the recommendations, limitations and conclusion of the study. The study investigates determinants of labour productivity in Zambia's manufacturing firms using panel data for period 2006 to 2010. The Hausman-Taylor technique is used to estimate a modified Cobb-Douglas production function as in the study by Corvers F. (1997).

The study show that firm size, skill and education, capital and wage have a positive influence on LP across all firm categories. The results further show that employment growth in a firm reduces LP across all firm categories. Finally, foreign ownership, export orientation, industry age, R&D are all insignificant across all firm categories, and therefore do not influence LP in Zambia's manufacturing firms. Having discussed the findings of the study, the study provides recommendations below:

6.2. Recommendations

6.2.1. Education, Skills Development and Business Incubation

The need to build a cadre of entrepreneurs with necessary skills and equipment in the manufacturing sector cannot be over emphasized if productivity of the sector is to improve. To this end, the government should facilitate the establishment of business incubators to provide physical space, assistance in product development, access to equipment and other relevant necessities. Government should also encourage technical training, mentoring, technology transfer and also establish demonstration centers. To this end, the construction of science parks to create synergies should be accelerated. For example, in China inventors are assigned to work under professionals (usually from a University) to couch them on how to improve a product to acceptable standards. During the incubation period, the inventor is entitled to a stipend. On vocational education, it is sad to note that the training centers established country wide seem to back track as most of them are offering business courses as opposed to their founding mandate. The relevant authorities therefore should take interest and necessary measures to correct these mistakes.

6.2.2. Zambian Market Development

Domestic consumption of locally manufactured goods is a vital source of effective market demand as this source of demand cannot be affected by advalorem taxes and quotas imposed by foreign countries. Such a source of demand could further be enhanced by government to launch a campaign to encourage locals to purchase locally manufactured goods. If this could be accompanied by a waiver on import duties on machinery so as to reduce the cost of production, the sector would become highly competitive. To further enhance competition, government should consider facilitating exhibitions of locally manufactured products. For example, undertaking biannual demonstrations on new innovations in the sector so as to encourage competition and ultimately encourage innovation and sector increased productivity.

6.2.3. R&D

Despite the study results indicating R&D to be insignificant, theory suggests otherwise that R&D increases labour productivity through increased competitiveness arising from new information and differentiated products. Government should consider commercializing R&D findings and patent them. This would instill security and assurances to innovators and encourage financiers to fund the projects.

6.2.4. Protection of Infant Firms

Most foreign domiciled manufacturing firms enjoy economies of scale arising from firm size. Conversely, a number of manufacturing firms in Zambia are in infancy and face higher production cost. Government should consider insulating infant firms from rival foreign firms by providing subsidies and waiving taxes to a point when they can withstand competition. This would increase profits and ultimately increase sector productivity and create jobs.

6.2.5. Access to Financing

Investment theories attach importance to business financing (equity or debt) as a way of capitalization. In Zambia, financing remains a challenge especially that the financial sector is still growing. The rent for capital is high and often collateral is a pre-requisite to obtaining a loan. The Lusaka Stock Exchange, in Zambia, is equally in its infancy and listing of MSMEs perhaps is not coming in the near future. The Government should ensure that MSMEs have

access to credit by being guarantor to the banks especially for viable business proposals and put up stiff measures to monitor entrepreneurs' activities up to the time when these loans are fully amortized.

6.2.7. Wage

Most of Zambia's manufacturing firms are labour intensive by nature of abundant cheap labour. This tends to adjust the wage rate downward resulting in low employee morale and low productivity levels. The gains from the minimum wage introduced through Statutory Instrument number 12 of 2011 have been significantly eroded by inflationary pressures over time. To this effect, stakeholders in the sector should consider negotiating for fair and motivating wages. Higher wages would enhance increased sector productivity through increased labour productivity.

6.3. Proposed Area of further Study and Limitation of the Study

Having looked at single-factor-based measure of productivity, it is true to state that this suffers from obvious limitations. First, in most industries or sectors, there are several factors of production that are almost of equal importance, in which case will be difficult to choose among them. Secondly, the relative importance of inputs may change over time. For instance, the relative importance of labour may be low in the initial stages of development when unemployment is high, but may become critical as the country becomes more developed because of declining birth rates and aging labour force. With this in mind, Total Factor Productivity (TFP) is a combined productivity of all inputs and hence avoids the problems faced by measures based on just one factor. Prospects for future research could therefore consider investigating determinants of productivity wholesomely. Undertaking such a mammoth task might not be an easy one in Zambia due to data availability challenges.

The most profound limitation of the study was missing observations in our data set and this posed a challenge when analyzing the data. Secondly, secondary data used in the study was not specifically collected for this purpose, and as such certain variables of interest were not captured. Furthermore, the data was collected in 2011 for the five year period (2006-2010). Given some

levels of illiteracy and poor record keeping among some respondents, the accuracy of the data might not be precise.

6.4. Conclusion

The main objective of the study was to investigate the determinants of labour productivity at the firm level in Zambia's manufacturing sector. Furthermore, the study investigated the effect of human capital variables (i.e. education and skills), capital, wages and firm size on labour productivity. The study results show that firm size, skill and education, capital and wage have a positive influence on LP across all firm categories. The results further show that employment growth in a firm reduces LP across all firm categories. Finally, foreign ownership, export orientation, industry age, R&D are all insignificant across all firm categories, and therefore do not influence LP in Zambia's manufacturing firms.

This clearly demonstrates the importance of human capital variables in influencing labour productivity especially across all firm categories and therefore all stakeholders in the manufacturing sector should be committed to ensure that skills development and education are encouraged so as to enhance the abilities of the sector workforce. The study show that different factors influence LP differently across firm categories. Wage, has more influence in micro firms followed by large firms and is least in medium firms. Skill has more influence in micro and large firms and is least in small firms. Firm size (firm assets) influence labour productivity more in large firms, followed by medium and is least in micro firms. Education of the employees (number of schooling years) influence LP more in micro firms followed by large firms and least in medium firms. The rate of employment growth (change in employment) reduces LP more in small firms than other firm categories.

Despite the different magnitudes the variables influence LP across firm categories, attention should be paid to all variables at all times and appropriate policies should target the variables in order to restore competitiveness of the sector so as to increase labour productivity. Any policy influenced by mere intuition and conjecture away from the identified important variables might just exacerbate further the low labour productivity debacles that the sector is facing.

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APPENDIX A

Marginal Productivity Analysis of Labour

In the study, data on capital (assets), annual sales (output value) and wages are expressed in monetary units except for labour. To analyze the labour input on output, we need to standardize and harmonize the units for compatibility and comparability. Hence multiplying labour by wage and use total expenditure on wages as a proxy for labour input.

Assumptions

1. Constant returns to scale
2. Technology A is constant in the short term ($T=5$)

Table A1: Summary of Manufacturing Data by Year²⁴

Year	Annual Capital	Annual Sales	Annual Wage	Labour (units)
2006	12789527274	4054965300000	46381821820272	16416
2007	19143829536	3637622675000	60699035364732	17883
2008	186551010167	4161581800000	85425776306388	19671
2009	44439096177	5306736800000	112306425768528	21444
2010	41417823670	6195748020000	137228869512564	23413
Total	304341286824	23356654595000	442041928772484	98827

Source: Author's illustration based on MISS 2011 data

Table A2: Change in Capital, Annual Sales and Labour²⁵

Year	Δ Capital	Δ Annual Sales	Δ Labour
2007	6354302262	-417343000000	1467
2008	167407000000	523959000000	1788
2009	-142112000000	1145160000000	1773
2010	-3021272507	889011000000	1969
Total	28628296396	2140780000000	6997

Source: Author's illustration based on MISS 2011 data

Sector Estimation of Elasticities of K and L

We begin with a Cobb-Douglas production function below:

²⁴ All figures for K and L are in unrebased Kwacha.

²⁵ All figures for Δ K and Δ L are in unrebased Kwacha, except for Δ Labour which is in headcount

$$Y = AK^\alpha L^\beta \text{ and since } A \text{ is constant we have } Y = K^\alpha L^\beta \quad (A1)$$

$$\text{Therefore } MP_L = \frac{\partial y}{\partial L} = \beta K^\alpha L^{\beta-1}$$

$$\text{Labour's share} = S_L = \frac{P \cdot MP_L \cdot L}{P \cdot Y} = \frac{\beta K^\alpha L^{\beta-1+1}}{AK^\alpha L^\beta} = \beta \quad (A2)$$

Where P is price of output Y .

$$\text{Elasticity of labour} = \beta = \frac{\Delta Y^* \cdot L^*}{\Delta L^* \cdot Y^*} \quad (A3)$$

Where; $\Delta L^* = \Delta L \cdot w$

$$w^* = \text{Average Sector Wage} = \frac{\sum_{2006}^{2010} \text{wage}}{T} = 88408385754496.80; T=5; \Delta L = 6997$$

$$\Delta L^* = w^* \times \Delta L = \ln(618593475124214000) = 40.97^{26}$$

$$L^* = \frac{\sum_{2006}^{2010} L}{T} = \ln(88408385754497) = 32.11^{27} \quad (A4)$$

$$\Delta Y^* = \ln(2140782720000) = 28.39$$

$$Y^* = \ln\left(\frac{Y}{T}\right) = \ln(4671330919000) = 29.17$$

$$\beta = \frac{\Delta Y^* \cdot L^*}{\Delta L^* \cdot Y^*} \quad (A5)$$

Substituting the values in equation (A4) in (A5) yields the following:

$$\beta = \frac{28.39 \cdot 32.11}{40.97 \cdot 29.17} = 0.8 \quad (A6)$$

Since $\beta = 0.8$ and $\alpha + \beta = 1$, then $\alpha = 0.2$

Therefore the Zambian manufacturing sector's production function is given $AK^{0.2}L^{0.8}$. Below is the calculation of MP_L and AP_L of the firm categories:

²⁶ We convert the figures to natural logarithms because they are arbitrary large

²⁷ Total wage L is given by the product of wage for unskilled labour by number of unskilled labour units, plus wage for skilled labour multiplied by skilled labour units.

Calculation of MP_L and AP_L

i) Micro Firms

$$\frac{\partial y}{\partial L} = \beta K^\alpha L^{\beta-1} = MP_L$$

$$AP_L = \frac{y}{L} = K^\alpha L^{\beta-1}$$

$$MP_L = 0.8 \left(\frac{K}{L} \right)^{0.2}$$

$$= \frac{K^{0.2}}{L^{1.2}} = \frac{(3855150000)^{0.2}}{(96113892000)^{1.2}}$$

$$= 0.8 \left(\frac{3855150000}{96113892000} \right)^{0.2} = 0.42$$

$$= 0.000000000000055$$

Therefore MP_L (Micro) is greater than AP_L (Micro)

$$MRTS_{K,L} = \frac{\beta K}{\alpha L} = \left(\frac{0.8}{0.2} \right) \left(\frac{3855150000}{96113892000} \right) = 0.16$$

Micro firms are less willing to substitute capital for labour.

ii) Small Firms

$$\frac{\partial y}{\partial L} = \beta K^\alpha L^{\beta-1} = MP_L$$

$$AP_L = \frac{y}{L} = K^\alpha L^{\beta-1}$$

$$MP_L = 0.8 \left(\frac{K}{L} \right)^{0.2}$$

$$= \frac{K^{0.2}}{L^{1.2}} = \frac{(168486643800)^{0.2}}{(63160397135664)^{1.2}}$$

$$= 0.8 \left(\frac{168486643800}{63160397135664} \right)^{0.2} = 0.24$$

$$= 0.0000000000000048$$

Therefore MP_L (Small) is greater than AP_L (Small)

$$MRTS_{K,L} = \frac{\beta K}{\alpha L} = \left(\frac{0.8}{0.2} \right) \left(\frac{168486643800}{63160397135664} \right) = 0.01$$

Small firms are less willing to substitute capital for labour.

iii) Medium Firms

$$\frac{\partial y}{\partial L} = \beta K^\alpha L^{\beta-1} = MP_L$$

$$AP_L = \frac{y}{L} = K^\alpha L^{\beta-1}$$

$$MP_L = 0.8 \left(\frac{K}{L} \right)^{0.2}$$

$$= \frac{K^{0.2}}{L^{1.2}} = \frac{(37466170803)^{0.2}}{(530192092195140)^{1.2}}$$

$$= 0.8 \left(\frac{37466170803}{530192092195140} \right)^{0.2} = 1$$

$$= 0.00000000000000003$$

Therefore $MP_{L (Large)}$ is greater than $AP_{L (Large)}$

$$MRTS_{K,L} = \frac{\beta K}{\alpha L} = \left(\frac{0.8}{0.2}\right) \left(\frac{37466170803}{530192092195140}\right) = 1$$

Medium firms are indifferent in choice of input between labour and capital.

iv) Large Firms

$$\frac{\partial y}{\partial L} = \beta K^\alpha L^{\beta-1} = MP_L$$

$$AP_L = \frac{y}{L} = K^\alpha L^{\beta-1}$$

$$MP_L = 0.8 \left(\frac{K}{L}\right)^{0.2}$$

$$= \frac{K^{0.2}}{L^{1.2}} = \frac{(5138958152)^{0.2}}{(2016302969400)^{1.2}}$$

$$= 0.8 \left(\frac{5138958152}{2016302969400}\right)^{0.2} = 1 \qquad = 0.000000000000015$$

Therefore $MP_{L (Medium)}$ is greater than $AP_{L (Medium)}$

$$MRTS_{K,L} = \frac{\beta K}{\alpha L} = \left(\frac{0.8}{0.2}\right) \left(\frac{5138958152}{2016302969400}\right) = 0.24$$

Large firms are indifferent in choice of input between labour and capital.

APPENDIX B

Table B1: Fixed Effects and Random Effects

. hausman fixed random, sigmamore

	Coefficients		(b-B) Difference	sqrt(diag(v_b-v_B)) S.E.
	(b) fixed	(B) random		
lnwG	-.2306569	.0544095	-.2850664	.1045283
lnk	.0766978	.0766497	.0000481	.0752492
S	1.617074	1.02028	.5967933	.1216706
skill	.5125312	.1419343	.3705969	.3491514
aveduca	-.1487768	-.0469737	-.1018031	.0603274
employgrowth	-.0032514	-.0014089	-.0018425	.0006378

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xtreg

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(6) &= (b-B)'[(v_b-v_B)^{-1}](b-B) \\ &= 28.20 \\ \text{Prob}>\text{chi2} &= 0.0001 \end{aligned}$$

Table B2: Fixed Effects and Hausman-Taylor Estimator

. hausman fixed xthtaylor

	Coefficients		(b-B) Difference	sqrt(diag(v_b-v_B)) S.E.
	(b) fixed	(B) xthtaylor		
lnwG	-.2306569	-.2373344	.0066774	.0637626
lnk	.0766978	.0678415	.0088563	.0469583
S	1.617074	1.583872	.033202	.0690703
skill	.5125312	.3634325	.1490987	.2164504
aveduca	-.1487768	-.1140296	-.0347471	.0353128
employgrowth	-.0032514	-.0031387	-.0001128	.0012097

b = consistent under Ho and Ha; obtained from xtreg
 B = inconsistent under Ha, efficient under Ho; obtained from xthtaylor

Test: Ho: difference in coefficients not systematic

$$\begin{aligned} \text{chi2}(6) &= (b-B)'[(v_b-v_B)^{-1}](b-B) \\ &= 1.29 \\ \text{Prob}>\text{chi2} &= 0.9724 \end{aligned}$$

APPENDIX C

Table C1: Determinants of LP; Hausman-Taylor Estimates (Within Effects) With *t* Values

Dependent Variable: Log of Value Added Annual Net Profit per Worker				
Independent Variable	Category of Manufacturing Firm			
	Micro	Small	Medium	Large
lnK	0.134* (1.80)	0.127** (1.78)	0.0942* (1.71)	0.262** (1.90)
lnS	1.077*** (19.84)	1.115*** (7.01)	1.618*** (12.87)	2.152*** (10.1)
lnSkill	2.732*** (30.11)	0.241*** (11.7)	0.430*** (15.21)	2.906*** (3.83)
lnaveduca	1.717* (1.76)	0.0587* (5.36)	0.00679** (3.27)	0.141* (2.25)
lnWG	5.585*** (54.59)	0.176** (13.26)	0.0126** (10.51)	0.704*** (2.24)
employgrowth	-0.00121* (1.80)	-0.00487* (1.69)	-0.00127* (2.81)	-0.00143* (1.97)
IndusAge	0.00836 (0)	0.0905 (0.42)	0.0597 (0.13)	3.3 (0.59)
FO	-0.718 (0.11)	-0.207 (0.13)	0.611 (0.55)	6.318 (0.94)
X	42.23 (1.13)	-1.127 (0.50)	-3.255 (0.83)	3.71 (0.53)
RD	3.508 (0.62)	0.327 (0.08)	-1.901272 (0.16)	-7.43 (1.14)
_cons	-93.06*** (10.75)	-11.00* (1.83)	-18.27*** (4.84)	-44.96*** (3.13)
sigma_u	4.5464094	1.5167979	3.239877	5.9270382
sigma_e	0.01551589	0.79412998	0.52760576	0.25268509
rho	.99998835 ^a	.78486047 ^a	.97416581 ^a	.99818576 ^a

t statistic: *(**) *** indicates significance at 10%, 5% and 1% respectively.

a. fraction of variance due to u_i