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Accounting for technical efficiency differentials among smallholder contract tobacco farmers in Hurungwe, Zimbabwe: impact of self-selection bias in contract participation

By

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DECLARATION OF ORIGINALITY

I declare that this thesis hereby submitted in partial fulfilment for the requirement of the degree Master of Agricultural Science (Agricultural Economics) at the University of Pretoria has not been submitted for any other degree award at any other institution. I also declare that this is my own work and ideas borrowed from other sources are fully referenced.

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DEDICATIONS

This thesis is dedicated to my wonderful and very supporting, my wife Gladys and my three lovely daughters Nakai, Danai and Vongai, I would like to say thank you so much for your patience and understanding. The lonely days you have spent have finally paid off. Thank you, Gladys, for taking care of the kids while I was studying. A special dedication to my late mother. This moment would have been more meaningful if you were present. Thank you for passing those never give up genes to me. To the Almighty God, Jehovah, I give you all the praise and may you please bless everyone who made this project a success.

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ABSTRACT

This study used farm-level data to test whether contract farming can account for technical efficiency differentials amongst smallholder tobacco farmers from Hurungwe District in Zimbabwe independent of self-selection bias, in response to the need (i) to inform policy on contract farming in Zimbabwe as an agricultural finance model, and (ii) the literature on impact evaluation which hypothesizes that contract participation is not a random process. A sample of 240 smallholder tobacco farmers was split into a treatment (contract farmers) and a control group (non-contract farmers) to enable comparison. Using 2016/17 farm-level production data collected through face-to-face interviews by means of structured questionnaires, the study compared 75 contract and 165 non-contract farmers purposefully selected through stratified random sampling. A Cobb-Douglas Stochastic Frontier Production Function (SPF) model was used to estimate technical efficiency differentials across the sub-samples before and after accounting for self-selection bias using Propensity Score Matching (PSM) techniques.

Without accounting for self-selection bias, the results show that contract farmers had a mean technical efficiency score of 83 percent (95 percent CI 0.799: 0.851) compared to 81 percent (95 percent CI 0.794: 0.819) for non-contract farmers. A t-test for equality of means showed no significant differences between the two groups ($t=-1.4332$, $p=0.153$), suggesting that participation in contract farming cannot account for the observed technical efficiency differentials. However, using PSM techniques to account for self-selection bias and the stratified matching algorithm, the results show that contract farmers were on average 4.8 percent ($t=4.075$, $p=0.012$) more technically efficient relative to their non-contract counterparts, suggesting that accounting for self-selection bias matters in evaluating the impact.

In the second stage of the SPF, bio-physical, socio-economic and policy variables were used as covariates to investigate determinants of technical efficiency across the two groups. For this group of farmers, the results suggest that household size ($t=2.34$, $p=0.020$) education level ($t=1.96$, $p=0.061$), access to extension services ($t=2.22$, $p=0.027$) and tobacco farming experience ($t=3.48$, $p=0.001$), and membership to a farmers' group ($t=2.84$, $p=0.008$) showed a positive effect on technical efficiency. Meanwhile area allocated to tobacco farming ($t=-2.57$, $p=0.011$) and off-farm income ($t=-2.49$, $p=0.013$) showed a negative effect on technical efficiency. These results suggest that, in addition to formulating policies that promote contract farming, policy makers should also work on policies that improve access to extension services, education, promote the formation of farmers' groups and encourage farmers to join them if productivity in smallholder tobacco farming sector is to be increased.

In a final model, the study established that membership to farmers' groups ($t=1.92$, $p=0.054$), agricultural field day attendance ($t=2.86$, $p=0.004$), and farm size ($t=4.65$, $p=0.000$) increased the probability that farmers will choose to participate in contract farming. Thus, to promote contract farming, the government and policy makers play an important role by encouraging farmers to join farmers' groups, attend agricultural field days in addition to making farmland accessible.

In conclusion, there exist considerable productivity losses due to inefficiency among this group of smallholder tobacco farmers that could be addressed at policy level. The study recommends contract farming as one policy vehicle that could be used to address such inefficiencies in capital-constrained smallholder agriculture. Further the existence of self-selection bias in contract participation must be addressed before assessing the impact of contract farming on technical efficiency of smallholder tobacco farmers. While acknowledging the role of contract farming in addressing productivity losses in the smallholder tobacco farming sector, the study also noted that there are additional variables that could be targeted by policy if these efficiency losses are to be addressed.

Key words: Contract farming, technical efficiency, self-selection bias, propensity score matching, Cobb-Douglas stochastic frontier production function, smallholder, Hurungwe District, Zimbabwe.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

AE	-	Allocative Efficiency
ATT	-	Average treatment effect on the treated
CES	-	Constant elasticity of substitution
CF	-	Contract Farming
CMAD	-	Corrected Mean Absolute Deviation
COLS	-	Corrected Ordinary Least Squares
DEA	-	Data Envelopment Analysis
DID	-	Difference in difference
EE	-	Economic Efficiency
ESAP	-	Economic Structural Adjustment Program
FTLRP	-	Fast Track Land Reform Program
IV	-	Instrumental Variable
KM	-	Kernel Matching
NNM	-	Nearest Neighbour Matching
OLS	-	Ordinary Least Squares
PSM	-	Propensity Score Matching
RM	-	Radius Matching
SM	-	Stratification Matching
TE	-	Technical Efficiency
TIMB	-	Tobacco Industry and Marketing Board
TC	-	Transaction Cost
VCG	-	Value Chain Governance

Chapter 1 : INTRODUCTION

1.1 Background

The Fast Track Land Reform Programme (FTLRP) in Zimbabwe which replaced large scale commercial farmers with mostly smallholder farmers was followed by a marked reduction in agriculture production. Both food crops and cash crops production, including tobacco plummeted raising concerns for food security as well as economic development of the country given the importance of agriculture in the Zimbabwean economy. To address these concerns, improving productivity of smallholder farmers should be prioritized in the economic development discourse if poverty alleviation and economic growth is to be attained. Improving technical efficiency of smallholder farmers is another way of improving agricultural productivity. Improving access to rural finance and markets is one way of raising productivity in agriculture. While contract farming has been identified as one vehicle to achieve this, it is interesting to investigate its impact on technical efficiency levels among smallholder farmers. This is motivated by the importance of agriculture and the tobacco sector in the Zimbabwean economy.

It is estimated that 70% of Zimbabwe's work force is employed in agriculture (Masunda & Chiweshe, 2015). This is in agreement with Mano (2006), who reported that about 70% of the Zimbabwe's population are now smallholder farmers, following the FTLRP. In addition, 40% of all raw materials comes from the agricultural sector (Masunda & Chiweshe, 2015). Most importantly, about 45% of all exports from Zimbabwe are of agricultural origin with tobacco accounting for a large proportion of the foreign currency generated. In 2015 alone, tobacco exports contributed US$855 million to Zimbabwe's export earnings (TIMB, 2015). Government also raise part of its revenue from taxing the tobacco sector. Zimbabwe has a tax structure that compel both the farmers and the tobacco merchants to pay a fixed percentage of tobacco sales as tobacco levy (FAO, 2003). In 2015 revenue amounting to US$17.8 million was generated from the tobacco levy (ZIMRA, 2015). All in all, agriculture contributes between 16-20% of Zimbabwe's total GDP (World Bank, 2010) hence any decline in the sector has far reaching effects on the economy.

According to Moyo (2004) and Richardson (2004), agriculture production decreased by between 30-50 percent between 2003 and 2004. A number of reasons have been given by various researchers as to the causes of these losses in agriculture production. According to the

World Bank (2008), low agricultural productivity in sub Saharan Africa is a result of low adoption of modern production technology and inputs. This low rate of adoption is linked to poverty, lack of access to capital and rural finance by smallholder farmers. Some blame the loss in productivity on the land fragmentation that characterized the land reform resulting in loss of economies of scale in agriculture (Webster & Wilson, 1980)

One of the crops that experienced this variation in production was tobacco. There has been upwards and downwards trends in tobacco production since 2000 when an all-time peak production was reached at 236,946,295kgs as shown in figure 1 (TIMB, 2014). This was followed by a gradual decline reaching an all-time low of 48,775,178kgs in 2008 followed by an upward trend until 2014 when production reached 216,196,683kgs (TIMB, 2014). The staple crop, maize, also experienced a significant decline in productivity from 1.5ton/ha in the 1990s to 0.7ton/ha post 2000 (Agritex, 2002).

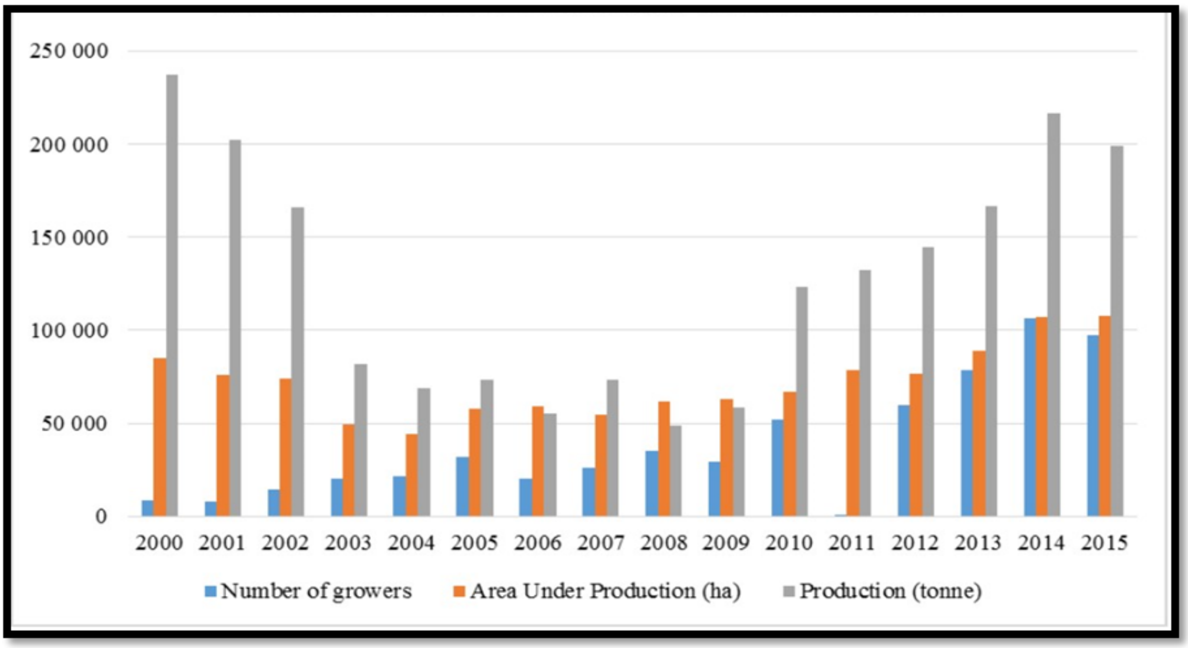

Figure 1.1: Zimbabwe tobacco production trend since 2002

Source: TIMB 2015

From the foregoing discussion, it is evident that a concerted effort is needed to come up with productivity enhancement mechanisms if this loss and variability in agricultural production is to be reversed. Given the fixed land area available, the need to feed the rising population, the increased demand for raw materials due to industrialization and competition for land due to urbanization, agricultural production can only be achieved through intensification methods rather than bringing more land under cultivation. Agriculture intensification involves enhancing productivity through adoption of modern technologies as well as improving production efficiency. This applies to the Zimbabwean context whose Fast Track Land Reform Program (FTLRP) has resulted in more people being allocated nearly all the available arable land leaving no opportunities of bring additional virgin land into cultivation.

Unfortunately, this option of agriculture intensification and the need for adopting modern technology comes with the burden of providing agricultural funding. Given the crippling economic crisis in Zimbabwe which has negatively affected the financial services sector, agriculture funding in Zimbabwe remains a challenge (Victoria, Mudimu, & Moyo 2012). Notwithstanding the efforts by the state in empowering the emerging crop of black farmers, the resource-constrained Zimbabwean government is falling short in providing financial support to the agriculture sector. Currently, despite its immense contribution to the Zimbabwean economy, the agriculture sector receives only about 5% from the national budget, which is half the proportion proposed under the Comprehensive Africa Agriculture Development Programme (CAADP, 2012). The situation is worsened by the fact that the majority of the FTLRP beneficiaries, who are now the backbone of Zimbabwe agriculture, are smallholders who lack collateral. There is therefore the reluctance by the financial institutions to extend credit to finance these 'risky emerging' farmers (Victoria et al., 2012)

The growth of contract farming (CF) arrangements in the last decade has played a significant role in covering this gap in rural finance. Rukuni et al. (2006) also noted this growth in contract farming in most developing economies following economic liberalization which reduced the role of the state in supporting farmers. There is general consensus that the upward trend in tobacco production since 2008 is attributed to availability of funding through contract farming (James, 2015). In addition to the funding aspect, CF is structured in such a way that it provides some technical advice as well as guaranteed access to markets thereby addressing some of the production constraints faced by smallholder farmers. Although the majority of tobacco crop in Zimbabwe is currently produced under CF, there is still a proportion of farmers producing independently. In the 2015 marketing season, 152,266,402kg (77% of total sales) was sold through contract whilst 23% was sold through the auction system (TIMB, 2015). However, in value terms contract tobacco accounted for 81% of the total value of tobacco produced in 2015 since contract tobacco was of higher quality (TIMB, 2015).

Because of the increasing role of CF as a finance mechanism in Zimbabwean agriculture, it is important to study among other parameters, the technical efficiency of contract farmers *vis a* *vis* that of non-contract farmers to assess its contribution to increasing productivity among tobacco farmers. Economists use two approaches in measuring technical efficiency. These are parametric and non-parametric approaches. Under non-parametric approaches, there is Data Envelopment Analysis and Corrected Ordinary Least Squares and under parametric approach there is Stochastic Frontier Analysis. DEA uses mathematical programming whereas SFA uses econometric methods in estimating technical efficiency (Battese and Coelli, 1995). This study used parametric approach (SFA) because of its advantages as explained in Chapter 3, (see section 3.7.3).

Although a number of studies have shown that contract farming has a positive impact on efficiency and productivity (Key and McBride, 2003, Igweoscar, 2014, Ajao & Oyedele 2013), other studies (Kumar, 2006, Gondwe, 2013, Paul et al., 2004) have shown no significant impact on efficiency. This makes it difficult to make a general conclusion on the impact of contract farming on efficiency hence the need for further research. With this in mind, this study aims to compare the technical efficiency levels between contract and non-contract farmers with the objective of finding out whether contract farming has an impact in reducing technical inefficiencies in smallholder tobacco farming.

1.2 Problem statement

The challenge facing Zimbabwe's agriculture sector in the past decade is low productivity. Although the country recorded significant productivity gains in maize in the 1980s to the 1990s due to introduction and adoption of high-yielding varieties, this has been followed by periods of low yields. Likewise, production of cash crops also enjoyed an upward trend during the same period owing to the vibrant, well-resourced commercial farming sector that enjoyed enormous support from the financial services sector and had lots of experience in agriculture. The implementation of the FTLRP, which changed the Zimbabwe's agrarian structure, was followed by a dip in the production levels of these cash crops. If the pre-2000 production levels are taken as the country's agricultural production potential, then it can be argued that Zimbabwe is currently producing below its capacity. In other words, the sector is producing inefficiently and this has far reaching effects on the country given the pivotal role agriculture plays in the Zimbabwean economy.

A ray of hope was given to the agriculture sector through the adoption of CF as a vehicle to improve productivity. However, the impact of contract farming is still a subject of debate among scholars. Theoretical arguments for the positive impact of CF on efficiency are being challenged by some researchers through empirical findings. Thus, despite theoretical basis for the positive impact of contract farming on technical efficiency, there are mixed results from empirical studies on how CF impacts on efficiency. As such, the impact of contract farming of technical efficiency is still empirically not clear and highly contested among scholars hence the need for further research on the subject.

In theory it is expected that CF has a positive impact on efficiency and productivity with a number of theoretical arguments given to support this assertion. The arguments are premised on the understanding that CF addresses a number of market imperfections in the rural markets that constrain smallholders' production. According to the World Bank (2001), CF is a potential avenue through which the private sector can take over the roles previously played by governments in providing agricultural information, inputs and credit to smallholders in developing countries to stimulate production.

But in practice how has CF fared in terms of its contribution to efficiency and productivity in the agricultural sector? As highlighted earlier, there is lack of consistence from previous studies on the impact of CF on technical efficiency and productivity (Kumar, 2006; Gondwe, 2013; Paul et al., 2004). Moreover, an analysis of the tobacco production trend in Zimbabwe since the introduction of contract farming shows a positive correlation between the number of tobacco farmers, area planted and tobacco output (TIMB, 2014) prompting further studies to establish if tobacco output increases recorded can also be attributed to efficiency gains.

Moreover, literature shows a general consensus among scholars that contract participation is not a random process. Some farmers are excluded from participating in CF arrangements due to failure to meet selection criteria yet others choose not to participate for their own reasons. Previous studies found that demographic and socio-economic characteristics of a farmer influence whether or not a farmer self-select into contract farming Mulatu et al., (2017); Azumah et al., (2016); Tinashe et al., (2013). It is therefore clear that contract participation is not a random process and as such a simple comparison between participants and non-participants will yield biased impact results. There is no study known to this researcher that addressed self-selection bias when investigating the impact of CF on technical efficiency among smallholder tobacco farmers in Zimbabwe.

From the foregoing discussion, it can be seen that there still exists a knowledge gap in understanding the impact of contract farming on technical efficiency and productivity. This study contributes to addressing this knowledge gap in the Zimbabwean context given the changes in the agrarian structure following the Fast Track Land Reform Program and the proliferation of contract farming arrangements between the agribusiness firms and the beneficiaries of the land reform program.

1.3 Research questions

Using detailed 2016/17 cross sectional data from smallholder tobacco farmers in Hurungwe district, this study aims to answer the following main question: Is the ability of CF to account for technical efficiency variations among smallholder tobacco farmers independent of selection bias? To address this question, the study compares the technical efficiency scores of contract and non-contract smallholder tobacco farmers before and after accounting for self-selection bias to find out if there are any significant differences. In order to answer the main research question, the following specific questions will be addressed;

i. Are smallholder tobacco farmers producing at their maximum potential?
ii. Are there any significant technical efficiency differentials between contract and non-contract tobacco farmers in Hurungwe?
iii. Does selection bias matter in assessing the impact of contract farming on technical efficiency among smallholder farmers?
iv. What are the determinants of technical efficiency in smallholder tobacco production?

These four research questions complement each other in trying to give a comprehensive understanding of the role of contract farming in smallholder tobacco production. Moreover, answers these questions can provide some policy insights on the potential of contract farming in contributing to the growth and development of the tobacco sector in Zimbabwe.

1.4 Research objectives

The overall objective of the study is to test whether the ability of contract farming to account for technical efficiency differentials amongst smallholder tobacco farmers from Hurungwe District in Zimbabwe is independent of self-selection bias.

To achieve this, the study will be guided by the following specific research objectives;

i. To estimate the level of technical efficiency of smallholder tobacco farmers at the prevailing level of technology in Zimbabwe

ii. To establish whether there are any technical efficiency variations between contract and non-contract smallholder tobacco farmers.
iii. To test whether selection bias matters in measuring the impact of contract farming on smallholder technical efficiency in tobacco production.
iv. To identify the determinants of technical efficiency and their impacts on smallholder tobacco productivity.

1.5 Statement of hypotheses

Neo-classical economic theory portrays economic actors (producers and consumers) as rational beings whose objective is to maximize their utility subject to given constraints. The same is applicable to the agriculture sector. Since tobacco farming is considered a source of livelihood in Zimbabwe's rural communities, it can be assumed that the farmers, as rational beings would want to maximize their utility (in this case tobacco revenue/profit since tobacco is a cash crop). Having said this, one way of maximizing profit is through efficient use of the scarce resource available to farmers. On the contrary, despite being a leading producer of tobacco in Africa, Zimbabwe is failing to fully exploit its tobacco production potential. A number of studies (Mushunje & Belete, 2003, Mango et al., 2015, Dube & Mugwagwa, 2017) concluded Zimbabwean farmers (tobacco farmers included) are producing below their frontiers hence are technically inefficient. This study therefore hypothesizes that;

Hypothesis 1: ***Zimbabwe's smallholder tobacco farmers are technically inefficient given their current production potential.***

Theory argues that contract farming as an institutional arrangement addresses a number of the market imperfections in the agricultural markets (Nguyen et al., 2015; Kirsten & Sartorius, 2002). Given the role of contract farming in addressing some of the constraints facing smallholders, the expectation is that contract farmers will be more productive than independent growers. This was supported by empirical studies by Dube and Mugwagwa (2017); Swain (2013); Key and Mc Bride (2003, 2007) who found that on average contract farmers were more productive than their non-contract counterparts. Although all these studies did not focus specifically on tobacco production, this study will use these results as a reference point and test the null hypothesis that;

Hypothesis 2: ***There are no significant differences in average technical efficiency between smallholder tobacco contract farmers and non-contract farmers.***

Regression analysis is a very powerful tool to analyse causal relationships between variables. Using regression analysis, economists have not only been able to determine how variables relate to each other but also how significant the explanatory variables are in explaining the outcome variable(s). While explaining technical efficiency in agriculture, a number of studies (Saigenji 2010, Sokchea & Culas, 2015, Dube & Mugwagwa, 2017), included contract farming as one of the explanatory variables. It was found that the variable "contract farming" explained some of the variation in the level of technical efficiency among farmers. In addition, the growth in the number of participants in contract farming arrangements worldwide can only be justified by a positive and statistically significant co-efficient of the variable "contract farming" in the production function of a number of crops. With this background in mind, this study proposes to test the hypothesis that;

Hypothesis 3: ***Contract farming significantly explains technical efficiency variations among smallholder tobacco farmers in Hurungwe.***

Lastly, credibility of impact evaluations is a matter of concern for researchers and policy analysts. Given the selective nature in which interventions are implemented across communities, it has become increasingly difficult to simply compare the program impact between participants and non-participants without understanding the targeting criteria, selection bias as well as individual-specific characteristics of the affected community. Miyata et al. (2009); Henningsen, Mpeta, Adem, Kuzilwa, & Czekaj (2015) found notable selection bias when investigating the impact of contract farming on smallholder agriculture. To obtain robust conclusions, these studies have adopted evaluation techniques that address selection bias. Having said this, it is also important to note that this study addresses selection bias by testing the hypothesis that;

Hypothesis 4: ***Selection bias matters when accounting for the impact of contract farming technical efficiency variations between contract and non-contract smallholder farmers.***

1.6 Justification and importance of the study

Given the importance of agriculture in developing economies and the prominence of contract farming in the agricultural development discourse, this study can be used to give policy advice on these two very important subjects in the African context. Although there is evidence that CF have a positive impact on farmers' technical efficiency and productivity (Saigenji & Zeller 2009, Dzator et al., 2015, Ajao & Oyedele 2013), there is limited empirical evidence on its impact on Zimbabwe's smallholder farmers post FTLRP. James (2015) argued that, to date there has been little research on the private-led contract farming in Zimbabwe. The few that have been conducted investigated the motivation behind smallholder participation in export value chains for vegetables (Masakure & Henson, 2005) and a case study of Canners Pvt Limited's operations in Mushandike resettlement areas of Masvingo (Dzingirayi, 2003). These studies did not look at the main contract crops like tobacco and given the importance of tobacco in Zimbabwe's economy, more studies need to be conducted. Therefore, this study will contribute to this literature gap by investigating the impact of contract farming on technical efficiency in Hurungwe district, Zimbabwe. More so, as highlighted in the problem statement, there seems to be conflicting results on the impact of contract farming on productivity hence the need to conduct further studies on the subject. Furthermore, building on similar studies on the same subject (Dube and Mugwagwa, 2017, Moyo, 2014), this study accounted for selection bias in the analysis for robust conclusions.

As stated by Mwambi et al. (2016), the subject of smallholder participation in CF is an important matter for policy makers seeking to alleviate poverty and promoting economic growth in rural areas. As such results from this study could assist policy makers to make informed decisions on deciding the future of contract farming as an alternative funding model for smallholder agriculture as well as developing policies on contract farming. It also contributes to the improvement of contract farming performance by highlighting aspects of this finance model that are constraining productivity. The decision by the smallholders to enter into contractual arrangements is determined by a number of factors, chief among them the conditions set by the contracting firms, individual farmer choice and the legal framework governing contracts. If the results of this study proves that contract farming enhances productivity, then policy makers will focus on addressing those factors constraining smallholder participation in contract farming as key entry points in developing legislation governing this finance model.

1.7 Assumptions and limitations of the study

Since this is a comparative study, we assume that contract and non-contract farmers in Hurungwe operate in the same geographic location where they are exposed to the similar political, economic and environmental conditions hence the variation in technical efficiency levels can be attributed to participation in contract farming and other farm specific variables. Moreover, both contract and non-contract tobacco farmers are assumed to be rational actors who aim to maximize production subject to the production constraints.

The study also has three contextual and scope limitations that have a bearing on the general applicability of the findings. Firstly, it is only limited to smallholder farmers in Hurungwe district of Zimbabwe. Although the smallholders share a number of similarities in a number of aspects, there are also notable differences making it inappropriate to generalize the findings to all smallholders. Secondly, the study focussed on tobacco production hence the findings cannot be generalized to all crops. Since tobacco is a cash crop, the results can be applied, with caution, to other cash crops but there is need for other studies focussing on impact of contract farming on food crops production if the food security goal is to be achieved. Finally, this study is based on a field survey data collected for the 2016/17 farming season hence it is a short-term impact assessment of contract farming. The findings cannot be used to analyse the long-term impact of contract farming on technical efficiency and productivity which might require some time series analysis.

1.8 Organization of the study

This research study is organized as follows; this introductory chapter is followed by Chapter 2 where theoretical and empirical literature on technical efficiency and contract farming is reviewed. Chapter 3 gives a brief background of the study area followed by the research design, methods and procedure section. Chapter 4 presents the research results and discussion. Chapter 5 gives a conclusion of the study together with policy recommendations and possible areas of future research.

Chapter 2 : LITERATURE REVIEW

2.1 Introduction

The purpose of this chapter is to review and examine theoretical and empirical literature on technical efficiency, contract farming and its impact. The first section gives a background on efficiency analysis in agriculture as well as the different approaches in efficiency analysis. This is followed by a brief section on the theoretical aspects of contract farming as an agricultural finance model and evolution of contract farming in Zimbabwe. The chapter concludes with a review of empirical studies that investigated the impact of contract farming where the impact of contract farming on farmers is explored together with determinants of contract participation and as well as drivers of technical efficiency. The empirical literature is meant to highlight the inconsistencies in the impact of contract farming as a justification to this study. In addition, the methods of analysis in the reviewed studies are used to inform the research process followed in this study.

2.2 Theoretical literature

2.2.1 Efficiency analysis theory

Efficiency is a very important area of economic analysis that has attracted the attention of economists, given the need to efficiently allocate and use scarce resources in production (Ajibefun, 2008). Economic efficiency is conceptualised as composed of two main components; technical and allocative efficiency (Farrell, 1957). Technical efficiency, the focus of this study, is defined as the ability of a producer to produce the maximum possible output from a given set of production inputs (Farrell, 1957). In other words, a firm is technical efficient if it is producing on the frontier of the given production technology. Technical efficiency can be modelled either as input oriented (IO) or an output oriented (OO) (Kumbhakar et al., 2008). Input oriented technical efficiency measures technical efficiency from the input perspective whereas output oriented does the same from the output perspective. Using the output perspective, a firm that is 80% technically efficient means that it is producing 20% below its potential given its technology and available inputs. Likewise from an input perspective a firm that is 80% technically efficiency means it can produce the same output it is currently producing using 20% less inputs (Coelli, Rao, & Battese, 2005).

Allocative efficiency can be defined the firm's ability to use the least cost combination of resources to produce a given output quantity. Thus a firm is said to be allocatively efficient if it is making efficient resource allocations in terms of choosing optimal inputs and outputs combinations (Coelli et al., 2005). All in all, a firm is said to be economically efficient if it both technically and allocatively efficient. The concept is diagrammatically illustrated in input and output space in figure 2.1 and figure 2.2 respectively.

2.2.2 Input-oriented measures of efficiency

Using figure 2.1, a firm is fully technically efficient if it produces along isoquant SS′. If the firm uses input vector denoted by point P to produce output represented by isoquant SS′, it is considered technically inefficient. Distance QP is a measure of its inefficiency and represents the amount by which the inputs that could be saved without sacrificing the output. Alternatively, technical efficiency will be calculated as the ration of OQ/OP and can be expressed as a percentage with 100% representing a technically efficient firm. Using figure 2.1 as an example, firms operating at points Q and Q′ are both technically efficient.

Given the input price information, allocative efficiency can be measured by drawing an iso-cost line and shifting it until it is tangent to the isoquant SS′. This is given by the point Q′ which can be calculated as;

$$AE = OR/OQ$$

Technical efficiency (TE) is then multiplied by allocative efficiency (AE) to give economic efficiency (EE) as given below;

$$\begin{aligned} EE &= TE*AE \\ &= (OQ/OP)*(OR/QP) \\ &= OR/OP \end{aligned}$$

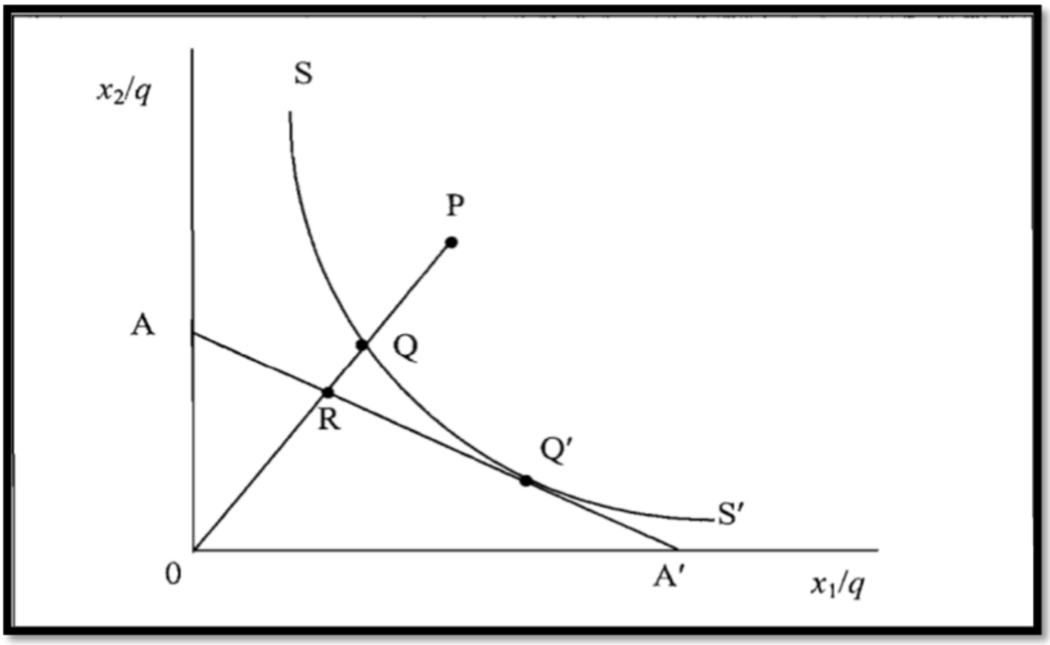

Figure 2.1: Input-oriented technical and allocative efficiency

Source: (Coelli et al., 2005)

2.2.3 Output-oriented measures of efficiency

Using the illustration in figure 2.2, a firm is technically efficient if producing along ZZ′ production possibility frontier. A firm producing at point A is technically inefficient and this inefficiency can be measured by the magnitude of line AB. Thus, there is potential for the same firm to increase its output by the same magnitude using the current level of inputs and at the prevailing technology (Coelli *et al*., 2005). The measure of output-oriented technical efficiency is given by the ratio OA/OB and can be expressed as a percentage with 100% representing a technically efficient firm. Using the illustration in figure 2.2, both B and B′ are technically efficient.

Given the output price information, allocative efficiency can be measured by drawing an iso-revenue line and shifting it until it is tangent to the production possibility frontier ZZ′. This is given by the point B′ and the measure of allocative efficiency (AE) is given by;

$$AE = OB/OC$$

Again, these two calculations give economic efficiency (EE) as follows;

$$
\begin{aligned}
EE &= TE*AE \\
&= (OA/OB)*(OB/OC) \\
&= OA/OC
\end{aligned}
$$

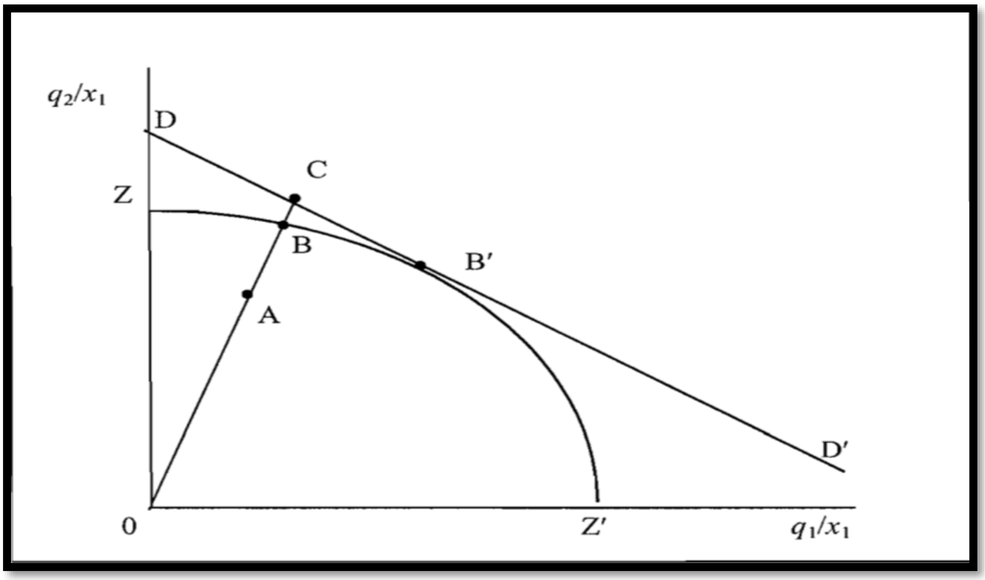

Figure 2.2: Output-oriented technical and allocative efficiency

Source: (Coelli et al., 2005)

2.2.4 Approaches in efficiency analysis

Given this importance of efficiency analysis, various methods have been developed to understand the subject (Ajibefun, 2008). Early attempts in studying efficiency used the classical approach which basically involved calculating the ratios of output-to-input (partial productivity measure), and output-to-inputs (total productivity measure) which had shortcomings that prompted economist to develop frontier methods (Ajibefun, 2008).

Economists use two approaches in measuring technical efficiency. These are parametric and non-parametric approaches. Figure 2.3 is an illustration of the two approaches. The parametric approach uses econometric techniques like simple regression analysis and Stochastic Frontier analysis. Under non-parametric approaches, there is Data Envelopment Analysis (DEA) which uses mathematical programming and Corrected Ordinary Least Squares (Ajibefun, 2008; Vasilis, 2002). The basic idea in the two approaches is to estimate the frontier production function which is then compared with observed output to determine the level of technical efficiency for individual or group of producers. The principal advantage of frontier analysis is that it allows calculation of technical, allocative and economic efficiency.

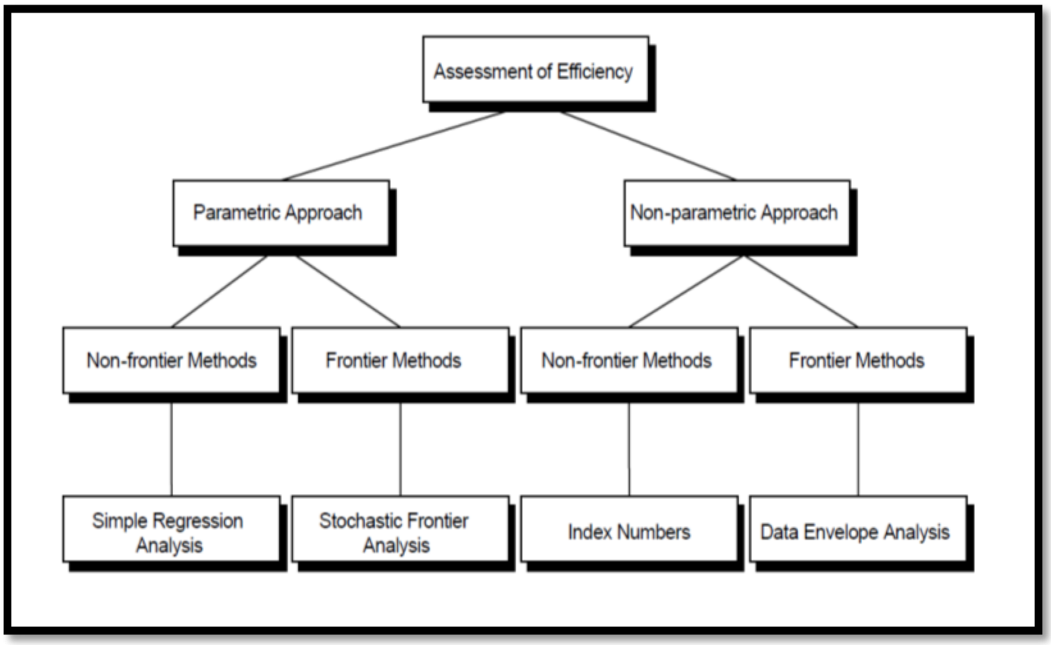

Figure 2.3: Taxonomy of efficiency measurement techniques

Source: Vasilis (2002)

While the two methods share some similarities, they have advantages and disadvantages that influence why different researchers prefer one method to the other. Parametric approaches have the advantage of allowing the researchers to test hypotheses concerning goodness of fit of the model. More so, it enables the analyst to separate inefficiency from random errors Vasilis (2002). However, its major drawback is that it requires specification of technology making it restrictive in nature and susceptible to specification error. On the other and, non-parametric approaches do not impose structure on the technology hence are less restrictive. The disadvantage is that one cannot estimate parameters for the model hence it is impossible to test hypotheses concerning performance of the model (Ajibefun, 2008).

Technical efficiency is important in economic analysis for a number of reasons. First, it enables comparison between production units (farms or group of farmers in this case) to see which one is performing better. Efficiency analysis is also important in policy formulation. For example, identification of determinants of inefficiency of the in agriculture enable policy makers to develop policies aimed at eliminating sources of inefficiencies thereby improving performance of the sector.

2.2.5 Definitions and theoretical perspectives of contract farming

This section explores the definitions of contract farming, types of contractual arrangements in agriculture and the theoretical justification of this institutional arrangement. This is important in understanding the concept of contract farming (CF) as well as locate in which category the Zimbabwe tobacco contract farming arrangement falls given the different types of agriculture contracts.

According to James (2015), the multiplicity and diversity in CF arrangements makes it difficult to come up with a general definition for CF. As a result, a number of definitions emerged and have been used by different authors. This has been the case because of the theoretical context in which the authors were focussing on and/or the need to adapt the contractual arrangement to suit the context in which the contracting parties would have agreed. As broadly put by Saigenji (2010), CF refers to an organizational or institutional arrangement that facilitates access to agricultural inputs and output markets for farmers. Similarly, Minot (2007) defined CF in more detail as pre-arranged agriculture production process between two contracting partners whereby the producer (farmer in this case) commits to producing a certain product according to the agreed standards which the buyer (contractor) agrees to purchase. In most cases, the buyer (agribusiness firm) provides technical assistance and inputs on credit as well as a guaranteed market and price to the farmer (Minot, 2007). However, this study adopts the definition by Rehber (2007) who defined contact farming as:

> "*A contractual arrangement between farmers and other firms whether oral or written, specifying one or more conditions of production, and one or more condition of marketing, for an agricultural product, which is non-transferable*".

This definition best describes how the tobacco contract arrangements are structured in Zimbabwe.

From the institutional economics perspective, CF is a governance mechanism that lies somewhere between fully vertically integrated investments (where the firm retain control of all the value chain activities from production to marketing) and spot markets (where market forces determines prices) (Kirsten & Sartorius, 2002). Contracts are developed as a response to the need to reduce transaction costs that arise due to the imperfect nature of agricultural markets. This allows the agribusiness firms to have some level of influence in the production process without directly entering the production node thereby reducing risk in the markets. As highlighted, there are variations in contract farming arrangements to suit the circumstances and context in which the agreement is made.

2.2.6 Types of agricultural contracts

Using Kohls and Uhl (1985) classification, agricultural contracts can be grouped into three broad categories namely market specification, resource providing and production management contracts depending on the objective and structure of the contract.

(i) Market Specification Contracts

These are pre-harvest arrangements agreed upon by the contractor and the farmer outlining conditions that govern the sale of the specified agricultural produce (Kohls and Uhl, 1985). These types of contracts guarantee the farmer a ready market after production. In addition, the farmer has an indication of the prices for his produce provided he meet the set quality standards by the buyer. Under this arrangement the farmers retain full control of the farm production process (Prowse, 2012).

(ii) Resource-providing Contracts

Under these types of contracts, the contracting firm commits to supply the farmer with physical and technical inputs with the agreement that the producer will sell the produce through the same firm. In theory this has the advantage that the farmer’s costs of sourcing the inputs are reduced and the agribusiness firm benefits from a guaranteed quality produce, usually as repayment. This arrangement is common in highly technical and speciality crops with specific input requirements and quality standards that are beyond the reach of under-resourced smallholders who struggle to access input due to poverty and imperfect markets (Prowse, 2012).

(iii) Production Management Contracts

Under these types of contracts, the contracting firm stipulates and enforces conditions of production as well as on-farm post-harvest and value addition processing to ensure that the produce meets the market expectations. In this arrangement, farmers relinquish some degree of control over production process to the contracting firm (Prowse, 2012). Market and price risk are transferred from the farmer to the contracting firm while the farmer is guaranteed of a certain level of revenue through pre-agreed prices (Kohls and Uhl, 1985). Although a bit expensive to the agribusiness firm, costs are recouped from high quality produce and low default rates (Prowse, 2012).

The last two types are prevalent in agriculture and are common in tobacco farming in Zimbabwe.

2.2.7 Theoretical perspectives of contract farming

A number of theories have been put forward to explain the emergence of CF. This section gives a summary of three of these theories.

(i) Life Cycle Theory

This theory view contract farming as a type of vertical integration. It argues that industries tend to be more vertically integrated in the early stages of development but reduces the degree of vertical integration at the later (mature) stages due to product differentiation and traceability requirement (Rehber, 2007). This contradicts the assertion by Casson (1984), who argued that a small industry does not facilitate specialisation but as industry grows, firms start to exploit specialisation to benefit from economies of scale hence the need for vertical integration.

(ii) Transaction Cost Theory

This theory originates in Coase's (1988) article on why firms exist. In conducting business, Coase (1988) identified costs for writing, execution and enforcing of business contracts and he called these transaction costs (TCs). Transaction costs refer to the costs of running of an economic system (Kirsten et al., 2009). High TCs discourage participation in the market leading to market failure. One of the reasons given for these high TCs is lack of market information and this problem is common in most rural economies and agricultural markets of developing countries. The result has been low production, low incomes and an increase in poverty among rural communities (Nguyen et al., 2015). According to Coase (1988), establishment of firms is motivated by the need to reduce these transaction costs. Using the New Institutional Economics lens, transaction cost theory explains contract farming as a mechanism aimed at reducing TCs thereby facilitating market participation as well as preventing market failure in agriculture economies (Kirsten et al., 2009). This is achieved through sharing of risk by contracting partners and sharing information during the contracting process. Another reason why agribusiness firms engage in contract farming is because of asset specific investments. The higher the degree of asset specificity the higher the incentive to entering into a contract arrangement (Meshesha, 2011). This is especially true for tobacco processors who after investing in tobacco specific processing plants find it prudent to contract farmers so that they have a guaranteed steady flow of raw tobacco for their investments to be economically viable.

(iii) Value Chain Governance (VCG)

The need to maintain quality and standards in the value chain of quality sensitive products has contributed to the growth of contractual arrangements. Whereas non-standard products can be easily traded on the spot markets, highly differentiated quality products for the niche and export markets like tobacco are traded via networks (contracts) or hierarchies depending on the producer competences and the ease with which market information about product quality and characteristics can be transmitted (Nguyen et al., 2015). Thus VCG gives the theoretical basis for contract farming as a governance mechanism to ensure quality as the product moves along the value chain (Silva, 2005).

2.2.8 Evolution of contract farming in Zimbabwe

Although CF has gained prominence as an agricultural finance model in Africa and Zimbabwe in particular over the last decade, the practice has been in existence centuries ago (Rehber, 2007). As reported by Rehber (2007), the history of CF can be traced back to the 19th century when it was practiced on Taiwan sugar plantations by the Japanese and by USA companies in Central America. In developed countries CF was used by the canning industry in the production of vegetables as well as by the seed producing companies in the 1930-1940s (Rehber, 2007). Following its growth in the developed world, CF rapidly spread into the Asia, Latin America and Africa owing to the high returns from exports and the impact of technology adoption (Kirsten & Sartorius, 2002). By the late 20th century CF was an integral part of the food and fibre value chain worldwide (Rehber, 2007).

Zimbabwe has a history of CF dating back to the 1950s (Murwira, 2012). Prior to the country's independence, contract farming was mostly used as a form of vertical integration by large tea and sugar plantations, in some form of out-grower schemes (Murwira, 2012). However, this changed after independence with CF being extended by private companies to cover a variety of crops like maize, soybean, cotton, paprika as well as seed production (Dawes et al., 2007). James (2015), noted that during the same period, CF was mostly linked to state-owned and state-controlled estates with sales being channelled through the government-owned marketing boards.

Chang et al. (2006), noted that globalization and trade liberalization modernized the agriculture sector thereby exerting pressure on both farmers and agribusinesses to improve on produce quality and safety. It is these quality/safety demands that pushed agribusinesses to collaborate with farmers through CF to enable quality monitoring right from the farms. Private-led CF intensified in the 1990s following the Economic Structural Adjustment Program (ESAP) which limited the role of state economic activities and led to the privatization of most state-owned parastatals (James, 2015). Economic liberalization through ESAP increased competition in the agricultural produce market. Realizing this development, agribusinesses involved in buying commodities like cotton and tobacco entered into various contract farming arrangements with farmers as a way of ensuring a guaranteed supply (James, 2015).

This private-led expansion in CF was short-lived following the implementation of the Fast Track Land Reform Program in 2000 and the subsequent economic collapse that followed. Political and economic instability that followed the FTLRP, accelerated by record inflation figures created panic and uncertainty in the economy. Most companies (including contracting firms) closed shop citing viability challenges. The situation was not helped by the heavy-handed state interventions that further distorted the market (Scoones et al., 2017).

The establishment of the government of national unity in 2008 and the adoption of the multicurrency regime restored some political and economic stability conducive for business. This stable environment resulted in renewed business opportunities that attracted both local and international companies (mainly from China, USA and India) to engage with the resettled smallholder farmers through CF arrangements (Moyo & Ngoni, 2013; James, 2015). According to Irwin et al. (2012), an estimated 50 firms contracted about 32,8000 smallholder farmers to produce a variety of crops on approximately 628000 hectares of land during the 2011/12 farming season. The number of cotton contractors increased to 13 in 2011 (James, 2015). Similarly, the number of firms involved in tobacco contracting rose from 3 in 2003 to 20 in 2017 (TIMB, 2017) so was the production of tobacco under contract as shown in table 2.1.

Table 2.1: Contract vs non-contract tobacco production

Year	No of contractors	Contract production million (kg)	USD/kg	Action production million (kg)	USD/kg	Total production million (kg)	USD/kg
2004	6	16	2.13	53	1.95	69	1.99
2005	6	28	1.87	45	1.44	73	1.61
2006	7	30	2.08	25	1.88	55	1.99
2007	11	44	2.26	30	2.40	73	2.32
2008	15	33	3.13	16	3.44	49	3.23
2009	13	42	3.03	16	2.86	58	2.99
2010	12	79	3.04	42	2.63	122	2.89
2011	12	74	2.97	58	2.42	132	2.73
2012	13	92	3.72	53	3.52	144	3.66
2013	15	113	3.74	54	3.54	166	3.67
2014	16	162	3.32	51	2.69	216	3.17

Source: TIMB, 2015

2.2.9 Theoretical arguments for contract farming

In theory it is expected that CF has a positive impact on efficiency and productivity. A number of theoretical arguments have been put forward to explain why CF increase efficiency and productivity. Improved productivity in the contracted crop could have spill-over effects to other crops, generating additional income and improving food security of the contract farmer (Minten, Randrianarison and Swinnen, 2009). The reasons are premised on the understanding that CF addresses a number of market imperfections in the rural markets that constrain smallholders' production. According to the World Bank (2001), CF is a potential avenue through which the private sector can take over the roles previously played by governments in providing agricultural information, inputs and credit to smallholders in developing countries.

It is argued that CF reduce the financial requirements of farmers thereby freeing capital for investment in productive assets and superior production technologies that contribute to more efficiency and productivity. With the contracting firm providing a large share of production inputs (seeds, fertilizers, chemicals, fuel, management, market services and in some cases working capital), smallholder farmers are relieved of the burden of having to fully finance their operations. For example, under the hog contract scheme in USA, the contractor contributed about 80% of the production costs (Key and Mc Bride, 2007).

Contract farming shifts input and output price risks to contractors in addition to reducing production risks for farmers (Martin, 1997). By lowering risk, CF induces lenders to raise the amounts they are willing to lend to farmers as well as relaxing some of the stringent requirements in applying for credit (Key, 2004). Improved access to credit can induce farmers to invest in more efficient production technologies (Key and Mc Bride, 2007).

Contract farming plays an important role in addressing information asymmetry in agricultural markets. A well-informed rational farmer is better equipped to make sound decisions to optimally allocate scarce resources to maximize returns. In addition, CF provides extension services that help farmers with information on best farming practices that can improve their efficiency and productivity. Moreover, contracting firms have access to modern production technologies and are likely to provide farmers with latest high yielding seed varieties on the market thereby improving efficiency of participating farmers (Key and Mc Bride, 2007).

2.3 Empirical literature review

2.3.1 Impact of contract farming on farm incomes and welfare

There are a number of studies that investigated the impact of CF on farm income. It also appears there are mixed results regarding the impact of CF on farm incomes making it difficult to make a valid conclusion on whether CF increase farm incomes or not. While some studies claim that CF increase farm incomes (Key & Rusten, 1999; Warning & Key, 2002, Simmons et al., 2005), others found that CF had no impact or even lowered farm incomes (Eaton & Shepherd, 2001; Glover & Kusterer, 1990; Abdallah, 2016). This section reviews literature on how CF impacted on the incomes of farmers in contacting. In addition, some of the studies reviewed try unpack the reasons behind these mixed results on the impact of CF on farm incomes. A comparison is also made between incomes of contract participants and non-participating farmers.

The impact of CF on smallholder incomes and welfare depends to a large extent on the nature of the contract. For example, Dedehouanon et al. 2013 found that CF improved subjective wellbeing of participants only under certain conditions and contract designs. By linking services like credit, training, technical advice including market information, CF offers an institutional solution to the problems of market failure in rural economies (Grosh, 1994, Rusten, 1992). In addition, CF encourages smallholder participation in markets and value chains leading to increases and stability in smallholder incomes (Bellemare, 2012) thereby improving farmer welfare. By making produce price known prior to production, CF reduces the risk of price fluctuation which is a common feature in agriculture markets (Eaton & Shepherd, 2001). Minimum price risk allows farmers to focus on efficiently allocating their productive resources to maximize returns to their farming investments (Saenger et al., 2013).

While reviewing the experiences of CF in Africa in the early 1990s, Porter and Howard (1997) observed significant welfare gains in famers that participated in contract farming. This observation was also supported by the study of contract vegetable production in India where farmers also recorded an increase in their incomes following their joining of the contract scheme (Singh, 2002). The same study also unearthed challenges like power asymmetry between the contracting firms and farmers, violations of terms of agreements, social differentiation (which threaten the fabric that hold society together) as well as lack of environmental sustainability. The last point poses a serious threat to the future of tobacco contract farming in Zimbabwe whose reliance on firewood for tobacco curing is a cause for concern to environmentalists.

An empirical analysis of groundnut contract production in Senegal by Warning and Key (2002) found that contract farmers realised statistically significant increases in gross agriculture revenue which was 55% more that the average revenue of non-contract farmers. However, the study was silent on the reason behind the increase in gross revenue. Since gross revenue is a function of price multiplied by quantity which is also a function of area planted and productivity, it is not clear from this study what caused the increase in gross income. This calls for further research to decompose the revenue effect to identify what really caused the increase in revenue.

While examining the emergence and benefits of CF in Indonesia, (Simmons et al. (2005) observed positive welfare effects for three agricultural products produced under contract. Using farm gross margin analysis, the study found that the welfare of farmers who participated in CF improved. The same study also concluded that seed corn and broiler contract farmers recorded an increase in their returns to capital leaving them better off than before. However, the results were different for rice contract farmers who did not enjoy any increase in farm gross incomes. Instead, they benefitted through access to secure markets. The authors further argued that CF reduced absolute poverty in the area. From a development perspective, this is very important since CF can be used as a poverty alleviation tool in poor rural communities in most developing countries. However, caution needs to be taken to address social inequalities brought about by agribusinesses who choose to contract only with large farmers at the expense of many dispersed smallholders to reduce transaction costs (Kirsten & Sartorius, 2002).

Interestingly, another study on the impact of CF on farm incomes of avocado producers in Kenya by Mwambi et al. (2016), revealed that although CF participants had higher incomes, the difference between their incomes and that of non-participants was not significant. This suggest that in this case CF was not responsible for the income differentials between the two groups. The study noted poor coordination between the contracting parties as the possible reason why CF could not significantly impact on the incomes of participants. For CF to make a difference in the welfare of the smallholder farmers, there is need for strong coordination among players. Government plays a very crucial role in creating an enabling environment through strengthening of the legal system to ensure contracts are enforced as well as development of rural infrastructure to facilitate the coordination of the contracting parties.

The study by Abdulai and Al-hassan (2016) on the impact of CF on the incomes of farmers showed that contract participation had a significant negative impact on income earned from soybean production. The study found that contract farmers earned lower incomes from soybean farming compared to independent farmers. The study further noted that contract farmers were compelled to sell their soybean to the contractors soon after harvesting at the agreed price unlike their non-contract counterparts who stored their harvest and only sold when prices were favourable. Also given that the contractors are profit oriented businesses entities, they paid less attention to the welfare of farmers in their pursuit of profits. This also demonstrates the power asymmetry between contractors and farmers that has resulted in the exploitation of smallholder farmers through skewed contracts (Parirenyatwa & Mago, 2014). This observation agrees with Clapp et al., 1994 who evaluated contract schemes in Africa and concluded that farmers were sometimes reduced to “quasi employees” by the agribusiness firms. This observation calls for policies that regulate the implementation of CF arrangements to protect the interests of the contracting parties and ensure viability.

In addition to government intervention in trying to regulate the operations of CF for the mutual benefit of the contracting parties, farmer organisations and farmer cooperatives can help in championing the interest of the farmers when it comes to CF. A study by Sokchea and Kulas (2015), found that marrying CF and farmer organization could assist minimize some of the problems in CF. The study found that farmer organisations compliment CF by increasing the bargaining powers of the smallholder farmers thereby eliminating the power asymmetry that are inherent in most contract arrangements resulting in improved farm incomes and farmer welfare. Moreover, since farmer organizations are farmer-owned, they represent the interest of all member farmers hence there are high chances that even the small farmers (usually excluded by contracting firms) will be engaged in CF. Therefore, in conclusion, the study showed how CF can be married with farmer organizations in improving smallholder productivity, incomes, and welfare as well as address inequalities in agricultural communities.

In a recent study, Mulatu et al. (2017) used a combination of quantitative and qualitative data to investigate the impact of vegetable contract participation on household income in Central Rift Valley of Ethiopia. To address the non-randomness of contract participation in the absence of baseline data, propensity score matching was employed to account for self-election bias. A t-test was used to estimate the treatment effect on the outcome variable (income) and it was found that on average, participation in CF increased income by 32 percent. Additional benefits in terms of livestock and asset accumulation were also reported by vegetable contract participants. Similar results were also reported by Saigenji and Zeller (2009) who found that contract participants in tea farming earned higher incomes than their non-contract counterparts in Vietnam. Begum (2005) also observed substantial income gains on contract poultry farms during his assessment of the vertically integrated poultry system in Bangladesh.

As demonstrated by the various studies reviewed in this section, the positive impact on income can be attributed to the increase in area planted since inputs were no longer a constraint favourable prices offered by the contractors while some attributed the income rise to efficiency gains. The empirical literature on impact on efficiency and productivity, which is the subject of this study, is covered in the following section.

2.3.2 Impact of contract farming on efficiency and productivity

Efficiency and productivity have been a subject of extensive research in the agriculture sector because of its implication on food security, poverty alleviation and agricultural growth. Given the increasing role of CF as an agriculture commercialization and finance model, several studies have been conducted to assess its impact on productivity. Whether CF improves efficiency and productivity remains a highly debatable subject as demonstrated by the studies reviewed in this section.

A positive impact of CF on productivity was reported by Key and Mc Bride (2003, 2007) following their studies of the hog sector in USA. Initially they used the maximum likelihood method and concluded that CF resulted in high productivity in the hog sector. This method had problems that the variables used in deciding whether to participate in contracts were also used in the efficiency model leading to endogeneity and biased conclusions (Key & Mc Bride, 2007). With this in mind, Key and Mc Bride (2007), conducted a follow-up study using instrumental variables to control for endogeneity problems. It was not surprising that the two studies came to the same conclusion, which was a positive causal relationship between CF and productivity rather than a simple correlation.

Positive impacts of CF were also observed by Nakano (2014), while investigating the impact of contract arrangement between a large-scale private farm and the surrounding smallholder farmers in Tanzania. The study found a positive impact on the adoption of improved farming practices, yields as well as profits by the participating smallholders. For instance, yields as high as 5tons per hectare were realised by contract farmers compared to 2.6tons for non-contract in the same area and 1.8tons average national yield per hectare. Unlike most studies, the results showed a long-term impact on CF as the technology adoption and productivity remained high even after the contractor had stopped supplying inputs. However, the drawback was that the program benefits did not spill-over into the neighbouring non-participants thereby creating inequity problems in the communities.

High productivity was also observed by Igweoscar (2014), when he compared technical efficiency between contract and non-contract cassava farmer in South Eastern Nigeria using OLS and the Cho test models. The study found that although productivity, net returns and welfare levels of contract farmers were higher than those of their non-contract counterparts it was only productivity that was statistically significant. Still in Nigeria, Olomola (2010), analysed the performance of contract farming on five crops namely cotton, ginger, rice, soybean and tobacco and observed that yields, quality of produce as well as farmer welfare improved although the magnitudes varied across crops.

Swain (2013), examined the impact of CF on the productivity and efficiency of paddy rice in Southern India by comparing efficiencies between contract and non-contract farmers using the Heckman sample selection model to account for selection bias. The study analysed the farmers' efficiency levels for both paddy rice grown under contract and paddy rice not covered under contract. The results showed that contract farmers were more efficient in producing the contracted paddy crop whereas non-contract farmers were efficient in the production of non-contracted paddy. In addition, the study also showed that smaller farms were more efficient than large farms. If this second observation is found to be the case in Zimbabwe, CF will go a long way in improving productivity since the expectation would be that the reduction in farm size brought about by the land reform will result in more efficient smallholder farmers than the former large commercial farms.

In a recent study, Mishra et al. (2017) compared the productivity and technical efficiency levels for contract and non-contract paddy seed and ginger smallholder farmers in Napal. The study used a Translog Stochastic Frontier Model to estimate the technical efficiency levels for the two groups of farmers as well as to identify the determinants of technical efficiency. To address the potential of self-selection bias into contract participation, the study used Propensity Score matching technique. The results showed that CF increased the average technical efficiency levels for smallholder seed rice farmers from 87 percent to 94 percent. On ginger farming, the same study reported that the average technical efficiency for ginger producers increased from 89 percent to 97 percent. Human capital and distance to the markets were identified as sources of inefficiencies for this group of farmers.

Ajao and Oyedele (2013), studied the impact of CF on economic efficiency of tobacco farmers in Oyo state in Nigeria. The study collected primary data from 495 contract tobacco farmers using a structured questionnaire and used Data Envelop Analysis to determine the levels of efficiency. It was found that the farmers were 83.1% technically efficient, 71.6% allocatively efficient and 59.2% economically efficient. The results concluded that there was room for farmers to improve their efficiency to attain higher levels of productivity with the level of technology at their disposal. One drawback of the design in this study is that it did not make a comparison between contract and non-contract farmers nor did it compare the before and after (contract) scenarios to isolate the impact of CF on productivity. This makes it difficult to make plausible conclusions on whether CF increased efficiency or not.

Although looking at the cotton sector, Mafuse et al. (2014), conducted a study on the impact of CF on profitability of smallholder farmers in Zaka, Zimbabwe. The researchers compared yield levels and profitability between contract and non-contract cotton farmer by means of a t-test of mean equality. Using data from 2009/2010 and 2010/2011 farming seasons, it was found that there were no significant yield differences between contract and non-contract farmers. As such the hypothesis that participation in cotton CF increased cotton productivity in smallholder agriculture was rejected. These results portray a picture that contracting as a funding mechanism for cotton production adds no value to productivity except increasing area under production due to input provision. This study seeks to find out if the same results apply to tobacco farming given the increase in the number of CF arrangement in the last decade.

One of the few studies in Zimbabwe on the efficiency impacts of CF on tobacco productivity known to this researcher was conducted by Dube et al. (2017) in Makoni District. Using stochastic frontier analysis on randomly selected smallholder tobacco farmers, the study concluded that contract farmers were more efficient (94 percent) compared to non-contract farmers (67 percent). Given that the average technical efficiency of smallholder tobacco farmers in the area was 73 percent, the findings imply that participation in CF significantly improves technical efficiency for smallholder farmers. Despite the contribution this study makes to the literature on the impact of CF on efficiency, it has two limitations that could affect the validity of the findings. Firstly, the study used tobacco bales sold as the output variable yet bales are not a standard unit in measuring output. Since different bales can contain varying amounts of tobacco, the accuracy of the results can be questioned. Secondly, in accounting for the technical efficiency differentials between the two groups of farmers, the study overlooked the influence of self-selection bias in contract participation hence the results could be biased. Following the same analytical procedure, this study will use kilogrammes (kgs) as the unit of measure for the output variable and incorporate propensity score matching in addressing self-selection bias for robust conclusions.

2.3.3 Determinants of contract participation

Previous scholars who investigated factors that influenced contract participation in smallholder agriculture found a number of socio-economic characteristics to be the main determinants of contract participation. However, results of such studies show that the influence is varied owing to different contexts and nature of contracts. For example, using a combination of the treatment effect and probit models, Azumah et al. (2016) examined the effects of CF on farm income as well as the factors that influence farmers' decision to participate in CF arrangements. They found that off-farm activities, access to extension, extra credit and farm size were individually and jointly significant in explaining contract participation. Farmers who engaged in other off-farm activities or with off-farm income sources and large farm sizes were found to be less likely to participate in CF arrangements. Thus, the argument by Poulton et al. (2010) in his review of the CF studies that contractors tend to engage well-off farmers is hereby disputed. The same study found that extension and credit access positively impacted on CF participation

Similar findings were reported by Kiwanuka and Machethe (2016) when they examined determinants of smallholder participation in dairy value chain in Zambia. The study also used the probit model and found among other factors landholding size, income from non-farm sources, access to marketing information and value of non-land assets owned to be key determinants of participation in the dairy interlocked contractual arrangements. Land holding and income from non-farm sources decreased the propensity to participate in the dairy value chain while access to dairy marketing information and the value of non-land assets increased the probability of participation. This last observation implied that asset ownership (wealth status) enhances chances of contract participation and support the notion that CF excluded the poor from participation. Evidence of positive effect of contract participation was also reported by Bellemare (2012), and Wang et al. (2013). Interestingly Leung et al. (2008), found a negative link between contract participation and farm size while Wainana et al. (2012) for land size to be insignificant in explaining contract participation.

The decision to adopt CF in smallholder cotton farming is influenced by a number of factors as reported by Tinashe et al. (2013). Two sub-samples (contract and self-financing farmers) were selected using stratified random sampling and a binary logistic model was used to identify the farmer characteristics that influenced farmers' decision to adopt CF. For this group of farmers, it was found that households whose main source of livelihood was farming, households that received frequent extension visits and more experienced farmers were more likely to adopt CF. Possible explanation for this observation is that full-time farmers with more experience in farming have established strong working relations with local extension staff hence they receive favourable recommendations when applying for CF arrangements.

While investigating tobacco contract participation and its impact on incomes in Urambo, Tanzania, Sambuo (2014) identified farming experience, membership to farmers' group and age of farmer to significantly influence contract participation by farmers. Using a Heckman's two stage model Sambuo (2014), described how these socio-economic factors influenced contract participation by smallholder tobacco farmers. Farming experience had the largest effect on contract participation followed by group membership then age. The study also identified variables like asset ownership and access to credit to have a negative influence on contract participation. According to Shaba et al. (2017), other factors that strongly influenced participation in tobacco CF include farm size, access to extension services, distance to the tobacco auction floors and gender of farmer.

2.3.4 Determinants of technical efficiency

Farm level technical efficiency is influenced by a number of factors as can be seen in a number of efficiency studies. Previous studies on determinants of technical efficiency at farm level have focussed on three groups of variables namely (i) farm characteristics, (ii) household demographic and socioeconomic characteristics and (iii) farm geophysical characteristics. Although there is little agreement amongst scholars as to which variables fall in which group and the units of measurement to use, there is consensus that these variables impact on technical efficiency albeit differently.

Under farm characteristics, farm size and cultivated area have been widely examined as determinants of technical efficiency in smallholder agriculture. Beyan (2014), used a Cobb-Douglas stochastic production frontier to compare the technical efficiency differentials between smallholder farmers under irrigation and rain-fed agriculture. In examining the determinants of technical efficiency, the study found that education, cultivated area, extension contact, access to irrigation, farmer training significantly determined technical efficiency.

A similar study was conducted in Malawi by Chirwa (2007), in Malawi when he used farm level data not only to estimate the technical efficiency level but also investigate the source of technical efficiency amongst smallholder maize farmers. The results obtained from the stochastic frontier production function showed that smallholder maize farmers in Malawi were producing well below their potential (mean TE was 46.23%). While investigating the sources of technical inefficiencies in the same study, Chirwa (2007), found that socioeconomics and demographic factors explained the technical inefficiencies amongst the sample. A similar study by Tchale et al. (2005), showed that education and household size services positively contributed towards improving technical efficiency amongst smallholder maize farmers in Malawi. The majority of policy variables like, credit access and access to extension also positively influenced technical efficiency. Larger farms were observed to be less efficient compared to smaller farms. This inverse relationship between farm size and technical efficiency has been reported in a number of farm efficiency studies (Townsend et al., 1998; Helfand & Levine, 2004).

In Uganda, Obwona (2006), used cross-sectional data from 65 small-medium scale tobacco farmers to investigate the determinants of technical efficiency. The objective of the study was to explore ways of enhancing tobacco productivity by targeting the determinants of technical efficiency in the area. The study found that the observed inefficiencies in tobacco farming could be explained by demographic and socio-economic factors. Access to extension service, credit and education were observed to positively impact of technical efficiency thereby steering policy direction towards addressing these factors. The study used a Cobb-Douglas Production frontier model to measure technical efficiency and identify its determinants. The level of technical efficiency was found to be 64.7%, implying that there was potential to increase production with the given level of inputs and technology. Among other factors, the study found that input credit use negatively affected technical inefficiency.

The call for tobacco farmers to embrace CF in tobacco farming was supported by a research by Ilembo and Kuzilwas (2014), which analysed technical efficiency of tobacco farmers in Tanzania. In that study, they estimated the technical efficiency of tobacco smallholder farmers as well as investigated the drivers of technical efficiency in Tanzania. Farm level data was analysed using a Cobb-Douglas stochastic frontier model. The study found significant technical inefficiencies among the sample of tobacco farmers. On average the farmers were attaining 64.7% of their potential implying that there was a huge opportunity to increase production by about 35.3% using the available resources if inefficiencies in the production process were addressed. Farm size, input credit, off-farm income and education level showed a positive influence on technical efficiency while older farmers were found to be inefficient compered to younger farmers. The study noted that, given the capital intensive nature of tobacco farming, resource-constrained smallholder farmers are encouraged to embrace input credit schemes like CF to improve technical efficiency.

Some of the variables reviewed in this section will be explored in this study together with other variables as covariates in explaining the sources of technical efficiency amongst smallholder tobacco farmers in Hurungwe District.

2.4 Conclusion

The chapter highlighted the different approaches in estimating efficiencies as well as the advantages and disadvantages of each approach. The choice of which approach to use is determined mainly by the objectives of the researcher. The chapter also explored the different types of contract arrangements used by different agribusiness firms in the agriculture sector. In addition, reasons justifying the growth of CF in developing countries were explored. Lastly the chapter reviewed some empirical literature on the impact of CF on farmer welfare and productivity. In addition, factors that explain why farmers self-select to participate were highlighted together with drivers of technical efficiency in the smallholder farming. As highlighted in the chapter, although most studies reported that CF had positive impacts on agriculture, a number of studies could not come up with the same conclusion. More so, some of the studies had some flaws in their designs that could affect the credibility of the results. Bearing this in mind, there is need for more research in the area by refining the study designs and analytical methods for robust conclusions.

Chapter 3 : STUDY DESIGN, METHODS AND PROCEDURES

4.1 Introduction

This chapter gives the description of the study area and outline the research process followed in this study. The chapter is broken down into nine main sections. Section 3.2 gives a background description of the study area to give context to the study. The research design and sampling procedure is presented in sections 3.3 and 3.4 respectively. The survey instrument design, data collection and data analysis process are discussed in section 3.5. Production variables used in the study are described in section 3.6. Section 3.7 explains the empirical models used in the analysis followed by the section 3.8 which explains how selection bias was addressed. The chapter summary is presented in section 3.9.

4.2 Study area

Hurungwe is one of the six districts located in Mashonaland West Province of Zimbabwe. It is situated in the North Western part of Zimbabwe some 200km from the capital city, Harare. Figure 3.1 is a map of Hurungwe district. According to the 2012 national census, the district is home to about 357,803 people (ZIMSTATS, 2012), settled on about 19,200 square kilometres of land. The district falls under natural regions II, III and IV (Chimhowu, 1997), which receive rain ranging from 500mm to 1000mm making it suitable for agricultural production. However, just like any district in Zimbabwe, the area experiences periodic seasonal dry spells and even drought making rain-fed agriculture risky.

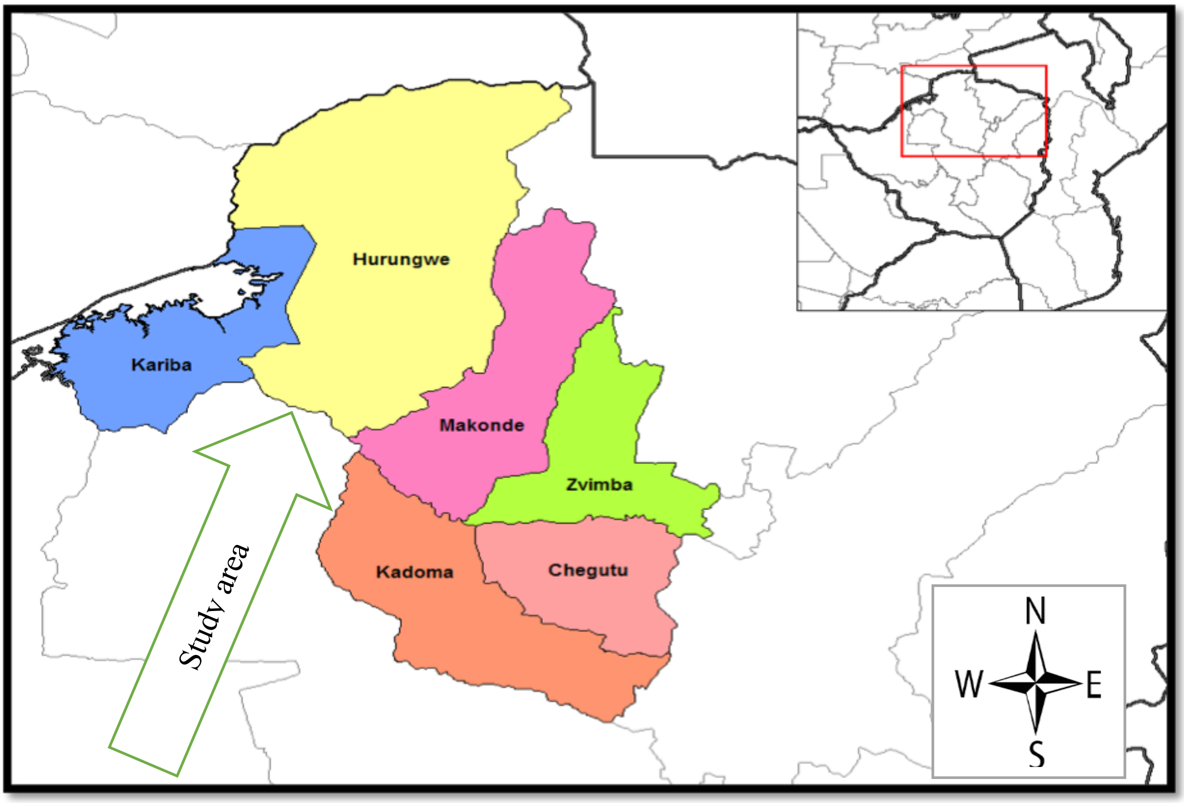

Figure 3.1: Map of Study Area

Source:
http://upload.wikimedia.org./wikipedia/commons/1/1d/Mashonaland_West_districts.png

Despite the threat posed by the erratic rainfall and periodic droughts, agriculture is the main livelihood activity in the area. The majority of the farmers in the area are smallholder farmers, categorized as those resettled under the A1 and A2 models during the FTLRP and those settled in the 1980s under the Old Resettlement Scheme. Conceptually it is difficult to define small farms or smallholder farming. However, in the African context, where quantification is possible, smallholders refer to that category of farmers who own or operate on less than five hectares (Eastwood et al., 2010, appendix table 1, p. 3394). A smallholder in the Zimbabwean context refers to famers who operate in communal areas, resettled small-scale areas and the famers who were resettled under the A1 scheme during the Fast Track Land Resettlement Program and can own up to 35 hectares (Mutami, 2015). Communal farmer refers to a group of farmers that are domiciled in the communal areas. Old resettlement farmers are a group of farmers that were allocated land on farms that were acquired by the government from the white commercial famers on a willing buyer willing seller basis in the 1980s to early 1990s. A1 farmers refer to a group of farmers who were allocated land under one of the models of the Fast

Track Resettlement Program (started in 1999) that was designed to decongest the communal areas and accommodate smallholder farmers. The common characteristic of all these famers is that they own small pieces of land averaging 6 hectares. Although the farmers grow a diverse range of crops, tobacco and cotton constitute the major cash crops with maize being grown mainly for consumption although maize sales occur in surplus seasons.

Tobacco is by far the most important cash crop in the area accounting for a large proportion of the farm incomes for the smallholder farmers. According to Tobacco Industry Marketing Board (TIMB, 2015), 30,644 farmers from the district were registered tobacco growers accounting for 70,595,404kg of national output which stood at 216,196,683kg in the 2014 season. Compared to other tobacco producing districts Hurungwe is ranked number one in terms of contribution to national tobacco output. Given the importance of tobacco in the livelihoods of Hurungwe, the crop was purposefully chosen for this study. In addition, the researcher once worked in the province making it easy to exploit the existing contacts to successfully execute the survey.

4.3 Study design

The study was implemented through a cross sectional survey of tobacco farmers in Hurungwe district. The rationale behind using the cross-sectional approach is that most smallholder farmers rarely keep their records hence the study only collected data from the most recent agricultural season which farmers could fairly remember with some degree of accuracy. In the presence of proper farm record keeping, time-series or panel data analysis would have been ideal designs. Split sampling was employed to ensure both contract and non-contract farmers were proportionally represented in the sample. Since this is an efficiency study the research design was mostly quantitative in nature focussing mainly on input-output data. Data was collected by trained enumerators under the supervision of the researcher. Before the actual survey, the questionnaire was pretested and necessary adjustments made to improve the data collection exercise.

4.4 Sampling procedure and data sources

A census of all smallholder tobacco farmers to estimate and compare efficiency scores of the all contract and noncontract farmers is the ideal way of obtaining accurate results. However, due to time and financial limitations, this approach was not feasible. The second-best approach that was used in similar studies is the survey approach which uses the laws of probability to select a sample that best represents the population to enable inferences to be made. The choice of the sampling method used depends to a large extent on how it meets the study objective. For this study, a combination of purposive, stratified and random sampling was used to ensure that only farmers in the resettlement areas were included in the survey.

The target population in this study are all smallholder tobacco farmers in Hurungwe district. Smallholder farmers constitutes three groups of farmers namely communal, old resettlement and A1 farmers as explained earlier.

To isolate the impact of CF on technical efficiency, the sample was split into contract farmers and non-contract farmers. Those not participating are the control group. However, both groups were drawn from a fairly homogeneous group of farmers in terms of the agro-ecological environment in which they are operating from, type of land tenure structure, socio-economic setting and climate among other factors so that the main notable difference was contract participation.

Due to the various factors that influence sample determination in surveys, coming up with an appropriate sample size was a hard task. In theory, the sample size used in this study was based on a statistical formula but due to resource limitation a sample of 240 smallholder farmers was used in this study. This number is fairly large enough to estimate the models, give statistical power to the models as well as allow inferences to be made about the population of tobacco farmers in the area. To enable comparison of the two groups of farmers by Propensity Score Matching technique, a fairly large number of non-contract (165 farmers) were interviewed against 75 contract farmers. This was done to increase the probability of finding a non-contract match for every contract farmer in the sample.

In the first stage of the sampling procedure, the smallholder farmers were identified using data from the Ministry of Lands and Rural Resettlement provincial offices in Chinhoyi. Using this resettlement database, purposive sampling was used to identify registered tobacco farmers in Hurungwe district. This was done through consultation with the local Agricultural Extension Department and the local Tobacco Industry and Marketing Board (mandated with registration of all tobacco farmers). The list of registered tobacco farmers was used as the sampling frame from which the study sample was drawn. At this stage stratified sampling was used to split the sampling frame into contract and non-contract farmers. To identify the contract farmers' sub-strata, the researcher liaised with the local TIMB officials and the contracting firms to assist with the list of contract farmers. Contract farmers were selected from the 6 contracting firms (see table 3.1) operating in the area to cater for different services offered by different firms. It was understood that different contractors offer different contracts and conditions to their farmers resulting in different impacts. From the two strata (that is contract farmers and non-contract farmers, random sampling was then used to select the 240 farmers for the survey.

Table 3.1: Contract farmers subsample by contractor

Contractor Name	Frequency	Percentage
Premium Tobacco	27	36
Ethical Leaf Tobacco	17	23
Agritrade	5	7
Shasha Tobacco	10	13
MTC	11	14
Boast Africa	5	7
Total	75	100

Source: Survey data, 2017

4.5 Survey instrument design, data collection and analysis

The study used both primary and secondary data. Primary data was collected through a field survey using the farmer as the unit of analysis. The main survey instrument for data collection was a structured questionnaire which was administered per farm either to the farm household/decision maker or their proxy. The questionnaire was designed in such a way that it contained questions that solicited information about the farm household's socio-economic characteristics, asset endowment, production inputs 2016/2017 farming season, and information on the production output for 2016/2017 season. Specifically, information on household demographics and economic characteristics, land area, seeds planted, fertilizer use, chemicals, fuel, irrigation, labour, capital, credit and support services was collected as they form to core of efficiency studies. The input and output parameters are important in addressing the first two objectives of the study while the socio-economic variables addressed the last two objectives of the study.

Enumerators who helped with data collection were sourced from the TIMB Karoi offices. They were chosen because they were familiar with the study area and were used to working with the tobacco farmers. The enumerators were trained on how to administer the questionnaire and all the variables in the questionnaire were explained to them. The questionnaire was pretested and a feedback session was held before the actual data collection commenced.

In addition to the primary data, secondary information was solicited from the key informants in the area like the extension officers, TIMB, tobacco contracting firms, Ministry of Agriculture and Rural Development. Such information was used for sampling purposes as well as verifying the accuracy of information collected through the questionnaire from the farmers.

Data, collected through the structured household questionnaires, was transcribed into a Microsoft Excel spreadsheet. The second step in preparing the data for analysis was data coding after which the data was exported to STATA version 14. Variable definition and labelling were done using STATA. Measures of central tendency and dispersion such as mean, median, mode, maximum and minimum were used to identify the outliers that might affect accuracy of the results. Data entry errors were identified and corrected while some unrealistic observations were replaced by the averages. Kernel density graphs and box plots were used to determine the extent of normality in the data and further identify outliers.

In the preliminary analysis, the basic description of demographic, socio-economic characteristics of the sample was done using cross-tabulations and simple statistics like frequencies, percentages and means. An attempt was made to compare the socio-economics characteristics of the two groups of farmers, which are contract and non-contract farmers. An appropriate production function was estimated in STATA to describe the production technology. Using a two-stage model a stochastic frontier production function was estimated to obtain the efficiency scores which were then regressed on the determinants of technical efficiency in an inefficiency model.

4.6 Production system variable description

Central to a productivity and efficiency studies is the availability of input and output data. This section gives a brief description and a priori expectations of the main variables used in this study. Land, seed, fertiliser, labour were identified as the main inputs used by smallholder farmers in tobacco production in the study area.

3.6.1 Yield

Tobacco yield (Y_i) is the output variable being measured in this study and refers to the quantity of leaf tobacco produced by each farmer during the 2016/17 agriculture season. While some studies have used bales and tonnes as the units of measurement, kilogrammes were used in this study because they are the units used on the tobacco market hence farmers can easily recall such information. The level of yield is determined, among other things by the variables described below. Before being used in the model, yield was transformed from its level to logarithmic form represented by lnYIELD. A positive relationship is expected between tobacco yield and the input variables described below.

3.6.2 Land

The variable land (X_1) measures the amount of land allocated for tobacco production by each smallholder farmer in the 2016/17 season. The units of measurement are hectares (ha). Although some farmers gave their answers in acres, this was converted to hectares using the conversion rate 1ha=2.49acres. This variable was included in the models as natural logarithm land (lnAREA). Its inclusion is justified because it is impossible to produce tobacco without a piece of land. It is therefore expected that there will be a positive relationship between land and tobacco yield.

3.6.3 Seed

Seed (X_2) is an important input in tobacco production and it was included to examine the how responsive tobacco yield was to an increase in the quantity of seed used. The seed variable refers to the quantity of seed used by each farmer in the 2016/17 agriculture season and was measured in grams (g). However, when used in the Cobb-Douglas models (production function and SF model), the natural logarithm of the seed quantity (lnSEED) was used. Tobacco yield is expected to be positively related to the quantity of seed used.

3.6.4 Fertilizer (NPK)

This variable NPK (X_3) refers to the total quantity of fertilizer (both basal and top-dressing) used by each farmer in producing tobacco in the 2016/17 season and was measured in kilograms (kg). In the models, fertilizer was represented by the variable lnNPK, the natural logarithm of the quantity of fertilizer used by the farmer. Fertilizer is also an important input in tobacco production as it replenishes soil nutrients and plays an important role in determining the quality of tobacco leaves produced hence so it also affects farmer productivity. Its inclusion in the model was determine how tobacco yields respond to variations in the quantity of fertilizer used. It is expected that tobacco yield will be positively related to the quantity of fertilizer applied.

3.6.5 Labour

Tobacco is a very labour-intensive operation. The labour variable (X_4), was estimated by summing up both family and hired labour. It was collected and recorded as labour days used by each farmer for tobacco production during the 2016/17 season. It is assumed that households with access to more labour are better placed to produce more tobacco than those with less access hence a positive relationship between labour and tobacco yield is expected.

3.7 Study models

Basically, two models namely the production function and the stochastic frontier were chosen for analysis in this study. The production system was analysed using the production function and the efficiency analysed using the stochastic frontier production model in a two-step procedure. The Cobb-Douglas was adopted as the functional form for this study.

3.7.1 Production functions

Production functions are very powerful tools used by economists to analyze production systems in different sectors of the economy both at micro and macro levels (Senouci & Moysan, 2013) Likewise, agricultural economists use production functions when analyzing and characterizing agricultural production systems. A production function is function that specifies the maximum possible output of a production unit (farm, firm, industry or whole economy) for all possible input combinations (Losonczi, 2010). Debertin (2002), described it as a technical relationship that transforms inputs into outputs. According to Chambers (1988), the objective of a production function is to give a mathematical representation of the relationship between inputs and outputs. Coelli et al. (2005), further asserts that an ideal production function has to conform to the law of diminishing marginal productivity as well as be non-decreasing in inputs. It can be represented in general form as;

$y = f(x_1, x_2, x_3, \ldots, x_n)$ where y is the quantity of output and $x_1, x_2, x_3, \ldots, x_n$ are factors inputs like land, seed, fertilizer and labour in this case.

This general form can be represented by more specific production functions that can be categorized as either exact or flexible functional forms. Exact functional forms (which includes the linear and Cobb-Douglas) imposes a priori structure to the production technology whereas flexible functional forms (which includes the translog, quadratic, Leontief and CES) do not impose a priori structure to the production technology. Given the multiplicity of functional forms, determination of the true functional form that capture the relation between inputs and outputs for a given data set is impossible hence the need to choose the best form for a given task (Griffin et al., 1987). However, from the different production functions mentioned above, two are widely used in studying agricultural production processes (Alyami, 2015). The first one is the Cobb-Douglas, developed by Cobb and Douglas (1928). The second one is the

Translog, developed by Christensen et al. (1973). In addition to addressing some of the limitations of the Cobb-Douglas such as imposing global returns to scale, the Translog also provide more flexibility by introducing the squared and interactive term in the model (Alyami, 2015).

In estimating the production technology for this study, a more flexible Translog was first estimated to see if it suits the production data for the smallholder tobacco farmers. All the covariates (land, seed, agrochemicals, fertilizer and labour) as well as the square and cross terms were found to be insignificant. The CES was also tried but was also found not to be a true representation of the production technology prompting this researcher to try the Cobb Douglas functional form. The generalized form of the Cobb-Douglas is given by the expression;

$$Y = \beta_0 X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} e \ldots\ldots\ldots\ldots (1)$$

Where

$\beta_0, \beta_1 \ldots\ldots\ldots, \beta_4$ are vectors of unknown parameters to be estimated

Y is the tobacco yield in kilograms

X_1 is the area allocated to tobacco in hectares

X_2 is the quantity of seed in kilograms

X_3 is the total fertilizer used in kilograms

X_4 is the total labour used in production tobacco in labour-days

e represents the error term

Before being logged, the variables violated the normality assumption and the production function was not linear in parameters hence ordinary least squares could not be used to estimate the parameters of the production technology. To address this, the generalized Cobb-Douglas was then transformed to logs and linearized as follows;

$$\ln(Y) = \ln(\beta_0) + \beta_1\ln(X_1) + \beta_2\ln(X_2) + \beta_3\ln(X_3) + \beta_4\ln(X_4) + e \ldots\ldots\ldots (2)$$

The coefficients ($\beta_0, \beta_1 \ldots\ldots \beta_4$) represents parameters to be estimated and are interpreted as elasticities of production. $\ln(X_1)$, $\ln(X_2)$, $\ln(X_3)$ and $\ln(X_4)$ are the natural logarithms of tobacco yield, land, seed, fertiliser and labour respectively. After taking logs the variables approached normality and OLS was used to estimate model.

As already mentioned in this chapter, the Cobb-Douglas was chosen as the functional form for this study. This was partly informed by past studies that found that the Cobb-Douglas type production functions are suitable for analyzing agricultural production more so when dealing with small data sets as is the case in this study (Battese, 1992; Bravo-Ureta and Pinheiro, 1993). This was also supported by Armagan & Odzen (2007), who argued that many researchers found the Cobb-Douglas production function to be a suitable functional form for analysis when conducting production-related agricultural studies. In addition to the above justification, the Cobb-Douglas was the selected because it is easy to work with algebraically and it satisfies most of the regularity conditions of the production functions such as essentiality of inputs, positive marginal product, decreasing marginal productivity (Husain & Islam, 2016).

3.7.2 Stochastic Production Frontier Model

The stochastic frontier models have been widely used in estimating technical efficiency in developing countries (Mango *et al*., 2015) for two main reasons. Firstly, the assumption from Data Envelopment Analysis (DEA) and Corrected Ordinary Least Squares (COLS) that all deviations from the frontier are due to inefficiency is not realistic given the observed variability in agriculture output due to factors beyond the farmers' control like weather, pests and diseases. The second reason is that most smallholder farmers in developing countries have poor record keeping thereby introducing measurement errors in the technical efficiency model. For instance, in this study, the researcher solicited for production information for the 2016/17 farming season of after harvesting is completed hence most farmers might not accurately recall the input variables.

Following the argument above, this study adopted the stochastic frontier production function (SFPF) as developed by Aigner et al. (1977), and Meeusen and Van de Broeck (1977) in estimating the technical efficiency for tobacco farmers. As argued by Battese and Coelli (1995), the SFPF model has the advantage of simultaneously estimating individual technical efficiencies of farmers as well as the determinants of technical efficiency if the one step procedure is used. This study adopted the two-step procedure despite the criticism that the results could be biased because of the misspecification in the first stage. The choice of the two-step is justifiable since it was also used by other scholars such as Pindiriri et al., (2016) and Naftali et al. (2014), because of its simplicity and ease in presenting results.

Step one involves estimating the stochastic frontier production function and calculation of the technical efficiency scores for individual farmers. The general stochastic frontier production function was specified as:

$$Y_i = f\ (X_i, \beta) + e_i \quad \text{..... (3)}$$

The model assumes that the error term e has two components such that $e_i = v_i - \mu_i$. Thus equation (3) can be rewritten as;

$$Y = f\ (X_i, \beta) + v_i - u_i \quad \text{.... (4)}$$

Using the production variables used in this sample a more specified model can be written as;

$$\ln(Y) = \ln(\beta_0) + \beta_1\ln(X_1) + \beta_2\ln(X_2) + \beta_3\ln(X_3) + \beta_4\ln(X_4) + v_i - \mu_i \qquad \text{...... (5)}$$

Where $\ln(X_1)$, $\ln(X_2)$, $\ln(X_3)$ and $\ln(X_4)$ are the natural logarithms of tobacco yield, land, seed, fertiliser and labour respectively while $\beta_0, \beta_1, \beta_2, \beta_3, \beta_4$, v_i and μ_i represents vectors of unknown parameters to be estimated. The v_i and μ_i are derived from the composite error term (e_i) in the production function. It is assumed that the two error terms v_i and μ_i are independent of each other as well as independent from the explanatory variables. This assumption is important because it removes endogeneity problem. The v_i represents the symmetric error term associated with factors beyond the farmer's, that is assumed to be identically independently distributed and following a normal distribution with zero mean and δ^2_v variance [$v_i \sim i.i.d.N(0, \delta^2_v)$]. This error term is assumed to be a result of favourable/unfavourable external shocks beyond the control of the farmer like weather conditions, natural disasters, and measurement error.

The μ_i component represents inefficiency and is determined by farm specific factors. μ_i is assumed to be non-negative, which is $u_i \geq 0$ or is truncated above zero. This error term which is also identically independently distributed follows a Normal distribution with zero mean and δ^2_u variance [$u_i \sim i.i.d.N^+(0, \delta^2_u)$], measures the deviation from the frontier. The negative sign in equation (2) combine with the non-negative values of u_i to give negative deviations from the frontier for each farm observed. This error term, called the half normal distribution (Aigner *et al*., 1977), captures technical inefficiency of the farmer and its magnitude measures the shortfall in observed output (Y_{actual}) from its maximum possible value for the given technology which is represented by the frontier output ($Y_{potential}$). Maximum likelihood method was used to estimate parameters β_i following Bravo-Ureta (1993) and Pinheiro and Bi (2004). The ratio of the observed output of the ith farmer relative to the frontier output estimated by equation (3) gives the estimate of the technical efficiency of the ith farmer. Using this argument and the general stochastic production frontier; $Y = f(X_i, \beta) + v_i - u_i$, the technical efficiency denoted by TE in this sample is calculated as follows:

$$TE_i = \frac{\text{Observed output } (Y_{actual})}{\text{Max possible output } (Y_{potential})}$$

$$= \frac{f(X_i, \beta) + v_i - u_i}{f(X_i, \beta) + v_i}$$

Given that the stochastic frontier production function is in logarithm form, we take the exponents and this reduces to;

$$= \frac{exp\,(X_i, \beta) + v_i - u_i}{exp\,(X_i, \beta) + v_i}$$

$$= \frac{exp(\ln(\beta_0) + \beta_1\ln(X_1) + \beta_2\ln(X_2) + \beta_3\ln(X_3) + \beta_4\ln(X_4) + v_i - \mu_i)}{exp(\ln(\beta_0) + \beta_1\ln(X_1) + \beta_2\ln(X_2) + \beta_3\ln(X_3) + \beta_4\ln(X_4) + v_i}$$

$$= exp(-u_i)$$

$$= e^{-u_i} \quad \ldots. (6)$$

For this study we assumed a half-normal distribution [$u_i \sim i.i.d.N^+(0, \delta^2_u)$] for u_i. TE_i takes the values ranging from 0 to 1. If a farmer is 100% technically efficient then he/she will be producing along the production possibility frontier where $Y_{potential}$ will be equal to Y_{actual} and the value of u will be zero hence exp (0) will equal 1. The formula above works well if one is interested in estimating the average technical efficiency of a sample. And is called the unconditional mean of μ_i. However, when one is interested in individual specific technical efficiency, Jondrow et al. 1982 proposed using the formula that estimated conditional mean of μ_i given the composite error e_i to estimate the point estimate of μ_i.

Step two is an examination of how household demographic and socio-economic impact on the technical efficiency of contract and non-contract smallholder tobacco farmers in the sample. Thus, two inefficiency models were estimated. This involved regressing the individual efficiency scores (μ_i) on exogenous variables such as farmer socio-economic and farm specific characteristics. In this study the variables included were age, off-farm income, primary occupation, household size, education level, tobacco farming experience, membership to farmer organisation, number of draft animals, size of tobacco field, size of maize field, total farm size and access to extension services. These were included as z_1, z_2, z_3, z_4 +…, z_{12} respectively in the following efficiency model:

$$\mu_i = \alpha_0 + \alpha_1 z_1 + \alpha_2 z_2 + \alpha_3 z_3 + \alpha_4 z_4 + \ldots, \alpha_{12} z_{12} + \varepsilon_i \quad \ldots..(7)$$

Where,

α_i are vectors of unknown parameters to be estimated,

εi are the unobserved factors influencing technical efficiency,

The variables access to extension services, membership to farming organisation and primary occupation were included as dummy variables in the model. Extension access was defined as 1 if farmer had access to extension and 0 otherwise, membership to farming organisation was recorded as 1 if a farmer belonged to a farmers' organisation and 0 if not. Lastly primary occupation was recorded as 1 if one farmer was a full-time farmer and 0 if otherwise. The other variables were recorded as continuous variables. Together, these variables are referred to as determinants of technical efficiency. They indicate farmer specific characteristics and policy variables influencing technical efficiency that can be targeted by government policy with the objective of improving farmer efficiency.

3.8 Accounting for self-selection bias

Literature has found that contractors do not randomly sign CF arrangement with farmers. As a result, contracts are not randomly distributed to farmers in a given farming community hence contracted farmers tend to have certain attributes resulting in firm-selection and self-selection biases (Minot & Ronchi, 2015; Barrett et al., 2012). Contracting firms look at certain background farmer characteristics before they decide to engage the farmer in CF. The selection criteria that tobacco contracting firm used included the following; access to land, farm size, possession of farming implements, membership to a farmer club, literacy level, experience in tobacco farming and access to tobacco curing facilities.

Given this selection criteria, it therefore means that farmers do not randomly participate in contract farming. Most of these attributes that the contracting firms look for in a farmer are also determinants of technical efficiency so simply comparing the average technical efficiency scores for contract and non-contract farmers will yield a biased impact of contract farming on technical efficiency. More so, the socio-economics characteristics of the farmers determine whether or not a farmer self-select into CF. To minimize this self-selection bias the study had to incorporate a technique that address selection bias into the research design.

There are a number of ways researchers use to address the self-selection bias in evaluation studies of which instrumental variables method (IV), difference-in-difference (DID) and propensity score matching (PSM) are common (Mulatu et al., 2017). In this study, the IV method was not used because it was difficult to identify instrumental variables that were not determinants of both contract participation and technical efficiency. After failing to find suitable IVs, DID could have been the ideal method of analysis but due to absence of a baseline survey another approach had to be found. After discarding IV and DID approaches, the study opted for the PSM method to address selection bias in assessing the impact of contract farming on technical efficiency.

First proposed by Rosenbaum and Rubin (1983), PSM is a technique used to reduce bias when assessing the impact of an intervention, program or policy. Unlike earlier evaluation methods, PSM produces better treatment effects by trying to match the observable characters between the treated and the control. In this study smallholder farmers participating in contract farming (treated group) were matched with non-participants (control group) with more or less identical observable attributes like gender and age of household head, size of farm, literacy level, membership to farmer organization, field day participation and off-farm income provided these are the observable variables explaining participation in contract farming.

By definition, propensity score matching is a non-experimental method for estimating average impact of an intervention Heckman *et al*., 1998. A propensity score is the predicted probability of participating in a program given observable characteristics (Wainana et al., 2012). Propensity score matching has been used in program or policy evaluation studies because it gives fairly unbiased comparisons between treated and non-treated groups than other models (Saijenji, 2010). PSM helps in identifying a group of non-contract farmers (control) similar to the contract farmers (participants) in relevant pre-treatment attributes with the only difference being that one group participated in contract farming while the other did not.

Mulatu *et al*. (2017), outlines steps to be followed in estimating the PSM model. First was the estimation of a probability (propensity score) of participation in contract farming for each individual farmer using a discrete choice model. In this case the probit model with maximum likelihood method was chosen.

Next was the selection of the best matching logarithm based on the data and after testing for matching quality. Matching was done to select a group of non-contract farmers who were matched with the contract farmers using pre-treatment covariates. Using past studies, (Mulatu *et al.*, 2017; Jony, 2011; Miyata et al., 2009; Cai et al., 2008), matching covariates selected for this study are farm size, age of household head, education, membership to farmer's club, field day attendance, family size and off-farm income.

To check for robustness of the conclusion after correcting for selection bias all the matching algorithms were used to see if there was consistency in the results. With these matching methods. After checking for overlaps and identifying the region of common support, non-contract farmers (neighbours) and contract farmers with propensity score very close to the were identified for comparison. Lastly matching algorithm with the largest number of observations and the most significant treatment effect was chosen to evaluate the impact of contract farming on technical efficiency.

Theoretically, program impact evaluation can be done by estimating the average treatment effect on the treated (ATT). The objective of this study is to measure the average impact of the participating in CF on farm level technical efficiency where participation in contract farming is the treatment and the contract farmers are the treated group. ATT can be estimated using the following model;

$$E(TE_i \mid \mathrm{I} = 1) = E(TE_{i1}|\mathrm{I} = 1) - E(TE_{i0} \mid \mathrm{I} = 1) \text{ ………………(8)},$$

Where TE_i denotes the unbiased estimate of the technical efficiency effect for contract farmers, TE_{i1} is the technical efficiency of contract farmers and TE_1 is the technical efficiency of the contract farmer if they had not participated in the program. Since it is not possible to simultaneously observe the "with and without contract" TE scores for each household at once using cross-sectional data, this study compared the TE scores for contract and non-contract farmers in the same geographic location. We use the following model to estimate the effect of contract farming on TE;

$$E(TE_i \mid \mathrm{I} = 1) = E(TE_{i1}|\mathrm{I} = 1) - E(TE_{i0} \mid \mathrm{I} = 0) \text{ ………………(9)},$$

But now; $(TE_{i0} \mid \mathrm{I} = 0)$ denotes the estimate of the technical efficiency of non-contract farmers,

3.9 Conclusion

This chapter gave a description of the research area together with the methods used in conducting the field research. The study area was purposefully selected because it is the leading tobacco producing district in Zimbabwe. The decision to focus on smallholder farmers was motivated by the fact that following the Fast Track Land Reform program, tobacco farming has been dominated by smallholder farmers, therefore accessing their productivity is important to understand the future of tobacco production in Zimbabwe. To assess the impact of contract farming of technical efficiency, a split sample of 75 contract and 165 non-contract farmers was used. The Cobb-Douglas functional form was adopted in the two analytical models. First, the production function was used model the production technology and then the Stochastic Production Frontier model was used in the efficiency analysis. Propensity score matching was incorporated into the efficiency analysis to address self-selection bias.

Chapter 4 : RESULTS AND DISCUSSIONS

4.1 Introduction

The aim of this chapter is to summarise and present the study results as they address the study objectives outlined in chapter one. The chapter starts by presenting descriptive statistics of the socio-economics characteristics of the sample in section 4.2 followed by the summary statistics of the production variables used in the study in section 4.3. The socio-economics characteristics and summary statistics of the production variables are discussed to give a contextual background to the study. The production technology is described in Section 4.4 to give context to the efficiency analysis. Section 4.5 outlines the technical efficiency estimation approach followed in this study. Section 4.5.1 presents the results of the distribution-free approaches. Tests for the relevancy of the inefficiency model are presented in Section 4.5.2 followed by a presentation of the results from the maximum likelihood estimations of the Cobb-Douglas stochastic production frontier for the sample using different distribution assumptions. Technical efficiency estimations for this sample of farmers are presented in Section 4.6. A comparison of mean technical efficiency scores between the contract farmers and non-contract farmers using a t-test of mean equality showed no significant differences between the two groups of farmers. Surprisingly these results were not in line with theory and *a priori* expectations. To check for robustness of these results, a further comparison of technical efficiency between the two groups of farmers was done after accounting for self-selection bias. To capture the impact of accounting for self-selection bias, the results the two results (before and after accounting for self-selection bias were compared. Determinants of technical efficiency amongst the sample are discussed in Section 4.6.5 followed by determinants of contract participation in Section 4.6.6. The last Section of the chapter presents the chapter conclusion.

4.2 Demographic and socio-economic characteristics of the sample

Literature has shown that a number of farm specific and household characteristics have an influence on farm level productivity and efficiency. In this study a number of characteristics that influence farm level technical efficiency are discussed together with other demographic and socio-economic characteristics of the sample. Table 4.1 presents a summary of the socio-demographic and socio-economic characteristics of the sample of farmers. An attempt is made to distinguish between the characteristics of contract and non-contract farmers.

Table 4.1: Demographic and socio-economic characteristics of sample

Characteristic/Variable	Non-contract farmers	Contract farmers	Chi ^{2}/ t-value	Pooled Sample
Respondent relation to household head				
Self	130 (78.79%)	62 (82.67%)	$Chi^2=0.831^{NS}$	192 (80%)
Wife	30 (18.18%)	12 (16%)		42 (17.50%)
Child	5 (3.03%)	1 (1.33%)		6 (2.50%)
Age of household head				
Min	20	29		20
Mean	39	46	t=-4.278***	41
Max	70	73		73
Standard Deviation	12.48	10.41		12.30
Gender				
Male	152 (92.12%)	70 (93.33%)	$Chi^2=0.109^{NS}$	222 (92.50%)
Female	13 (7.88%)	5 (6.67%)		18 (7.80%)
Marital status of household head				
Married	147 (89.09%)	70 (93.33%)		217 (90.42%)
Single	4 (2.42%)	-	$Chi^2=2.218^{NS}$	4 (1.67%)
Divorced	2 (1.21%)	1 (1.33%)		3 (1.25%)
Widowed	12 (7.27%)	4 (5.33%)		16 (6.67%)
Household size				
Min	3	3		3
Mean	6	7	t=-3.018***	6
Max	11	14		14
Standard Deviation	1.85	2.06		1.95
Sample gender composition				
Female	545 (52.15%)	274 (50.64%)	t=-2.676***	819 (51.63%)
Male	500 (47.85%)	267 (49.36%)	t=-2.319**	767 (48.36%)
Total	1045 (100%)	541 (100%)		1586 (100%)
Education level				
No Formal Education	6 (3.64%)	1 (1.33%)		7 (2.92%)
Primary	10 (6.06%)	6 (8%)	$Chi^2=4.865^{NS}$	16 (6.67%)
Secondary	102 (61.82%	53 (70.67%)		155 (64.58%)
Tertiary	47 (28.48%)	15 (20%)		62 (25.83%)
Main occupation				
Farmer	114 (69.09%)	51 (68%)		165 (68.75%)
Employed in Private Sector	12 (7.27%)	4 (5.33%)	$Chi^2=3.498$*	16 (6.67%)
Civil Servant	26 (15.76%)	10 (13.33%)		36 (15%)
Trader	13 (7.88%)	10 (13.33%)		23 (9.58%)
Off-farm income				
No	13 (7.88%)	20 (26.67%)	$Chi^2=15.347$***	33 (13.75%)
Yes	152 (92.12%)	55 (73.33%)		207 (86.25%)
Tobacco farming experience				
Min	1	2		0
Mean	8	10	t =-2.572**	9
Max	27	22		27
Standard Deviation	5.424	4.944		5.341
Membership to farmers' club				
No	152 (92.12%)	55 (73.33%)	$Chi^2=15.347$***	207 (86.25%)
Yes	13 (7.88%)	20 (26.67%)		33 (13.75%)
Draft power				
Min	0	0		0
Mean	3	4	t=-2.261**	3
Max	12	7		12
Standard Deviation	1.839	1.663		1.801

Access to extension services				
Min	0	3		0
Mean	3	9	t=-20.011***	5
Max	10	10		10
Standard Deviation	1.990	2.101		3.311

Notes: *The frequencies are shown outside the parenthesis while the percentages are inside the parenthesis*
****Significance at 1%; **Significance at 5%; *Significance at 10%;* ^{NS} *not significant*

The results in Table 4.1 shows that most households (80% of the sample) were represented by the household heads during the interviews. This gives some credibility to the responses since the household head is in most cases the household's decision maker hence is most likely to be knowledgeable of the household farming operations. The wives and children were respondents in about 17.5% and 2.5% of the households interviewed respectively. Moreover, all of the household heads were aged between 20 and 73 years with the average age being 41 years indicting a fairly middle-aged generation of tobacco farmers. However, on average contract farmers were older than non-contract farmers.

Out of the 240 sampled households, males constituted the majority of household heads (92.5%) with females only constituting the remaining 7.5% of the sample. These statistics indicate that tobacco farming is male dominated business. This could be a manifestation of patriarchal society in most African cultures where resource access, including land, is biased towards men. Moreover, following the death of household head, land inheritance is also biased towards sons at the expense of daughters. This is true in most African cultures despite females constituting the majority in terms of household composition. For instance, in this study females constituted the majority at 51.63%. These results are in agreement with the 2012 National census statistics which found that the population in Mashonaland West, where Hurungwe is located, was dominated by females at 51.2% to 49.8% males (ZIMSTATS, 2012).

The majority (90.42%) of the household heads were married and the remaining 8.58% were either widowed (6.67%), divorced (1.25%) or single (1.67%). While the average household size in the study area was 6, contract farmers had slightly bigger households averaging 7 members. Household size is a very important variable in smallholder agriculture studies because it determines the availability of labour for farming operations. Given that tobacco farming is a labour-intensive enterprise, it is understandable why the average household size was notably greater than the provincial average of 4.3 members (Zimstats, 2012).

A large proportion of the households (68.75% of the sample) relied largely on agriculture as a source of livelihood with the remaining 31.25% engaged in additional off-farm activities. For example, civil servants (15%) constituted the second largest group of tobacco farmers in the area followed by traders (9.58%) with the remainder (6.67%) being those employed in the private sector. Although these results points to a growing role of farming in complimenting other professions in Zimbabwe, there are two more possible explanations for this observation given the average age of the farmers; (1) young people are beginning to take farming as a profession; (2) the decline in formal employment opportunities in Zimbabwe as a result of the economic crisis.

Off-farm income is also another important variable in smallholder agriculture. It indicates whether a farmer is fully dependent on farming or has other means of livelihoods. While off-farm income can play an important part in funding farming operations and improving efficiency, it can also have the opposite effect if the farmer gives more attention to the off-farm activities thereby neglecting farm activities. The net effect on efficiency therefore depends on the level of off-farm income generated and how the farmer balances the attention between farm and non-farm activities. About 13% of the farmers did not have any source of off-farm income while about 87% reported having some form of off-farm income. However, the proportion of non-farm income was very small compared to what they earned in agriculture.

Off-farm activities and incomes have implications for smallholder resilience, incomes, food security and rural poverty. As argued by Tittonell (2014), off-farm income can be reinvested in agricultural assets like irrigation equipment and livestock thereby building resilience to whether related shocks. It can therefore be argued that off-farm activities and incomes contribute to household food security especially when one looks at the economic access and stability components of food security. By strengthening resilience and improving food security, off-farm income plays an important role in addressing rural poverty.

Literacy levels in the study sample were fairly high. More than 97% of the farmers in the area had at least attained some level of primary formal education and was in line with the 2012 National census findings which put the literacy level for those above 15 years at 96% (Zimstats, 2012). Although education level cannot be used as a yardstick for farming competence, it can be argued that it (education) equips the farmers with the basic reading and writing skills necessary to understand as well as carry out basic agriculture operations.

Years of experience in tobacco farming was also included in the farmer characteristics as it is an important variable in determining a farmer's level of productivity and efficiency. In theory the expectation is that the more the number of years in tobacco farming the more productive and efficient the farmer. This study revealed that on average the smallholders in the area under study had about 9 years of tobacco farming experience. Contract farmers were more experienced at 10 years than non-contract farmers who averaged 8 years. These results show that the majority of smallholders in the area started farming tobacco after they received land through the Fast Track Land Reform program. Although it is advisable that farmers join farmers' groups so that they can share experiences, pool resources together and collectively bargain for better terms of trade, it was observed that the majority of smallholders in the study area (86%) did not belong to any farmers' groups. However, in comparison a larger proportion of more contract farmers (27%) were members of the farmers' groups compared to 9% for non-contract farmers. Access to extension services was also analysed as an important variable because of its bearing on farmer productivity and efficiency. Given that tobacco requires some level of technical guidance, it was interesting to investigate how technical advice as measured by the number of extension visit would affect efficiency. On average the farmers received 5 extension visits during the 2016/17 tobacco season. This is a fairly high number of visits since the visits could cover all the critical stages in tobacco production if well spread over the season.

Most smallholder farmers in Zimbabwe depends to a large extent on draft power for land preparation due to low levels of farm mechanization. In this study the number of draft animals was considered in the efficiency model as a determinant of efficiency as they have a bearing on the timeliness with which land preparations are completed. It is therefore expected that those farmers with more draft animals will be more efficient than those without draft animals. From the sample it was found that on average contract farmers had 4 draft animals whereas non-contract farmers had 3. This means contract farmers could afford to have two pairs of draft animals at any given point compared to one pair for the non-contract.

4.3 Variable summary statistics

Summary statistics of production variables that were used to model the production system as well as the efficiency models for this study are presented in table 4.2. A comparison is made between the contract and non-contract farmers to see if there were any differences in the quantities used between the two sub-groups.

Table 4.2: Summary statistics for the output and input variables

	Non-Contract			Contract			Pooled Sample		
Variables	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**	**Min**	**Mean**	**Max**
Tobacco yield/Ha (kg)	450	1125	2050	500	1285	2800	450	1344	2800
Area (Ha)	0.25	1.119	3	0.5	1.386	3	0.5	1.2	3
Seed (Grams)	2.5	6.394	15	2.952	6.933	15	2.952	6.6	15
Fertilizer (kg)	200	681	1650	350	747	2250	350	747	2250
Labour (man-days)	215	472	1030	155	424	1023	155	424.32	1023
Observations		**165**			**75**			**240**	

Tobacco yield data was recorded in kilograms (kgs). Since tobacco is produced specifically as a cash crop, it was easy to accurately capture the output as the farmers remembered well how much tobacco they sold in the 2016/17 tobacco season. Tobacco yields of 450kg to 2800 per hectare were observed in the sample. In terms of total yield, the farmer with the least yield sold 250kg and the highest sold 5100kg with the average being 1550kg per farmer. Contract farmers managed to produce an average of 1285kg/ha while non-contract managed 1125kg/ha. Compared to 1750kg per farmer produced by smallholder farmers in 2014, this sample of farmers were less productive than an average Zimbabwean smallholder tobacco farmer (Scoones *et al.*, 2017).

The area allocated to tobacco production which averaged 1.20 hectares was far less than the 4 hectares that was reported for smallholder farmer in Makoni district (Dube & Mugwagwa, 2017). As expected, contract farmers on average had bigger pieces of land allocated to tobacco production than their non-contract counterparts. The minimum and maximum quantity of tobacco seeds planted per farmer was 2.5grams and 15grams respectively with an average farmer using 6.6 grams. On average, contract farmers also used more seed than non-contract farmers. All the fertilisers (basal and top dressing) used in tobacco production were combined and recorded in kilograms. Total fertilizer use ranged from 200kg to 2250kgs and the average was 747kg per farmer with contract farmers also using more fertiliser than no-contract farmers on average. The average of 622kg/ha of fertiliser was within the 600-700kg/ha blanket fertiliser recommendation of tobacco compound fertiliser for Zimbabwe (Gonese, 2001).

The agrochemicals variable included all the chemical used in tobacco production process. These include the herbicides, pesticides, insecticides fungicides as well as suckercides. Since these chemicals were measured in different units like millilitres, litres, grams and kilograms, it was difficult to use a common unit of measure to capture the quantities used. The farmers were asked to approximate the total amount of money spent on agrochemicals and this cost was captured in questionnaires. On average about US$168.75 was incurred by each farmer in purchasing agrochemicals. Given that on average each farmer in the sample planted 1.2 hectares, this translate into US$140.63/Ha in agrochemical costs. Just like seed and fertilisers, contract farmers spent more money on agrochemicals than non-contract farmers. Total labour used by each farmer was captured in man-days. A minimum of 155 man-days were used in tobacco production and 1032 was the maximum. On average about 424 labour-days were used per farmer. Unlike in other variables, non-contract farmers used more labour on average than contract farmers. One possible explanation could be that due to capital constraints, non-contract farmers limited access to herbicides hence relied more on manual labour for weeding and collecting firewood for curing.

In addition to the above variables, additional variables that were used as determinants of efficiency in the two-stage regression model were also described and summarized in the following section.

4.4 Description of the production technology

Building on the production variables description and summary statistics in Sections 3.6 and 4.3, this section describes the production system for this sample of farmers. The Cobb-Douglas (CD) production function is estimated and the production system is characterised using parameters of economic interest to help understand how farmers make their choices. Although economists are only interested in those aspects of the production technology that influence economic behaviour of producers, it is important to estimate the entire production technology so that those parameters of economic importance like elasticities of production/ marginal product, returns to scale, elasticity of substitution average product, can be derived and used in understanding farmer choices.

4.4.1 Estimation of the Cobb-Douglas production function

The purpose of estimating production function was to give a background to the production technology used by these smallholder farmers. According to production economics theory a regular production function must satisfy structural properties such as essentiality of inputs, positive marginal product, decreasing marginal productivity (Husain & Islam, 2016). The results of the CD production function in Table 4.3 were used to check for these properties and it was found that the production function for this sample of farmers satisfied the conditions of regular production functions. The third and fourth columns gives the results of the C-D regression estimated separately for non-contract and contract farmers respectively. The last column presents the pooled regression results when the two groups of farmers were estimated together.

Table 4.3: Cobb-Douglas production function results

Variables	Coefficients	Model 1 (non-contract)	Model 2 (contract)	Model 3 (Pooled)
Contract	β_{dummy} (non-contract is base category)	-	-	0.096*** (0.034)
lnArea	β_1	0.146 (0.106)	0.271 (0.301)	0.081 (0.106)
lnSeed	β_2	0.242*** (0.066)	0.576*** (0.202)	0.323*** (0.069)
lnNPK	β_3	0.513*** (0.077)	-0.081 (0.308)	0.470*** (0.084)
lnLabor	β_4	0.303*** (0.092)	0.280 (0.198)	0.300*** (0.088)
Constant	β_0	1.448** (0.596)	4.979** (1.934)	1.604*** (0.619)
Observations		165	75	240
R-Squared		0.895	0.576	0.841

Notes: *Robust standard errors in parentheses*
Prob > F = 0.0000
**** Significant at 1%, ** Significant at 5%, * Significant at 10%*

The pooled model shows that all the right-hand variables except land were statistically significant at 1 %. The coefficients of all the inputs had the expected positive signs thereby satisfying the property that regular production functions are non-decreasing in inputs. They indicated a positive relationship between contract participation, land, labour, fertilizer and seed implying that tobacco yield responded positively to an increase in any of these inputs. This result is not surprising given that as rational beings, tobacco farmers would be seen operating in the region of the classical production function where marginal physical product is positive and the monotonicity assumption is respected. This also confirms that the CD used in this analysis also conforms to this monotonicity assumption and satisfy the regular conditions of being non-decreasing in inputs, and positive marginal product. The R-squared value is 0.841 implying that approximately 84% of the variation in the tobacco yield was explained by the right-hand variables included in the model. Moreover, the model is statistically significant ($p=0.000$) meaning that the regression is correctly specified. The empirical model for the pooled sample is represented by the following equation and the coefficients are explained in section 4.2.2;

$$\ln(Y) = 1.604 + 0.096C + 0.081\ln(X_1) + 0.323\ln(X_2) + 0.470\ln(X_3) + 0.300\ln(X_4)$$

4.4.2 Elasticities of Production

This section presents the interpretation of the regressors' coefficients estimated in the regression. They represent the elasticities of production and are interpreted as the percentage change in output resulting from a 1% change in each input factor holding other inputs constant. Elasticities are an indication of the magnitude of influence each input has on tobacco yield when its quantity is changed. As can be seen from the regression, all the estimated coefficients of the inputs are positive except NPK for contract farmers thereby satisfying the monotonicity condition of regular production functions.

(i) Contract

Contract is a dummy variable equal to 1 when a farmer participates in CF and 0 if the farmer does not participate. The model shows that participation in contract farming had a positive and significant impact on tobacco yields for the smallholder farmers in Hurungwe. A positive coefficient of 0.096 means that contract farmers achieved about 0.1% more yield than noncontract farmers and this was significant at 1%. This result is not surprising given that rational farmers would only participate in contract farming if they tend to benefit from the arrangement. In addition, literature provides evidence that contract farming addresses some production constraints faced by farmers and by so doing improves yields. Refer to Chapter 1 Section 1.1.

(ii) Land

Land has a positive elasticity of 0.081 for the pooled model, 0.146 (non-contract) and 0.271 (contract) but it is not statistically significant in explaining variation in tobacco yields, similar to what was found by Kidane and Ngeh (2015). This implies that land size is not a significant input in explaining yield variation among smallholder tobacco farmers in Hurungwe. This implies that although land is a very important input in tobacco production (without land no production will occur), increasing area under tobacco will not necessarily increase tobacco output. These results also imply that land is not a limiting factor in tobacco production given that smallholder farmers own an average of 6 hectares of which about 1.2 hectares were allocated to tobacco farming. Production constraints like lack of capital could be the reason why farmers are only allocating smaller portions of their farms to tobacco production and government can complement contract farming companies by crafting polies that improve access to capital for tobacco farmers. It was noted during the study that only about 7% of the farmers had access to some form of credit apart from contract farming.

(iii) Seed

The elasticity of seed was found to be 0.323 for pooled regression, 0.242 for non-contract and 0.576 for contract farmers. In all the three regressions the results were positively significant at 1% confidence level. This implies that tobacco yield was responsive to an increase in the quantity of seed used with a 1% increase in the quantity of seed used resulting in approximately 0.288% increase in tobacco yields *ceteris paribus*. This is not a surprising result; given that it is not possible to produce tobacco without any tobacco seed. Thus, making high quality seeds available to tobacco farmers is one way of ensuring that Zimbabwe remains amongst the top tobacco producing countries in the world.

(iv) Fertilizer (NPK)

With a positive elasticity of 0.513 for the non-contract farmers and 0.470 for the pooled sample, fertilizer was found to be statistically significant at 1% in explaining tobacco variation among these tobacco farmers. Holding everything constant, this means, a 1% increase in the amount of fertilizer was associated with about 0.47% increase in tobacco yield for the pooled sample and 0.513% for the non-contract farmers. Surprisingly, fertilizer showed a negative but insignificant effect on tobacco yields for contract farmers. Tobacco is highly sensitive to the quality and quantity of fertilizer used and its highest elasticity confirms that it is the most limiting factor in tobacco production in the study area. Out of all the inputs used by farmers in this sample, fertilizer was the most productive input as also reported by Dube & Mugwagwa (2017) was contrary to (Peng & Kong, 2015.), who found fertilizer to be the least important input. The result shows that using the correct type and quantity of tobacco fertiliser is one way of boosting tobacco production in the study area.

(v) Labour

One of the most important inputs in tobacco production, labour, had an elasticity of 0.3 for the pooled sample and was significant at 1%. Increasing labour by 1% results in a 0.3% increase in tobacco yield, everything else held constant. Labour also showed a positive and significant (at 1%) effect on tobacco yields for non-contract farmers. The impact of labour on tobacco yields was not significant for contract farmers maybe because contract farmers substitute some of their labour requirements like weeding by herbicides and use of labour-saving equipment. The results show that labour was the second most productive input for this sample of farmers contrary to Dube & Mugwagwa (2017)' findings who found labour to be not significant in explaining tobacco yield variations among smallholder farmers in Makoni district, Zimbabwe. These results are not surprising given that tobacco is a labour-intensive operation. The result suggests that households with access to a large labour pool are expected to be more productive than those with limited access to labour. This observation concurs with (Ören & Alemdar, 2006) who also found labour shortage to be a limiting factor in growing tobacco. Therefore, due to the fact that smallholder farmers rely mostly on family labour, households with large households are expected to be more productive.

Table 4.4: Input elasticities of production

Input	Non-contract	Contract	Pooled sample
Contract	-	-	0.096
Land	0.146	0.271	0.081
Seed	0.242	0.576	0.323
Fertiliser	0.513	-0.081	0.470
Labour	0.303	0.280	0.300
Returns to scale	**1.204**	**1.046**	**1.27**

4.4.3 Returns to scale (RTS)

Having looked at how tobacco yields respond if one input is varied with all other inputs being held constant, it is interesting to find out how yields respond to a simultaneous change in all inputs. The statistic used to measure this aspect is the returns to scale (RTS). If a proportionate increase/decrease in all inputs results in a less than proportionate increase/decrease in the output, it means the production function exhibits decreasing returns to scale (DRTS) (Coelli, 2005). Constant returns to scale (CRTS) is when a proportionate increase/decrease in all inputs results in the same proportionate increase/decrease in output (Coelli, 2005). Likewise, increasing returns to scale (IRTS) occurs when a proportionate increase/decrease in all inputs results into more than proportionate increase/decrease in the output (Coelli, 2005).

The empirical Cobb-Douglas production function for this sample of tobacco farmers exhibit increasing returns to scale (pooled sample RTS=1.27; non-contract RTS=1.0204; contract RTS=1.046). These results agree with Gondwe (2013) who also found that smallholder tobacco farmers in Malawi exhibits IRTS and Peng and Kong (2015) who also observed ICTS for tobacco farmers in China with a scale elasticity of 2.67. Technically this means that the farmers are operating in region 1 of the classical production function where the marginal product is higher than the average product. Therefore, it can be concluded that smallholder tobacco farmers in Hurungwe are not producing in the economically feasible region 2 of the classical production function. The economic interpretation of this observation is that smallholder tobacco farmers in the study area are enjoying economies of scale because their tobacco farms are too small and can possibly move to the economically feasible region 2 of the classical production function if they increase area allocated to tobacco or if their plots are consolidated into large farms. These observations are not surprising given the fact that the sample was drawn mainly from the smallholder farmers who own an average of 6 hectares of which about 1.2 hectares were allocated to tobacco farming in the 2016/17 season.

These results imply that investing in expanding scale of production will be beneficial for both groups of farmers. However, the greatest impact of expanding scale will be on non-contract farmers. Given that non-contract farmers in the sample are poorer compared to their contract counterparts, this observation has implications for rural poverty alleviation. Investments aimed at expanding scale in smallholder tobacco agriculture will yield more benefits to the less endowed non-contract farmers thus reducing poverty. This is true because at their current capacity, non-contract farmers cannot afford to expand their tobacco production enterprises because of resource constraints.

4.4.4 Elasticity of substitution

Elasticity of substitution is defined as a measure of the degree of substitutability between two inputs along an isoquant (Debertin, 2002). It measures how easy it is for one input to be substituted for another in the production of a given quantity of output. If inputs are perfect substitutes, a rational cost minimizing farmer will respond to economic signals like price changes by substituting the expensive input with the cheaper one (Debertin, 2002). This implies that the elasticity of substitution has important applications in agricultural policies.

Using the elasticity formula and the empirical model given in section 4.41, it was found that the elasticity of substitution between all the inputs was unitary (equal to one) ***(See appendix C***

for the elasticity of substitution formula and calculations). This implies that the rate of substitution between the inputs is independent of level of input use. In other words, we cannot use X_i to influence the production system. This result confirms the restrictive nature of the Cobb-Douglas function as one of its limitations in analysing production systems which can be overcome by using flexible functional forms. Since economic theory does not provide guidance on the selection of functional form to use for given data set, this study was guided by the principle of parsimony in selecting the simplest functional form (Cobb-Douglas) capable of handling the analysis.

The interpretations and magnitudes of elasticities of substitution has policy implications. The size of the elasticity of substitution between a pair of inputs shows the degree of flexibility the farmer has in responding to input price variations. A large elasticity of substitution means the farmer is more flexible and can quickly adjust the input mix in response to changing relative prices. However, a small elasticity of substitution implies that it difficult to alter the input mix even if relative input prices change. In this model the unitary elasticity of substitution across all inputs implies that the Cobb-Douglas is not a very useful function when analysing how inputs can be substituted in the production process in response to economic stimuli.

Having described and characterised the production system for this sample of farmers, the next part of the chapter focuses on technical efficiency analysis. The research questions posed in chapter 1 and the study hypotheses are tested.

4.5 Efficiency estimation approaches

The procedure outlined by Kumbhakar et al. (2015), is in line with best practice in conducting efficiency studies using cross sectional data. Since this study also used cross sectional data, the same procedure was adopted in estimating the efficiency scores for this sample of farmers. Having estimated the production function using ordinary least squares (Section 4.4.1), this section focuses on efficiency analysis. The first step implementing efficiency analysis involved use of distribution-free/non-parametric approaches whereby the efficiency scores were estimated using (i) the Corrected Ordinary Least Squares (COLS) and (ii) Corrected Mean Absolute Deviation (CMAD) models as presented in section 4.5.1. These two approaches use the one-sided error term as inefficiency without allowing for random error (therefore are non-stochastic). As explained in section 4.5.1, this affects accuracy of the efficiency estimates which justifies need for a parametric/stochastic approach to separate inefficiency from random error. However before estimating stochastic frontiers and estimating the technical efficiency, it is necessary to test for the validity of the stochastic frontier specification, which is done using three tests namely (i) Skewness test on OLS residuals (Schmidt and Lin, 1984), (ii) M3T test (Coelli, 1995) and (iii) Likelihood Ratio (LR) test in section 4.5.2. Upon validating the stochastic frontier specification, the study estimates stochastic frontiers in section 4.5.3. The frontiers are then used to estimate and compare technical efficiencies in section 4.6 without accounting for self-selection bias, and in section 4.6.3 after accounting for self-selection bias using PSM. Determinants of TE are presented in section 4.6.5, and factors that explain participation in contract farming are presented in section 4.6.6.

4.5.1 Corrected ordinary least squares (COLS)

Proposed by Winsten (1957), COLS is a deterministic frontier model used in estimating efficiency in production entities. It is simple to implement but the simplicity comes at a cost because it excludes the statistical error hence it treats all the deviations from the frontier as inefficiency. This results in overestimating the levels of inefficiency in firms. The basic idea behind COLS is estimating the OLS and then shifting the intercept upwards by the amount of the maximum predicted OLS residuals so that the function bounds the observations from above. Table 4.5 presents the efficiency results obtained using COLS.

Table 4.5: Frequency distribution of efficiency estimates from COLS

	Non-contract		Contract		Pooled sample	
Efficiency level	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
<40	10	6.1	6	8	16	6.7
40-49	34	20.1	10	13.3	44	18.3
50-59	48	29.1	14	18.7	61	25.4
60-69	55	33.3	20	26.7	77	32.1
70-79	11	6.7	11	14.7	21	8.8
80-89	7	4.2	9	12	16	6.7
90-100	0	0	5	6.7	5	2.1
Total	165	100	75	100	240	100
Mean	0.571		0.636		0.591	
Minimum	0.344		0.265		0.265	
Maximum	0.928		1		1	
Standard Dev.	0.107		0.172		0.134	

The results show that contract farmers achieved a mean efficiency of 63.6 percent compared to 57.1 percent for non-contract farmers. The pooled sample was producing at 59.1 percent of their potential implying that considerable yield losses (about 40.9 percent) were a result of inefficiency.

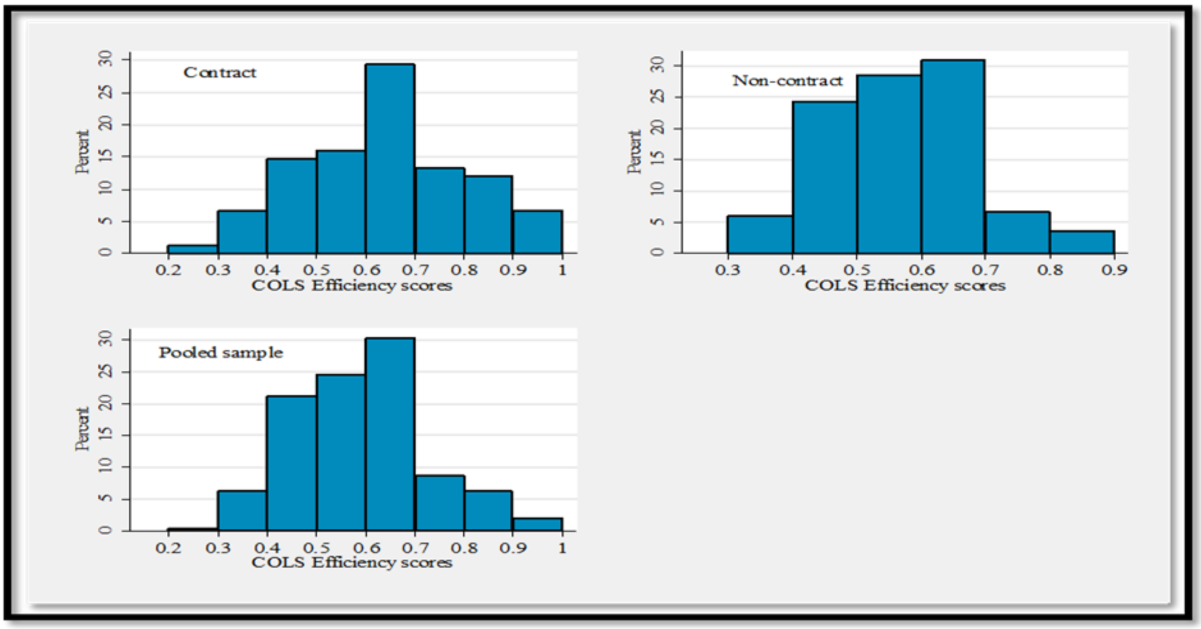

Figure 4.1: Histogram of COLS TE scores

Figure 4.1 is a graphic illustration of the distribution of the efficiency scores for the tobacco farmers in Hurungwe using COLS. As can be seen from figure 4.1, the majority of the farmers are producing at between 40% and 80% efficiency meaning there is room to improve productivity at the current level of technology. A visual comparison of the contract and non-contract graphs could not give a conclusive result on the performance of the two groups hence the need for a formal t-test presented in table 4.6

Table 4.6: COLS TE comparison (t-test)

Group	Obs	Mean	Std. Err	Std. dev	(95% Conf. Interval)
Non-contract	165	0.571	0.008	0.107	0.555 ; 0.588
Contract	75	0.636	0.019	0.172	0.596 ; 0.675
Pooled	240	0.591	0.009	0.134	0.574 ; 0.608
Diff		-0.065	0.018		-0.101 ; -0.029

diff = mean(NON-CONT) - mean(CONTRACT) t = -3.5593
Ho: diff = 0 degrees of freedom = 238

Ha: diff < 0 Ha: diff! = 0 Ha: diff > 0
Pr(T < t) = 0.0002 Pr(|T| > |t|) = 0.0004 Pr(T > t) = 0.9998

A t-test of mean comparison showed that there were significant differences (p=0.0004) in the efficiency levels of the two groups of farmers using COLS. To check the robustness of these results another distribution-free approach, Corrected Mean Absolute Deviation (CMAD) was used to estimate and compare the efficiency level for the two groups of farmers as presented in table 4.7

Table 4.7: CMAD TE comparison (t-test)

Group	Obs	Mean	Std. Err	Std. dev	(95% Conf. Interval
Non-contract	165	0.587	0.009	0.113	0.569 ; 0.604
Contract	75	0.630	0.020	0.177	0.589 ; 0.671
Pooled	240	0.600	0.009	0.137	0.583 ; 0.618
Diff		-0.043	0.019		-0.081 ; -0.061

diff = mean(NON-CONT) - mean(CONTRACT) t = -2.2924
Ho: diff = 0 degrees of freedom = 238

Ha: diff < 0 Ha: diff != 0 Ha: diff > 0
Pr(T < t) = 0.0114 Pr(|T| > |t|) = 0.0228 Pr(T > t) = 0.9886

Using distribution free approaches (COLS and CMAD), the results show contract farmers achieved a significantly higher level of technical efficiency than non-contract farmers implying that participation in contract farming improves technical efficiency for this sample of famers. As shown in table 4.8 on average the farmers achieved more or less the same level of technical efficiency using COLS and CMAD approaches.

Table 4.8: Comparison between COLS and CMAD TE scores

Variable	Obs	Mean	Std. Dev.	Min	Max
TE COLS	240	0.591	0.134	0.267	1
TE CMAD	240	0.600	0.137	0.261	1

However, the accuracy of these results needs further verification because they are based on the distribution free approaches (COLS and CMAD) in which the one-sided error term does not separate inefficiency effects from random error effects. Due to deterministic nature of the distribution-free approaches the accuracy of the efficiency estimates becomes questionable. By attributing the entire deviations from the frontier to inefficiency, the distribution free approaches tend to overestimate the levels of inefficiencies in the farmers. To address this shortcoming in the distribution free approaches and improve on the efficiency estimates, we use parametric/stochastic approaches in which one-sided error is separated into two random variables, (v_i) which captures the random error and (u_i) which captures inefficiency, thereby accurately capturing the inefficiency effects. This helps in verifying whether it is really true that participating in contract farming results in higher levels of technical efficiency.

4.5.2 Testing for the validity of the stochastic frontier specification

However, before implementing the parametric approaches, the study had to first verify the relevance of the stochastic frontier specification. This is done using three tests. The first two tests which are based on OLS residuals are (i) Skewness test on OLS residuals (Schmidt and Lin, 1984) and (ii) M3T test (Coelli, 1995). The third test which is based on the log likelihood values of the OLS (restricted) and SF (unrestricted) models is called the Likelihood Ratio (LR) test.

(i) Skewness test on OLS residuals

This test was performed to check the validity of the stochastic frontier model on the collected data by checking the skewness of the OLS residuals. Figure 4.2 shows some evidence of negative skewness in the OLS residuals though not very clear. However, after performing a more formal test following Schmidt and Lin (1984), which yielded the skewness statistic of -0.368, it was confirmed that the residuals are indeed skewed to the left. This result led to the rejection of the null hypothesis of no skewness thereby confirming the existence of the on-sided error term as required for the efficiency model. The test was significant at 5% (p-value-0.020).

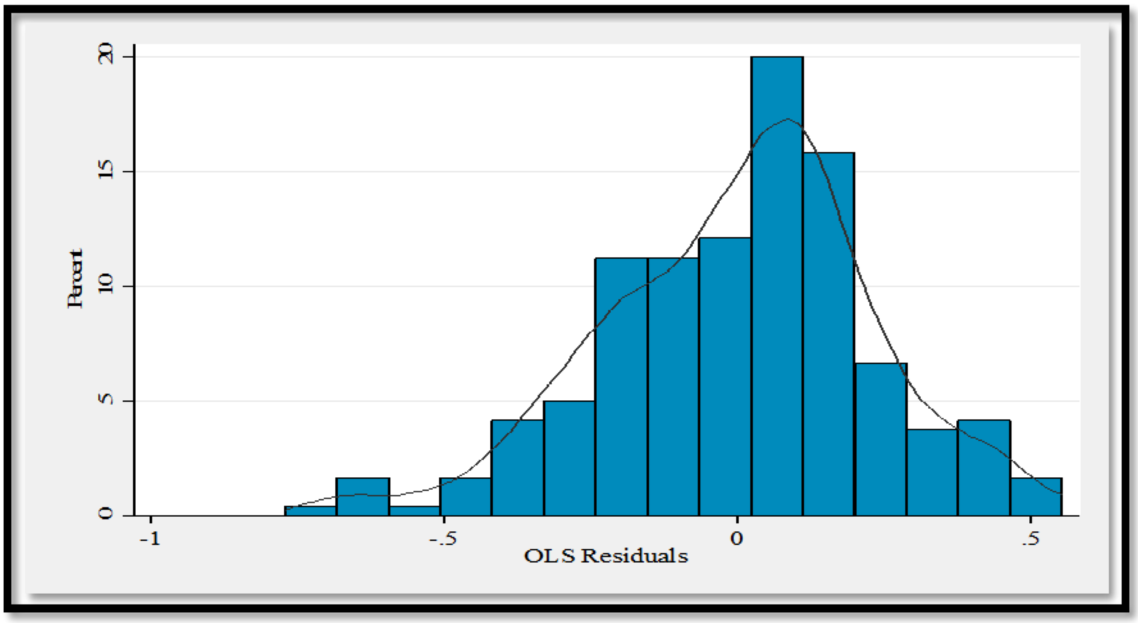

Figure 4.2: Histogram of OLS residuals

(ii) M3T test

Skewness of the OLS residuals was also supported by the M3T test (Coelli, 1995) which gave a computed statistic of –2.325. Given that the test statistic follows a normal distribution with a critical value of 1.96, the null hypothesis of no skewness in the OLS residuals is also rejected.

Passing the skewness tests means there was enough evidence to support the existence of a left-skewed error distribution therefore, it is justified to use stochastic frontier model with parametric distributional assumptions in estimating efficiencies in the sample. Although these two tests only serve as a pre-tests before the Maximum Likelihood estimations are done (Kumbhakar, Wang, & Horncastle, n.d.), they provided enough support for the existence of inefficiency in the sample. After passing the skewness test, the data was also tested for the validity of the stochastic frontier specification using the likelihood ratio test.

(iii) Likelihood ratio test of inefficiency

This is the more expensive test conducted following the skewness tests to confirm the existence of inefficiency effects in the sample. Simply put, this test amounts to testing for the existence of μ_i (inefficiency term) in the model. For this sample a Likelihood Ratio test for the null hypothesis of no one sided error was conducted. The LR test statistic is calculated as follows;

$$LR = -2|L(H_0) - L(H_1)|,$$

Where $L(H_0)$ and $L(H_1)$ are log-likelihood values of the restricted Cobb-Douglas (OLS) model (without the inefficiency term, μ_i) and the unrestricted Cobb-Douglas (SF) model (with the inefficiency term) respectively while the degree of freedom is equal to the number of restrictions in the test which is one in this case.

The result, 6.223, led to the outright rejection of the null hypothesis of no inefficiencies thereby confirming that there were farm level inefficiencies in the production of tobacco within this sample of smallholder farmers in Hurungwe.

Table 4.9: Hypothesis tests for the validity of the stochastic frontier specification

Null hypothesis	Description of test	Critical value	Test value	Decision
(1) H_0: No skewness	Schmidt & Lin (1984), Skewness test (Tests whether OLS residuals are skewed to the left)	Negative (-)	-0.368 **	Reject
(2) H_0: No skewness	Coelli, 1995), M3T test (Skewness test on OLS residuals)	1.96	-2.325**	Reject
(3) H_0: No technical inefficiency ($\delta_u^2 = 0$)	LR test (tests the existence of inefficiency)	5.412	6.223***	Reject

Notes: ***Significance at 1%; **Significance at 5%; *Significance at 10%

The three tests led to the conclusion that the stochastic frontier specification is relevant. Now that the existence of inefficiencies in tobacco farming has been confirmed through the three tests in Table 4.9, it was justifiable to use stochastic frontier production function to estimate technical efficiency levels for the sample of farmers and make a comparison between the contract and non-contract tobacco farmers. In Section 4.5.3 we use stochastic frontier model to estimate and compare the inefficiencies between the contract participants and non-participating farmers. Estimating the stochastic frontier production function was done to address objective 1 of the study which is a pre-requisite to answering all the three research questions and estimating the levels of technical efficiency for the farmers.

4.5.3 Estimating stochastic frontiers

Upon validating the stochastic frontier specification through the 3 tests in this section we proceeded to estimate stochastic frontiers using pooled data, following Kumbhakar et al. (2015). Given the existence of a number of distributional assumptions on the inefficiency term, namely gamma, half-normal, truncated normal and exponential distribution, the choice of which distributional assumption to use becomes an important issue that needed to be addressed. In this study, the stochastic frontier was estimated using the half-normal, truncated normal and exponential distributions and the results are presented in table 4.10.

Table 4.10: Estimation of the Stochastic Production Frontier models

		SPF models with different distribution assumptions					
		Truncated		Half normal		Exponential	
Variables	**β_i**	**Co-eff (SE)**	**p-value**	**Co-eff (SE)**	**p-value**	**Co-eff (SE)**	**p-value**
Contract dummy		0.136 (0.031)	0.000	0.139 (0.032)	0.000	0.135 (0.031)	0.000
lnArea	β_1	0.148 (0.100)	0.139	0.123 (0.097)	0.203	0.162* (0.096)	0.091
lnSeed	β_2	0.280*** (0.076)	0.000	0.319*** (0.070)	0.000	0.265*** (0.067)	0.000
lnNPK	β_3	0.463*** (0.072)	0.000	0.456*** (0.073)	0.000	0.464*** (0.072)	0.000
lnLabour	β_4	0.334*** (0.080)	0.000	0.316*** (0.080)	0.000	0.337*** (0.080)	0.000
Constant	β_0	1.697*** (0.541)	0.002	1.843*** (0.592)	0.001	1.682*** (0.538)	0.002
mu constant		-1.311 (3.701)	0.723	-	-	-	-
Etas		-	-	-	-	-3.421*** (0.283)	0.000
u-sigmas constant		-1.082 (1.988)	0.586	-2.272*** (0.187)	0.000	-	-
v-sigmas constant		-3.957*** (0.343)	0.000	-4.228*** (0.305)	0.000	-3.839*** (0.233)	0.000
Log-likelihood		22.795		22.120		22.653	
Obs		240		240		240	

Notes: *Figures in Parentheses are the robust standard errors*
****Significance at 1%; **Significance at 5%; *Significance at 10%*

Interpreting the production inputs coefficients follows the interpretation done in the production function in section 4.4.2.

Although distribution assumptions matter in efficiency analysis, there are empirical studies that show that ranking of producers is less sensitive to these assumptions. Fuiji and Ohta (1999); Rosko (1999); Fuiji (2001) and Street (2003) calculated efficiency levels using different distributional assumptions but found more or less similar results. As can be seen in the results, the three models were more or less similar. Thus, the choice of the distributional assumption to use is a matter of personal choice and computational convenience. In this study the choice of model was guided by applying the principle of parsimony which favours the use of the simpler half-normal model.

4.6 Technical efficiency estimations and comparisons

In this Section, technical efficiency scores for contract and non-contract smallholder tobacco farmers in Hurungwe district are estimated and compared. The results showed that the average technical efficiency of the pooled sample of farmers was below 100% implying that smallholder tobacco farmers in the study area were producing below their potential production frontier given the existing production technology. As shown in table 4.11, the least efficient farmer had a TE score of 49.5% while the most efficient farmer had a TE score of 95.6%. On average the farmers were producing at 86.6% implying that about 13.4% of potential yield was being lost due to technical inefficiency. Alternately, the tobacco farmers in Hurungwe can improve their yield by 13.4% using their current resources and without incurring additional costs if they improve on their production efficiency. Using these results, we therefore fail to reject hypothesis 1 of the study and conclude that smallholder tobacco farmers in Hurungwe are producing inefficiently.

Table 4.11: Sample TE estimates summary statistics

	Technical efficiency score		
Statistic	**Non-contract**	**Contract**	**Pooled sample**
Mean	0.807	0.825	0.866
Minimum	0.526	0.495	0.495
Maximum	0.945	0.956	0.956
Standard deviation	0.006	0.013	0.082

Table 4.11 presents a comparison of the summary statistics of the efficiency estimates for the sample obtained from the stochastic frontier function. The standard deviations for the split samples show that there was more variation in the efficiency levels for contract farmers (standard deviation=0.006) than non-contract farmers (standard deviation=0.013). This is quite surprising because one would expect the variation to be less for contract farmers given that they receive fairly uniform input packages per hectare and are exposed to more or less similar support services from the contractors. Thus, one would expect the variation to be less for contract farmers than non-contract farmers.

As shown in table 4.12, all the farmers except one were producing at efficiency levels above 50%. Among non-contract farmers, the largest percentage (47.9%) were producing at between 80 and 89%. However, for the contract farmers, the largest percentage (58.7%) was producing closer to the frontier at above 90%.

Table 4.12: Distribution of technical efficiency scores

	Non-contract		Contract		Pooled sample		
Efficiency	**Freq**	**Percent (%)**	**Freq**	**Percent (%)**	**Freq**	**Percent (%)**	**Cum. percent (%)**
<50	0	0	1	1.3	1	0.42	0.42
50-59	1	0.6	4	5.3	5	2.1	2.52
60-69	5	3.0	1	1.3	24	10	12.52
70-79	17	10.3	7	9.3	54	22.50	35.02
80-89	79	47.9	18	24.1	123	51.25	86.27
90+	63	38.2	44	58.7	33	13.75	100.00
Total	**165**	**100**	**75**	**100**	**240**	**100**	

To address objective 2 of the study which was ***'To establish whether there were any production efficiency differentials between contract and non-contract smallholder farmers'***, a comparison of technical efficiency levels for the two groups of farmers was done. The estimated technical efficiency scores for non-contract farmers ranged from 52.6 to 94.5% with a mean technical efficiency score of 81.3%. This means that non-contract tobacco farmers in the study area are producing 81% (95% confidence interval; 0.794: 0.819,) of the potential yield that they could produce using the same input mix. This result shows that there is potential by the non-contract farmers to increase tobacco yield by about 19% if they are to match the production levels of the fully efficient non-contract farmer.

The estimated technical efficiency scores for contract farmers ranged from 49.5 to 95.6%. Their mean technical efficiency score was found to be 82.5% implying that on average contract farmers were able to achieve about 83% (95% confidence interval; 0.799: 0.851) of their yield potential using the current technology and input mix. This means there is potential for contract farmers to increase their tobacco yield by 17% to reach the frontier, if they improve on their level of technical efficiency.

Figure 4.3 gives a visual comparison of the efficiency performance between the two groups of farmers. Both graphs are skewed to the left, implying that the majority of farmers across the sample were producing towards the frontiers despite notable differences in the efficiency levels between the two groups of farmers. For instance, more that 60% of the non-contract farmers were operating at efficiency levels greater than 80% and about 40% were operating below the sub-ample average TE score. Regarding contract farmers, about 1.3% were producing below 50% of potential yield. The majority of the contract farmers (more than 70 %) were producing at above 80% of their potential.

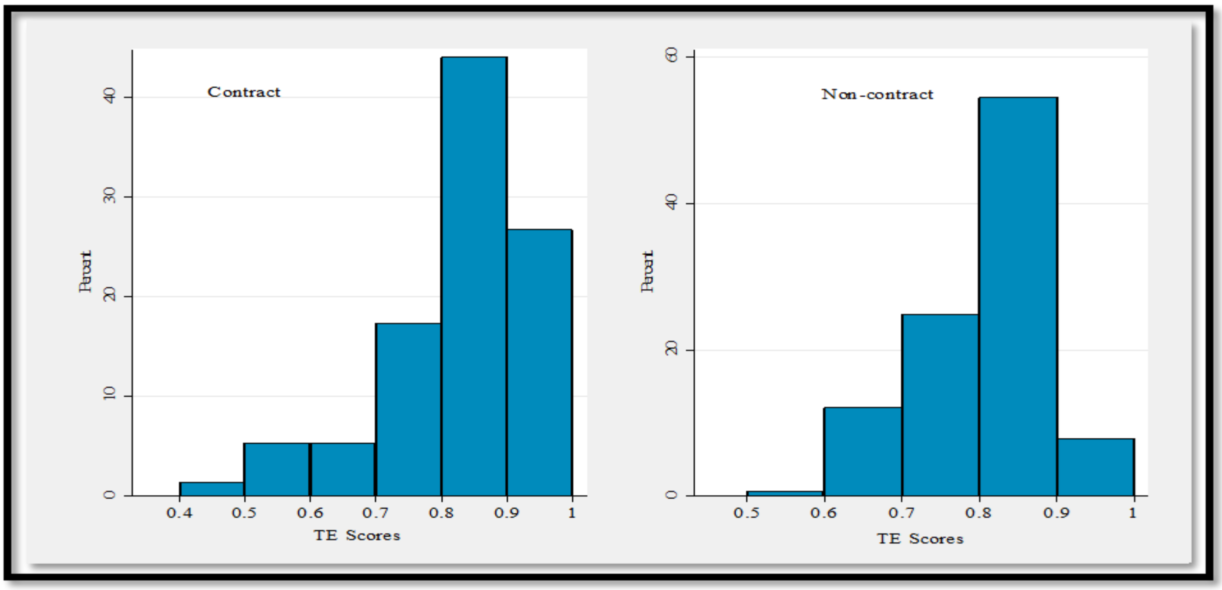

Figure 4.3: Technical efficiency scores distribution comparison

Results from table 4.12 and figure 4.3 show that contract farmers were on average more efficient than non-contract farmers but a formal test is needed to make sound conclusions. A t-test of mean equality was implemented to test the Hypothesis 2 which hypothesized that; **'*There are no significant differences in average technical efficiency between contract farmers and non-contract farmers'.*** The results are presented in Table 4.13.

Table 4.13: Technical efficiency comparison (t-test)

Group	Observations	Mean TE	Std. Error
Non-contract	165	0.807	0.006
Contract	75	0.825	0.013
diff = mean (Non-contract) – mean (Contract)		t = -1.4332	
Ho: diff = 0		degrees of freedom = 238	
Ha: diff < 0	Ha: diff != 0	Ha: diff > 0	
Pr (T < t) = 0.0766	Pr(T > t) = 0.1531	Pr(T > t) = 0.9234	

A formal comparison between the contract and non-contract farmers using the two-tailed t-test shows that there was no significant difference in the mean technical efficiency scores for the two groups of farmers (p=0.1531). Therefore, using the t-test results, we fail to reject the null hypothesis of no significant differences in the mean technical efficiencies between contract and non-contract farmers. This leads to the conclusion that participating in contract farming does not matter in explaining technical efficiency variations among smallholder tobacco farmers in Hurungwe.

These results do not agree with *a priori* expectation that CF results in higher technical efficiency. They also contradict findings by Dube and Mugwagwa (2017); Swain (2013); Key and Mc Bride (2003); Key and Mc Bride (2007) who found that on average contract farmers were more efficient than their non-contract counterparts. They also contradict with Rawlins (1985)' findings that non-contract peasant farmers achieved a higher average technical efficiency than their contract counterparts although CF drives up the production frontier of contract farmers.

Could there be any reasons why the results from this study are contradicting some empirical evidence and theoretical arguments that CF enhances technical efficiency? In other words, is it really true that CF cannot be used to account for TE variations in this sample of farmers? A close look at the demographic characteristics of the sample ***(see table 4.1)*** reveals some notable differences between the contract and non-contract farmers which could have an impact in the results obtained. In addition, literature on CF shows that contract participation is not a random process. A number of studies (Miyata et al., 2009; Beaman et al., 2014; Mwambi et al., 2016) found that either farmers self-select into CF or that contractors use certain selection criteria when selecting participants. More importantly, despite the conditions set by contracting firms for farmers to join CF arrangements, farmers choose either to participate or not in such arrangements. There is a possibility that self-selection bias could be the reason why CF failed to account for TE variations among this sample of farmers. To address the two questions posed at the beginning of this paragraph, further investigations were conducted in which the selection bias was accounted for before another technical efficiency comparison was done.

Sections (4.6.2 and 4.6.3) were motivated by the need to check robustness of the conclusion made in Section 4.6 given that literature has found that farmers self-select into contract farming arrangements and contract participation is not a random process.

4.6.1 Addressing self-selection bias through Propensity Score Matching

The following section presents the results of the comparison of efficiency levels of the non-contract and contract tobacco farmers using PSM. See section 3.8 for the justification and steps in PSM analysis.

4.6.2 Maximum likelihood estimation of PSM model

The initial step in propensity score modelling involves the maximum likelihood estimation of the probit regression and the results are presented in table 4.14. The probit regression model was used to calculate the probability that a farmer will participate in contract farming based on a number of covariates.

Table 4.14: Maximum likelihood estimates of the PSM probit regression

Variables	Co-efficient	Standard error	P-value
Membership to farmers' club	0.612*	0.318	0.054
Age of household head	0.005	0.012	0.693
Household size	0.021	0.065	0.747
Field day attendance	1.405***	0.488	0.004
Farm size	1.473***	0.318	0.000
Education level (years)	-0.005	0.037	0.890
Off-farm income	-0.558*	0.323	0.084
Constant	-10.470***	2.091	0.000
Observations = 240; Pseudo R^2 = 0.349; P-value =0.000			

Notes: **significance at 10%; **significance at 5%; ***significance at 1%*

The probit regression in table 4.14 saves two purposes. (i) To estimate the probability of a farmer participating in CF given the following pre-treatment covariates; membership to farmers' club; age of household head; household size; field day attendance; farm size; education level (years); off-farm income which is then used in calculating the average treatment on the treated (ATT). (ii) The covariates also serve as determinants of contract participation and are further explained in section 4.6.6. The likelihood ratio test of goodness of fit (p value = 0.0000) shows that the probit model was a best fit of the data. The results also show that about 35% of contract participation can be explained by the probit model.

4.6.3 The treatment effect

After calculating the probability of participating in CF using the probit model, this section reports the impact of participating in contract farming on the outcome variable (technical efficiency) using all the matching algorithms mentioned in the preceding sections. This is summarized in table 4.15. ATT refers to the average treatment effect on the treated which is a measure of the net change in technical efficiency that can be attributed to CF.

Table 4.15: Treatment effect results from the three matching algorithms

Matching algorithm	Treated (contract farmers)	Control (non-contract farmers)	ATT	Std. Err	t
Nearest Neighbour Matching (NNM)	75	36	0.072**	0.031	2.339
Kernel Matching (KM)	75	97	0.057*	0.030	1.907
Stratification Matching (SM)	73	97	0.048**	0.023	2.046
Radius Matching (RM)	68	97	0.020*	0.011	1.860

Notes: **significance at 10%; **significance at 5%; ***significance at 1%*

Using all the four matching algorithms the results indicate that participation in tobacco CF arrangements have a positive impact on farm level technical efficiency. The TE gains as a result of CF participation range from 2% to 7.2%. The results from the two matching algorithms, KM (t=1.907) and RM (t=1.860) were significant at 10% while those from NNM (t=2.339) and SM (t=2.046) were more significant at 5%. Despite the overwhelming positive impact of CF on TE from all the four matching algorithms, this study used the results from the stratification algorithm to make the overall conclusion because it had a larger sample (n=170). The study therefore found that contract farmers were on average 4.8% more technically efficient than non-contract farmers. This result led to the rejection of the hypothesis that, '***There is no significant difference in average technical efficiency between contract farmers and non-contract farmers'***. Therefore, it can be concluded that contract farming increases technical efficiency by an average of 4.8%.

The study therefore concludes that there are significant differences in the average technical efficiency scores between contract and non-contract farmers. This means contract farming participation can be used to explain the efficiency differences between smallholder tobacco farmers. The study clearly demonstrated that contract farming has a positive and significant impact on technical efficiency for the smallholder tobacco farmers in Hurungwe.

These results suggest that encouraging agribusinesses and farmers to venture into contract farming arrangements could enhance tobacco productivity. This will translate into improved tobacco earnings for the farmers as well as the government given that tobacco is among the top foreign currency earners for Zimbabwe.

4.6.4 Impact of accounting for self-selection bias on technical efficiency

The forth objective of the study was to find out whether selection bias matter in assessing the impact of contract farming of technical efficiency. This was addressed by comparing the results in section 4.6 (impact of contract farming on technical efficiency before accounting for self-selection) and those in section 4.6.3 (after accounting for self-selection through PSM). It was found that before matching, CF could not account for TE variations in the sample but after matching, CF was able to account for TE variations. In other words, before matching, there was no significant differences between average efficiency scores for contractors and non-contractors (t= 0.1531) but after matching it was found that contractors were 4.8% (t= 2.046) more efficient that non-contractors.

These results were used to test Hypothesis 4 which reads: ***Selection bias matters in explaining the impact of contract farming on farm level technical efficiency differentials between***

participants and non-participants. The study failed to reject this hypothesis. This led to the conclusion that self-selection bias matters in evaluating the impact of CF on TE variations in smallholder tobacco farming in Hurungwe. Therefore, the study concluded that to have plausible contract farming impact assessments and to capture the differential impacts of contracting on technical inefficiency, we must account for self-selection bias.

Now that the study has proved that CF significantly improve technical efficiency, we fail to reject the third hypothesis of this study which reads; ***Contract farming is one of the significant variables in explaining farm level technical efficiency for smallholder tobacco farmers in Hurungwe.***

4.6.5 Determinants of technical efficiency

Now that the study has reported technical efficiency variations within the sample, it is important to investigate the drivers of farm level technical efficiency paying particular attention to contract participation, socio-economic-demographic characteristics, biophysical and policy variables. This section of the analysis specifically addresses research question 3 and research objective 3 of the study aimed at identifying determinants of technical efficiency. The ideal situation would be to estimate separate models for contract and non-contract farmers following the style of presenting the earlier results. However, this was made difficult by the following considerations:

(1) After matching the two groups of farmers using PSM, it was not possible to extract the matched sub samples for contract and non-contract farmers to enable estimation of the separate models.
(2) Some observations from both groups of farmers were discarded during the matching as they could not find matches hence, we could not regress the efficiency scores obtained using a full sample on a reduced matched sample.

As a result, we only present a pooled model for the determinants of TE in this study. Following the analysis by Kidane and Ngeh (2015); Obwona (2006); Ilembo and Kuzilwas (2014); and Bravo-Ureta and Pinheiro (1993) in their review of farm level technical efficiency in developing countries, the following covariates were included in the inefficiency model; the dummy variable contract, age of farmer, off-farm income, main occupation of household head, years of formal education, years of tobacco farming experience, membership to farmers’ club, number of draft animals, area under tobacco, area under maize, total farm size and access to extension using the pooled sample and the results are presented in table 4.7**.** It should be noted that these results are based on the TE scores before the accounting for self-selection bias hence may fail to accurately capture the impact of these covariates on technical efficiency. The ideal would have been to use the TE scores from the matched sample but this could not be done because the PSM technique used only managed to capture the average treatment effect on the treated without necessarily extracting the TE scores of the matched sample.

Table 4.16: Determinants of technical efficiency

Variables	Parameter	TE Co-efficient	Standard Error
CONTRACT	α_1	0.010	0.014
AGE	α_2	-0.001	0.001
OFFFARM_INCOME	α_3	-0.043**	0.017
OCCUPATION	α_4	0.026	0.245
HOUSEHOLD_TOTAL	α_5	0.009**	0.004
EDU_LEVEL_YEARS	α_6	0.004*	0.002
TOBACCO_EXP	α_7	0.006***	0.002
FARMERCLUB_MEMBER	α_8	0.037**	0.016
DRAFT_NUMBER	α_9	0.003	0.005
AREA_TOBACCO	α_{10}	-0.050**	0.019
AREA_MAIZE	α_{11}	-0.010	0.010
FARM_SIZE	α_{12}	-0.008	0.005
EXTN_ACCESS	α_{13}	0.065**	0.029
Constant	α_0	0.746***	0.065
Observations		240	
R-squared		0.266	

Notes: **significance at 10%; **significance at 5%; ***significance at 1%*

As can be seen from the table 4.16, a number of these covariates are insignificant in explaining technical efficiency. However, it is worth examining the signs of the coefficients as they give an indication of the direction of impact on technical efficiency for each covariate.

A positive coefficient on the dichotomous variable CONTRACT means that contract farming has a positive impact on technical efficiency, although the impact was not statistically significant. We have already concluded in section 4.8.1 that contract participation increases farm level and average technical efficiency for the smallholder tobacco farmers. Therefore, statistical insignificance in this model can be explained by the use of TE scores before accounting for self-selection bias.

For this group of farmers, age of household head had a negative influence on technical efficiency but was not statistically significant (p=0.238). This result implies that older farmers are less efficient than younger farmers. These results were consistent with findings of Battese and Coelli (1995) and Ceyhan, 2007 who found that age was negatively significant in explaining technical efficiency. More so, Ajibefun and Daramola (2015) and Onyenweaku and Nwaru (2005) also found a negative but insignificant relationship between age and technical efficiency. Taking age as a proxy for farming experience, these results are surprising because one would expect older farmers to have more experience in farming and more technically efficient. One possible explanation for this result is that younger farmers are more receptive to new farming practices that improve technical efficiency whereas it might be difficult to influence older farmers to change their old farming methods and habits.

Off-farm income showed a negative effect on technical efficiency and was statistically significant at 5% (p= 0.013). This result contradicts the findings by Hussaina (2016) who found income to be negatively related to technical inefficiency and argued that more income means more and timely inputs purchases. According to Hussaina (2016)'s argument, inputs purchased on time ensures timely farm operations thereby positively impacting on technical efficiency. In contrast results from this study implies that farmers who get additional income from sources other than farming tend to put more focus on these off-farm activities than they do on farming. One possible explanation for this finding is that maybe these off-farm sources are less risky than rain-fed agriculture hence farmers concentrate more them to hedge against weather induced losses in agriculture. These results were consistent with Ceyham (2007) results who also found a negative relationship between off-farm income and technical efficiency. These findings imply that investing in irrigation and other weather resilient farming practices can go a long way in reducing the perception that farming is a risky business and that can influence farmers to invest more time and effort in their farming enterprises and improve on technical efficiency.

Whether a farmer is full-time in farming or is engaged in other non-farm activities also affect technical efficiency. Although not statistically significant (p= 0.326), this study showed a positive relationship between being a full-time farmer and technical efficiency. This reinforces the results and explanation outlined in the preceding paragraph.

Household size is a variable that can be used to measure the impact of family labour on technical efficiency. Household size showed a positive and statistically significant (p=0.020) impact on technical efficiency. This result was consistent with findings by Ceyham (2007) who also observed that family size impacted positively on technical efficiency. The results were also similar to results of Naftali et al. (2014) who found that households with large families were more technically efficient in cocoa production than households with smaller families. One possible explanation of this observation is that the greater the household size, the more the labour force available for carrying out agricultural activities. Given that smallholders farmers rely to a large extent on household labour, and that tobacco farming is considered a labour-intensive operation, this result is not surprising since one would expect households with a larger labour-force to carry out their farming operations on time thereby achieving higher levels of technical efficiency compared to labour constrained households.

Education level as measured in terms of years of formal education, showed a positive and statistically significant returns on technical efficiency at 10% (p=0.061). Increasing the farmer's years of formal schooling by one year resulted in technical efficiency gains for the farmer of about 0.4 percent. This implies that farmers with a higher level of education tend to be more efficient in tobacco production. This is not surprising given that more educated farmers tend to understand and embrace new technologies hence they tend to produce closer to the frontier than less educated farmers. Embracing new technology is one way of addressing productivity challenges caused by use of less productive traditional technologies as explained by Ike and Inoni (2006). This result agrees with results by Ceyham (2007), Masunda and Chiweshe (2015) and Ibrahim et al. (2014) who found that education is a significant determinant of technical efficiency. Whilst conducting a study on the impact of drought on technical efficiency in the same district (Hurungwe), Pindiriri et al. (2016) also found that increasing years of schooling by one year increased technical efficiency of maize farmers by 1.4 to 1.5%. These results suggest that investment in education is one way of increasing productivity of smallholder farmers in Zimbabwe.

Tobacco farming experience, measured by number of years a farmer was involved in tobacco farming showed a positive and significant impact (p=0.001) on technical efficiency at 1 percent. This conforms to *a priori* expectation because the more the farmer is involved in tobacco farming, the more he/she gains understanding of all the operations involved tobacco production hence they tend to produce closer to the production frontier. It is therefore important to distinguish between age and experience because age of the farmer does not necessarily translate to farming experience as assumed by some studies. These results agree with those of Rahman and Umar (2009); Peng and Kong (2015); Naftali *et al.* (2014) who found that more experienced farmers more efficient than less experienced farmers but contradict findings by Onyeweaku and Nwaru (2005). These results imply that although new farmers can be inefficient in the short run, they can develop into efficient farmers as they acquire experience if they continue growing tobacco. This is an important observation in the Zimbabwean context given that most smallholder farmers are still in the learning phase of tobacco farming following the Fast Track Land Reform Program. This calls for government to formulate policies and ensure economic conditions that encourages new farmers not to abandon farming in preference to other forms of livelihoods.

Another interesting finding of policy relevance unearthed in this study is the role of farmer organisations in enhancing technical efficiency. Belonging to a farmers' organisation was found to increase farmer's level technical efficiency by 3.7% (p=0.023). This can be explained by the role farmers' organisations play in coordinating and educating their members as well as collective bargaining power they wield in negotiating better terms of trade when purchasing inputs and marketing their produce. Thus, encouraging the formation of vibrant farmers' clubs and strengthening the existing ones coupled with encouraging farmers to join the organisations will go a long way in addressing inefficiencies in smallholder tobacco sector in Hurungwe.

Low levels of mechanisation in the smallholder farming communities mean heavy reliance on animal draft power for farm operations. The study found that although not statistically significant (p=0.567), the number of draft animals positively influenced technical efficiency in the study area. The insignificant contribution of draft power on technical efficiency can be explained by the following two factors. The first reason is that a number of tobacco farmers are now investing in farm mechanization through tractor purchases which is replacing the need for draft power. The second reason is that smallholder communities are known to help each other with draft power given the existence of strong social ties among rural communities. This means that even if a farmer does not own draft power, he/she can still have access through borrowing from family or neighbours.

Farm size, area allocated to maize production, and area allocated to tobacco production were found to negatively impact on technical efficiency with the first two being insignificant while the third variable was significant at 5% (p=0.011). Although the average farm size in the study area of about 6 hectares fits well in the smallholder category, undercapitalization of these farms could be the reason for low technical efficiency. This result agrees with the critics of the Fast Track Land Reform program who argue that parcelling out land to smallholder farmers without the necessary support was the main reason for loss of productivity in these former commercial farms. Given that maize production competes for the same production resources like labour, capital and other inputs with tobacco production, one would expect a negative relationship between technical efficiency in tobacco production and an increase in the area under maize production as shown by the results. Likewise, increasing area under tobacco without a proportionate increase in other farming inputs means the farmers end up spreading the few inputs over the expanded tobacco fields thus explaining the negative relationship between technical efficiency and an increase in area allocated to tobacco farming.

Another important policy variable in explaining technical efficiency variation in the study area is access to extension services. Agriculture extension links farmers with institutional support through information dissemination on better seed varieties, fertilizer application practices for improved production and better farming practices (Jimi et al., 2016). The results showed that access to extension services has a positive and significant (p=0.027) impact on technical efficiency. The results show that access to extension services have the greatest effect on technical efficiency. This study shows that having access to extension services increases TE by about 6.5%. A possible explanation for this observation is that tobacco is a highly specialised crop that require a lot of technical guidance right from the seedbed up to the grading and bailing hence extension is a critical variable in its production. Given that a considerable number of farmers only started growing tobacco following the FTLRP, it can be argued that they lack the technical knowledge and experience hence the need for frequent extension visits by agricultural extension officers. It is also important to note that contract farmers received on average more extension visits because they benefitted from both government and contractor extension officers. The results show that on average contract farmers received about 9 extension visits compared to about 3 for non-contractors. Assuming that these visits were evenly distributed throughout the tobacco production cycle, this means that contract farmers received at least one visit during the critical stages of tobacco production season such as land preparation, seedbed, transplanting, weeding, fertiliser application, reaping, curing and grading.

4.6.6 Determinants of contract participation

Since the study has established that CF is associated with increased technical efficiency, the study further investigated the factors that encourage farmers to self-select into contract farming arrangements using the pooled sample. Identifying these factors is important in advising policy makers to formulate policies that encourages farmers to self-select into contract farming programs. The probit model (table 4.14) shows that 4 covariates; membership to farmers' club (p=0.054), farm size (p=0.000), off-farm income (p=0.084) and attending field days (p=0.004) are significant variables in explaining farmers' participation in tobacco contract farming.

From the results we now understand that probability to participate in CF is high for farmers who are members in farmers' organisations, attended field days and with larger farms and was lower for farmers with off-farm income. The results show that farmers who were members of farmers clubs were 0.6% more likely to participate in contract farming than non-members. During the study it was also noted that contractors only selected those farmers that were registered with the Tobacco Industry and Marketing Board further proving that belonging to farmers' organisations increased the chances of contract participation. To promote contract participation there is need educate farmers on the need to belong to farmers' organisations by the extension officers. Farmers who attended field days increased their chances of participation in contract farming by more than 1.4 percent. It is therefore important to educate farmers on the benefits of attending agricultural field days. These results are not surprising because the two variables are information related and they help farmers to access agriculture information like potential contracting firms in agriculture. Most firms involved in contract farming use farmers' clubs and field days as advertising platforms for their services.

The study also found that farmers with larger farms are 1.5 percent more likely to be accepted into contract farming arrangements. This result implies that access to farming land is a very important variable that influence contract participation. This was also supported by representatives of the contracting firms who said proof of land ownership was one of the criteria used in selecting farmers who participate in contract farming. Therefore, policy makers are advised not only to formulate policies that make agricultural land accessible to smallholder farmers, but to also ensure tenure security as a way of promoting contract farming as a funding model for agriculture. This is a wakeup call for the government of Zimbabwe through the ministry of Lands, Agriculture and Rural Resettlement to speedily address the land disputes in the resettlement areas as well as finalize the processing and issuance of 99-year lease agreements to the resettled farmers.

Lastly, farmers with access to off-farm income were 0.6% less likely to participate in CF arrangements. There are two possible explanations for this observation. One reason could be that this group of farmers use part of their off-farm income to fund their farming operations hence there is little motivation for them to enter into contract farming arrangements. The second reason could be that these farmers are not full-time farmers and hence contractors are reluctant to work with them. Contract firms may feel that these farmers lack full commitment to farming and as such are risky to work with. Policies and programs that promote farming as a fulltime profession can go a long way in promoting contract farming.

4.7 Conclusion

The chapter focussed on addressing the research objectives, answering the research questions and testing the research hypothesis of the study. The key variables used in the analysis include the socio-economic characteristics the inputs used inn tobacco production and the tobacco yields. A Stochastic Production Frontier model was used to estimate the technical efficiency of smallholder farmers in Hurungwe as well as the associated socio-economic, biophysical and policy drivers of technical efficiency. The results demonstrated technical efficiency explained the farm level tobacco yield variations observed in the study area. Smallholder tobacco farmers in Hurungwe were found to be operating below the production frontier hence were inefficient. Before addressing selection bias, it was found that despite its popularity in the tobacco farming communities, contract farming did not have a significant impact in improving technical efficiency on participating farmers. This was clearly demonstrated using the t-test of mean equality to compare the average technical efficiency levels between the contract and non-contract farmers. However, after accounting for selection bias using propensity score matching, it was found that contract farming significantly increased technical efficiency of smallholder farmers and that contract farmers were 4.8 percent more efficient than non-contract farmers. This observation clearly demonstrated that contract farmers and non-contract farmers are different in observable characteristics and that there is selection bias when it comes to participation in contract farming which must be addressed before any impact evaluation is conducted.

Chapter 5 : SUMMARY OF FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter presents a summary of the research findings for the scientific enquiry into the impact of contract farming on the efficiency of smallholder tobacco farmers. These findings were very important because they shed some light into role of the private sector in agriculture development in Zimbabwe. This is an important subject given that most African governments (Zimbabwe included) either lack the financial capacity to fund agricultural development and have through, structural adjustment programmes, reduced their direct involvement in economic affairs of their countries. Based on the findings, conclusions were drawn that were translated into policy recommendations aimed at raising smallholder productivity. Lastly, although the study contributed to the academic debate on the role of contract farming, further studies are recommended to shed more light on the subject.

5.2 Summary of findings

The major objective of the study was to test whether the ability of contract farming to account for technical efficiency differential among smallholder tobacco was independent of self-selection bias. This was done through a comparison of the average technical efficiency scores between contract and non-contract tobacco farmers in Hurungwe district of Zimbabwe before and after accounting for self-selection bias through Propensity Score Matching techniques. The study also intended to identify determinants of technical efficiency to help understand farm-level variations in efficiency levels as well as efficiency differences between contract and non-contract farmers. Using cross sectional data for the 2016/2017 tobacco production season, the study applied stochastic frontier analysis to compute farm level technical efficiencies for the sample. The Cobb-Douglas production function was found to be the best fit for the data and was adopted as the functional form in the analysis.

The analysis revealed that smallholder tobacco farmers in Hurungwe were producing below their potential at 81.3%. In other word, they were producing inefficiently. Even after accounting for random error, both contract and non-contract farmers could increase their output if they improved on their technical efficiency. A formal t-test of mean equality was used to compare the mean technical efficiency scores between the two groups of farmers and showed no significant difference in their level of technical efficiency although contract farmers were slightly more efficient (83%) than non-contract farmers (81%).

The study also revealed that although the sample was drawn from the same geographic location, the socio-economic characteristics of the contract farmers were significantly different from those of their non-contract counterparts. For instance, contract farmers were on average an older group than con-contract farmers, literacy levels for contract farmers were higher than non-contractors. It was also observed that contract farmers were better networked and had better access to agricultural information via membership to farmers' groups, participation in field days and access to both contractor and government extension services compared to non-contract farmers. These observed differences introduced selection bias into contract participation.

Two sources of selection bias were identified in the sample. First the contracting firm looked at certain attributes like farming experience, track record in tobacco farming, access to tobacco curing facilities and proof of registration with the Tobacco Industry and Marketing Board before engaging a farmer in CF. Secondly, farmers participated in CF on a voluntary basis, in other words they chose to self-select into the program. It is this selection bias that prompted further analysis to come up with robust and credible conclusions on the impact of contract farming on technical efficiency. Propensity score matching was used to account for this bias.

When propensity score matching was used to address the selection bias, contract farming turned out to be a significant variable in explaining efficiency differences between the two groups of farmers. A comparison between the two groups using average treatment effect (ATT) found a significant difference in technical efficiency levels with contract farmers being 4.8% more efficient than non-contract farmers. Alternatively, non-contract farmers could raise their technical efficiency by about 4.8% if they participated in contract farming. These results clearly showed that selection bias matters in evaluating the impact of contract farming on technical efficiency in smallholder agriculture in Hurungwe, Zimbabwe.

5.3 Conclusions

The findings revealed that tobacco farmers in Hurungwe have the potential to increase their output if they address inefficiencies in their production systems. At the current level of technology, Hurungwe farmers can further consolidate their status as the prime tobacco producers in Zimbabwe by improving their resource use efficiency. Based on these conclusions, we fail to reject the hypothesis that smallholder tobacco farmers in Zimbabwe are technically inefficient given their current production potential. These findings are significant in that it helps in understanding why despite tobacco farming being classified as a lucrative business, smallholder tobacco farmers still remain amongst the poorest members of the community in Zimbabwe. This also explains why it is taking long for smallholder farmers to wean themselves from these contract farming arrangements despite complaining about unfair trade practices by some contracting firms. The results can also be used to explain the fall in national tobacco output from the peak levels of 1998.

The study also concluded that there are significant demographic and socio-economic differences between contract and non-contract farmers which influences participation in contract farming. This observation confirms that selection bias matters in assessing impact of contract farming on technical efficiency hence the need for robust impact evaluation techniques.

Finally, the question on whether contract farmers were more efficient than noncontract farmers was settled after accounting for self-selection bias through PSM. It was found that contract farmers were more efficient that non-contract farmers and this leads to the conclusion that contract farming improves technical efficiency. The hypothesis that; "***There are no significant differences in average technical efficiency between contract farmers and non-contract farmer"*** is therefore rejected. However, despite achieving a higher average technical efficiency score than non-contract farmers, it should be noted that contract farmers also produced below their frontier meaning that inputs provided under contract farming were not being complemented by comprehensive package of services to ensure full efficiency. It further shows that contract farming is just one part of the big puzzle that need to be solved if efficiency levels are to be improved in smallholder tobacco farming.

5.4 Policy recommendations

Following this investigation, the results presented in chapter 4, and having concluded that contract farming has a positive impact on productivity for smallholder farmers, it is imperative to ask whether it is worth pursuing contract farming as a funding model for smallholder tobacco production or agriculture in general. This study makes a number of policy recommendations on this and other issues of importance in agriculture.

Basing on this research, CF can be adopted as a funding model for smallholder tobacco farming. Contract farming can be viewed as an institutional machinery used for addressing some of the production constraints in agriculture. As argued by Miglani (2016), a machine can either perform good or bad depending on where it is used, how it is used and who used it. Using the same argument, the success of contract farming hinges on identifying the right crop to contract, the right farmers to engage.

The study revealed that there are notable differences in socio-economic characteristics of smallholder farmers. Given the observed positive impact of CF on TE, government can play an important role in building the capacity of farmers by identifying and developing those characteristics or attributes that contractors look for before engaging farmers in contract farming arrangements. The study established that membership to farmers' groups, agricultural field day attendance and farm size increased the probability that farmers will participate in CF. Thus to promote CF, the government and policy makers play an important role by encouraging farmers to join farmers' groups, attend agricultural field days in addition to making farmland accessible. In addition, issues like secure land tenure, irrigation development, transport infrastructure and strengthening of farmer organisations should be prioritized when developing agriculture policies as they promote contract participation.

As highlighted in the preceding section, CF is just part of a complicated agricultural development conundrum when it comes to addressing farm-level efficiency losses. To address productivity challenges, faced by smallholder tobacco farmers, this study identified some issues that need to be included in the agriculture policy formulation.

For instance, the socio-economic differences within the smallholder sector can also give some policy direction in the sense that when proving assistance to these farmers, government programs need to be individual or group specific noting that smallholder farmers is comprised of communal, old resettlement as well as A1 farmers who have different needs and objectives. "Blanket" implementation of agricultural development interventions will not address farmer specific needs hence will not be effective or sustainable.

Education level was found to have a positive impact on farm-level technical efficiency. Although the country needs to be commended for its education policy which is responsible for the high literacy rate amongst its citizens, more investment in this area could narrow the gap between the current production levels and the frontier. Given that most of these farmers are past their school-going age, this can be achieved through adult-education, farmer trainings and vocational training as key educational policy instruments for improving productivity in agriculture.

Taking farming as a full-time profession impacted positively on production efficiency while off-farm income showed a negative impact although it (off-farm income) makes rural livelihoods more resilient. Policy makers can use this observation to formulate policies that encourage farmers to take farming as a full-time profession. This can be achieved by investing in rural infrastructure like irrigation, roads, electricity, financial and other social services to match those in urban areas. Such policies will make rural areas attractive habitats thereby curbing rural-urban migration which has given rise to the increase in the so called 'cellphone' farmers. More importantly, services such as irrigation, financial and insurance services reduce the risks associated with agriculture, promotes investment in agriculture and encourage farmers to take farming as a full-time profession thereby improving productivity.

The efficiency regression model revealed that farm size and area under tobacco had an inverse relationship with technical efficiency. This result can be used to justify the land reform, which resulted in the subdivision of the large commercial farms into smaller pieces that could be more efficient if well managed. However, there is need for formulation of policies that encourage intensive farming so that the smallholder farmers are more productive. Further redistribution of underutilized land and capital provision to resettled farmers could boost efficiency in smallholder farming. Extension access was also found to positively impact on efficiency. This calls for government and the private sector to invest in an effective extension system in terms of coverage and quality of service. In this regard there is need for investment in extension mobility to increase accessibility of extension services as well as refresher trainings aimed at intensive farming practices to improve efficiency. Extension workers can also encourage farmers to participate in field days and joining farmers' clubs since it is through such networking that they can share farming experiences and get vital information like firms offering contract farming arrangements in their areas.

5.5 Areas of further study

This study provided some insight into the impact of contract farming on technical efficiency in Hurungwe district. This information feeds into the ever-expanding literature on contract farming and its impact on productivity. However, a number of limitations *(see section 1.6)* were identified in the way this study was designed hence this study address some of the knowledge gaps on contract farming. To address this knowledge gap as well as contribute to this growing body of literature, this study recommends three dimensions that future research can take.

(i) Given that this study focussed on private-led contract farming, it can also be extended to government-led contract farming arrangements like the ‘command agriculture’ which are targeting other crops like maize and wheat in Zimbabwe. Focussing on these food crops could shed more light into the impact of contract farming on efficiency as well as well as on food security.

(ii) This study on technical efficiency could not give a more comprehensive economic efficiency analysis, hence the study could be extended to include allocative efficiency. Another dimension of the study could be doing a comparative study across all the tobacco producing regions to see how contract farming effects on efficiency differ across regions. Results from such a study can be useful in that farmers across the geographic space can learn from each other on how to manipulate certain variables to increase productivity and efficiency.

(iii) Lastly, just like the majority of previous studies on the impact of contract farming, this study focused on the short-term impact hence the conclusions only apply in the short run. Such short-term analysis does not allow for a comprehensive trend analysis on the impact of contract farming on productivity. Therefore, in the presence of panel data, it would be interesting if this study could be extended to a time series analysis so that the impact of contract farming can be evaluated over a time period. Such a study could shed more light on whether contract farming can sustain the efficiency gains in tobacco farming. In addition, the question of whether or not the improvements in efficiency is a short-term phenomenon will also be addressed by such a study.

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Appendix A: LETTER OF CONSENT

Accounting for technical efficiency differentials among smallholder contract tobacco farmers in Hurungwe, Zimbabwe: impact of self-selection bias in contract participation

Research conducted by: Mr G. Mhondoro

Contact details: Cell: +27 (0) 844862798; Email: gwenzimhondoro@gmail.com

Dear respondent

You are invited to participate in a research study conducted by Gwenzi Mhondoro, a Masters student from the Department of Agricultural Economics, Extension and Rural Development at the University of Pretoria.

The purpose of the study is to investigate whether the ability of contract farming to account for technical efficiency differentials amongst smallholder tobacco farmers from Hurungwe District in Zimbabwe is independent of self-selection bias. The study is targeting beneficiaries of the Fast Track Land Reform Programme (FTLRP) in Hurungwe district. Participation in this survey involves responding the questions that will be asked and this should take less than an hour. The questions require you to provide information on your household characteristics, assets, agricultural inputs, agricultural outputs, access to agricultural markets as well as any other information that relate to agriculture. Please note the following when responding;

- This study involves an anonymous survey. Although your name will appear on the questionnaire, the information you provide will be treated strictly as confidential.
- Your participation in this survey is very important to us and the study. However, this is a voluntary exercise and you may choose not to participate and you may stop participating at any time without negative consequences.
- The results of this study are solely for academic purposes as well as influencing policies that impact on agriculture and may be published in academic journals. If interested, we will provide you with a summary of the results of this study.
- Please contact my supervisor, Dr. E. D. Mungatana at eric.mungatana@up.ac.up if you have any queries or comments about the study
- Please sign this form to indicate that you understand the information provided above and that you are willing to participate in this study on a voluntary basis.

Respondent signature…………………………..Date………………..

Appendix B: SURVEY INSTRUMENT

Questionnaire No ☐

Title of study: **Accounting for technical efficiency differentials among smallholder contract tobacco farmers in Hurungwe, Zimbabwe: impact of self-selection bias in contract participation**

Institution: **University of Pretoria, Department of Agricultural Economics**

Researcher: **Gwenzi Mhondoro**

Contact details: **+27844862798; gwenzimhondoro@gmail.com**

Date : ___/_______/2017

SECTION A: IDENTIFYING INFORMATION AND HOUSEHOLD CHARACTERISTICS

Name of Interviewer: ____

Grower Number								
Name of Interviewee								
Relationship of interviewee to Household head (tick box below)	Self	Wife	Husband	Manager	Child	Parent	Other	
Address/location/Farm number								
Contact Number/email								

1. HOUSEHOLD HEAD CHARACTERISTICS				
Age	Gender 1=male 2=female	Marital status 1=married 2=never married 3=divorced 4=separated 5=widowed	Main occupation 1=farmer 2=employed in private sector 3=civil servant 4=trader 5=not in the labour force 6=other (specify………	Education level 1=Primary level 2=Secondary level 3=Tertiary certificate 4=Tertiary diploma 5=First degree 6=Postgraduate 7=No formal education

2. HOUSEHOLD COMPOSITION			
Age group	Gender		Total
	M	F	
0-10			
11-17			
18-65			
65+			
Total			

SECTION B: CONTRACT FARMING PARTICIPATION

1. Are you a contract or independent tobacco producer? 1=Contract 2=Independent ***(If independent go to question11)***
2. What motivated you to go into contract farming?...
3. If contract, give the name of the contractor………………………………………………………………………………………
4. What is the duration of the contract agreement?......................Years
5. For how long have you been growing tobacco under contract?.........Years
6. What input(s)/service(s) did you receive from your contractor during the 2016/17 season? Circle all input(s)/service(s) received.
   1=seed 2=fertilizers 3=agrochemicals 4=land preparation/fuel for land preparation 5=packaging material 6=coal/firewood 7=training

   8=extension 9=transport 10=cash advances 11=others
7. Were the inputs from the contractor **sufficient** for your tobacco production requirements? 1=Yes 2=No
8. If **No**, give reasons for the shortfall. 1=limited stock from contractor 2=poor estimates 3=other (specify)

9. Did you receive your inputs **on time**? 1=Yes 2=No
10. Has the area allocated to tobacco production by your household been increasing or decreasing **since joining contract farming**?
    1=Increasing 2=Constant 3=Decreasing
11. If **independent** did you try to apply for contract farming with one of the contractors? 1=Yes 2=No
12. If **No**, give reasons why did you chose to produce independently?…..
13. If **Yes**, why was your application rejected?..

SECTION C: RESOURCE ENDOWMENT

1. LAND OWNERSHIP AND TENURE					
Size of land (Ha)	Distance from homestead	Portion of Land allocated to tobacco during 2016/17 season (Ha)	Land ownership/access 1=offer letter 2=government lease 3=rented (give rental charges/season) 4=communal	Mode of acquisition 1=government allocation 2=rented 3=purchased 4=other	Year acquired

3. How many of the following assets do you own?																
	Draft Animals		Farm Implements							Transport related assets			Appliances and electronics		
Asset	Cattle	Donkey	Tractor	Tractor drawn Disc harrow	Tractor drawn planter	Tractor drawn trailer	Ox drawn plough	Ox drawn planter	Ox drawn trailer	Bicycle	Motorbike	Car	TV	Radio	Mobile phone
No															

4. Does your household have access to electricity? 1=Yes 2=No
5. Do you have functional irrigation facilities on your tobacco fields? 1=Yes 2=No
6. Do you own or rent tobacco curing barns? 1=Own 2=Rent 3=Communal barns
7. What type of tobacco curing barns do you use? 1= tunnel system barns 2= bulk curers 3= conventional barns 4=rocket barn 5= plastic barns
8. Give a motivation for your choice of tobacco curing barn……………………...…………………………………………………………..

SECTION D: EXPERIENCE AND NETWORKING

1. For how long have you been involved in agriculture?..................Years
2. How long have you been growing tobacco………………………Years
3. Do you attend/participate in field days? 1=Yes 2=No
4. Do you belong to a farmer's club/organisation/cooperative? 1=Yes 2=No
5. If **Yes**, give reason(s) for joining the club/organisation/coop. 1=Government directive 2=Contractor directive 3=Need to learn and share experiences with fellow farmers 4=To easily acquire inputs 5=To market produce collectively
6. If **Yes** for how long have you been a member?…………………………Years

SECTION E: ACCESS TO SUPPORT SERVICES (EXTENSION AND FINANCIAL SERVICES)

1. Do you have access to agriculture extension services? 1=Yes 2=No
2. If **Yes,** where do you get extension advice from? 1=Government extension officers 2=Contractor 3=Both

3. On average how many extension visits did you get during the 2016/17 season?
4. **In addition to your answer to question 2**, how else do you get agriculture information? (*Put an X below source)*

Source	Television	Radio	National newspapers	Local newspapers	Farmer magazines	Internet	Posters and brochures	Farmer/village meetings	Other (specify)

5. Do you have access to any source of credit **(other than from the contractors)** 1=Yes 2=No
6. If **Yes**, indicate source(s) 1=Financial institutions 2=Informal sources 3=Input suppliers
7. **Apart from farming,** do you have other sources of income? 1=Yes 2=No
8. If **Yes**, indicate sources. 1=Formal employment 2=Casual labour 3=Trading 4=Remittances
9. How does this off-farm income compare to your farming income? 1= Very small 2=Small 3=Same 4=Large 5=Very large

Key: ***Very small - Less or equal to half the farm income***

Small - Greater than half farm income

Same - Equal to farm income

Large - Greater than farm income

Very large - Double plus farm income

SECTION D: AGRICULTURE PRODUCTION INFORMATION FOR 2016/17 SEASON

1. Which crops did you grow in the 2016/17 season?

Crop	Tobacco	Maize	Cotton	Soybean				
Area (Ha)								
Output (ton/kg)								

2. Name(s) of tobacco variety grown...

3. When did you plant your tobacco?

	Seedbed sowing	Transplanting
Earliest date		
Latest date		

4. Reasons for different planting dates...

5. Tobacco Production inputs for 2016/17 season

	Tobacco Production Stages					
Input	1) Seedbed		2) Main Field Operations (Transplanting-harvesting)		3) Post-harvest	
	Quantity	Cost	Quantity	Cost	Quantity	Cost
Seed/seedling						
Land Preparation						
Fertilizer						
Herbicides						
Pesticides						
Fuel						
Firewood/coal						
Packaging						
Other						

6. What is the distance to your input market?...kms

7. How much labour did you use for the following operations?

Operation	**Family labour**		**Hired labour**		**Wage rate per day**
	No. of people	**Days worked**	**No. of people**	**Days worked**	
Tobacco Nursery (from seedbed prep to transplanting)					
Land preparation (Ploughing and ridging of main field)					
Transplanting					
Fertilizer application					
De-suckering and topping					
Weeding					
Spraying					
Harvesting					
Curing					
Grading and bailing					

SECTION E: MARKET INFORMATION

1. Where did you market your tobacco during the 2016/17 marketing season?

Market	Quantity (kg)	Distance to market	Do you deliver or they collect	Average price/kg
Contractor				
Auction floors				
Middlemen				
Other				
Total				

SECTION F: CHALLENGES

1. What challenges do you face in the production of tobacco? ***Put an X bellow the challenge***

Challenge	Labour shortage	Shortage of seed/seedlings	Shortage of fertilisers	Shortage of chemicals	Shortage of fuel for curing	Lack of technical knowhow	Unreliable rainfall	Inadequate extension services
X								

2. What challenge(s) did you face when marketing your tobacco?
………
3. Are you planning to grow tobacco next season? Yes ☐ No ☐
4. Give reason(s) for you answer ……..…………………………………………………………………………………
5. If **Yes to 3**, are you planning to increase, decrease, or maintain your area under tobacco?
1= Increase area 2=maintain current area 3=decrease area
6. Motivate your answer. ..…..……………………………………………………………………………………………
7. Provide any other information or comments with regards to your farming operations…………………………………………………
……

Thank you very much for your time

Appendix C: ELASTICITY OF SUBSTITUTION CALCULATIONS

Elasticity of substitution can be calculated using the following formula;

$$\delta_{ij} = \frac{-f_{ii}/f_i^2 + 2(f_{ij}/f_i f_j) - f_{jj}/f_j^2}{1/x_i f_i + 1/x_j f_j} \quad \textit{where,}$$

f_i is the first order conditions of the of the i[th] input

f_{ii} is the second order conditions of the of the i[th] input

f_i is the first order conditions of the of the j[th] input

f_{ii} is the first order conditions of the of the j[th] input

f_{ij} cross partial of the i[th] input I with respect to the j[th] input

X_i and X_j are the i[th] and j[th] inputs respectively

Given the production function;

$$\ln(Y) = 1.497 + 0.103\ln(X_1) + 0.288\ln(X_2) + 0.500\ln(X_3) + 0.300\ln(X_4) + \mu$$

$f_1 = \frac{0.103}{X_1}$ $\qquad f_{11} = \frac{-0.103}{(X_1)^2}$

$f_2 = \frac{0.288}{X_2}$ $\qquad f_{22} = \frac{-0.288}{(X_2)^2}$

$f_3 = \frac{0.5}{X_3}$ $\qquad f_{33} = -\frac{0.5}{(X_3)^2}$

$f_4 = \frac{0.3}{X_4}$ $\qquad f_{33} = -\frac{0.3}{(X_4)^2}$

$f_{12} = f_{13} = f_{14} = f_{23} = f_{34} = 0$

Using the elasticity formula above,

$$\delta_{12} = -\frac{(-0.103)/(X_1)^2 * (X_1)/0.103^2 + 0 - (-0.288)/(X_2)^2 * (X_2)/0.288}{1/X_1\left(\frac{0.103}{(X_1)}\right) + 1/X_2\left(\frac{0.288}{(X_2)}\right)}$$

$$= \frac{(X_1/0.103) + (X_2/0.288)}{(X_1/0.103) + (X_2/0.288)}$$

$$= \mathbf{1}$$

$$\boldsymbol{\delta_{13}} = -\frac{(-0.103)/(X_1)^2 * (X_1)/0.103^2 + 0 - (-0.5)/(X_3)^2 * (X_3)/0.5}{1/\left(X_1\left(\frac{0.103}{(X_1)}\right)\right) + 1/\left(X_3\left(\frac{0.5}{(X_3)}\right)\right)}$$

$$= \frac{(X_1/0.103) + (X_3/0.5)}{(X_1/0.103) + (X_3/0.5)}$$

$$= \mathbf{1}$$

$$\boldsymbol{\delta_{14}} = -\frac{(-0.103)/(X_1)^2 * (X_1)/0.103^2 + 0 - (-0.3)/(X_4)^2 * (X_4)/0.3}{1/\left(X_1\left(\frac{0.103}{(X_1)}\right)\right) + 1/\left(X_4\left(\frac{0.3}{(X_4)}\right)\right)}$$

$$= \frac{(X_1/0.103) + (X_4/0.3)}{(X_1/0.103) + (X_4/0.3)}$$

$$= \mathbf{1}$$

$$\boldsymbol{\delta_{23}} = -\frac{(-0.288)/(X_2)^2 * (X_2)/0.288^2 + 0 - (-0.5)/(X_3)^2 * (X_3)/0.5}{1/\left(X_2\left(\frac{0.288}{(X_2)}\right)\right) + 1/\left(X_3\left(\frac{0.5}{(X_3)}\right)\right)}$$

$$= \frac{(X_2/0.288) + (X_3/0.5)}{(X_2/0.288) + (X_3/0.5)}$$

$$= \mathbf{1}$$

$$\boldsymbol{\delta_{24}} = -\frac{(-0.288)/(X_2)^2 * (X_2)/0.288^2 + 0 - (-0.3)/(X_4)^2 * (X_4)/0.3}{1/\left(X_2\left(\frac{0.288}{(X_2)}\right)\right) + 1/\left(X_4\left(\frac{0.3}{(X_4)}\right)\right)}$$

$$= \frac{(X_2/0.288) + (X_4/0.3)}{(X_2/0.288) + (X_4/0.3)}$$

$$= \mathbf{1}$$

$$\boldsymbol{\delta_{34}} = -\frac{(-0.5)/(X_3)^2 * (X_3)/0.5^2 + 0 - (-0.3)/(X_4)^2 * (X_4)/0.3}{1/\left(X_3\left(\frac{0.5}{(X_3)}\right)\right) + 1/\left(X_4\left(\frac{0.3}{(X_4)}\right)\right)}$$

$$= \frac{(X_3/0.5) + (X_4/0.3)}{(X_3/0.5) + (X_4/0.3)}$$

$$= \mathbf{1}$$