Two Stage Maize Supply Chain Model for Production and Marketing Efficiency

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Abstract

This study, aimed at examining the economic efficiency of resettled A1 maize farmers in maize supply chains. The main objective of the study was to find out the most economic supply chain Descriptive statistics was used to describe inputs sources and outputs while DEA was used to assess the economic efficiency of farmers in supply chains. Multi-stage sampling procedure was adopted to sample the respondents in Marondera District. A total of 343 respondents were interviewed using structured interview guide. Results indicated that, A1 farmers participate in a number of markets that include agricultural inputs markets and credit markets which include banks as well as labour markets. Results also indicated that formal channel is more efficient than informal channel. Farmers are economically efficient at production stage than marketing stage. Farmers are recommended to use formal channel of marketing because they are more efficient than informal channel. Farmers will get more money by using the formal channels than informal channels. The government is also recommended to correct inefficiencies and ineffective institutions that have given rise to more informal activities.

1. Introduction

Agricultural sector plays an important role in the development of the Zimbabwean economy, through its impact on the overall economic growth, households' income generation and food security (Juana and Mabungu, 2005). It provides employment and income for 60-70 percent of the population, supplies 60 percent of the raw materials required by the industrial sector and contributes 40 percent of total export earnings (FAO, 2016). The sector accounts for 25 percent of the total workforce in formal employment while contributing an average of 17 percent of Gross Domestic Product (Juana and Mabungu, 2005).

One of the distinguishing features for Zimbabwean agricultural sector is its dualism, existence of two major groups based on land size. The larger group is unsophisticated and comprises a heterogeneous set of smallholder farmers of about 7.1 million and communal farmers occupying a total of 21 million hectares (FAO, 2016). According to Rukuni et al., (2006), the smallholder or small scale farmers are further sub divided into small-scale commercial sub-sector, the model A1 sub-sector and the communal area sub-sector while the large scale commercial farmers are subdivided into the large scale commercial sub-sector and the model A2 sub-sector.

FAO (2016), reports that, most of the smallholder farmers occupy areas of lower natural potential for agriculture in terms of rainfall, soils and water for irrigation expect for the resettled A1 farmers who were born out of the decongesting the communal areas. Most of these farmers occupy the former white commercial farmers' farms. However, the rest of areas for other groups of smallholder farmers are characterized by low economic potential

because of long distances from markets and poor communication and social infrastructure. Within the smallholder sector, the communal subsector constitutes 64% (1100000 farms), the A1 subsector constitutes 22% (141656 farms) while the remaining 14% is classified under old resettlement (72000 farms) (FAO, 2010). In relation to maize production, the smallholder sector contributes, on average over 60% of the national maize output (Rukuni et al., 2006).

In Zimbabwe, maize is one of the most important crop as it is the staple food crop and accounting for over 50 percent of the average calorie consumption of about 13.1 million people (USAID ,2016).It is also an important component of food security and livelihoods among smallholder farming communities (Mazvimavi et al., 2006). Food security in Zimbabwe is closely associated with maize production, which is the country's staple crop (Rubhara et al., 2020) Maize is grown by over 90 percent of the 1.3 million farming households across the country accounting for over 60 percent of the total annual cropped area, or between 80 and 90 percent of the total land area under cereal production (USAID, 2016). However, the majority of resettled A1 farmers grow maize primarily for subsistence and surplus for marketing.

A distinctive trend in most agricultural production since land redistribution in Zimbabwe has been a decline in output largely due to institutional deficiencies resulting in reduced areas. One such factor that has contributed to low maize production among the A1 farmers is the complexities of supply chains. Many agricultural supply chains are highly complex, making it very difficult for A1 farmers to perform economically. The complexities of the supply chains are due to deficiencies of institutional factors such as access to input market information, access to inputs markets, poor road infrastructure, access to credit unavailability of contractual agreements and unavailability of extensive social capital (FAO, 2016).Structured supply chains that are dependable with transparent information systems, supportive financial systems or credit facilities, and quality storage facilities that would enhance A1 farmers' maize production and marketing economic efficiency are missing.

For agriculture to prosper, farm inputs need to be available, affordable, accessible, and good quality (John et al., 2015). Seeds, fertilizers, and agro-chemicals, are essential for improving the productivity and incomes of smallholder farmers (John et al., 2015).However, most A1 farmers in Zimbabwe rely on intermediaries or known as middlemen in purchasing their inputs .They rely on middleman because they are resource constrained. It is important however to note that, the more intermediaries are involve in the supply chain, the more expensive it is for the farmers to get the inputs and the lesser it is for the farmer to get profit though the consumers will pay high prices for the maize products.

The success of A1 farmers in maize production and marketing lies on, successful supply chain development which reduce not only the transaction costs but also the institutional barriers that decouple individual links in traditional distribution channels (John et al., 2015). Better supply chains allows participant to achieve higher levels of service and to capture substantial added value thereby improving economic efficiency in both maize production and marketing which serves as a leverage for both poverty reduction and economic growth.

This study therefore, describes maize supply chains and marketing channels used by A1 resettled farmers and then evaluates their economic efficiency because, improvement of economic efficiency is important for maize productivity. Maize production and efficiencies among the A1 maize farmers have been low since the land reform (Mugabe and Etienne, 2016). In this regard economic efficiency among the resettled A1 maize farmers in Zimbabwe is important because it increases maize output, raises farmers' income and improves household food security which contributes to reduction of poverty in the country.

Problem statement

The study examined economic efficiency of A1 farmers. This is because, improvement of economic efficiency is important for agricultural productivity and production and marketing efficiencies among A1 maize farmers have been low since land reform Mango et al., (2015). Mango et al., (2015) reiterated that, per capita maize production is slowly declining because of a significant decline in yield per hectare over time. One such factor that has contributed to low maize production among the A1 farmers is the complexities of supply chains. Many agricultural supply chains are highly complex, making it very difficult for A1 farmers to perform economically and this has not studied among the newly resettled A1 famers in Zimbabwe. In this regard economic efficiency among resettled A1 maize farmers in Zimbabwe is important because it increases maize output, raises farmers' income and improves household food security which contributes to reduction of poverty in the country.

2. Materials and Methods

2.1 Description of the study area

Marondera District

The study was conducted in Marondera District of Mashonaland East province in Zimbabwe which is one of the nine provinces that constitutes the breadbasket of the country. Marondera District is mainly characterized by

farming in the form of urban, peri-urban and rural communities constituting rural resettlements areas. The rural resettlement areas are made up of A1 and A2 and also sizeable numbers of commercial farms which are found in and around Marondera urban areas. The district has more A1 resettled farmers than any other district in the province. People in resettled areas rely mainly on farming and those near farms found livelihoods as farm workers. Records from Mashonaland East Province statistical office shows that Marondera District has the total population of around 118547 farmers.
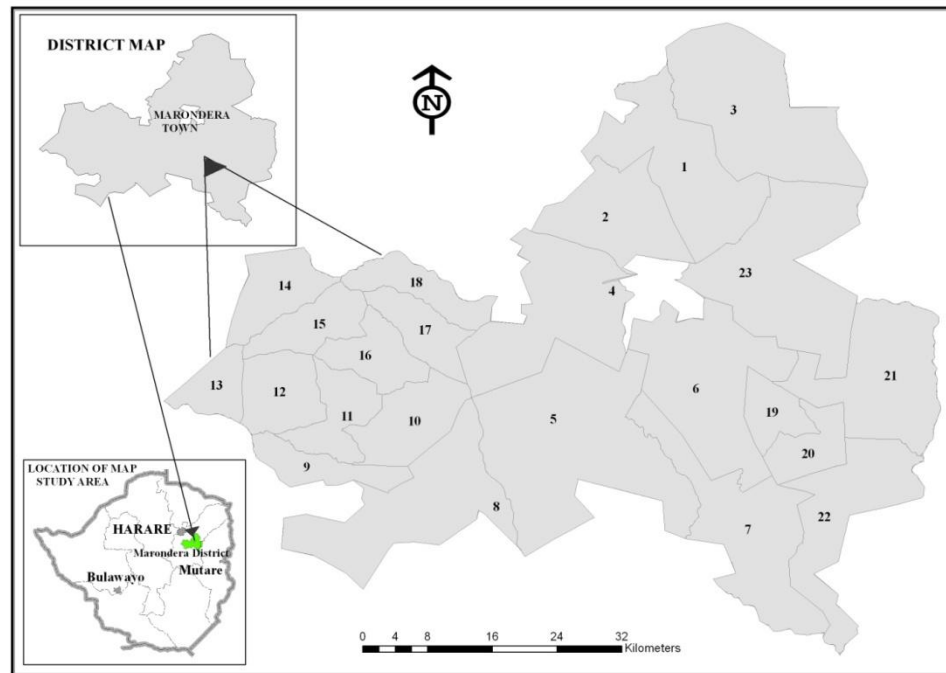

Figure 1. Showing the map of Marondera District.

The district is situated in agricultural natural region 2 with an average annual rainfall of about 500mm-1000. High rainfall and very cold temperatures are usually recorded around months of December to February and May to July (Mash East Zimstats, 2014). The month of October is warmest with an average temperature of 30.1 °C at noon. July is coldest with an average temperature of 6.5 °C at night. The district has no distinct temperature seasons; the temperature is relatively constant during the year. Temperatures drop sharply at night and increases during the day. These climatic conditions are favourable for maize production and subsequent marketing.

Marondera District has some of the most fertile lands in the province and the lands are particularly suited to grow maize and other heavy feeder crops like tobacco, paprika, tomatoes, potatoes and sorghum. The climate is classified as a humid subtropical (dry winter, hot summer), with a subtropical dry forest biozone. The soil in the area is high in lixisols (lx), soil with clay-enriched lower horizon, own cation exchange capacity and high saturation of bases which are suitable for maize production.

The distinguishing symbols of success in Marondera District are the modest houses with the asbestos roofs, sizeable herds of cattle and its ability to harvest even when there is a drought in the whole country. In times of drought, people from surrounding districts like Hwedza, Seke, Goromonzi, Murehwa and Chikomba would come to seek grain from Marondera District. The farmer manages to ride over most of the droughts by farming three main crops namely maize, beans and finger millet and these grains are supplemented by vegetables, Irish potatoes, sweet potatoes, tobacco and citrus fruits. Their main market for, tomatoes, citrus fruits, and a vegetable is Mbare Musika. Grains are sold at Grain Marketing Board (GMB) and many other grain dealers like Manyame grain millers, Adult millers and many others

2.2 Sampling frame and sample selection

A multi-stage sampling procedure was adopted. Firstly the study district was purposively selected owing to its largest number of resettled A1 farmers of about seven thousand and twelve farmers .The list of A1 farmers was obtained from Marondera District AGRITEX officer who works with the farmers. This was followed by stratifying the district wards using the villages with highest number of A1 farmers. Then, the villages with highest number of resettled A1 farmers were purposively selected and finally, simple random sampling was conducted within the villages.

Determination of sample size and method used to collect data

An approach based on precision rate and confidence level method to determine the sample size of A1 finite farmers was used as the farmers are homogeneous in terms of the size of land and populations known (Kothari, 2004). A Sample of four hundred A1 farmers was to be randomly selected and interviewed. However, seven farmers who produced maize for consumption only were not included in the final sample of farmers as they do not market their maize.

Sampling technique of Slovin's formular was used to calculate a sample of farmers in study area. This technique allows the researcher to sample the population with some degrees of accuracy and so it gives the idea of how large is the sample size should be to ensure reasonable accuracy of results.

This formula takes into account the confidence levels and margins of error.

Slovin's formular (1960)

$$n = \frac{N}{(1 + Ne^2)}$$

Where
n= Sample of A1 resettled farmers in Marondera District
N=Total number of resettled A1 farmers in Marondera District.
e = Error tolerance to be allowed in selecting the A1 resettled farmers in Marondera District
n= 7012/(1+7012 *0.05²)
n= 400
In this case
N =7012 A1 resettled farmers in Marondera district
e = 95 percent which give an error margin of 0.05
Adapted from Kothari,(2004)

Four hundred of A1 resettled maize farmers out of seven thousand and twelve (7012) were selected and three hundred and forty –three were interviewed using structured household questionnaires. Primary data was collected through administration of well designed, comprehensive and pre-tested structured questionnaire. The questionnaire was pre-tested in different sites of the study area and modified accordingly to improve the clarity of questions and remove irrelevant questions through a survey method.

2.3 Data Analysis

Descriptive production and marketing analysis of maize typically examines the activities involved in producing and marketing. The process starts from research and development, to raw materials supply and production, transport and delivery, noting where value could be added, as well as examining business needs and how upgrading particular activities could enhance profitability of farmers. Analysis of production and marketing related activities requires for identification of input supply chains which are important variables in maize production and marketing processes.

Input supply chains describes information collected during input market mapping about which products are purchased by whom, from where and on what terms, and how farmers access markets (Mau, 2002).This also describes costs involved such as transportation (both inputs and person), purchase prize, storage, labour, accommodation and food purchased by the famer. This information can help to construct input supply chain for maize and identify when institutional or infrastructural problems associated with a crisis are likely to disrupt previous market participation patterns. Input supply chains can pinpoint how market actors may be affected by a supply shock. Input supply shocks can disrupt the movement of maize inputs along any point of the supply chain (McArthur and McCord, 2017). For instance, input supply shocks can impact production through increased prices of inputs such maize seed, fertilizer, herbicides, pesticides and labour shortages   may results in production failures or shortfalls. Supply shocks can also occur following infrastructural damage, disruption to transportation, new regulations, conflict, and new trade policies.

However, the process of identifying and analysis of the supply chains is complicated due to presence of multiple inputs and multiple outputs in the maize sector. (Theodoras et al., 2005). This implies that it is multi-dimensional. The multi-dimensionality involves numerous interdependencies and conflicts between the goals. The complexity of

most input supply chains makes it difficult to understand how production and marketing activities at multiple tiers are related and impact each other. Another complexity that input supply chains is facing is the conflicting goals of individual actors in the chain. Each individual actor has its own goals and optimization criteria. Conflicting interests of different actors in the chain complicates the availability of information. The relevance of information differs in each stage of the chain, even if information is of high importance for the production and marketing of maize performance. Moreover, the strategic value of some of information inhibits a free exchange between chain partners

In this study focus is on A1 resettled maize farmers' economic performance in maize supply chains. This requires the understanding of economic efficiency .The following section will therefore explain economic efficiency and different type of efficiencies as well as the models used to analyse efficiency.

Economic efficiency

Efficiency has always been on the agenda of agricultural production economics literature because inputs are scarce and expensive. There is need therefore to investigate agricultural efficiency through evaluating how farmers perform under existing supply chains.

Farrell (1957), explicitly decomposed overall economic efficiency into components namely technical efficiency and allocative efficiency. Profit maximisation requires a farmer to produce the maximum output given the level of inputs employed (technically efficient), use the right mix of inputs in light of the relative price of each input (input allocative efficient) and produce the right mix of outputs given the set of prices (output allocative efficient) (Kumbhaker and Lovell, 2000). Technical efficiency reflects the ability of the Decision Making Unit (DMU) to obtain maximum output from a given set of inputs or to minimize inputs to produce a given bundle of output. Allocative efficiency is the ability of a DMU to use inputs in optimal proportions, given their respective prices and production technology. In this study emphasis was given to allocative efficiency, economic efficiency and then technical efficiency as explained in the following section.

Technical Efficiency

The ratio between the observed and potential output of a production unit) are two indicators that are widely used to provide a rigorous measure of the efficiency of production of a unit/farm (Porcelli, 2009).These indicators shows the rate at which inputs are transformed into outputs or how the production system is maximising the outputs from a set of minimal inputs. In this study the resettled farmers' technical efficiency is of concern because inputs are scarce and maize production is declining yearly.

Allocative efficiency

In Zimbabwe inputs are expensive because resources used to manufacture inputs are scarce, hence resettled A1 famers must decide how to use those inputs for their maximum benefit. In agricultural production, when inputs like seed and fertiliser are used to produce maize, those inputs become unavailable for any other purpose. Because inputs are scarce, farmers have to decide what those inputs will be used to produce, since any input that is used to produce maize reduces the inputs available for the production of other crops like vegetables. Allocative efficiency therefore has to do with the extent to which resettled farmers make decision by using inputs up to the level at which the marginal value product (MVP) equal to the Marginal Factor Cost (MFC). This means that, a farmer has to choose the inputs in optimal proportions, given their input prices to avoid misallocation or allocative inefficiency.

Allocative efficiency measures the extent to which an analyzed Diminishing Marginal Utility (DMU) produces its outputs in a production that minimizes cost of production, assuming that the unit is already fully technical efficient that is when allocative is pareto efficient (Deng and Leonard, 2008). A farmer therefore is considered to be allocative efficient in the use of production inputs if the farmer is able to equate the value of the marginal value product (MVP) of the factor to that of factor price and able to maximize profit with respect to that input.

Technical and allocative efficiency provide four ways for explaining the relative performance of farms. Firstly, a farm might show both technical and allocative inefficiency and secondly, it might be technically efficient but allocatively inefficient. The third scenario is that, it may display allocative efficiency but technical inefficiency; while the fourth scenario might be both technically and allocatively efficient.In this study, economic efficiency was analysed by Data Envelopment Analysis (DEA) Model and is described below.

Data Envelopment Analysis (DEA) Model

To evaluate the economic efficiency of maize input supply chains among the A1 resettled farmers, an approach that incorporates multiple performance criteria was required so; DEA was used. The problem with respect to efficiency in maize production is that, beside direct outputs, which are delivered directly to the market, a farm also produces output that is input to a farm in the next stage. These intermediate outputs are intermediate inputs to the farm in the adjacent stage, next to the direct inputs. DEA allows inclusion of various dimensions, for example, economic and environmental performance; therefore, it was employed in this study.

DEA is a linear programming-based and non-parametric technique for evaluating the relative efficiency of each member of a set of organizational units (Charnes et al., 1978).The idea of DEA is to estimate a frontier that envelops

all the input/output data with those observations lying on the frontier considered technically efficient. DEA estimates a production frontier using information on inputs and outputs by enveloping the observed combinations of inputs and outputs. The envelopment technique implies that all best performers along the different dimensions are used to form the production frontier through local linear interpolation. Given maize production frontier, these best maize performers will be located on the frontier while the least performers will be located on the interior of the production function .The best performer are said to be technically efficient because they maximize outputs subject to inputs constraints .They attempt to minimize the amounts of inputs necessary to produce a given amount of outputs.

DEA was proposed by Charnes et al., (1978) and later developed further by Fare et al,.(1994) and it uses linear programming to construct a piece-wise efficient frontier with the best performing farm businesses of the sample used.

According to Zhu (2003), DEA has numerous modelling advantages. DEA takes a systems approach, which means that it takes into account the relationship between all inputs and outputs simultaneously. DEA generates detailed information about the efficient supply chain within a sample and identifies the supply chains that can be used as a benchmark so that is why different supply chains which supply inputs for maize production will be identified(supply chain mapping).Production efficiency will be based on information from supply chains. DEA does not require a parametric specification of a functional form to construct the frontier like Cobb Douglas and its modifications, translog, stochastic frontiers and other parametric models like corrected ordinary least squares(Jill ,2006).Thus, there is no need to impose unnecessary restrictions on the functional forms that very often become a cause of distorted efficiency measures. However, DEA has the disadvantage of being a deterministic approach, which implies that statistical noise may be confounded with inefficiency (Zhu, 2003).
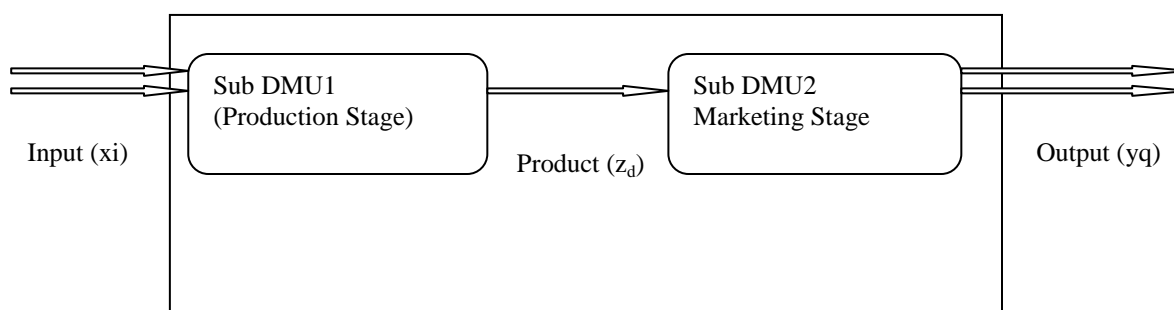

Figure 2. Two stage supply chain. Source: Lu (2006).

Following Lu (2006), the classical DEA model was extended to two-stage model as shown in Figure 2. Inputs were fed into production operations (DMU1). The A1 maize farmers' producers are envisioned as the DMUs, with production stage as sub-DMU1 and marketing stage as sub-DMU2. In the first stage, A1 resettled farmers use farmland, inputs in the inform of seed, fertilizers, pesticides, herbicides, labour, insecticides, transportation, and managerial inputs to produce certain quantity of maize (intermediate products), then at the second stage, the maize was sold at the market place to gain income. The first Sub-DMU consumes inputs xi obtained from input supply chains to produce intermediate products zd. These, in turn, are the inputs to the second Sub-DMU, which were used to produce the DMU's final outputs .Information for marketing stage comes from marketing related variable costs. These costs were identified through chain mapping and the costs are food, transportation, both hired and owned, labour. The economic efficiency of each chain were examined in Sub DMU2.The advantage of the two-stage model is that, it is capable to evaluate the relative efficiencies of each DMU and each of its sub-DMUs in production and marketing processes.

Mathematical representation of the DEA Model

The mathematical specification of the input-oriented model where the inputs are minimized and the outputs are kept at their current levels is as follows:

$$\theta^* = \min \theta$$
subject to
$$\sum_{j=1}^{n} \lambda_j x_{ij} \leq \theta x_{io} \quad i = 1,2,...,m;$$
$$\sum_{j=1}^{n} \lambda_j y_{rj} \geq y_{ro} \quad r = 1,2,...,s;$$
$$\sum_{j=1}^{n} \lambda_j = 1$$
$$\lambda_j \geq 0 \quad j = 1,2,...,n.$$

(1)

Adapted from Giang Thi Ngan Dao (2013), Banker et al., (1984)   Charnes et al., (1978).

Where,

θ^* = the efficiency score of the DMU under analysis,

Yr = the vector of outputs for DMU

n = number of DMUs under analysis;

λ (j = 1,2,...n) = the respective weights for output iand input r (2)

(r = 1, 2,…,s) = possible outputs achievable by the DMU   (3)

(i= 1, 2,…,s) = possible inputs achievable by the DMU Banker et al,. (1984)

3. Results and Discussion

The backbone of any agricultural production is access and affordability of farmers to modern agricultural inputs. These agricultural inputs range from improved seeds, fertilizers and crop protection chemicals and labour. These inputs are key determinants of maize production in Zimbabwe and are supplied by different agro-dealers, gifts and the government.

Input supply stage: Sources of inputs

Seed suppliers

Supply of affordable seeds is critical to successful crop production and inevitably, farm productivity and profitability of maize production. The highest source of seed from the study was agro-dealers (43.4%).These agro dealers include seed houses and other private seed distribution stockists. Government, through different institutional innovations like Command Agriculture and Presidential Scheme was the second source of maize seed (25.1%) followed by stocks from last season (22.2) while NGO vouchers was the lowest with 1.2 %. Farmers used stocks from last season constitute retained seed.

The high use of hybrid seed by A1 maize farmers could be attributed to high adoption levels of new technologies (seeds) as a result of extensive promotion of hybrid seed varieties by private agro-input companies and by public support organizations such as the Department of Agricultural Extension and technical Services (Agritex).

Table 1: Sources of maize seed

Sources of seed	Frequency	Percent
Stocks from last season	77	22.4
Agro-dealers	149	43.4
Government	86	25.1
NGO Voucher	4	1.2
Gifts(transfers)	8	3.2
Supermarkets	18	5.2

Source: 2019 survey

Fertiliser and chemical suppliers

Zimbabwe has an oligopoly market for fertilizers serviced by three major fertilizer-manufacturing companies. Zimbabwe Fertilizer Company Limited (ZFC), Windmill, and Chemplex Corporation are Zimbabwe's largest manufacturers of fertilizers and agricultural chemicals. The companies serve the entire farming community, namely large-scale commercial, communal, resettlement and small-scale commercial sectors. ZFC sells directly to the farmer or via stockists, co-operatives, traders and its own depot network. Respondents revealed that, fertiliser supply is very erratic during the production period. This shortage of supply for fertiliser has contributed immensely to low productivity among the resettled A1 farmers. It is the most expensive maize input in Zimbabwe, costing about $ 35-47 per 50 Kg yet in other sub Saharan countries is around $ 7-10 per 50 kg. The respondents revealed that due to fertiliser shortages and the unaffordable prices in the parallel market, they were now relying heavily on fertiliser distributed through various government support programmes for example Command Agriculture which contributed 19.8 % and 19 % for basal and topdressing respectively.

Table 2. Sources of chemical fertiliser

Sources of seed	Basal		Topdressing	
	Frequency	Percent	Frequency	Percent
Supermarkets	78	22.7	33	9.6
Stocks from last season	37	10.8	50	14.6
Agro-dealers	155	45.2	185	53.9
Government	68	19.8	65	19
NGO Voucher	3	9	3	9
Others	2	6	7	2.1

Source: 2019 survey

However, due to stringent targeting measures used by government on agriculture, most A1 farmers resorted to buying fertiliser from the agro-dealers despite being expensive. The shortages of inorganic fertiliser forced some of A1 farmers to use kraal manure because of its affordability. Thus, manure from kraal forms a major part of their production system.

Crop protection chemicals

Crop protection chemicals (pesticides, herbicides, insecticides and fungicides) control weed species, harmful insects and plant diseases that afflict and reduces maize productivity. Most farmers from the study area purchased crop protection chemicals from supermarkets with 72.6 % and 83.3 % for herbicides and pesticides, respectively. Purchases from own stock from last season and agro-dealers contributed least percentages of 1.5 % and 9% for herbicides and pesticides. These low percentages could be attributed to nature of the inputs that requires strict handling process such that most farmers prefer to buy chemicals when they are ready to use them rather than storing.

Labour

Labour is a key asset for smallholder households in rural farming areas. The quality and quantity of labour available to the farmer in terms of numbers, educational level, skills, and health constitute the human capital that becomes the basis for constructing household livelihood strategies (Tsutomu, 2008).

Despite labour being the key assets for constructing livelihood, agricultural production is still dominated by family labour, where family members provide labour input at different times of the year and hire casual workers on peak periods. The study showed similar characteristics where most of labour for maize production and marketing was obtained from family members (83.6%) while the remainder was hired.

The described inputs sources were then grouped into supply chains where by tracing its sources, buyers and the final users as detailed in the next section.

Mapping supply chain

Identification of supply chains within the maize sector

Agricultural supply chains are networks that typically trace physical product movement from input suppliers to producers, buyers and to final consumers (Duwei Lu, 2011). A supply chain identifies how goods and services flow through an economy. The study identified three simplified supply chains, which were common in the area of study. Supply chain 1 (Figure2) involved direct marketing, operating through the informal sector that included road side marketing with proportion of 28.3 per cent of respondents. Farmers were selling to mission schools, mission hospitals and villagers. In the second supply chain, produce were sold directly to GMB and delta and approximately 57.1 per cent of respondents were part of formal chain players.

Some maize was passing through maize traders market which was dominated by group of women who buys maize and resale to suburbs (chain 3) and approximately 14.3 per cent of respondents were participating in this chain.
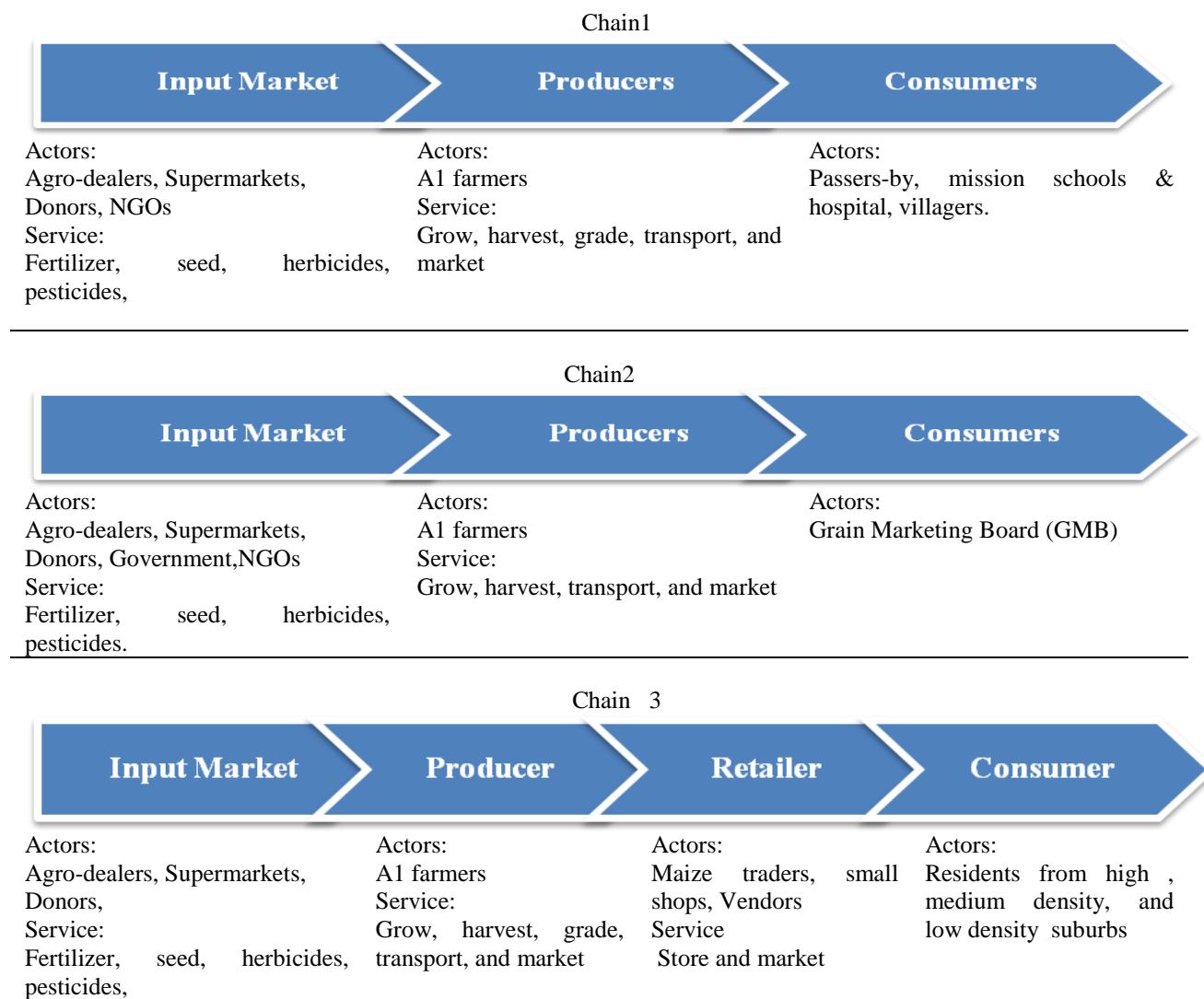
Chain1

| Input Market | Producers | Consumers |

Actors:
Agro-dealers, Supermarkets, Donors, NGOs
Service:
Fertilizer, seed, herbicides, pesticides,

Actors:
A1 farmers
Service:
Grow, harvest, grade, transport, and market

Actors:
Passers-by, mission schools & hospital, villagers.

Chain2

| Input Market | Producers | Consumers |

Actors:
Agro-dealers, Supermarkets, Donors, Government,NGOs
Service:
Fertilizer, seed, herbicides, pesticides.

Actors:
A1 farmers
Service:
Grow, harvest, transport, and market

Actors:
Grain Marketing Board (GMB)

Chain 3

| Input Market | Producer | Retailer | Consumer |

Actors:
Agro-dealers, Supermarkets, Donors,
Service:
Fertilizer, seed, herbicides, pesticides,

Actors:
A1 farmers
Service:
Grow, harvest, grade, transport, and market

Actors:
Maize traders, small shops, Vendors
Service
Store and market

Actors:
Residents from high , medium density, and low density suburbs

Figure 3. Maize supply chains. Source: 2019 survey

Product volume mapping

The volume of products is closely related to mapping the product flow. The dimension of volume is added to follow the product through the supply chain. Within the supply chain, farmers were further grouped into channels (formal and informal) depending on the market they supply. This was used to find out the volume of product and an overview of the size of the different channels within the supply chain.This enabled tracking down the product throughout the supply chain.

Volume mapping results indicated that a total of 1091.1 tonnes of maize were produced by the respondents in Marondera District under the period of study (20116/17 season). A total of 503.7 tonnes were consumed while the remainder was sold. Figure 6.3 shows that chain 3, which involved direct marketing to GMB and delta markets, was the largest maize supply chain handling about 365.4 tonnes of maize sold in one production cycle during the period of study. Chain 1, which involved direct informal market, was the least chain handling 100.3 tonnes of maize sold in 2017 season while chain 2 of informal channel was the higher than chain 1, handling 112.4 tonnes of maize. Chain 4 represents the total volume of maize that was consumed or returned by the famers

Overall, formal market was larger than informal market in terms of quantity handled as the two markets handled 63 % per cent and 36.7 per cent respectively. This shows that formal markets are still the main markets for maize in Zimbabwe. The results are in contrast to the research that was conducted by (Mujeyi, 2010) on Emerging Agricultural Markets and Marketing Channels within newly resettled areas of Zimbabwe. Mujeyi (2010) found out that, informal markets were dominating the Zimbabwean maize sector. Therefore, integrating A1 maize farmers into

formal markets or improving aspects of formal supply chains are likely to have strongly pro-poor outcomes for the farmers.
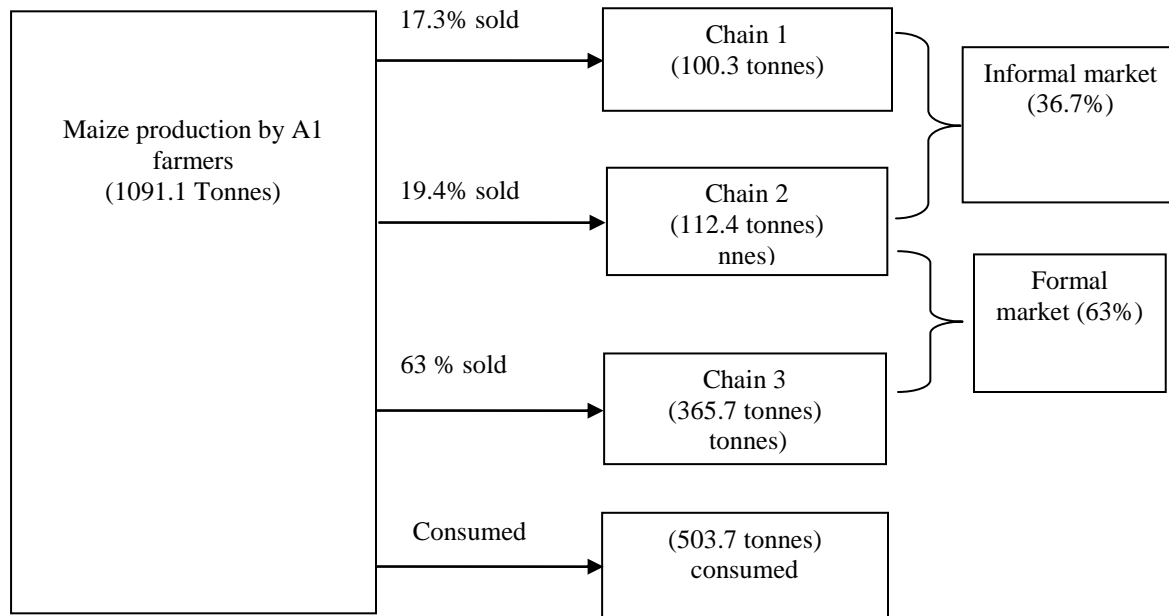

Figure 4. Product volume mapping. Source: Survey data, 2019

Integration of farmers within the channel depends on detailed information like their economic performance on production and marketing with the supply chains. In this regard, efficiency scores for production and marketing stage, obtained from DEA model for individual farmers were grouped into formal and informal channels depending on type of market supplied as shown on Table .3 on subheading (economic performance in supply chains).

Economic performance in maize supply chains
Table 3 showed the results of the DEA and two-stage value chain model. Results showed that the informal supply chains are less efficient as compared to formal chains both at production and marketing stage. Results for the mean technical, allocative, and economic efficiency indices   for   informal supply chains are 77 % ,96 %,and 74% for production stage while the marketing stage mean technical, allocative, and economic efficiency indices are 79 % ,97% and76% respectively .Two-stage value chain model infers maize producers in Marondera District are performing much better for marketing than production for informal supply chains while the formal supply chains are efficient (100%) at both production and marketing stage.

Thus the results from both production and marketing stage, showed some considerable levels of inefficiencies in maize technical efficiency both for production and marketing stages , while allocative efficiency is the best of the three efficiencies for maize production and marketing .

The results, however, showed that there is still some considerable level of inefficiencies in the use of inputs for the output levels. High allocative efficiency scores for both stages   imply that A1 farmers are quite price-sensitive to the input prices. The overall economic efficiency was low for both production and marketing stages implying that inputs were not optimally allocated for production and marketing by A1 farmers.

The relatively high levels of technical efficiencies for formal supply chains defies the notion that informal supply chains in Zimbabwe are more efficient than the formal chains(Mujeyi, 2010). This study showed that well regulated chains are more efficient than the informal chains that are not well regulated (Rukuni et al., 2006).

Table 3. Supply Chain scores for technical, allocative and economic efficiency

Chain	Production stage			Marketing stage		
	Technical efficiency	Allocative efficiency	Economic efficiency	Technical efficiency	Allocative efficiency	Economic efficiency
Informal	0.545	0.924	0.503	0.579	0.935	0.541
Formal	1.000	1.000	1.00	1.000	1.000	1.00
Mean	0.773	0.962	0.743	0.789	0.967	0.763

Source 2019 survey

4. Conclusion and Recommendations

From the results presented in table 3, on maize production and marketing efficiency, showed that,A1 farmers are technically, allocatively and economically inefficient for both production and marketing stages. The maximum efficient score is 1 while the minimum score is 0.01 for both production and marketing stage. The mean scores for production stage are 0.195, 0.504 and 0.072 for technical, allocative and economic efficient respectively. The mean scores for marketing are 0.103, 0.688, and 0.068 for technical, allocative and economic efficiency respectively.

Farmers are performing better at production stage than at marketing technically while there is better allocative and economic efficiency at marketing stage.

Farmers are recommended to use formal channel of marketing because they are more efficient than informal channel.

An efficient supply chain is crucial for getting the right products to the right place at the right time and helps A1 farmers to stay competitive and maximise revenue. The government is therefore, recommended to correct inefficiencies and ineffective institutions in input supply chains that has given rise to more informal activities that has disrupted efficient supply chain management systems built over many years.

Suggestions for further research

Researchers interested in studying maize supply chains can also consider undertaking a comparative study of resettled A1 farmers and A2 farmers in all provinces of Zimbabwe where maize or any other crop farming is undertaken. The results obtained in this study would however, proved useful guideline on what is actually happening in the country. One can also study agricultural marketing economic efficiency for communal farmers and compare with the resettled A1 farmers. Other researchers can specifically study governance issues as they relate to agricultural production and its impact of economic efficiency.

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