

# Studies in Agricultural Economics

Volume 121, Number 1

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The cost of printing this issue is supported  
by the Hungarian Academy of Sciences.

© Research Institute of Agricultural Economics, 2019  
1463 Budapest, POB 944, Hungary  
<https://www.aki.gov.hu/studies>  
ISSN 1418 2106 (printed)  
ISSN 2063 0476 (electronic)  
Established 1962

## Foreword

The year 2019 brings a wide range of changes in the life of *Studies in Agricultural Economics*. In line with the plans described in the foreword of the latest issue, 120-3, changes in three areas have become apparent. First of all, the focus of the journal has been extended to Europe and Central Asia (ECA) from its former focus (Central and Eastern Europe). Second, we have started to modernise our website – results of which will hopefully be visible by June 2019. Third, the Editorial Board has also been reorganised and we welcome several new colleagues on board; plus, we give special thanks for all the out-going members of the Editorial Board for their work and continuous efforts in increasing the scientific value of *Studies in Agricultural Economics*.

I think the first issue of 2019 well reflects the ‘transition’ we are faced with by offering papers and topics from all around the world that has a certain relevance to our readership. The first paper, written by Heijman, Szabo and Veldhuizen, analyses the contribution of a Hungarian biorefinery to rural development and employment and shows that the operation of a biorefinery stimulates the creation and maintenance of jobs in both farming and service industries. Results also suggest that biorefineries are an important driver of rural development and that this aspect of the industry should be given greater weight in formulating biofuel policies in the future.

The second paper, written by Gonzales-Corzo, investigates agricultural reforms, land distribution and non-sugar agricultural production in Cuba. The paper usefully discusses the series of reforms the Cuban government has introduced since 2007 to increase non-sugar agricultural production and reduce the country’s dependency on food and agricultural imports. Although the author suggests that these reforms have contributed to the redistribution of Cuba’s agricultural land from the state to the non-state sector and have resulted in notable reductions in idle agricultural land, they have also brought mixed results in terms of agricultural output. However, as the author suggests, the reforms have not been able to sufficiently incentivise output and reduce the country’s high dependency on agricultural and food imports.

The third paper in this issue, written by Ramirez Pastore and West, provides a review of competition barriers to Paraguayan beef exports. The authors have found that both a perceived and an actual absence of quality controls over beef production, coupled with the lack of an industry body representing Paraguay’s beef sector, have been the major impediments to growth in the Paraguayan beef export market. The authors also suggest that the lack of sustained support and marketing of export-quality beef has led to

persistent price discounting, despite quality improvements across the supply chain. As a policy recommendation, the paper suggests that an industry-wide effort to coordinate food safety and quality activities, as well as maintaining certification programmes, market intelligence, export promotion and research and development could offer some degree of competitive advantage to Paraguay’s producers.

The remaining three papers provide insights to agri-food related issues in Africa. The fourth paper, written by Ndiritu and Ruhinduka, analyses climate variability and post-harvest food loss abatement technologies in Tanzania. The authors find that climate variables significantly influence farmers’ choice of improved storage technologies and preserving decisions. Using a bivariate probit model, they find that modern storage technologies and preservation measures are substitutes and farmers can significantly reduce annual costs associated with preservation by adopting modern storage facilities.

The fifth paper, written by Abel, Gor, Okuro, Omanga and Bokelmann, investigates how value chain governance influences farmer participation in vegetable markets and food security in Kenya. By applying a mixed method approach involving a multistage sampling technique of 339 respondents, spot market relations were found to dominate traditional value chains in rural areas, while peri-urban areas exhibited both traditional and coordinated value chains. The value chains are found to be characterised by very weak linkages between upstream actors and downstream partners, where wholesalers and supermarkets play the role of leading firms in traditional and coordinated value chains, respectively. The paper recommends the inclusion of farmers in market management committees and the establishment of binding contractual arrangements with supermarkets.

The remaining short communication, written by Aleme, analysed the expansion of sugarcane production in Ethiopia by applying a computable general equilibrium model and SAM dataset to Ethiopian data. The results of the study indicated that the average aggregate income and consumption expenditure of households compared to the baseline scenario are negative, although the magnitude of the loss is small. The author found strong evidence that the average aggregate economic welfare of households in Ethiopia had deteriorated by 3.43 percent and concluded that the strategies that the government had been implementing are highly detrimental to household welfare. Thus, the author suggests that the Ethiopian government should favour only the use of marginal and barren lands for upcoming sugarcane projects.

On the whole, I think this issue well reflects the ‘transition’ period we are currently facing and offers a wide range of different papers and conclusions for our traditional and (hopefully) new readership.

**Attila JÁMBOR**  
Budapest, April 2019

Wim HEIJMAN\*, Zoltán SZABÓ\*\* and Esther VELDHUIZEN\*

# The Contribution of Biorefineries to Rural Development: The Case of Employment in Hungary

Most recent research concerning biofuels focuses on their potential for mitigating climate change, while their rural development dimension is given less prominence. Ongoing policy debates, including EU and US biofuel policies, pay little attention to this feature of the industry. This paper explores the impact of biorefineries on rural development, and employment in particular. It shows that biorefineries can have a considerable economic impact on the regions in which they are located. Embedded in the local social and economic fabric, the paper demonstrates their influence on regional and national labour markets. The case of a bioethanol plant in Hungary and its effect on the rural labour market in two counties of the country is studied by way of an input-output model. The research has found that the operation of a biorefinery stimulates the creation and maintenance of jobs in both farming and service industries. Results suggest that biorefineries are an important driver of rural development and that this aspect of the industry should be given greater weight in formulating biofuel policies.

**Keywords:** Biofuels, Biofuel Policies, Ethanol, Rural Development, Input-Output Analysis, Employment

**JEL classifications:** Q16, Q57

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Received: 11 October 2018, Revised: 14 February 2019, Accepted: 21 February 2019.

## Introduction

Biofuels have long been of interest to scientific research. They have been promoted for a variety of reasons, including their potential for mitigating climate change. The majority of scientific papers appear to focus on the climate profile of biofuels. However, this topic gained further prominence when the concept of indirect land use change (ILUC) impact was introduced, which suggests that a more complete picture of the impact of biofuels is necessary. Accordingly, climate change is perhaps the most often used angle in research papers looking at biofuels. A relatively smaller share of studies focuses on environmental impacts, and research angles include biofuels' impact on biodiversity, water and other environmental aspects. A substantial number of papers consider the so-called food versus fuel issue, that is, the food security dimension of biofuel production and use. Some authors focus on the agricultural aspects of biofuel production (Szabó, 2019). Combined, these topics are dealt with by the vast majority of research papers published in the scientific literature.

However, thus far, less attention has been paid to the rural development dimension of biofuel production. The impact of biofuel production on rural employment is a relatively little researched topic. By way of illustration, Wojan *et al.* (2014) stated that no research to that date had empirically evaluated the combined direct, indirect, and induced employment effects of ethanol plant operations in the US. The aim of our paper is to contribute to this particular aspect of the biofuel debate. Our aim is to investigate the local economic impact of a biofuel plant and in particular look at the impact on the number of jobs generated through an ethanol plant located in a disadvantaged rural region in Europe. Typically, biofuel plants are located in rural environments, often in the heart of areas that produce the feedstocks, and are embedded in the local economies. Biorefineries are plants producing a range of products from fuel, feed, food, green electricity, biochemicals to any other bio-based materials using feedstock as biomass.

Biorefineries are enterprises closely linked to agriculture. The feedstocks used in the plants are typically locally sourced. Therefore, biofuel plants have a strong link to the farmers in their vicinity. In the United States (US), bioethanol plants are often run as co-operatives, where farmers have a stake in the plant. In Europe, except for instances where the plant is located close to a port and relies on imported feedstock, the model is similar; a typical biofuel plant sources its feedstock from about a 50km radius, hence local farmers are its primary suppliers, and their business relationships are strong. The plant is significantly embedded in the local social and economic fabric. This notion is what makes biorefineries a special industry that has a close link to rural businesses, farming in particular.

Jobs are created directly (within the plants themselves) and indirectly (through impacting the regional economy). Urbanchuk (2018) finds that when the direct, indirect and induced jobs supported by ethanol production, construction activity, agriculture, exports, and R&D are included, the US ethanol industry supported nearly 360,000 jobs in 2017. Although not based on conventional biofuel feedstocks such as sugars and starches, Thornley *et al.* (2014) found that for straw and woody biomass feedstocks, a single facility could generate tens of thousands of man-years of employment.

After solar power production, biofuel production may be the second largest employer globally in the renewable energy industry. IRENA (2016) reports that the total employment, including direct and indirect jobs, in the biofuel sector globally amounted to 1.678 million in 2015. With 821,000 jobs, Brazil continues to have the largest biofuel workforce by far. The US comes in second place with 277,000 jobs, followed by the European Union (EU) with 105,000 jobs. In total, the jobs created by the biofuel industry amount to about one fifth of the total jobs created by the global renewable industry. Thus biorefineries may advance the socio-economic dynamics of the region, closing rural-urban income gaps and equalising intra-European disparities (Katainen, 2017).

## Biofuel Policies

There are substantial differences in the rationale behind biofuel policies in the various jurisdictions globally. In this section the brief history of and the justification stated in the three key jurisdictions; namely the European Union (EU), the United States (US) and Brazil, are discussed.

The EU laid out its initial biofuel policy in the 2003 directive (EU Directive, 2003), which stated that biofuels are primarily promoted for their contribution to climate change mitigation, energy security and promoting renewable energy sources. The European Union adopted its flagship regulation on biofuels in 2009 under the Renewable Energy Directive (RED). The RED's overarching aim was to promote renewable energy, which is explained as something that contributes to climate change mitigation, promotes the security of energy supply (reducing dependence on imported oil), promotes technological development and innovation and provides opportunities for employment and regional development, especially in rural and isolated areas. The RED deals with the sustainability criteria of biofuels, focusing primarily on their impact on climate change (including ILUC), biodiversity and, to a lesser extent, on food security. Its impact on water and soil also gets mentioned.

The RED also states that “when favouring the development of the market for renewable energy sources, it is necessary to take into account the positive impact on regional and local development opportunities, export prospects, social cohesion and employment opportunities”. It must be noted that the above sentence and another with a similar meaning are the only references in the entire document to the importance of considering the impact of the renewable energy industry on jobs. Also noteworthy is the fact that data is difficult to find on the direct and indirect employment provided by the biofuel sector in the EU.

Arguably, the opportunities for growth and employment that an investment in the regional and local production of energy from renewable sources brings about in the Member States and their regions are important. The European Court of Auditors (2018) finds that even though the RED refers to the rural development dimension of renewable energy deployment in its recitals, there are no specific provisions in the legislative part of the Directive related to promoting rural development.

In Europe, in essence, the key reason for supporting biofuels appears to be climate change mitigation. The ongoing policy debate in the EU about RED II (the revision of the RED) reinforces the above-mentioned priorities and does not give prominence to employment impacts. As an illustration of these priorities, the impact assessment behind the RED II proposal states that “only direct, permanent jobs were estimated; construction jobs and indirect employment impacts were not assessed” (Impact Assessment, 2016). In other words, the job aspect appears not to have been given a priority. This conclusion appears to be reinforced by the findings of the European Court of Auditors (2018), which finds that the rural development dimension of renewable energy, including bioenergy, was not adequately considered in the Commission and the Member States' policy framework.

The US is the world's leading producer of biofuels, most notably ethanol. In the US, the primary impetus for biofuel policies has been the desire to become less dependent on foreign oil, i.e. furthering energy security and supporting the agricultural industry. The history of the biofuel policy of the US can be traced back to the Energy Policy Act of 1992. The Energy Policy Act of 2005 created the Renewable Fuel Standard (RFS), a centrepiece of the US regulation on biofuels, whereby a minimum volume of biofuels is required to be used in the transportation fuel supply in the US each year. In 2007, another important regulation stressed the notion of “Energy security through increased production of biofuels”. The Environmental Protection Agency assessed the impact of the policy along the lines of reduced energy dependence, reduced fuel prices, reduced GHG emissions, increased farm incomes and impacts on trade, food price and air emissions. The above listing includes impacts on employment or job creation as a decisive metric, whereby the outcome of the biofuel policy is to be evaluated on. The current policy debate in the US around the RFS is centred mostly around energy independence, fuel prices and impacts on farming, while job creation opportunities are not prominent in the debate.

Brazil is the world's second largest producer of bioethanol. Brazil has perhaps the longest history, over four decades, of biofuel policy. Its policy is based around its sugarcane programme, unlike in the US and the EU where the dominant feedstock is grain, and corn in particular. Since 1976, blending ethanol into petrol has been mandatory. Brazil has the highest blending rate, currently at 27%, reflecting the strength of the sugarcane industry. The policy's aim is primarily the promotion of the economy. The Brazilian ethanol industry produces sugar as well as ethanol, and the two products are considered important. However, their impacts are difficult to disentangle. Hence the underlying justifications behind the policies relate to both the biofuel and sugar businesses. Given that its policy is primarily an industry policy, economic contribution and employment impacts are prominent in the discussions about biofuel policies.

In summary, the key policy documents in the US and the EU, in contrast to Brazil, do not rely substantially on justification backed up by the rural development benefits, let alone the job creation opportunities. In the two major grain-based biofuel jurisdictions, especially in the EU, the benefits biorefineries may bring to rural communities seem to have been neglected.

## Methodology

In order to examine the economic impact of biorefineries in rural areas, the case has been specified for a business (Panonia Ethanol) that operates an ethanol plant or a biorefinery in Dunaföldvár, Hungary (Annex 1). The biorefinery has a significant impact on the regional and national corn market, utilising about a million ton of corn each year, which is about 15% of total nation production.

The assessment has been carried out by means of an input output model (I-O model). Only the national I-O table is available in the national statistical datasets, therefore, by means of the RAS-procedure the regional I-O tables of Tolna



and Fejér, the two counties in Hungary directly impacted by the operation of the plant, was calibrated. Furthermore, the multipliers per sector were determined such that the change in employment per sector can be measured.

The biorefinery produces bioethanol, animal feed, corn oil and other bio-based materials from feed grade corn as the feedstock used in processing. The ethanol is eventually blended in petrol and used as a biofuel. The plant was constructed in 2010-2011, but capacity expansion investments have been undertaken on a constant basis and are continuing today. Farms in the regions of Fejér and Tolna supply over one million tons of corn to the plant each year. From this amount, the refinery produces 325,000 tons of animal feed, 450 million litres of bioethanol and 10,000 tons of corn oil. Based on a grey publication (Koós, *et al.*, 2016), the business directly employs 172 people and has created over 2,000 jobs indirectly, and it can be said that the economic impact on the region is significant.

The biorefinery is set on the banks of the Danube one hundred kilometres from Budapest, in the heart of Hungary's corn growing region, with the nearest town Dunaföldvár, which has around ten thousand inhabitants (Annex 1). The major economic activity in this region is farming. The biorefinery has been expanding and has more than doubled in capacity since 2012. Besides producing bioethanol, the business is also engaged in the development of new bio-based technologies. It is clear that the business stimulates the local economy, but it is unknown to what extent (Major, 2016). Therefore, the main aim of this analysis is to estimate the impact of the business on the local and national employment level. For this endeavour, the multiplier effects of the sectors of the two regions were to be determined. Additionally, the expenditures of the business in the different sectors were to be investigated such that the effects per sector can be measured. Therefore, a standard tool, an input output (I-O) model has been built and calibrated to the regional economies of Fejér and Tolna. In this way, it can be simulated how the plant influences incomes, jobs and production output.

As stated above, it is expected that the development of biofuels in rural areas influence the local economy. A tool to measure the regional economic impact is the I-O model. The model provides an answer to questions such as: *How much additional employment will be generated due to the establishment of new biorefineries?* The focus of this model is to measure the impact on output, additional income and employment. The model was originally developed by Leontief in the sixties, since then, it has been used to calculate the regional economic impacts of many activities (Heijman, *et al.*, 2017).

The I-O model is one of the most commonly used models in economic impact analysis (EIA). Other methods which can be used to measure the impact of new plants in regions are: the computable general equilibrium (CGE) model and the non-linear input output (NLIO) model. The CGE model is more extensive than the I-O model. With this model it is possible to provide an answer to more types of questions. Furthermore, it can be specified according to the economic reality. The downside of this model is that much more knowledge of economic and mathematical concepts is required for its application, also substantially more data is

required. Therefore, it is harder to apply this model in practical studies, especially at the regional level. The NLIO model can be considered as an intermediate form between the I-O and the CGE models. This model can also take other issues into account, such as productivity changes and substitution, without an extreme increase in the data requirement (Klijs, 2016).

Among these three models, the I-O model remains the most popular method for economic impact studies. The advantage is that the model is relatively simple and the computations can be done with standard software such as Microsoft Excel. In addition, the model is well known, and the advantages and disadvantages are described in many publications. Moreover, in the absence of a regional I-O table it is simple to generate one based on the national I-O table. This is convenient when there is no time to conduct an extensive survey in a particular region. Further, the I-O model requires a relatively modest amount of data. Still, the outcome of the table is detailed and shows the impact on production, value added, income and employment, in total and by sector (Klijs, 2016).

The model also has its disadvantages, which should be taken into account before application. Most of the disadvantages are strongly dependent on the assumptions made in the research. First of all, in the case of our research, the model is based on technical coefficients that are fixed ratios between the total revenues and the expenditures of a sector. This relationship implies that a change in the final demand will never lead to productivity changes, which would not necessarily be the case in reality. Furthermore, the model does not consider substitution as a possibility.

In reality, substitution of production factors may occur. This is not accounted for in the I-O model. Secondly, the model does not provide answers to detailed questions. Thus, it is not possible to say anything about the impact of lower or higher subsidies on the production of ethanol for instance. Also, the model only predicts the impact on regional level and cannot be specified to municipalities. Thirdly, the I-O model only shows the differences between the old and the new equilibrium demand. In reality this can take quite some time before an economy will adapt to the changes in the final demand and quantities. Lastly, in some cases the I-O table is not available and hence needs to be created. The process requires assumptions about employment and the shares of regions in sectors and these assumptions may lead to a distorted image of reality. Moreover, research needs to determine how to collect the necessary data to determine the change of the final demand. The decision can be complicated since it is hard to determine how much money will be spent if the money is not actually there already (Heijman, *et al.*, 2017).

Although some scientists advocate the usage of the more advanced models, such as the CGE and the NLIO models, their use is not always necessary. In order to measure the regional impact of the biorefinery some assumptions need to be made, but the case is relatively small, making the I-O model applicable.

First, an appropriate scale for the I-O table and data must be chosen. The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing

the economy territory of the EU. These classifications are made with the purpose to 1) collect, develop and harmonize the European regional statistics, 2) analyse socio-economic regions and 3) frame the European regional policies. For our research only the second point is of relevance. The statistical database of the European Commission distinguishes three 'levels' within a country, namely:

NUTS 1: Major socio-economic regions

NUTS 2: Basic regions for the application of regional policies

NUTS 3: Small regions for specific diagnoses

The NUTS 1 regions are the major economic regions, which are divided into NUTS 2 regions, which are finally further divided into NUTS 3 regions. It is important to use these classifications since the data (value added, employment rate and output per industry) are per NUTS region. Hungary has in total 20 NUTS 3 units, 7 NUTS 2 units and 3 NUTS 1 units (Eurostat, 2013).

The following division applies for Hungary:

- NUTS 0 region 'Hungary', HU
- NUTS 1 region 'Dunántúl', HU2
- NUTS 2 region 'Közép-Dunántúl' HU21
- NUTS 3 region 'Fejér', HU211
- NUTS 2 region 'Dél-Dunántúl' HU23
- NUTS 3 region 'Tolna' HU233

Annex 1 shows all the NUTS regions of Hungary. As stated above, the regions Fejér HU211 and Tolna HU233 are NUTS 3 regions. These are the regions in which the impact of the biorefinery is the most apparent.

After examining which NUTS regions are of interest, one should determine the national economic activity per sector as well as the national and regional employment rates per sector. Unfortunately, there are no I-O tables available for these regions, but they can be constructed through the RAS procedure based on the national I-O table combined with the employment rates per sector. Each region should be treated separately. Thus, the procedure must be carried out twice. The national I-O table of 2016 can be obtained from the Hungarian Central Statistical Office. Before regionalizing the national I-O table, it is useful to split the industry into separate sectors. Since it is unclear at the start in which sector the business has the largest impact, all sectors will be taken into account.

The following nineteen sectors will be used:

- Agriculture, hunting, forestry and fishing
- Mining and quarrying
- Manufacturing
- Electricity, gas and water supply
- Water supply, wastewater collection and treatment, waste management and pollution treatment
- Construction
- Wholesale and retail trade, repair of motor vehicles and household goods
- Transport and storage
- Hotels and restaurants
- Information and communication
- Finance and insurance
- Real estate, renting and business activities
- Professional, Scientific and engineering activities

- Administrative and support service activities
- Public administration and defence as well as compulsory social security
- Education
- Health and social work
- Arts, entertainment and recreation
- Other activities

By compressing the industry into nineteen sectors the I-O model is easier to conduct. With the I-O table, it is possible to visualize how much each sector contributes to itself or to the other sectors since the product of one sector can be used as an input for another sector. In tables in Annex 2 and 3 the rows record the outflow of production, showing how the production of an activity sector is distributed among the other sectors of the economy. The columns of the table record the necessary inputs for production, showing the structure of inputs used by each sector of the productive activity. The totals of the columns and the rows record the total output of each sector, which should be equal, thereby indicating the balance of the economy where the costs of each sector are equal to their respective revenues.

The national I-O table describes the linkages within an economy at a specified point in time. It records the various interdependencies between the various sectors in the economy and their consumption of intermediate goods and services. Furthermore, it also describes the final demand of the sectors, the exports, the imports and the value added. For this model three important economic assumptions are needed: (i) a production function with constant return to scale, because of the fixed technical coefficients; (ii) each sector produces unique products which are not produced by other sectors and (iii) sufficient production capacity (Brand, 2012).

The regional I-O table can be considered a scaled-down version of the national I-O table. This will be derived through a mathematical procedure. This requires information, such as sector sizes, on the national and regional levels in order to create the regional input output table. This information can be calculated with the use of different methods. The RAS procedure will be applied since this method is considered appropriate for the available data. A description of the RAS procedure is as follows.

The available data are the national employment rates and the employment rates in Fejér and Tolna. We can assume that the work efficiency on the national level is equal to the local work efficiency. The RAS procedure is considered an application of the bi-proportional matrix scaling algorithm, which was proposed by Stone (Lahr and De Mesnard, 2004) and elaborated on by Szabó (2015).

The initial matrix is the national table. The regional table is assumed to be identical to the national one ( $Z^o = Z^n$ ). However, this will not satisfy the equality criteria between the total of the rows, columns and regional frames. Thus in order to scale down the national table, the rows need to be multiplied with a ratio such that the regional frame and total supply in  $Z$  are equal. In our case the ratio is the employment ratios of each region (Fejér and Tolna). Secondly, the same procedure should be done for the columns. The row scaling ratio (column vector) is

$$r_i^1 = \frac{Z_i^r}{\sum_j Z_{ij}^1} \quad (1)$$

where,  $Z_i^r$  implies the actual regional data and  $\sum_j Z_{ij}^1$  implies the sum of the stabilised table by j. In this equation, if  $r_i^1 < 1$  then the elements in row i of the estimated table are higher than they should be and vice versa. Thus, the rows of the estimated table will satisfy the regional constraints by multiplying the table by this vector. In this stage the column totals will differ from the regional column frame. Therefore, the same procedure has to be applied for the columns as well. The column scaling ratio (row vector) is

$$s_i^1 = \frac{Z_i^r}{\sum_i Z_{ij}^1} \quad (2)$$

The previous elaborations also account for this situation; if  $s_i^1 < 1$ , then elements in the estimated table are higher than they should be. Thus, they need to be scaled down by  $s_i^1$  to achieve consistency ( $Z^2 = \hat{r}^1 Z^0 \hat{s}^1$ ).

At this stage, it is likely that the rows will no longer satisfy regional constraints, thus the procedure has to be started again. The sequential repetition of step 1 and step 2 will adjust the initial table to be constrained by regional frames. Usually the procedure is convergent and after a few iterations, the estimated values will be very close to the regional frames (Szabó, 2015).

Through the RAS method the regional input output tables are created (see Annexes 2 and 3). The second step is to determine the technical coefficients. The technical coefficients are needed in order to calculate the multipliers such that one can calculate the direct and indirect effects of a change in the final demand. If the demand changes, the household incomes will change as well, which will lead to a change in employment. In this case, it is interesting to examine to what extent the increase in demand for inputs such as corn will lead to more jobs.

The multipliers are mathematically derived from the regional I-O table. It is important to realise that the model does not take increasing returns to scale into account, but only assumes a linear relationship between input and output. Moreover, all firms in a given industry are assumed to employ the same production technology.

The initial monetary values in the transaction matrices can be converted into ratios via the so-called technical coefficients. The technical coefficients, matrix  $A$ , represent the relationship between the total revenue of the sectors and the intermediary inputs they demand. This conversion can be done by dividing each cell of the domestic intermediate matrix by its column total (output at basic prices). This computation should also be done for the imports (intra and extra EU) and the added value.

As stated above the matrix visualises the intermediary demand. The following equation describes the intermediary demand ( $Int.$ ) plus the supply to the final demand ( $F$ ), which is equal to the total supply ( $X$ ).

$$Int. + F = X. \quad (3)$$

The intermediary demand can be derived from the revenue received by the sectors of the economy. As already mentioned the technical coefficients, matrix  $A$ , represents the relationship between the total revenue of the sectors and the intermediary inputs they demand. Matrix  $X$  represents the total supply of the sectors as well as their total revenue. From these definitions it follows that the matrix  $Int.$  can be created by multiplying  $A$  with  $X$ :

$$Int. = AX. \quad (4)$$

These two equations can be combined such that the following equation will appear:

$$AX + F = X. \quad (5)$$

This equation can also be expressed as:

$$X = (I - A)^{-1}F. \quad (6)$$

where  $I$  for the Unity Matrix. Writing it in first differences gives:

$$\Delta X = (I - A)^{-1}\Delta F. \quad (7)$$

Equation (8) shows that a change in demand ( $\Delta F$ ) multiplied by the multipliers (matrix  $(I-A)^{-1}$ ) will lead to the change in the total output ( $\Delta X$ ). In this way equation (8) immediately reveals how much the total output per sector will change based on a change in the final demand. (Heijman *et al.*, 2017).

The model predicts that if the output in one sector increases, the output of other sectors to a certain extent will also increase. In this way expenditures of a business affects the economic development of a country directly as well as indirectly. In our research we will look at the effect of the influx of money from a biofuel refinery on the employment rate. Thus, the following hypothesis will be tested: *'The expenses of the ethanol plant in several sectors leads to an increase in job opportunities in the regional as well as the whole economy'*. Using the I-O model the impact of the expenditures of the biorefinery on output per sector has been analysed. The increase in output will eventually lead to more jobs in the sectors. The model predicts that economic growth within one section stimulates growth in other sectors due to the multiplier effect.

The primary input for the production of ethanol is corn; hence, the agricultural sector will probably experience a sharp rise in demand. This increase will be mostly noticeable in the surrounding regions of the bioethanol plant, thus in Tolna and Fejér. The ethanol is transported to other regions and abroad; the transport sector is strongly involved. It will depend on the transport services for which regions will benefit the most from this increase in demand. The next sector that should experience considerable economic growth is the manufacturing sector, followed by the service industry. The plant initially employed 172 people plus external personnel for maintenance support, thus it stands to reason that this sector will experience a direct increase in employment opportunities. In short, it is expected that

there will be a rise in jobs due to the expenditures of the biorefinery in the Hungarian economy.

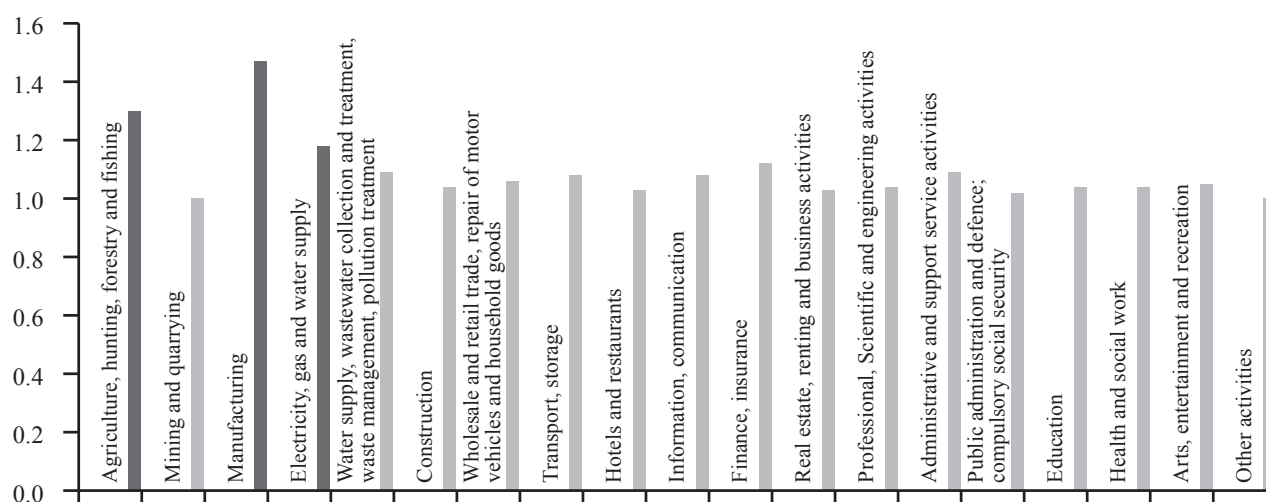
## Results

This section presents the results derived by the use of the input output analysis. The data needed for the I-O table was obtained from the website of the Hungarian Central Statistical Office. In cooperation with the biorefinery the regional I-O table has been created for the regions of Tolna and Fejér (see Annex 2 and 3).

The multiplier effect is caused by an increase in the final demand (an impulse) within the economy. This extra demand leads to more supply, which will lead in turn to a higher income and eventually to higher expenditures. The multiplier effect refers to the increase in the total output arising from any new impulses in a sector of the economy. The multipliers have been estimated with the use of the national and regional I-O tables. These multipliers concern the so-called Type 1 multipliers, which do not take into account the

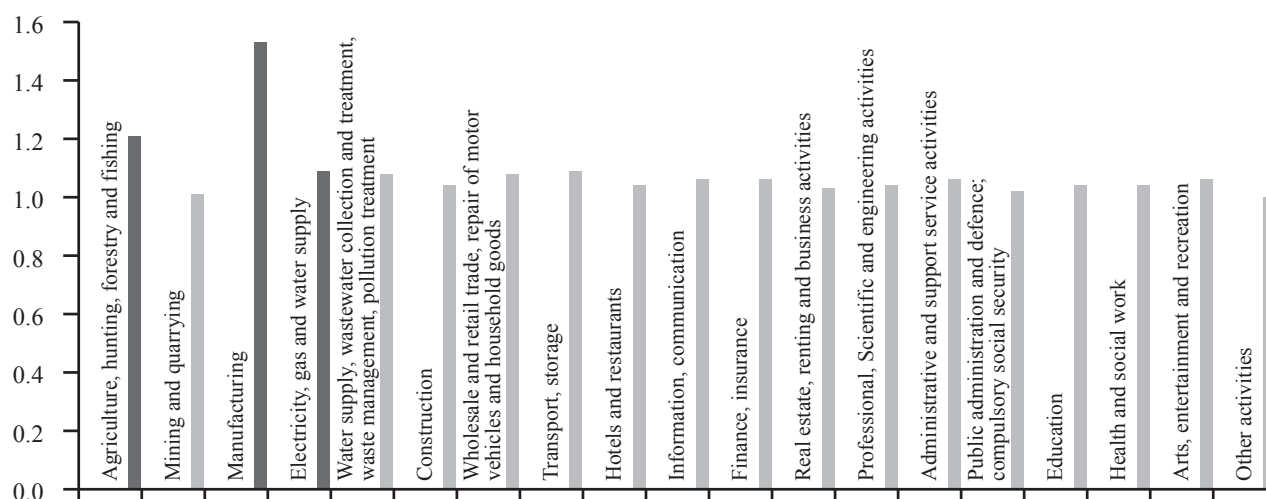
increased spending because of higher incomes (Perez-Verdin *et al.*, 2008).

For this research it is interesting to examine which sectoral impulse generates the highest regional impact (see Figure 1 and 2). The following sectors contain the highest multipliers: Agriculture, Hunting and Fishing (1.30 Tolna; 1.21 Fejér), Manufacturing (1.47 Tolna; 1.53 Fejér) and lastly Electricity, Gas and Water supply (1.18 Tolna; 1.09 Fejér). The multiplier effects at the national level slightly differ from ones at the regional level. The effects are the highest in the following sectors: Agriculture (1.27), Manufacturing (1.49) and Finance and Insurance (1.25). At the regional level the multiplier effect of the Finance and Insurance sector is smaller. The plant spending one HUF extra in the agricultural sector of Tolna will lead to a total effect of 1.30 HUF. This is because an impulse in one sector stimulates other sectors indirectly. From these results we can conclude that the expenditures of the biorefinery have the highest regional impact in the following sectors: agriculture, manufacturing and electricity.



**Figure 1:** Multipliers for 'Tolna' region in 2017.

Source: Own composition based on HCSO (2018) data.



**Figure 2:** Multipliers for 'Fejér' region in 2017.

Source: Own composition based on HCSO (2018) data



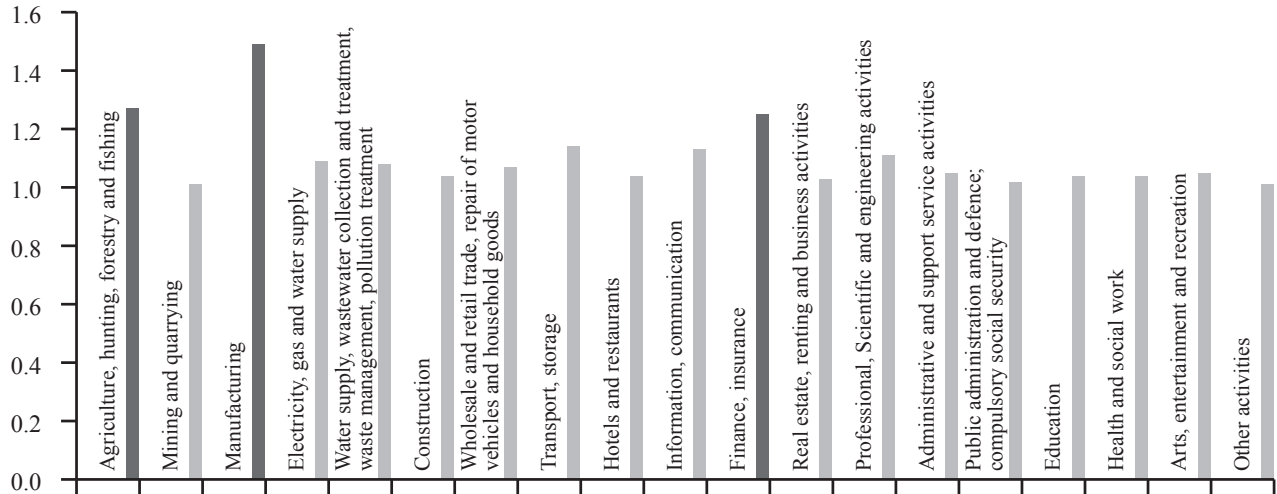
The increase in demand (the impulse) can be estimated using the expenditures figures of the business among all of the sectors. In 2016, the biorefinery spent 58,116 million HUF in total on production factors and labour (Table 1). These expenditures, together with the expenditures of the households of the employees, form the total economic impulse. Remarkably, the results show that the biorefinery spends most of its money outside the regions of Tolna and Fejér. Hence, one can assume that the total impact of the biorefinery can be greater at the national level than at the regional level. Moreover, it is interesting to examine in which sectors most of the money is spent.

The majority of the expenditures of the biorefinery and the households were spent in 2016 in the Agriculture, Hunting and Fishing sector (more than 70%), with the remainder being spent in Electricity, Gas and Water supply (around 10%) and Transportation and Storage (6-7%). Smaller parts are spent in Construction (around 2%), Professional and Scientific Engineering (around 2%) and Public Administration and Defence (around 3%) (see Table 1).

The importance of the expenditures in the sectors will be further detailed when analysing the change in employment. As already shown, the multiplier effect is the highest in the sectors of Agriculture, Fishing and Hunting and Electricity, Gas and Water supply. Therefore, it is reasonable to assume that an increase in jobs will be significant in these two sectors at the national as well as local level.

The biorefinery's expenditures lead to a change in the total output of Hungary. Using the calculated multipliers, an estimation can be made on the size of the change. With the use of the national output per sector and the national employment rates, it is possible to estimate the labour productivity per Full Time Equivalent. Moreover, we assume no variation across regions in Hungary in labour productivity. Since it is reasonable to assume that labour productivity differs between countries, we only focus on the changes in output within Hungary.

The biorefinery spent 58,116 million HUF in total in 2016, mostly in the agricultural sector (Table 1). If we take the change in output,  $\Delta F$ , and we multiply this with the multipliers, we will get the total change in output per sector. In order



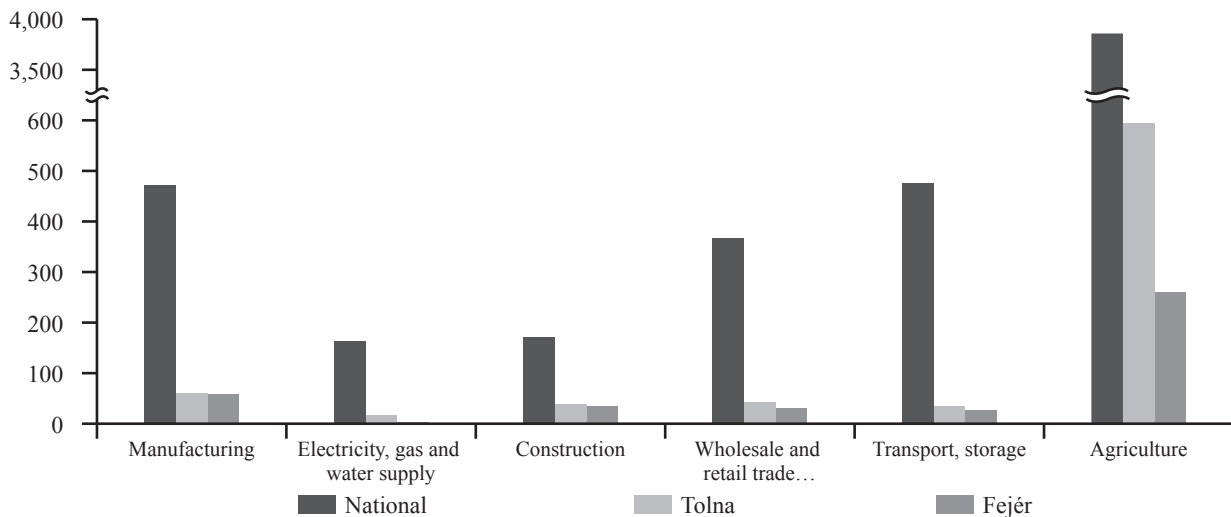
**Figure 3:** Multipliers for Hungary in 2016.

Source: Own composition based on HCSO (2018) data.

**Table 1:** Expenditures of the biorefinery per sector in 2016 (Millions of HUF).

	National	Tolna	Fejér
Agriculture, hunting, forestry and fishing	41,631.83	6,249.71	2,926.83
Mining and quarrying	19.20	5.99	9.30
Manufacturing	1,738.64	111.90	863.61
Electricity, gas and water supply	5,895.87	243.78	14.13
Water supply, wastewater collection and treatment, Waste management and pollution treatment	14.55	4.54	7.04
Construction	1,209.83	302.51	302.65
Wholesale and retail trade, repair of motor vehicles and household goods	5.66	1.77	2.74
Transport and storage	3,728.45	283.66	268.02
Hotels and restaurants	130.02	21.81	39.02
Information and communication	41.75	13.03	20.21
Finance, and insurance	449.55	12.98	20.13
Real estate, renting and business activities	97.39	30.40	47.14
Professional, scientific and engineering activities	1,069.12	0.33	0.51
Administrative and support service activities	353.56	106.14	20.14
Public administration and defence as well as compulsory social security	1,651.03	495.32	0.63
Education	13.69	4.27	6.63
Health and social work	21.82	6.81	10.56
Arts, entertainment and recreation	18.51	5.78	8.96
Other activities	25.78	8.05	12.48
<b>Total Expenditures</b>	<b>58,116.26</b>	<b>7,908.77</b>	<b>4,580.73</b>

Source: Own composition based on HCSO (2018) data.



**Figure 4:** Expected increase in the number of jobs per sector.

Source: Own composition based on HCSO (2018) data.

to estimate the change in employment per sector the last step is to divide this change in output by the labour productivity per sector. The main findings are displayed in Figure 2.

Given the increase in expenditures in the agricultural sector, we see that this sector will experience the sharpest rise in the number of jobs. At the national level the biorefinery generates 3,859 jobs in the agricultural sector. In Tolna and Fejér, this number corresponds to 594 and 261 jobs, respectively. The Transport and Storage sector also shows a sharp increase in employment. However, in comparison to the agricultural sector the change in employment is higher at the national level than at the regional level. Therefore, we can conclude that the biorefinery mainly uses transport facilities outside the regions of Tolna and Fejér. The construction, the manufacturing, the electricity, gas and water supply and the trade and repair sectors show a significant increase in jobs as well.

The biorefinery has kept expanding and will continue to do so in the next couple of years, but this trend may slow down in the mid future. Thus, it is possible that the expenditures for construction will decrease in the future, which will have a mitigating effect on the rise of employment in the construction sector. The increase in jobs is partly due to constant expenditures and partly due to one-time expenditures in the establishment of the plant.

Overall, the biorefinery creates around 5,500 jobs. This is a large number if we take into account that directly the plant itself employs only 172 people. This means that the number of indirect jobs connected to the biorefinery includes more than 5,000 jobs in total. At the regional level this is approximately 785 jobs in Tolna and 416 jobs in Fejér counties. These numbers show that the biorefinery creates jobs at the regional as well as national level. These numbers are estimated using the 2016 expenditures, and therefore may change over the years.

## Discussion and Conclusions

The results of our research show that at the national level the number of jobs related to the activities of the biorefinery

is around 5,500 jobs. For the regions Tolna and Fejér this number corresponds to 785 and 416 jobs, respectively. These figures are significant compared to the size of the regions assessed. Furthermore, the reason behind the relatively high figures may be the specific nature of biorefineries; embedded in the local economy, low level of inputs from outside of the region, most expenditures have impacts within the region, which, as a consequence, may lead to largely keeping the jobs created in the region and in the country.

Direct and indirect jobs are also created. While Hunsberger *et al.* (2017) fails to consider indirect jobs in the service sector and therefore their analysis is lacking, the latter category appears larger. Our finding shows that the number of jobs created indirectly in the agriculture and services industries are more than an order of magnitude higher than jobs created and maintained within the plant gates (5,000 v 172). Little previous research has focused on indirect jobs; however, our modelling underlines their importance. Furthermore, biorefineries are embedded in the local economy; therefore, most expenditures lead to jobs being created in the region, more specifically in the rural areas, because the major inputs for the biorefinery are generated by agriculture.

The significance of the national jobs with respect to county level ones may be due to the fact that biorefineries operate across the borders, i.e. the products they make are sold across countries. For instance, ethanol is a commodity freely traded on the European market and beyond. This notion implies that the adjacent service industry may be of cross-boarder character, and, as a result, jobs created and maintained are not strictly rooted in the local or regional economies.

The value of the multipliers is in line with results from similar analyses. For example Heijman *et al.* (2017) computed regional multipliers for the 12 Dutch Provinces, of which results are comparable to the findings in this article. Though we are of the opinion that our results are rather robust, in order to find out how much changing the assumptions may modify results, it may be considered to carry out a sensitivity analysis in a follow up study. This may concern variations in sectoral and regional labour productivity and

other assumptions. For a reasonable range of values concerning these variables, a considerable impact on the final results is not to be expected.

Ultimately, the results show that there is a considerable contribution by the biorefinery to the Hungarian economy. What has not been discussed is its effect on the surrounding countries. Unfortunately, it is difficult to make an educated guess regarding the extent to which trading partners benefit in terms of jobs. The use of the I-O model is insufficient for answering such a question, since it makes use of the national labour productivity. One cannot assume that the labour productivity is the same for all European countries. Nonetheless, it is reasonable to assume that the surrounding countries will experience an increase in the demand for their products. Looking at the results, it can be expected that the imports will increase in comparison to the previous situation. Thus, it is likely that the surrounding countries will also experience some rise in employment. We can conclude that there must be a positive effect on those countries; only the size of this effect is unclear.

Since its primary input is corn, the bioethanol plant we examined increases the demand in the agricultural sector significantly. The service industries, including the construction, logistics and administrative sectors, have also experienced an increase in demand. The increase in demand in these sectors leads to an indirect demand effect in the remaining sectors. Due to the multiplier effect and the increase in demand the economy as a whole grows, which leads to more jobs at the national level.

Our conclusion is that the spending of the biorefinery in the agricultural sector significantly effects the economic development at the national as well as regional and perhaps international level. In particular, rural areas benefit from this type of spending, since biorefineries are typically located in rural settings. The resulting increase in jobs may help rural regions overcome poverty and can positively influence the national and European economy as a whole. Our results appear to be in line with figures presented by IRENA (2017) and Urbanchuk (2018). Based on this result it may be a good idea to explore the potential in Europe and elsewhere to expand the production of biofuels to foster rural development.

As a thought experiment, the European context and potential may be scaled by a simple calculation. 5.81 billion liters of bioethanol was produced in Europe in 2015 (ePURE, 2017). The production of the biorefinery in question (450 million litres) amounted to 7.7% of total European bioethanol production. To put the findings into perspective, provided the impact on jobs does not differ significantly across the European bioethanol industry, we may extrapolate that about 70 thousand jobs are created and maintained in various rural regions in Europe by the European ethanol industry (5,500 divided by 7.7%). Needless to say that the actual impacts of each biorefineries are different, depending among other things on their technology, spending patterns and the contexts of the regional economies, so more research is warranted to extrapolate to European context.

The revision of the Common Agricultural Policy (CAP) offers an opportunity to consider rural development impacts of EU policies. One of the objectives of CAP reform has

been to foster rural development. Our finding suggests that biorefineries may be seen as a useful element in achieving such objective. In addition to the CAP, it is proposed that the Renewable Energy Directive as well as other energy, climate, agriculture or transport related policies are to consider the rural development dimension of biofuels, or the bioeconomy in general.

## Acknowledgement

Authors would like to thank Katalin Tarr for her work in data processing.

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## Annex

### Annex 1: NUTS Regions in Hungary.



Source: Eurostat, 2013



Annex 2: I-O Table for Fejér.

Fejér (Million HUF)	Agriculture, hunting, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply, sewerage, waste management and remediation activities	Construction	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Accommodation and food service activities	Information and communication	Financial and insurance activities	Real estate activities	Professional, scientific and technical activities	Administrative and support service activities	Public administration and defence; compulsory social security	Education	Human health and social work activities	Arts, entertainment and recreation	Other activities	F	Total Sum horizontal X
Agriculture, hunting, forestry and fishing	10,521	2	26,576	338	52	81	2,957	53	354	6	3	112	42	81	28	15	118	9	4	20,941	62,293
Mining and quarrying	46	49	6,360	696	49	313	129	39	9	2	1	77	12	26	29	31	37	8	3	1,043	8,957
Manufacturing	13,230	461	594,715	12,239	2,573	14,402	29,007	8,349	5,280	1,208	329	7,935	1,551	4,437	1,499	1,450	9,961	590	468	1,101,577	1,811,258
Electricity, gas and water supply	1,100	69	18,467	4,220	818	307	5,182	838	527	181	59	1,776	233	468	1,238	961	974	340	89	19,635	57,483
Water supply, wastewater collection and treatment, waste management, pollution treatment	194	11	4,908	301	1,548	147	1,244	95	126	19	16	536	40	190	356	200	396	104	38	10,729	21,198
Construction	64	12	2,011	679	299	1,530	551	546	52	54	8	2,518	64	139	955	333	200	83	30	32,204	42,336
Wholesale and retail trade, repair of motor vehicles and household goods	3,155	78	44,627	1,188	642	2,978	13,597	1,598	922	332	134	2,939	499	1,869	518	414	1,737	218	146	150,363	227,955
Transport, storage	806	110	16,016	2,527	364	915	9,252	4,079	203	188	127	838	222	1,308	1,533	265	349	130	87	15,539	54,857
Hotels and restaurants	15	5	794	31	13	66	418	90	616	28	12	75	82	1,553	345	142	558	44	99	13,700	18,684
Information, communication	84	9	4,482	470	170	202	2,852	382	109	905	191	534	333	768	576	516	313	326	126	4,181	17,528
Finance, insurance	225	12	1,716	188	70	211	1,522	234	82	45	593	3,487	123	272	316	42	74	25	34	903	10,174
Real estate, renting and business activities	302	24	7,243	839	762	808	10,333	887	650	453	233	2,622	747	1,590	2,119	985	1,141	609	349	93,761	126,455
Professional, Scientific and engineering activities	228	65	7,185	1,053	208	535	6,154	324	126	263	139	1,708	790	996	362	124	202	137	51	2,725	23,376
Administrative and support service activities	271	76	24,112	1,749	575	929	8,974	1,686	484	579	539	3,291	644	3,383	829	515	898	542	158	19,001	69,235
Public administration and defence; compulsory social security	93	16	1,443	300	310	111	1,593	560	89	169	120	388	129	254	929	80	54	90	83	55,891	62,703
Education	23	1	754	54	34	38	540	56	21	38	40	90	63	122	5	1,481	23	6	32	38,518	41,940
Health and social work	4	1	610	48	26	21	398	73	53	7	8	36	14	75	12	23	2,035	19	30	49,594	53,085
Arts, entertainment and recreation	11	1	409	30	16	29	260	37	21	50	7	66	24	247	5	4	16	499	20	7,805	9,556
Other activities	72	1	592	78	77	56	792	101	82	46	27	243	58	153	86	69	189	38	20	3,149	5,929
added value	23,844	1,279	246,376	22,392	10,414	17,391	107,879	22,472	7,625	9,089	6,938	96,386	12,788	31,664	50,142	34,110	33,641	5,427	3,908	743,765	
Imports cif intra EU	6,822	1,434	550,859	5,439	1,956	976	17,129	7,406	971	2,205	529	599	3,761	13,122	572	141	123	210	73	614,327	
Imports cif extra EU	1,169	5,241	250,726	2,612	221	282	7,152	4,944	277	1,658	122	186	1,153	6,509	245	37	41	100	80	282,757	
Total Sum vertical (X)	62,279	8,957	1,810,981	57,471	21,195	42,327	227,914	54,849	18,681	17,526	10,173	126,443	23,373	69,227	62,698	41,937	53,079	9,554	5,929		

Source: Own composition based on HCSO (2017) data.

Annex 3: I-O Table for Tolna.

Tolna (Million HUF)	Agriculture, hunting, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Water supply, sewerage, waste management and remediation activities	Construction	Wholesale and retail trade; repair of motor vehicles and motorcycles	Transportation and storage	Accommodation and food service activities	Information and communication	Financial and insurance activities	Real estate activities	Professional, scientific and technical activities	Administrative and support service activities	Public administration and defence; compulsory social security	Education	Human health and social work activities	Arts, entertainment and recreation	Other activities	F	Total Sum
Agriculture, hunting, forestry and fishing	8,738	0	9,332	965	39	73	741	25	220	6	3	70	27	74	20	11	132	6	2	18,442	38,927
Mining and quarrying	7	1	411	366	7	52	6	3	1	0	0	9	1	4	4	4	8	1	0	28	913
Manufacturing	7,070	42	134,372	22,495	1,249	8,306	4,675	2,582	2,114	769	247	3,196	642	2,613	698	721	7,179	259	130	245,253	444,612
Electricity, gas and water supply	1,301	14	9,229	17,158	879	392	1,847	574	467	255	98	1,583	213	610	1,275	1,058	1,553	330	55	84,707	123,597
Water supply, wastewater collection and treatment, waste management, pollution treatment	133	1	1,417	707	960	109	256	37	65	16	15	276	21	143	212	127	364	58	14	6,994	11,924
Construction	39	1	516	1,417	165	1,001	101	192	24	39	7	1,151	30	93	504	188	164	42	9	20,491	26,173
Wholesale and retail trade, repair of motor vehicles and household goods	1,448	6	8,657	1,875	267	1,475	1,881	424	317	182	87	1,017	177	945	207	177	1,075	82	35	21,470	41,803
Transport, storage	413	10	3,466	4,448	169	505	1,428	1,208	78	114	91	323	88	738	684	126	241	55	23	4,635	18,843
Hotels and restaurants	9	0	190	60	7	40	72	30	262	19	9	32	36	971	171	75	427	21	29	5,922	8,382
Information, communication	72	1	1,629	1,389	133	188	739	190	70	926	231	346	222	728	432	413	363	230	56	4,460	12,817
Finance, insurance	247	2	800	715	70	251	506	150	68	60	919	2,898	105	330	303	43	110	23	19	1,516	9,134
Real estate, renting and business activities	185	3	1,872	1,764	423	533	1,905	314	298	330	200	1,208	353	1,071	1,129	561	941	306	111	45,069	58,574
Professional, Scientific and engineering activities	153	8	2,040	2,432	127	388	1,246	126	64	211	131	865	411	737	212	78	183	75	18	1,456	10,960
Administrative and support service activities	229	11	8,600	5,074	441	845	2,283	823	306	582	640	2,092	421	3,145	610	405	1,022	375	69	18,099	46,070
Public administration and defence; compulsory social security	56	2	366	618	169	72	288	194	40	121	101	176	60	168	485	45	44	44	26	30,080	33,154
Education	14	0	191	112	18	25	98	19	9	27	34	41	29	80	3	827	18	3	10	22,158	23,716
Health and social work	3	0	154	98	14	13	72	25	24	5	7	16	7	50	6	13	1,642	9	9	40,292	42,458
Arts, entertainment and recreation	7	0	105	63	9	19	47	13	10	36	6	30	11	165	3	2	13	248	6	4,170	4,962
Other activities	36	0	127	136	35	30	121	30	31	28	19	93	23	86	38	33	129	16	5	851	1,866
added value	14,043	130	61,350	45,359	5,573	11,053	19,160	7,660	3,364	6,376	5,744	42,793	5,832	20,552	25,736	18,710	26,720	2,626	1,193	323,977	
Imports eif intra EU	4,018	146	137,170	11,017	1,047	620	3,042	2,525	429	1,546	438	266	1,715	8,517	293	77	97	102	22	173,088	
Imports eif extra EU	688	533	62,434	5,291	118	179	1,270	1,685	122	1,163	101	83	526	4,225	126	20	32	49	24	78,670	
Total Sum vertical (X)	38,906	912	444,426	123,560	11,920	26,168	41,784	18,830	8,380	12,810	9,128	58,563	10,951	46,045	33,151	23,715	42,456	4,962	1,865		

Source: Own composition based on HCSO (2017) data

Mario A. GONZALEZ-CORZO\*

# Agricultural Reforms, Land Distribution, and Non-Sugar Agricultural Production in Cuba

Since 2007, the Cuban government has introduced a series of agricultural reforms to increase non-sugar agricultural production and reduce the country's dependency on food and agricultural imports. The most important agricultural reforms implemented in Cuba (so far) include: (a) increases in the prices paid by the state for selected agricultural products, (b) restructuring the Ministry of Agriculture (MINAGRI) and the Ministry of the Sugar Industry (MINAZ), (c) a new agricultural tax system, (d) the authorisation of direct sales and commercialisation of selected agricultural products, (e) micro-credits extended by state-owned banks to private farmers and usufructuaries, and (f) the expansion of usufruct farming. These reforms have contributed to the redistribution of Cuba's agricultural land from the state to the non-state sector, notable reductions in idle (non-productive) agricultural land, and mixed results in terms of agricultural output. However, they have not been able to sufficiently incentivise output and reduce the country's high dependency on agricultural and food imports to satisfy the needs of its population. Achieving these long-desired objectives requires the implementation of more profound structural reforms in this vital sector of the Cuban economy.

**Keywords:** Agricultural reforms, Cuban agriculture, Cuban economy, transition economies

**JEL classifications:** Q15, Q18

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Received: 2 September 2018, Revised: 2 January 2019, Accepted: 7 January 2019.

## Introduction

In 2007 the Cuban government began the implementation of agricultural reforms to increase production, improve efficiency, and reduce the country's dependency on imported food and agricultural products. The most significant measures included: (a) increases in the prices paid by the state for certain agricultural products, (b) the reorganisation of the Ministry of Agriculture (MINAG) and the Ministry of the Sugar Industry (MINAZ), (c) a new agricultural tax regime, (d) direct sales and decentralisation of selected agricultural products, (e) micro-credits by state banks to non-state agricultural producers, and (f) the expansion of usufruct farming, which constitutes the most profound and far-reaching structural reform in the recent history of Cuban agriculture.

This paper discusses the agricultural reforms implemented in Cuba since 2007, as part of its efforts to "update" its socialist economic model, and evaluates the impact of these reforms on two important indicators: (1) land distribution and (2) non-sugar agricultural production. The paper is organized as follows. Section one describes the agricultural reforms implemented in Cuba since 2007. Section two analyses the impact of these reforms on land distribution and non-sugar agricultural production during the 2007-2017 period. Section three presents the conclusions of the paper.

## Cuba's Agricultural Reforms: 2007- Present

### *Prices increases for selected agricultural products*

Beginning in 2007, Cuba's state-run agricultural procurement and distribution agency, Acopio, raised the prices it paid to agricultural producers for a selected group of products, including beef, milk, potatoes, and rice (Nova González and

González-Corzo, 2015).<sup>1</sup> To incentivise non-sugar agricultural production, between 2007 and 2013, Acopio increased the price it paid rice producers by 226.5%; similarly, the price paid for potatoes was raised by 20%; the price paid to milk producers increased by 479.8%, and the price paid to beef producers rose by 263.3% (Spadoni, 2014).

The approval of Resolutions 238 and 239 in 2015 increased the prices paid by Acopio for beef, milk, potatoes, and tomatoes. The price of beef was raised from 6.50 Cuban pesos (CUP) per kilogram (kg) to 12 CUP / kg; milk prices were increased from 2.50 CUP per litre (L) to 4.50 CUP/L; the price of potatoes was raised from 45 CUP per quintal (qq) to 65 CUP/qq; and the price of tomatoes was increased from 100 CUP/qq to 110 CUP/qq (Cubadebate, 2015; Gaceta Oficial de Cuba 18, 2015).

### *Restructuring of the Ministry of Agriculture (MINAG) and the Ministry of the Sugar Industry (MINAZ)*

The approval of Decree-Law 287 in 2011 restructured the Ministry of Agriculture (MINAG) and the Ministry of the Sugar Industry (MINAZ) in order to improve efficiency. The MINAG was placed in charge of managing the areas dedicated to sugar cane cultivation, which were previously administered by the Ministry of the Sugar Industry (MINAZ) (Gaceta Oficial de Cuba 37, 2011). The MINAG also became responsible for overseeing all aspects of non-sugar agricultural production, as well as the functions related to sugar

<sup>1</sup> Acopio, which is officially known as the Unión Nacional de Acopio (UNA), currently operates under the Ministry of Agriculture (MINAGRI) and consists of 12 enterprises (empresas nacionales) and 15 basic enterprise units (Unidades Empresariales de Base – UEBs) that operate nationwide, except in the provinces of Artemisa, Mayabeque, and Havana, and in the Isle of Youth, where the direct commercialization of selected agricultural products is permitted (Martín González, 2018). Acopio supplies an estimated 400 state-run agricultural markets (Mercados Agropecuarios Estatales – MAEs) and some 1,200 agricultural sales outlets (puntos de venta) on daily basis with domestic agricultural products, which are collected from state farmers, agricultural cooperatives, and private producers (e.g., independent farmers and usufructuaries) (Martín González, 2018).

production previously assigned to the MINAZ under Law 95 – also known as the “Law of Agricultural Production Cooperatives and Credit and Services Cooperatives” approved in 2002 (Gaceta Oficial de Cuba 37, 2011).

Decree-Law 294 replaced the Ministry of the Sugar Industry (MINAZ) with a State-owned holding company known as Grupo Azucarero, S.A. (AZCUBA) in 2011 (Gaceta Oficial de Cuba 37, 2011). AZCUBA reports directly to the Council of Ministers, and is responsible for implementing policies and strategies related to the production of sugar and its derivatives (Gaceta Oficial de Cuba 37, 2011).

The replacement of the MINAZ with AZCUBA in 2011 was part of the continuation of the restructuring process initiated in 2002, which consisted of four (4) key elements: (1) closing 71 of the country’s 156 sugar mills, (2) repurposing 14 mills to specialise in the production of sugar and molasses for animal feed, (3) reallocating land from sugar to non-sugar crop production, and (4) reassigning some 100,000 sugar industry workers to other sectors of the economy, particularly tourism (Álvarez and Pérez-López, 2005; Pérez-López, 2016; Pollit, 2010).

Since 2002, there has been a notable reduction in the area dedicated to sugarcane cultivation, particularly in the state sector (Pérez-López, 2016). This trend has continued after the replacement of the MINAZ with AZCUBA in 2011. During the 2001/2002 harvest (or *zafra*), the last year before the 2002 restructuring, a total of 1,041,200 hectares (ha) were dedicated to sugar cane (ONEI, 2017). A year later, during the 2002/2003 harvest, the area dedicated to sugar cane fell by 38.2% to 643,800 ha (ONEI, 2017). During the first harvest under AZCUBA in 2011/2012, the area dedicated to sugar reached a historical low of 361,300 ha, which was 65.2% below the area dedicated to sugar cane during the 2001/2002 harvest (ONEI, 2017).

The reduction in the area dedicated to sugar cane production, along with the massive reduction in the number of operating sugar mills, and the marked decline of the sugar agro-industrial complex since 2002 have adversely impacted Cuba’s sugar production and exports (Pollit, 2010; Pérez-López, 2016). Between 2011 and 2016, Cuba’s sugar production reached an annual average of 1.5 million metric tons (mt), which is quite low by historical standards; and in recent years, Cuba has been forced to import sugar from Brazil, Colombia, and (more recently) France, to meet its international obligations and satisfy domestic demand (Hernández, 2018). Sugar output for the 2018/2019 harvest is expected to fall well below the 1.6 million mt forecasted by AZCUBA at the beginning of the year, signalling the continuation of the ongoing decline of this vital sector of the Cuban economy (Hernández, 2018).

### *A New Agricultural Tax System*

Law 113 introduced a new agricultural tax system in Cuba in 2012. Under Law 113 (2012), natural and legal persons that possess agricultural land, including forested areas and idle land, regardless of the type of tenure or ownership, are required to pay taxes in Cuban pesos (CUP) for the possession and utilization of such land based on its classification (Gaceta Oficial de Cuba 53, 2012). Law 113 (2012) also

introduced income (or sales) taxes for individual agricultural producers, agricultural cooperatives, and state-owned agricultural enterprises. Initially, agricultural producers were given a two-year grace period, during which they were exempted from the land and sales taxes established by Law 113 (2012). This grace period was extended several times until the approval of Decree-Laws 350 and 358 in August 2018, which stipulated that agricultural producers must pay land and income (sales) taxes as stipulated in Law 113 (2012) (Gaceta Oficial de Cuba 39, 2018).<sup>2</sup>

Agricultural land, including forested areas and idle land, classified as Level I (or top-quality agricultural land) is subject to a land tax of 180 CUP per hectare (ha) (Gaceta Oficial de Cuba 53, 2012). Holders of agricultural land classified as Level II are required to pay a land tax of 90 CUP/ha; those who possess Level III land are required to pay a land tax of 90 CUP/ha; and holders of Level IV land (i.e., land considered to be of the worst quality – often covered by marabú<sup>3</sup>) are required to pay a land tax of 45 CUP/ha. (Gaceta Oficial de Cuba 53, 2012). According to official estimates, only 20% of Cuba’s agricultural surface is considered as Level I land (Castro Morales, 2018).<sup>4</sup>

According to Law 113 (2012), individual agricultural producers are required to pay a minimum income (sales) tax of 5%. They are also required to pay additional taxes on personal income based on the following scale: 10% on annual income up to 12,000 CUP, 15% on annual income between 12,001 CUP and 24,000 CUP, 20% on annual income between 24,001 CUP and 48,000 CUP, 30% on annual income between 48,001 CUP and 72,000 CUP, 35% on annual income between 72,001 CUP and 100,000 CUP, 40% on annual income between 100,001 CUP and 150,000 CUP, and 45% on annual income of 150,001 CUP or higher (Gaceta Oficial de Cuba 53, 2012).<sup>5</sup>

Law 113 (2012) establishes a minimum income (sales) tax of 5% for agricultural cooperatives and state-run agricultural enterprises. Agricultural Production Cooperatives (*Cooperativas de Producción Agropecuaria – CPA*) and

<sup>2</sup> According to Cuban authorities, the tax on idle land (which became effective after August 2018) aims to incentivize holders to “put their idle land to productive use” (i.e. to plant it with suitable crops) (Castro Morales, 2018). While the land tax on idle land is not intended as a source of tax revenue for the state, according to Law 125 of the State Budget for 2018, the revenues collected will be used to support the country’s agricultural programs and policies (Castro Morales, 2018). Unlike other agricultural taxes, land tax payments cannot be deducted (Castro Morales, 2018).

<sup>3</sup> Marabú (*Dichrostachys cinerea*) grows in large, open spaces (e.g. unattended pastures or grazing areas, abandoned or idle agricultural land, etc.) and thrives under various climatic conditions (e.g., intense heat, arid terrain, etc.). It is hard to cut down, often requiring mechanised cutting and elimination by chemical treatment. In the case of Cuba, marabú occupies a significant portion of Cuba’s idle agricultural land and underutilised pastures.

<sup>4</sup> For tax purposes, Level I land is defined as high quality land suitable for diverse types of crops, with the potential of reaching 70% or more of its minimum potential yield (as defined by the MINAG) (Castro Morales, 2018). Level II land consists of good quality land, which requires some minimal conservation or soil improvement measures, and can potentially achieve between 50% and 70% of its estimated (agricultural) yield (Castro Morales, 2018). Level III land includes medium quality land, with medium or low fertility levels, which require significant conservation or soil improvement measures, and can achieve agricultural yields ranging from 30% to 50% of their estimated potential (Castro Morales, 2018). Finally, Level IV land consists of poor quality land, with relatively low fertility rates, often covered in marabú, requiring very large conservation or soil improvement measures, and normally dedicated to reforestation or similar purposes (Castro Morales, 2018).

<sup>5</sup> The first 10,500 CUP of income are exempted from the income (sales) tax; individual agricultural producers can deduct up to 70% of the expenses incurred during the regular course of business, and are only required to provide supporting documentation for half of the deducted expenses (Castro Morales, 2018; Gaceta Oficial de Cuba 53, 2012).



Basic Units of Cooperative Production (*Unidades Básicas de Producción Cooperativa – UBPC*) are required to pay additional income taxes on their per capita income (i.e. income per associate or member) based on the following scale (Gaceta Oficial de Cuba 53, 2012): 5% on annual per capita income up to 10,500 CUP, 10% on annual per capita income between 10,501 CUP and 23,500 CUP, 12% on annual per capita income between 23,501 CUP and 46,500 CUP, and 17.5% on annual per capita income of 46,501 or higher.<sup>6</sup>

#### *Decentralized Commercialization of Selected Agricultural Products*

The approval of Agreement 6853 and Resolution 206 in 2010 authorised the direct sale of agricultural products at roadside kiosks operated by agricultural cooperatives, self-employed workers and state enterprises (González-Corzo, 2013). Producers or their representatives operating in roadside kiosks are allowed to sell their excess production after meeting their contractual obligations with Acopio (González-Corzo, 2013).<sup>7</sup>

Resolutions 90, 121, 122, and 369 (2011) regulate direct sales of selected agricultural products to tourism enterprises (Gaceta Oficial de Cuba 38, 2011). Resolution 90 (2011) created a new entity, Fintour, S.A., to provide credit financing, factoring services, and consultancy to tourism enterprises, including those that buy directly from authorised agricultural producers (Gaceta Oficial de Cuba 38, 2011).<sup>8</sup> Prices can be determined without state intervention; payments can only be made in Cuban pesos (CUP), unless otherwise stated; however, in the case of transactions approved in convertible pesos (CUC), Fintour, S.A. is authorized to act as a transfer payments agent, and converts CUC to CUP at a predetermined exchange rate (Gaceta Oficial de Cuba 38, 2011).<sup>9</sup>

The approval of Resolutions 37, 58, and 352 in 2013 authorised direct sales of selected agricultural products in Cuban pesos (CUP) to tourism enterprises by *all* types of agricultural producers, without state intermediation, including individual (private) farmers and usufructuaries. The list of authorized products was expanded to include fresh cut flowers, gardening services, floral arrangements, dry spices, and eggs (Gaceta Oficial de Cuba 4, 2013).

Decree-Law 318 (2013) further expanded the direct commercialization of agricultural products by authorizing direct sales to the population at the following outlets: State Agricultural Markets (MAEs), Demand and Supply Markets (MOD), Leased Markets (agricultural outlets leased by the state to non-state producers), and stalls, or kiosks located in neighbourhoods, and highway rest stops. Retail prices of

these agricultural products are set by the Ministry of Finance and Prices; however, producers that operate in the MAEs that have been converted to non-agricultural cooperatives (CNAs) can set their own prices, but these must be approved by the Ministry of Finance and Prices (Gaceta Oficial de Cuba 35, 2013).

#### *Micro-credits for Non-State Agricultural Producers*

The approval of Decree-Law 289 2011 authorised the extension of micro-credits (or micro-loans) by state-run banks to private farmers and usufructuaries in Cuban pesos (CUP) (Gaceta Oficial de Cuba 40, 2011). The terms of these micro-credits are set by the lending institution based on the borrower's risk profile, and type and value of collateral; the Central Bank of Cuba, rather than the lending institution, determines the interest rates for these micro-credits; and farmers can use them to purchase equipment and supplies, cover the costs associated with field preparation and conditioning, and any other activities to improve agricultural production (Gaceta Oficial de Cuba 40, 2011).

#### *Expansion of Usufruct Farming*

The most profound agricultural reform implemented in Cuba since 2007 has been the expansion of usufruct farming (Febles *et.al.*, 2017; Mesa-Lago, 2013, 2014; Nova González, 2013, 2013a, 2014; Nova González and González-Corzo, 2015; Villalonga Soca, 2015). This process began with the approval of Decree-Laws 259 and 282 in 2008, which authorized the transfer of idle state-owned land to natural persons for up to ten (10) years and to legal persons for periods of up to twenty-five (25) years (Gaceta Oficial de Cuba 4, 2008). The maximum amount of land that could be transferred to usufruct farmers was limited to 13.42 hectares (ha); permanent investments in housing for usufructuaries and their families were excluded; the transfer of usufruct rights to third parties was prohibited; and the cancellation of usufruct contracts was only allowed under exceptional circumstances (Gaceta Oficial de Cuba 4, 2008).

Decree-Laws 259 and 282 (2008) were repealed with the approval of Decree-Laws 300 and 304 in 2012. The limit of 13.42 ha for first-time usufructuaries was kept, but the maximum amount of land that could be transferred to natural persons who already possessed land (either in direct ownership or in usufruct) was increased from 40.26 ha to 67.10 ha (Gaceta Oficial de Cuba 45, 2012). Usufruct farmers who already possessed land were required to be directly associated with a CPA or UBPC, and their plots had to be located in the immediate proximity of such cooperative or within five (5) kilometres (km) from its territory (Gaceta Oficial de Cuba 45, 2012). Usufruct farmers were allowed to construct permanent structures—including housing, but their size was limited to 1% of their plots, and they could receive compensation from the state for the assessed value of such structures upon the termination of the usufruct contract (Gaceta Oficial de Cuba 45, 2012).

Decree-Law 311 and Decree-Law 319 (2014) authorise farmers associated with the Credit and Services Cooperatives (CCS) to obtain up to 67.10 hectares (ha) of idle state-

<sup>6</sup> CPAs and UBPCs can deduct up to 12,000 CUP per associate or member from gross income for tax purposes (Gaceta Oficial de Cuba 53, 2012).

<sup>7</sup> Agricultural producers operating under this modality are required to pay taxes and make social security contributions as stipulated by Law 113 (2012).

<sup>8</sup> In addition to Fintour, S.A., Resolution 121 (2011) authorized the *Banco de Crédito y Comercio (BANDEC)* and the *Banco Metropolitano (BM)* to provide custody, and transfer payment services in Cuban pesos (CUC) or convertible pesos (CUP) on behalf of tourism entities with direct purchases from authorized agricultural producers.

<sup>9</sup> The Cuban economy operates under a system of monetary dualism with multiple exchange rates. For example, the official exchange rate between the “regular” Cuban peso (CUP) and the “convertible” Cuban peso (CUC) is 25 to 1, and the official exchange rate between the CUC and the USD is 0.80 per 1.00 USD. (See Mesa-Lago and Pérez-López (2015), Posada (2011), and Spadoni (2014) for more information about Cuba's dual currency and multiple exchange rate systems.).

owned land in usufruct (Gaceta Oficial de Cuba 4, 2014). Usufruct farmers can acquire land beyond 5 km from CPAs, UBPCs, and state farms (Gaceta Oficial de Cuba 4, 2014).

The laws that regulate usufruct farming in Cuba were further modified with the approval of Decree-Laws 350 and 358 in August 2018 (Gaceta Oficial de Cuba 39, 2018). These regulations, which replaced Decree-Laws 300 and 304 (2012), extended usufruct contracts from 10 years to 20 years for natural persons and from 25 years to an indefinite time period for legal persons; the size of the plots that can be transferred to first-time usufructuaries was doubled from 13.42 ha. to 26.84 ha.; usufruct farmers can be associated with (state-owned) forestry and sugar agricultural enterprises; and usufruct rights can be granted for raising cattle (but farmers are required to grow their own fodder) (Gaceta Oficial de Cuba 39, 2018).

However, to obtain the land, usufructuaries are required to work on the land and administer it directly and personally (Gaceta Oficial de Cuba 39, 2018). The usufruct contract can be terminated (by the state) due to the use of illicit financial sources (by the usufructuary) for any purpose or reason (Gaceta Oficial de Cuba 39, 2018).

## Impact of the Agricultural Reforms

### *Land distribution*

As Table 1 illustrates, there has been a significant redistribution of Cuba's agricultural surface and cultivated area from the state sector to the non-state sector since 2007.<sup>10</sup> In 2007, 35.8% of Cuba's agricultural surface (2,371,200 ha) was held by the state sector, compared to 30.7% (1,912,000 ha) in 2016. Similarly, the state's share of the cultivated area declined from 23.2% (694,200 ha) in 2007 to 19.1% (521,900 ha) in 2016. Conversely, the non-state sector's share of the agricultural surface increased from 64.2% in 2007 (4,248,300 ha) in 2007 to 69.3% (4,314,700 ha) in 2016. The non-state sector's share of the cultivated area increased from 76.8% (2,294,300 ha) in 2007 to 80.9% (2,211,600 ha) in 2016 (Table 1).

There has been a notable reallocation of agricultural land within the non-state sector from the least autonomous and inefficient agricultural cooperatives (i.e., the UBPCs) to the more autonomous and productive CCSs and private farmers since 2007. As Table 1 shows, the UBPCs' share of the agricultural surface decreased from 37% (2,448,200 ha) in 2007 to 24.5% (1 528 400 ha) in 2016. Similarly, their share of the country's cultivated area declined from 39.8% (1,189,900 ha) in 2007 to 30.7% (840,400 ha) in 2016. The CCSs and private farmers held 18.3% of Cuba's agricultural surface (1,214,300 ha) and 26.7% of its cultivated area (799,100 ha) in 2007 (ONEI, 2010, 2017). By the end of 2016, the CCSs and private farmers held 36.7% of the agricultural surface (2,283,000 ha) and 40.4% of the cultivated area (1,103,900 ha) (Table 1).

Another tangible effect of the agricultural reforms implemented in Cuba since 2007 has been the reduction of

idle land.<sup>11</sup> As Table 2 shows, the amount of idle land was reduced from 1,282,800 ha in 2007 to 917,300 ha in 2017, representing a decrease of 25.6% during this period (ONEI, 2008, 2018). The most notable reductions have taken place in the non-state sector, which experienced a decline in idle land of 44.7%, from 605,600 ha in 2007 to 335,100 ha in 2017. Within the non-state sector, the CCSs have experienced the most significant (-91.5%) decline in idle land during the 2007-2017 period, followed by the CPAs (-90.0%), UBPCs (-64.2%), and usufruct farmers (-20%) (Table 2).

The agricultural reforms introduced in Cuba since 2007 have also contributed to the redistribution of idle land from the state to the non-state sector (Table 2). In 2007, the state sector held 50.9% (627,200 ha) of Cuba's idle land; this figure increased to 63.5% (582,200 ha) in 2017 (Table 2). By contrast, the non-state sector's share of the country's idle land fell from 49.1% (605,600 ha) to 36.5% (582,200 ha) during the 2007-2017 period (Table 2). As Table 2 indicates, the share of idle land held by non-state agricultural producers, except private farmers, and usufructuaries, declined between 2007 and 2017. This is mainly attributed to the expansion of usufruct farming after 2008 and 2012, and the reduction in the amount of agricultural land (including idle land) held by the state sector (Nova González, 2018).

### *Non-sugar agricultural production*

Increasing agricultural output to substitute imports, and improving food security remains one of the principal objectives of the agricultural reforms implemented in Cuba since 2007 (García-Álvarez and Nova González, 2014; Riera and Swinnen, 2016). As Table 3 demonstrates, production increased in six (6) out of the nine (9) principal non-sugar crop categories reported by Cuba's National Statistics Office (ONEI) during the 2008-2016 period. Output increased in the following crop categories: (1) cocoa (87.1%), (2) legumes (40.5%), (3) plantains (34%), viandas (33%), (5) other fruits (27.9%), and (6) cereals (i.e. rice and corn) (20.6%). Conversely, the following crops experienced lower output levels between 2008 and 2016: (1) citrus fruits (-69.5%), (2) tobacco (-8.4%), and (3) vegetables (-2.2%) (Table 3).

These trends seem to suggest that at least in terms of production Cuba's recent agricultural reforms have achieved mixed results. However, at the present time, domestic agricultural production is unable to satisfy the country's food demand, and Cuba imports a significant share of the food and agricultural products consumed by its population. In 2007, Cuba imported approximately \$1.5 billion in food and agricultural products, representing 15.4% of total merchandise imports (ONEI, 2010). Food and agricultural imports increased to an estimated \$1.8 billion in 2016, representing 17.3% of total merchandise imports (ONEI, 2017). Cuba imports 64% of the rice, 52% of the beans, 68% of the corn, 100% of the wheat flour, and 100% of the vegetable oils consumed by its population, highlighting its relatively-high levels of external sector dependency, and its inability

<sup>10</sup> The non-state sector includes Basic Units of Cooperative Production (UBPC), Agricultural Production Cooperatives (CPAs), Credit and Services Cooperatives (CCSs), private farmers (agricultores pequeños) and usufructuaries (ONEI, 2017).

<sup>11</sup> Between 2002 and 2007, the amount of idle land in Cuba increased by 32.7%, from 929,200 ha to 1,232,800 ha; according to Riera and Swinnen (2016), the need to reduce the amount of idle state-owned land to increase production, substitute imports, and improve food security was one of the principal objectives of the agricultural reforms implemented in Cuba since 2007.

**Table 1:** Land distribution based on tenure form in Cuba, 2007 and 2016.

2007		State Sector		Non-State Sector		
Thousand Hectares	Total	Total	Total	UBPC	CPA	CCS and Private
Total Land Surface	10,988	6,088	4,900	2,804	692	1,402
Agricultural Surface	6,620	2,371	4,249	2,448	585	1,214
Cultivated Area	2,988	694	2,294	1,189	305	799
Non-Cultivated Area	3,631	1,677	1,954	1,258	280	415
Idle Land	1,232	627	605	465	73	66
2016						
Thousand Hectares	Total	Total	Total	UBPC	CPA	CCS and Private
Total Land Surface	10,988	6,081	4,907	1,782	509	2,616
Agricultural Surface	6,226	1,912	4,314	1,528	503	2,283
Cultivated Area	2,733	521	2,212	840	267	1,104
Non-Cultivated Area	4,761	4,168	593	254	6	333
Idle Land	883	520	363	192	9	162

Source: ONEI 2010, and 2017.

**Table 2:** Idle Land by Tenure Type in Cuba, 2002-2017, Thousand Hectares.

	2002	2007	2013	2014	2015	2016	2017
<b>Total</b>	<b>929.2</b>	<b>1,232.8</b>	<b>1,046.1</b>	<b>962.1</b>	<b>924.8</b>	<b>883.9</b>	<b>917.3</b>
State Sector	516.1	627.2	574.9	546.6	537.6	520.4	582.2
Non-State Sector	413.1	605.6	471.2	415.5	387.2	363.5	335.1
UBPC	301.3	465.4	258.5	230.7	216.8	192.0	166.6
CPA	53.6	73.4	5.2	6.9	8.9	8.8	6.7
CCS	53.6	45.7	4.0	3.9	5.1	4.5	3.9
Private Farmers	58.0	20.6	96.7	76.7	68.4	70.9	72.5
Usufruct Farmers	n.a.	n.a.	106.8	97.3	87.9	87.3	85.4

Sources: ONEI, 2008, 2014a, 2015a, 2016a, 2017a, and 2018.

**Table 3:** Non-sugar agricultural production in Cuba, selected crops, thousand tons.

CROPS	2008	2009	2010	2011	2012	2013	2014	2015	2016
Viandas <sup>(a)</sup>	2,151	2,236	2,250	2,280	2,337	2,239	2,507	2,634	2,860
Plantains	758	670	735	835	885	659	836	890	1,016
Vegetables	2,439	2,549	2,141	2,200	2,112	2,407	2,499	2,424	2,385
Cereals	762	868	779	920	1,002	1,099	1,013	781	919
Legumes	97	111	80	133	127	130	136	118	137
Tobacco	22	25	21	20	20	24	20	25	20
Citrus Fruits	392	418	345	265	204	167	97	115	119
Other Fruits	739	748	762	817	965	925	884	943	945
Cocoa	1	1	2	2	2	1	2	2	2

Sources: ONEI, 2010, 2011, 2012, 2013, 2014, 2015, 2016 and 2017.

to substitute essential food and agricultural imports (Nova González, 2018).

The mixed results of the agricultural reforms implemented in Cuba since 2007, and the agricultural sector's inability to satisfy domestic demand, generate substantial export earnings, and reduce the country's dependency on imports can be attributed to several factors. According to Nova González (2013), there are three (3) fundamental unresolved issues that limit the impact of the agricultural reforms introduced since 2007: (a) producers must be allowed to freely choose the optimal inputs (e.g., labour and capital) to produce the desired output levels, (b) the state needs to recognise and accept the role of the market as complementary coordinating and rationing mechanism, and (c) the state procurement monopoly must be eliminated and replaced with more diversified forms of agricultural commercialization and distribution.

Non-sugar production has also been hindered by reductions in the cultivated area since 2007. The cultivated area decreased by 8.5% from 2,988,500 ha in 2007 to 2,733,500 ha in 2016, and fell in four (4) of the nine (9) major crop categories reported in Table 3 (ONEI, 2017). Between 2008 and 2016, the area planted and under production dedicated to vegetables decreased by 28.3%, from 259,073 ha to 185,743 ha (ONEI, 2013, 2017). Similarly, the area planted and under production dedicated to tobacco (Cuba's principal agricultural commodity) fell by 46.7%, from 23,048 ha in 2008 to 12,292 ha in 2016; the area planted with citrus fruits (another important crop) decreased by 64.7%, from 45,635 ha in 2008 to 16,105 ha in 2016; and the area planted with various tropical fruits (e.g., guava, mango, and papaya) decreased by 1.8%, from 83,058 ha to 81,585 ha between 2008 and 2016 (ONEI, 2013, 2017).

Cuba's non-sugar agricultural output has also been affected by the exodus of qualified workers, field workers, and technicians (Nova González, 2018). Agriculture's share of total employment fell from 18.8% in 2007 to 17.8% in 2016, and employment in this key sector of the Cuban economy decreased by 10.7%, from 919,100 workers in 2007 to 820,900 workers in 2016 (ONEI, 2010, 2017). Other demographic pressures, such as the aging of the Cuban population, the displacement of workers to other sectors of the economy, and overseas migration, have contributed to declines in agricultural sector employment.

The limited scope and nature of the agricultural reforms introduced since 2007, excessive regulations, and strenuous bureaucratic processes have hindered agricultural production in Cuba (Mesa-Lago, 2014). State-imposed restrictions on private property rights, prohibitions against the concentration of wealth, foreign investment, and exports, as well as an onerous tax system, and a restrictive business environment<sup>12</sup> (particularly towards private farmers and usufructuaries) have been (and remain) important limiting factors (Mesa-Lago, *et. al.*, 2018; Spadoni, 2014).

Finally, since 2007, other factors that have constrained and continue to affect Cuba's non-sugar agricultural output include the poor conditions of warehouses and storage facilities, an antiquated communications system, dilapidated roads, rail networks, and transportation system, an inefficient and disconnected supply chain, insufficient access to essential inputs (e.g. fertilizers, irrigation equipment, machinery, seeds, and other technologies) (Feinberg, 2018; Mesa-Lago, *et. al.*, 2018; Spadoni, 2014).

## Conclusions

Despite its economic importance, Cuba's agricultural sector faces a wide range of challenges and limitations that constrain its productive capabilities and economic contributions. Agricultural producers face excessive state intervention, onerous taxes, restrictive state policies, inadequate access to capital, insufficient access to essential inputs (including labour), a deteriorated infrastructure, and inefficient and inadequate transportation and telecommunications systems. The state limits their access to foreign investment, and agricultural producers are unable to freely participate in global supply chains.

To address some of these challenges, incentivise production, and substitute imports, the Cuban government has implemented a series of agricultural reforms since 2007. These reforms have contributed to the redistribution of Cuba's agricultural land from the state to the non-state sector, and to the redistribution of agricultural land within the non-state sector. Since 2007, the share of the agricultural surface and cultivated area held by the less Basic Units of Agricultural Production (UBPC) has declined, while the amount held by the more productive and efficient Credit and Services

Cooperatives (CCS) and private farmers has increased significantly.

Cuba's agricultural reforms have also resulted in significant reductions in the amount of idle land since 2007. This process has been mainly driven by the expansion of usufruct farming after 2012. The largest reductions in idle land have taken place in the non-state sector, particularly the CCS.

Non-sugar agricultural production has experienced mixed results since 2007. Even though output increased in six (6) of the nine (9) non-sugar production crop categories reported by Cuba's National Statistics Office (ONEI) during the 2008-2016 period, the agricultural sector has been unable to generate the quantities of output required to satisfy domestic demand, and Cuba currently imports a significant share of the food and agricultural products consumed by its population. These trends suggest that (at least so far) the agricultural reforms implemented since 2007 have not been able to sufficiently incentivise production to reduce Cuba's (relatively-high) dependency on food and agricultural imports.

This situation can be attributed to several factors. The area dedicated to agriculture and under production has decreased significantly since 2007; at the same time, agricultural yields for important crops have declined, mainly due to the lack of fertilisers, irrigation equipment, and machinery, and to adverse weather conditions. Cuba's agricultural producers lack the autonomy necessary to make optimal input and output decisions. The role of the market as an important economic coordination mechanism and its price-signalling and rationing functions remain strictly constrained by excessive state intervention. Despite limited "liberalisation" measures, the state retains its monopolistic control over key aspects of the commercialisation and distribution of most agricultural products.

Cuban agriculture has also been affected by the displacement of labour to other sectors of the economy, overseas migration, and the aging of the Cuban population (particularly the agricultural labour force). On the institutional front, agricultural producers face strict limitations on private property rights and on the concentration of wealth, excessive taxes, a complex bureaucracy, and hostile state policies (particularly towards private farmers and usufructuaries). Finally, Cuba's agricultural producers regularly contend with a wide range of logistical and administrative constraints and challenges (e.g. deteriorated infrastructure, poor telecommunications, a disconnected supply chain, insufficient access to essential inputs and sources of financing, etc.) that affect production and limit the agricultural sector's contributions to the economy.

While the agricultural reforms implemented since 2007 represent a step in the right direction, more profound structural reforms are necessary to achieve sustainable, long-term, progress in this vital sector of the Cuban economy

<sup>12</sup> The preferential tax treatment given by Law 113 (20123) to agricultural cooperatives and state enterprises is an example of the hostile business environment confronted by individual agricultural producers in Cuba; in addition, cooperatives and state enterprises receive subsidized essential inputs (e.g., fertilizer, equipment, machinery) from the state, operate under a friendlier regulatory framework, and may be authorized to receive foreign investment.



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# Competition Barriers to Paraguayan Beef Exports: An Economic Review

Paraguay's beef industry has suffered sustained damage in credibility directly related to meat quality and process hygiene standards over the past two decades. These factors alone, however, are not the primary cause of persistent price discounting in export markets. Paraguay's direct competitors have suffered similar export restrictions related to quality control but have since recovered to capture their original market share. We find that both a perceived and an actual absence of quality controls over beef production, coupled with the lack of an industry body representing Paraguay's beef sector, are the major impediments to growth in the export market. The lack of sustained support and marketing of export-quality beef has led to persistent price discounting, despite quality improvements across the supply chain. The capacity to gain international market share remains diminished due to the disaggregated approach in which Paraguayan beef is marketed to foreign buyers. An industry-wide effort to coordinate food safety and quality activities, as well as maintaining certification programmes, market intelligence, export promotion and research and development could offer some degree of competitive advantage to Paraguay's producers. While the idea of a central industry body has clear advantages, of greater value would be establishing meat quality standards that address the deficiencies in consumption-level responsiveness to meat quality. The establishment of an industry body would need to overcome the hurdles associated with related transaction costs across the alliance.

**Keywords:** Beef value chain, consumption trends, premium markets, diminished value, Paraguay

**JEL classifications:** Q11, Q17

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Received: 11 December 2018, Revised: 14 January 2019, Accepted: 21 January 2019

## Introduction

Beef production and exports have become an important pillar of Paraguay's economy over the past 20 years. Exports have increased sixfold in 20 years, recently representing roughly 12 per cent of the Paraguayan total and contributing 6.6 per cent to national GDP (Arce, 2012; Arce and Arias, 2015). Since 1998, cattle numbers in Paraguay have grown from 2 million to 13 million (USDA, 2018). Growth in the Paraguayan beef industry has been a result of substantial efforts made by private operators to increase production as well as incrementally enhance product quality. Some producers have also invested heavily in genetic technology to improve production volume (Valiente, 2013). This has enabled greater access to premium beef markets (Latimori et al., 2008; Arce, 2012). Several countries now import Paraguayan beef that meets high quality standards, including Chile and several nations in the European Union (Lesmo Duarte et al., 2017; Arce, 2012; Valiente, 2013).

However, export growth has come at some cost. Paraguayan beef receives lower prices than that produced by its regional competitors (i.e. Brazil, Argentina and Uruguay) and this price discounting has persisted over the past 20 years (Asociación Rural de Paraguay, 2016). Schnettler et al. (2014) recently found that consumers consistently favour beef from Brazil or Argentina over Paraguayan beef, which implies a persistent weakness in price bargaining on the part of Paraguayan producers. Despite often maintaining equivalent standards in quality and quality control, the reasons underpinning the persistent price discounting of Paraguayan beef are unclear. Price discounting of Paraguayan beef in the export markets is the single greatest factor limiting the future growth of Paraguay's beef export industry.

Using an economic analysis of the value of consumer information relative to the level of consumer responsiveness to marketing quality standards, we will now address three questions:

- 1) What are the factors that have led to a persistent undervaluation of Paraguayan beef?
- 2) What factors differentiate the export marketing success of Paraguay's main competitors?
- 3) What marketing mechanisms are available to eliminate the value discounting of Paraguayan beef exports?

In this paper, we will analyse alternatives to reposition Paraguayan beef for international consumption at a price commensurate with its quality characteristics. While it is clear that investment in the sector has been extensive, little research attention has been paid to a deeper examination of value-added activities, including the appropriate marketing of major improvements to the sector. We have found that to overcome persistent price discounting, Paraguayan beef exporters need to simplify the content of information related to beef quality provided to consumers. Information simplicity will overcome the main barriers inhibiting consumer responsiveness to Paraguayan beef quality and will eventually eliminate the current price-volume disadvantage the industry faces.

## The export beef market

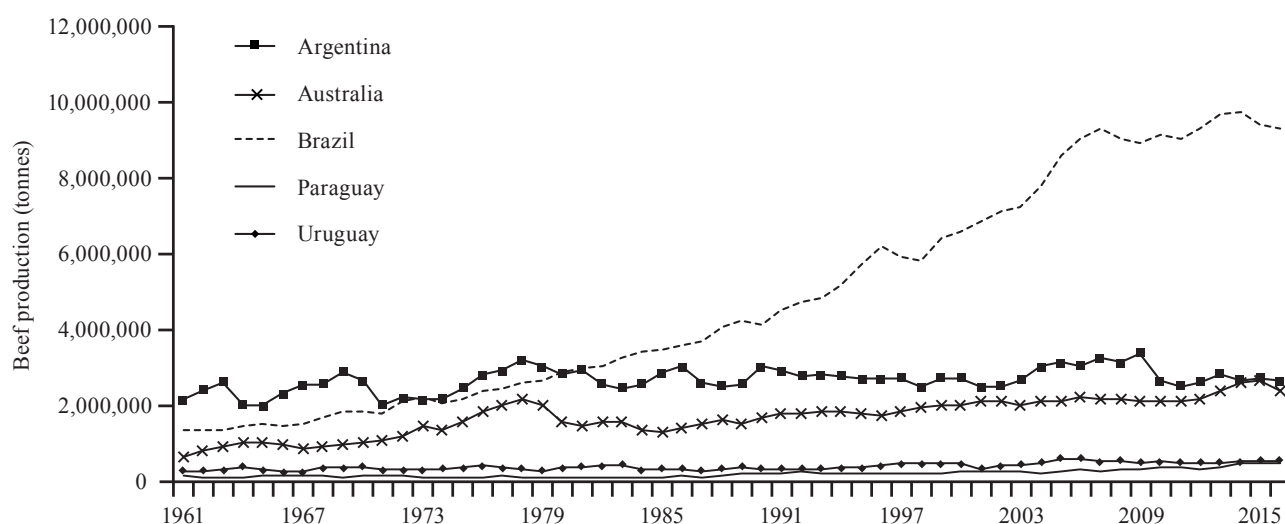
Consumers are known to exhibit differing attitudes towards products based on country of origin (Pouta *et al.*, 2010). Annual beef production for major exporting nations is provided in Figure 1.

While it is claimed that a lingering prejudice against non-British cattle breeds persists in Paraguay, this is difficult to prove. Although Argentina's reputation for high-quality beef stretches back decades, strategic branding of high-quality produce only commenced after 2000. Argentinian beef producers have thus been able to sustain and improve consumer perceptions and building an emotional connection with them based on heritage for a relatively short period of time ('Argentinian Beef: Beefing up the brand' 2007). Capped production of Argentinian beef – which is enforced by government – is caused by domestic price pressures. However, the cap in Paraguayan production is not due to internal restrictions, but rather a restriction in accessing export markets.

Figure 2 illustrates international export beef prices for major exporting nations. Figure 3 illustrates the quality-adjusted export beef price differential between Argentina and Uruguay relative to Paraguay. From this representation, it can be seen that Argentina and Uruguay both earn substantial and persistent price premiums relative to Paraguay.

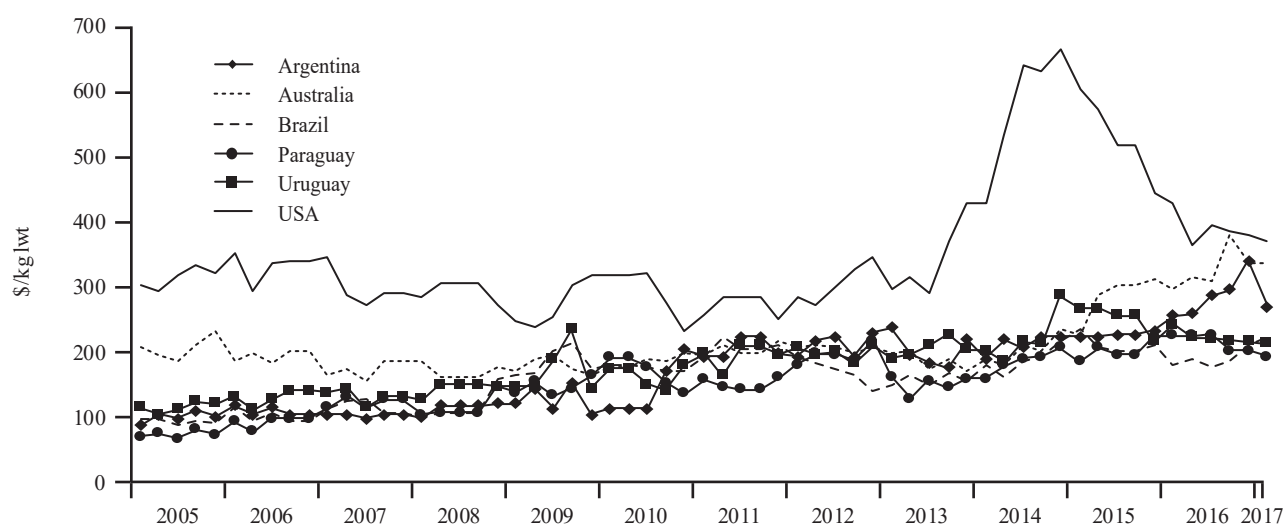
We examine Paraguay's export beef sector performance from 1988 to 2018, given that noticeable export growth in Paraguay's beef industry has only occurred during this period (Arce, 2012). Prior to 1990, Paraguayan beef was produced solely for the domestic market mainly due to the below-export-quality nature of its beef production (Valiente, 2013; Lesmo Duarte et al., 2017). Beef production increased markedly after 1990, when the exports of various processed beef cuts began to meet market expectations. However, this produce was exported to a very limited market, concentrated toward lower-quality demand centres (Valiente, 2013).

However, despite the significant effort devoted to improving product quality, Schnettler et al. (2014) have suggested that consumers who prefer Paraguayan beef do so because it is seen as a low-cost alternative to other main exporters. They further argue that the lack of branding and marketing practices by Paraguayan producers confuses the communication of quality characteristics to international consumers, leading to a persistent failure to achieve superior positioning



**Figure 1:** Beef production among major exporting nations (excluding the US), 1961-2018.

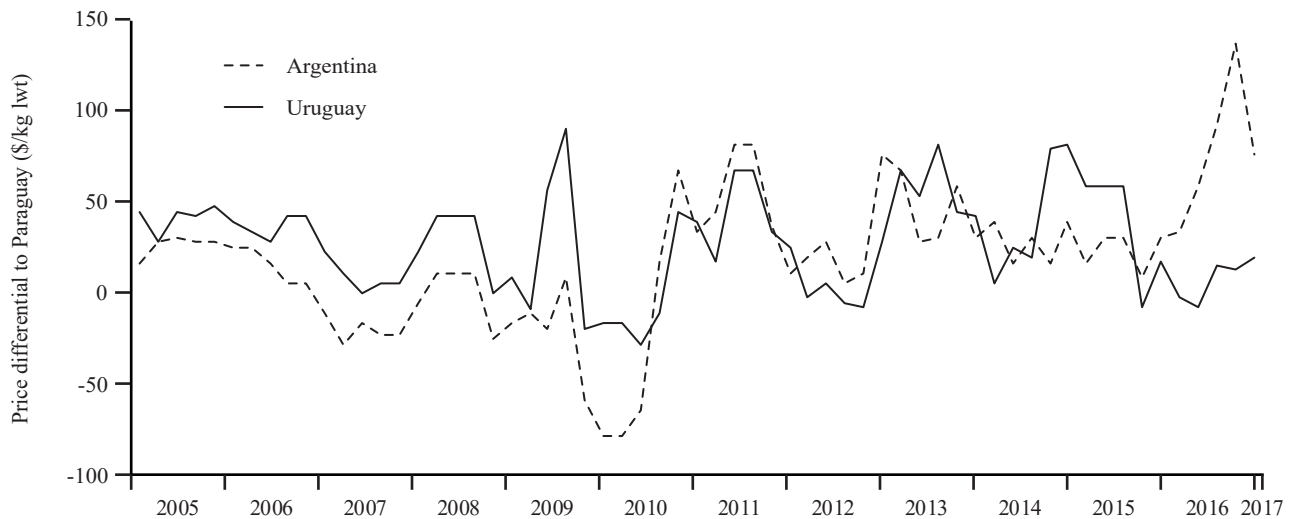
Source: FAO.



**Figure 2:** Beef prices (in AU\$/kg lwt) among major exporting nations 2005-2018.

Source: IPCVA (Argentina, Paraguay), MLA (Australia), Esalq/Cepea (Brazil), INAC (Uruguay), USDA/Steiner Consulting Group (US).





**Figure 3:** Beef prices (in AU\$/kg lwt) among major exporting nations 2005-2018.

Source: IPCVA (Argentina, Paraguay), MLA (Australia), Esalq/Cepea (Brazil), INAC (Uruguay), USDA/Steiner Consulting Group (US).

of beef products aligned to the true level of export quality now manifest in the market.

Some evidence shows that strategic decisions and targeted investments can heavily impact a country's brand image. For instance, De Tavares Canto Guina and De Moura Engracia Giraldi (2014) argue that forging a country image and brand could successfully link environmental credentials with the sense of product quality. Entire supply chains are now becoming increasingly important for building food brands. The capacity to access premium beef markets using a premium brand must therefore be accompanied by the appropriately targeted marketing of ethics, environmental sustainability and animal welfare.

### Quality control

A first step towards the control of food processing standards and maintaining stable hygiene practices is the strengthening of legal and other powers granted to entities responsible for maintaining such standards (Munoz et al. 2015). Investments in infrastructure, laboratory equipment and training embedded within a controlling authority would also yield positive returns to help secure the quality standards of export beef supply chains. Without centralisation of these functions, Paraguayan beef exporters will remain at the mercy of beef farmers and processors to self-enforce hygiene and quality control standards through the supply chain.

Paraguay has made some progress towards addressing quality control concerns. For instance, Paraguay has implemented a national traceability system. But in isolation, this is not sufficient to translate improvements of brand image into sustained export price premiums.

An efficient value chain, where chain economic surplus is maximised, is one in which no single chain participant can be made better off without another participant being made potentially worse off. The differential between a chain's potential maximum and actual economic surplus quantifies the extent of chain underperformance. The value chain implications of each grading approach introduced above can have vast impacts on the beef industry.

### Sustainability

Many Paraguayan beef farmers remain insensitive to international standards in building sustainability into their contribution within the sector. Sustainability and profitability are perceived by many beef producers as being incompatible (Verijdt, 2015). This has created a degree of friction in some quarters, where the incentive to increase farmland availability has resulted in high rates of deforestation, raising concerns around the level of sustainability in greater beef production for export markets (Huang et al., 2007; Munoz et al., 2015). Consumer concern over sustainability has become a key plank in price negotiations, particularly in the premium beef market (Henchion et al., 2014). Thus, failing to address these issues will lead to the further erosion of value for exporters.

First, traceability systems that were created to measure information about the origin, movement, hygiene/sanitation and nutrition of cattle would need to be advertised and information be made more transparent for external verification. This is already required for the entry into most international markets (USDA, 2008) so this needs to be addressed at a minimum level. The single existing traceability programme in Paraguay has been in operation since 2004 (SITRAP) and has been largely successful. However, out of a total of almost 148,000 beef producers, only 419 are signed up to the programme (SENACSA, 2017), representing less than 1 per cent of the market. Most of the industry thus operates outside the monitoring of hygiene standards.

Second, unlike other major beef exporters, Paraguayan producers do not use hormones for accelerating the growth of cattle (Labraga, 2016). Almost all Paraguayan beef is produced in pastureland under natural conditions. Previous attempts to implement 'Natural Beef' certification programmes have been unpopular because the added cost in developing the programmes did not translate into an immediate consumer response (de Belmont, 2015). The reasons for this are discussed below.

## Competing jurisdictions

### *Australia*

Support of the major agricultural groups receives strong government support in Australia. A total of 15 agriculturally-focused industry bodies are enshrined in Federal Government legislation. Of the 15 rural development corporations (RDCs), five are statutory corporations or authorities, owned by the Federal Government while the remaining 10 are industry-owned, not-for-profit companies. Funds are sourced through levies imposed on market participants, who can become members or shareholders and participate in strategic decisions. The RDCs form a network that enables primary producers through effective research, development and extension, and delivers substantial benefits at the farm gate and across the economy.

One of the significant bodies supporting Australian meat production is Meat and Livestock Australia Limited (MLA), which provides research and development activities as well as a centralised marketing function to represent the interests of Australia's cattle producers (Meat and Livestock Australia, 2016). A key contribution of MLA is research addressing the main factors influencing eating quality and consumer satisfaction. In response to questions over quality control, MLA developed the Meat Standard Australia (MSA) grading regime, which is flexible enough to continually update such standards and ultimately improve export quality. Marketing efforts for Australian beef focuses on attributes such as nutrition qualities, provenance of the product, animal welfare, sustainability of production systems and eating quality (Meat and Livestock Australia, 2016). This has resulted in a 30 per cent increase in gross income per kilogram of beef exported (Henchion et al., 2014).

These attributes are essential and valuable characteristics in the premium consumer segments of the market (Henchion et al., 2014) with ready access to all global premium beef markets. For instance, MLA has implemented programmes to create awareness in North American consumers of the benefits of buying grass-fed Australian beef; Australian producers now dominate the niche market for grass-fed products in North America. With the entire beef industry representing a united front for promotion of products to the export markets, Australian producers are able to take advantage of the evolution in consumer tastes.

### *United States*

The American beef industry is built on a foundation of the family ranch, despite the corporatized-level of beef production that dominates production volumes. Promotional campaigns leveraging the 'cowboy halo' effect to connect with consumers have proven very effective (National Cattlemen's Beef Association, 2015). While being the largest producer of beef in world, the United States remains a net importer. Exports of high-quality grain-fed beef are offset by imports of low-value beef used to produce processed meat (USDA, 2018). The US beef industry also has a competitive advantage from the use of genetic research to improve quality and taste.

Several outbreaks of Bovine Spongiforme Encephalopathy (BSE) between 2003-12 resulted in an immediate end to beef exports. However, a centralised approach to disease control and management, along with marketing efforts to rescue the image of American beef, have largely countered the sustained decrease in export demand. Systems and safeguards adopted to eradicate BSE by the USDA were shown to be effective with disease impact declining by 99 per cent after each outbreak (USDA, 2018).

### *Brazil*

Expansion of Brazil's export beef market is supported by the Brazilian Association of Beef Exporters, which was incorporated to develop technical excellence and market information flow, as well as build promotional capability (Marques and Traill, 2008). The creation of a common brand, 'Brazilian Beef,' greatly increased the bargaining power of Brazilian exporters and offset the competitive advantage initially gained by Australian and New Zealand exporters. Their aim is to jointly increase both the volume and the quality of exported beef products (Steiger, 2006). The industry also promotes the use of grass-fed production systems, natural beef and environmental sustainability as image-enhancing efforts to create further value for its exporters (Marques and Traill, 2008).

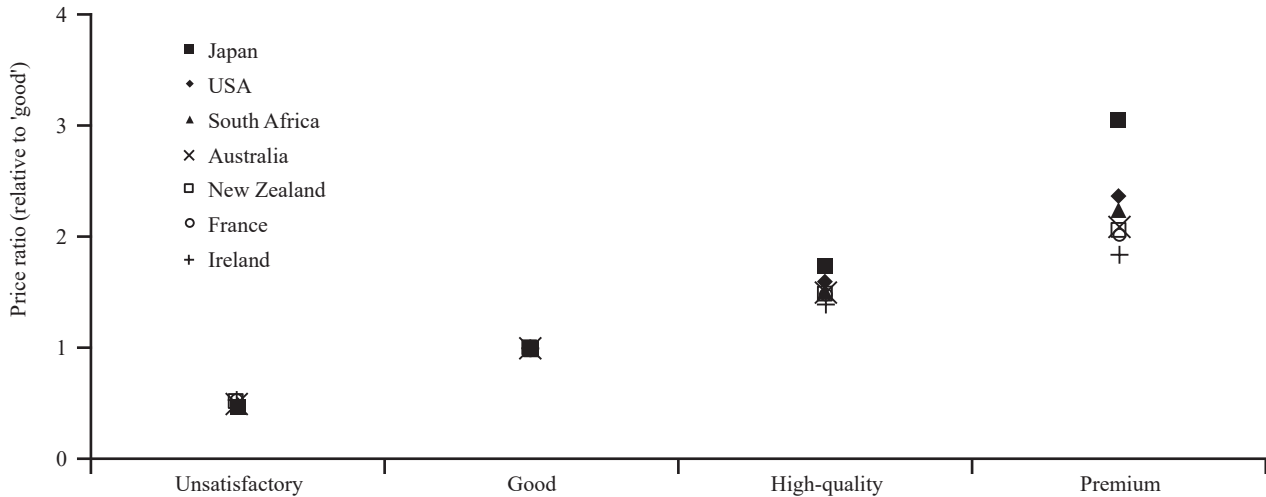
### *Uruguay*

The beef industry in Uruguay is supported by the National Meat Institute (INAC). This institute was created to promote, regulate, coordinate and oversee the production, processing and marketing of meat products. They also promote the research and development, education, innovation and communication to add value for the beef export sector (INAC, 2018). Uruguayan beef maintains access to around 120 countries, many of them in the premium sector. The diversity of supply acts as a source of insurance for the sector, diminishing the effects of damaged to relations in particular markets (INAC, 2018).

Uruguayan beef producers have taken a leadership position in promoting quality coupled with low cost (INAC, 2018) while promoting the benefits of traceability and sustainability in its production process (INAC, 2018). The industry body maintains a robust health service management and disease eradication capability (Zurbriggen and Sierra, 2017) as well as traceability systems and certification programmes (Gorga and Mondelli, 2014). Moraes and Viana (2015) claim that this resulted in an increase of 11 per cent in annual export prices over 2001-2013.

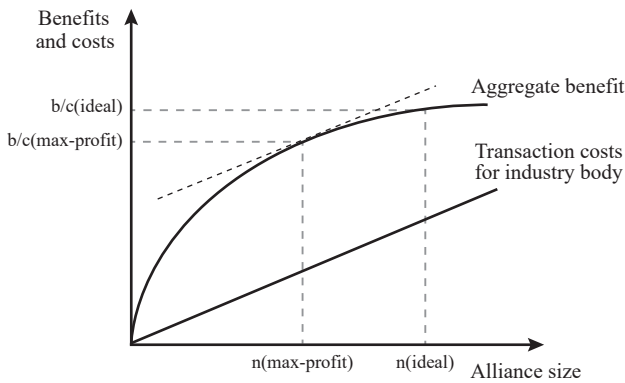
Figure 4 depicts willingness to pay (WTP) data collected in conjunction with consumer testing for several beef consuming countries. This shows that unsatisfactory beef is rated at half the value of good quality with better than average quality rated around 1.5 times and premium quality rated 1.8 to 3 times the average price.

Price premiums available in Japan and the US are attractive motivators for improving brand and quality information. However, the marketing of quality standards does not result in uniform increases in prices or sales volumes on its



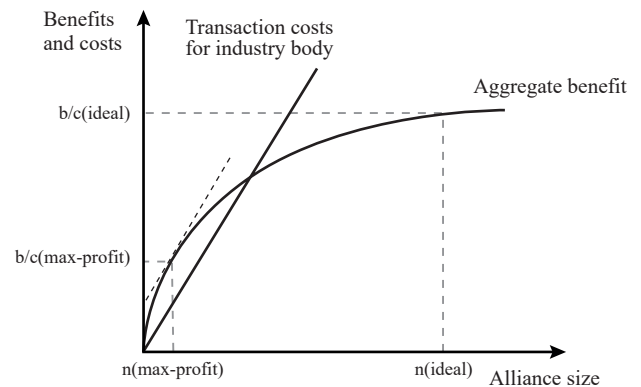
**Figure 4:** Willingness to pay ratios for beef (relative to average quality) for several countries.

Source: Polkinghorne et al (2014).



**Figure 5:** Industry body establishment with low transaction costs.

Source: Adapted from Swann (2003).



**Figure 6:** Industry body establishment with high transaction costs.

Source: Adapted from Swann (2003).

own. The notion of ‘what’ information is shared is just as important as ‘how’ it is shared. We will discuss this issue below.

### Centralization to create competitive advantage

The above examples demonstrate that the use of a dedicated industry body charged with the development of its beef industry and engaged in activities to support that goal is a key success factor in maintaining access to export markets. The Paraguayan beef sector lacks a central organisation representing the beef sector, a fact which puts Paraguay at a constant disadvantage. Even minor projects focused on research into quality control, improvements in the production cycles, market intelligence and promotion of products would benefit the entire sector. Instead, many of these activities are developed piecemeal and by private operators, which has only a limited impact on the industry (Asociacion Rural del Paraguay, 2015).

Maintaining food safety and quality is not the only task of an industry body. Its extended duties would need to implement marketing programmes aimed at value creation. Through the enforcement of certification programmes Para-

guayan beef has the potential to seize a share of the growing premium market.

One scenario related to the economic impacts of funding research and development through an industry body is depicted in Figures 5 and 6. Value chains seek to maximise profits by setting marginal benefit to the marginal cost, but this may not be the case for every participant in the chain. Figure 5(a) shows that low transaction costs in a chain with few alliance members means that the profit-maximising alliance level is high relative to an ‘ideal’ level (Swann, 2003). This would be achieved where every new member added to the alliance could be conducted at a low marginal cost.

In contrast, Figure 6 shows that the benefits to the profit-maximising alliance is low relative to the ideal level when the marginal cost of adding new members to the alliance is high. Positive benefits to an industry are therefore most effective when participation in an industry alliance is not costly and accessibility is not limited to any part of the value chain. So, a centralized industry body would offer qualified advantages to the Paraguayan beef sector, highly dependent on the transaction costs associated with alliance participation.

## Economic implications of quality standards

Quality standards across an industry to promote the taste of its products are typically voluntary grading systems designed to predict eating quality. The MSA meat grading system was introduced in the domestic market in Australia in 1999/2000 (Griffith et al., 2010). The MSA grades are based on taste panel responses from 'normal' consumers (Griffith and Thompson, 2012) while the system itself uses a 'total management approach,' from animal genetics through to cooking method (Polkinghorne et al., 1998; Thompson, 2002).

An alternative to this approach is to construct a more comprehensive measure, along the lines of a 'paddock to plate' standard, which measures the treatment of produce through the whole value chain (Polkinghorne et al., 2010). This approach ensures correct emphasis is placed on the most critical phase in the beef production process, from the start of the final muster on the farm to several hours after slaughter at the abattoir. Cattle that are poorly treated and transported to a processor in dirty and crowded trucks may cease eating and start to lose weight. Within a day, cattle can lose up to five percent of their weight, which can transform the meat from high-quality to a below-standard product (Polkinghorne et al., 2010). A 'paddock to plate' style standard could emphasise traceability, quality effects at each point in the value chain and contributes to brand identification. It can form a more comprehensive metric. However, it does come at a higher cost, especially in terms of information content, and does not translate into immediate price and sales volume outcomes.

### Single metric standards

The rationale for investing in research and development activities that establish quality standards (such as the MSA model in Australia) was that beef consumers were turning away from beef because each time they purchased beef, they could not be guaranteed the same eating quality experience. Eating quality is subjective and based on vague notions of breed, age and feeding regime and the relationship between consumer preferences, willingness to pay and quality differentials is difficult to reconcile. Ways of classifying beef carcasses, and therefore ways of describing quality, varies across suppliers. Brands are of little use to retailers when there is no objective, uniform system to provide the guarantee that consumers expect (Griffith and Thompson, 2012).

The value of a meat grading scheme is concentrated at the retail level where consumers are willing to pay a premium for beef cuts that are guaranteed to offer desirable characteristics in contrast to ungraded beef (Griffith et al., 2009; Doljanin, 2012; Griffith and Thompson, 2012). The differences in WTP between beef consuming countries in Figure 4 highlights this fact. The emphasis on carcass quality provided by registered producers facilitates consistency in both beef production and consumption. Poorly functioning beef grading schemes, coupled with asymmetric information in favour of producers leads to adverse selection and moral hazard.

The processing of large volumes of beef matched to thousands of consumer taste tests is typically too large to be performed by a single firm, so an industry-wide approach is needed to bridge the need for cohesion between beef producers. The grading of beef is assessed using a single metric that assesses beef carcass attributes for all producers, matched to consumer expectations.

Analysis of beef quality can be achieved by transforming the axes for assessing production possibilities from volume measures to value measures. Using Weaver (2010), the definition of production as the 'production of value' enables the representation of increases in output through quality improvement as upward shifts of the production possibility frontier (PPF). Changes in product quality characteristics resulting from new technologies are viewed as exogenous demand shifts, a perspective which assumes that consumers will demand more of the product for a given price if quality is improved.<sup>1</sup>

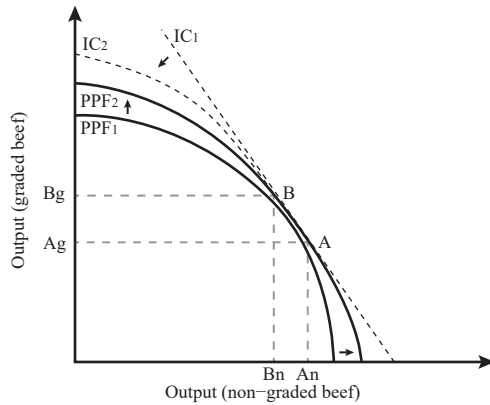
We now demonstrate the economic implications of implementing a single-metric for beef quality standards. Point A on the initial production possibility frontier (PPF<sub>1</sub>) in Figure 7 represents the optimal throughput under a conventional marketing system with no compensation for increasing the level of responsiveness in the value chain to consumer preferences. The PPF is used to determine the extent of scope economies between consumer-level responsiveness and low cost for two channels (graded and non-graded beef) within a value chain. Inefficient value chains lie inside the frontier.

An increased willingness to pay for graded beef over ungraded beef is given by the iso-revenue curve IC<sub>1</sub> representing a linear relationship, which implies no reduction in 'demand uncertainty' from responsiveness. The iso-revenue curve reflects the fact that a value chain is likely to achieve higher prices when it is more responsive to consumer preferences. In the linear iso-revenue case, producers receive no additional payoff for being responsive, but this relationship becomes more elastic and shifts in favour of a responsive approach as beef consumers are willing to pay more for reduced demand uncertainty, forming curve IC<sub>2</sub>. Figure 7 illustrates a shift of the frontier from PPF<sub>1</sub> to PPF<sub>2</sub> towards higher levels of responsiveness associated with greater throughput of graded beef (A<sub>g</sub> to B<sub>g</sub>) and away from ungraded beef (A<sub>n</sub> to B<sub>n</sub>).

In isolation, this type of metric does not explicitly contribute to improvements in quality across the beef value chain. However, it does help with improving information throughput along the value chain because it serves as a form of compliance. Increased consumption is due to the substitution of ungraded beef by graded beef, assuming a 'closed' economy for beef. Information embedded in compliance with a single metric would therefore improve beef quality through changes in on-farm management practices and supply chain processes (Griffith and Thompson, 2012).

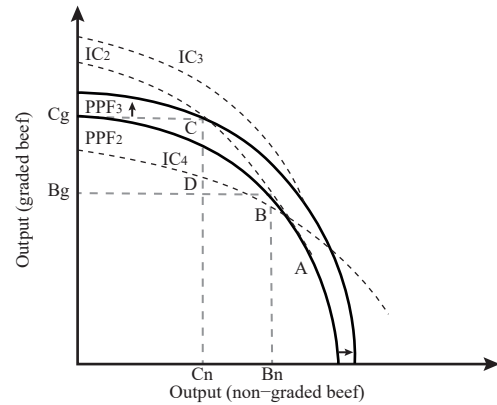
<sup>1</sup> There are a number of difficulties in establishing an objective measurement of quality in output (Alston et al. 1995). Quality measures do not necessarily equate to added consumer willingness to pay extra for a higher-quality beef. So, the PPF will not be wholly symmetric, especially given that higher-quality products are sold into niche markets which do not share the same opportunities to exploit scale economies as mainstream channels.





**Figure 7:** Single metric export beef grading systems with differences in eating quality.

Source: Adapted from Griffith and Thompson (2012).



**Figure 8:** Single metric export beef grading systems with differences in eating quality.

Source: Adapted from Griffith and Thompson (2012).

The basic framework of a meat grading system should markedly differ in only the eating quality between graded and non-graded beef. That is, the metric needs to be as simple as possible. It is possible to invoke value-based models that offer price differentials across multiple grades of quality. However, a key problem in conventional beef value chains, like Paraguay, is the existence of network externalities among participants at different levels in the chain, resulting in poor levels of information exchange. The provision of feedback on meat quality is generally viewed by processors as an administrative overhead that can be costly, which results in them providing minimum information back through the chain (Doljanin, 2012), which is a predominant value constraint for Paraguay's supply chain.

Grading systems require commitment from the bulk of producers matched to consumer expectations, which requires additional resources. But the value of benefits using this approach can be substantial, which is evident in Figure 7.

In contrast, multiple sources and uses of information defining beef quality is a concern because they cannot be reduced to a single factor for reliably describing carcass quality. A simple carcass index helps to alleviate information overload by providing a single tool to assess on-farm genetic progress, something that also allows for a comparison of the impact of different processing activities (Thompson et al., 2012). A comprehensive, single metric that meets this requirement however requires further development in the beef sector. This is a challenge facing Paraguay's producers in the present climate.

### Whole-of-value-chain quality standards

In Figure 8 the change in relative prices from  $IC_2$  to  $IC_3$  represents the higher premiums paid for added responsiveness features using a whole-of-value chain instead of a single quality compliance measure. Additional responsiveness is the outcome of information transfer in the value chain facilitated by traceability throughout the processing stages (Doljanin, 2012).

A whole-of-value chain standard can more fully establish information channels and provide value-based pricing outcomes (Polkinghorne et al., 2008) at each stage in the

production system. Information about the product could be provided across the value and allow full traceability from producer to consumer. Standards could be established for each chain participant, who in turn would receive an adjustable percentage of the retail value based on the attribution of value from their impact on the quality of the final product.

Traceability and record keeping suggests that a value for each 'primal'<sup>2</sup> can be established. The 'live' inventory value, yield and eating quality information creates the opportunity to optimise the return of primals by choosing how they would be processed on any given day. This level of traceability facilitates the flexibility necessary for the business to respond to changing consumer demands requiring alternative inventory use, isolating quality assurance breaches and, most importantly, translating into value for each participant in the supply chain. Point B on  $PPF_2$  in Figure 8 represents the initial optimal levels of production for both a single retail standard and whole of value chain standard.

If we considered how data from a whole-of-value chain approach could inform farm-level production decisions, we could identify short-term responses (e.g., assessment and management of fat distribution in meat) and long-term responses (e.g., breeding and management strategy changes) (Polkinghorne et al., 2008). Long-run production responses are represented by an upward shift in production value from  $PPF_2$  to  $PPF_3$  while consumer preference results in an increase in WTP represented by a shift in the iso-revenue curve from  $IC_2$  to  $IC_3$ . The new optimal point at C represents a substantial shift in value for the entire industry.

The 'value' of beef is governed by substantial complexity in many factors that influence eating quality (Griffith and Thompson, 2012). Beef value chains are known to experience high variability in production processes, something that introduces risks to value right across the value chain. While information made available to consumers is shown to be clearly valuable, the provision of too much information is known to create inefficiencies. This is illustrated in Figure 8 where, at D, the value chain is technically inefficient relative to the PPF. At this point, value chain participants are adding information characteristics (to generate a consumer

<sup>2</sup> Beef carcass primals are a combination of the three primary tissues of muscle, fat and bone, according to the boning priorities of individual processing facilities.

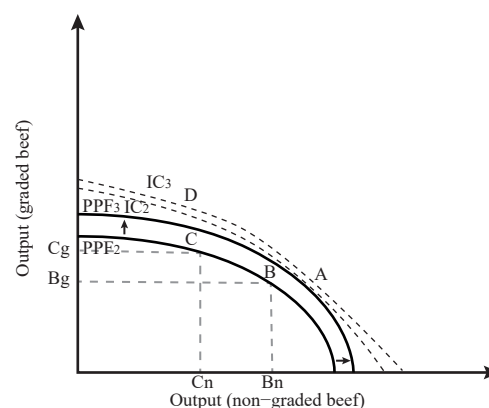
response) to meat of insufficient quality to warrant such a response. Revenue earned along  $IC_4$  is less than that revenue earned for the original ungraded beef sold through the conventional system in the non-graded beef chain operating at point A. This outcome illustrates that a complex combination of consumer-specific information may in fact undermine the total value of beef sold to consumers. In this circumstance, the best way to achieve a gain in value is returning to the non-graded beef chain. This has the effect of reducing the degree of consumer-level response while expanding output. Figure 8 highlights that the optimal outcome would be to increase efficiency under the whole-of-value chain approach and move to C, which is on a higher IC than A, than to revert to the conventional system. The preferred way for this to occur would be to simplify information exchange.

If Paraguayan producers are unwilling or unable to adapt the export beef industry to become more responsive to consumer tastes complemented by comprehensive graded beef programme, then the capacity to fundamentally capture this value will remain structurally constrained. The measurable premium embedded in consumer responsiveness that promotes graded beef relative to ungraded beef will remain suppressed and the expected value premium may not recover the additional costs needed through the value chain to restructure towards a graded beef programme. This is portrayed as an extreme flattening of both the production frontier and the iso-revenue curve in Figure 9. If the higher reward for quality is only marginal, then the incentive for the value chain to produce more of the higher value product and less of the lower value product will be limited. An industry unable or unwilling to make sustained quality improvements over a broad scale may be structurally constrained from capturing value in the consumer responsiveness dimension. This could forever consign the industry to be a low-cost producer and limit the value creation capacity of high-quality producers within it.

## Conclusion

We have found that both a perceived and an actual absence of quality controls over beef production, coupled with the lack of an industry body representing Paraguay's beef sector are the major impediments to growth in the export market. The lack of sustained support for, and marketing of, export quality-beef has led to persistent price discounting despite quality improvements implemented across the supply chain.

The capacity to gain market share remains diminished due to the disaggregated approach in which Paraguayan beef is marketed to foreign buyers. An industry-wide effort to coordinate food safety and quality activities as well as maintaining certification programmes, market intelligence, promotion and research and development could offer some competitive advantage to Paraguay's producers. While a central industry body has clear advantages, of greater value would be the establishment of meat quality standards addressing the deficiencies in consumption-level responsiveness to meat quality. The establishment of an industry body would also need to overcome the hurdles associated with transaction costs across the alliance.



**Figure 9:** Single metric export beef grading systems with differences in eating quality, constrained by capacity to address quality.

Source: Adapted from Griffith and Thompson (2012).

Establishing meat quality metrics as a priority, however, offers the industry a potential gain in competitiveness, as long as information dissemination to consumers is matched to their level of demand responsiveness. Focusing on meat quality embedded in a relatively simple metric would provide an optimal outcome for Paraguayan beef producers, at the lowest cost. However, this structural change would need to be addressed across the entire beef sector to and not simply introduced to small pockets of producers, in order to ensure that the margins available to high-quality operators are fully realised.

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# Climate variability and post-harvest food loss abatement technologies: evidence from rural Tanzania

This paper focuses on improved storage and preservation technologies as an adaptation strategy in response to climate change. We also study the trade-off between improved cereal storage technologies and the preservation techniques among rural households in Tanzania. We find that climate variables significantly influence farmers' choice of improved storage technologies and preserving decisions. Using a bivariate probit model, we find that modern storage technologies and preservation measures are substitutes. Farmers can significantly reduce annual costs associated with preservation by adopting (usually long lasting) modern storage facilities.

**Keywords:** Climate change adaptation, storage technologies, preservation methods, post-harvest loss abatement, bivariate probit model, Tanzania

**JEL classifications:** C35, O33, Q54

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Received: 17 December 2018, Revised: 7 March 2019, Accepted: 14 March 2019.

## Introduction

Poor post-harvest management of cereals is one of the major challenges to food security in Sub-Saharan Africa (SSA), accounting to 15–30% annual grain losses (Affognon *et al.*, 2015; Bradford *et al.*, 2018; Kumar and Kalita 2017; Sheahan and Barrent, 2017; World Bank 2011). Assuming the minimum losses, World Bank (2011) estimates a monetary value of more than \$4 billion a year out of an estimated annual value of grain production of \$27 billion. This loss is estimated to exceed the total value of food aid (\$6.1 billion) SSA received over one (1998–2008) decade. In addition, the loss is equivalent to the annual caloric requirement of at least 48 million people (at 2500 kcal per person per day) (World Bank, 2011). Therefore, there is potential for great gains in food security and significantly reducing food aid dependence by improving post-harvest cereals management.

Cereals production in SSA has been very low, compared to the rest of the world (World Bank, 2008; Abbas *et al.*, 2014). Low agricultural production has been blamed for food problems in SSA, an argument that has motivated hundreds of studies on the adoption of improved and production enhancing technologies in the region (Feder *et al.*, 1985; Sunding and Zilberman, 2001; Foster and Rosenzweig, 2010). Consequently, a significant amount of financial aid and support has been extended to these countries to address production related issues. However, can we continue to emphasise only production problems when 20–30% of the yields of the cereals harvested never reaches the consumers? Post-harvest losses continue to worsen food insecurity by contributing to high food prices, and by removing part of food supply from the market (Tefera, 2012). Although adoption of sustainable intensification practices is a promising step in making SSA food secure, existing post-harvest losses can reduce the benefits to be gained from such improved technologies. Reducing food losses arising from storage can be more environmentally sustainable than a corresponding increase in production.

Some studies have literally argued that some modern storage technologies are good enough to the extent that if

they are adopted, one does not necessarily need to introduce any additional preservation technique for the safety of the crops (see, for example, the metal silos discussion in Gitonga *et al.* 2013, 2015 and Tefera, 2012). Nonetheless, experience has shown that some farmers still adopt both improved storage techniques and some additional preservation methods. If the former is scientifically proven to be an effective substitute for the latter, yet both are currently adopted together by farmers, then it is important to understand why that is the case, as this might help farmers reduce their storage costs significantly by choosing only one of the options.

In this paper we study the factors influencing the choice of improved cereals storage technologies and the preservation techniques among farming households in rural Tanzania, and assess how such technologies could act as adaptive strategies in response to climate change. First, we use farm level climate data to investigate the role of climate variables (rainfall, temperature and altitude) on the adoption decision of storage and preservation measures across households. Second, by using a bivariate probit model, we study the trade-off farmers make when choosing storage and preservation technologies during post-harvest food storage. Through this we can shed some light on complementary/substitutability nature of the technologies.

The current study contributes to the literature in two ways. First, to the best of our knowledge, this is the first study to exploit farm level climate data (temperature and rainfall) to estimate the effect of these variables on the adoption of storage technology and preservation methods. Second, we analyse the trade-offs farmers make in the choice of storage technologies and preservation measures. Unlike Adegbola and Gardebroek (2007), we study the trade-off farmers make when choosing improved cereals storage technologies and the preservation techniques. We relax the assumption of Adegbola and Gardebroek (2007) that the two adoption decisions are made separately. We do this because modern storage technologies (e.g. metal silos) do not need preservatives as they work hermetically (Tefera, 2012), and thus the decision to adopt modern storage is likely to affect the decision on whether to use preservation measures. Surprisingly, there is a limited number



of empirical studies in the peer-reviewed journals (from which Tanzania can learn) that assess the adoption of agricultural storage technologies in developing countries, and to the best of our knowledge, none of them investigates the role of climate variables and on the joint adoption decision.

In order to enable this, we exploit a very rich data set, the living standard measurement survey (LSMS) for Tanzania, collected in 2010/2011. The main findings of the study contribute to a new tweak in the climate change literature that climate variables (mainly rainfall and temperature) do influence the choice of improved storage technologies and preserving methods. In addition, we find that access to extension services significantly influences in increasing the adoption of improved storage technologies. Also, consistent with our expectation, we find that adoption of the modern storage technologies indeed negatively affects the adoption of preservation technology (i.e. substitution effect).

The rest of the paper is organized as follows: section 2 reviews the literature, while section 3 discusses methodology. Section 4 presents the data and descriptive statistics. Section 5 presents the results, while section 6 presents discussions and concludes the study.

## Literature review

Post-harvest cereal loss is the loss of grains between harvest and consumption (Proctor, 1994; USAID, 2011a). A recent definition by Bellemare *et al.* (2017) state that food waste is the difference between the amount of food produced and the sum of all food employed in any kind of productive use, whether food or nonfood. The majority of post harvest cereal losses are due to rodents, grain borers, grain weevils and microorganisms (molds, bacteria), resulting from poor post-harvest storage management (Abbas *et al.*, 2014; Kumar and Kalita, 2017; Mendoza *et al.*, 2017; World Bank, 2011). Adoption of improved post-harvest storage facilities (e.g. open drums, Metal Silo, airtight (hermetic) bags/drums, etc.) or one of various preservation methods are major approaches towards loss reduction (Abass *et al.*, 2018; Affognon *et al.*, 2015; Kumar and Kalita, 2017; Manandhar *et al.*, 2018). For a long time, cereal storage in SSA has relied on traditional methods (e.g. traditional granaries, etc.) of grain storage. But these traditional storage methods do not effectively protect the grain from climate change, pest and diseases, resulting in huge losses and threatening food security. This has resulted to introduction of several improved post-harvest technologies and/or other preservative techniques to minimise such huge loss. However, empirical information on the determinants of adoption of such technologies is scanty (Tefera *et al.*, 2011), with a good fraction of SSA farmers remaining to their traditional methods.

On the other hand, climate change and variability have continued to aggravate food security problems in Africa and world at large<sup>1</sup>. In response, research has focused on how

farmers respond to such challenges on the production side (e.g. Di Falco *et al.*, 2011; Mendelsohn *et al.*, 1994; Deressa and Hassan, 2009). However, the post-harvest responses to such climatic shocks have largely been overlooked. Climate variables such as temperature, moisture content and relative humidity are asserted as principal physical factors that affect grain in storage as they influence insect and mold development, which causes deterioration and loss of grain in storage (USAID, 2011a; Tefera, 2012; Abass *et al.*, 2014). Higher (or very low) temperatures and low humidity level are less likely to support the growth and development of most of the pests and insects. Bendito and Twomlow (2015) have recently started the debate on strategies to save the existing and future post-harvest facilities from impacts related to floods, droughts, high temperatures and other weather-related disasters due to climate change and from earthquakes. There is also a need to understand how farmers residing to different climatic conditions respond in terms of storage and preservation technologies is important. If indeed different technologies work best under certain climatic conditions, then with current climate change and variability (where the less humid areas become more humid and the previously humid areas are now changing to semi-arid), such technologies could be promoted as ideal adaptations strategies in those areas.

Like many other countries in SSA, Tanzania is not immune to the post-harvest loss of cereal crops, neither to the negative shocks of climate change. It is estimated that up to 40 percent of the harvested cereals does not reach the final consumer due to the poor post-harvest management (Mauanya, 2002 as cited in Rugumamu, 2003; USAID, 2011b). World Bank (2011) estimates that lack of or poor storage facilities account up to 38% of the post-harvest losses in the country. This type of loss generally refers to either qualitative or quantitative measurable decrease of the foodstuff mainly caused by insects, molds, bacteria, rodents, birds, sprouting and rancidity (USAID, 2011a). With low levels of agricultural productivity by many poor subsistence farmers in the country, such huge losses can have adverse effects on the food security of the farmers and of the country at large.

## Methodology

After harvesting the crops, cereal farmers must decide on how much of the harvest to store for either future household food consumption, seeds or later selling at higher market prices<sup>2</sup>. Then at this point, a farmer has to simultaneously decide on the use of storage and preservation technique that will maximise the value of stored cereals, at least for this period storage. The household faces a storage technology choice set to choose from, which contains traditional methods, improved traditional and modern methods, where the latter is assumed to be the most effective (i.e. with highest efficacy rate) storage method and this feature is common knowledge.

Storage handbook by USAID (2011a, p33) classify farm level storage facilities as traditional or modern based on some physical characteristics of the structures. Informed by

<sup>1</sup> When it comes to Tanzania, there is already strong evidence suggesting that climate change is an issue in the country as indicated by the drastic change in the annual mean rainfall of 1067 mm for the 1960-1990 period to 767 mm in the 2001-2009 period. A study by Rowhani *et al.* (2011) predicts that the temperature increase of 2°C by 2050 will reduce average maize, sorghum and rice yields in the country by 13%, 9% and 8%, respectively.

<sup>2</sup> This study only focuses on the decisions farmers make once they have decided to store a certain amount of their harvest.

this report, in this paper, we classify these facilities into three groups, traditional, improved and modern storage technologies. While traditional technologies include locally made traditional structures, improved locally made structures, unprotected piles and ceiling, while improved technologies include sacks/open drums, modern stores and airtight drums, while modern technologies only include airtight drums and modern stores (i.e. excludes sacks/open drums).

Following the discussions above, the econometric specification of this paper consists of two parts: in the first part, we test if the adoption of improved/modern technologies and preservation methods are interdependent by estimating a bivariate probit model; in the second part, we analyse the determinants of the three possible groups of storage technologies (i.e. traditional, improved traditional and modern technologies) by estimating an ordered probit model.

### Bivariate probit model

The choice of the storage technology is likely not to be independent of the decision to adopt preservation measures. To estimate the bivariate model, first, we consider the broad category of improved technologies (i.e. improved traditional and modern), where the base is traditional technologies. In the second bivariate estimation, we consider only the modern technologies, where the base is traditional and improved traditional. Following Greene (1998; 2008) we model simultaneously the choice of the storage technology and the preservation measures. Thus, we adopt the following bivariate probit model:

$$\begin{aligned} y_1^* &= X_1'\beta_1 + \varepsilon_1, S = 1, \text{ if} \\ y_1^* &> 0; S = 0, \text{ otherwise} \end{aligned} \quad (1)$$

$$\begin{aligned} y_2^* &= X_2'\beta_2 + \varepsilon_2, P = 1, \text{ if} \\ y_2^* &> 0; P = 0, \text{ otherwise} \end{aligned} \quad (2)$$

where  $S=1$  for the choices of improved/modern storage technologies, zero otherwise and  $P$  is the decision to preserve.  $\varepsilon_1, \varepsilon_2, \rho$  are assumed to be bivariate normal (BVN).  $y_1^*$  and  $y_2^*$  are the unobserved latent variables from which the two decisions are defined;  $X_1$  and  $X_2$  are the vectors of independent variables for both decisions;  $\varepsilon_1$  and  $\varepsilon_2$  are the error terms, which may be correlated (given by the correlation coefficient,  $\rho$  statistics), otherwise, univariate binary probit model is appropriate (Greene, 2008).

### Ordered probit model

Because the different technologies have different levels of efficacy, we group the technologies as low efficacy rate (traditional technologies), medium efficacy rate (improved traditional technologies) and high efficacy rate (modern technologies). Given the different efficacy rates, the storage technologies used have ordinal meaning: modern storage technologies are better than improved traditional, which are better than traditional storage technologies. In the literature, a standard way of modeling ordered response variables like our dependent variable is by means of ordered probit or ordered logit (for details of the models estimation see

Greene, 2008). These two models are very similar; we opt for an ordered probit in this paper, because of its greater flexibility and it is relatively easy to estimate. The model assumes a normally distributed cumulative density function (cdf). For the model probabilities to be positive, we define two threshold parameters,  $U_1$  and  $U_2$ , with  $U_1 < U_2$ . We do not observe the efficacy rate but we do observe choices made by respondents. Assuming  $y_i = (1, 2, \text{ and } 3)$  for traditional, improved traditional and modern storage, respectively, then the interval decision rule is:

$$\begin{aligned} y_i &= 1 \text{ if } y_i^* \leq U_1 && \text{(Traditional technologies)} \\ y_i &= 2 \text{ if } U_1 < y_i^* \leq U_2 && \text{(Improved traditional technologies)} \\ y_i &= 3 \text{ if } y_i^* > U_2 && \text{(Modern technologies)} \end{aligned}$$

Where  $y_i^*$  is the latent index of efficacy rate. To estimate this model, we apply the usual maximum likelihood estimation to obtain both the threshold parameters and the model parameters.

The choice of control variables for both the bivariate probit model and the ordered probit model is mainly informed by existing post-harvest loss literature (e.g. Adegbola, 2010; Adegbola and Gardebroek, 2007; USAID, 2011a; World Bank, 2011; Tefera, 2012). The decisions made by farmers depend on a number of factors including the amount harvested, household size, short term climate variables (rainfall, temperature and altitude, with terms for rainfall and temperature squared in order to capture any nonlinearities), humidity (i.e. as measured by the interaction term between rainfall and temperature), amount of rainfall in the previous season, crops grown, marketing infrastructure and assets which is a proxy for wealth indicator.

## Data and descriptive statistics

We employ a very rich and nationally representative household survey data set from Tanzania, collected in year 2010-2011. The data was collected based on a stratified, multi-stage cluster sample design using the national master sampling frame constituting a list of all populated enumeration areas in the country (NBS, 2012). Information was collected from a total of 3846 households, 2121 (55 percent) of them from the rural areas. From this dataset, we select those rural cereal farming households who reported storing at least part of their crop, giving us a sample of 927 cereal storage (and or preservation) observations for 557 rural and cereal farming households<sup>3</sup>. From the final data set, 56% of households cultivate maize, 23% cultivate rice and the remaining 21% cultivate other cereals mainly millet, sorghum and beans.

<sup>3</sup> Households are likely to adopt different types of storage/preservation technique for different cereal crops. Following this, we use observations for cereal storages or/and preservation as our primary unit of analysis other than households. This also enables us to retain the highest number of observations in our dataset. However, for robustness checks, we shall also do the models estimation using household as unit of analysis.

**Table 1a:** Major types of storage facilities usage.

	% of total population	Efficacy rate
<b>Tradition</b>	<b>24.10</b>	<b>LOW</b>
Locally made traditional structures	16.85	
Improved Locally made structures	1.61	
Unprotected pile	1.79	
Ceiling	3.85	
<b>Improved storage</b>	<b>68.01</b>	<b>MEDIUM</b>
Sacks/Open drums	68.01	
<b>Modern storage</b>	<b>6.36</b>	<b>HIGH</b>
Airtight drums	5.91	
Modern Stores	0.45	
Others	1.52	

Source: Own composition

**Table 1b:** Proportion of households preserving, disaggregated by storage type.

	Traditional storages	Improved storages	Modern storages	Whole population
Whether preserves (% of sample)	29.0%	31.6%	18.3%	30.7%
Distribution by category of preservation measure				
Spraying	18.6%	29.2%	16.9%	26.3%
Smoking	4.5%	2.2%	0.0%	2.8%
Others	5.6%	0.2%	1.4%	1.5%

Source: Own composition

**Table 2:** Descriptive statistics of key variables.

Storage type	Tradition		Improved		Modern		Whole sample
Variable	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	
Whether hhld adopts any preserving method	29%	-	32%	-	18%	-	31%
Mean annual temp	22.56	2.295	22.81	2.797	20.81	2.446	22.8
Mean annual rainfall (mm)	778.7	177.840	745.3	221.802	571.0	228.816	754.4
Households living in a humid region	71%	-	75%	-	90%	-	74%
Access to extension services	14%	-	15%	-	21%	-	15%
Number of years hhld lived in the village	40.6	21.208	38.0	19.099	30.2	19.751	38.5
Distance to the nearest major road (km)	22.624	20.255	20.594	23.516	11.755	14.529	20.9
Share of households sold any of the harvested crops	47%	-	39%	-	58%	-	41%
Maize farming hhld (dummy)	58%	-	52%	-	83%	-	54%
Proportion of heads without any formal education	57%	-	44%	-	24%	-	47%
Female headed households	15%	-	18%	-	23%	-	17%
Age of the household head (Years)	52	13.578	49	15.271	52	12.521	50
Asset Index	-1.355	1.037	-0.110	2.587	2.198	3.068	-0.4
Proportion of household encountered any storage losses	6%	-	8%	-	3%	-	8%
Household size	9.1	9.129	6.2	3.313	6.4	2.992	6.9

Source: Own composition

Table 1a provides a detailed distribution of storage facilities. Major types of farm level storage facilities used in Tanzania mainly include: traditional storage (i.e. locally made traditional structures, improved locally made structures, unprotected pile and ceiling) adopted by 24% of our sampled households; improved storages (i.e. sacks/open drums) adopted by 68% and modern storages (i.e. airtight drums or modern store), adopted by 6%. Since modern storages are subset of improved storages, in the subsequent analyses we consider improved storages to constitute of both the only improved and the modern stores (i.e. sacks/open drums, airtight drums and modern store) but modern storage category does not include the only improved one (i.e. sacks/open drums).

We consider household to have adopted a preservation measure (preserve) if it reported to do something to protect the stored crops. In our sample (as presented in Table 1b), only 30.7% of the households reported to preserve their stored crops, with majority using spraying (26.3 %). We notice a small difference in the proportion of households who report to use preservative measures between those using improved and traditional storage methods (32% versus 29%, respectively). However, we notice that a much smaller share of households that adopt modern storage technology (i.e. 18.3 %) also preserve compared to that of 29% by those still using traditional storage methods.

In Table 2, we provide descriptive statistics of other major variables by type of storage technologies adopted. Adopters of modern storages live in areas with less temperatures and rainfall, have more access to extension services, are relatively more educated and wealthier when compared to those adopting traditional storages. However, when we investigate share of households living in humid regions (good environment for pests, insects and other microorganisms), we find that relatively larger share of modern storage adopters (90%) compared to 71% of the traditional storage adopters live in these regions. The mean annual temperature for the whole sample is 22.8 degrees Celsius but varying from 15.4°C in some areas to 27.8°C in others, and average rainfall is 754mm (varying from 359mm to 1652mm).

Regarding gender, only 17% of households in our sample are headed by females. However, 23% of households that have adopted modern storage technologies are female headed, as opposed to only 15% of the traditional storages adopters. In addition, larger share of maize farmers adopts modern technologies (constituting 83% of adopters) compared to those cultivating other cereals. This is not very surprising as maize storage dominates the food storage activity in Tanzania, with over 70% of the functional stores having it or its products as the main product (USAID, 2011b, p14). Adopters live much closer to major roads than their counter-

**Table 3:** Bivariate probit: Improved storage and preservation methods.

Variables	Improved	Preserve
Mean annual temperature (long-term)	-0.680** (0.274)	0.817*** (0.253)
Mean annual temperature_SQR	0.016*** (0.006)	-0.017*** (0.006)
Mean annual rainfall (long-term)	0.003 (0.003)	0.007*** (0.002)
Mean annual rainfall _SQR	4.26e-07 (1.09e-06)	-2.14e-06** (9.25e-07)
Annual rainfall in previous year (2008/2009)	-0.001 (0.001)	0.001** (0.001)
Interaction of rain and temperature	-0.001 (0.001)	-0.001** (8.92e-05)
Elevation/Altitude in metres	-0.001*** (0.001)	-0.001 (0.001)
Access to extension services	0.295* (0.154)	0.441*** (0.131)
Number of years lived in village	-0.006* (0.003)	0.016*** (0.003)
Distance from the nearest major road (in logs)	-0.010 (0.041)	-0.229*** (0.036)
Selling households	-0.064 (0.106)	-0.223** (0.101)
Maize producing households	-0.189 (0.123)	0.489*** (0.118)
No schooling	-0.014 (0.115)	-0.114 (0.116)
Female headed households	0.181 (0.152)	-0.168 (0.142)
Age of household head	-0.001 (0.005)	-0.011** (0.004)
Asset Index	0.160*** (0.037)	0.032 (0.023)
Whether any crop was lost from storage	0.104 (0.209)	-0.615*** (0.225)
Amount of crop harvested (in logs)	0.018 (0.052)	0.209*** (0.048)
Household size	-0.073*** (0.012)	-0.038*** (0.011)
Semiarid regions	-0.108 (0.155)	-0.528*** (0.156)
Coast regions	-1.313*** (0.186)	-0.164 (0.155)
Constant	9.740*** (3.645)	-13.420*** (3.305)
rho		0.070 (0.066)
Observations	993	

Note: Wald test of  $\rho = 0$ ;  $\chi^2(1) = 1.125$ ; Prob >  $\chi^2 = 0.289$ ; Robust standard errors in parentheses. \*\*\*  $p < 0.01$ , \*\*  $p < 0.05$ , \*  $p < 0.1$

Source: Own composition

parts and a relatively larger fraction (i.e. 21% versus 14%) of this group received some extension services.

## Results

First, we estimate the bivariate model of improved storage technologies and preservation methods. Estimation results (Table 3) suggest that there exists no statistically significant relationship between the adoption of improved storage methods and preserving, with the  $\rho$  value of 0.07, but a  $p$ -value of 0.289. The statistical insignificance of the results implies that the adoption of each of the two technologies (i.e. improved storage and preservation) can be modeled separately using an

independent regression function. Following this, we estimate the binary probit model for each of the technologies.

The marginal effects from regression results of the improved storage and preservation probit models are presented in Table 4. As expected, climatic conditions influence (non-linearly) the households' decision to preserve the stored crops. We find significant positive and negative marginal effects for temperature and temperature squared variables respectively. This suggests that, at lower levels, the probability of preserving increases with temperature but the relationship reverses at higher levels of temperature (turning point is 20 degree Celsius, meaning that majority of the sampled households are in the regions where the use of preservatives declines with higher temperature). In addition,



we find that mean annual rainfall increases the probability of preserving and that households who experienced very high rainfall in previous years are more likely to adopt preserving measures in the current year. These findings are in line with Stathers *et al.* (2013), arguing that postharvest systems will be affected by changes in temperature, rainfall, humidity, extreme events and the natural and human responses to climate change and variability

Furthermore, higher cost of acquiring the preservatives (as proxied by household distance from the nearest major roads) reduces the probability of preservation usages. Households living far from the nearest major road are 7.6 percentage points less likely to adopt preservation measures. We also find that amount of crops harvested increases the probability of preserving. A 10% increase in the amount of crops harvested increases the likelihood of preserving by 7 percentage points.

With regard to storage, we find that households living in higher temperatures have a lower probability of adopting the improved storage, but this effect gradually falls and later changes its sign (turning point is 23.5 degree Celsius, meaning around 40% of the sampled households are in the regions where the adoption of improved storage increases with higher temperature). However, results suggest that neither rainfall nor humidity matter on the adoption of improved storage. Although, controlling for regional fixed effects shows those households living in semi-arid regions (i.e. long run climate average of both dry and hot) have lower probability to adopt preservation measures but no effect on improved storage adoption. Households living in semi-arid regions are 15 percentage points less likely to adopt preservation. In addition, households living in higher altitude areas are less likely to adopt improved storage methods.

Moreover, we find that extension services matter significantly for both improved storage and preserving. Households with access to these services are 7 and 16 percentage points more likely to adopt improved storage and preserve, respectively, compared to their counterparts. Other factors strongly related to the probability of adoption of improved storage are household wealth or income (as proxied by asset index) and household size. These results are in line with finding by Gitonga *et al.* (2015) that household size and land size (wealth) increased the likelihood of adopting the metal silo technology.

Table 5 reports bivariate probit model results for modern storage and preservation methods. Contrary to improved storage, here we find that modern storage and preservation methods are substitutes, with a rho value of -0.25 and P-value of 0.022 which allows us to reject the null hypothesis of independence.

Our data does not provide the price information for the adopted storage methods but coefficient of assets is statistically significant, indicating that wealthier households are more likely to choose modern storage. Given the adoption relation between modern storage and preserving, we jointly estimate their adoption decisions and we find that indeed transaction costs (as proxied by distance from the nearest major road) and household wealth (as proxied by asset index) are respectively negatively and positively correlated with the adoption of the modern storage. These results support find-

**Table 4:** Marginal Effects results for the binary probit model for adoption of improved storages and preserving.

VARIABLES	improved storage	preserve
Mean annual temperature (long-term)	-0.182** (0.073)	0.272*** (0.084)
Mean annual temperature_SQR	0.004*** (0.002)	-0.006*** (0.002)
Mean annual rainfall (long-term)	0.001 (0.001)	0.003*** (0.001)
Mean annual rainfall _SQR	1.31e-07 (2.77e-07)	-7.14e-07** (3.08e-07)
Annual rainfall in previous year (2008/2009)	-0.001 (0.001)	0.001** (0.001)
Interaction of rain and temperature	-3.45e-05 (2.87e-05)	-7.20e-05** (2.98e-05)
Elevation/Altitude in metres	-0.001*** (7.67e-05)	-3.86e-05 (9.26e-05)
Access to extension services	0.070** (0.033)	0.159*** (0.049)
Number of years lived in village	-0.002* (0.001)	0.005*** (0.001)
Distance from the nearest major road (in logs)	-0.002 (0.011)	-0.076*** (0.012)
Selling households	-0.016 (0.028)	-0.073** (0.033)
Maize producing households	-0.049 (0.032)	0.159*** (0.038)
No schooling	-0.004 (0.030)	-0.037 (0.038)
Female headed households	0.046 (0.035)	-0.055 (0.044)
Age of household head	-2.14e-05 (0.002)	-0.004** (0.002)
Asset Index	0.042*** (0.009)	0.011 (0.008)
Whether any crop was lost from storage	0.030 (0.050)	-0.167*** (0.047)
Amount of crop harvested (in logs)	0.004 (0.014)	0.069*** (0.016)
Household size	-0.019*** (0.003)	-0.013*** (0.004)
Semiarid regions	-0.029 (0.043)	-0.154*** (0.039)
Coast regions	-0.440*** (0.066)	-0.053 (0.048)
Observations	993	993

Robust standard errors in parentheses

\*\*\* p<0.01, \*\* p<0.05, \* p<0.1

Source: Own composition

ings that household characteristics and climate-related factors influences farm households' agricultural intensification technology adoption (Teklewold *et al.*, 2013; Ndiritu *et al.*, 2014; Beyene *et al.*, 2017).

Table 6 reports ordered probit results. Consistent to the bivariate probit and probit models estimated above, households are less likely to adopt modern storage and improved storage technologies as temperature increases but the sign changes at very high temperatures (turning point is 26.6 degrees Celsius, with most of the farmers being on the downward sloping portion of the curve). Similar signs are observed for the rainfall and altitude variables. It is difficult to explain these results but one could suspect that possibly initial fixed costs of obtaining modern storage are so high to the farmers such that even those living in the riskiest envi-

**Table 5:** Estimation results: bivariate Probit for modern storage and preserve.

VARIABLES	Modern storage	preserve	marginal effects (see note*)
Mean annual temperature (long-term)	0.112 (0.411)	0.825*** (0.252)	0.004 (0.003)
Mean annual temperature_SQR	-0.015 (0.011)	-0.017*** (0.006)	-0.001* (9.53e-05)
Mean annual rainfall (long-term)	-0.011*** (0.004)	0.008*** (0.002)	-3.76e-05 (3.02e-05)
Mean annual rainfall _SQR	4.98e-07 (1.48e-06)	-2.17e-06** (9.34e-07)	-5.44e-09 (1.07e-08)
Annual rainfall in previous year (2008/2009)	0.002 (0.001)	0.001** (0.001)	1.15e-05 (8.45e-06)
Interaction of rain and temperature	0.001* (0.001)	-0.001** (8.95e-05)	1.18e-06 (1.23e-06)
Elevation/Altitude in metres	-0.001* (0.001)	-0.001 (0.001)	-6.38e-06 (4.28e-06)
Access to extension services	0.061 (0.198)	0.444*** (0.131)	0.003 (0.003)
Number of years lived in village	-0.017*** (0.005)	0.016*** (0.003)	-4.42e-05 (4.40e-05)
Distance from the nearest major road (in logs)	-0.087 (0.058)	-0.230*** (0.036)	-0.002* (0.001)
Selling households	0.113 (0.170)	-0.219** (0.101)	-0.001 (0.001)
Maize producing households	0.241 (0.196)	0.485*** (0.118)	0.003 (0.002)
No schooling	-0.153 (0.247)	-0.109 (0.116)	-0.001 (0.002)
Female headed households	0.132 (0.217)	-0.173 (0.142)	0.001 (0.001)
Age of household head	0.021** (0.009)	-0.011** (0.004)	8.80e-05 (7.83e-05)
Asset Index	0.125*** (0.042)	0.033 (0.023)	0.001* (0.001)
Whether any crop was lost from storage	-1.244* (0.692)	-0.600*** (0.225)	-0.003* (0.002)
Amount of crop harvested (in logs)	0.058 (0.081)	0.209*** (0.048)	0.001 (0.001)
Household size	-0.037* (0.022)	-0.038*** (0.011)	-0.001 (0.001)
Semiarid regions	-0.708** (0.344)	-0.527*** (0.156)	-0.003* (0.002)
Coast regions	0.233 (0.262)	-0.164 (0.155)	0.001 (0.002)
Constant	4.704 (5.202)	-13.570*** (3.309)	
Athrho		-0.259** (0.113)	
rho	-0.254** (0.106)		
Observations	993		

Wald test of rho = 0: chi2(1) = 5.238 Prob &gt; chi2 = 0.022

\*Marginal effects after biprobit  $y = \Pr(\text{improved} = 1, \text{preserve} = 1) (\text{predict}) = .002$ 

Robust standard errors in parentheses. \*\*\* p&lt;0.01, \*\* p&lt;0.05, \* p&lt;0.1

Source: Own composition

ronment cannot afford buying them. However, consistent with the adoption of preservation technologies, we uncover that households living in semi-arid regions have lower probability to adopt improved and modern storage technologies, but more likely to adopt traditional storage methods.

The empirical results also suggest that extension services and household wealth as key determinants to the adoption of improved and modern storage technologies. A household that received extension services is 4 percentage points and 2 percentage points more likely to adopt improved and modern storage technologies, respectively. Wealthy households are

3 percentage points more likely to adopt improved storage technologies but 4 percentage points less likely to adopt traditional storage. Our results support Bokusheva *et al.* (2012) finding that access to training and advisory services for grain production and household wealth (proxy by land holding) influence adoption of metal silo and relevance of the content of the extension services and wealth in driving adoption of modern storage technologies. Earlier findings by Adegbola and Gardebroek (2007) also underscored the role of extension services in influencing adoption of improved storage technologies.

**Table 6:** Ordered Probit: Coefficients estimates and marginal effects estimation results.

VARIABLES	Coefficient	Tradition	Improved	Modern
Mean annual temperature (long-term)	-0.626*** (0.242)	0.175*** (0.067)	-0.128** (0.051)	-0.047** (0.019)
Mean annual temperature_SQR	0.010** (0.005)	-0.003** (0.002)	0.002* (0.001)	0.001** (0.001)
Mean annual rainfall (long-term)	-0.005** (0.002)	0.001** (0.001)	-0.001** (0.001)	-0.001** (0.001)
Mean annual rainfall_SQR	0.000* (0.000)	-3.51e-07* (1.84e-07)	2.56e-07* (1.36e-07)	9.46e-08* (5.04e-08)
Annual rainfall in previous year (2008/2009)	-0.000 (0.000)	3.82e-05 (0.001)	-2.79e-05 (8.82e-05)	-1.03e-05 (3.25e-05)
Interaction of rain and temperature	0.000 (0.000)	-2.59e-05 (2.29e-05)	1.89e-05 (1.67e-05)	6.99e-06 (6.38e-06)
Elevation/Altitude in metres	-0.001*** (0.000)	0.001*** (6.46e-05)	-0.001*** (4.79e-05)	-4.62e-05** (1.85e-05)
Access to extension services	0.248** (0.120)	-0.064** (0.029)	0.042** (0.017)	0.022* (0.012)
Number of years lived in village	-0.012*** (0.003)	0.003*** (0.001)	-0.002*** (0.001)	-0.001*** (0.001)
Distance from the nearest major road (in logs)	-0.044 (0.032)	0.012 (0.008)	-0.009 (0.007)	-0.003 (0.002)
Selling households	-0.012 (0.096)	0.003 (0.027)	-0.002 (0.020)	-0.001 (0.007)
Maize producing households	-0.049 (0.107)	0.014 (0.029)	-0.010 (0.022)	-0.004 (0.008)
No schooling	-0.064 (0.107)	0.018 (0.030)	-0.013 (0.022)	-0.005 (0.008)
Female headed households	0.207* (0.125)	-0.055* (0.031)	0.037* (0.019)	0.018 (0.012)
Age of household head	0.009** (0.004)	-0.003** (0.001)	0.002** (0.001)	0.007** (0.001)
Asset Index	0.131*** (0.023)	-0.037*** (0.006)	0.027*** (0.005)	0.010*** (0.002)
Whether any crop was lost from storage	-0.290* (0.149)	0.089* (0.049)	-0.072* (0.043)	-0.018** (0.007)
Amount of crop harvested (in logs)	0.016 (0.049)	-0.005 (0.014)	0.003 (0.010)	0.001 (0.004)
Household size	-0.070*** (0.010)	0.020*** (0.003)	-0.014*** (0.002)	-0.005*** (0.001)
Semiarid regions	-0.284** (0.140)	0.0857* (0.045)	-0.068* (0.038)	-0.018** (0.008)
Coast regions	-0.884*** (0.150)	0.295*** (0.056)	-0.253*** (0.054)	-0.042*** (0.007)
cut1	-11.967*** (3.214)			
cut2	-9.302*** (3.195)			
Observations	993			
Model chi-square	227.9			
Pseudo R2	0.180			

Robust standard errors in parentheses. \*\*\* p<0.01, \*\* p<0.05, \* p<0.1  
Source: Own composition

Female headed households are less likely to adopt traditional storage but more likely to adopt improved storage technologies. Female farmers are 4 percentage points more likely to adopt improved storage technologies and 5.5 percentage points less likely to adopt traditional storage. Each year of age decreases chance of reporting traditional storage by 0.3 percentage points and increases chances to adopt improved technologies by 0.2 percentage points. This result collaborates with Bokusheva et al. (2012) finding that the probability of adoption declined with the age of the household head. Our analysis further reveals that household size reduces the changes to adopt improved and modern storage

technologies but increases the likelihood to adopt traditional storage by 2 percentage points.

## Discussion

Climate change is indeed an issue in Tanzania as we have already observed a significant decrease in the mean annual rainfall in the country, with several regions affected differently, suggesting that more households are at risk of losing their crops as a result of poor storage. We find that farmers in risky climatic environment do respond by adopting

preservative measures against storage pests. Putting this to a policy perspective, we argue that preservation and modern storage methods could be useful adaptation measures to climate change. The finding that households' adoption of preservation methods, improved and modern storage technologies reduces with increase in temperature is consistent with scientific explanations that very hot environments are not conducive for the reproduction and growth of pests, insects and other micro-biological organisms like fungus, and hence households have less incentive to adopt preservation measures. Given the high poverty levels in semi-arid regions, there is increased adoption of traditional technologies as opposed to other regions with better-off farmers.

Farmers residing in humid and relatively warm areas (i.e. pests conducive environment) are more likely to adopt both improved storage technologies and preservation methods. This suggests therefore that with the climate change problem when the least humid and cold areas turn to humid and warm, modern storage and preservation technologies could be promoted as ideal adaptive measure. These would eventually shield the poor farmers from potential post-harvest loss attributable to the change. A growing body of literature has proven that African farmers' adaptation to climate change is an important action for improved food security and farmers' overall well-being (Di Falco *et al.*, 2011; Deressa and Hassan, 2009 and Rowhani *et al.*, 2011). At this point, proper storage and preservation methods could become useful adaptation measures by farmers.

This study uncovers that resources matter on the adoption of both improved and modern storage technologies, while large households reduce the likelihood of adopting both improved and modern storage. Similar results are found in the agricultural technology adoption literature (see Foster and Rosenzweig (2010) for a review). Often improved and modern storage facilities are relatively costlier than the traditional methods, and larger rural families have higher dependency rate and are relatively poorer; all of which implying that wealthier and smaller households are better positioned on the adoption of both improved and modern storage technologies. These results thus corroborate those that have reported relatively low usage of modern granaries (e.g. Admire and Tinashe (2014) in Zimbabwe, and Midega *et al.*, 2016 in Kenya) with traditional granaries being more commonly used to store maize in most of rural Africa since modern granaries are perceived to be expensive and unaffordable for most of smallholder farmers.

In addition, our results also point to the role of extension services, age of the household head, female headed households and transaction cost, on adoption of preservation methods, improved and modern storage technologies. These results resonate with previous findings that extension services influences the dispersion of improved storage technologies information (Adegbola and Gardebreek 2007). Increasing farmers' technical know-how on adaptation of the farming systems to climate variability, and training on post-harvest management could reduce food losses (Abass *et al.*, 2014). Following our findings and previous findings in the literature, this study recommend that extension services should include comprehensive post-harvest loss abatement

components. In countries like Tanzania, where majority of its farmers have a maximum of primary education, extension services are a major source of such information.

On the other hand, the joint estimation of improved storage and improved methods and modern technologies and preservation methods results suggests that while a slightly improved storage facility is unlikely to affect the preservation decision, adoption of modern storage is a substitute to adopting any preserving measures. These results also give an empirical support to the discussion in Tefera *et al.* (2011) and Gitonga *et al.* (2013), suggesting that adoption of modern technologies such as metal silos is sufficient to prevent grains from damage by pests. Therefore, the multi-million projects in Africa to promote modern storage technologies (e.g. metal silos and super grain bags) as post-harvest abatement technologies are worthwhile because they reduce the need for preservation.

Generally, there are a number of policy messages to be drawn from this study. First, modern storage and preservation techniques are potential adaptation strategy to climate change and that policy environment should be designed to foster their adoption and usage in climate prone areas. Second, a policy action to promote adoption of modern storage facility does not only abate post-harvest loss but also does that at significantly lower cost as farmers will not need to complement storage with any preservation measures. Third, for all these to happen, there is a strong need to stimulate the drivers for such adoption including increased extension education on post harvest management practices, reduced cost of the technologies through for example subsidy and distribution, etc.

Notably, the cost aspect of the modern technology however raises another yet important policy and research question; are the increased costs of these facilities justified by their net benefits? In other words, could the reduced loss by these technologies crowd out the incurred costs of their adoption? To provide some light to this question, an attempt to estimate the net impact of these technologies on farmers (income based) welfare is needed. This is the main limitation of our study considering the coverage of our data set. Future research should therefore collect comprehensive data on costs and benefits of the combination of the different technologies to strengthen the debate on the cost effectiveness of adopting modern storage technologies.

## Acknowledgements

The Authors thank Yonas Alem, Hakan Eggert, Jesper Stage and Katarina Nordblom (all are at the Department of Economics, University of Gothenburg, Sweden) for their valuable comments, advice and support. In addition, we would like to thank Sied Hassen and Hailemarium Tecklewold (Ethiopian Development and Research Institute, Addis Ababa, Ethiopia) for their input to the paper. The paper benefited from comments given at the University of Gothenburg-Economics Department Seminar Series and several other international conferences. Comments from the Editor and the anonymous reviewers are gratefully acknowledged. We would also like to acknowledge financial support from



Sida (Swedish International Development and Cooperation Agency) through the Environmental Economics Unit, University of Gothenburg, as well as from the Jan Wallander and Tom Hedelius Foundation. All errors and omission are of the authors.

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# The African Indigenous Vegetables Value Chain Governance in Kenya

Increasingly, food security interventions in developing economies are adapting value chain approaches to facilitate the integration of smallholders into high margin value chains. In Kenya, the resurgence of African Indigenous Vegetables due to their medicinal value and rich micronutrients is a case in point. The vegetables are cultivated by smallholders, and the supply has not matched the demand in the high margin markets among urban consumers. Access to such high margin markets necessitates that smallholders gain entry or upgrade into the networks of those buyers who possess considerable control of these value chains. There is limited value chain scholarship on chain governance and its implication for smallholder participation in Kenya. This study investigated how value chain governance influences farmer participation in vegetable markets and food security in Kenya. This study employed exploratory case study design to provide chain architecture, isolate primary actors, their roles, relations, constraints and opportunities for upgrading by smallholders. A mixed method approach involving a multistage sampling technique of 339 respondents was employed to bring to the surface insights on chain architecture, market margins and governance structures and their implications as regards upgrading trajectories for small-scale farmers in Kenya. Thematic analysis was used for data analysis. Spot market relations were found to dominate traditional value chains in rural areas while peri-urban areas exhibited both traditional and coordinated value chains. The value chains are characterised by very weak linkages between upstream actors and downstream partners, where wholesalers and supermarkets play the role of leading firms in traditional and coordinated value chains, respectively. The study recommends the inclusion of farmers in market management committees and the establishment of binding contractual arrangements with supermarkets.

**Keywords:** Africa, indigenous vegetables, value chains, governance

**JEL classification:** Q13

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Received: 1 October 2018, Revised: 25 February 2019, Accepted: 5 March 2019

## Introduction

There is increasing recognition that smallholder commercialisation and integration of smallholders into high-value agro-food systems offer sustainable pathways for poverty reduction, food security, employment, women's empowerment, conservation and climate change in the developing economies (FAO, 2016). Kenya, like other developing countries in Sub-Saharan Africa, is experiencing growing supermarket penetration, fast urbanisation and rising per capita income resulting into changing consumer preferences (Trienekens, 2011). This trend has created emerging market opportunities for smallholders (World Bank, 2016). However, despite the growing market opportunities, many smallholders continue to encounter considerable barriers to accessing these markets (Poulton et al., 2012; Okello et al., 2011).

Many studies on firm participation decisions are based on Williamson's (1985) work on institutional economics and organisational theory, and are mainly concerned with establishing the link between transaction cost (TC) and channel choice. Transaction cost theory presupposes that a farmer's decision to participate in particular markets is based on comparative institutional efficiency: that is to say, the TC minimising condition (Gereffi and Fernandez-Stark, 2016). However, access to high value markets is more than a question of mere fulfilment of production volume requirements and minimizing TC; it is more about how farmers embed themselves into the networks of value chain lead actors (Kilelu et al., 2017).

For instance, supermarkets offer better opportunities but impose stringent quality and safety requirements, making it costly for smallholders to participate (Rao et al., 2012). The high margin segments of traditional markets, however, are dominated by opportunistic brokers and middlemen with exclusionary tendencies that drive smallholders out of participating in the market. Besides, the domestic traditional food value chains are characterised by poorly developed information channels, low productivity, lack of storage facilities, high transaction costs and limited value-adding activities (Barret, 2010).

This study investigated how value chain governance influences smallholder participation in the emerging markets for African indigenous vegetables and its implication on food security in Kenya. In this study, value chain governance (VCG) is construed as the framework and power relation dynamics among agents governing business transactions and the way these transactions are organised (Gereffi and Fernandez-Stark, 2016). Understanding the governance structure of the value chain would be important in that it would provide information on the constraints and opportunities involved in drawing up food systems policy-related recommendations for Kenya. Extant scholarship proposes VCG mechanisms such as a relational or contractual form, or a combination of both, to improve value chain integration (Gereffi and Fernandez-Stark, 2016). In this study, the relational mechanism is conceptualised so as to describe the level of trust between value chain agents that causes repeat transactions. The contractual mechanism is meanwhile con-

ceptualised so as to describe the degree to which contracts minimise uncertainties when establishing exchange transactions between actors.

The rest of the paper is organized as follows. First, given the renaissance of the African indigenous vegetables (AIVs) in Kenya, we give a brief overview of traditional vegetable production systems in the study areas. In the subsequent sections, we briefly discuss value chain governance, linking it to understanding inclusive value chain upgrading for smallholders. We then describe the methods, the study area and techniques of data analysis. This is followed by a presentation of the study findings with a highlight of value chain mapping, opportunities and constraints following a SWOT analysis and upgrading strategies. Finally, we conclude by outlining the associated agribusiness investment implications and recommendations.

## African Indigenous Vegetables in Kenya

African indigenous vegetables (AIVs) are vegetable crops whose natural habitat originated in Africa (Maundu et al., 1999). In Kenya, there are more than 210 species that are important in traditional diets (Mwaura et al., 2014). However, many of them have often been ignored in favour of exotic vegetables such as kales and cabbages (Muriithi and Matz, 2015). The most popular AIVs include both wild and cultivated leafy greens such as slender leaf (*Crotalaria brevidens*), African kale (*Brassica carinata*), African eggplant (*Solanum aethiopicum*), pumpkin leaves (*Cucurbita pepo*), amaranth (*Amaranthus* spp.), nightshade (*Solanum* spp.), spider plant (*Cleome gynandra*), cowpea (*Vigna unguiculata*), and jute mallow (*Corchorus olitorius*) (Abukutsa, 2010). They are more popular with smallholder farmers because they require fewer inputs and are better adapted to local agro-ecological conditions (Ekesa et al., 2009).

The AIVs present a niche market for smallholders in the emerging lucrative value chains in Kenya. They are predominantly produced by smallholders in rural and peri-urban areas but many consumers in urban areas access them through traditional and supermarket channels (Gido et al., 2017). Consumer preference literature argues that although these vegetables may be consumed in small quantities by many households, they are more affordable and improve household dietary diversity by influencing the intake of cereal staples, manage hunger and play a central role in household food security (Mayekiso et al., 2017). Besides their importance to household diets, they can also be important in addressing micronutrient deficiencies because they are rich in micro-nutrients such as vitamins A and C as well as calcium, zinc, and iron (Abukutsa, 2010) and possess bioactive compounds with antioxidant potential (Kamga et al., 2013). Therefore, improved production, distribution, marketing and consumption of indigenous vegetables could help mitigate food insecurity and alleviate malnutrition in developing countries like Kenya.

The above benefits have led to concerted promotional campaigns by development agencies, research institutions

and government agencies as a strategic crop for addressing households' income, food and nutrition in Kenya (Irungu et al., 2007). Presently, the demand for AIVs in the domestic market is growing and remains unmet (Ngugi et al., 2007). However, despite the potential to improve household food and nutritional security, empirical evidence on smallholder participation in AIV markets and food security still remains poor, missing, mixed and inconsistent (Mayekiso et al., 2017). There is anecdotal evidence so far of possible positive income, employment and technology adoption, and market demand (Olabode et al., 2017; Weinberger and Msuya, 2004), plus differentials in urban and peri-urban production and marketing (Oluoch et al., 2009; Ambrose-Oji, 2009), but these largely emanate from analysis of incomplete sections of value chain segments or else focusing on peri-urban areas and supermarket chains (Mwaura et al., 2014). The global market literature emphasises that access to such emerging markets depends on more than just production efficiency, so farmers must gain entry or upgrade into the buyer networks that form these markets (Kilelu et al., 2017). Linking agri-food value chains to food and nutrition security in the face of transformations in food systems would be important in informing policies and designing strategies for better smallholder integration in the emerging high margin segments of the AIVs value chains in Kenya.

There is a lack of information on the power relations between various actors along AIV value chain right from seed production and distribution, production processes, produce marketing up to the consumption point. Extant studies do not explain the exclusion of smallholders under the prevailing value chain governance and the upgrading opportunities available for AIV farmers. Moreover, conclusions from many of such studies are derived from econometric analyses that may not adequately account for exclusionary effects induced by power relations, trust, coordination and other social dynamics. This situation gives a strong impetus to the identification of actors and their activities and socio-economic elements influencing inclusive participation and upgrading in the AIV value chains. A holistic inquiry capturing the entire value chain governance for AIVs and its effects on food security and sustainable livelihoods is needed to inform decisions concerning effective upgrading strategies potentially available for improving value chain participation for small producers (Kilelu et al., 2017).

## Governance in Agro-food Value Chains

Value chain governance is defined as “authority and power relationships that determine how financial, material, and human resources are allocated and flow within a chain” (Gereffi, 1994). Governance defines the structure of relationships and coordination mechanisms that exist between transacting partners across time and space of a given value chain (Gereffi and Lee, 2012). It refers to the inter-firm relationships and institutional mechanisms through which non-market coordination of activities, the setting and enforcement of product and process parameters to be met by actors



in the chain take place (Humphrey and Schmitz, 2001). More often than not, buyers play an important role in setting and enforcing private standards and rules of engagement with the producers because of the (perceived) risk of producer failure. These parameters are also set and enforced by government and international agencies concerned with quality standards or labour and environmental standards (Humphrey and Schmitz, 2001).

Extant literature has referred to governance structures variously as distribution styles, channel types and vertical coordination. Humphrey and Schmitz (2001) distinguish three possible types of governance: network, quasi-hierarchy and hierarchy. However, Gereffi and Fernandez-Stark (2016) build on this work to point out a continuum-like transactional power dynamics between lead firms, subordinate firms and suppliers ranging from spot market to hierarchy. In the spot market, goods are exchanged between multiple buyers and sellers at the current time period with price as the main determinant of the final transaction. The other end of the chain continuum is the vertical integration, which refers to a situation where products move between various stages of production, processing and distribution as a result of within the firm managerial orders rather than at the direction of prices (Gereffi and Fernandez-Stark, 2016).

In between the two polar forms are the intermediate types of governance structures like modular, relational and captive. However, value chains are not static and change their organisation, governance, and linkages with changes in markets and competition (Pietrobelli and Staritz, 2013). The governance structure changes as the industry evolves and matures and governance patterns within an industry can vary from one stage or level of the chain to another. Firms and actors sometimes operate in multiple and interacting governance structures and these affect opportunities and challenges for economic and social upgrading (Gereffi and Lee, 2012). They observe that the degree of power of the buyer over the supplier decreases as value chains move from hierarchy to market. Gereffi and Fernandez-Stark (2016) contends that the variables that determine governance structures include: the complexity of information and knowledge transfer required to sustain a particular transaction; the extent to which this information knowledge can be codified and, therefore, transmitted efficiently and without transaction-specific investment between the parties to the transaction and the capabilities of actual and potential suppliers in relation to the requirements of the transaction.

An extensive body of literature on smallholder participation on higher value agro-food markets focuses on Global Value Chains (GVCs) (Trienekens, 2011; Gereffi and Lee, 2012; Minten et al., 2009). These studies robustly explain the vertical coordination by dominant lead firms from developed economies and resource-constrained producers from developing countries and the impact of such value chains on income and development. Despite these efforts, if we adopt the perspective of Gereffi and Sturgeon (2013), GVC in the context of the AIV value chain has not been explored; hence, this study is highly relevant as it aims to investigate the implications of value chain governance mechanisms on smallholder participation in AIV emerging markets and food security in Kenya.

## Materials and Methods

A multistage sampling procedure was employed to select regions, smallholders and other actors for the study. In the first stage, four counties of Nairobi, Kiambu, Kisii, and Kakamega were purposively selected for the study. The choice of the four counties was based on their known differentials in factors that are crucial to market participation by smallholder AIV farmers. In particular, they provided an opportunity to assess differentials in market participation between rural and peri-urban farmers as well as a chance to contrast procurement arrangements between supermarkets and traditional wet market traders. For instance, Kisii and Kakamega are rural counties where there is a significant volume of production and marketing by smallholders. Kiambu is a peri-urban area where farmers have significant interactions with wholesale, supermarkets and urban retail traders. Nairobi city was selected because it is the largest urban market with highly differentiated market outlets, including supermarket outlets, to provide cases for coordinated value chains.

In the second stage, two sub-counties with a high concentration of farmers and farmer groups involved in production and marketing of AIVs were purposively selected from each county. In the third stage, purposive sampling was used to strategically select information-rich farmer groups and key informants that would assist the study with in-depth understanding of actor relations and upgrading opportunities in the AIV value chains.

Data was obtained through focus group discussions and individual in-depth interviews using semi-structured discussion guides. Discussion topics orbited around governance themes such as private safety and quality standards, market information flow, price setting, repeat transactions and contractual arrangements. In each sub-county, two focus group discussions (FGD) were carried out with purposively selected participants of between eight and twelve farmers per session. Care was taken to ensure that selected farmers had certain commonality and heterogeneous characteristics and similar levels of understanding of a topic. Besides, deliberate attempts were made to attain a fair mix of participants based on gender, age, socioeconomic background and education level. In addition, 25 in-depth interviews were conducted with key informants drawn from supermarket managers, government offices, value chain consultants and managers with NGOs involved in promoting AIV value chains.

Discussions were further held with 99 traders including middlemen, transporters, retail traders and wholesalers. Separate discussion guides were prepared for different actors. Discussions and in-depth interviews entailed examination of patterns and explanatory factors, first at each node of the chain, and, secondly, through exploration of the nature and range of the relationships between actors at different nodes in the chain. Emphasis was given to governance dimensions such as coordination of value creation activities, contractual arrangements, access to information, market competition, price determination, private rules and standards, trusts and uncertainties. Researchers also made observations of the actors' interactions and business practices such as price negotiations, units of measure, product quality, the presence

of storage facilities and condition of the general environment and value addition among others.

Qualitative data was first transcribed and thematic analysis was performed as devised by Mertens (2010) and Braun and Clarke (2006). Value chain map was developed using functional analysis. The core processes, actors involved, flow and quantity of product at each node of the value chain were determined. A flow chart was used to represent the activities in the value chain.

## Results and Discussion

### Mapping of the AIV Value Chains

Mapping of key activities of the whole economy is the first step in conducting the chain analysis and this process explores input-output structure as well as territoriality of the value chain. Gereffi and Fernandez-Stark (2016) assert that mapping assists in identifying important nodes, how the distribution of rewards takes place through social relations and a range of interconnected economic activities. This study dealt with four dimensions: types of value chains; core processes (segments); actors involved and their functions as well as the existing types of relationships and linkages. Caution should be taken that this study only provides a snapshot of the value chain structure and does not adequately represent all factors that influence the conduct of individual value chain participants. For instance, this study did not look into consumer (end market) requirements and opportunities. Two value chains represented by traditional and coordinated value chains co-exist side by side as shown in Figures 1 and

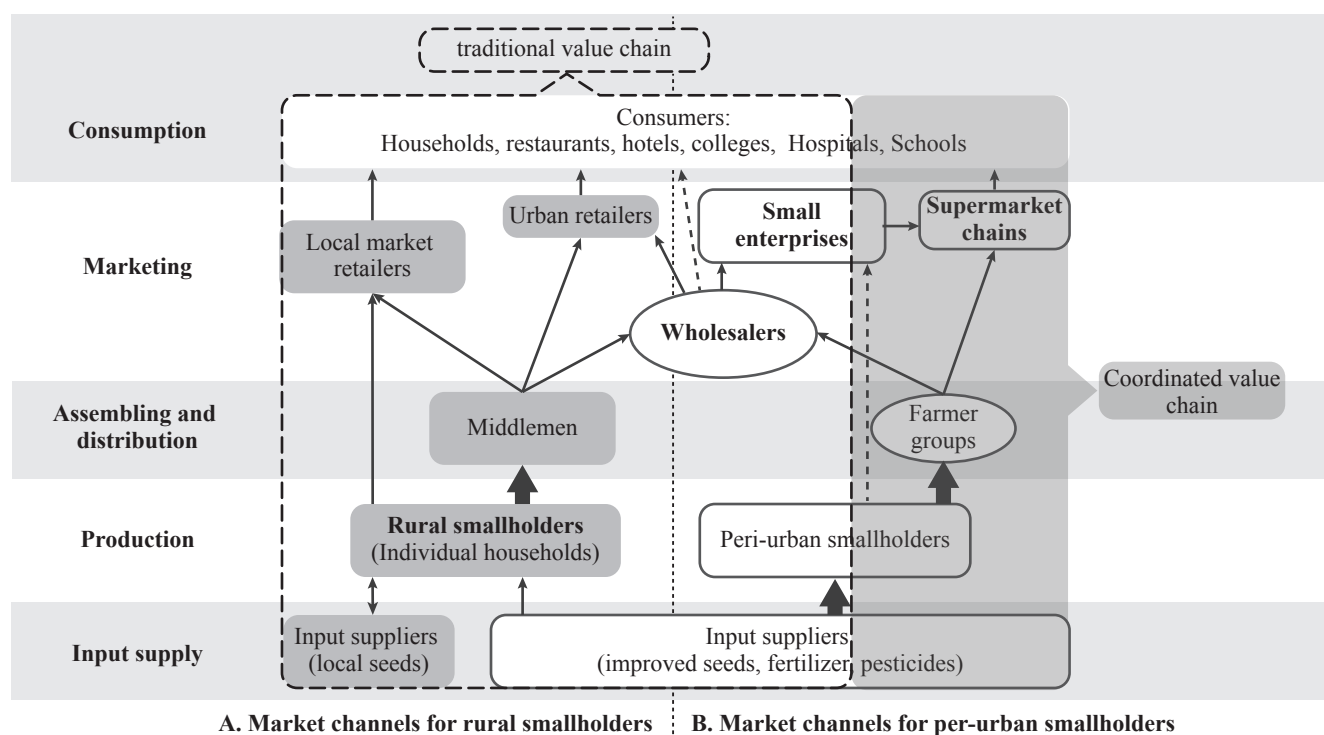
2. Parameters such as contractual arrangements, retail practices, and private food safety and quality standard requirements to delineate traditional value chain from coordinated value chains. The traditional value chains were defined by traditional market sourcing where producers and traders had no prior arrangements on production, quantities delivered or payment arrangements. Coordinated value chains, on the other hand, featured modern procurement arrangements where farmer activities were aligned based on contracts with supermarket which specified quantities, vegetable qualities, delivery timing and prices (Bijman et al., 2011).

### Key actors and their functions in AIV value chains

The study categorized actors into those from peri-urban areas and rural regions. Generally, the segments and actors were similar for rural and peri-urban regions (Figure 1). Actors included input suppliers (agro-vets), farmers and farmer groups, middlemen, wholesalers, retail traders and supermarkets. Marketing segments had the largest and most complex network of primary actors. For example, farmer groups, middlemen, wholesalers, brokers and retailers all converged at this node. The ensuing section provides detailed account of the functions of various actors.

#### Input Suppliers

Input suppliers fell in four categories: agro-vets, NGOs, local seed retail traders and farmers preparing their own seeds. The major inputs for indigenous vegetables included seeds, fertilizers, water and labour. In the rural areas, retail traders were supplied seeds by farmers regenerating from own farms. Some NGOs also provided farmers with certified AIVs seeds



**Figure 1:** Value chain map for AIVs.

Source: Own composition

as part of input credit packages. In the peri-urban areas, agro-vets sold certified seeds, chemicals, farm equipment and also provided technical support to farmers. There were no contractual arrangements between input suppliers and farmers, indicating weak backward vertical linkages. These findings concurred with earlier works of Mmasa and Msuya (2012) who found that input suppliers for sweet potatoes in Tanzania were not vertically integrated with producers and that input suppliers played the least role in the value chains.

#### *Farmers and farmer groups*

The study established that farmers grew many types of indigenous vegetable crops. However, the scope of this study was limited to establishing the extent of production and marketing of five key vegetables, namely: African nightshades (*Solanum spp.*), leafy amaranth (*Amaranthus spp.*), spider plant (*Cleome gynandra*), cowpeas (*Vigna unguiculata*) and Ethiopian kale (*Brassica carinata*). Farmer activities and practices included seed preparations, land preparation, nursery preparation, planting and sowing, weeding, irrigating, applying fertilizer, harvesting or selling their vegetables before harvest. There were differences in practices for rural and peri-urban farmers. For example, in the peri-urban areas, many farmers prepared nurseries where vegetable seedlings were transferred to the main plots. On the other hand, farmers from the rural areas mainly practised direct seeding. In the peri-urban areas, farmers planted indigenous vegetables as monocrops, while in the rural areas, vegetables were intercropped mostly with maize. In the rural areas, farmers planted between three and five types of vegetables, while in peri-urban areas, the majority of farmers grew averagely two to three types of vegetables.

The study also established that many farmers in peri-urban areas while only a few farmers in the rural areas irrigated their vegetable farms during dry seasons. Farmers made production decisions independently and were not influenced by group activities or contractual engagement with any buyer. All input costs and production risks were solely borne by the individual farmer.

All farmers sampled for this study belonged to farmer associations. There were two different organizational forms of farmer groups: the specialized 'farmer marketing groups' and the general-purpose 'farmer associations'. General-purpose 'farmer associations' were most common in rural areas. Their functions included organizing production technology demonstrations, member training and in some cases and member-to-member extension services. They provided platforms for collaboration with support service providers such as NGOs and government extension programs. Specialised farmer marketing groups were mainly found in peri-urban areas. In addition to functions undertaken by the general-purpose farmer associations, the specialized ones organised joint transportation of vegetables to the markets. In some instances, these groups were collective action marketing groups, which lobbied and negotiated with the wholesale market authorities for designated trading space and lower market access fees. For the farmer groups that were supplying supermarkets, they were involved in grading, bunching and negotiating contracts for their members.

#### *Middlemen*

In the rural areas, farmers loosely referred to middlemen as 'brokers'. Middlemen were the first link between producers and other downstream actors. There were two categories of middlemen: individual small-scale traders without formal registration or trade licensing and small to medium formal businesses. The small-scale traders assembled vegetables directly from rural farmers and sold to retailers at the local markets or wholesalers in urban markets. Those selling to wholesalers carried out additional functions such as sorting, aerating and re-packing vegetables. Middlemen from Kisii region were exclusively trading in AIVs throughout the year. This implies that indigenous vegetable trade was their major source of livelihood.

The second category of middlemen specialized in supplying supermarket outlets and other institutional consumers such as hotels, education institutions and hospitals. They bought vegetables from diverse sources ranging from farmers, middlemen, wholesalers and retail traders. Their functions included assembling vegetables, cleaning, trimming, sorting, re-bunching before they transported to buyers. They were mostly preferred by supermarkets as first choice suppliers of AIVs due to their financial capacities and ability to supply assorted vegetables within short notices.

In general, there were no contractual arrangements between middlemen and farmers. One unexpected finding of this study was that during off-peak seasons, some middlemen made pre-harvest payment arrangements with the farmers and harvested vegetables by themselves. Similar pre-harvest arrangements have also been found in Chile between medium and large-scale horticultural producers and their buyers (McCullough et al., 2008).

#### *Wholesalers*

Wholesale markets were located either in the peri-urban areas (Wangige) or within Nairobi city (Wakulima, Gikomba, and Kangemi). Wholesalers bought vegetables from middlemen in the rural areas or farmers from the peri-urban areas and then sell to retail traders. Their functions include assembling vegetables from different middlemen, repackaging the vegetables from the rural suppliers and selling to retailers. They are responsible for assessing market demands set prices and communicate their decisions to middlemen and retailers. Wholesalers are well networked with trusted middlemen from different parts of the country.

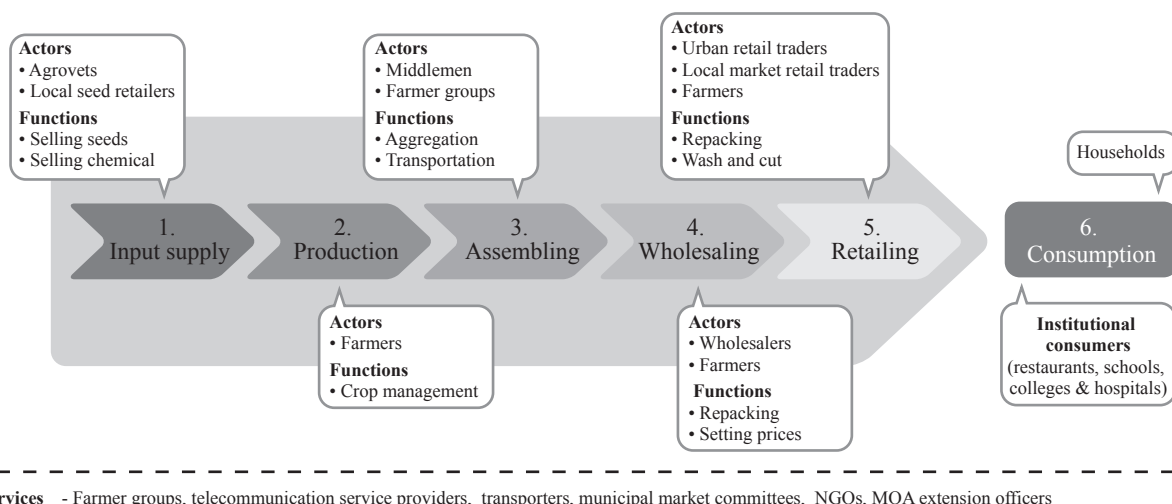
#### *Retail traders*

Retailers were the final links of downstream actors that delivered vegetables to final consumers. They bought vegetables from diverse actors such as farmers, middlemen and wholesalers. Retailers traded in relatively low quantities and were trading a whole range of vegetables and were not specialized in individual vegetables. There were two broad categories of retailers: traditional and modern retailers. This categorization was based on differences in their contractual arrangements with suppliers, quality and quantity requirement, capital investments and retailing practices.

Traditional retailers were mainly found in traditional market channels. They carried out their businesses in diverse locations such as alongside wholesalers within municipal wholesale markets, in wet markets, temporary estate stalls, and kiosks, by roadsides and in public bus parks. No business licensing was required for retail trading except for daily market fee charged by municipal market authorities. Their functions included buying vegetables, transportation, re-bunching, cleaning, displaying and selling to consumers. The study observed that some retailers within urban residential areas were hawking vegetables, while others were selling vegetables that were pre-washed, chopped, and packed. Most retail traders were women confirming earlier assertions by Maundu et al. (1999), who indicated that 95% of indigenous vegetable traders in Nairobi were women. Retailers sold more than one type of indigenous vegetable alongside other exotic vegetables.

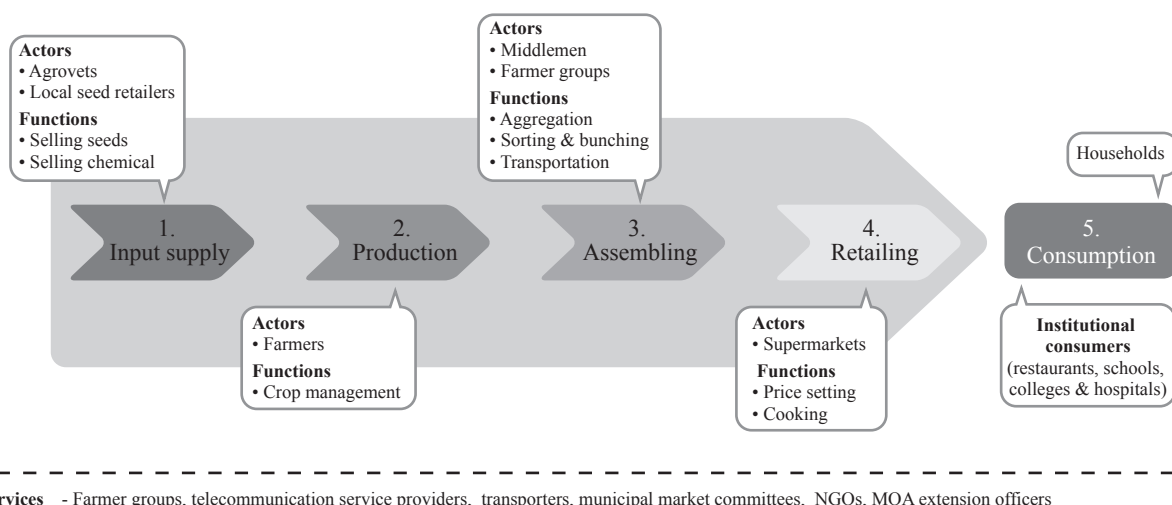
Modern retailing of fresh fruits and vegetables in supermarkets is a new phenomenon in Kenya like other developing economies (Macharia et al., 2013). Supermarket procurement system and retailing of AIVs typifies the coordinated value chains (Figure 2). Their functions included advertising and selling vegetables. It was also observed that some supermarkets sell cooked AIVs in addition to fresh vegetables.

The study established that supermarkets only bought vegetables from some formal farmer groups. However, supermarkets preferred dealing with a few prequalified middlemen because they were able to meet quantity and consistency requirements. This finding is consistent with the observation of Hichaambwa and Tschirley (2006) about supermarkets in Zambia, which also preferred engaging farmer groups and a few intermediaries to reduce transaction costs. The results further agree with the findings of Bidogez et al. (2016), whose study on the indigenous vegetables value chains in



**Figure 2:** Chain segments of traditional AIV value chains.

Source: Own composition



**Figure 3:** Chain segments of coordinated AIV Value chains.

Source: Own composition



Cameroon found that major nodal points in the traditional value chain consisted of input supply, production, harvesting, marketing and consumption.

Table 1 summarizes the actors and functions in the AIV chains.

### The chain governance structure

In this study, “chain governance” encompasses the systems of coordination, regulation and control within and between value chain segments through which value is generated. Various scholarly works have proffered different forms of chain governance models. Governance models as identified by Gereffi and Fernandez-Stark (2016), are market, modular, relational, captive and hierarchy, were employed to explain AIV power relations. The findings on parameters of value chain governance are presented below.

### Horizontal coordination

As has been highlighted earlier, many farmers and market traders had formal and informal relationships with actors in similar positions or other nodal points in the value chains.

The coordination examined *at the production level* was to establish whether farmers align their production and marketing activities to some collective decisions by their groups. Many farmers in the rural areas considered their associations to be helpful in enabling them to acquire new production skills and attracting collaboration with NGOs and government extension agencies. Farmer groups provided platforms through which development agencies carried out farmer capacity building activities. All groups had formal or informal group constitutions and executive office bearers consisting of a chairperson, secretary and treasurer who were entrusted with mobilizing members for group activities. No

**Table 1:** Summary of actors and functions in the AIV value chains.

Segment	Actors	Function	Activities	Traditional value chains	Coordinated value chains	Linkages
Input Supply	Agrovets	Input suppliers	– Sell certified seeds, chemicals and provide technical assistance to farmers	- +	+ +	Seed companies, farmers
	Local seed traders	Supply seeds	– Sell local seeds	+ +	- +	Farmers
	NGOs	Input Supply	– Provide input credit in the form of certified seeds, chemicals and light equipment	+ +	- -	Farmers, Agrovets and extension service providers
	Farmers	Local seed production	– Prepare seeds from own harvests – Sell local seeds traders in local markets	+ +	- +	Neighboring farmers, seed traders in local markets
Production	Farmers	Produce AIVs	– General crop management	+ +	+ +	NGOs, Ministry of Agriculture,
	Farmer Associations	Farmer mobilization	– Mobilize members for trainings	+ +	+ +	NGOs, Ministry of Agriculture,
	NGOs	Facilitators	– Technical assistance to farmers – Input credit	+ + - +	+ + - -	Farmers, MOA
	Ministry of Agriculture	Coordination of extension services	– Technical assistance to farmers through extension services – Input subsidies	+ + - -	+ + - -	Farmers, NGOs
Assembly and Distributions	Farmer groups	Aggregating vegetables	– Organize transportation to wholesale markets – Supply vegetables to supermarkets	- +	+ +	Farmers, transporters
	Middlemen	Buying vegetables	– Packaging for transportation	+ +	- +	Farmers, transporters
	Transporters	Transportation	– Delivering vegetables to the markets	- +	+ +	Middlemen, wholesalers
Wholesaling	Farmer groups	Secure market space	– Pay markets fee for members	- -	+ +	Market management, famers
	Famers	Selling vegetables	– Sell vegetables to wholesalers or retailers	- -	+ +	Wholesalers, urban retailers
	Wholesale traders	Selling to retailers	– Setting price for middlemen and retailers	+ +	- +	Middlemen, retailers, market management
Retailing	Retail traders	Selling to consumers	– Bunching of vegetables – Cutting vegetables	+ +	- -	Wholesalers, middlemen, market management, brokers
	Intermediaries	Sell to supermarkets	– Clean, sort and re-bunch			Wholesalers, farmers, supermarket
	Supermarkets	Selling to consumers	– Cold storage, pack and display – Cook vegetables	- -	+ +	Farmer groups, intermediaries, banks

Note: Actors presence = -- not present, -+ partly present, ++present

Source: Own composition

farmer group was involved in collective actions towards joint procurement of inputs or marketing in the rural areas.

However, farmer groups in peri-urban areas engaged in collective actions especially through joint transportation of vegetables to wholesale markets and supermarkets. A farmer group in Kabete sub-county negotiated with Wangige market authorities for reduced market access fees and a designated space within the market, where farmers directly engaged in wholesaling. However, farmers were not procuring inputs collectively except for the shared water resources for irrigation. Farmers also sold vegetables individually and not as a group. Therefore, collective action was limited to costs sharing on transportation and market access fees. The case for farmer groups contracted with supermarkets was slightly different. Such farmer groups were required to be formally registered, operate bank accounts and have group constitutions. Group members shared transportation costs and losses proportionately.

*At the assembly and distribution level*, middlemen from rural areas had informal welfare associations based in the local markets. They were mainly rotational savings and credit associations (ROACAS). Middlemen were represented in the market management committees which enabled them to negotiate and secured lower market access fees. The associations were not involved in collective actions such as joint transportation that would help them minimise transaction costs. Middlemen transporting vegetables to Nairobi were merely using same transporters but each trader met their costs separately. Association members relied on each other's knowledge about a prospective wholesaler before one could engage them. Middlemen never competed with each other over wholesaler customers. Middlemen colluded in setting daily producer prices. The associations were also cartels for preventing farmers and new suppliers gaining entry into the business. Middlemen supplying institutional consumers and supermarkets were not organised into associations.

*At the marketing (wholesaling and retailing level)*, trader associations operated cartel-like informal business association making it difficult for new entrants into the business. Wholesalers, on their part justified the cartel tendencies as mechanisms for maintaining price stability. Traditional retail traders were not organised, and entry into the retail business was free. This could be attributed to their large numbers and the diversity of their operation locations.

#### *Vertical coordination*

The traditional value chains were dominated by arm's length spot market chain governance with no vertical coordination between smallholders and buyers. In the case of coordinated value chains, supermarkets had loose and intermittent informal agreements with some farmer groups in Kiambu region, thereby exhibiting weak vertical coordination. Unlike in the Global Value Chains, the contracts in the AIV value chains in Kenya were informal in nature and less binding to both parties. For instance, supermarkets were not obliged to offer any technical or financial support to farmers, while farmers were not compelled to supply every order placed by the supermarkets.

## **Private food safety and quality standards**

Vegetable quality was an important element in transaction negotiations between farmers and buyers. However, traders used quality arguments to suppress prices offered to farmers especially when the vegetables appeared to be of low quality. In the coordinated value chains, the supermarkets set private rules and standards. Supermarkets in Kenya do not have production process certification schemes such as GLOBALGAP quality protocols in horticultural exporters markets. Nevertheless, there were common basic codes of practice and quality standards adopted by the supermarkets. The vegetable quality requirements were based on the physical attributes similar to the traditional value chains except the standards were higher. Supermarkets did not offer premium prices for high-quality vegetables.

## **Contractual arrangements**

There were no contractual arrangements in traditional value chains. However, during dry seasons, some middlemen entered into oral contractual agreements with farmers whereby they paid for unharvested vegetables. Contract values were estimated based on prevailing market prices and projected yield estimates. In such arrangements, middlemen assume all risks and costs related to harvesting and marketing.

The coordinated value chains contracts were based on oral informal arrangements. Supermarket managers would call farmer group leaders a day or two in advance to make specific orders. Such oral orders were not scheduled and only specified prices, vegetable types, quantities required, and time of delivery. Orders were irregular and unpredictable, making it difficult for farmers to schedule harvesting activities. The orders did not specify payments dates. In spite of all these challenges, farmers considered supermarkets as better options since prices were predictable and relatively stable throughout the year. The arrangements between supermarkets and farmer groups were more inhibiting to achieving smallholder integration. For instance, supermarkets paid farmers on quantities sold and not quantities delivered. Suppliers were informed with every order to replace unsold vegetables by supermarkets. On average, suppliers replaced 4-7 bunches with every order placed.

## **Information flow**

Many farmers in rural areas received market information through middlemen. The traditional chains were characterised by asymmetrical access to information on the part of actors. The study found that market information originated from wholesales to other actors. Wholesalers were the gatekeepers of information flow in the chain. They knew of market demand because of forward linkages with retailers and supply availability due to their backward linkages with middlemen and farmers. For example, every morning, wholesalers contacted middlemen to inform them of prices offered, quantities and vegetable types required. On the contrary, middlemen did not share such information with farmers but, instead, used it for negotiating prices. Similarly, downstream

information flow from wholesalers to the retailer was weak. Retailers did not have prior knowledge on prices and vegetable type availability until they met with wholesalers. It was observed that some urban retailers passed price information to consumers through small boards placed on the displayed vegetables. In the coordinated chains, however, supermarket managers passed market information directly through group leaders. Such information included aspects such as vegetable types required, quantities and prices offered. Additional information related to payments due and required replacements for unsold quantities.

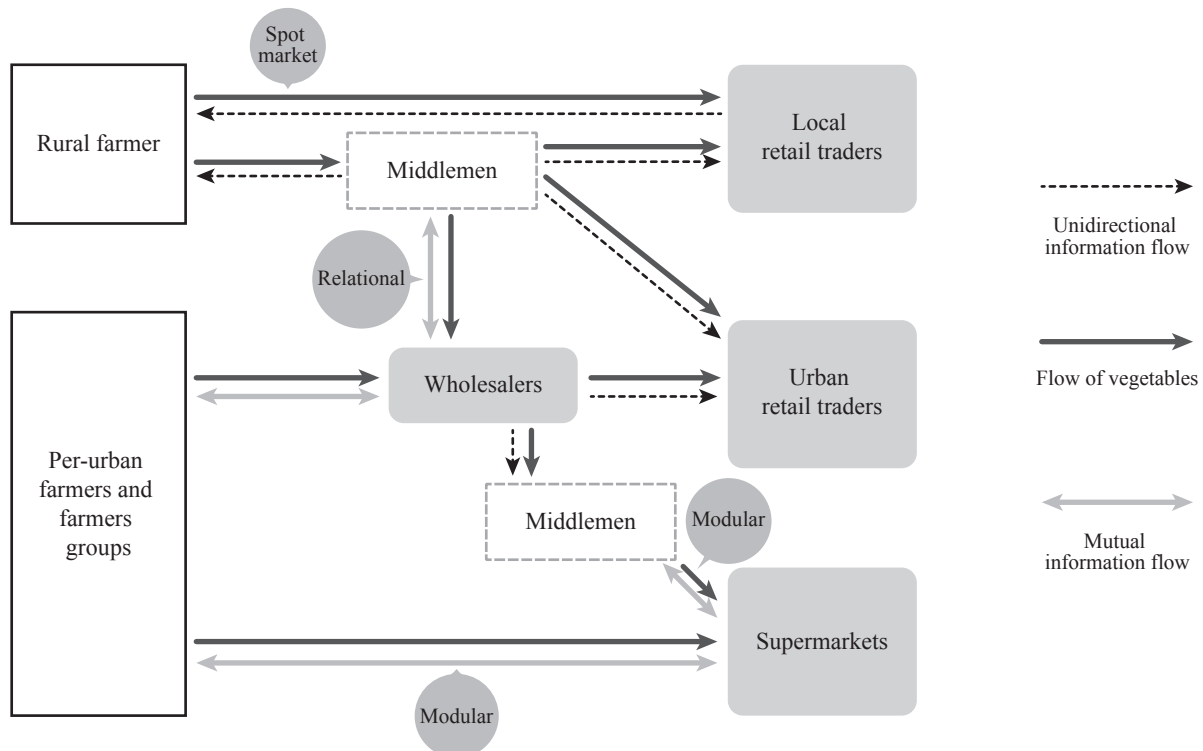
## Product flow

Along the traditional value chains, vegetable flows started from farmers, who, after harvesting, transported them to the middlemen at collection centres or local trading centres where the middlemen assembled, packaged and transported them to wholesalers and retail traders. Wholesalers repacked and sold to retail traders based on quantities demanded. Retailers further re-bunched the vegetables into smaller units and sold directly to consumers.

Supermarkets procured their vegetable supplies directly from farmer groups. Group members assembled their vegetables at a point where they were sorted and selected. Good quality vegetables were sent to the supermarket, while the rest were sold to buyers in the traditional markets. Supermarkets also bought vegetables from intermediaries who sourced the vegetables from diverse sellers. Middlemen were preferred by supermarkets because smallholder farmers did not have the capacity to supply the consistent volumes that they required throughout the year.

The results further revealed that many farmers sell vegetables through channels in the traditional value chains, only farmers from peri-urban areas sold vegetables to supermarkets in Nairobi. The governance parameters discussed above indicate that wholesalers and supermarkets were the lead actors in traditional and coordinated value chains respectively. The AIV value chains exhibit multiple and, sometimes, alternating governance arrangements within some market channels. Nonetheless, the dominant governance arrangements in the traditional value chain is characterized by “arm’s length” spot market systems, where actors engaged at random to discover prices with every transaction. The information and knowledge of vegetable quality standards was minimally based on physical attributes such as freshness, greenness, and tender leaves. It was also characterized by low trust levels between farmers and traders, with farmers blaming traders for offering low prices, on the one hand, and traders blaming farmers for supplying inconsistent quantities, on the other. In the midstream, however, the relationship between middlemen and wholesalers was characterised by relational governance arrangements as shown in Figure 4. Middlemen and wholesalers had high levels trust due to long-term trade relationships to the extent that transactions no longer involved face-to-face contact.

In the coordinated value chains, the relationship between farmers and supermarkets was by modular governance, where vertical linkages were limited to suppliers meeting procurement conditions only. This finding was consistent with other studies on domestic value chains in developing countries (Trienekens, 2011). Farmers had minimal bargaining power and were forced to sell vegetables at the price offered by supermarkets.



**Figure 4:** Governance structure of AIV value chains.

Source: Own composition

There were two alternating and sometimes overlapping modes of governance in the traditional value chains (Figure 4). The grey dotted arrows show the unidirectional information flow from middlemen and wholesales to farmers and retail traders signifying spot market governance arrangements. The thick grey arrows show mutual market information sharing between actors, which demonstrate either relational governance arrangements between wholesalers and middlemen or modular governance arrangements between supermarkets and their suppliers (farmer groups or middlemen). The multiple nature of governance arrangements in the traditional value chains was such that from farmers to middlemen, the transactions were spot market, then they turn to relational between middlemen and wholesalers and, finally to spot market arrangements between wholesalers and retailers or other middlemen and supermarkets. The green arrows are indicative of the flow of vegetables between actors.

## Discussion and conclusions

Our discussion of chain governance has been predicated on the three dimensions suggested by (Gereffi and Lee, 2012); the results have then been interpreted through the lens of the global value chains theory. The findings have shown that intermediaries govern the AIV value chains and as such, determine the accessibility of these vegetables to non-producing households through distribution and food costs. In the traditional value chains, wholesalers determine quantities and prices, while in the coordinated chain, supermarkets set parameters such as quality and quantity requirements as well as prices. The ensuing sections interpret the dynamics of AIV value chains based on the dimensions of governance.

*As to complexity of the transactions*, in the traditional value chains, there are no quality specifications and the main information sharing between actors revolves around simple daily prices. Vegetables sold in the traditional market outlets were found not to be graded and therefore farmers did not require additional information, other than knowing the prevailing market prices, in order to supply the markets. Execution of every transaction was purely based on the ability of the negotiating partners. Equally, consumers in the traditional chains preferred higher quality vegetables but as Gido et al. (2017) observed, quantities per unit price greatly influence consumer choice for retail outlets. As explained in the previous section, middlemen do not share adequate and reliable market information with farmers. Poor transmission of product quality information to farmers may explain why there was value addition in the chains.

In the coordinated chains, retailing of indigenous vegetables is a niche for supermarkets. Consequently, the product and process specifications required were not relatively simple to transfer. Suppliers were to comply with quantity and vegetable type specifications that varied with every order. In addition to high-quality requirements, suppliers were to deliver vegetables at specific locations at scheduled time. Such specifications were communicated directly to contracted suppliers as and when supermarkets required vegetables. These consistency requirements make transactions

more complex especially because of the seasonal nature of vegetable production.

*As for the ability to codify transaction information*, quality standards related information and knowledge on indigenous vegetables in both traditional and coordinated value chains were not codified. Farmers entirely determined production process and assumed all risks. There were neither private standards nor certification of indigenous vegetables produced in Kenya. Our results suggested that compliance with the physical quality requirements as set by supermarkets were not in themselves too complex for farmers so as to impede access to coordinated chains. Rather, it was the execution of the incomplete contracts on the part of supermarkets that made it costly for farmers (Williamson, 1985). The contracts were incomplete and shifted the risk burdens to farmers. In essence, these contractual arrangements were ridden with uncertainties incapable of providing incentives for upgrading. Such uncertainties on payments and verification of sales were likely to affect trust between farmers and supermarkets (Singh, 2002). Contrary to this study's expectation, the contractual arrangements between some intermediaries and farmers during dry seasons were comparatively better. In such arrangements risks and marketing costs burden were transferred to middlemen.

*As to supplier capabilities*, farmers in the rural areas engaged in less intensive production characterised by low application of productivity-enhancing technologies such as improved seeds and irrigation practices. Production decisions were not based on market demands. In addition, farmers were not able to supply adequate vegetables throughout the year. Comparatively, more farmers in the peri-urban areas used improved seeds, fertiliser and irrigation. These technology adoptions were indicative of a more commercialized approach to production, albeit with shortcomings. On average, farmers produced two types of AIVs yet there was a huge demand for other varieties (Gido et al., 2017). The demand for more varieties provided opportunities for product upgrading but it appeared that farmers did not have adequate information regarding market demands for other AIV types. This partly explained why supermarkets preferred the loose oral contractual arrangements with farmers. The inability to consistently supply adequate vegetables to the market affects food availability in the markets and regular income to smallholders.

On the whole, the value chain for African indigenous vegetables in Kenya was replete with weak producer collective action towards marketing, incapable of fostering beneficial vertical coordination with buyers. Differentials in the structure and dynamics of the chain, such as the rural and peri-urban perspectives, provided diversity of marketing outlets within the same value chains. Interestingly, participation in the coordinated value chains provided greater income security due to low price volatility. However, such stable prices were not attractive compared to traditional market channels during dry seasons.

This study contends that contractual arrangements in the modern value chains for AIV were not precipitating vertical integration. The governance arrangements in the AIV value chains was beset with low trust between farmers and downstream actors which negatively impacted on year round



availability of AIVs to poor households in urban areas. A more beneficial contractual arrangement between farmers and other coordinated value chain actors is feasible when farmers strengthen their collective actions towards production and marketing. The County Governments efforts to promote inclusive markets should emphasise the importance of infrastructure investments and establishment value chain platforms that inform policies and trade agreements.

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## Short communication

Timkete ALEME\*

# Expansion of Sugarcane Production in Ethiopia: Welfare Opportunity or Devastation?

The government of Ethiopia is aiming to boost sugarcane and ethanol production, together with cogeneration. To achieve this goal, enormous sugarcane production strategies have been undertaken without there being concrete evidence as to their benefits or detriments to the welfare of households. Here, we used a computable general equilibrium model and SAM dataset to provide useful insights into this story. The results of the study indicate that the average aggregate income and consumption expenditure of households compared to the baseline scenario are negative, although the magnitude of the loss is small. We further find strong evidence that the average aggregate economic welfare of households has deteriorated by 3.43 percent and we conclude that the strategies that the government has been implementing are detrimental to welfare and devastating. Thus, we suggest that the government should cease sugarcane expansion that succeeds at the expense of food crops and policies that favour the use of marginal and barren lands for upcoming sugarcane projects should instead be implemented.

**Keywords:** Sugarcane, economic welfare, household, general equilibrium, Ethiopia

**JEL classifications:** I31, I38, Q16, R13

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Received: 25 January 2019, Revised: 14 March 2019, Accepted: 20 March 2019.

## Introduction

Ethiopia has traditionally been perceived as the water tower of Africa (Ingebreetsen, 2015) and is endowed with a favourable physiographic setting for sugarcane growth and productivity. The country has identified more than half million hectares of land suitable for sugarcane growth with an average productivity of 130 tons per hectare (ESC, 2010). In recent years, the government of Ethiopia has been making considerable investments to boost the sugar sector after observing its immense potential and the dynamic behaviour of domestic demand for sugar and ethanol (USDA, 2015). Between 2009 and 2019, the government has had a plan to expand the area covered with state-run sugarcane cultivations by 333,630 hectares by means of setting aside the land allocated for private farms (ESC, 2010).

This enormous diversion of tracts of land for sugarcane production has been subject of controversy for the last 8 years and will continue to be contentious in the future. Some considered land grabs by the government as a new style of imperialism and appropriation in the name of economic development, while others refer to abuses of the basic human rights of native people. In contrast, advocates of the programme claim that this practice of land use change will not be detrimental and will not lead to the deracination of those indigenous people who were relocated and displaced. They rather argue that those displaced households will have enhanced access to better livelihood and development opportunities (Ingebreetsen, 2015).

The shaky argument between proponents and opponents of the programme was lent further support by the contradictory empirical evidence of earlier studies in different countries. Studies by Kennedy and Cogill (1988), Rist *et al.* (2010), Akoth (2016) and Rocca (2016) have found that replacing land for sugarcane cultivation has not jeop-

ardised the income and food security status of households. In contrast, studies by Terry and Ryder (2007), Sparovek *et al.* (2009), Amrouk *et al.* (2013), Hughes *et al.* (2016) and Mwavu *et al.* (2018) reported that land diversion for sugarcane expansion has had detrimental effects on the income and livelihood of households. Similarly, previous studies in Ethiopia by Mengistu *et al.* (2016) and Ingebreetsen (2015) predicted adverse results and contradicted the findings of Timkete (2017), who found a positive but small change in GDP.

The mixed results of empirical studies, coupled with human rights abuses reported by different human rights organisations, have led many to ask of whether the policy of reallocating land for sugarcane production should be regarded as an opportunity or instead, a tragedy. This article therefore aims to measure and quantify the impact of the expansion of sugarcane production in Ethiopia by using a computable general equilibrium model, covering the period 2009 to 2019.

The article is structured as follows. The next section briefly reviews the empirical literature on sugarcane production and welfare. Data and methodological issues are described in section three. Section four analyses and discusses the findings, while the conclusions and policy implications are presented in section five.

## Review of empirical literature

There is a limited amount of literature about the economic modelling of sugarcane and ethanol production coinciding with cogeneration. Amrouk *et al.* (2013) used an econometric model of a matching technique to analyse structural transformation of sugar market and its implications for smallholder sugarcane farmers in Ethiopia and Tanzania. Their results

indicated that a 1% increase in sugar acreage share led to a 0.3% reduction in the income of households. Moreover, Mengistu *et al.* (2016) empirically investigated the effects of the public sugarcane growers scheme in Ethiopia and found that participating in these schemes produced significantly negative effects on the income as well as asset stocks of producers and decreased food security in associated villages.

Hughes *et al.* (2016) investigated the effects of large scale sugarcane production on households' food security in El Salvador and their findings implied that farmers involved in commercial sugarcane farming were driven out of business and were vulnerable to food insecurity. A recent study on the expansion of commercial sugarcane production and its impacts on households' food security in Uganda by Mwavu *et al.* (2018) meanwhile found that sugarcane production was among the main causes of food insecurity for households who were engaged in this sector. They also reported that the increased use of land for sugarcane cultivation had reduced the availability of arable fields designated for food crops production. Earlier, Terry and Ryder (2007) also reached the conclusion that converting lands into sugarcane cultivation was the major cause of food insecurity in Swaziland. Similarly, Hartley *et al.* (2018) analysed the economic impacts of developing a biofuel industry in Mozambique using CGE analysis and showed that enlargement of sugarcane farming displacing normal agricultural activities decreased the amount of agricultural food crops produced as well as the welfare of households.

Regarding environmental impacts, Akoth (2016) showed that sugarcane farming reduced grazing fields and forest coverage in Kenya by 12 percent. Similarly, the study by Mwavu and Witkowski (2008) reported that enlarging sugarcane cultivation in Uganda resulted in 8.2% loss of forests. In the study of Sparovek *et al.* (2009), the impact of sugarcane expansion was analysed and a significant reduction of pastures and livestock was reported. Filho and Horridge (2011) estimated the effects of indirect land use change on sugarcane production and found that the expansion of sugarcane cultivation for ethanol production would lead to a fall of pasture land by 0.21%, planted forest land by 0.65% and unused land by 0.02%.

Conversely, some studies reached different conclusions. Akoth (2016), for instance, analysed the socio-economic impacts of sugarcane farming in Kenya and found that sugarcane farming had significantly improved the households' access to income and consequently increased their standards of living. Rocca (2016) meanwhile studied the impacts of commercial sugarcane production in Zambia and found that household income, consumption level and food security of household engaged had improved.

## Data and the CGE model

The main dataset generally used in CGE analysis is the Social Accounting Matrix (SAM). This study uses an updated version of 2005/2006 SAM for Ethiopia which was constructed by the Ethiopian Development Research Institute (EDRI). It was updated in 2009. The original SAM disaggregated the economy into 113 activities, 64 commodities

and 16 factors. It also has 13 institutions including 12 household groups. Household groups are disaggregated by location as rural zones and urban centres. They are also divided based on poverty status as poor and non-poor households. The rural households are further distinguished based on four main agro-ecological zones (humid, high land cereals, drought prone and pastoralist zones).

In the original SAM, there were no ethanol and cogeneration (bioelectricity) sectors. Ethanol can be produced either from sugarcane through direct conversion or from sugar cane molasses. Ethiopia uses the latter as the sole source of ethanol production yet. Bagasse is another by-product of sugar production used to generate heat and electricity and such technology is known as cogeneration. Thus, omission of these sectors from analysis would understate the aggregate picture of the sugar sector. Therefore, ethanol and cogeneration were included in the SAM and data were collected from four old sugar factories in Ethiopia. By doing so, the SAM has been thoroughly modified to grasp different level of aggregations. It is now disaggregated into 115 activities and 65 commodities, thereby ensuring the originality of the study.

As partial models generally fail to consider the welfare implication of policy changes (Gohin and Moschini, 2006; Hosny, 2013), a multi-sectoral and economy-wide Computable General Equilibrium (CGE) model is used here. The recursive dynamics of the CGE model applied was developed by the International Food Policy Research Institute (IFPRI) as described in Lofgren *et al.* (2002), which is an extension of the IFPRI static model developed by Thurlow (2008). The recursive model basically comprises of two components: the within-period component and the between-period component. The within-period component describes a one-period static CGE model with a total of 46 equations, while the between-period component involves the dynamic part of the model with 6 additional equations. The within-period component consists of four blocks: prices, production and trade, institutions, and system constraints (Lofgren *et al.* 2002). Since the detailed mathematical description of the four blocks would include the description of sets, parameters, variables and equations, we concentrate here on the institutions block for the sake of brevity, and examine how households' income and expenditure equations are specified.

In the CGE model, institutions consists of households, government, enterprise and the rest of the world. Equation 1 represents the total income of each factor.  $YF_f$  is total factor income,  $WF_f$  is average price of factor,  $\overline{WFDIST}_{fa}$  is the wage distortion for factor  $f$  from activity  $a$ , and  $QF_{fa}$  is the quantity demanded of factor  $f$  from activity  $a$ .

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{fa} \cdot QF_{fa} \quad f \in F \quad Eq.(1)$$

The factor income of the institution is divided among domestic institutions in the form of fixed shares after the payment of direct taxes and transfers to the rest of the world.

$$YIF_{if} = shif_{if} \cdot [YF_f - trnsfr_{row f} \cdot EXR] \quad i \in INSD; f \in F \quad Eq. (2)$$



$YIF_{if}$  stands for income for domestic institution  $i$  from factor  $f$ ,  $shif_{if}$  represents the share of income by domestic institution  $i$  from factor  $f$ , and  $transf_{row f}$  stands for transfers from factor  $f$  to the rest of the world.

$$YI_i = \sum_{f \in F} YIF_{if} + \sum_{i \in INSDNG'} TRII_{i'} + transf_{i gov} \cdot \overline{CPI} + transf_{i row} EXR \quad Eq. (3)$$

$i \in INSDNG$

Where,  $TRII_{i'}$  denotes transfers from domestic institution  $i'$  to institution  $i$ ,  $transf_{i gov}$  represents transfers from government to institution  $i$ , and  $transf_{i row}$  represents transfers from the rest of the world to institution  $i$ .

In equation 3, income that households and enterprises received from factors of production and the transfers they obtain from other institutions is included. Households use this income to make consumption, pay taxes, save and transfer to other institutions. Therefore, the total spending of households for consumption is defined as the income difference that remains after taxes, savings and transfers to other non-governmental domestic institutions. We have specified the household consumption expenditure by equation 4 as follows.

$$EH_h = (1 - \sum_{i \in INSDNG} shii_{ih}) \cdot (1 - MPS_h) \cdot (1 - TINS_h) \cdot YI_h \quad Eq. (4)$$

$h \in H$

Here,  $EH_h$  denotes household consumption expenditure,  $shii_{ih}$  denotes the share of net income that household  $h$  transfers to institution  $i$ ,  $MPS_h$  stands for marginal propensity to save for household  $h$ ,  $TINS_h$  symbolizes direct tax rate for household  $h$ , and  $YI_h$  denotes the income of household  $h$ .

Household consumption expenditure can be further divided into household consumption demand for marketed commodities and home commodities. In equation 5 and 6, we have specified household consumption demand for marketed commodities and home commodities, respectively.

$$PQ_c \cdot QH_{ch} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot (EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma_{ac'h}^h) \quad Eq. (5)$$

$c \in C; h \in H$

$$PXAC_{ac} \cdot QHA_{ach} = PXAC_{ac} \cdot \gamma_{ach}^h + \beta_{ach}^h \cdot (EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m - \sum_{a \in A} \sum_{c' \in C} PXAC_{ac'} \cdot \gamma_{ac'h}^h) \quad Eq. (6)$$

$a \in A; c \in C; h \in H$

Here,  $PQ_c$  stands for composite commodity price,  $QH_{ch}$  represents quantity consumption for commodity  $c$  by household  $h$ ,  $EH_h$  denotes consumption spending for household  $h$ ,  $QHA_{ach}$  represents quantity for household home consumption of commodity  $c$  from activity  $a$  for household  $h$ ,  $PXAC_{ac'}$  denotes producer price of commodity  $c'$  for activity  $a$ ,  $\gamma_{ch}^m$  denotes substitute consumption of marketed commodity  $c$

for household  $h$ ,  $\gamma_{c'h}^m$  denotes substitute consumption of marketed commodity  $c'$  for household  $h$ ,  $\gamma_{ach}^h$  denotes substitute consumption of home commodity  $c$  from activity  $a$  for household  $h$ ,  $\gamma_{ac'h}^h$  represents substitute consumption of home commodity  $c'$  from activity  $a$  for household  $h$ ,  $\beta_{ch}^m$  symbolises marginal share of consumption spending on marketed commodity  $c$  for household  $h$ , and  $\beta_{ach}^h$  symbolises marginal share of consumption spending on home commodity  $c$  from activity  $a$  for household  $h$ .

In the baseline scenario, we assumed that the Ethiopian economy continued to grow with its current growth trajectory between 2009 and 2019. We have updated the CGE model for each year to reflect changes in supply of land, population, supply of labour and the productivity of factors. The expansion of land for sugarcane production is assumed to be made on new potential cultivable land (Ferede *et al.*, 2013), grazing land (Timkete, 2017) and on lands where different crops are cultivated (Mengistu *et al.*, 2016). In our model, total factor productivity (TFP) of all non-agricultural activities is assumed to grow by the rate of 2.9% and for sugarcane activity, by the rate of 5% (Ferede *et al.*, 2013; Gebreegziabher *et al.*, 2013). Finally, the results of these baseline scenarios are compared with the sugarcane scenario so as to separate the effect of sugarcane production from other effects.

In order to see changes in the welfare of households, the sugarcane scenario was constructed, assuming that large proportions of land was allocated to sugarcane production. In doing so, from 2009 to 2019, we have increased the land allotted for sugarcane cultivation by 6976.96 hectares each year. Given the land assigned to sugarcane production is being utilised, we assume that expansion of sugarcane will influence smallholder farmers in terms of land allocation as they currently account for 95% of the total area suitable for agricultural production.

## Results and Discussion

According to the simulation results, diversion of land for sugarcane production can potentially lead to considerable changes in the output of different sectors of the economy. In this regard, Table 1 presents the potential impacts of sugarcane production on sectoral output. Apart from forestry and fishery, the two major agricultural activities, crops and livestock sectors have experienced a reduction in output. Food crop production has reduced by 0.03%, implying that households are more vulnerable in terms of food security as crops account for more than 60 percent of their food items. The overseas studies in El Salvador by Hughes *et al.* (2016), in Uganda by Edward *et al.* (2018) and in Mozambique by Hartley *et al.* (2018) have reported similar negative results. However, results of previous studies in Ethiopia are mixed. The findings of Mengistu (2015) indicate that sugarcane production has threatened the production of food crops. On the contrary, Ferede *et al.* (2013) and Gebreegziabher *et al.* (2013) found a strong positive association between sugarcane production and food crops.

When looking at crops by decomposing into cereals and pulses, again the model predicted that both activities experienced a reduction in output by 0.04% and 0.51%, respec-

**Table 1:** Sectoral Impacts of Land Use Change.

Sectors	Initial (in billion Birr)	% change from baseline
Crops	122.65	-0.03
Cereals	60.91	-0.04
Pulses	12.75	-0.51
Livestock	49.50	-0.94
Fishing and Forestry	16.64	0.09
Sugarcane	1.02	34.07
Sugar refining	2.79	19.43
Ethanol	0.22	0.59
Food processing industry	29.27	-0.24
Electricity	3.68	0.62
Services	342.88	1.11

Source: Ethiopian Dynamic CGE model simulation results

**Table 2:** Changes in Agricultural Exports and Imports.

Household Categories	Initial (in billion Birr)	% change from baseline
Agricultural Exports	11.81	-0.74
Agricultural Imports	13.98	0.86
Wheat Import	6.65	2.05

Source: Ethiopian Dynamic CGE model simulation results

tively. This result is consistent with the findings of Terry and Ryder (2007) and Mwavu *et al.* (2018), who also estimated reduction in crops production caused by commercial sugarcane farming. Overall, the reduction in food processing output accompanied with the reduction in cereals and pulses would be detrimental for domestic food supplies and would increase food insecurity and malnutrition for households in Ethiopia.

Our model also show livestock numbers to decrease by 0.94%, which is consistent with the findings of Sparovek *et al.* (2009) and Gebreegziabher *et al.* (2013), indicating that sugarcane production has a negative effect on livestock. Consistent with the finding of Hartley *et al.* (2018), the food processing industry also records a decline in output by 0.24% in our model. Conversely, as presented in Table 1, forestry and fishery, service, sugarcane, sugar refining, ethanol processing, and electricity sectors shows signs of output growth.

As clearly illustrated in Table 1, sugarcane production leads to decline in the two imperative components of agricultural output, crops and livestock. A reduction in agricultural output also leads to a 0.74% decline in agricultural and a corresponding 0.86% increase in agricultural imports as evident from Table 2. It is obvious that a small reduction in agricultural exports would largely exacerbate the trade deficit of the country as more than 90% of the Ethiopian export is generated from agricultural output and livestock products (Asresie and Zemedu, 2015). This result is consistent with the finding of Ferede *et al.* (2013) who find sugarcane expansion (under sugarcane scenario) to have contributed to the worsened trade balance in Ethiopia.

Conversely, the model predicted that the Ethiopian import of agricultural commodities could essentially increase in response to sugarcane production. This could force the country to import agricultural and livestock products to maintain domestic food consumption. The increase in the import of wheat by 2.05%, as presented in Table 2, is a good sign of

**Table 3:** Impacts of Sugarcane Production on Household Income.

Household Categories	Initial (in billion Birr)	% change from baseline
Rural poor	74.60	-0.72
Rural non-poor	251.16	0.11
Urban poor	3.73	0.33
Urban non poor	31.05	0.32
<b>Total</b>	<b>360.54</b>	<b>-0.04</b>

Source: Ethiopian Dynamic CGE model simulation results

**Table 4:** Impact of Sugarcane Production on Household Expenditure.

Household Categories	Initial (in billion Birr)	% change from baseline
Rural poor	70.18	-1.41
Rural non-poor	237.98	-0.60
Urban poor	3.44	-0.58
Urban non poor	27.17	-0.47
<b>Total</b>	<b>338.77</b>	<b>-0.76</b>

Source: Ethiopian Dynamic CGE model simulation results

increased food insecurity. Previous studies by Terry and Ryder (2007), Hughes *et al.* (2016) and Mwavu *et al.* (2018) support our finding that expansion of sugarcane is contributing to the food insecurity of households.

The simulation also brought consequences for households' income, as Table 3 suggests. Our results indicate that the average aggregate household income decreased since crop production and livestock give a significant portion of households' income in Ethiopia (Ayele *et al.*, 2003). When looking at the impact by type of households, the adversely impacted households are rural poor (0.72%). However, in consistent with the finding of Akoth (2016), the results of the present study for rural non-poor and urban households are positive.

As reported in Table 3, this study finds an average aggregate deterioration in households' income by 0.04%. This implies that the improvements in the income of the rural non-poor and urban households are not adequate to offset the losses felt by rural poor households. The general deterioration of income by 0.04% is not astonishing as the expansion of sugarcane production is being applied on rural farmers' land, and land is the primary source of rural income. In keeping with the studies of Amrouk *et al.* (2013) and Mengistu (2015), we found that expansion of sugarcane cultivation had reduced the income of households in Ethiopia. However, it remains the case that the findings of Akoth (2016) and Rocca (2016) showed that sugarcane production improved the income of households.

Table 4 presents the potential impacts of sugarcane production on households' consumption expenditure. Simulation results show that all categories of households have been adversely impacted with an average aggregate decline of 0.76%. Household expenditure decline was the highest for rural poor households (-1.41%) and lowest for urban non-poor households (-0.47%). The decline in consumption expenditure for rural non-poor and urban poor households are moderate (0.60% and 0.58%, respectively). The average aggregate result implies that massive sugarcane production would force both rural and urban households to remain poor

**Table 5:** Impact of Sugarcane Production on Household Welfare.

Household Categories	Initial (in billion Birr)	% change from baseline
Rural poor	70.18	-3.94
Rural non-poor	237.98	-3.52
Urban poor	3.44	0.20
Urban non poor	27.17	-1.74
<b>Total</b>	<b>338.77</b>	<b>-3.43</b>

Source: Ethiopian Dynamic CGE model simulation results

in consumption expenditure terms during the period under consideration. This is mainly due to a decrease in the income of households. This finding contradicts Rocca (2016) but supports the findings of Hartley *et al.* (2018).

As reported in the discussion of Juana *et al.* (2008), the sign of the Equivalent Variation (EV) has different implications for households' welfare. A positive EV represents an improvement in the welfare of households and a negative EV indicates deterioration in the welfare of households. Similarly, the pattern of households' income and expenditure determines the welfare status of households. A rise in the income and expenditure of households represents an improvement in the welfare of households and a fall implies welfare loss. Therefore, in this study, changes in households' income and expenditure considered as the measurements of welfare.

On this basis, we have undertaken a single policy simulation to examine the impacts of sugarcane production on the economic welfare of households in Ethiopia as presented in Table 5. The average aggregate households' welfare has shown deterioration by 3.43% when using equivalent variation as a measure of welfare during the period of the study. Among the household categories, the largest welfare loss was found to have been experienced by the rural poor (3.94%). The only household category that recorded a small improvement in welfare was the urban poor, by 0.20%. This is contrary to the findings of Rocca (2016), while our results support the finding of Mengistu *et al.* (2016), and prove that the expansion of sugarcane production is causing general economic welfare losses to households in Ethiopia.

## Conclusions

The article has analysed the potential impacts of sugarcane production in Ethiopia by using a CGE model quantifying the underlying welfare benefits and losses that households would incur using a 2009 updated SAM. According to the results, the diversion of land for sugarcane production brings about considerable changes in sectoral output, agricultural trade and economic welfare. The simulation results have shown that sugarcane expansion decreases crop and livestock production by 0.03% and 0.94%, respectively. Agricultural export is assumed to decrease by 0.74%, household income by 0.04% and households expenditures by 0.76%. All this results in a welfare loss of 3.43%, according to the scenario simulations.

The most important conclusion of the analysis is that there is a strong trade-off between sugarcane plantation and household welfare in Ethiopia, resulting in food inse-

curity and malnutrition. Consequently, sugarcane production should only be expanded in degraded and marginal lands with prudent planning and implementation. As to future research, it would be interesting to examine the distributional and poverty impact of sugarcane production using micro-simulation models to get more insights into our story.

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