Essays on the Sustainability of the Coffee Value Chain

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ABSTRACT

The overarching theme of this dissertation will be the improvement of the value chain of coffee. The work is based on two countries: Ethiopia and Rwanda where coffee plays a pivotal role in their respective economy and is one of their main sources of foreign exchange. In Ethiopia, we study the impact that the introduction of Ethiopian commodity Exchange (ECX) has had on the prices of exported coffee. The results demonstrate that the ECX has brought about a loss of the traceability for a substantial portion of Ethiopian coffee and as corollary has resulted in the emergence of an important pricing differential between two subcategories of Ethiopian coffee.

Since the early 2000s, Rwanda sifted from the production of ordinary coffee towards fully washed coffee or specialty coffee. As opposed to ordinary coffee, specialty coffee fetches much higher prices on the international market. The production of specialty coffee however requires investments in processing capabilities such as wet mills or coffee washing stations (CWS). Rwanda now faces a challenge with regards to its CWS. There is currently an oversupply of CWS in the country up to 300. Most of those operate below capacity. We conduct an economic analysis to ascertain both the optimal number of CWS that should operate in Rwanda as well as the price coffee farmers should be paid under perfect competition.

Our Results demonstrate that the owners of CWS receive high margins to the detriment of farmers. Farmers could potentially be paid the double of the fixed price they currently receive for coffee cherry. Furthermore, Rwanda could save considerable economic resources on an annual basis by allowing the number of CWS to decline by dint of unadulterated competition among them which would then force the least competitive ones out of business and reduce thereby production costs.

Keywords: Sustainability, Agriculture, Coffee Value Chain, Investment Appraisal, Cost Benefit Analysis, Ethiopian Commodity Exchange, Coffee Washing Stations, Rwanda, Ethiopia.

ÖZ

Bu tezde ele alınan kapsayıcı tema, kahve değer zincirinin iyileştirilmesi olacaktır. İki ülke temel alınacaktır; Etiyopya ve Ruanda. Bu iki ülkede kahve önemli bir rol oynamakta ve ana döviz kaynaklarından birini oluşturmaktadır. Etiyopya'da, Etiyopya Emtia Borsası'nın (ECX) devreye girmesinin ihraç edilen kahvenin fiyatları üzerindeki etkisini inceliyoruz. Sonuçlar, ECX'in Etiyopya kahvesinin önemli bir kısmı için izlenebilirlik kaybına yol açtığını ve sonuç olarak Etiyopya kahvesinin iki alt kategorisi arasında önemli bir fiyat farkının ortaya çıkmasına neden olduğunu göstermektedir.

Ruanda'da 2002 yılından bu yana kahve üretimi ağırlıklı olarak tamamen yıkanmış kahve ya da özel kahveye yöneliktir. Özel kahve, sıradan kahvenin aksine uluslararası pazarda çok yüksek fiyatlar getirmektedir. Ancak özel kahve üretimi, ıslak değirmenler ya da kahve yıkama istasyonları (CWS) gibi işleme tesislerine yatırım yapılmasını gerektirmektedir. Ancak halihazırda 300'e varan CWS arz fazlası bulunmaktadır ve bunların çoğu yerleşik işleme kapasitelerinin altında çalışmaktadır; bu da bu tesislerin ekonominin farklı bir sektörüne yatırılabilecek ekonomik kaynakların israfına yol açtığı anlamına gelmektedir.

Sonuçlarımız, kahve yıkama istasyonu sahiplerinin kahve çiftçilerinin aleyhine olacak şekilde yüksek marjlar elde ettiğini göstermektedir. Çiftçilere potansiyel olarak şu anda kiraz kahvesi için aldıkları sabit fiyatın iki katı ödenebilir. Ayrıca, Ruanda, kahve yıkama istasyonlarının sayısının, aralarındaki doğal rekabet nedeniyle azalmasına izin vererek yıllık bazda önemli miktarda para tasarrufu sağlayabilir ve bu da daha az rekabetçi olanı işten çıkarmaya zorlar ve böylece özel kahvenin üretim maliyetini düşürür.

AnahtarKelimeler: Sürdürülebilirlik, Tarım, Kahve Değer Zinciri, Yatırım Değerlendirmesi, Maliyet Fayda Analizi, Etiyopya Ticaret Borsası, Kahve Yıkama İstasyonları, Ruanda, Etiyopya.

DEDICATION

To the memory of my late father **Mathieu Yopa**

and

To the children who will never lose their innocence

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CLU	Control Liquoring Unit
CWS	Coffee Washing Station
ECX	Ethiopian Commodity Exchange
ENPV	Economic Net Present Value
EOCK	Economic Opportunity Cost of Capital
ETB	Ethiopian Birr (ETB)
FEP	Foreign Exchange Premium
FNPV	Financial Net Present Value
FOB	Free On Board
FWC	Fully Washed Coffee
KG	Kilogram
MEIRR	Modified Economics Internal Rate of Return
MFIRR	Modified Financial Internal Rate of Return
MOT	Ministry of Trade
NAEB	National Agriculture and Export Board
NPV	Net Present Value
PV	Present Value
RWF	Rwandan Francs
USAID	United States Agency for International Development

Chapter 1

INTRODUCTION

There are many rationales that guide the adoption of agricultural policies by governments some of the most common include: ensuring food self-sufficiency, addressing markets imperfections, ensuring greater competitiveness of crops, strengthening farmer's position in the value chain, protecting food quality and health to mention all but a few. Governments enact laws and regulations with the hope that those would ultimately benefit all stakeholders in the industry. These laws and regulations are supposed not only to improve yields, weed out inefficiencies by streamlining operations in the value chain which would ultimately generate more revenues for farmers, but also simultaneously ensure that consumers pay prices that are deemed fair. Unfortunately, more often than not, Governments' regulations of markets result in greater inefficiencies that tilt the balance in favor of some markets participants to the detriment of others. This is especially true if agricultural policies are designed without fully taking into account how market incentives might affect the most vulnerable stakeholders which are usually the small-scale farmers. The intervention of the respective Governments in the value chain of coffee in Ethiopia and Rwanda are good illustrations of the detrimental impact that ill-suited regulations can have on the efficiency of markets.

1.1 Ethiopian Commodity Exchange and Traceability of Coffee

Given its strategic importance to the country, the government of Ethiopia had historically kept a tight grip of the coffee industry. However, in the wake of the

structural adjustments policies imposed by the international monetary fund of the early 1990s, Ethiopia began in a wave of market-oriented reforms that aimed at adopting more neo-liberal policies much like in many sub-Saharan countries. Thus, the Ethiopian government started to loosen its grip on the coffee industry and adopt a series of incremental reforms that ultimately lead to the creation of the Ethiopian Commodity Exchange (ECX) in 2008. In chapter 2 of this dissertation, we will investigate the adverse impact that the creation of the ECX had on the traceability of Ethiopian coffee as well as the effects on prices that occurred as a corollary of this depletion of the traceability of coffee.

1.2 The Coffee Value Chain in Rwanda

Just like in Ethiopia, coffee has always had a prominent role in Rwanda not just from an economic perspective, but also in the socio-political arena. After the country's independence, coffee was for a long stretch of time the main sources of foreign exchanges of Rwanda. In the aftermath of the Rwandan Genocide, the focus of most international donors and development institutions in the agricultural sector was to ensure that Rwanda met its basics food security needs (USAID, 2006). However, by the early 2000s, as the country's economic and political landscape showed steadfast signs of improvements, the focus of the involvement of these multilateral agencies in Rwanda shifted and geared more towards fostering greater investments by the private sector in the agricultural value chain. The aim behind this paradigm shift was to render Rwanda and its products more appealing to the international market.

Coffee was one of the main beneficiaries of this new trend. Given the quality of its soil, its geographic location and the constraints on available lands it faces, it was determined that Rwanda would be better off to put an emphasis on the production high quality specialty coffee instead of the ordinary coffee it had been producing up to that

point. The production of specialty coffee warrants investments in wet mills or commonly called coffee washing stations (CWS) which were non-existent at that time in Rwanda.

The United State Agency for International Development (USAID) along with other multilateral donors paved the way by propping up the nascent specialty coffee industry. Those institutions provided assistance in the forms of funding and technical assistance for the purpose of opening CWS through a flagship program called the Agribusiness Development Assistance to Rwanda (ADAR). In the year 2000, Rwanda only had two coffee washing stations however by 2006, there were 46 coffee washing stations 38 of which had been built entirely with the support of the United States Agency for International Development (USAID). In present days, Rwanda has a little over 300 coffee washing stations (NAEB 2018). For a country of its size and given its yearly production volume of coffee, this number of washing stations is high. The oversupply of CWS has ineluctably led to a situation whereby most of them are operating below capacity or are idle. This situation in Rwanda leads one to ask what the optimal number of CWS should be in order to ensure that both farmers and owners of CWS are fairly compensated or receive compensations that derived from perfect competition. The dissertation will proceed as follows:

In Chapter 3, we present a succinct list of the main challenges faced by the coffee value chain in Rwanda. The relevance of this chapter lies in the fact that it gives the reader a bird eye view of the nature of the problem in Rwanda and lays the foundation for the subsequent financial and economic analysis we will conduct.

In Chapter 4, we undertake a financial and an economic evaluation of an investment in a generic CWS where we assume different production scales. This evaluation allows us to depict the current market situation on an aggregate level for

the whole of Rwanda as it pertains to CWS. We compute the average processing cost of transforming coffee cherry into specialty coffee. The Computation of the average cost of processing specialty coffee enables us to determine the margins CWS owners are currently enjoying given the selling price of parchment coffee on the international market. This step further enables us to ascertain what prices coffee farmers would earn for coffee cherry under competitive conditions if less inefficient coffee washing stations are removed from the market.

Chapter 5 will be devoted to studying ways of tackling one of the main challenges to the long-term sustainability of the coffee industry in Rwanda namely the ageing and non-replacement of a substantial proportion of its coffee trees and the poor yields that are a direct consequence of this current situation. This work will to that effect conduct a cost benefit analysis of a program of progressive renewal of coffee trees throughout Rwanda and gauge its financial impact on farmers through the potential revenues they would get as well as the welfare impact on the Rwandese society as a whole. Chapter 6 will conclude this dissertation.

Chapter 2

TRACEABILITY, VALUE AND TRUST IN THE ETHIOPIAN COFFEE MARKET

2.1 Introduction

Coffee is the backbone of the Ethiopian economy and represents its highest source of foreign exchange earnings. According to the United State Department of Agriculture (UDSA) 2021 annual coffee report, Ethiopia's coffee exports for the 2019/2021 fiscal year amounted to 821.14 million USD. This amount represents approximately 31% of the total value of the country's exports and 42% of the value of agricultural exports for the same fiscal year. Historically, the Government of Ethiopia kept a tight grip on the coffee sector. Up until 2008, coffee had to be traded through an auction system that had many deficiencies.

The Ethiopia Commodity Exchange (ECX) was established in April 2008. It was assigned four primary roles: a) lowering the cost of transactions, b) safeguarding price transparency and price discovery by creating a secure and steady system for handling, grading and safekeeping services for transactions, (c) bolstering risk-free and fast payments, and lastly (d) providing a goods delivery system to conclude transactions (Gabre-Madhin, 2006; Meijerink et al. 2010).

The ECX was initially conceived as a marketplace for grain trading. However soon after its inception, ECX was faced with many challenges that threatened its viability. First, grain trading at the ECX was happening at a sluggish pace mostly since the main grain traders in Ethiopia were disinclined to join the ECX marketplace. At

that time, the ECX was perceived by those traders as a threat to their business. Mas Aparisi, A (2021). Moreover, in the wake of the 2008 financial crisis, Ethiopia like many developing countries experienced a sharp decline in the demand for coffee which is one of its main export commodities thereby jeopardizing the country's ability to earn foreign exchanges. In attempt to save the ECX, the Ethiopian government decided that trading coffee from then on would have to be conducted through the ECX. However, three types of entities were exempted from this rule: cooperatives and large private estates and states farms. Private estates and state farms could bypass ECX and directly export their coffee while in the cooperatives case the involvement of the ECX was minimal.

The idea behind ECX was championed by academics and practitioners who argued that Ethiopia a country prone to food crisis could tackle this issue of famine by adopting a market-oriented solution such as a commodity exchange (Eleni Gabre-Madhin & Goggin, I (2005). Ethiopia received broad support from multinational development agencies for the establishment of the ECX. The ECX was initially conceived primary as a marketplace for grains trade although it was planned that export products such as coffee might eventually be traded on its floor at a later stage.

Although coffee was not originally the main target of this exchange, it became the ECX's most predominant traded commodities after the government passed a law mandating that all coffee trade with few exceptions would have to go through ECX. In December 2008 few months after the opening of the ECX, coffee began to be traded on the exchange thereby replacing the pre-auction system that had been in place for decades. Despite its flaws, the pre 2008 auction system had the advantage of preserving coffee traceability. At the auction center, coffee from the various growing origins were kept apart to preserve the specific cup tasting characteristics of each region. For a

product such as coffee, cup taste and spatial or grower origin are important features that are highly desirable. International buyers are particularly interested in traceability and are willing to pay higher prices for this attribute. Trading coffee through the ECX however, lead to homogenization and a commoditization resulting in the loss of traceability. This meant that overseas buyers could no longer ascertain from which regions the coffee they bought came. The focus of this chapter is to use the information gained from this natural experiment to evaluate the willingness to pay for the attribute of traceability of Ethiopian coffee by foreign buyers.

2.2 Economic Value of Traceability

Traceability is a term used to designate the ability to track every aspect of the production, processing, and distribution of a good from "farm to fork". Traceability was first defined in ISO 8402 standard in 1987 as "the ability to retrieve history, use or location of an entity by means of recorded identifications". The entity may designate: an activity, a process, a product, an organization or a person.

Traceability is critical for various reasons; overseas buyers are usually willing to pay a premium price for coffee beans that can be traced all the way back to cooperatives, production area and even to individual farms. This not only ensures that overseas buyers get coffee from suppliers who abide by a set of ethical and sustainability standards, but it also helps companies to gauge the quality of the product they acquire. A system in which traceability is non-existent hurts both buyers and sellers, suppliers lose out on potential higher revenues whereas sellers may end up with product that are below par in terms of quality.

Traceability or the lack thereof can also have public health implications especially in the pharmaceutical, agriculture and food industries. A good traceability system also makes it possible to assign responsibilities in a supply chain when security or quality

standards fail.

In the more specific case of coffee, traceability is a highly sought-after feature, overseas consumers are more and more concerned with sustainability and ethics in the supply chain and this consumers' awareness forces firms to only deal with suppliers whose coffee is traceable. International firms will shun untraceable coffee to avoid negative publicity and loss of revenues that may arise in the future.

The value of coffee is like wine and is inextricably linked to its place of growing origin. A country such as Ethiopia is known for its coffee brands that are grown in specific regions. Traceability of coffee allows farmers to acquire a reputation and claim recognition. In some situations, traceability might enable to farmers to bargain for better compensation and build lasting business relations with foreign buyers.

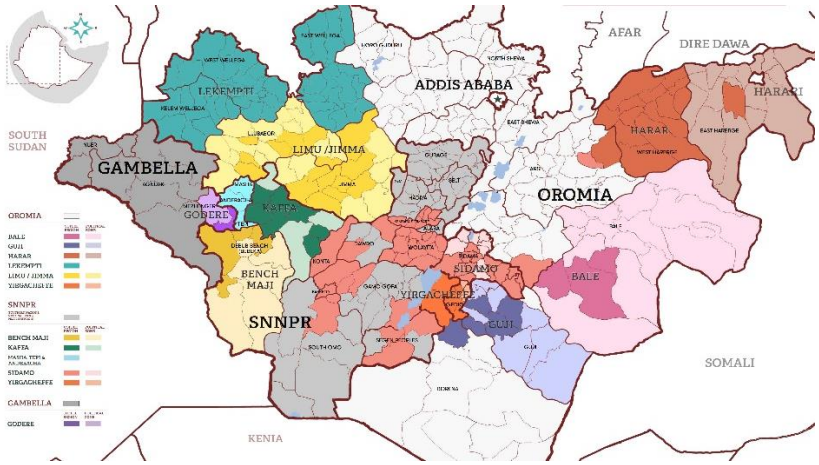


Figure 1: The map of "coffee regions in Ethiopia"
Source: https://www.trabocca.com/

2.3 Evolution of the Institutions Regulating the Sale and Export of Coffee from Ethiopia

2.3.1 The Pre ECX-Auction System

Figure 2 depicts the coffee value chain under the old auction system. As shown

on the left hand side of the figure, small scale farmers would sell their harvest to locally licensed collectors (or "sebsabies" in Ethiopian parlance). Collectors would then proceed to sell the coffee to licensed warehousing suppliers ("akrabies"). Suppliers would then have to physically bring the coffee to one of the two auction centres either in the capital Addis Ababa or to Dire Dawa where it would be graded by the Control and Liquoring Unit (CLU) before being ultimately sold to exporters. Suppliers were prevented from exporting their coffee and exporters could only buy coffee from the auction centres. State plantations on the other hand were exempted from the auctions centres and add the ability of directly exporting coffee as illustrated by the furthest right hand side of figure 2 below.

The prior auction system suffered from many deficiencies such as: High transaction costs, low contracts enforcement, significant delays in payments, collusion between the main stakeholders of the coffee which are collectors and suppliers, delivery of coffee that did not match the previously agreed specifications to name all but a few. Overall, the pre-ECX system was highly inefficient with high costs of doing business that would eventually be passed unto the farmers who as a result would be paid lower prices than what they should have been. The previous auction system was also prone to dishonesty by traders with regards to taxes owed As an example, one recurrent complaint levied at traders was the fact that price manipulations occurred through the understatement of volume of coffee sold. This practice led to a loss of tax revenues to the state given that exporters had to go through the auction to enable tax collection, traders would try to avoid paying taxes by placing fake bids on their own coffee to repossess it. This scheme would work so long as the seller had enough money to cover the amount due as taxes (Chris Korman: January 2019) Prior to the establishment of ECX, farmers could sell their coffee either to cooperatives or to local

traders also referred to as licensed collectors (or sebsabies in the Ethiopian coffee parlance). It was however often the case that cooperatives were not able to buy the coffee farmers produced in its entirety due to financial constraints. Farmers were therefore obligated to sell the rest of their stock to collectors (Kodama 2007).

The competition for the purchase of coffee between collectors and cooperatives resulted the price that farmers received. Collectors in turn would sell their coffee to large traders known as suppliers and suppliers would then trade it at the auction house. In principle, collectors and suppliers were supposed to be counterparts to the coffee trade. Before they were outlawed, Ethiopia had 2,291 licensed collectors meanwhile, there were 1,068 suppliers spread throughout the country (Petit, 2007). If we go by (Minten et al., 2014), the number of farmers in Ethiopian amounted to approximately 5.3 million individuals. It was easy for collectors and suppliers to collude not only to offer lower prices given their low number in comparison to coffee farmers but also to collude with fake invoices thereby lowering the tax they were supposed to pay.

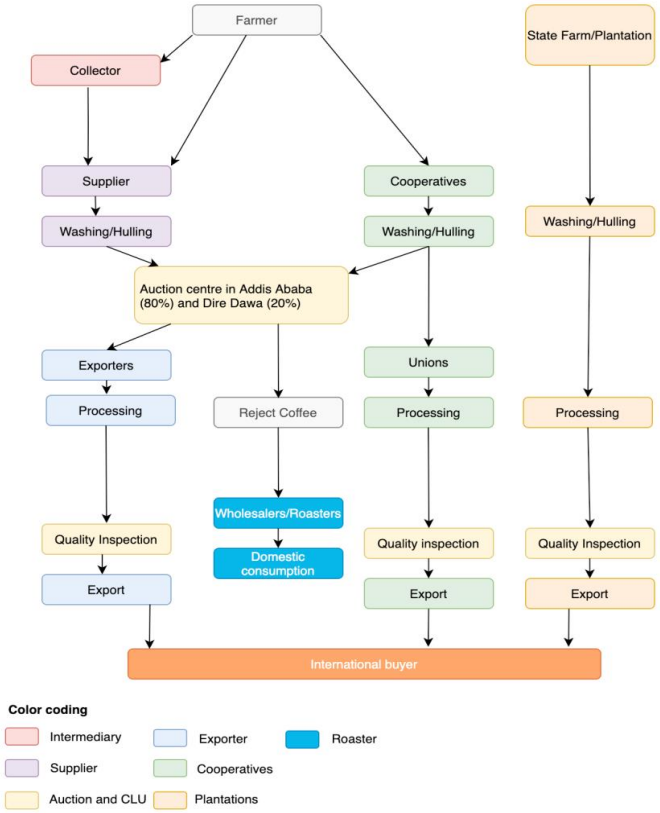


Figure 2: Coffee value chain in Ethiopia before the creation of the ECX.
Source: Mas Aparisi, A. (2021)

2.3.2 The Initial ECX Period (2008-2017)

Soon after its inception in April 2008, the ECX was faced with many challenges especially the reluctance of prominent grains traders to transact through the ECX. The ECX was perceived by them as a threat to their business. The lacklustre performance of the ECX in its beginning meant that its viability was threatened. In attempt to booster trading volume at the ECX and to optimize foreign exchange earnings, the Government of Ethiopia decided that henceforth all coffee trade would have to be conducted through the ECX. The only exceptions were cooperatives and large private estates. Those two entities could directly export their coffee without going through ECX. Figure 3 depicts the coffee value chain in Ethiopia from the year 2008 till 2017 when a new reform was adopted. The ECX was touted as an organized trading platform

where traders could meet and engage in trading transactions with the full confidence that they would receive timely payment and delivery and that both the quantity and the quality of the commodity bought would match their requirements. The ECX is credited for correcting many of the major deficiencies that characterized the pre ECX auction system including: the weak contract enforcement, delayed or defaulted in payments, the non-access to up-to-date pricing information on the part of farmers located far from the trading place and collusion between buyers and sellers to name all but a few (Gelaw et al 2018).

Despites its merits, the ECX nonetheless ineluctably led to the homogenization in the trade of commodities. Specifically pertaining to coffee, stocks coming from a common geographic region were mixed and stockpiled in the same compartment of ECX warehouses without distinction. This practice of overlooking the subtle differences in cup taste that exist within a grade category and overlooking the fact that there are other specific spatial characteristics even among coffee coming from the same broad area would prove detrimental for the traceability of Ethiopian coffee and by ripple effect the prices overseas customers would be willing to pay. Furthermore, the first-in-first-out delivery method was employed at the warehouse which had the similar effect of homogenizing coffee thus further undermining the traceability of Ethiopian coffee. Buyers would as a result receive a coffee blend from various, anonymized sources which made it impossible ascertain exactly the coffee origin and its grades. For some commodities such as cereals commoditization might not be detrimental and does not necessarily affect prices. However, a commodity such as coffee commoditization is detrimental since coffee quality and the price foreign buyers attached to it are intrinsically linked to its growing origin, cup tasting and the reputation the growing region has attained over the years.

Ethiopian coffee varieties are identified by agro-ecological and local conditions, shape, acidity, body, flavor, aroma and processing method, and they are generally auctioned by their corresponding origin of production. More specifically, the Ethiopian coffee is labelled and traded in the world market according to the regional territory in which it was grown (e.g., Sidama, Yirgachefe, Harar, Jimma, Lekemt, Teppi, Limu and Bebeka) (Hernandez et al. 2015).

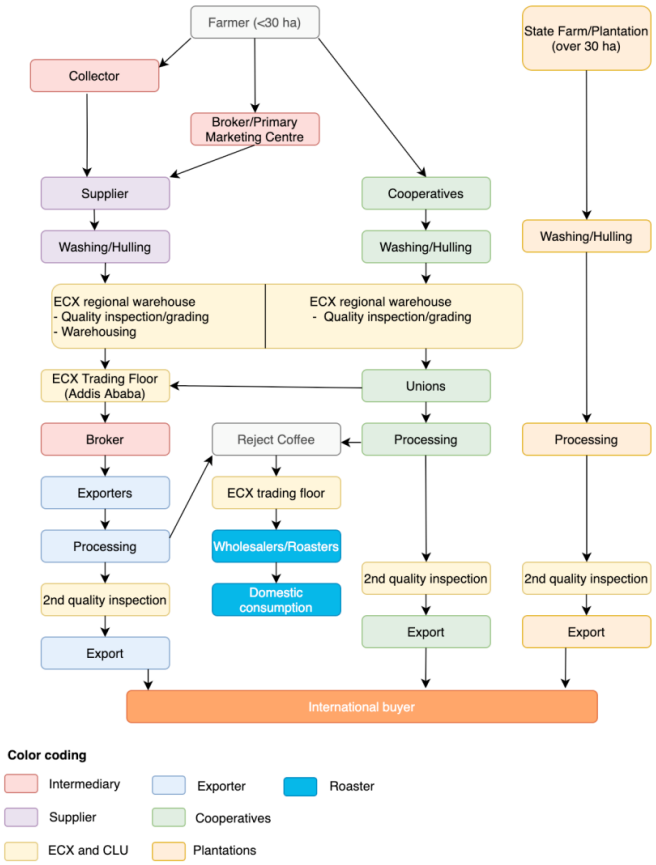


Figure 3: Coffee value chain in Ethiopia after the creation of the ECX (2008-2017). Source: Mas Aparisi, A. (2021)

2.4 Estimating the Willingness to Pay for Traceability

In order to measure the impact that the loss of traceability that arose due to the ECX, we need to define two important terms: “Producer coffee” and “trader coffee”.

For the purpose of our analysis, Ethiopian coffee belonged to one category or the other depending on the itinerary it took to reach the end consumer overseas.

2.4.1 Producer Coffee

The subcategory of coffee we refer to as producer coffee followed a dual pathway to reach overseas customers. The first trail went as follow; coffee destined to exports left state farms or plantations over 30 hectares and went directly to the port completely bypassing the ECX (right hand side of figure 3 furthest to the right). Alternatively, coffee moved from individual farmers to final exporters via cooperatives but it had to pass through ECX. However, the ECX role in this instance was limited to quality inspection and grading. After undergoing grading and quality inspection coffee would then be exported directly by unions without being traded on the ECX trading floor (green boxes of figure 3). The coffee coming from large plantations and or cooperatives therefore retained its full traceability given that this type of coffee was not stored at ECX warehouses nor was it traded on the ECX trading floor. Not being stored in the ECX's warehouses prevented the mixing of coffee from various geographic origins that would ineluctably result in a homogeneous coffee. The direct consequence of the handling at the ECX's warehouses was the fact overseas buyers could no longer be certain of the exact geographic origin of the coffee they were purchasing and well as the grade that was assigned to the coffee at ECX. We shall henceforth refer to the type of coffee that retained its traceability due to being exempted from the ECX's handling as **producer coffee**.

2.4.2 Trader Coffee

The second road via which coffee could be exported was through brokers (left hand side of figure 3). In this case, coffee ineluctably had to go through the ECX warehouse before being traded on the ECX. In the warehousing phase, coffee lots of

similar geographic origin was bagged together creating a sort of anonymity and thereby disregarding subtle cup taste differences that exit even among coffee of similar origin. This was done as an attempt to stamp out collusion that plagued the old auction system as anonymity would make is impossible for buyers and sellers to collude as described previously. This practice however created a new issue which is coffee became untraceable meaning that overseas buyer would no longer be able to know the exact origin of the subcategory of the coffee they purchased from Ethiopia. This also casted doubts as to the integrity of the grading process at ECX warehouses. For the purpose of our study, the ECX sourced coffee shall be referred to as **Trader coffee.**

This article estimates the impact that the loss of traceability had on coffee prices after it was required that all coffee, with a few exceptions, but be sold via the ECX. Our empirical analysis based on data from 2007 to 2012 show that the coffee that was exported through cooperatives which was exempted from trading at the ECX thereby retaining its traceability prices significantly increased in price after the ECX took over the sales of most of the coffee.

The reason for this increase in price can be attributed to the fact that the ECX eliminated the traceability attribute from approximately 80 percent of the coffee sold from Ethiopia. The shortage of traceable coffee from Ethiopia meant that the remaining coffee that could be traced was now able to command a substantial price premium. As a result of the price premium that arose after 2008 for traceable coffee there was an aggressive lobbying by coffee growers to reform the ECX system so that the traceability of coffee in terms of the location from which it was sourced would be retained even if graded and processed via the ECX system. Widespread smuggling of coffee to market the coffee around the ECX to the foreign buyers in a way that the attribute of traceability could be preserved.

2.5 Literature Review

There have been many articles written to study the impact that the creation of the ECX had on the Ethiopia coffee sector the closest to our analysis include.

(Handino et al. 2019), who investigated the impact that the post-ECX membership to a certified cooperative has on the living condition of small-scale coffee producers in south-western Ethiopia. This paper is built on a previous work done by (Jena et al. 2012) which however limited itself to studying the welfare effects that certification had on the welfare of small-scale producers in the JIMMA area of production without incorporating the impact of market reforms brought about by the establishment of ECX. More specifically, (Handino et al. 2019) set out to find out if coffee producers who sell their harvest through cooperatives would receive higher prices, boost their productions and thus achieve a higher household income in comparison to producers who to go through ECX. Their results demonstrate that members of certified cooperatives achieve higher prices on average however higher prices do not necessarily improve their income and welfare.

(Handino. 2017) employs the (Pesaran et al. 2001) autoregressive distributed lag model (ARDL) and the (Shin et al. 2014) nonlinear autoregressive distributed lag model (NARDL) to examine the extent to which the various Ethiopian coffee brands are integrated with prices of different Arabica natural and Robusta coffees on the international market. Their results reveal that for the period prior to the implementation of ECX (January 1998 - November 2008) Ethiopian coffee originating from a geographic area that enjoyed a reputation of producing coffee of higher and premium quality achieved stronger levels of integration and price adjustment relative to Arabica-type coffees on the international markets. However, for the post ECX area (December 2008- May 2013) the highest pace of adjustment towards equilibrium was

observed for relatively lower quality Ethiopian coffees. Furthermore, premium Ethiopian coffee did not appear to cointegrate with any of the Arabica coffees. For the whole period under consideration both pre and after ECX, they observe that market disruptions in the price of Colombian Mild coffees had a strong and direct impact on the prices for most of the Ethiopian coffees. Furthermore, the results also point to evidence that relatively lower quality-rated Ethiopian coffees achieved the greatest price adjustments after price shocks for Brazilian Natural coffee.

A similar article by (Hernandez et al. 2015) uses multivariable GARCH techniques to investigate if the coming into effect of the ECX has led to great level of integration between Ethiopian coffee prices and prices on international markets during the first five years of ECX existence. Their results show that out of the main five coffee growing regions, only two were able to achieve greater higher interdependence between local and international price returns. Furthermore, local Ethiopian coffee markets did not exhibit higher price integration after the launch of the ECX.

(Andersson et al. 2016) examined the impact that the creation of the ECX and its decentralized warehouse system has had on market efficiency in Ethiopia. More explicitly, they study whether regional warehouses that were linked to the ECX did in fact lower transaction costs and reduce price transmission between the various regional markets in the country. Their findings reveal that for the period ranging from 2007 to 2012, when a pair of markets had a warehouse, it resulted in a decrease in the average price spread in the range of 0.86 -1.775 ETB between them and the average price spread over the full period was 3.33 ETB.

(Minten et al. 2015) study the impact that the adoption of Voluntary Sustainability Standards (VSS) had on the coffee sector in Ethiopia. Their study aimed at figuring out how the gains stemming from VSS especially Fairtrade and Organic certification

were shared between coffee producers and the coffee exporters. Their results reveal that coffee exporters obtained the bigger chunk of the benefits from large quality premium whereas coffee farmers only receive one third of those premium. Furthermore, given that quality premiums are negligible, and a most famers production is small scale, these premiums would only bring about a 20 USD raise in farmers' income per year even if premiums were perfectly transmissible consequently, they conclude that premiums would result in little positive impact on the welfare of the average coffee farmer.

(Gafesa, 2018) studies alternatives methods of improving the Ethiopian coffee value chain by developing custom-made solutions of incorporating traceability in sustainable coffee production aimed at small producers who are members of cooperative unions.

2.6 Data Sources and Empirical Analysis

2.6.1 Data Sources

For our analysis, we use a dataset that was first obtained during a consulting field trip in Ethiopia from the country Ministry of Trade (MOT). It contains monthly entries on such information as: the value of exported coffee FOB in US dollars, the volume of coffee exported in KG, the coffee variety, the Grade assigned by the Coffee Liquoring Unit (CLU), and the country of destination. In total, the dataset contains a little more than 13000 observations covering the 2007 to 2012 period. Between 2007 and 2012 there were close to 270 coffee exporters in Ethiopia. In-depth research was conducted on the field to determine both the nature of coffee exporters and the size of their plantation. In the case where exporters grew their own coffee exported it themselves directly the shipment would be labelled as producer coffee otherwise, if coffee were sourced through ECX, it would be classified as trader coffee. After the

classification was completed, the price/KG of the coffee was calculated by dividing the total export value FOB (USD) of the shipment by its volume in KG. The descriptive statistics of our dataset are presented in table 1

Table 1: Descriptive statistics on coffee types and coffee grades

Descriptive Statistics of Coffee Price ($/KG)	**Trader**	**Producer**
Mean ($/KG)	3.72	4.95
Standard deviation	1.45	1.85
9 coffee types in the dataset (% of shipments)	**Trader**	**Producer**
Sidamo	31.41	37.21
Jimma	28.35	12.24
Lekempti	16.45	4.16
Harar	11.32	5.69
Yirgacheffe	7.93	15.73
Limmu	3.71	17.14
Ghimbi	0.83	-
Teppi	-	4.20
Bebeka	-	3.59
Total	100	100
Coffee grade tabulation (% of Shipments)	**Trader**	**Producer**
1	0.52	-
2	27.60	61.20
3	2.07	3.98
4	17.61	16.89
5	41.91	9.79
6	9.64	4.59
7	0.66	3.55
8	-	-
Total	100	100
Number of observations	**10,673**	**1634**

There is a total of 10673 observations that are categorized as trader coffee and 1634 observations that are classified as producer coffee.

2.6.2 Econometric Estimation

In order to measure the impact of the ECX on coffee prices for the two set of coffee we previously described, we use two different sets of regressions one for the trader coffee, and the other one for the producer coffee.

$$P_{\hat{\hat{T}}} = \beta_0 + \beta_1 \overline{\overline{ECX}} + \beta_2 P_{\ddot{NY}} + \beta_3 Cof_{TYPE} + \beta_4 Grade_{\ddot{X}} + \varepsilon \quad (1)$$

$$P_{\hat{\hat{P}}} = \beta_0 + \beta_1 \overline{\overline{ECX}} + \beta_2 P_{\ddot{NY}} + \beta_3 Cof_{TYPE} + \beta_4 Grade_{\ddot{X}} + \varepsilon \quad (2)$$

Where the dependent variables $P_{\hat{\hat{T}}}$ and $P_{\hat{\hat{P}}}$ respectively represent the FOB price for trader coffee per KG and the FOB price per kg for producer coffee both dependent variables are expressed in USD. They define the export price of either producer or trader coffee for a specific coffee variety and grade that is exported during a given month of a given year. Outlier values of $P_{\hat{\hat{T}}}$ and $P_{\hat{\hat{P}}}$ were excluded.

The independent variable $P_{\ddot{NY}}$ is the monthly average coffee price quoted at the New York Mercantile Exchange, published by the International Coffee Organization (ICO 2013). Unfortunately, the MOT data set does not fully provide information on whether the export coffee is Fairtrade or organic certified. This constraint precludes us from using certification as a control variable in our analysis. The variable $P_{\ddot{NY}}$ is inserted as a proxy for the general world price of coffee. As the world price of coffee rises and falls, so too will the general export price of Ethiopian coffee.

The control variables $Cof_{TYPE}$and $Grade_{\ddot{X}}$ are used as dummy variables for coffee type and grade. Coffee type includes brands such as: Yirgacheffe, Sidamo and Harar, Limmu. Ethiopian coffee brands have a geographical name coming the region where they are cultivated. Those regions are characterized each by distinct variations in landscape and altitudes which determine the quality of the grown coffee. In international markets as well, Ethiopian coffee is differentiated by region, altitude, and cupping score, rather than by variety. In total there are 09 types of coffee grown and sold in Ethiopia with 9 different possible grades. Coffee with a grade of 1 or 2 are considered “specialty.” Coffee with grade 3 through 9 are classified as “commercial.” Grades are assigned after visual inspection for defects and depend on cup quality.

We expect the variables $\boldsymbol{Cof_{TYPE}}$ and $\boldsymbol{Grade_{\ddot{X}}}$ regression coefficients to be exhibit higher statistical significance in relation to the price in the case of producer coffee than in the case of trader coffee. This is because for the most part, producer coffee is made of high end and specialty coffee and for those types of high end products, the impact of traceability or the lack thereof would be more potent. With Producer coffee being fully traceable in the backdrop of trader coffee losing its traceability, it is only reasonable to expect producer coffee to become relatively more valued and its prices to be more consistent with coffee type and grades.

The last explanatory variable $\overline{\overline{\boldsymbol{ECX}}}$ is a dummy variable used to indicate whether the export date was prior to or after Ethiopian coffee began to be traded on the ECX in December 2008. In the event the export date was before the ECX this variable would take 0 and it would take the value of 1.

2.7 Estimation Results

In this section we present the results of our empirical analysis. The following set of tables present our results from to Ordinary least squares regression and the bootstrap regression.

Table 2: OLS regression: with the complete data set

	Trader Coffee		**Producer Coffee**	
	With Control Variables	Without Control Variables	With Control Variables	Without Control Variables
Intercept	**1.683*** **	**0.952 *** **	**9.441*** **	**1.430*** **
$\overline{\overline{\boldsymbol{ECX}}}$ **Dummy**	**0.124*** **	**0.128*** **	**0.770*** **	**0.893*** **
$\boldsymbol{P_{\ddot{N}\ddot{Y}}}$	**0.713*** **	**0.714*** **	**0.693*** **	**0.718*** **
R-squared	0.3389	0.3333	0.5817	0.3275
Adj.Rsquared	0.3362	0.3332	0.574	0.3267
Fstatistics	127.3 on 45	2804 on 2	75.78 on 32	431.9 on 2
p-value:	**< 2.2e-16**	**< 2.2e-16**	**< 2.2e-16**	**< 2.2e-16**
Num of obs	**11173**	**11173**	**1777**	**1777**

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1.18 on 11230 degrees of freedom
(1 observation deleted due to missingness)
Multiple R-squared: 0.3398Adjusted R-squared: 0.3371

Table 3: OLS Regression with detailed Control variables

Explanatory Variables	**Regression Coefficients ***	
	Trader Coffee	**Producer Coffee**
Intercept	0.80 ***	1.55 ***
	(0.06)	(0.19)
$\overline{\overline{ECX}}$ **Dummy**	**0.14 *** **	**0.80** ***
	(0.03)	(0.09)
$P_{\ddot{N}\ddot{Y}}$	**0.72 *** **	**0.71 *** **
	(0.01)	(0.02)
Control Variables (Cof_{TYPE} and $Grade_{\ddot{X}}$)		
Bebeka	-	−0.87 ***
		(0.22)
Harar	0.17 ***	0.78 ***
	(0.04)	(0.18)
Lekempti	0.02	−0.04
	(0.04)	(0.18)
Limmu	0.17 **	−0.13
	(0.08)	(0.17)
Sidamo	0.07	0.75 ***
	(0.05)	(0.16)
Teppi	-	−1.28 ***
		(0.18)
Yirgacheffe	0.23 ***	0.99 ***
	(0.07)	(0.18)
Ghimbi	−0.29 **	-
	(0.13)	
Grade1	0.11	-
	(0.17)	
Grade 3	0.11	−0.24
	(0.09)	(0.17)
Grade 4	0.02	−0.51 ***
	(0.04)	(0.12)
Grade 5	0.11 **	−1.48 ***
	(0.05)	(0.18)
Grade 6	−0.11 **	−1.76 ***
	(0.06)	(0.17)
Grade 7	0.09	−1.26 ***
	(0.17)	(0.18)
Number of observations	10,673	1634

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
Residual standard error: 1.18 on 11230 degrees of freedom
(1 observation deleted due to missingness)
Multiple R-squared: 0.3398, Adjusted R-squared: 0.3371
F-statistic: 128.4 on 45 and 11230 DF, p-value: < 2.2e-16

2.7.1 Interpretation of the Results and Discussion

We present our regression results in **table 2 table 3 and table 4** for both the case where control variables are included and when they are not included in the regression. In table 2, where we conduct the econometric analysis on the entire data set without

removing outliers. We also include control variables coffee Grade and types as a group without listing them invidiously in the regressions. The regression results from table 2 show that the coefficients of the trader coffee $\overline{\overline{\boldsymbol{ECX}}}$ dummy variable are respectively 0.124 and 0.128 respectively for the with control variables and the without control variables while the coefficients on the Producer $\overline{\overline{\boldsymbol{ECX}}}$ dummy variable are respectively 0.770 and 0.893. Both set of results are highly statistically significant with p-values lower than 0.001.

The interpretation goes as follows, after coffee began to be traded at the ECX in December 2008, for every 1 USD increase in the per KG FOB price of trader coffee $\boldsymbol{P}_{\widehat{\boldsymbol{T}}}$ there was a corresponding increase of 0.124 USD/KG that can be attributed to the ECX existence. On the other hand, when it comes to Producer coffee $\boldsymbol{P}_{\widehat{\boldsymbol{P}}}$ after the ECX took over the trade of coffee in December for every 1 USD increase in the price of producer coffee $\boldsymbol{P}_{\widehat{\boldsymbol{P}}}$ there is a corresponding increase in the price of producer coffee of 0.77 USD/KG.

From the estimations of table 2, we can make an important observation; those results demonstrate that the ECX has brought about a significant increase in the FOB price per KG of Ethiopian coffee regardless of whether the coffee was classified as was trader coffee $\boldsymbol{P}_{\widehat{\boldsymbol{T}}}$ **or** producer coffee $\boldsymbol{P}_{\widehat{\boldsymbol{P}}}$. Furthermore, the most poignant observation is the fact that the ECX caused a difference in prices between the FOB price per KG of trader coffee and that of producer coffee. It appears that producer coffee prices increased much more following December 2008 ECX. Trader coffee represented around 80% of the coffee in our dataset and the ECX caused this coffee to lose it traceability with also meant that the value of traceability coffee would increase for the producer coffee.

In table 3, outliers meaning very high prices/KG and prices below 0.5 USD/KG were excluded from the dataset and the variables $\boldsymbol{Cof_{TYPE}}$and $\boldsymbol{Grade_{\ddot{X}}}$ were included in the regression in a detailed manner meaning they were split into various coffee types and coffee grades as opposed of being aggregated into broad categories as done in table 2. We observe that the regression coefficients on the variable $\boldsymbol{\overline{\overline{ECX}}}$ dummy are respectively 0.14 for trader coffee $\boldsymbol{P_{\hat{\hat{T}}}}$ and **0.80** $\boldsymbol{P_{\hat{\hat{P}}}}$ for producer coffee. Again, these set of results are highly statistically significant with p-values **lower than** 0.001. Those results can be interpreted as follows: After the ECX came into effect, there was an increase 0.14 of USD on average per kilo of trader coffee exported while for the producer coffee there was an increase of 0.80 USD on average per kilo of coffee exported. As trader coffee became untraceable, the international market was will to pay a premium of $0.66/KG for the attribute of traceability that producer coffee kept.

The difference between the increase in the price per KG after the ECX between the two types of coffee is considerable and the potential revenues loss that Ethiopia would have suffered could be large given that Ethiopia coffee exports are in the range of 400,000 metric tons per year. The results suggest that the international market placed a high premium on traceable coffee. The FOB price per kilo of traceable and certified coffee (producer coffee) has increased by 0.80 USD on average after coffee began to be traded on the ECX while the increase in non-traceable coffee (trader coffee) was on average just 0.14 USD per kilo of coffee exported.

The regression coefficient on the variable $\boldsymbol{P_{\ddot{N}Y}}$ reflects the impact of the world price of coffee on the selling price of coffee from Ethiopia. The results from table 3 show that both in the case of trader and producer coffee, this coefficients is 0.7 and similarly highly statistically significant at 0.1%. They can be interpreted as follows: for every increase of 1$ in the average coffee price quoted at the New York Mercantile

Exchange, we expect trader and producer coffee to increase by 0.7$ on average. We can conclude that the ECX say that the ECX made the prices of Ethiopian coffee to be more aligned with world prices.

This increase in price brought about by the ECX reflected the increase in services that was provided by the ECX that reduced the costs to the foreign buyers. Of course, the ECX had to charge for these services so the final position of the coffee growers of non-traceable coffee is not known. At the same time, the practice of under invoicing sales to reduce the payment of export taxes was no doubt reduced by the ECX administration. Those results shows that traceability and certification bring a lot of value to coffee.

2.7.2 Impact of Coffee Types and Grades on Reported Export Prices before and after the ECX

These results from table 2 to table 3 raise two further questions. First, did the Ethiopian export price of coffee track the world price of coffee as closely before the sale of coffee was required to be conducted via the ECX as after the introduction of the ECX in the coffee market? Second, did the types and grades of coffee play different roles in determining the price before and after trader coffee was sold through the ECX? To address these two questions, the data series for both trader and producer coffee were divided between the observations that occurred prior to December 1, 2008 and those that occurred after that date. For trader coffee, there were 3371 observations prior and 7302 after 1 December, 2008. For producer coffee, there were 352 observations prior and 1282 observations after December 1, 2008. The analysis of the impacts of the same set of explanatory variables on these two separate sets of data is presented in Table 4.

Table 4: Comparison between ordinary least squares regressions before and after coffee began to be traded at the ECX

	Trader Coffee		**Producer Coffee**	
	Regression Coefficients		**Regression Coefficients**	
Explanatory variables	**Before the ECX**	**After the ECX**	**Before the ECX**	**After the ECX**
	1	**2**	**3**	**4**
Intercept	2.53 ***	0.91 ***	2.24 *	2.62 ***
	(0.28)	(0.07)	(0.78)	(0.19)
$\boldsymbol{P_{\ddot{N}\ddot{Y}}}$	**0.13**	**0.74 *****	**0.11**	**0.72 *****
	(0.08)	(0.01)	**(0.24)**	(0.02)
Control variables($\boldsymbol{Cof_{TYPE}}$ and $\boldsymbol{Grade_{\ddot{X}}}$)				
Bebeka	-	-	1.17 ***	−1.66 ***
			(0.42)	(0.19)
Harar	0.12	0.18 ***	1.66 ***	0.61 ***
	(0.09)	(0.04)	(0.38)	(0.19)
Lekempti	0.03	0.00	−0.04	0.10
	(0.07)	(0.04)	(0.62)	(0.17)
Limmu	0.07	0.17 **	0.66 **	−0.36 *
	(0.19)	(0.08)	(0.29)	(0.19)
Sidamo	0.12	0.03	1.38 ***	0.55 ***
	(0.10)	(0.05)	(0.28)	(0.17)
Teppi	-	-	−0.33	−1.49 ***
			(0.31)	(0.19)
Yirgacheffe	−0.00	0.29 ***	1.60 ***	0.76 ***
	(0.14)	(0.07)	(0.31)	(0.19)
Ghimbi	−0.10	−0.41 ***	-	-
	(0.24)	(0.15)		
Grade1	0.18	0.34	-	-
	(0.22)	(0.26)		
Grade 3	0.09	0.11	−0.74	−0.33 *
	(0.22)	(0.09)	(0.61)	(0.18)
Grade 4	0.03	−0.01	−0.01	−0.70 ***
	(0.09)	(0.04)	(0.29)	(0.13)
Grade 5	0.12	0.09	0.51 *	−2.18 ***
	(0.11)	(0.06)	(0.31)	(0.19)
Grade 6	0.15	−0.24 ***	−0.14	−2.45 ***
	(0.12)	(0.06)	(0.25)	(0.17)
Grade 7	0.77 **	−0.20	−1.57 ***	−1.26 ***
	(0.36)	(0.17)	(0.28)	(0.21)
Number of observations	3371	7302	352	1282

Before coffee was traded through the ECX, there was no significant statistical relationship between the types and grades of coffee and the reported export prices of the trader coffee (Table 4, col. 1). In the trader regression case for after the ECX (Table

4, col. 2), the coffee types Harar, Yirgacheffe, and Ghimbi had an impact on the reported export price with a significance level of at least 5%. When it comes to grades, we observed that after trader coffee was sold via the ECX, only Grade 6, a low-quality type, exhibited a significant (negative) impact on the reported export price. As previously mentioned, the old auction system was fraught with deficiencies. It is to be expected that in such a context, the market would not particularly trust the results of its grading and inspection. After 2008, trader coffee was auctioned after the coffee was graded by the ECX. However, the impact of grades on prices for trader coffee did not change much, even with the grading being conducted by the ECX and auctioned in a transparent manner. The mixing of the coffee from different growers and the elimination of traceability to the original growers seems to have reduced the information value of the ECX grading of trader coffee.

The problem of the lack of traceability of trader coffee existed to a considerable degree prior to the decision to force its sale through the ECX. For some suppliers of trader coffee, the value chain might be quite long from the original grower through the various collectors to the ultimate licensed warehouse suppliers who would then sell the coffee to the international buyers. At the point of export, much of the trader coffee would probably not be traceable. This lack of traceability, however, was exacerbated by the requirement that all coffee be graded and sold via the ECX.

The situation changed greatly for producer coffee before and after 2008 (Table 4, col. 3). For export sales of producer coffee before 2008, the coefficients of four of the seven types of coffee were statistically significant in explaining the reported export prices. However, prior to 2008, the final grades of the coffee were in general not significant, except for Grade 7. This is a very low grade of coffee for which the sign of the coefficient was negative, as expected.

After 2008, the situation was quite different. The ECX was required to grade all producer coffee before it was sold, but the final sale could be made directly by producers to exporters. Out of the seven coffee types, a total of six had a significant impact on the export price of the consignment. The coefficients of all the grades of coffee were significant at the 5% level. When coffee is fully traceable and there are fewer intermediaries in the value chain, the market appears to agree that grades and coffee types should have a greater impact on export prices. Traceability is not only a valuable feature in and of itself, but it also enables the export prices to reflect more accurately the type and quality of the coffee. Although trader coffee is graded twice by the ECX before it is sold, it often lacks the information that would allow the buyer to trace it to where it was grown. The export buyers do not trust the grading conducted by the ECX when traceability is not present. This problem does not seem to be as prevalent with producer coffee, where all the coefficients on grades and types were of the expected sign and had a high degree of statistical significance.

Although the ECX also graded the producer coffee, the traceable nature of the coffee allowed the exporters to better assess the true type and grade of the coffee they were buying.Combining the attributes of specialty coffee and traceability led to higher prices for producer coffee given that that the ECX caused traceability to disappear altogether in the case of trader coffee. In a sense, the ECX made producer coffee more valuable in the eyes of foreign buyers by reducing the supply of this attribute. Traceability is a feature that gives more incentives to cooperatives and the few large producers to make sure that their shipment of coffee meets the quality specification of their oversea customers. In the case of trader coffee, there are many different participants in the value chain, and hence, trust in the reported grade and type may not exist.

2.7.3 Robustness Check: Bootstrap Regression

For robustness check, we opt for the use of the bootstrap regression algorithm. Bootstrapping is a statistical technique that consists in estimating a model a multitude times from data that have been resampled or simulated. Bootstrapping techniques then use those generated samples to draw inferences about the actual data. This procedure allows us to compute several sample statistics such as standard errors, to approximate the unknown distribution of a statistic by its empirical distribution, to construct confidence intervals, and to perform hypothesis testing. In our case we repeat the previous estimation of equation (1) and equation (2) (using bootstrap and 1001 simulations replications. The results are shown in table 5 and table 6 respectively for trader and producer coffee.

Table 5: Confidence interval trader coffee: bootstrap regression with 1001 replications.

CI	0.90 with Control	0.95 No Control	0.95 with Control	0.99 with Control
Intercept	[1.26, 2.15]	[0.89, 1.02]	[1.09, 2.30]	[0.85, 2.55]
$\overline{\overline{ECX}}$	[0.09, 0.16]	[0.08, 0.17]	**[0.08, 0.17]**	[0.05, 0.19]
$P_{\ddot{N}\ddot{Y}}$	[0.70, 0.73]	[0.70, 0.73]	[070, 0.73]	[0.69, 0.73]

Table 6: Confidence interval producer coffee: bootstrap regression with 1001 replications

CI	0.90 with Control	0.95 No Control	0.95 with Control	0.99 with Control
Intercept	[2.19, 9.92]	[1.24, 1.62]	[1.97, 10.18]	[1.9, 10.61]
$\overline{\overline{ECX}}$	[0.66, 0.87]	[0.74,1.04]	**[0.64, 0.90]**	[0.59, 0.97]
$P_{\ddot{N}\ddot{Y}}$	[0.67, 0.72]	[0.67, 0.76]	[0.66, 0.73]	[0.65, 0.74]

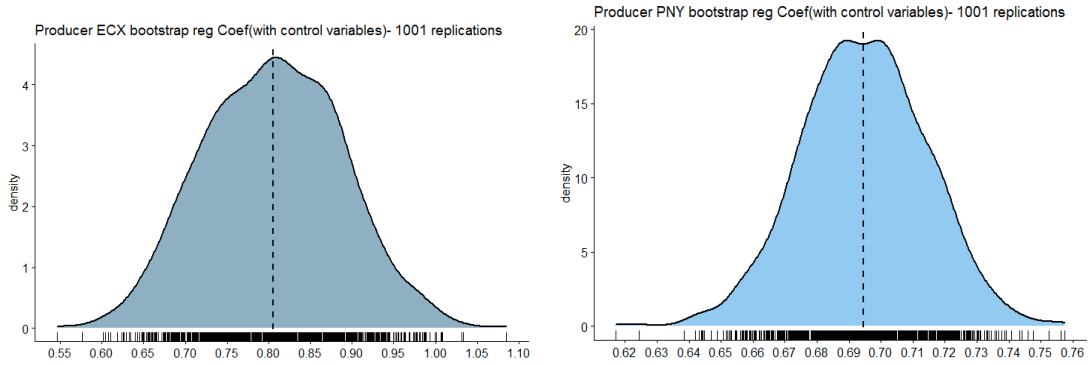


Figure 4: Dist. Function producer coffee
$\overline{\overline{ECX}}$ and $P_{\ddot{N}\dot{Y}}$ regression coefficients from bootstrap regression

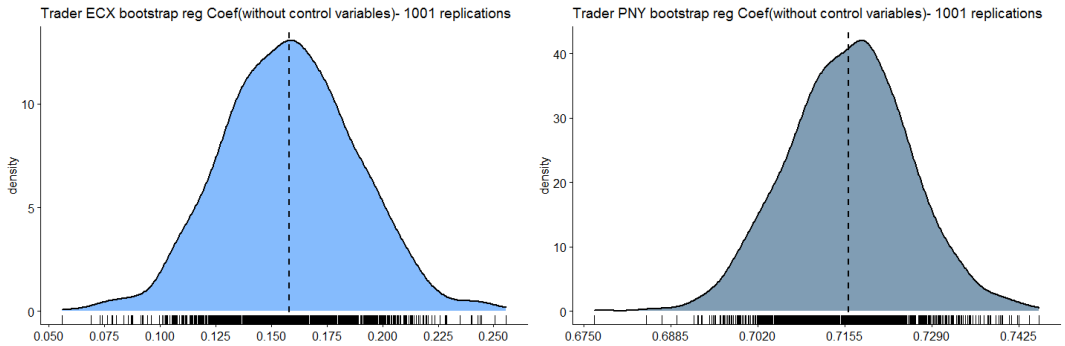


Figure 5: Dist. function trader coffee
$\overline{\overline{ECX}}$ and $P_{\ddot{N}\dot{Y}}$ regression coefficients from bootstrap regression.

2.7.4 Robustness Check Results

In table 5, we present the results for the trader coffee category obtained from the bootstrap regression with and without control variables. In the case of the trader coffee regression with control variable at 95% confidence interval, the $\boldsymbol{\overline{\overline{ECX}}}$ coefficient (third row of table 5) is found to be contained the confidence interval **[0.08, 0.17]**. The interpretation is as follows: we are 95% confident that after coffee began to be traded on the ECX in December 2008, for every 1 USD increase in the per KG FOB price coffee, subsequent per KG price increase in the trader coffee $\boldsymbol{P_{\hat{\bar{T}}}}$ would be contained in the interval **[0.08, 0.17]**. The same explanation holds for the regression without control variables.

In the case of producer coffee on the other hand, at 95% confidence interval, as shown in table 6, the bootstrap regression results with control variable on the dummy $\overline{\overline{\boldsymbol{ECX}}}$ show that the coefficient of $\overline{\overline{\boldsymbol{ECX}}}$ is found within the interval **[0.64, 0.90].** We can interpret those results in the same manner as follows: We 95% confident that after the ECX took over the trade of coffee, we are 95% confident that for every 1 USD increase in the per KG FOB price, the increase in producer coffee $\boldsymbol{P_{\widehat{P}}}$ per KG FOB price is found within the interval **[0.64, 0.90].** Figure 5 and Figure 6 show the graphs of the distribution function drawn from the bootstrap regression of the variable $\overline{\overline{\boldsymbol{ECX}}}$ and $\boldsymbol{P_{\ddot{NY}}}$ respectively producer coffee and trader coffee.

The results from the bootstrap regression corroborate the fact that there is a substantial difference between the per KG price increase of producer coffee and that of trader coffee. This differential might stem from the fact that that overseas customer no longer had complete trust in the origin label and grade tabulation assigned to trader coffee at the inspection and grading phase performed at the ECX so the trader coffee traceability became dubious. Producer coffee on the other hand kept its full traceability since it continued to be exported directly by cooperatives and large estate thereby this type of coffee became even more valuable in the eyes of overseas customers in light of the doubt on the authenticity of the trader coffee category.

2.8 Some Improvements in the Coffee Sector Brought by the ECX

The ECX brought about several improvements to coffee value chain in Ethiopia. The most conspicuous enhancements include a greater access to pricing information, more transparency and competition between suppliers and exporters, less middlemen, and a reduction in transaction costs (Aparisi, A. 2021). The expected combined effect of these innovations is to make it possible for coffee farmers to be paid higher prices for their products.

- **Greater Access to Pricing Information**

The ECX took steps to ensure that coffee producers have greater access to up-to-date information on coffee prices through various means such as: radio and television broadcast, print media and toll-free number, SMS, as well as ticker boards installed in rural areas (Gabre-Madhin, 2012; Gabre-Madhin & Goggin, 2005).

- **Tackling Collusion between Collectors and Suppliers**

The ECX was able to tackle collusion at the supplier exporter level with standardisation and commoditization. Suppliers are required to bring their coffee to ECX run warehouses where lots of identical grades and geographical original were pooled together making them undistinguishable. The ECX also opted for the first in first out delivery approach which meant buyers would not receive the specific lots that the seller put on sale thus erasing any incentive to collude (Leung 2014).

- **Less Middlemen due to Primary Coffee Marketing Centres**

Primary coffee marketing centres are another innovation brought by the ECX. They are marketplaces located in rural area whose goal is to better link farmers and suppliers thereby cutting out the middlemen collectors which were viewed by the government as expendable to the coffee value chain. Farmers now have the possibility of bringing their coffee to primary marketing centres and meet potential suppliers if they are unsatisfied with prices offered, they have the option of storing their merchandises at the ECX warehouses while waiting to be offered higher prices at a future date. In 2017, there were 1907 of such centres spread throughout Ethiopia. Although primary marketing centres have eliminated the need for collectors to a large extent, there are still many in business despites being outlawed by the government. This can be in part explained by the fact that a lot of farmers still live in very remote locations from the nearest centres which compels them to still rely on collectors.

Furthermore, in many cases the nature of the bond between collectors and farmers are long standing and not only of an economic nature but also social and familial (El Ouaamari, 2014). The effectiveness of the primary marking centres in improving competition and reducing transaction costs and has been called into question notably by (Minten et al. 2019) whose work showed that the prices coffee farmers obtained at farms gates were also identical the prices they would obtain at the primary marketing centres.

- **Reduced Transaction Costs due to Warehouse Receipts System**

Under the old auction system, traders had to physically bring their coffee to the auction venue either at Addis Ababa or Dire Dawa and only at the auction premise they would proceed to look for a buyer. It was only after finding a potential buyer that they would unload their merchandises. The bid price was determined after some coffee samples were taken and checked visually from the unloaded truck (Gabre-Madhin, 2012). This inefficient practice allowed shrewd exporters to take advantage of the situation by offering low prices since they understood that coffee sellers would face high transaction costs the more the truck stayed unloaded. Furthermore, if coffee sellers failed to find a suitable buyer, they would be forced to transport the coffee back where they came from thus incurring high transportation costs. In order to avoid incurring transportation cost without the certainty of selling the coffee, both parties would agree on price before sellers would take the risk of transporting their product from local markets to the Auction house. (Gelaw et al 2018).

The problem was that very frequently buyers would renegade on their previous commitments and refuse to pay or take delivery of the product on grounds such as low quality or inexact volume. Sellers would therefore be forced to accept a lower price than previously agreed upon. In essence, sellers were at the mercy of the whims of

buyers who had lot of incentives to take advantage of the situation. Other deficiencies of the old auction model included non-payment, forged checks, price manipulation, weak quality review Renkow and Slade, (2013); Gabre-Madhin, 2007).

The establishment of the ECX Warehouse Receipts System helped to significantly curb transactions costs. This system allows traders or farmers to deposit their coffee in ECX warehouse and receive an Electronic Goods Received Note as well as a printed copy. The Electronic Goods Received Note serves a proof that coffee of a certain volume of a specified quality and grade has indeed been stored in an ECX warehouse by the depositor. This allows traders the flexibility of trading without the need of transporting physical lots of coffee to the ECX. Electronic Goods Received Notes are not negotiable, nor are they transferable and do not represent legal title to the deposited commodity. Once the first step of getting an Electronic Goods Received Note has been completed, traders can now get an Electronic Warehouse Receipt issued by the ECX Central Depository in order to establish legal title to the deposited commodity. Electronic Warehouse Receipts are transferable and negotiable on ECX through the ECX Central Depository.

2.9 The Coffee Marketing Reform of 2017

Since the inception of the ECX the government of Ethiopia had been under intense pressures from exporters, overseas buyers and development agencies to loosen up its rules and allow for greater flexibility in the coffee sectors. In March 2017, in an attempt to improve its export revenues and to crack down on the flourishing illicit domestic trade, the Ethiopian government adopted a series of measures aimed at reducing the prominent role of the ECX had accumulated in coffee trading. More specifically under the new sets of rules, ECX would still continue to be responsible for the inspection and the grading of almost every lot of coffee that is traded however, besides large

cooperatives and large plantations estates any producer or supplier processing coffee into green beans can now engage in trade without going through ECX (Aparisi, A.,2021). Moreover, exporters were granted the ability to track coffee from a washing station, through the ECX grading system, and on to port.

The practice of blending coffee lots at ECX warehouses that resulted in loss of traceability was abolished and lots sold at the ECX can now be traced back all the way to the initial washing station. Furthermore, other restrictions were lifted; Farmers gained the right to hold an export license, individual exporters now can own washing stations, exporters can directly sell to overseas buyers bypassing the ECX but under the condition that they do so within three days after coffee reaches the warehouses in Addis Ababa.

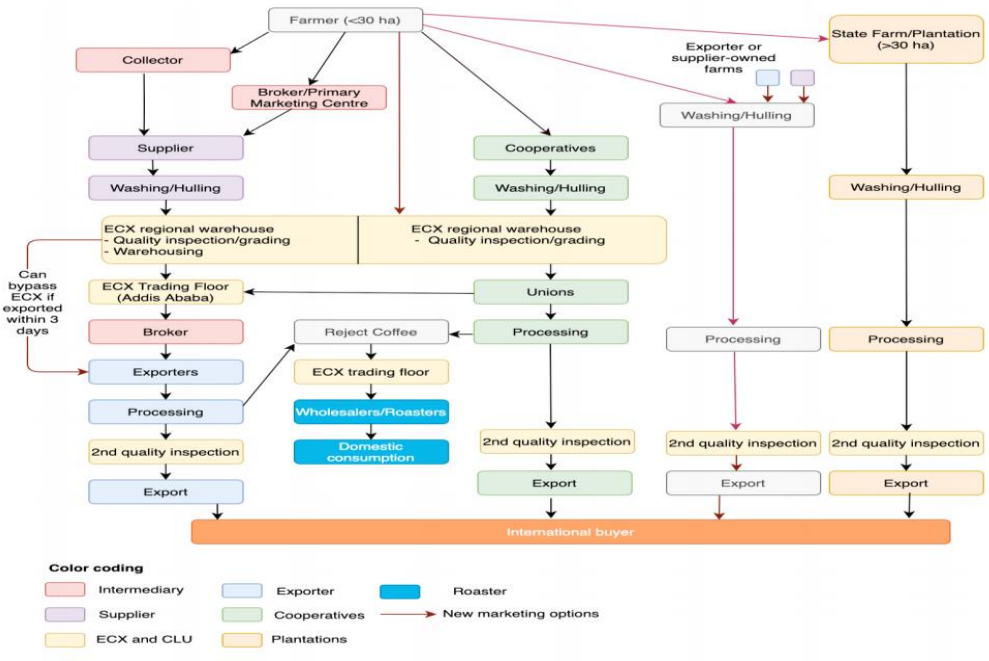


Figure 6: Coffee value chain in Ethiopia after the ECX reform of 2017
Source: Mas Aparisi, A. (2021)

2.10 Study Limitations

This study would have been greatly improved by the inclusion of transaction costs at the ECX. Unfortunately, such data were not available. FOB prices fail to show the pricing dynamic that could simply results from the specific operating costs at the ECX. However, the very limited access to ECX data made such endeavour impossible. Secondly, this study could be improved if a long-time frame of the dataset were available. The data at our disposal cover a period of 5 years. It would be interesting to see what the price dynamic between trader coffee and producer coffee over a longer time horizon are. Lastly, the Econometric methods used in this work is simplistic. A more appropriate method would involve the uses of time series cointegration techniques given that coffee is an internationally traded goods and local prices tend to follow to an extend world prices.

2.11 Chapter Conclusion

Ethiopia is a country constantly beset by drought that triggered mass famine in the past. A leading cause of food scarcity in Ethiopia was the highly localized nature of its markets that hampered the availability and the free movements of goods across the country. The Government of Ethiopia sought to tackle this recurring problem with a market-oriented solution such as commodity exchange. The Ethiopian Commodity Exchange (ECX) was established primary to provide systems easing the trade and movement of foodstuffs like grains and sesame.

In December 2008, few months after its launch however Coffee began to be traded on the exchange floor and soon became its most traded commodity. In the case of coffee, the ECX replaced the old auction system that had been operating since the 80's. Despite its longevity, that old auction system had several deficiencies such as

high transaction costs, collusion among powerful players in the coffee industry to offer lower price to farmers, weak contract enforcement which meant that parties could renegade on their previous agreement, corruption, coffee smuggling to other nations.

The ECX was touted as a mechanism to iron out those inefficiencies and ensure that the approximately 5 million Ethiopian coffee farmers received higher and fairer prices for their products. Many improvements in the Ethiopian coffee industry can be credited to the ECX. However, after coffee was introduced at ECX a new issue emerged, the loss of traceability. Ethiopian coffee destined for exports can be split into two broad categories; ECX sourced coffee that became untraceable as a result of commoditization and coffee from cooperatives that fully retained its traceability. The value of coffee is inextricably linked to its place of growing origin, taste cup mode of cultivations and processing. Commoditization made it impossible for international buyers to both trace ECX-sourced coffee and distinguish it using cup taste. In order to satisfy the exigencies of its increasingly aware customers overseas buyers are willing to pay premiums for traceable coffee.

The purpose of this work was to study the impact that the introduction of coffee at the ECX had on export prices of each of those two categories of coffee. Using export data from 2007 to 2012, we find that after Coffee was introduced at ECX, traceable coffee export price has increased on average by 0.9 USD per KG. On the other hand, the price increase in ECX sourced non-traceable coffee was only of 0.13 USD per KG on average. This substantial difference in the pricing of these two types of coffee confirms the view that traceability is an important and sought-after feature and its increases the value of coffee. By the year 2017, the government was faced with mounting pressures from both exporters and buyers of Ethiopian coffee as the loss of traceability increasingly became a major challenge in their operations. As a result, a

coffee market reform law was enacted by the Government of Ethiopia curtailing the role of the ECX through the adoption of a coffee reform in March 2017. Under this new system, besides large plantations and state farms, any exported of trader coffee can now export coffee without systematically having to go having to go through the ECX trading floor. The ECX can be bypassed under some conditions and its role in this case is limited to the inspection and grading of coffee, Furthermore, the practice of mixed coffee at the ECX warehouse has been abandoned.

Chapter 3

A BRIEF ANALYSIS OF THE COFFEE VALUE CHAIN RWANDA

3.1 Brief History of Coffee in Rwanda

Coffee was introduced to Rwanda in 1904 by German missionaries. However, its production became widespread in the 1930s when Rwanda felt under the rule of Belgium and the colonial administration subsequently instituted a policy of mandatory coffee planting in the country. Coffee has always played a central role in both the economy and the politics of Rwanda. By the time the country achieved its independence in 1962, coffee represented 55% of Rwanda's exports (Macchiavello and Morjaria 2019). Rwanda was thus heavily dependent on coffee and the government kept its grips on coffee exports implemented a fixed producer price regime. Coffee was also used a central piece of the political agenda of the two regimes that followed the independence and has been unfortunately linked to period of instability in the country as (Behuria 2018) put it the pre-1994 political settlement in Rwanda was largely organized through social relations around the coffee sector.

Today coffee continues to play an important role in the Rwandan economy it is one of the country's largest cash crops. Coffee provides a source of livelihood to the approximately 400,000 coffee farmers in the country; secondly, it is one of Rwanda's main sources of export revenues. According to the UN trade, statistics database Comtrade, Rwanda's exports revenues from coffee amounted to 68 million USD for the year 2018 representing around 6% of Rwanda total export for the same year. For

the year 2021 2022, coffee exports amounted for 75,571,428 USD which represents approximately 11.8 percent of total agriculture exports value (NAEB 2023).

The goal of this chapter is to present the reader with a brief discussion of the value chain of coffee in Rwanda as well as to synopsize the main threats and challenges it faces. We will use this chapter to lay the groundwork of the financial and economic analysis we will conduct in the next two chapters with the aim of proposing some viable alternatives.

3.2 Analysis of the Coffee Value Chain in Rwanda

3.2 .1 Coffee Production

According to FAO figures, Rwanda's coffee production in the early 80s was between 30,000 to 40,000 tons per year. Coffee outputs began to shrink by the late 1980s. The collapse of the International Coffee Agreement in 1989 coupled with the tragic event of the Rwandan genocide reduced coffee production to 1000 metric tons. From the year 1995, there was an upswing in coffee production, but the country has never managed to reach the same production level of the early 80s. Rwanda is the least coffee producer in comparison to its other east African fellow coffee producers Uganda, Tanzania and Kenya produce respectively 212 000, 48 000 and 46 000 tons per year (ICO, 2017). In recent years, the production of coffee in Rwanda has been oscillating between 20000 Metrics tones and 30000 metric tonnes per year as shown in Figure 7.

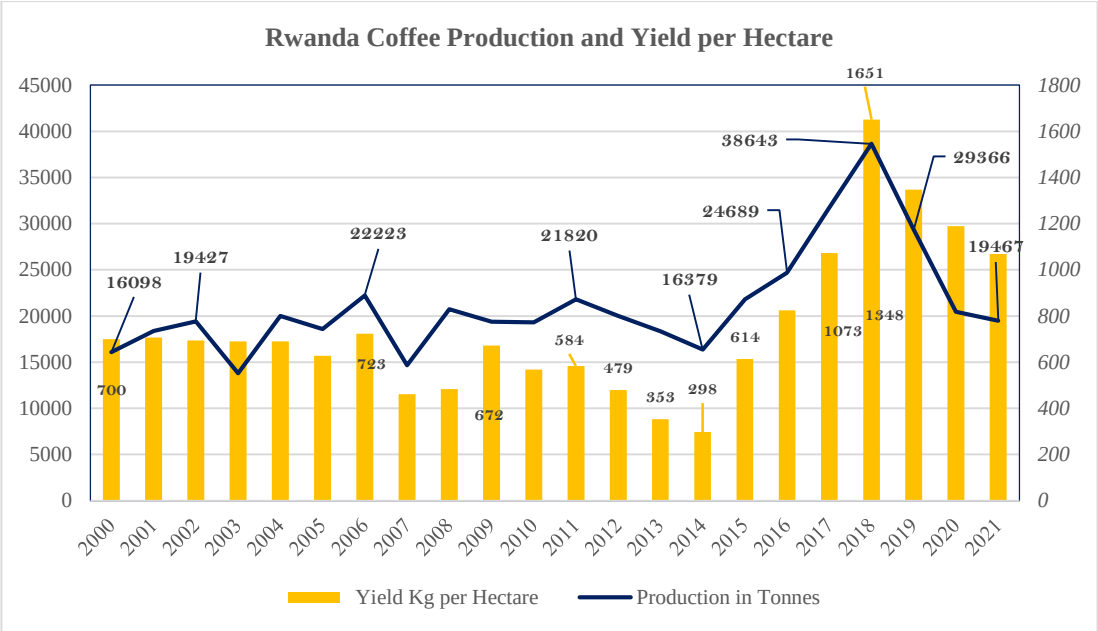


Figure 7: Coffee production in Rwanda and yield per hectare.
Sources: FAO statistics 2023

3.3 The Coffee Value Chain in Rwanda

3.3.1 Description of the Coffee Value Chain in Rwanda

Figure 8 depicts the coffee value chain in Rwanda. Coffee farmers harvest and sell the major part chunk of their harvest called coffee cherry to coffee washing stations (CWS). Coffee washing stations are processing plants where coffee cherry is processed and transformed into fully washed coffee (FWC) also referred to as parchment coffee. Throughout the dissertation we will employ those two terms interchangeably. More specifically in CWS pulp are removed from the coffee cherries, beans are then fermented and thoroughly washed and dried. The end product is a coffee that has a distinctive taste and is more expensive than the unwashed coffee or ordinary coffee.

The negligible portion of remaining coffee is processed at home by farmers is sold to authorized traders. At CWS, coffee cherry From CWS fully washed coffee is sent to dry mills before been finally exported to overseas customers. The domestic consumption of coffee is extremely low 98% of the Rwandan production is exported.

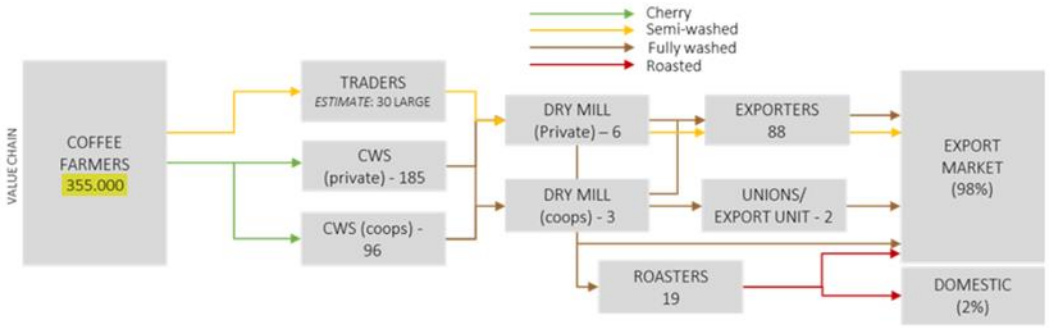


Figure 8: Coffee value chain in Rwanda as of 2018
Source: (Agri- Logic 2018 report)

3.3.2 Main coffee Types in Rwanda

Broadly speaking, coffee in Rwanda can classified into two broad categories based depending on the way it was processed after harvest. The two principal processing methods include ordinary, and fully washed coffee. By **"ordinary coffee" or semi washed,** we mean coffee that farmers clean and process at home or farm. This processing method is called the dry processing and involves the use of rocks to clean cherries and mats to dry them on once they are deemed clean. (Macchiavello and Morjaria 2019). Dry processing is rudimentary and therefore produces a cheap coffee of low quality.

Full Washed Coffee is obtained by employing the wet method. Beans are processed at coffee washing stations or wet mills. As its name suggests, this method requires the heavy use of water and a pressing machine. Right after beans are harvested and still moist the coffee cherry is washed to take out the skin of the cherry and pulp of the fruit. After the first step is completed, beans are soaked into water for fermentation lasting between 24 to 72 hours. Fermentation is used to remove the mucilage layer and gives coffee its peculiar flavor. After fermentation, the next step is to meticulously wash cherries with clean water and dry them on the sun for approximately three weeks.

Since the year 2002, the Government of Rwanda has put a strong emphasis on fully washed coffee in a bid to improve farmers' income. The number of CWS has significantly increased from two in 2002 to 301 in 2018 (NAEB 2018). It is worth mentioning that not all washed coffee is specialty coffee. Specialty coffee requires on top of being fully washed additional features and certifications such as: (FairTrade, Rainforest Alliance, etc.).

Ponte Stefano (2002) defines specialty coffee as "all coffees that are not traditional industrial blends, either because of their high quality and/or limited availability on the producing side, or because of flavoring, packaging and/or "consumption experience" on the consumption side''. According to the coffee division manager National Agriculture and Export Board (NAEB), by the year 2019, specialty coffee was exported on average at a price of $4 to $5 in comparison to $2 for non-specialty coffee. In a previous article, (Macchiavello & Morjaria 2016) had reached similar conclusions.

3.4 Threats to the Coffee Value Chain in Rwanda

This section enumerates the main threats to the coffee value chain in Rwanda. However, the emphasis will be mainly on the production side meaning farmers and the primary processors which are the coffee washing stations. These two groups are critical stakeholders of the value chain and the long-term success of the agricultural policy of Rwanda hinges of their respective ability to sustainably produce their outputs cheaply and efficiency and remain in business. The main threats to the coffee value chain of Rwanda are:

3.4.1 Scarcity of Land

Rwanda with a population of 12 million habitants is one of the most densely populated country in Africa. Land in Rwanda is scare and has historically been one of the main potential triggers of ethnic violence in the country. Pertaining specifically to

coffee, roughly one-half of farmers own less than a half hectare of land; more than 60% own less than 0.7 hectare and more than 25% cultivate less than 0.25 hectare of land. (Karol C. Boudreaux 2011). Coffee farming is labor intensive and requires some investments. Farmers with limited land would not have much incentives to heavily invest in their plantations even if they have the means to do. This is simply because they would not expect a high output in terms of harvested cherries. Those farmers might find it more profitable to switch to other crops.

3.4.2 Old Coffee Trees

The National Agricultural Export Development Board (NAEB) of Rwanda estimated that approximately thirty percent of the 100 million coffee trees that Rwanda has are older than thirty years and are thus classified as old. An old coffee tree typically produces between 800 grams and 2 kilograms of coffee cherries. On the other hand, a coffee tree in its prime would yield between 6 to 8 kilograms of coffee cherries. Ageing coffee trees and the ageing of the farmer population are some of the main causes of low coffee productivity in Rwanda.

3.4.3 Low Compensation of Farmers and the Lack of Incentives

As we will demonstrate in the next chapters, coffee farmers are not appropriately compensated as the prices they receive per KG of cherries coffee is lower than what a competitive market would dictate. This situation induces two important negative consequences. Firstly, farmers have little incentives to remain in coffee farming they rather switch to other crops that generate more income. Secondly for the farmers who do not give up, the low compensation they obtain makes it impossible for them to make the needed investments in their plantations which ultimately negatively impact the quality of the coffee they harvest. The long-term sustainability of the coffee industry

in Rwanda rests to la large extent on addressing farmers' compensations and given them more incentives to remain in coffee farming.

3.4.4 The Oversupply of CWS and Their Below Capacity Utilization.

The oversupply of CWS and the resulting below capacity utilization have been an issue for many years. In 2015, the NAEB and International Growth Centre (IGC) conducted a study that reported that out of the 229 CWS in Rwanda at the time; only 199 were active but were operating at 50 per cent of their capacity. In 2018, another study by AGRI LOGIC revealed that there were 299 CWS in Rwanda and 276 of those were running but only on average at 60% of their capacity. Under capacity CWS utilization, undermines the ability of the coffee sector to be efficient and therefore lead to wasteful investments that could have otherwise been implemented in a different sector of the Rwandese economy. If CWS were to function at their current full capacity, then the number of CWS would decrease and the cost of processing fully washed coffee would subsequently reduce.

3.4.5 The Coffee Zoning Policy

After Rwanda transitioned from the production of ordinary coffee to specialty coffee it began to enjoy international acclaim from international coffee buyers. The lure of high prices combined with various incentives from the government and donor resulted in a rush to build more and more CWS. However as the number of CWS increased, the competition for cherry subsequently intensified especially given the fact that coffee production remained stagnant. A multitude of CWS that were unable to sustain the fierce competition or gain access to financing went out of business. In an attempt to shore up the industry, the Government stepped in by implementing a coffee zoning policy.

The coffee zoning policy was first put into effect in 2016 and it constrained the sale of coffee cherry by farmers to CWS to be limited within the confines of a pre-established zone. Sales and purchase of coffee cherry outside of zones are prohibited (Gerard et al., 2017). The government's stated goals of this policy as enumerated by the NAEB were to enhance traceability in the Rwanda coffee sector, to cut out the middlemen, to bolster relationships between farmers and CWS, to increase the availability of coffee supply to struggling CWS, to increase farmers income and lastly to improve the quality of coffee (Feed the Future, 2017).

The zoning policy however is an impediment to market efficiency and competition. By preventing buyers and sellers to choose with which counterparts to trade, it leads to a situation where some CWS that would have gone out of business are kept artificially alive given that they are guaranteed to obtain a certain some volume of coffee cherry for their operations. The zoning policy seems to have been designed more to protect washing stations than for the welfare of farmers. This is counterproductive since farmers are the main reason why washing stations can function in the first place. In general, the zoning policy has had a negative impact on farmers by decreasing their income due to the limited competition for cherry and the monopsony buying power of washing station within a zone.

The zoning policy further forces to government to intervene in the coffee market by setting a selling price for coffee cherry and enforcing this price. A situation in which the markets forces were left to operate unrestrictedly would naturally beget an efficient outcome as the least performing washing stations would exit the market and the remaining washing stations would bid up cherry prices and as a natural corollary farmers would be better off since they would be paid a much higher price. In the current situation, the government is forced to impose strict sanctions against washing stations

that are tempted to offer prices above the mandated price of 410 Rwandan Francs (RwF) per kilo of coffee cherry. In the long run the zoning policy poses a threat to the sustainability of the coffee sector in Rwanda as it results in lower incentives for farmers to remain in the coffee business due to lower compensation.

Another major flaw in the design and the implementation of the zoning policy stems from the fact that the zoning policy does not prevent owners and businesses from operating many stations in different zones. It means that in order to get enough cherries, CWS owners are forced to build washing stations in as many zones as they can afford instead of having one or two CWS that could have processed the same total volume of coffee cherry.

Opening CWS in multiple zones represents very substantial unnecessary capital expenditure. This further exacerbates the issue of overcapacity as many washing stations are built in order to process smaller quantities of cherry. Many companies in Rwanda own and operate many washing stations two examples illustrates this phenomenon, Rwacof owns and operates 30 CWS while the Rwanda Trading Company owns and operate 18 CWS. The zoning policy therefore heavily contributes to the waste of economics resources that could have been injected in the improvement of coffee plantations.

3.4.5 Financial Constraints Faced by Coffee Washing Stations

A major hindrance to the viability of any CWS is its inability to access financing. (Macchiavello and Morjaria 2015) estimate that coffee washing stations requires between 70-80% of cash flows as working capital during the coffee campaign (in comparison to 20-40% for SMEs in the manufacturing sector). Local Financial institutions are reluctant to advance loans to CWS due to their perceived riskiness and the lack collaterals. When loans are granted, they are given with stringent terms and

high interest rate. Due to the stiff competition for coffee cherries among CWS, earlier access to financing is of paramount importance for the success of each coffee campaign. The inability to secure financing on favorable terms makes it impossible for CWS to compete competitively for cherries of adequate volume and quality, to retain qualified and experienced staffs all these would in turn significantly impede on the quality of washed coffee produced and thus limits the premium or the margin the washing station would have earned.

3.4.6 CWS Lack of Skilled Staffs

Another major hurdle faced by CWS is the lack of skilled staffs and outdated equipment. Managing and running CWS day-to-day operations in an efficient manner requires qualified personnel. Staff training has not kept pace with the proliferation of CWS in the country. Lack of technical and management expertise significantly impede on the productivity of existing CWS and contribute to their perceived unattractiveness for loans by financial institutions.

Further aggravating the lack of skills is the fact that coffee washing station employ the bulk of their workers during the harvest period only for four months beginning in March for the remaining eight months of the year staffer their knowledge of process and operations at a CWS significantly dwindle. There is also no guarantee that a specific CWS would be able to rehire the same workers as it did for the past harvest period. For every new batch of recruits a significant number of new employees lack experience.

Chapter 4

ENHANCING COFFEE QUALITY IN RWANDA: A COST BENEFIT ANALYSIS OF GOVERNMENT POLICIES

4.1 Introduction

Rwandese coffee is acclaimed on the international market for its high quality. Rwanda unlike its other coffee exporting neighbors is a small landlocked country nonetheless, it has ideal growing conditions for coffee farming due to its rich volcanic soil, high altitude and ample rainfall. However, land is a scare resource where coffee is in competition with other crops for the limited space available. Furthermore, a substantial portion of Rwanda's coffee plants are older than 30 years meaning that their yield is low. Given its small size and the constraints on available lands it faces, Rwanda has opted since 2002 to adopt a policy geared toward the production of specialty coffee or fully washed coffee rather than ordinary coffee. Specialty coffee fletches high prices in contrast to ordinary coffee which was the type of coffee exported by Rwanda prior to 2002.

The main difference between the two types of coffee is that ordinary coffee is unwashed and is usually processed at home by Rwandan farmers themselves using rudimentary equipment therefore its production does not entail a sophisticated process. On the other hand, the production of fully washed coffee as its name implies requires coffee to be washed intensively. This is done in Coffee washing stations (CWS) or wet

mills. Producing and exporting fully washed coffee therefore requires investments in the processing segment of the value chain of coffee of which CWS are a critical component.

The potential of Rwanda to become a major player on the specialty coffee niche market on the world stage was recognized in the early 2000s by international development agencies, NGO and the Government of Rwanda (GoR). This realization coupled with the reputation Rwanda had been begun to enjoy for its strides on the socio-economic front lead to an outpouring of technical and financial assistance from international developments agencies and donors into investments in the coffee value chain most specifically into CWS. The United State Agency for International development (USAID) paved the way by providing a wide range of assistance both financial and technical to the nascent industry. Consequently, the number of CWS has increased from 2 in 2000 to 46 by the year 2006 38 of which were funded by the USAID. According to official figures, the number of registered CWS stands today at a little over 300.

CWS have contributed positively to raising Rwanda's reputation in the global coffee market as illustrated by the number of international awards its coffee has won but more importantly to push for higher quality coffee has been greatly beneficial to Rwanda as it is an important source of foreign exchange earnings. As an illustration for the 2021-2022 fiscal year Rwanda total agricultural exports were evaluated at 640,952,296 USD out of which coffee exports accounted for 75,571,428 USD which represent approximately a share of 11.8% of the total value agricultural exports from Rwanda.

At its inception, the policy of improving the quality of coffee was needed and made perfect sense in its inception. However, it is unfortunately the case that, the

various financial incentives from both donors and the government combined with the expectation of earning high profits has had the adverse effect of causing a rush into the sector resulting in an oversupply of coffee washing stations in Rwanda. The high number of CWS in Rwanda has given rise to a fierce competition for the purchase coffee cherry since the supply of coffee cherry in Rwanda is limited. As a corollary of this plethora of CWS and the competition they face the vast majority of CWS operate way below their built-in processing capacity. In a competitive market only the most efficient washing stations would survive such an environment with the less competitive going out of business.

The government in Rwanda decided to tackle the growing unavailability of cherry and the high rate of bankruptcy among CWS, by implementing a zoning policy consisting of limiting the area in which specific CWS are allowed to operate. Farmers are also required to sell their cherry to CWS within their zone at a fixed price mandated and enforced by the government. Failure to abide by these rules is a punishable offence. The zoning policy has therefore had the adverse effect of artificially maintaining inefficient washing stations in business while capping the revenues farmers could have gotten from a competitive setting. A washing station in a zone is guaranteed to purchase some cherries if it has the means to purchase cherry at the mandated floor price.

The policy of restricting cherry sales to CWS with their designated zones is viewed negatively by farmers as having an adverse impact on their livelihood. In a survey by Gerard et al. 2017, 61.9% believed that the zoning policy has resulted in them getting lower prices for coffee cherry. The goal of this paper will be to estimate the economic welfare loss that has resulted as consequences of the policies that have led to an overinvestment in coffee washing stations and to quantify the impacts this

has had on the main participants of the coffee value chain in Rwanda.

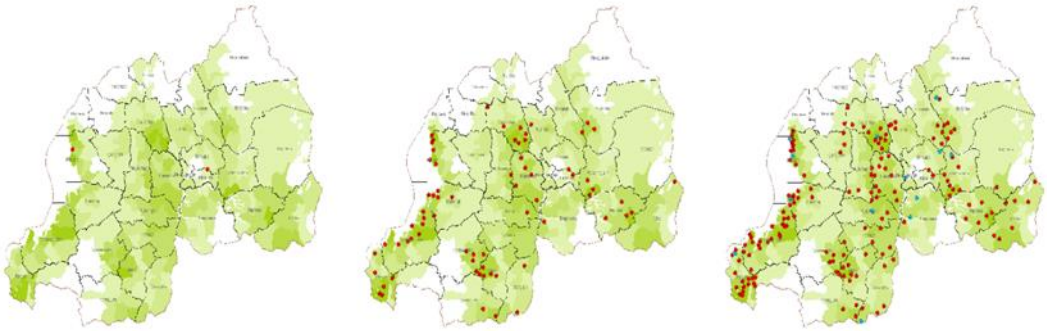


Figure 9: Expansion of coffee washing stations from 2002 to 2006 and 2012
Source: Macciavello & Morjaria (2015)

4.2 Literature Review

The improvement of the Coffee value chain in Rwanda has attracted an interest from many researchers whose work are closely related to our work including:

(Church, 2018) used as benchmark for her analysis the Government stated goal of exporting 80% of its total coffee production as fully washed by 2018. The article quantifies in monetary terms the negative impact of not reaching this target from the perspective of three major actors of the coffee value chain in Rwanda namely: coffee farmers, Coffee exporters, and lastly the Government of Rwanda. Her results indicated that farmers' losses were estimated at 125 RWF /KG of cherry sold for the period considered. Exporters realized a profit 43% lower than what they would have achieved if the government targets of 80% fully washed coffee exports were met and the lastly the loss of foreign exchange to Rwanda was evaluated a 2.6$ millions solely for the year 2016.

Clay et al. (2016) estimated the cost of production of cherry to Rwandan coffee farmers. Their work reveals that the true cost of production of cherry for farmers in Rwanda is 177 RWF/KG which is far above the 80 RWF/KG benchmark commonly

used by the Government of Rwanda to determine the price of cherry. As a negative corollary of the underestimation of production cost, a large proportion of coffee farmers in Rwanda are operating at loss or have very little margin and they would be better off being employed as workers on someone else farm rather than owning and operating themselves a coffee plantation. The article further observes that the processing tranche of the Rwandan coffee value chain namely exporters and coffee washing stations have been flourishing but the benefits from this improvement have not trickled down to coffee farmers. The failure to incorporate farmers as full partners in their view is the reason behind the stagnation of the production level in Rwanda.

Gerard et al. (2017) investigate the perceptions that the main stakeholders of the coffee value chain in Rwanda have of the zoning policy implemented in 2016. The result from their survey reveals some important points; 75% of the stakeholders believe that the zoning policy has mainly be beneficial to coffee washing stations and cooperatives to the detriment of coffee farmers. 69.6% of stakeholders surveyed believe that the zoning policy resulted in increased cherry sales to CWS. Overall, the article demonstrates that most stakeholders of the value chain consider the zoning policy to be advantageous only to CWS and to a lesser extend to cooperatives.

Clay and Bizoza (2018) investigate ways to sustain growth in the coffee sector in Rwanda in the long run. The article shows that coffee farmers have very little incentives to remain in the coffee business due to the high production costs they incur and the very low margin they achieve. Consequently, farmers are uprooting their trees in favor of other crops thus necessary critical investments that are needed to boost coffee production levels are not made. Given that the long-term targets of the Government for coffee sector performance in production, productivity and sale revenues hinges on the availability of enough coffee, the article recommends that all

stakeholders of the value chain commit to ensuring that farmers be fairly compensated, and that coffee be given more importance over other crops since Rwanda has a comparative advantage in specialty coffee on the world stage. Rwanda does not have this comparative advantage for its other high priority crops such as maize, bean, rice, wheat, and cassava.

Other articles that are similar or related to our work include Behuria (2019) who studies the evolution of the coffee value chain over the years in Rwanda. Murekezi (2003) who used cost benefit analysis to conduct a financial feasibility of an earlier investment in the production of specialty coffee by a cooperative in Rwanda. Fitriani et al. (2020) who employed cost benefit analysis to evaluate the economic viability of coffee farming in agroforestry systems in Indonesia. In the same vein, Karim et al (2019) make a comparison between different methods of coffee processing using the cost benefit methodology to ascertain the most suitable processing methods for a rural community. To the best of our knowledge, despite the vast interest that the coffee industry in Rwanda has generated from researchers, our article is the first of its kinds to undertake both a financial and economic analysis of government policies pertaining to the move to the production of specialty coffee.

4.3 Data and Methodology

Our work is based on a cost benefit analysis methodology that can be referred to as an integrated investment appraisal by authors such as: Jenkins et al. (2019), Sartori et al. (2014), Boardman et al. (2011), Quah & Mishan (2007), ADB (2013), ADB (2017). Gittinger (1982). This approach allows us to gauge the viability of investments project as well as their broad impact on the society. We conduct a financial, economics and stakeholder analysis of a generic CWS for different outputs production levels. The objective behind this approach is to use the results from our project models of CWS to

assess to what degree the policies to incentivize the investments made in this sector have resulted in an overexpansion of number of washing stations beyond what would have been most cost efficient for sector. This analysis is undertaken with a clear appreciation of the underlying constraints facing the supply of coffee cherry production of the country.

4.3.1 Financial Analysis of an Investment in a Generic CWS

4.3.1.1 Cost Structures of a Coffee Washing Station

A typical coffee washing station purchases freshly harvested coffee cherries from farmers within its zones. Once at the station, the cherries undergo four main processing phases which include sorting, soaking fermentation and finally beans are thoroughly washed (Technoserve, 2022). The final product resulting from this process is called fully washed coffee or parchment coffee. In our analysis, we focus mainly on the cost of processing or transforming cherry into parchment coffee. CWS are fully operational only during the portion of the year that coincides with the coffee harvest season in Rwanda.

The season typically last three months or approximately 78 operating days. The lower the cost of the coffee washing processes the greater is the financial surplus available for participants in the sector. In a competitive market for the input of cherries, the farmers are likely to receive higher prices for their coffee cherries as the owners of the washing stations seek to buy more coffee cherries to expand their operations and increase their profits.

The main components of the fixed capital investment are (among others) the land, coffee pulping machines, electricity generators, recycling pumps, drying tables, and the construction costs. In 2022 prices, the estimated investment cost of such a mid-range washing station is approximately $200,000. Data on the initial capital cost,

operating costs and important characteristics of a typical washing station were obtained from a feasibility study commissioned by the Agribusiness Development Assistance to Rwanda (ADAR) (USAID, 2006). Investment costs information were adjusted to the price level of 2022. The information on the Investments and operating cost of a typical CWS were further corroborated in 2023 through interviews with owners of washing stations in Rwanda. The detailed breakdown of our estimates of these costs are reported in the appendix table A1.

In the case of variable costs, a distinction is made between seasonal and non-seasonal variable costs. **Seasonal fixed costs** include costs that occur during the operating season and do not fluctuate based on the volume of coffee processed. Seasonal fixed costs include the core staff the CWS employs, which receive monthly salaries. Other examples of seasonal fixed costs are miscellaneous expenses that are commonly incurred such as offices supplies.

Seasonal variable costs are costs that are incurred solely during the season and vary according to the amount of cherry the station processes. A good illustration of seasonal variable costs are the workers that the station employs during the harvest season they and are paid a daily wage for each day of work. The bulk of the employment of labor is of this type. Other examples of seasonal variable cost include cost items such as transportation cost, fuel, bags of jute etc.

For the purpose of our analysis, we chose four levels of annual production of a washing station starting from 25 tons, 50, 100 and 200 tons. It is assumed that the fixed costs are the same for each of these levels of production. The current average production of a CWS in Rwanda is approximately 50 tons of parchment coffee per year. However, the range of production is quite large where many CWS are operating

below this average level of production, and a few are producing substantially larger amounts.

In this analysis, we wish to compare the total costs of processing the production of coffee cherry in Rwanda when the average level of production of washing stations varies from 25 tons to 200 tons of parchment coffee per year. If each CWS produces more coffee, then the number of stations required is correspondently lower. The main determinants of the quantity of parchment coffee that can be produced by a typical CWS are the number of laborers employed to process the cherries and the quantity of financing that the CWS owner can afford to obtain to purchase cherries for processing.

4.3.1.2 Total Seasonal Variable Costs

For the sake of simplicity, we divided our seasonal variable costs into three categories: seasonal labor, transportation and other variable costs. The total seasonal variable cost of a CWS for a single year is found using (3)

$$TV(\tilde{Q})_{\widehat{f.t}}{}^{F} = [(n(\tilde{Q}_t) * D_{op} * D_{\widehat{lab}\tilde{q}}{}^{F}) + (\tilde{Q}_t * 1000 * (c_{\widehat{trans}\tilde{q}}{}^{F}) + T(\tilde{Q}_t)^{F}{}_{\widehat{oth}}] \quad (3)$$

where the variable $\tilde{Q}_t$ is the total output of parchment coffee produced in tons by a CWS during a season. The variable $n(\tilde{Q}_t)$ is the number of seasonal workers the station needs to employ in a season. $n(\tilde{Q}_t)$ Varies according to the total volume processed. The larger the volume processed, the larger the number of employees needed. The variable D_{op} represents the number of working days during the season. Seasonal staff typically work 26 days each month during the 3 months of the season for a total of 78 days. The variable $D_{\widehat{lab}\tilde{q}}$ is the daily wage rate of seasonal labor. The transportation cost per KG of parchment produced. The variable $T(\tilde{Q}_t)^{F}{}_{\widehat{oth}}$ is the total sum of other variable costs that the CWS bears during a season. Lastly one ton is equivalent to 1000 KG. The details of the seasonal variable inputs for these three different scales of CWS are presented in Appendix table A1.

4.3.1.3 The Total Seasonal Fixed Cost

The seasonal fixed cost is the sum of seasonal fixed labor and other fixed costs[1] incurred during a season. The total seasonal fixed cost of a CWS is given by (2)

$$TFC_{\overline{f.t}}{}^{F} = \left[\left(n_t * T_{Mths} * {w_i}^{F}\right) + FC_{\overline{o.t}}{}^{F}\right] \quad (4)$$

where the variable n_t represents the number of workers that will be employed for a period of T_{Mths} months during the year. Given the critical nature of their work, some staff members would have to be employed throughout the whole year such as the station manager other would be employed for a shorter period but all at least for three months. Permanent workers are paid a monthly wage of ${w_i}^{F}$ where the wage amount differs depending on the position occupied. The variable $FC_{\overline{o.t}}{}^{F}$ represents the sum of other fixed seasonal costs incurred by the CWS. The details of the seasonal fixed inputs for these three different scales of CWS are presented in the Appendix table A1.

4.3.1.4 Working Capital Loan

The working capital loan is extremely critical to the success of a CWS and the vast majority of CWS in Rwanda finance their activities through this means. Before the beginning of each harvest season the CWS decides that it wants to process a volume $\tilde{Q}$ of parchment coffee when the season ends. The CWS would consequently seek to obtain a loan from banks. Ideally, the obtained loan amount should be enough to cover not only the purchase of the cherry but also sufficient to cover all the CWS operating expenses for the season.

Those operating costs include labor costs both variable and fixed as well as other operating expenses. The only cost that is not financed with the working capital loan is the initial investment in the fixed costs of the CWS. Failure to obtain financing earlier most likely would result in the station not being able to purchase coffee cherry from

[1] **Other fixed costs:** Office supplies, Communication expenses, Printing expenses, Mechanic Repair and maintenance, Spare parts Advertising

farmers hence not being able to operate independently of other producers. The loan principal is found using (5)

$$WC_{p.t} = C_{\tilde{Q}}{}^{F} + TV\left(\tilde{Q}\right)_{\widehat{f.t}}{}^{F} + TFC_{\overline{f.t}}{}^{F} \quad (5)$$

$$\hat{I}_t = WC_{p.t} * r_s * t \quad (6)$$

The variable $C_{\tilde{Q}}{}^{F}$ is the total cost of coffee cherry purchased per season. In Rwanda, the coffee cherry price per KG is decided and announced by the government at the beginning of each coffee season. The coffee cherry price is currently fixed by the government at 410 RwF per KG. This capped cherry price has traditionally known a slow progression. It went from 145 RwF per kg in 2010 to 248 RwF in 2021. The most substantial increase in the cherry price occurred in the year 2022 when it jumped to the current 410 RwF per KG. CWS are prohibited from offering higher prices than the stipulated prices and failure to abide by this rule constitutes a punishable offence. CWS are therefore in theory paying the same price per kg of cherry only the volume purchased by each CWS differ. Each KG of parchment coffee or fully washed coffee produced necessitates 5KG of cherry. The variable $\hat{I}_t$ is the total interest paid by the CWS on the working capital loan. Usually, the working capital loan is given for a period of one year. The interest rate charged by the bank is denoted by the variable r_s, and t is the loan tenor.

Table 7 shows an estimation of the amount of working capital per season that a typical CWS would require for each of the four production volumes. We observe that cherry costs are the most substantial part of the working capital requirement and thus are a critical factor for the CWS. Obtaining enough fund to cover the working capital of critical importance for the success during each coffee campaign unless one has enough financial cushion to self-finance which is the case only for very few powerful companies. Macciavello & Morjaria (2015) pointed out, access to finance is difficult

for CWS. Local Financial institutions are reluctant to advance loans to CWS due to their perceived riskiness and lack collaterals. When loans are granted, they are given with stringent terms and high interest rate. On top of the stiff competition for cherries, the CWS also must obtain a working capital loan large enough to obtain a certain volume of coffee but even more important the loan must have been granted on a timely manner.

Table 7: Estimation of the yearly working capital loan for a typical CWS

Row	**Output Production Levels**	**25 tons**	**50 tons**	**100 tons**	**200 tons**
1	Coffee cherry Purchase from Farmers or Suppliers **USD**	47,897	95,794	191,589	383,178
2	Total seasonal variable labor costs **USD**	10,579	12,403	16,051	25,900
3	Total transportation costs and others variable costs **USD**	1,252	2,504	5,006	10,011
4	Seasonal Fixed Cost **USD**	22,312	22,312	22,312	22,312
5	**Yearly Working Capital loan USD (r1+r2+r3+r4)**	**82,040**	**133,013**	**234,958**	**441,401**
6	Interest paid on working capital for the season @ 10%	8,204	13,301	23,496	44,140

As reported in row 1 of table 7 we see that for a CWS the most substantial cost for which a working capital loan is required is the coffee cherry costs. The total amount that must be financed by a working capital loan is reported in row 5 of table 7, for each of the four scales of CWS operations being considered. The amount of the interest expense for financing the working capital for the period will depend on the interest rate charged. In this analysis, we assume that the interest rate on a US dollar loan as being equal to 10 % per annum. These interest expense amounts are reported in row 6 of table 7.

The results in table 7 demonstrate that the working capital loan amount is a function of the volume of the cherry purchased, the mandated cherry price per KG, the interest rate charged, and the number of staff employed and their respective salaries. Any change in these variables would result in either an increase or decrease in the

amount working capital loan required in each season. As the volume of cherry purchased increase, the working capital loan amount will also increase. We clearly see that in such an environment, only CWS that have the ability to obtain large amount of working capital loans and subsequently purchase a large volume of cherry would thrive in the long run. The zoning policy contributes to the riskiness of CWS given that obtaining a loan is no guarantee that the CWS would be able to find enough coffee cherry within its zone to purchase.

4.3.1.5 The Total Operating Cost

The total financial operating cost of processing $\tilde{Q}_t$ tons of parchment coffee per season at a CWS is given by the sum of the seasonal variable costs $TV(\tilde{Q})_{\widehat{f.t}}^{F}$, the seasonal fixed costs, $TFC_{\overline{f.t}}^{F}$ and the financing costs of the working capital $\hat{I}_t$. This is shown in equation (7)

$$TC_{\widehat{op.t}}^{F} = TV\left(\tilde{Q}\right)_{\widehat{f.t}}^{F} + TFC_{\overline{f.t}}^{F} + \hat{I}_t \qquad (7)$$

4.3.1.6 Present Value of Costs

Equations (3) to (5) show the computation of a CWS just for a single season which is a limited time frame to gauge the worthiness of an investment. In order to measure the attractiveness of a project one needs to measure the cost for the entirety length of the project duration this is best capture by the using the present value of cost (PV) concept. The PV entails discounting a series of cash flows that will occur over the lifetime of a project back to the starting year or the first year. The discount rate used is the assumed rate of return an investor considering implementing the said project would require for taking the risk of investing. In our case, we assume that an investor in a CWS would be satisfied with a real rate of return of 12% per annum.

Equation (8) describes the PV of the total volume of Parchment coffee in KG produced by a CWS over a period of 10 years. Equation (9) shows the PV of the total

financial cost of processing parchment coffee at a CWS over a 10 years period it is noted by the variable $PV_T C_{\tilde{q}}{}^F$ which comes from the summation of the PV for seasonal variable costs $TV(\tilde{Q})_{\widehat{f.t}}$, the PV of seasonal fixed cost $TFC_{\overline{\overline{f.t}}}{}^F$, and lastly the PV of the initial investment cost $(I_{\bar{k}_t})$. The PV of the total volume of parchment produced is given by (8)

$$PV(\tilde{Q}_t)^F = \sum_{t=0}^{T=11} \frac{(\tilde{Q}_t * 1000)}{(1+r)^t} \tag{8}$$

Given that in a year there is only one coffee season in Rwanda, the number of years thus corresponds to the discounting period. Table 9 shows the present value of the levels of production and the financial costs of or three levels of output from CWS over a period of 10 years.

$$PV_T C_{\tilde{q}}{}^F = \sum_{t=0}^{T=10} \frac{TV(\tilde{Q})_{\widehat{f.t}}{}^F + TFC_{\overline{\overline{f.t}}}{}^F + (I_{\bar{k}_t})}{(1+r)^t} \tag{9}$$

Table 8: Table of parameters for the financial analysis Equations (3) - (9)

Parameters	Definition
	Financial Analysis
$NPV_{\tilde{q}}^F$	Financial net present value, as of year t= 0 (2022) for a production level of q̃ metrics tons of parchment.
$P_i{}^F$	Parchment Coffee Financial Selling price per KG
$\tilde{Q}$	Production scales in metrics tons of parchment. (25 tons, 50 tons, 100 tons, 200 tons)
$PV_T C_{\tilde{q}}{}^F$	PV of Total Processing Cost of parchment coffee for a production scale of $\tilde{q}$
$TV(\tilde{Q})_{\hat{f}}{}^F$	Total Financial variable cost of processing parchment for a season
r	Real Financial discount rate
$TFC_{\bar{f}}{}^F$	Total Financial seasonal fixed cost of a CWS for a season
$ap_{c_{\tilde{q}}}{}^F$	Average Financial cost of processing a KG of parchment coffee for production scale of $\tilde{q}$
$P_{\ddot{C}}{}^F$	Financial Fixed Price for 1 KG of cherry set by Government at the beginning of each season.
wc_p	Working capital per season
$c_{\ddot{q}}{}^F$	Average Financial Cherry cost per KG of parchment coffee produced
$I_{\bar{k}}$	Total Financial Initial capital cost for a washing station

Table 9 : Financial present value at 12% of the outputs and costs for four production levels of a CWS for 10 years

Row		25 tons	50 tons	100 tons	200 tons
1	PV of parchment coffee produced in KG	141,256	282,511	565,022	1,130,045
2	PV of total seasonal variable labor in **USD**	59,773	70,079	90,690	146,341
3	PV of total transportation costs and others variable costs in **USD**	7,077	14,147	28,286	56,566
4	**PV of Total seasonal Var. Costs without Financing** in **USD**	**66,850**	**84,226**	**118,976**	**202,907**
5	PV of total seasonal fixed labor costs and other in USD	126,065	126,065	126,065	126,065
6	PV of interest paid on working capital loans USD	46,354	75,155	132,756	249,401
7	**PV of Total Seasonal costs with Financing in USD (r4+r5+r6)**	**239,269**	**285,446**	**377,797**	**578,373**
8	PV of Total Investment Costs in USD	200,034	200,034	200,034	200,034
9	**PV of Total Cost of Processing at CWS in USD (r7 +r8)**	**439,303**	**485,480**	**577,831**	**778,407**

The results of the financial analysis are presented in table 9 for the PV of costs and table 11 for the average processing cost per KG of fully washed coffee. We obtained the results in table 9 by applying (8) and (9). Equation (9) can be broken into three separate equation). From the values for the PV of total seasonal processing costs table 9, row 7 we find that there are substantial economies of scale. The PV of total seasonal processing costs for a 200 tons operation is $578,373 while the total seasonal processing costs of a 50-ton level of operation is $285,446. While the total production of the 200 tons CWS is 4 times larger than the production of the 50 tons CWS, its total seasonal costs however only the double of that of the 50 tons CWS and the fixed capital costs are the same in both instances.

When fixed costs are included (table 9 row 8). We find that the total long-term costs of the larger operation are only 1.6 times as large while producing four times as large an annual production. We now turn to examining the overall profitability of the operations of a CWS as measured by the financial net present value and the internal rates of return for such operations.

4.3.1.7 The Financial Net Present Value of an Investment in a CWS

We now turn to examining the overall profitability of the operations of a CWS as measured by the financial net present value and the internal rates of return for such operations.

The NPV of a CWS is obtained by deducting from the present value of sale revenues of parchment coffee the present value of the total cost incurred over a period of 10 years including the initial investment cost. We compute the NPV for the four assumed production scale of parchment coffee namely: 25 tons, 50 tons, 100 tons and 200 tons using equation (10). Where the variable P_i^F is the net export price for each KG of internationally sold parchment coffee. In our case we use the average net price at which the Rwandan coffee was exported in the year 2022 which is \$5.5/KG

$$NPV_{\tilde{q}}^{F} = \sum_{t=0}^{T=10} \frac{\left[\left(P_i^F * \tilde{Q}_t * 1000\right) - \widehat{TC_{op.t}}^F - \left(I_{\bar{k}_t}\right)\right]}{(1+r)^t} \quad (10)$$

Table 10: Financial net present values for a CWS for a period of 10 years and 12% discount rate

Row		25 tons	50 tons	100 tons	200 tons
1	PV of parchment Revenues in USD	776,906	1,553,810	3,107,621	6,215,247
2	PV Coffee cherry purchased in USD	270,630	541,260	1,082,519	2,165,039
3	PV of total cost of processing at CWS in USD	439,303	485480	577,831	778,407
4	**Net Present Value in USD**	**66,973**	**527,070**	**1,447,271**	**3,271,801**
5	**Internal Rate of Return (%)**	**18.33%**	**50.75%**	**94.55%**	**146.52%**

The results from table 10 show our NPV results using (10). The results reveal that for an operating period of 10 years, and a price of parchment fixed at 5.5 USD/kg. a washing station would realize a positive financial NPV of 66,973 USD if it were able to produce 25 tons of parchment coffee per season. Such level of outputs would be attained if the washing station were able to purchase 125 tons of coffee cherry. The

chosen a net export price per KG of parchment of 5.5 USD is a rather conservative assumption. From the information we gleaned from our discussion with CWS operators, it became evident that CWS could potentially obtain higher prices depending on the contract they have the entity which is their overseas customers. As the level of outputs increase, we observe that the NPV gets higher to 527,070 USD for a production of 50 tons of parchment per season finally reaching 3,271,801 USD for an output level of 200 tons of parchment per season.

The NPV results demonstrate that an investment in a CWS could potentially be a very lucrative endeavor which is one of the reasons why it is appealing to investors. This profitability however is contingent on three important conditions: Firstly, a CWS must be able to secure financing in the form of a working capital loan to covers its operating expenses prior to the beginning the season. Secondly, the station must be able to purchase enough cherry within its zones to cover it operations lastly, the CWS must have secured a contract with one or many oversea customers for the purchase of its parchment. In the event the contract is not secured in a timely manner or not secured at all, the CWS would ineluctably sell its outputs domestically to another exporter for much lower prices.

The PV of costs and the PV of the outputs of parchment produced as reported in Table 9 will be used in the computation of average cost per KG of parchment produced by each of the three production levels of CWS. This is done by taking the ratio of the PV of the costs to the PV of the outputs for each level of parchment production scales of CWS.

4.3.1.8 Parchment Coffee Average Variable and Long Run Production Costs

In order to ascertain if farmers are properly compensated in comparison to the owners of CWS, we need to determine the margins CWS are making per KG of

parchment coffee sold. This necessitates the computation of parchment average processing costs at CWS. The results in table 11 from row 1 to row 9 are found by taking the ratio of the PV of costs by the PV of outputs for each cost category item. More specifically, in order to obtain the results in row 1 of table 10 for instance, we take the ratio of row 2 of table 3 to row 1 of table 8. We repeat the same procedure till row 9.

Row 7 of table 11 shows the average seasonal operating cost of processing 1 KG of parchment coffee or fully washed coffee per season at a generic CWS in Rwanda. We also call it the short run cost per KG of processing parchment coffee. The value of total variable costs used to estimate this variable excludes from the computation of total costs the initial investment cost needed to open a CWS. The short run cost tells us how much the CWS spends to process a KG of parchment for the different production volume during the season.

The long run perspective is that of an investor who is considering making the initial investment to enter the sector. However, it is the short run costs that are relevant in making the day to day operating and buying cherry decisions when the fixed capital investment has already been made. This distinction is important because a CWS after it has made the initial investment (hence it is a sunk cost), would normally continue operating its existing plant as long as the price of parchment coffee is at least equal to its average seasonal variable cost per KG of parchment.

The results in row 7 of table 11 represent a gauge of efficiency of the CWS in the short run meaning for a season, the lower it is the more efficient the CWS is at processing parchment. The CWS would ideally want to process coffee at the lower cost possible. When we include the initial investment costs to row 7, we obtain row 9 which shows the total cost of processing a KG of parchment coffee at the CWS. We

also refer to it as the long run cost of processing a KG of parchment coffee. When the CWS produces 25 tons of parchment coffee, its operating cost per season or the short run cost is 1.69 USD per KG of parchment coffee its total costs per KG is 3.11 USD.

Table 11: Financial average short run and long run unit processing costs in USD per Kg of parchment coffee.

Row		25 tons	50 tons	100 tons	200 tons
1	Average seasonal variable labor production costs per KG[2]	0.42	0.25	0.16	0.13
2	Average transportation costs and others costs per KG	0.05	0.05	0.05	0.05
3	**Average Seasonal Variable Costs without Financing per KG**	**0.47**	**0.30**	**0.21**	**0.18**
5	Average seasonal fixed labor costs and others per KG	0.89	0.45	0.22	0.11
6	Average of interest paid on working capital per KG	0.33	0.27	0.23	0.22
7	**Average Total Seasonal Production Costs per KG (r3+r5+r6)**	**1.69**	**1.02**	**0.66**	**0.51**
8	Average Total Investment Costs per KG	1.42	0.71	0.35	0.18
9	**Average Total Financial cost of processing a KG of Parchment (r7+r8)**	**3.11**	**1.73**	**1.01**	**0.69**

4.3.1.9 Producer Surplus and Profit Margins with Regulated Cherry Prices

Row 5 of table 12 shows the profits a typical CWS would realize per KG of parchment coffee processed per season for the four respective production levels. We notice that when the station processes 50 tons of parchment coffee it enjoys a net profit of 1.85 USD per KG. If on the other hand it achieves a production volume of 100 tones, the profit climbs to 2.57 USD /KG finally, the profit per KG soars to 2.89 USD/KG if the CWS can process 200 tons of cherry. Those profits unveil one of the reasons why CWS are enticing to investors and why there has been a surge of CWS in Rwanda since 2003. However, the results also testify to the fact that the ability to purchase a large amount of cherry from farmers is of paramount importance. In the value chain cherry is the sinews of war. This is further exacerbated by the fact that Rwanda

[2] Row 2 of table 4 divided by row 1 of table 4. We follow the same for the rest of items in the table.

production levels are low and stagnant the number of CWS is high and each kg of parchment necessitates on average 5 KG of coffee cherries.

Table 12: Producer surplus and profit per kg of parchment coffee

Row		25 tons	50 tons	100 tons	200 tons
1	Net Export Price USD/KG	5.5	5.5	5.5	5.5
2	Average total seasonal production costs per KG	1.69	1.02	0.66	0.51
3	Cost of Cherry input per KG of coffee if cherry price is 410 RwF per KG[3]	1.92	1.92	1.92	1.92
4	**Producer Surplus ($/KG)** (r1-r2-r3)	**1.89**	**2.56**	**2.92**	**3.07**
5	**Profit ($/ KG) of coffee if cherry price is 410 RwF /KG**	**0.47**	**1.85**	**2.57**	**2.89**

4.3.1.10 Equilibrium Cherry Prices in a Competitive Industry

The next step in this analysis entails estimating what would be the price of cherry if the CWS industry operated under perfect competition. In other words, what would be the price of a KG of coffee cherry if it were increased to the point where the industry would just earn a rate of return sufficient to attract investors into the CWS sector. Simply put, what should the price of a KG of coffee cherry be so that each CWS in the industry make a zero economic profit. We refer this price as the break-even price of coffee cherry. This will be carried out under two cases. First, the long run equilibrium price of cherry is estimated for alternative assumptions concerning the long run selling price at the CWS of parchment coffee. This is characteristic of the long run situation for an industry where firms are making investments to enter the sector and at the same time, the supply of cherry is not perfectly elastic at any given price. For this analysis we are assuming that a 12 percent real rate of return would be sufficient to attract investors into the sector.

3 PV of costs of cherry purchased divided by row 1 of table 4.

The second case considers the short-term situation where the investment has already been made in CWS in the sector and a surplus of investment has been made in CWS. In this case it is assumed that the current investment in the coffee washing stations is a sunk cost. Furthermore, it was assumed that the supply of cherry in the short run is fixed at the total supply in the country.

In each of these two cases the analysis is carried out under four different assumptions about the scale of production of a representative CWS. In this way we can separate the analysis of what is the degree of price suppression of cherry due to the impact of the fixed selling price, enforced by the zoning regime, and the cherry price suppression due the fact that the economic conditions were created to allow too many CWS to be set up in Rwanda.

In order to find the equilibrium price of cherry, the estimation must consider the fact that the size of the working capital loan and the annual interest expense, as calculated in table 2 with a 10% real (net of inflation) interest rate would increase as the price of cherry is bid up. To find the break-even price of coffee cherry (RwF / KG) of table 13 and table 14, we first need to find the margin per KG available for the CWS to purchase cherry. Meaning the amount of money per KG, a CWS would have left at its disposal for the purchase of cherry after covering its entire costs except the cost of the purchase of cherry and interest expense incurred on the cherry purchase portion of working capital loan.

The margin available for the purchase of cherry in the long run $M_{\overline{LB}}$ is found using the average total seasonal production cost of a KG of parchment coffee (table 11 row 7, excluding the financing costs associated with the purchase of cherry). The margin is further reduced by the deduction is the average fixed investment costs per KG (table 11 row 8) denoted as $ap_{I_{\overline{k}_t}}$.

$$M_{\widetilde{LB}} = \left[P_i^F - \ ap_{M_{\tilde{B}}} - \ ap_{I_{\bar{k}_t}}\right] \quad (11)$$

The margin available for the purchase of cherry in the short run $M_{\widetilde{SB}}$ treats the initial investment cost in a CWS as a sunk cost, and it is estimated using equation (12),

$$M_{\widetilde{SB}} = \left[P_i^F - ap_{M_{\tilde{B}}}\right] \quad (12)$$

The average interest paid on the cost of cherry purchase is excluded from both equation (11) and (12) this is to avoid counting it twice as it would be included in the computation of the working capital under the new set of coffee cherry prices. Given the margins available for cherry purchase the maximum price that could be paid for cherry in the long run analysis is given by equation (13). The maximum price of coffee cherry that the CWS could potentially be offered $P_{\widetilde{LB}}$ is estimated for the four chosen scale of production and for parchment coffee export prices P_i^F ranging from \$5/KG to \$7/KG. $E_{\tilde{x}}$ is the exchange rate between RWF and the USD. The variable r_s is the interest rate charged on the working capital which as in table 1 is assumed to be 10%. The variable $\bar{\bar{q}}$ is the number of KG of coffee cherry needed to produce a KG of parchment coffee.

$$P_{\widetilde{LB}} = \frac{M_{\widetilde{LB}}}{\bar{\bar{q}} * (1 + r_s)} * E_{\tilde{x}} \quad (13)$$

The estimates of the competitive price of cherry are presented in table 13 for the long run scenarios. In this case, we continue to assume that the industry is characterized by CWS of an average production of 25, 50, 100 and 200 tons of parchment coffee and facing average net long run export prices of parchment coffee ranging from \$5.00 to \$7.00. The analysis is carried out still assuming that the life of a CWS is 10 years. At each of these set of parchment export prices in table 13 and table 14, the cherry prices per KG are calculated that would cause the CWS to just break even. In such a case, there would be a zero economic profit each year and

subsequently an NPV of zero over the entire lifetime of the project. However, at each of these sets of parchment and cherry prices the owner of the CWS therefore is earning a competitive real rate of return on its investment of 12 percent.

Table 13: Long run break-even price of coffee cherry (RwF / KG)

Row	Net Export price (USD per KG) Parchment Coffee	Annual Production			
		25 tons	50 tons	100 tons	200 tons
1	5.00	405	673	807	871
2	5.50	**501**	**770**	**903**	**968**
3	6.00	598	866	999	1,064
4	6.50	694	962	1,096	1,160
5	7.00	790	1,058	1,192	1,257

The results in table 13 show that, under the current situation, where a KG of coffee cherry is fixed at 410 RwF, a CWS producing 50 tons of parchment coffee would be willing to pay 770 RwF / KG and it will still be able to make a real rate of return of 12%. The price of 770 RwF is 88 % greater than the current regulated price. If on the other hand, we assumed that each CWS processes on average 200 tons of parchment coffee per season, then they would be willing to pay 968 RwF/KG of coffee cherry meaning more than the double of the current fixed price. The difference between those two prices is 558 RwF/KG or 136%. We clearly see that if by dint of a fiercer competition, the number of CWS were to be reduced by 4 (meaning 75 CWS each on average producing 200 tons of fully washed coffee) then farmers would gain substantially early price for each KG of coffee cherry.

This analysis shows that the long run effects of the combination of coffee zones and a regulated price of cherry have clearly resulted in the creation of an inefficient industry with overinvestment in CWS. In addition, those two policies have not

provided sufficient incentives to Rwandan farmers to replant their coffee trees and expand production.

In order to find the maximum per KG price that a CWS owner would be willing pay for coffee cherry during a given season, we need to compare the short run average cost with the selling price of parchment. In the short run, the capital investments in the CWS can be considered a sunk cost. The per KG price of cherry that would result in a zero profit, is found by replacing the numerator of equation (13) by $M_{\widetilde{SB}}$ (12). The maximum cherry prices in the short run are presented in table 14. In a short run scenario, the CWS would be willing to pay a price for cherry up to the point where the marginal producer surplus is zero. When the output price is $5.50/KG, the reported maximum price a CWS processing 50 tons of parchment would be willing to pay is 905 RwF/KG. This price for a KG of cherry is 120.07% greater than the prevailing price of 410 RwF /KG being paid to farmers. For a CWS operator who wishes to get its production to a level of 200 tons/year, they would be willing to pay up to 1006 RwF/KG for cherry, or a price that is 145.37 %, above the current regulated cherry price.

From the previous analysis, it is clear why it is important for owners of CWS to seek expanding their production volume of parchment coffee by purchasing additional quantity of coffee cherry. With the government mandated cherry price of 410 RwF/KG, there is a high incentive to engage in the illicit purchase coffee cherry by offering higher per KG prices despite the threats of punishment from authorities. Some unofficial reports indicate there have been instances where some CWS offered prices as high as 800 RwF/KG to farmers despite the threat of sanction from authorities. It should also not be a surprise then that the government has been forced to abandon its

zoning policy restricting the area in which of individual CWS can legally buy coffee cherry.

Table 14 : Short run break-even price of coffee cherry (RwF / KG)

Row	Net Export price (USD/ KG) Parchment Coffee	Annual Production			
		25 tons	**50 tons**	**100 tons**	**200 tons**
1	5.00	678	809	875	905
2	**5.50**	**775**	**905**	**972**	**1006**
3	6.00	871	1002	1068	1098
4	6.50	967	1098	1164	1194
5	7.00	1064	1194	1260	1290

4.3.1.11 Lost to Farmers as a Result of Government Pricing Policy and Excess Investment in CWS

According to the latest figures from the national agriculture export board of Rwanda NAEB (2023) Annual Report (2021-2022), the country exported around 15000 tons of fully washed coffee in 2022. The production of coffee in Rwanda has been and usually oscillates between 18,000 tons to 23,000 tons per year. We will therefore use this figure of 15000 tons as the production benchmark level for Rwanda to evaluate inefficiencies in CWS in Rwanda.

The difference between the government-imposed price of 410 RwF per kilo and the long run break-even price of row 2 of table 13 represents the average loss incurred by farmers for every kilo of parchment processed at the CWS. These are the losses imposed on the farmers from the cherry pricing and regulatory policy designed by the government for this sector. In table 15 estimates of these annual losses are presented

for the case when the average long run price of parchment coffee is $5.50/ kg with an annual quantity of exports of processed coffee exported of 15,000 tons.

Table 15: Annual aggregate long run losses to Rwandese farmers due to low regulated cherry prices

Col 1	Col 2	Col 3	Col 4	Col 5
	25 tons	**50 tons**	**100 tons**	**200 tons**
Long run parchment price a $5.50/KG	501	770	903	968
Fixed cherry price 410 RwF/KG	410	410	410	410
Difference per RwF/KG	91	360	493	558
Annual Loss to coffee growers in Millions RwF	**6,825**	**27,000**	**36,975**	**41,850**
Annual Loss to coffee growers USD	**6,378,505**	**25,233,645**	**34,556,075**	**39,112,150**

Table 15 row 1 col 3 reports that in order a CWS owner producing 50 ton of parchment coffee a year to earn a real rate of 12 percent, the breakeven price for cherry has to be 770 RwF. This means that the farmers are potentially losing 360 RwF/KG of cherry they sell to the CWS. Considering that 15,000 tons of parchment coffee are exported the loss to the Rwandan coffee farmers is 25 billion RwF or $25,233,645 per year. This is the loss from the restriction on the price of cherry, given the inefficient over investment in washing station so that on average they only produce 50 tons/year of parchment coffee. This is essentially the amount of income that is being transferred from the farmers to the owners of the CWS over and above the amount received by the owners of the CWS to compensate them for the higher costs they incur because of the inefficient investment and operations of the sector.

From table 15 row 5 col 4 the annual loss to the coffee growers with the price ceiling of 410 RwF/KG for cherry would have been $39,112,150 if the industry had been more efficient with only 25% as many CWS with each producing on average 200 tons/year of parchment coffee. The difference between the annual loss at 200 tons

capacity $39,112,150 and the loss at the 50 tons capacity $25,233,645 is $13,878,505. This loss is created by the greater investment and operating costs incurred by the owners and operators of the CWS because of excess number of CWS that has emerged because of the policy framework designed by the government over time. This analysis is being carried out in a static framework where the amount of coffee exported is fixed at 15,000 tons/ year. A major current problem with the sector is that with the existing price structure farmers are unwilling to invest in replanting and expanding their coffee trees. There is little doubt that the attitude of the farmers toward investing in replanting and expanding their coffee groves would be greatly enhanced by these potentially much higher prices.

4.3.2 Economic Analysis of an Investment in a Generic CWS

The financial analysis estimates how much it costs private owners of a washing station to produce parchment coffee. It focuses on profitability of a project from the viewpoint of private investors and bankers. An economic analysis on the other hand focuses on whether a particular project has had a positive or negative impact on the entire aggregated members of society. Unlike the financial appraisal whose concern is limited solely to the viability of an investment project from the perspective of a private individual or a private entity, the economic analysis aims rather at accessing the welfare impact that a project has on the societal level. An economic analysis is necessary in order to gauge a project contribution to the economic welfare of the society in which it is implemented. The economic analysis is conducted using shadow prices instead of financial prices which are observed in the marketplace. Under a perfectly competitive and efficient Market, shadow prices would be equal to financial prices. However, in the real-world financial prices are distorted by inefficiencies, such as duties, taxes, subsidies, and exchange rate policies, asymmetric information to name

all but a few. Those distortions create disparities between market prices and the marginal social value of goods and services.

Shadow or economic prices on the other hand, encompass the marginal value of goods and services to the society. In other words, the appraisal seeks to answer the question what is the societal opportunity cost of the inputs and outputs that are employed in a project. When a project generates an economic NPV that is greater than the one obtained under the financial analysis it means that the project generated positive externality on the society.

The economic analysis therefore evaluates a project using the opportunity costs of these good and service in order to ascertain its true impact on the society.

We proceed by repeating the same equations we previously used, however this time we use economic prices and economic costs instead of financial ones. Economic prices and costs also referred to as shadow prices are obtained by multiplying the financial values by economic conversion factors that correct the financial prices for market distortions such as tax, import duties, subsidies, and foreign exchange premium (Jenkins et al. 2019).

The divergences between the economic and the financial evaluation are referred to as externalities. Externalities can be either positive or negative. The economic analysis uses as discount rate an economic opportunity cost of capital ($EOCK$). The EOCK also called social discount rate is the official rate that should be used in order to evaluate the worthiness of implementing publicly funded projects. It is a measure of the opportunity cost of funds used in a project Harberger (1972), Zhuang et al. (2007), Chun -Yan Kuo et al. (2003). Stiglitz (1983). The social discount rate

recommended by the Rwandese Ministry of Finance and Economic Planning for an economic appraisal of a project in Rwanda[4] is 13%.

Shadow prices and economic costs used to transform financial values are similarly obtained from the website of Ministry of Finance and Economic Planning of Rwanda. The exact estimation procedure to obtain those conversion factors and social discount rate is beyond the scope of this dissertation. The variables and symbols used in the subsequent equations have the same meaning as in the financial analysis however we use the superscript E to emphasize that we are now dealing with economic values.

4.3.2.1 The Total Economic Seasonal Variable Costs

The total seasonal variable economic cost of a CWS for a single year is found using (14)

$$TV(\tilde{Q})_{\hat{f}}^{E} = [(n(\tilde{Q}) * D_{op} * D_{\widehat{lab}\tilde{q}}^{E}) + (\tilde{Q} * 1000 * (c_{\widehat{trans}\tilde{q}}^{E}) + T(\tilde{Q})_{\widehat{oth}}^{E}] \quad (14)$$

The Total Economic Seasonal Fixed Cost of a CWS is found using (15)

$$TFC_{\overline{f.t}}^{E} = \left[\left(n_t * T_{Mths} * w_i^{E}\right) + FC_{\overline{o.t}}^{E}\right] \quad (15)$$

The Economic PV of the total parchment produced is found using (16):

$$PV\left(\tilde{Q}_t^{E}\right) = \sum_{t=0}^{T=11} \frac{(\tilde{Q}_t * 1000)}{(1+EOCK)^t} \quad (16)$$

4.3.2.2 PV of Total Economic Processing Cost of Parchment Coffee

The present value of the total economic cost of processing parchment coffee is the sum of the economic PV of Seasonal Variable Costs $TV(\tilde{Q})_{\widehat{f.t}}^{E}$, the economic PV of total seasonal fixed cost $TFC_{\overline{f.t}}^{E}$, and the initial investment cost $I_{\overline{k.t}}^{E}$. The total economic cost of processing is expressed by equation (17).

[4] For more information, please consult the Commodity-Specific Economic Conversion Factors Database for the Republic of Rwanda. Available online at: https://rwanda-cscf.cri-world.com/

$$PV_T C_{\tilde{q}}{}^{E} = \sum_{t=0}^{T=10} \frac{TV(\tilde{Q})_{\overline{j.t}}{}^{E} + TFC_{\overline{f.t}}{}^{E} + I_{\overline{k.t}}{}^{E}}{(1+EOCK)^t} \quad (17)$$

4.3.2.3 Economic Average Costs of processing Parchment Coffee

The Average Economic cost of processing a KG of parchment coffee (18) is found by taking the ratio of (15) to (14). It gives use a measure of how much it cost the Rwandan economy to process a KG of parchment coffee at a CWS of a specific production scale.

$$ap_{c\,\tilde{q}}{}^{E} = \frac{PV_T C_{\tilde{q}}{}^{E}}{PV(\tilde{Q})^E} \quad (18)$$

The results of the present values of economic costs and outputs at a CWS of different production scale are listed in the table 17.

Table 16: Table of parameters for the economic analysis equations (9) - (18)

	Economics Analysis
EOCK	Economic opportunity cost of capital
$\tilde{Q}$	Production scales in metrics tons of parchment. (25 tons, 50 tons, 100 tons, 200 tons)
$NPV_{\tilde{q}}^{E}$	Economic net present value, as of year t= 0 (2022)
$PV_T C_{\tilde{q}}{}^{E}$	PV of Total Economic Processing Cost of parchment coffee
$ap_{c\,\tilde{q}}{}^{E}$	The Average Economic cost of processing a KG of parchment coffee
$P_{i}{}^{E}$	Parchment Coffee Economic Selling price per KG
$TV(\tilde{Q})_{\hat{j}}{}^{E}$	Total Economic Variable Cost
$TFC_{\bar{f}}{}^{E}$	Total Economic Seasonal Fixed cost
$P_{\ddot{c}}{}^{E}$	Economic Floor Price for 1 KG of cherry set by Government at the beginning of each season.
$c_{\ddot{q}}{}^{E}$	Average Economic Cherry cost per KG of parchment coffee produced
$I_{\bar{k}}{}^{E}$	Total Economic Initial capital cost for a washing station

Table 17 : Economic present value at EOCK 13% of the outputs and costs for the 04 production levels of a CWS for 10 years.

Row		**25 tons**	**50 tons**	**100 tons**	**200 tons**
1	PV of parchment coffee produced in KG	120,050	240,099	480,199	960,397
2	PV of total seasonal variable labor in **USD**	47,506	67,301	87,095	140,540
3	PV of total transportation costs and others costs in **USD**	5,954	11,907	23,815	47,630
4	**PV of Total Seasonal Variable Costs** in **USD**	**53,460**	**79,208**	**110,910**	**188,170**
6	PV of Total Seasonal Fixed labor costs and others in USD	105,829	105,829	105,829	105,829

7	**PV of Total Seasonal Costs (r4+r5+r6)**	**159,289**	**185,037**	**216,739**	**293,999**
8	PV of Total Investment Costs in USD	176,479	176,479	176,479	176,479
9	**PV of Total Economic Cost of Processing at CWS in USD (r7 +r8)**	**335,768**	**361,516**	**393,218**	**470,478**
10	**Average Total Long Run Economic Cost of Processing a KG of Parchment**	**2.80**	**1.51**	**0.82**	**0.49**

Row 10 of table 17 reports the estimated average long run total economic costs required to process 1 KG of parchment coffee in washing stations for different production levels. These long run average economic costs are estimated by taking the ratio of 9 to row 1 of table 17. We see that when a washing station produces 25 tons of parchment coffee, the economic total economic cost or long run cost is $2.80 per kg. On the other hand, if the washing station produces 50 tons of parchment coffee, the long run economic cost per KG of parchment to Rwanda drops to $1.51/KG while the total economic cost or the long run cost of a 100 tons production volume is $0.82 per KG. Lastly, when the total economics cost per KG falls to $0.49 per KG if the CWS achieve a production level of 200 tons. As it was the case of the financial analysis, we observe that as the volume of parchments processed increases the cost per unit decreases.

The long run average total economic costs are somewhat lower than financial cost in all the three production levels. For the financial costs we have $3.11/KG, $1.73/KG, $1.01/KG and $0.69/KG, respectively, for production levels of 25 tons, 50 tons, 100 tons and 200 tons. This downward adjustment of the financial costs to their economic value arises primarily because there are several taxes on such items as fuel that are included in the financial costs but not economic costs. Also, for some of the types of labor used in the CWS the economic opportunity cost of labor is less than the wages paid.

4.3.2.4 Estimation of Economic Loss to Rwanda from Excess Capacity of Coffee Washing Stations

The coffee sector in Rwanda is facing the twin problems of having an excess capacity in CWS and at the same time a shortage of cherry. At the present time there are approximately 300 licensed washing stations in Rwanda and an annual production of 15,000 tons of parchment coffee. Hence, on average a CWS produces 50 tons/year of parchment coffee. The following analysis estimates the economic cost of processing the annual production of 15,000 tons of parchment coffee using current the average production of a washing station 50 tons as compared to the cost if the average annual washing station production was 100 tons or 200 tons. The difference between the total cost incurred bore by 300 CWS during a season and lower number of CWS represents the losses Rwanda suffered for a period. 150 CWS and 75 CWS would be needed to respectively produce on average 100 tons and 200 tons a season.

4.3.2.5 Rwanda's Potential Yearly Economic Costs Saving

From table 18 we find that the average total long run economic cost of producing parchment coffee with a CWS producing 50 tons a year (${ap_{c_{\widetilde{50t}}}}^{E}$) is \$1.51/kg. With an annual production of 15 million/KG the total annual production costs are estimated to be \$22,585,434. Similarly, with a CWS producing 100 tons, the average total long run economic cost of producing parchment coffee (${ap_{c_{\widehat{100t}}}}^{E}$) is \$0.82/KG. The total annual production costs are estimated in this case would be \$12,282,970 and 150 CWS would be needed to maintain the production of parchment coffee at 15 million KG.

The yearly saving on Economic costs to Rwanda if the number of CWS reduces from 300 CWS to 150 CWS is given by (19)

$$15\ Million\ KG * \left[{ap_{c_{\widetilde{50t}}}}^{E} - {ap_{c_{\widehat{100t}}}}^{E}\right] \tag{19}$$

Similarly, the yearly saving on Economics costs to Rwanda if the number of CWS reduces from 300 CWS to 75 CWS is given by (20)

$$15\ Million\ KG * \left[ap_{c\widetilde{50t}}{}^{E} - ap_{c\widehat{200t}}{}^{E}\right] \quad (20)$$

Table 18: Rwanda's potential yearly economic costs savings

Col 1	Col 2
PV of total Economic processing costs of 15000 tons by 300 CWS	$22,585,434
PV of total Economic processing costs of 15000 tons by 150 CWS	$12,282,970
PV of total Economic processing costs of 15000 tons by 75 CWS	$7,348,180
Yearly Saving on Economic costs from 300 CWS to 150 CWS	**$10,302,463**
Yearly Saving on Economic costs from 300 CWS to 75 CWS	**$15,237,254**

If the number of washing station is greater than what would be optimal, it implies that the industry has captured economic resources that could have been better employed elsewhere. From table 18 row 1, we see that reducing the number of CWS by half would result in a total welfare saving of $10,302,463 per year to Rwanda. This amount is substantial and could potentially be used to offer higher prices to farmers for their coffee cherry instead of mandating a fixed price. If the number of coffee washing stations could be reduced further to 75 by having each produce 200 tons or parchment coffee/year, the economic resource savings as compared to the current situation would be $15,237,254 per year. This improvement would ultimately be beneficial for Rwanda as farmers will have more incentive to continue to farm coffee and invest in their plantations and the production volume of Rwanda will improve.

4.3.2.6 Total Economic Welfare loss to Rwanda due to the Oversupply of CWS.

In order to evaluate the overall economic losses created by the excessive number of CWS, we need to evaluate these costs over the life of CWS which we assumed was of 10 years. In the current situation, we have 300 CWS that process parchment coffee each at a present value ($PV_T C_{\widetilde{300}}{}^{E}$) of $335,768 so the total processing cost incurred by

300 CWS is therefore $122,554,061 over 10 years. The total economic welfare Rwanda could have saved if only 150 CWS[5] were operating instead of 300 is given by (21).

$$\left[\left(300cws * PV_T C_{\widetilde{300}}{}^{E}\right) - \left(150cws * PV_T C_{\widetilde{150}}{}^{E}\right)\right] \quad (21)$$

Similarly, the total economics welfare Rwanda could have saved if only 75 CWS were operating is given by:

$$\left[\left(300cws * PV_T C_{\widetilde{300}}{}^{E}\right) - 75cws * PV_T C_{\widetilde{75}}{}^{E}\right)] \quad (22)$$

The results from (21) and (22) are shown in table 15. They indicate that Rwanda would have saved over $66.650.387 if only 150 CWS were built instead of 300 CWS furthermore, if only 75 CWS were built, we notice that Rwanda could have approximately saved up to $73,168,950 over a period of 10 years. Those figures further confirm that the oversupply of CWS in Rwanda came in at a large economic cost to the country. In the long run, such policy is not sustainable if investments in coffee cherry production at farm level does not keep pace with investments made in the processing to enhance the end product of the value chain. As we have mentioned above, a large number of farmers are switching from coffee for other crops due to the low revenues they get.

Table 19: Total Economic welfare loss to Rwanda due to the oversupply of CWS

Col 1	Col 2
PV of total economic processing costs of 15000 tons by 300 CWS	$108,454,800
PV of total economic processing costs of 15000 tons by 150 CWS	$58,982,700
PV of total economic processing costs of 15000 tons by 75 CWS	$35,285,850
Economic costs saved if there are 150 CWS rather than 300	**$ 49,472,100**
Economic costs saved if there are 75 CWS rather than 300	**$ 73,168,950**

[5] $PV\_TC_{\widetilde{150}}$: PV of Total Economic Cost of Processing by 150 CWS each processing 100 tons on average
$PV\_TC_{\widetilde{300}}$: PV of Total Economic Cost of Processing by 300 CWS each processing 50 tons on average

4.4 Chapter Conclusion

Rwanda is facing serious threats to the sustainability of its coffee industry in the long-term stemming from two main factors: first, a large proportion of its coffee plants are older than 30 years, therefore their production yields are low and stagnant. Secondly, many farmers are leaving coffee production for other crops that are deemed more profitable due to the low revenues they obtain from the sale of their harvest Miklyaev et al. (2021) In the early 2000s, Rwanda mindful of its small size and geographic characteristics shifted its focus from producing ordinary coffee to the production of specialty coffee. This move was initially a sound decision and overall, it has been beneficial to Rwanda as it has unarguably reaped many benefits from the production of specialty coffee. Nowadays, the country has become an important player in the specialty coffee niche and coffee is one Rwanda's main source of foreign exchange.

However, once Rwanda moved away from ordinary to specialty coffee, the high coffee prices the first exporters got at the inception of this trend generated a rush to build washing stations largely fuelled by the eagerness of international donors and the Government to support the nascent niche with easy financing and technical assistance. The number of CWS has increased from 2 in the 2002 to a little over 300 in 2022. As the number of washing stations increased due to the lure of high revenues as well as the almost no barrier to entry, an increasing substantial number of them went out of business due to their inability to survive the competition or fund their activities.

To tackle this growing issue, the Government of Rwanda opted to implement a zoning policy in 2016 that was effective until June 2023. The zoning policy restricted the purchase and sales of coffee cherry within the confines of a specific geographic area thereby guaranteeing to a certain extent the availability of coffee cherry to

washing stations within that zone. The government also maintained the long-standing policy of setting a fixed per kg price for coffee cherry at the beginning of each harvest season. Infringing on these rules was a punishable offense in Rwanda.

The combined effect of the oversupply of CWS, the zoning policy, and the fixed per KG coffee cherry price gave rise to substantial inefficiencies with coffee farmers bearing the brunt of the cost caused by theses inefficiencies through being paid a lower price for coffee cherry than would be justified by market conditions.

It is unfortunate that the same eagerness to promote and maintain an excessive number coffee washing stations was not extended to supporting farmers growing coffee cherry. The welfare of farmers has not been keeping pace with the rush to invest in CWS to improve the quality of coffee sold by Rwanda on the international market.

The policy of upgrading the quality of coffee sold by Rwanda is not sustainable if investments in coffee cherry production at farms level does not keep pace with investments made in the processing segment of the value chain. This analysis indicates that if the profits that the CWSs are earning above a real rate of return of 13 percent paid out to the farmers through higher cherry prices, there would be a powerful incentive for farmers to replant and upgrade their coffee trees and make other necessary investments in their plantations.

This chapter presents a good illustration of the unintended consequences that occur when governments want to prop up and protect one component of the value chain of a sector by adopting ill-designed policies that end up restricting competition that is a detriment to the earnings of the primary producers. For a small economy such as Rwanda, the annual amounts of economic waste are substantial. The welfare savings resulting from the improvement in efficiency of washing stations would be beneficial first to coffee farmers if the prices of coffee cherry were allowed to rise. Secondly,

farmers would have more of an incentive to remain in coffee farming and invest in their coffee plantations. This would ultimately boost the coffee production volume of the country in the long run and allow the country to sustain its exports of specialty coffee and grow economically.

The government of Rwanda repealed the zoning policy in June 2023 thereby allowing CWS and farmers to trade without geographic restrictions. One caveat though is the fact that the Government is committed to continue the policy of setting a fixed price for coffee cherry moving forward. By letting competition for cherry take place this will likely result in farmers either officially or unofficially receiving higher prices. This will give the farmers an incentive to remain in coffee farming and make the needed investments required on their plantations to increase their production of coffee cherry. It will take time for coffee washing stations owners to optimize their segment of the coffee supply chain. However, over time the market forces if allowed to operate will likely significantly improve the livelihood of coffee farmers in Rwanda.

Chapter 5

AN INTEGRATED COST BENEFIT ANALYSIS OF A PROGRAM OF REJUVENATION OF COFFEE TREES IN RWANDA

5.1 Introduction

This chapter will be devoted to studying the coffee sector in Rwanda from the perspective of the coffee farmers and their financial welfare. The previous chapter demonstrated that the long-term viability of the broad coffee industry in Rwanda faces major hurdles and current policies in place are not sustainable. One of the main difficulties that the Rwandan coffee sector faces stems from the fact that a sizeable proportion of the coffee trees in the country are older than 30 years. The ageing of coffee trees is one of the reasons behind the low compensations that farmers receive for their cherries since those old trees cannot produce larger volumes. Farmers have limited incentives to remain in coffee farming and to make the necessary investments on their plantations. As yields are low and compensations paid to farmers remain financially unattractive, many farmers are abandoning coffee farming all together for other crops that are deemed more profitable Miklyaev et al. (2021). The abandonment of coffee farming and the slow renewal of its ageing coffee plants are some of the main factors behind the stagnation of the production levels in Rwanda.

Rwanda must tackle this growing challenge by designing policies and programs that would in the long run be beneficial to the coffee industry. One of such programs

would be to rejuvenate the entirety of the country coffee trees. Replanting coffee trees would in the long run be beneficial to all the main stakeholders of the Rwanda coffee industry. Firstly, Farmers will derive more income from supplying larger volume of coffee cherry to CWS, especially if the government lifts the restrictions on cherry prices as we proposed in the previous chapter. Secondly, the Government of Rwanda will increase its foreign exchange earnings as the volume of specialty coffee produced will increase. Replanting coffee trees will result in at least a fourfold increase in the production volume. A young Arabica coffee tree can produce five kilograms whereas trees that is 30 years old bare produces 1 KG of cherry per tree. Coffee washing stations would have greater volume of coffee cherry to process thereby alleviate the very fierce competition they face for the purchase of cherry. Given that the vast majority of farmers in the country face financial constraints, it is therefore unrealistic to expect them to be the driving force behind a vast program of rejuvenation of the country's coffee tree. The Government of Rwanda or an international development agency could fund such a venture.

The purpose of this chapter is many folds: Firstly, we would like to ascertain using the tools of cost benefit analysis the total funding requirement such a project would cost to the government of Rwanda if it were to embark on a vast coffee tree rejuvenation project throughout the country. Secondly, will evaluate the potential gains Rwanda farmers stands to obtain from such a program. Furthermore, we will gauge the potential revenue boost CWS and the government stand to have. Our analysis will entail a financial appraisal, an economic appraisal and lastly a stakeholder analysis which will ultimately ascertain the long-term impact that such a program would have on coffee farmers, the government and on Rwanda as a whole.

5.2 The Coffee Production Landscape in Rwanda

Before delving into the analysis is it important to have the lay of the land, in order to understand the current state of coffee production in Rwanda. According to the national agricultural and export board of Rwanda (NAEB), coffee is grown on 40000 hectares most of which are hillsides in high-altitude regions ranging from 5,600 to 7,200 feet. NAEB estimates that the country currently has approximately 100 million of coffee trees spread-out throughout the 04 major provinces of Rwanda: Table 20 shows the distribution of coffee tree across the 04 main provinces of Rwanda as of the year 2017. From discussions gleaned from officials at the ministry of agriculture, the majority of coffee trees in Rwanda that are in the 3-30 years brackets are older than 25 years old. Doubtlessly, the volume of coffee production in Rwanda would substantially be improved if a much lower proportion of coffee trees were older.

Table 20: Coffee trees age distribution in the 04 provinces of Rwanda as of 2017.

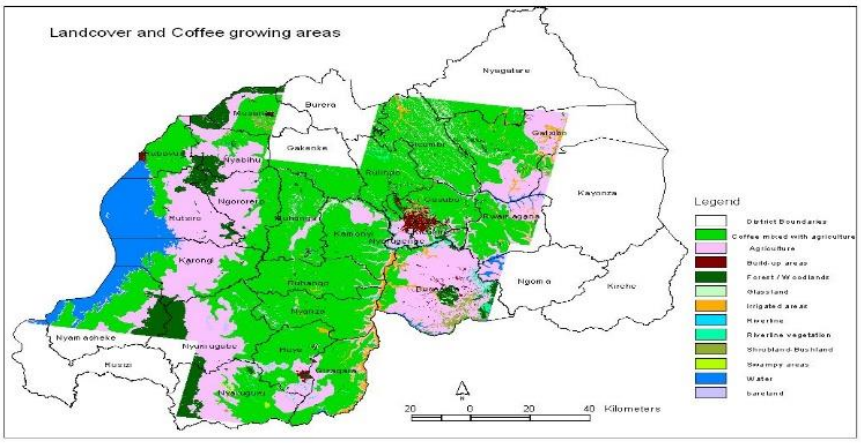
Coffee Tree Age Distribution	Northern	Southern	Western	Eastern
Proportion of trees 0 - 2 years	21%	13%	12%	19%
Proportion of trees 3 - 30 years	46%	52%	67%	64%
Proportion of trees > 30 years	33%	35%	22%	17%

Source: Cambridge Resources International (obtained from field trip in Rwanda)

Table 21: Area under cultivation for each of the 04 Provinces of Rwanda

Northern	Southern	Western	Eastern
4,308 Hectares	13,211 Hectares	14,113 Hectares	10,368 Hectares

Source: Cambridge Resources International (obtained from field trip in Rwanda)



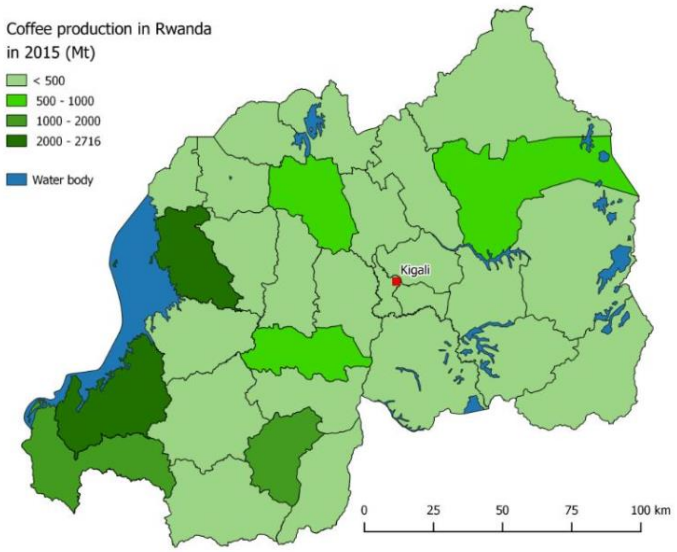


Figure 9: Coffee production map in Rwanda
Source: http://landscapeportal.org/

Figure 10: Administrative map of Rwanda

5.3 Characteristics of the Project of Coffee Plants Rejuvenation

Our project is evaluated over a period of 20 years meaning we assume the new coffee crops will be productive over a life span of 20 years. We choose 2024 as a starting year. Our analysis is conducted separately for each of the four main administrative provinces of Rwanda as shown in figure 11. Our analysis encompasses all the phases from land preparation to the sale of coffee to the final customers overseas. In order to gauge the impact of such a program on farmers' income, we will conduct the analysis under two scenarios: **Without intervention** and **with intervention case or recommended farming practice case**. The differences in benefits, costs and welfare ensuing from these two respective scenarios constitutes a measure of the potency and appeal of the rejuvenation program.

5.3.1 Evaluation without Intervention

In the "Without Intervention'' case, we conduct the cost benefit analysis using the current farming landscape and age distribution as illustrated in table 20. In other words, we assume that the coffee plants remain in the current state and no rejuvenation. No improvement takes places. Therefore, under such a scenario yield would remain lower than in the alternative case. We conduct an analysis of the profitability of total farms area of each province over a period of 20 years from both the farmers perspectives. In simpler words, the evaluation without intervention tells us how much farmers are expected to earn per hectare of coffee farms if no action is taken. It is assumed in both cases that farmers sell 95% of their production to coffee washing stations at a fixed price mandated and enforced by the government. The remaining 5% being defective cherries or any losses that could not be bought by coffee washing stations.

5.3.2 Evaluation with Intervention

In the “With Intervention” case on the other hand, farmers progressively uproot their old coffee tree and replant new one at the rate of 10 % per year meaning that each year they would uproot and replace 10 % on the coffee tree on their farms and replant new one.

The new coffee trees are unproductive for a period 02 years following seeding which implies that farmers cannot derive any income from those new plants. It is therefore important that farmers renew their plants progressively to ensure that they can still derive revenues from their farms while new plants are unproductive. Once the new plants begin to produce, the yield per tree grows to 6.25 KG per tree. Table 22 summarizes the most important inputs and parameters of our proposed intervention.

5.4 Analytical Methodology and Data

Our analysis will consist of conducting an integrated investment appraisal (financial, economic and stakeholder analysis) of the rejuvenation program under the two previously described scenarios and using the inputs and parameters of table 22. We will use three important concepts: the net Present value (PV). The net present value (NPV) and the modified internal rate of return. (MIRR). It is however important to stress here that our results will be presented in aggregate terms more specifically, our analysis and results will be conducted and presented in **per hectare** term and at the **aggregate level** of each individual province.

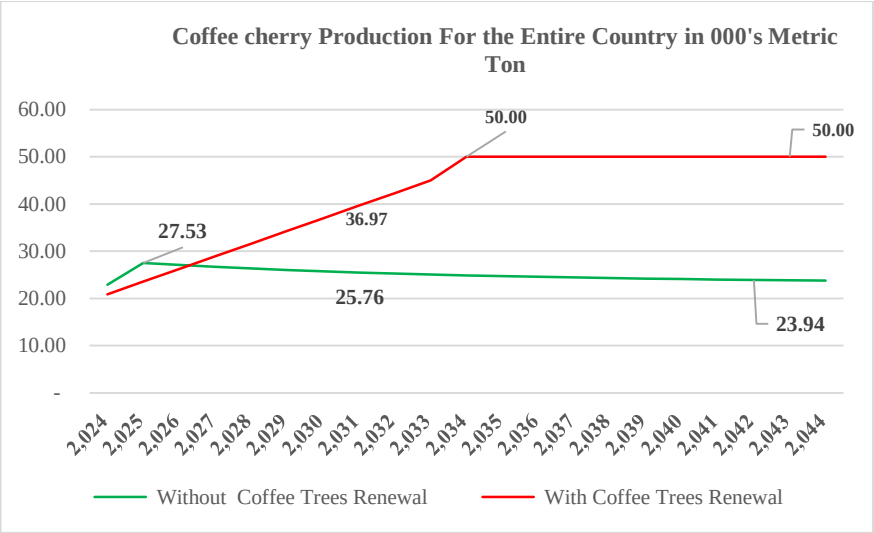


Figure 11: Potential coffee cherry yield in metric ton over the next 20 years
Sources: Author's calculation

5.4.1 Financial Analysis of the Coffee Trees Rejuvenation Program

The Financial Net Present Value.

The financial net present value is a measure of the attractiveness of an investment project. It consists of subtracting the sum of costs incurred by a project from its inception till the end of operation from the income stream generated by a project and discounting them all by a chosen discounting factor. The discount factor is the real rate of return investors considering a project require to take implement the project. The NPV gives us in monetary term the net income or loss from a project at the time zero.

When a project has a net present value, it implies that the benefits that will be generated by the project outweigh its costs therefore, a project with a positive NPV is a worthwhile investment and should be undertaken. It is important to stress that the terms project here can encompass many things. It could be an actual physical project, it could be a policy, a decision.

For each of the four provinces (i), the net present value per hectare that a famer will obtain if he/she progressively renews its coffee crops is represented by the variable

$FNPV_{i_Ha}^{F}$ and its computation is shown by (23). It tells us the net benefit computed at year zero that a farmer living in one of the four provinces would realize by hectare of coffee farm.

$$FNPV_{i_Ha}^{F} = \sum_{t=0}^{T=20} \frac{[(P_{\bar{c}}{}^{F} + P_{sh_i}{}^{F} + P_{c_i20}{}^{F} + P_{sh_i20}{}^{F}) * \tilde{Q}_{i_Ha})) - TC_i{}^{F}])}{(1+R)^t} \quad (23)$$

The revenues are made of: $P_{\bar{c}}{}^{F}$ which is the cherry price per KG sold to CWS. This price fixed by the government at the beginning of each coffee season. $P_{sh}{}^{F}$: is Revenue from shade tree branch sales. $P_{c_i20}{}^{F}$: is the terminal value, coffee trees in province (i) meaning the prices at which the coffee tree could be potentially sold at the end of the production period of 20 years.

$P_{sh_i20}{}^{F}$: is the terminal value from shade tree branch sales after 20 years of production $\tilde{Q}_{i_Ha}$: is the total potential cherry production per hectare in province (i). It comes from the summation of the yield of old coffee trees in the province as well as the production of the newly planted coffee trees. $TC_i{}^{F}$:is the yearly total cost of operating the area under cultivation. The tables 6-A to tables 8-A in the appendices show the detailed lists of different costs and other important parameters involved in operating a coffee plantation R: is the real financial discount rate per annum required by the farmers. All those financial prices and costs are expressed in real terms to remove the impact of inflation.

The Appendices table 6-B to table 12-B present the detail financial and economic models with all cost and revenues. We will next proceed by computing the combined NPV at the provincial level all to find out the NPV for each province. Given that each province has its own specificity, the yield and the costs are different for each of them.

The aggregated financial NPV for a province specific (i) $FNPV^{F}_{AGGR\_i}$ is given by (24) where the variable $T_{i_{HA}}$ represents the total area under cultivation in the province (i) as shown in table 21.

$$FNPV^{F}_{AGGR\_i} = \sum_{i=}^{4}(FNPV^{F}_{i_{H}a} * T_{i_{HA}}) \quad (24)$$

Besides, the NPV, an alternative way of gauging the financial worthiness of an investments is through the use of a measure called of the Modified internal rate of return (MIRR). The MIRR is the rate at which the present value of cash inflows for the whole duration of the project and the initial investment cost are equal. It is the rate at which the present value of cash inflows during operation equals the initial cash outlay. A project is worthwhile investing in it if the MIRR is above the discount rate. The MIRR is given by (25)

$$MIRR = \sqrt[t]{\frac{\text{Future value(positive cashflow}*\text{cost of capital)}}{\text{PV(negative cashflow}*\text{financing costs)}}} - 1 \quad (25)$$

Table 22: Inputs and parameters for the coffee tree renewal program in Rwanda

GENERAL PARAMETERS		**LABOR**	
Coffee cherry Price	410 RwF/KG		
Program evaluation Period	20 years		
Variety of Coffee seeds to be planted	Pop 3303/21	Weeding	25 days
Yield of new trees (Pop 3303/21)	6.25 KG/tree	Pruning	100 days
Yield of old trees	2.51 KG/tree	Fertilizer	50 days
Economic life of coffee trees	30 years	Pest and disease control	13 days
New tree unproductive period	2 years	Harvesting	80 days
Financial Real Discount rate	12%	**INVESTMENT COST**	
Economics opportunity cost of capital (EOCK)	13%	Price of coffee seeds with subsidy	5,460
Exchange Rate	1$= 1070 RwF	Land preparation	560,000

SUBSIDIES		Compost	840000
Subsidy on coffee seeds	35%	Transplanting of young trees	16800
Subsidy on fertilizer - NPK 17	15%	Planting coffee trees	21,000
Subsidy on insecticide -Confidor	15%	Planting shades	
Subsidy on insecticide - Fastac	15%	% of tree to be replaced per year	10%
Subsidy on fungicide - Cabrio	15%	Planting shades	16,800

5.4.1.1 Financial Analysis Results

Our financial analysis results for each of the four provinces are presented in table 23 to table 25. The first two rows of each of those tables show the NPV per hectare while the third row shows the internal rate of return. Row 3 to row 6 present the results at the aggregate provincial level. The aggregate results are obtained by multiplying the results for each hectare by the total area under cultivation as shown in table 21. In each case we present a table under the "**Current farming practices" or "Without intervention"** Scenario and the corresponding table under the **"With intervention"** Scenario.

5.4.1.2 Evaluation Results with "Current Farming Practices or Without Intervention"

We see that in the current situation meaning without rejuvenation, the financial NPV over the next 20 years per hectare for the four provinces are: 6.75 million Rwandan francs or 6,308 USD for the Northern Province. This figure implies that a farmer in the northern provinces of Rwanda will earn an NPV per hectare of 6038 USD over the 20 years period if he or she does not replant new coffee trees. Similarly, a farmer in the southern province of Rwanda will earn over a period of 20 years a financial NPV of 4.25 million Rwandan francs or approximately 3,972 USD per hectare if he or she does not renew its coffee trees.

Farmers of the Western and Eastern under the current state of affair meaning without rejuvenation will respectively earn per hectare of coffee farm an NPV of 16.82 million Rwandan francs or 15,710 USD and 6.56 million Rwandan francs or 6,130 USD over a period of 20 years. The MIRR in all the four cases are greater 20% which is a figure greater than the real financial discount rate of 12%. A real discount rate of 12% implies than a potential investor would only consider such a project if the minimum nominal discount rate he or she is offered to consider an investment is made of the sum of the real discount rate and the expected inflation rate in Rwanda. Given that the various provinces are of different size, in terms of hectares of coffee, it is impossible to make a comparison among them. Based on the MIRR. It suffices to say that the renewal of coffee trees is a sound investment based on the high MIRR figures.

Table 23: Financial NPV and modified IRR current farming practices (Northern & Southern provinces)

Evaluation Criteria	Northern	Southern
Current Farming Practices per Hectare		
Financial NPV per hectare **(in Million) RwF**	6.75	4.25
Financial NPV per hectare **(in USD)**	6,305	3,969
Financial Modified IRR per hectare practices %	21.83%	19.65%
Current Farming Practices for the whole Province (Million & %)		
Aggregate Financial NPV per region **RwF**	29,063	56,098
Aggregate Financial NPV per region **USD**	27.16	52.43
Aggregate Financial Modified IRR per region %	21. 83%	19.65%

Table 24: Financial NPV and modified IRR with intervention (Northern & Southern provinces)

Evaluation Criteria Recommended farming practices	Northern	Southern
Recommended farming practices Per Hectare		
Financial NPV per hectare **(in Million RwF)**	19.33	16.87
Financial NPV per hectare **(in USD**)	18,068	15,769
Financial MIRR per hectare %	21.55%	20.23%

For the whole Province "with Intervention (Million & %)"		
Aggregate Financial NPV per province RwF	44,377	118,770
Aggregate Financial NPV per province USD	41.47	111.00
Aggregate Financial MIRR per province %	21.55%	20.23%

Table 25: Financial NPV and modified IRR current farming practices (Western & Eastern provinces)

Evaluation Criteria Current Farming Practices	**Western**	**Eastern**
Per Hectare Current Farming Practices		
Financial NPV per hectare, **(in Million RwF)**	16.82	6.56
Financial NPV per hectare **(in USD)**	15,723	6,132
Financial MIRR per hectare %	26.29%	21.90%
Current Farming Practices Whole Province (Million & %)		
Aggregate Financial NPV per region **RwF**	237,429	68,023
Aggregate Financial NPV per region **USD**	221.90	63.57
Aggregate FMIRR per region %	26.29%	21.90%

Table 26: Financial NPV and modified IRR with intervention (Western & Eastern provinces)

Evaluation Criteria Recommended Farming Practices	**Western**	**Eastern**
Per Hectare "With Intervention"		
Financial NPV per hectare **(in Million RwF)**	29.80	18.90
Financial NPV per hectare **(in USD)**	27,850	17,659
Financial MIRR per hectare	25.72%	21.43%
With Intervention For the whole Province (Million & %)		
Aggregate Financial NPV per region RwF	240,499	104,383
Aggregate Financial NPV per region USD	209.43	97.55
Aggregate Financial MIRR per region	25.72%	21.43%

5.4.1.3 Evaluation Results "With Intervention"

We see that if Rwanda were to embark on a vast program of coffee tree rejuvenation, the impact would be substantial. In row 1 table 24 we observe that over a period of 20 years, each hectare in the **Northern Province** would give a Financial NPV of 19.33 million of Rwandan Francs or 18,065 USD. A farmer in the northern

province of Rwanda would earns a net income per hectare of 18,065 USD as opposed to 6,305 USD per hectare if farms are left in their current state. The new NPV represents a threefold increase from the case in which the trees are not replaced.

Similarly, in the **Southern province** of Rwanda, the implementation of rejuvenation policy would result in a financial NPV per hectare over a period of 20 years of 15,766 USD per hectare in comparison to 3,969 USD per hectare they are projected to earn if the coffee trees of the provinces are not renewed.

In the **Western** province as seen in row 1 table 26, we observe that renewing the province's coffee plants will likewise have a positive financial impact. Each farmer of the western province of Rwanda would earn an NPV per hectare of 27,850 USD per hectare as contrasted with 15,723 USD per hectare. Lastly, in the **Eastern** province, replanting coffee trees would result in an increase of the financial NPV per hectare from 6,132 USD to 17,659 USD

5.4.2 Economic Analysis of the Coffee Trees Rejuvenation Program

The previous section dealt with the financial impact that the renewal of coffee trees would have on coffee farmers. In order to access the impact that such a program would have on the whole economy of Rwanda we need to conduct an economics appraisal. As previously mentioned, the economic analysis uses shadow prices to ascertain the viability of a project. The difference between the financial analysis and the economic analysis represents the net impact of the society also called externalities. We will proceed by repeating the same equations used in the previous section this time using shadow prices and economics costs.

The economic net present value per hectare with intervention $ENPV_{i_H a}^{F}$ is found using (26) where the variables have the same meaning as in (23). The subscript "E'' is employed to stress the fact that we are using economics values. The discount factor is

the economic opportunity cost of capital (EOCK)[6] that is currently employed in projects appraisal in Rwanda.

$$ENPV_{i_Ha}^{F} = \sum_{t=0}^{T=20} \frac{([(P_{\bar{c}}{}^{E} + P_{sh_i}{}^{E} + P_{c_i20}{}^{E} + P_{sh_i20}{}^{E}) * \tilde{Q}_{i_Ha})) - TC_i{}^{E}])}{(1+EOCK)^t} \quad (26)$$

Similarly, the aggregated economic NPV for a province specific (i) $ENPV_{AGGR\_i}^{F}$ is given by (27) where T_{i_HA} represents the total area under cultivation in the province (i) as shown in table 21.

$$FNPV_{AGGR\_i}^{F} = \sum_{i=}^{4} (ENPV_{i_Ha}^{F} * T_{i_HA}) \quad (27)$$

5.4.2.1 Economic Analysis Results with "the Current Farming Practices"

Table 27: Economic NPV and modified IRR current farming practices (Northern& Southern provinces)

Evaluation Criteria Current Farming Practices	Northern	Southern
A Current Farming Practices Per Hectare		
Economic NPV per hectare **(in Million RwF)**	6.99	4.56
Economic NPV per hectare **(in USD)**	6,531	4,258
Economic MIRR per hectare %	23.01%	20.96%
Aggregate for the whole Province (Million & %)		
Aggregate Economic NPV per region **RwF**	30,105	60,187
Aggregate Economic NPV per region **USD**	28.14	56.25
Aggregate Economic MIRR per region %	23.01%	20.96%

Table 28: ENPV and modified IRR with intervention (Northern & Southern provinces)

Evaluation Criteria Recommended Farming Practices	Northern	Southern
With Intervention Per Hectare		
Economic NPV per hectare **(in Million RwF)**	18.38	16.09
Economic NPV per hectare **(in USD)**	17,180	15,042
Economic MIRR per hectare %	22.84%	21.51%
With Intervention for the whole Province (Million & %)		
Aggregate Economic NPV per region **RwF**	40,187	107,133
Aggregate Economic NPV per region **USD**	37.56	100.12

[6] For more information, please consult the Commodity-Specific Economic Conversion Factors Database for the Republic of Rwanda. Available online at: https://rwanda-cscf.cri-world.com/

Aggregate Economic MIRR per region %	22.26%	20.96%

Table 29: Economic NPV and modified IRR current farming practices (Western& Eastern provinces)

Evaluation Criteria Current Farming Practices	**Western**	**Eastern**
Current Farming Practices Per Hectare (Million & %)		
Economic NPV per hectare, **(in Million RwF)**	17.04	6.80
Economic NPV per hectare **(in USD)**	15,926	6,360
Economic MIRR per hectare	27.41%	23.09%
Current Farming Practices for the whole Province (Million & %)		
Aggregate Economic NPV per region **RwF**	240,499	70,552
Aggregate Economic NPV per region **USD**	224.77	65.94
Aggregate Economic MIRR per region	27.41%	23.09%

Table 30: Economic NPV and modified IRR with intervention (Western& Eastern provinces)

Evaluation Criteria Recommended Farming Practices	**Western**	**Eastern**
Recommended Practices, (Million & %)		
Economic NPV per hectare **(in Million RwF)**	28.08	17.77
Economic NPV per hectare **(in USD)**	26,241	16,605
Economic MIRR per hectare %	26.39%	22.56%
With Intervention for the Whole Province (Million& %)		
Aggregate Economic NPV per region **RwF**	204,560	94,530
Aggregate Economic NPV per region **USD**	191.18	88.35
Aggregate Economic MIRR per region %	26.22%	22.12%

5.5 Sensitivity Analysis under Intervention

As previously mentioned, in Rwanda the price of coffee cherry is set by the Government. At the time of writing this dissertation the price was set at 410 RwF per KG. The results presented in tables 27 to table 30 were computed with the assumption that the cherry price would remain fixed at 410 RwF/KG. In table 31 and table 32, We present the results of the per hectare Financial Net Present value (FNPV), the Modified

financial internal rate of return (FMIRR), the per hectare Economics net present value (ENPV) and modified economic internal rate of return EMIRR under different coffee cherry prices ranging from 300RwF/KG to 1000 RwF/KG. They show how those per hectare variable would respond to increase or decrease in the prices of coffee cherry.

We still assume progressive renewal of coffee trees with the same parameters of table 22 as previously used. The only change is the coffee cherry price which is assumed to change range from 300 RwF to 1000 RwF. It is a normal assumption that over the next 20 years coffee cherry prices will ineluctably increase as the demand for specialty coffee continue to grow and CWS are in constant competition to purchase higher volume of coffee cherry.

In table 31, we see for instance that if coffee cherry prices were to be set at 500 RwF per kg, then over the next 20 years a farmer in the Northern Province will realize a net present value per hectare of 25,638 USD instead of 18,068 USD if price remain at 410 RwF. Similarly, in the southern province, a farmer would earn a financial present value of 22,927 USD per hectare over a period of 20 years instead of 15,769 USD if price is maintained at 410 RwF. The same trend persist for the rest of the two provinces and the increase is cheery prices generated higher and higher benefit to farmers. Table 31 and table 32 shows not only that it is important that coffee tree be replaced but also that cheery price be increase or left to the markets to decide.

Table 31: Sensitivity of the financial NPV per hectare to changes in cherry prices

Cherry Price in RwF/KG	**Financial NPV per Hectare in USD**			
	Provinces			
	Northern	**Southern**	**Western**	**Eastern**
300	8,817	7,021	16,167	8,642
410	**18,068**	**15,769**	**27,850**	**17,659**
500	25,638	22,927	37,410	25,036
600	34,048	30,879	48,031	33,233

700	42,458	38,832	58,652	41,430
800	50,869	46,785	69,274	49,627
900	59,279	54,738	79,895	57,824
1000	67,690	62,691	90,517	66,021

Table 32: Sensitivity of the economic NPV per hectare at EOCK 13% to changes in cherry prices

Cherry Price in RwF/KG	**Provinces Economic NPV per Hectare in USD**			
	Northern	**Southern**	**Western**	**Eastern**
300	8,452	6,780	15,258	8,095
410	**17,180**	**15,042**	**26,241**	**16,605**
500	24,321	21,801	35,227	23,568
600	32,255	29,311	45,212	31,305
700	40,190	36,821	55,197	39,041
800	48,124	44,332	65,181	46,778
900	56,059	51,842	75,166	54,514
1000	63,993	59,352	85,151	62,251

5.6 Cost to the Government of Rwanda

The previous results from both the financial and economic analysis have revealed that renewing coffee trees in Rwanda would be a sound investment from the farmers and the economy of Rwanda perspectives. However, we are yet to address how much it would potentially cost the government of Rwanda in terms of loss taxes, subsidies and well as how much the government potentially stands to gain in terms of foreign exchange premium (FEP). Table 33 shows the net impact of the proposed project on the government.

5.6.1 Base Case Distributive Analysis: Cherry Price 410 RwF/KG

Table 33: Distributive analysis, government expenses "with intervention"

Stakeholder Analysis: Government						
	Provinces				Total in Million	
Components In Million RwF	**Northern**	**Southern**	**Western**	**Eastern**	**RwF**	**USD**
Foreign Exchange Premium	4,468	12,971	18,520	10,486	46,445	43.41
Subsidies	-408	-1251	-1336	-982	-3,977	**-3.72**
Taxes	-636	-1949	-2082	-1530	-6,197	**-5.8**
Net Externalities	**3,425**	**9,771**	**15,102**	**7,974**	**36,272**	**33.90**

Table 33 shows that it would costs a total of 3.98 billion of Rwanda francs or 3.72 million USD in subsidies cost to implement the coffee rejuvenation program similarly, the potential taxes loss to Rwanda is evaluated at 5.8 million USD in total the combined cost of the program to Rwanda is estimated at 9.52 million USD. However, we see that the positive impact for the government far outweigh the combined costs. We see that the rejuvenation is expected to generate a next externality of 33.9 million USD this amount represents the net impact that such a policy would have on Rwanda as a whole. We clearly see the benefits far outweigh the costs. The impact that the renewal of the coffee trees will have on farmers, and the Government is positive.

5.6.2 Externalities Sensitivity Analysis to Coffee cherry Prices

As the cherry prices paid to farmers increase what would be the impact on the Rwandan economy? The term externality used here is a misnomer as the increase in cherry prices would come at the detriment of CWS owners the net externality are essentially transfers from CWS owners to farmers. We will present our analysis for all the four provinces as shown in table 34 to table 37 the sensitivity analysis for the next externality.

In each of those tables, we see that the total costs to the Rwandan government which are made only of the subsidies and taxes would remain constant as the cherry prices increase. However, both the foreign exchange premium and the net externalities increase. We further see as in the previous chapter that the policies of setting a low fixed price for cherry is detrimental to farmers. In the Western province for instance, If the government were to subsidize farmers to renew their coffee crops and allow coffee cherry price to increase the net impact would be substantial for example, if the coffee cherry is set at 800 RwF per KG in the western province, we will have a net positive externality to Rwanda would be 30.872 million Rwandan francs or approximately 28.852 million USD solely in the western province. The same dynamic is observed in all the four provinces as shown in table 35, table 36 and table 37

Table 34: Externalities sensitivity analysis to cherry prices (Western province)

Cherry Price in RwF/KG	**Government Stakeholder Analysis in Million RwF Western Province**			
	FEP	**Subsidies**	**Taxes**	**Net Externalities**
300	14,072	-1336	-2082	10,654
410	**18,520**	**-1336**	**-2082**	**15,102**
500	22,159	-1336	-2082	18,741
600	26,203	-1336	-2082	22,784
700	30,246	-1336	-2082	26,828
800	34,290	-1336	-2082	30,872
900	38,334	-1336	-2082	34,915
1000	42,377	-1336	-2082	38,959

Table 35: Externalities sensitivity analysis to cherry prices (Northern Province)

Cherry Price in RwF/KG	**Government Stakeholder Analysis in Million RwF Northern Province**			
	FEP	**Subsidies**	**Taxes**	**Net Externalities**
300	3,389	-407.90	-636	2,346
410	**4,468**	**-407.90**	**-636**	**3,425**
500	5,351	-407.90	-636	4,307

600	6,332	-407.90	-636	5,288
700	7,313	-407.90	-636	6,269
800	8,294	-407.90	-636	7,250
900	9,274	-407.90	-636	8,231
1000	10,255	-407.90	-636	9,212

Table 36: Externalities sensitivity analysis to cherry prices (Southern province)

Cherry Price in RwF/KG	**Government Stakeholder Analysis in Million RwF Southern Province**			
	FEP	**Subsidies**	**Taxes**	**Net Externalities**
300	9,839	-1251	-1949	6,639
410	**12,971**	**-1251**	**-1949**	**9,771**
500	15,533	-1251	-1949	12,333
600	18,381	-1251	-1949	15,180
700	21,228	-1251	-1949	18,028
800	24,075	-1251	-1949	20,875
900	26,922	-1251	-1949	23,722
1000	29,769	-1251	-1949	26,569

Table 37: Externalities sensitivity analysis to cherry prices (Eastern province)

Cherry Price in RwF/KG	**Government Stakeholder Analysis in Million RwF Eastern Province**			
	FEP	**Subsidies**	**Taxes**	**Net Externalities**
300	7,954	-982	-1530	5,442
410	**10,486**	**-982**	**-1530**	**7,974**
500	12,557	-982	-1530	10,046
600	14,859	-982	-1530	12,348
700	17,161	-982	-1530	14,649
800	19,463	-982	-1530	16,951
900	21,764	-982	-1530	19,253
1000	24,066	-982	-1530	21,555

5.7 Chapter Conclusion

In this chapter, we studied the financial and economic impact that the progressive renewal of the coffee trees in Rwanda would have on both the farmers and on the Rwandan society as a whole. The results of our analysis reveal that each farmer would

earn a positive financial net present value per hectare of coffee even if the price of coffee cherry were to be maintained at the low current price of 410 RwF per KG. In some of the provinces, the renewal of coffee trees would go as far as tripling the profits per hectare over an evaluation period of 20 years.

The least rentable estimation generates one and half times more profit in comparison to the current farming practices. If, however coffee cherry prices are allowed to increase as they would normally in a competitive situation, the financial gain per hectare for the farmers per hectare would be very substantial. The impact of the government is as well positive. In the base case scenario, whereby the government would initially spend almost 10 million USD to cover subsidies on fertilizers and coffee seeds and suffer taxes losses. However, the net externality would be 33 million USD. Which is the triple of initial expenses.

Furthermore, as the price of coffee cherry increases, the cost to the government will remain the same at 10 million USD however the net positive impact on the farmers continue to accrue. Granted the increase in Coffee cherry would come at the detriment of CWS but as we saw in the previous chapter, CWS would be willing to pay higher prices and still make a zero economics profit. The results in this chapter further corroborate the idea that fixing the cherry price at a low level is counterproductive as it deprives both farmers and the government of Rwanda of long-term benefits. If Rwanda wants to continue reaping benefits from its coffee industry, it is important that cherry prices be allowed to freely more according to the market and that government takes steps to encourages the renewal of the country‘s old coffee trees.

Chapter 6

CONCLUSION AND POLICY IMPLICATION

This dissertation dealt among others with the topic of government interventions into the agricultural sector which later results in less than efficient outcomes most especially for the famers who are the backbone of the sector. In chapter 2, we saw in the case of Ethiopia that the creation of the ECX had an undeniable positive impact in terms of tackling many of the deficiencies of the old coffee auction system that had previously been in place. Many of the innovations that have emerged have been overall beneficial to the coffee industry in Ethiopia most notably to the farmers who now have the ability of benefiting from the streamlined trading process via the ECX and can be paid prices that closely match the prices at the ECX. Nonetheless, in tackling collusion with anonymity at the exchange, the government created a detrimental situation for the Ethiopian coffee value chain. Trading coffee through the ECX led to the loss of traceability for a substantial portion of Ethiopian coffee export. Traceability is one of exported coffee most appealing attribute. The loss of traceability for the ECX traded would ineluctably lead to lower revenues as overseas customers purchasing Ethiopian coffee traded through ECX lost the confidence that the coffee they procured met their requirements. At the same time, the exempted coffee gained in value since this was the only price that retained its traceability.

The situation in Rwanda is more poignant when it comes to ill-designed policies. In Chapter 4, we saw that Rwanda had shifted away from the production of ordinary coffee to the production of specialty coffee. The various initial incentives provided by

the NGO, donors and the government of Rwanda to spring up the nascent specialty coffee industry combined with the appeal of high prices led to an oversupply of coffee washing stations or wet mills much of which operate below their processing capacity. Furthermore, the fixed farm gate price and the zoning policy impede on the efficiency of the market by restraining trade and competition.

Our analysis has revealed that coffee farmers are undercompensated for their cherry while Coffee washing stations owners are given remarkably high margins. Given the potential high margins to be had, there are high incentives for CWS to obtain as much coffee cherry of they can. By imposing a fixed price per KG of coffee cherry and implementing the coffee zoning, the government inadvertently created two negative outcomes: Non-competitive and less efficient CWS are artificially kept alive which contributes the waste of much needed economics resources, and farmers are losing interest in coffee farming and investing in other crops that are deemed more rentable. The sustainability of the coffee sector in Rwanda is threatened not only by the lack of incentives for the farmers but as well by the fact that a significant portion of coffee trees in Rwanda are old and therefore, they produce a very low yield. If the government of Rwanda were to lift the restrictions, less efficient washing stations would go out of business and the country could save yearly a substantial amount of money that could be invested in other area.

In chapter 5, we studied the impacted that the progressive renewal of coffee trees in Rwanda would have. Our results reveal that farmers and the government would be better off. We saw that for over the next 20 years the impact of a rejuvenation policy would be greatly beneficial both for the farmers in terms of higher income per hectare but also to the government of Rwanda in terms of higher foreign exchange revenue lastly Coffee washing stations would benefit as well given that they would have more

coffee cherry at their disposal to produce parchment consequently they would be able to generate receive higher revenues from the export of specialized coffee.

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APPENDICES

Appendix A: Investment Parameters for a Coffee Washing Station

Table 1 A: Capital Expenditure for a Coffee washing station in Rwanda
Capacity 200 tons of parchment coffee a season

Items	Quantity	Unit Prices USD 2022 Price Level	Total in USD 2022 Price Level
Land Acquisition	1	4,000	4,000
Capitalized Cost	1	8,000	8,000
Coffee Pulper Machine	1	69,395.3	69,395
Generator 10 KW	1	20,000	20,000
Moisture meter	1	1,000	1,000
Loading Scales	1	500	500
Dial scales	2	70	140
Drying tables and accessories	86	300	25,800
Recycling Pumps	2	5,000	10,000
Motorcycle	1	5,000	5,000
Total Expenditures land and equip			143,835
Construction and Engineering			56,165
Total Initial Investment Cost		200,000	

Table 2 A: Variable and Fixed Costs for a CWS

Seasonal Variable Costs	Fixed Costs
Cherry Transportation Cost Farmgate to the CWS	**Permanent Workers**
Washed coffee Transportation Cost	Station manager
Fuel	Agronomist
Purchase of bags	Production head
Loading and offloading fees	Machine operator
Hulling costs	Quality head
Insurances	Cashier
Electricity	Scale Operator
Water costs	Accountant and
Materials costs	Administrative head
Seasonal Workers	Security during the season
Cherries Selection-Reception-Floatation	Security for the rest of the year
Tank- Fermentation - Grading	**Operating Costs**
Drying team	Office supplies
	Communication expenses
	Printing expenses

Seasonal Variable Cost Without Financing	Mechanic Repair and maintenance
	Spare parts
	Advertising
Interest on Working Capital	Lubricants and greases
	Insurances
	Seasonal Fixed Costs
Total Seasonal Variable Costs	**Initial Investment Cost**

Table 3-A: Seasonal Variable Labor and Salary Assumptions

Permanent labor	Employees For a 200 outputs station	Employees For a 100 outputs station	Employees For a 50 outputs station	Daily Salary Rate in Rwandan Francs 2022
Cherries Selection-Reception-Floatation	6	2	2	5000
Tank- Fermentation - Grading	5	2	2	5000
Drying team	60	40	30	5000

Table 4-A: Seasonal Fixed Labor and Salary Assumptions based on a station producing 200 tons of Parchment Coffee.

Permanent labor	**# of employees**	**# of months**	**Monthly Salary in Rwandan Francs 2022**
Station manager	1	12	630,000
Agronomist	1	12	250,000
Production head	1	5	310,000
Machine operator	1	3	310,000
Quality head	1	3	190,000
Cashier	1	3	200,000
Scale Operator	1	3	190,000
Accountant and Administrative head	1	3	310,000
Security during the season	4	3	180,000
Security for the rest of the year	2	12	180,000

Table 5-A: General Assumptions & Parameters of CWS operation

Initial Investment Cost for a washing station	200,000 USD
Main Inputs for a washing station:	Coffee cherry
Main Output:	Parchment coffee or Fully Washed coffee
Cherry prices per kg set by the Government	410 RwF/KG
Parchment Coffee selling in USD per KG	5.5 USD / KG
Conversion ratio from coffee cherry to Parchment coffee	1 KG Cherry =0.2 KG of Parchment
Coffee Season Duration in Rwanda	3 Months
Operating Days per month	26 days/ Month
Latest Export volume of Fully washed coffee year 2022	15000 tons
Discount rate	12%
EOCK	13%
Exchange Rate	1USD = 1070 RwF

Appendix B: Inputs and Parameters the Rejuvenation Program of Coffee Trees in Rwanda

Table 6-B:

GENERAL INPUTS

REGION	NORTHERN	Switch	NORTHERN	SOUTHERN	WESTERN	EASTERN
PRODUCTION						
AREA						
Area Under Evaluation	10000	Cm2				
Spacing Convention	**4**	Cm2	4	4	4	4
PRODUCTION REVENUE						
Price of cherry	410	RwF/KG	410	410	410	410
Price of Unwashed Coffee	850	RwF/KG	850	850	900	850
Price of Shade Tree Branch	70	RwF/Tree				
PRODUCTION COSTS						
Input Requirements						
Fertilizer - NPK 17	0.1	KG/Tree				
INPUT COSTS						
Price of polythylene bags for cherries	2.8	RwF/Bag				
CIF price of fertilizer - NPK 17	398.048	RwF/KG				
Subsidy on fertilizer - NPK 17	15.00%	%				
Price of fertilizer - NPK 17	338.341	RwF/KG				
CIF price of Insecticide - Confidor	35996.8	RwF/Litre				
Subsidy on Insecticide - Confidor	15.00%	%				
Price of Insecticide - Confidor	30,597	RwF/Litre				
RENTAL COSTS						
Knapsack sprayer	**57,400**	RwF	57400	74620	74620	74620
Land rental	**70,000**	RwF/Ha	70000	70000	112000	70000
Tree Maintenance						
Coffee Tree Rejuvenation	**11,200**	RwF/Ha	11200	28000	28000	12600
LABOUR COSTS						
Weeding wage	**1,120**	RwF/day	1120	1120	1120	840
Pruning wage	**1,120**	RwF/day	1120	1120	1120	840
Fertlizer application wage	**1,120**	RwF/day	1120	1120	1120	840
Pest and disease control wage	**1,120**	RwF/day	1120	1120	1120	840
Harvesting wage	**1,120**	RwF/day	1120	1120	1120	840
COFFEE CONVERSIONS						
Fresh cherry to Parchment	0.2	CF				
Parchment to Green Bean	0.8	CF				
GREEN DISTRIBUTION						
Price of export Fully Washed Coffee	5.5	USD/KG				

Price of export Unwashed Coffee	2.58	*USD/KG*					
GREEN BEAN CONVERSION							
Domestic roasting	0.25%	*%*					
Fully Washed Coffee export	95.00%	*%*					
Unwashed Coffee export	5%	*%*					
Adoption Rate							
Departure Rate	10.00%	*%*					
Adoption Rate	10.00%	*%*					
Adoption rate ceiling	90.00%	*%*					
% Use of Current Farming Practices	100.00%	*%*					
EFFECTIVE ADOPTION RATE		*Flag*	0	1	1	1	1
Rate of Depature from Current Farming Practices		*%*	100%	90%	80%	70%	60 %
Adoption rate of intervention		*%*	0%	10%	20%	30%	40 %
Newly adopted area under cultivation		*%*	0%	10%	10%	10%	10 %

Table 7-B:

WITHOUT INTERVENTION

Region	**NORTHERN**	*Switch*	**NORTHERN**	**SOUTHERN**	**WESTERN**	**EASTERN**
PRODUCTION						
Variety Yield	2.65					
BM139	2.65	*KG/Tree*	2.65	2.35	4.1	2.51
Area						
Area under shade trees	0%	*%*	-	-	-	-
Cherry Distribution						
To CWS	95%	*%*	95.00%	95.00%	95.00%	95.00%
Unwashed Coffee (Unwashed Coffee)	5%	*%*	5%	5%	5%	5%
Proportion of trees 0 - 2 years	21%	*%*	21.29%	13.05%	11.70%	19.48%
Proportion of trees 3 - 30 years	46%	*%*	45.74%	52.18%	66.75%	63.90%
Proportion of trees > 30 years	33%	*%*	32.97%	34.77%	21.55%	16.62%
COFFEE TREE AGE EFFECT ON YIELD						
Effect on yield of trees 0 - 2 years	100%	*%*				
Effect on yield of trees 3 - 30 years	0%	*%*				
Effect on yield of trees > 30 years	20%	*%*				
PRODUCTION COSTS						
Insecticide - Confidor	1.125	*Litre/Ha*				
INPUT COSTS						
TREE MAINTENANCE						
Shade tree maintenance	-	*RwF/Ha*	-	-	-	-
Erosion control	**210,000**	*RwF/Ha*				
Mulching	**700,000**	*RwF/Ha*				
LABOUR DAYS						
Weeding	**50**	*Days*	50	50	63	25
Pruning	**100**	*Days*	100	100	100	100
Fertilizer application	50.000	*Days*				
Pest and disease control	**10**	*Days*	10	13	13	13
Harvesting	**40**	*Days*	40	70	100	80
ECONOMIC DEPRECIATION						
Economic life of Coffee Trees	30	*Switch*				

Economic Life of shade Trees	-	*Switch*	-	-	-	-