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Enhancement of Coffee Quality in Rwanda: A Stakeholder Analysis of Government Policies

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ABSTRACT

Over the past two decades, Rwanda has positioned itself as a leading producer of specialty coffee. The shift away from ordinary coffee began in the early 2000s and was buoyed by international donors, NGOs and the government. They all supported the nascent specialty coffee industry by providing a combination of technical assistance and funding to invest in coffee washing stations. Coffee washing stations (CWS) are a pivotal piece of the value chain in Rwanda since it is where ordinary coffee undergoes a process that turn it into specialty coffee. The policy of shifting to specialty coffee has been significantly beneficial to Rwanda. However, there was a rush to build a large number of CWS throughout the country which has resulted in an over capacity of these plants and fierce competition among them for the purchase of cherry coffee from farmers. In an attempt to shore up the industry the Government implemented a zoning policy which effectively is a trade barrier to artificially maintain a high margin between the input price of cherry coffee and the sales price of coffee received by the CWS. This study uses a cost-benefit analysis to estimate the economic welfare loss to Rwanda of these policies. Over a ten year period the present value of the economic loss is estimated to be $73 million. An increased competition in the market for cherry coffee would raise the price of cherry coffee at the expense of the profits of CWS owners. If such a policy were implemented coffee growers could potentially receive up to 150% more from their sales of cherry coffee, or $45 million per year. These enhanced revenues would allow famers to finance the replanting of their coffee fees and maintain the sustainability of this sector.

Keywords: Coffee value chain, coffee washing station, specialty coffee, coffee zoning policy

JEL Classification: D40, E23, Q17

1. Introduction

The Rwandan coffee is acclaimed on the international market for its high quality. Although a small landlocked country, Rwanda nonetheless has ideal growing conditions for coffee farming due to its rich volcanic soil, high altitude, and ample rainfall. Land is a scarce resource where coffee is in competition with other crops for the limited amount available. Furthermore, many of Rwanda's coffee trees are older than 30 years and consequently, their yield is low. Since 2002, Rwanda has opted to adopt a policy to encourage the production of specialty coffee or fully washed coffee rather than ordinary coffee. Prior to 2002, it was mainly ordinary coffee that was exported by Rwanda. Specialty coffee fetches much higher prices in contrast to ordinary coffee. This has been a common objective of most coffee producers such as in Ethiopia and elsewhere [1].

The main difference between the two types of coffee is that ordinary coffee is un-washed and is usually processed at home by Rwandan farmers themselves using rudimentary equipment. 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 for coffee.

The potential for Rwanda to be a major player on the specialty coffee niche market was recognized in the early 2000s by international donor agencies and the Government of Rwanda (GoR). This led to an outpouring of technical and financial assistance from international developments agencies and donors into investments in the coffee value chain most specifically into opening CWS. USAID paved the way by providing a wide range of assistance both financial and technical to the nascent industry. Consequently, the number of CWS had increased from 2 in 2000 to 46 by the year 2006. Of this total, 38 were funded by the USAID [2] and [3]. According to official figures, the number of registered CWSs in 2022 stood at 300 [4]. The spread of 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. More importantly, the export of higher quality coffee has been very beneficial for Rwanda as it is an important source of foreign exchange earnings. As an illustration for the 2021-2022 fiscal year, Rwanda's total agricultural exports were estimated at $640,952,296 out of which coffee exports accounted for $75,571,428. According to the 2021 to 2022 annual report [5]. of the National Agricultural Export Development Board (NAEB), this amount rep-resented approximately 11.8% of the total value of agricultural exports from Rwanda.

Although the policy of improving the quality of coffee was justified at its inception the government's policies surrounding the licensing and price margins received by the CWS has created a suboptimal result. These polies have led to a situation where there is an oversupply of CWS in Rwanda due to the financial support provided for the initial investment combined with the subsequent cherry pricing and zoning policies. The large number of CWS in Rwanda has given rise to a fierce competition for the purchase of coffee cherry. The supply of cherries in any given year is limited. Because of this plethora of CWS the vast majority of CWS in Rwanda operate far below their built-in processing capacity. In Rwanda however, the government decided to tackle the scarcity of cherry, by implementing a zoning policy consisting of limiting the area in which a specific CWS is allowed to purchase cherry. Farmers were also required to sell their cherry to CWS within their zone at a fixed price mandated and enforced by the government. From our discussions with CWS owners in Rwanda we learned that failure to abide by these rules is a punishable offence. A CWS can lose its license if it infringes those rules.

The zoning policy has had the adverse effect of artificially keeping in business in-efficient washing stations while capping the revenues farmers can receive from the sale of their cherries. The policy of restricting cherry sales to CWS within their designated zones was viewed negatively by farmers as having an adverse impact on their livelihood. In a survey [6], 61.9% believed that the zoning policy has resulted in them getting lower prices for cherry coffee than they would have otherwise received.

As of the year 2022, Rwanda had a little over 300 CWS and a total export volume of fully washed coffee of approximately 15,000 tons for the same year. This implies that a CWS produces on average only 50 tons of parchment coffee per year. Most of the washing stations were built with the capacity to process much more cherry since they were built during the period when there were many incentives to open CWS. It has been pointed out [7], that, of the 214 washing stations that were installed in Rwanda in 2012, one in four washing station processed only 25% of their capacity and the median washing station processed only 53% of their capacity.

This paper reports on the analysis that is retrospective in focus. It is asking the question what could have been the size the allocation of the net benefits of the coffee upgrading policies of the government if it had implemented a policy of increasing the minimum price paid to farmers for cherry while restricting the number of CWS licensed to operate in Rwanda? It also estimates the potential economic resource cost savings if there were fewer CWS and hence both lower capital and operating costs to process the parchment coffee. In the quantitative analysis it is postulated that the policies could have been formulated so that the growers of cherry coffee received all the net benefits from this policy redesign. However, in reality the total allocation of the improvement of net benefits in excess of the required rate of return to the CWS could be allocated partially to the farmers, to the owners of the CWS and the government. From the analysis that follows it would appear that there was considerable potential for the farmers to be paid a higher price for the cherry, and still have enough CWS capacity to produce at least 15,000 tons of parchment a year. Such policies would also provide the farmers with a strong incentive to replant coffee threes and hence expand the overall output of high-grade parchment coffee over time.

1.1. Literature Review

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

(Church, 2018) [8] used as benchmark for her analysis the Government's 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. The results indicated that the losses to coffee farmers 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) [9] estimate 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 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. The conclusions of Clay et al is strongly supported by the findings of this study.

Gerard et al (2017) [6] 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 extent to cooperatives.

Clay and Bizoza (2018) [10] investigate ways to sustain growth in the coffee sector in Rwanda in the long run. The article finds 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, the necessary critical investments are not being made that are needed to boost coffee production levels. Given that the long-term targets of the Government for coffee sector performance in production, and sale revenues hinges on the availability of enough cherry, the article recommends that all stakeholders of the value chain commit to ensuring that farmers be compensated fairly, and that coffee be given more importance over other crops since Rwanda has a comparative advantage in specialty coffee on the world stage.

2. The CWS Zoning Policy in Rwanda

The coffee zoning policy was first put into effect in 2016. It constrained the sale of cherry coffee by farmers to a CWS within the confines of a pre-established zone. Sales and purchase of cherry coffee outside of zones were prohibited. The government 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 [11].

The zoning policy, however, has been an impediment to market efficiency and to increasing the income of the producers of cherries. By preventing buyers and sellers to choose with which counterparts to trade it has led to a situation where some CWS that would have gone out of business are kept artificially alive because they are guaranteed access to a certain volume of cherry coffee for their operations. The zoning policy seems to have been designed more to protect the owners of washing stations rather than to promote the welfare of farmers. In general, the zoning policy has had a negative impact on farmers by restraining their income due to limiting the competition for cherry within a zone. The zoning policy further forced the government to intervene in the coffee market by setting and enforcing a selling price for cherry to the CWS. If the markets forces were left to operate more freely, or if the government mandated prices for sales of cherry coffee were increased, the poorly managed or underfinanced washing stations would exit the market as the remaining washing stations could operate more efficiently. The growers would be better off since they would receive a higher price for their cherry. In some cases, the government has been forced to impose strict sanctions against washing stations that are tempted to offer prices above mandated price which ins 2022 was 410/KG. In the long run the zoning policy posed a threat to the sustainability of the coffee sector. The lower prices for cherry have resulted in the removal of the incentive for farmers to make the investment in replanting coffee trees so that they can remain, or expand, the coffee business for the long term.

Another major flaw in the design and the implementation of the zoning policy stemmed from the fact that the zoning policy did not prevent owners and businesses from operating many stations in different zones. It means that for them to get enough cherry they have been forced to build washing stations in many zones instead of having one or two CWS that could have processed the same volume of cherry coffee. Opening small CWS in multiple zones represents very substantial unnecessary capital expenditure. This further exacerbates the issue of overcapacity as many washing stations are built to process smaller quantities of cherry. Several companies in Rwanda own and operate many washing stations for example, Rwacof owns and operates 30 CWS while the Rwanda Trading Company owns and operate 18 CWS [12]. The zoning policy therefore contributes heavily to the waste of economic resources that could have been injected in the improvement of the coffee plantation. Following intense pressures from coffee farmers the zoning policy was repealed by the Ministry of Agriculture and Animal Resources of Rwanda in June, 2023. How-ever, the National Agricultural Export Development Board (NAEB) will continue to set and publish a fixed purchase price per KG for coffee cherries each season. Whether NAEB can force all the cherry to be purchased at this official price is still an open question.

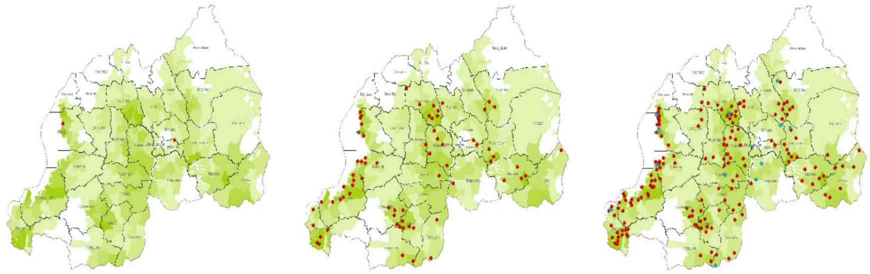

Figure 1. Expansion of the number of coffees washing station from 2002 to 2006 and 2012
Source: [7].

3. Data and Methodology

Our analysis is based on a cost benefit analysis methodology which is referred to as an integrated investment appraisal [13]. This approach allows us to gauge the financial viability of investments project as well as their impacts on the affected stakeholders. We conduct a financial, economic and stakeholder analysis of a generic CWS for different annual production levels of parchment coffee. 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 production of specialized coffee have resulted in an over expansion of the number of washing stations beyond what would have been economically efficient. This analysis is undertaken with a clear appreciation of the underlying constraints facing the supply of cherry coffee production in the country.

3.1. Financial Analysis

3.1.1. Cost Structures of a Washing Station

A typical coffee washing station purchases freshly harvested cherry coffee from farmers. Once at the station, cherry coffee undergoes four main processing phases which include sorting, soaking fermentation and finally the coffee beans are thoroughly washed [14]. 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 at CWS. A typical CWS is fully operational only during the portion of the year that coincides with the coffee harvest season. The season typically lasts three months or approximately 78 operating days. The lower the processing cost of parchment coffee at a CWS, the greater is the financial surplus available for other participants in the sector.

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) [2]. 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 during that season. Seasonal fixed costs include the core staff the CWS employs, other examples of seasonal fixed costs are commonly incurred expenses such as offices supplies.

Seasonal Variable Costs are costs that are incurred solely during the coffee harvest season and vary according to the volume of cherry the CWS processes. A good illustration of seasonal variable costs are the workers that the station employs during the harvest season. These workers are paid a wage for each day of work. The bulk of the employment of labor is of this type. Other examples of seasonal variable cost include transportation cost, fuel, and jute bags etc. The list of variable and fixed costs is reported in the appendix table A2, table A3 and table A4.

For the purpose of our analysis, four scales of annual production of parchment coffee by a CWS are chosen namely: 25 tons, 50 tons, 100 tons and 200 tons. Fixed costs are the same for each of these levels of production as most CWS were built with a capacity to produce 200 tons or more parchment coffee a season. Given the number of CWS stands at 300, the current average annual production volume of a CWS in Rwanda is approximately 50 tons of parchment coffee. However, the range of production is quite large where many CWS are operating below this average level of production to produce as little as 25 tons per year, while other CWS are producing substantially larger amounts. The seasonal variable labor assumptions are reported in table A3 for the different scales of production.

In this analysis, a comparison is made between the total annual costs of producing parchment coffee or fully washed coffee in Rwanda when the average level of production of washing stations ranges from 25 tons to 200 tons of parchment coffee per year. If each CWS produces more coffee, then the number of stations required to process the entire crop of Rwandan cherry coffee is correspondently lower. The main determinants of the quantity of parchment coffee that can be produced by a typical CWS are first and foremost, the amount of financing that the CWS owner can achieve to obtain for the purchase the required volume of cherry cherries for processing secondly the number of laborers employed to process the cherries.

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 financial variable cost of a CWS for a single year is represented by the variable $TV(\tilde{Q})_{\widehat{j.t}}^{F}$, where the superscript ^{F} refers to financial costs as opposed to economics costs, and it is computed using (1).

$$TV(\tilde{Q})_{\widehat{f.t}}{}^{F} = [(n(\tilde{Q}_t) * D_{op} * D_{\widehat{lab\tilde{q}}}{}^{F}) + (\tilde{Q}_t * 1000 * (c_{\widehat{trans\tilde{q}}}{}^{F}) + T(\tilde{Q}_t)^{F}{}_{\widehat{oth}}] \quad (1)$$

Where $\tilde{Q}_t$ denotes the total output of parchment coffee produced in tons by a CWS during a season. $n(\tilde{Q}_t)$ is the number of seasonal workers the station needs to employ in a season. $n(\tilde{Q}_t)$ is a positive function of the total volume processed. 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. $D_{\widehat{lab\tilde{q}}}$ is the daily wage rate of seasonal labor. The transportation cost per KG of parchment produced is denoted by $c_{\widehat{trans\tilde{q}}}{}^{F}$. $T(\tilde{Q}_t)^{F}{}_{\widehat{oth}}$ is the total sum of other variable costs that the CWS incurs during a season. Lastly one ton is equivalent to 1000 KG. Appendix table A5 contains the definitions of all the symbols used in the article.

3.1.3. The Total Seasonal Fixed Cost

The seasonal fixed cost is the sum of seasonal fixed labor and other fixed costs incurred during a season. The total seasonal financial fixed cost of a CWS is represented by the variable $TFC_{\overline{f.t}}{}^{F}$ and it is given by equation (2)

$$TFC_{\overline{f.t}}{}^{F} = \left[\left(n_t * T_{Mths} * w_i{}^{F}\right) + FC_{\overline{o.t}}{}^{F}\right] \qquad (2)$$

Were n_t represents the number of workers that must be employed for a period of T_{Mths} months during a 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) others would be employed for a shorter time, but all for at least for three months. These permanent workers are paid a monthly wage of $w_i{}^{F}$ where the wage amount differs depending on the position held. $FC_{\overline{o.t}}{}^{F}$ represents the sum of other fixed seasonal costs incurred by the CWS. The details of the seasonal fixed inputs for these four different scales of CWS are presented in Appendix table A4.

3.1.4. The Working Capital

The working capital funding is critical for the successful operation of a CWS. Before the beginning of each harvest season, the CWS decides on the volume of parchment coffee it wishes to produce over the season. This volume is determined by the size of the export contracts that the owner of the CWS has been able to obtain for the sale of parchment coffee. The CWS would consequently seek enough financing to cover not only the purchase of the cherry but also all of the CWS operating expenses for the season. Those costs include labor costs, both variable and fixed as well as other operating expenses. Failure to obtain an export contract and financing would most likely would result in the station not being able to purchase cherry coffee from farmers and hence not being able to operate independently of other producers.

The amount of working capital to be financed is found using equation (3) and it is represented by the variable $WC_{p.t}$. Where $C_{\tilde{Q}}{}^{F}$ is the total cost of cherry coffee purchased per season

$$WC_{p.t} = C_{\tilde{Q}}{}^{F} + TV(\tilde{Q})_{\widehat{f.t}}{}^{F} + TFC_{\overline{f.t}}{}^{F} \quad (3)$$

The cherry price per KG in 2022 was fixed by the government at 410 RwF per KG. This capped cherry price has followed a slow progression in nominal prices. 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 kilo. In Rwanda, CWS are prohibited from offering higher prices than the stipulated prices. and failure to abide by this rule constitutes a punishable offence. Each CWS is therefore in theory paying the same price per KG of cherry. Only the volume purchased differs. Each kilo of parchment coffee produced requires 5 KG of cherry coffee as inputs.

Securing financing for working capital is of crucial importance for the success of a typical CWS during each coffee campaign. Only a handful of large companies operating many CWS across Rwanda have the ability to self-finance or borrow internationally. Access to finance by CWS from local financial institutions is an arduous process as most are perceived as risky [7].

Table 1 shows an estimation of the seasonal amount of working capital that a typical CWS would require for the four chosen production scales of parchment coffee. Cherry costs are the most substantial part of the working capital requirement and thus are a critical factor for the CWS. The results in row 2 and row 3 of table 1 are computed using equation (1) while row (4) was found using (2). Row (5) is found using equation (3). Row 6 was computed using equation (4). From table 1, row 5 we see that the amount of working capital to be financed is a function of the volume of the cherry purchased, the mandated cherry price per kilo, 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 of working capital required in each season. As the volume of cherry purchased increases, the working capital requirements will also increase.

Table 1. Estimation of the yearly **working capital requirements** for a typical CWS US$ 2022 prices

Row no.	**Output production levels**	**25 tons**	**50 tons**	**100 tons**	**200 tons**
1	Cherry Coffee 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 requirements USD (r1+r2+r3+r4)**	**82,040**	**133,013**	**234,958**	**441,401**

As reported in row 1 we see that for a CWS the most substantial determinant of the size of the working capital is the cherry coffee costs. The total amount that must be financed to cover the working capital is reported in row 5, for each of the four scales of CWS operations being considered. For a CWS producing 200 tons the magnitude of the working capital requirements is almost twice the value of the initial capital investment in the facility.

This working capital can be financed by either loans or equity. As these are relatively small firms, we assume that the cost of finance whether debt or equity is a real rate of 13%.

In this way we can capture the cost of financing in the estimation of the net present values of the investment and operation of the CWS by applying a 13% discount rate to the net cash flows. In the construction of the net cash flows the sales of the output are made one period after the expenditures are made in the purchase of cherries and the operating costs are incurred and the inflows of cash begins two periods after the initial investment is made in the facility. In this way the annual costs of financing of both fixed investment and working capital are assumed to cost, or have an opportunity cost, of 13% a year.

3.1.5. The Total Operating Cost

The total financial operating cost of processing $\tilde{Q}_t$ tons of parchment coffee per season $TC_{\widehat{op.t}}{}^F$ is given by the sum of the seasonal variable costs, $TV(\tilde{Q})_{\widehat{f.t}}{}^F$, excluding the cost of cherries and the seasonal fixed costs, $TFC_{\bar{f}},{}^F$. This is shown in equation (4)

$$TC_{\widehat{op.t}}{}^F = TV(\tilde{Q})_{\widehat{f.t}}{}^F + TFC_{\overline{f.t}}{}^F \quad (4)$$

3.1.6. Present Value of Costs

Equations (1) to (4) show the computation of the total costs of a CWS just for a single season which is a limited time frame to gauge the worthiness of an investment in a CWS. The present value on the other hand gives us an estimate of the costs of the CWS for the entire duration of the life of a CWS. We assume that the CWS is operational for a period of 10 years. For this analysis we assume a financial discount rate of 13%. The discount rate represents the minimum rate of return an investor would want to obtain for making an investment in a CWS. Equation (5) describes the PV of the total volume of Parchment coffee in KG produced by a CWS over a period of 10 years.

$$PV(\tilde{Q}_t)^F = \sum_{t=0}^{T=11} \frac{(\tilde{Q}_t * 1000)}{(1+r)^t} \qquad (5)$$

3.1.7. The PV of Total Processing Cost of Parchment Coffee

Equation(6) shows the PV of the total financial cost of processing parchment coffee at a CWS over a 10 years period is noted by the variable $PV_T C_{\tilde{q}}{}^F$ and it is found by the summation of the PV for seasonal variable costs $TV(\tilde{Q})_{\widehat{J.t}}$, the PV of seasonal fixed cost $TFC_{\overline{f.t}}{}^F$, and lastly the PV of the initial investment cost $(I_{\bar{k}_t})$.

$$PV_T C_{\tilde{q}}{}^F = \sum_{t=0}^{T=10} \frac{TV(\tilde{Q})_{\widehat{J.t}}{}^F + TFC_{\overline{f.t}}{}^F + (I_{\bar{k}_t})}{(1+r)^t} \quad (6)$$

Given that in a year there is only one coffee season in Rwanda, the number of years thus corresponds to the discounting period. Table 2 shows the present value of the volume of parchment coffee and of present value of each component of the total costs of processing parchment coffee for the four chosen production volumes. These costs (capital investment in year zero and operating costs from year 1 to 10) occur over a period of 11 years and are expressed in 2022 prices.

The results of the financial analysis are presented in table 2 for the PV of costs and in table 4 for the average processing cost per KG. We obtained those of table 2 by applying equations (5) and equation (6). In row 1 of table 2, the assumed production volume of parchment coffee in tons are reported for the four scales of operation. From the values for the PV of total seasonal processing costs table 2, row 6 we find that there are substantial economies of scale between the a CWS producing 50 tons to a CWS producing 200 tons. The PV of total seasonal processing costs for a 200 tons operation is \$315,919 while the total seasonal processing costs of a 50 tons level of operation is \$201,943. While the total production of the 200 tons CWS is 4 times the production of the 50 tons CWS its total seasonal costs only increase by 56.44% and the fixed capital costs are the same in both instances. When fixed costs are included (table 2 row 8). We find that the present value of costs of the larger operation of 200 tons over 10 years \$515,953 are only 1.28 times as large than \$401,977 (50 tons) 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.

Table 2. Financial Present Value at 13% of the Outputs and Costs of CWS with four different production scales (in US$ 2022 prices

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.	47,506	67,301	87,095	140,540
3	PV of total transportation costs and others variable costs.	6,796	13,586	27,165	54,323
4	**PV of Total seasonal Variable Costs (r2+r3)**	**54,302**	**80,887**	**114,260**	**194,863**
5	PV of total seasonal fixed labor costs and other fixed seasonal costs.	121,056	121,056	121,056	121,056
6	**PV of Total Seasonal Costs in USD (r4+r5)**	**175,358**	**201,943**	**235,316**	**315,919**
7	PV of total Investment Costs in USD	200,034	200,034	200,034	200,034
8	**PV of Total Cost of Processing at CWS in USD (r6 +r7)**	**375,392**	**401,977**	**435,350**	**515,953**

3.1.8. 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 (7). Where ${P_i}^F$ is the per KG net export price of parchment coffee sold internationally.

$$NPV_{\tilde{q}}^{F} = \sum_{t=0}^{T=10} \frac{\left[\left({P_i}^F * \tilde{Q}_t * 1000\right) - {TC_{\widehat{op.t}}}^F - \left(I_{\bar{k}_t}\right)\right]}{(1+r)^t} \qquad (7)$$

The NPV results are reported in table 3. In estimating the net present values for these different scales of CWS an average export price FOB of $6 per kilo was applied $6 was the average gross export price of coffee obtained by Rwanda during the 2021-2022 fiscal year according to [5]. This price may be a rather conservative assumption. From our discussions with CWS operators we gleaned that they can obtain higher prices than $6 per KG depending on the nature of contract they got from their overseas customers. An estimated average export cost of $0.5 per KG reduces the net export price obtained by the CWS for parchment coffee to $5.5 per KG.

Table 3. Financial Net Present Values for a CWS for a 10 years period and 13% discount rate

Row.		**25 tons**	**50 tons**	**100 tons**	**200 tons**
1	PV of parchment revenues in USD	660,275	1,320,545	2,641,095	5,282,184
2	PV Cherry coffee purchased in USD	259,902	519,804	1,039,607	2,079,215
3	PV of total cost of processing parchment at CWS in USD	375,392	401,977	435,350	515,953
4	**Net Present Value in USD**	**24,981**	**398,764**	**1,166,138**	**2,687,016**
5	**Internal Rate of Return**	**14.80%**	**34.11%**	**57.02%**	**81.73%**

The results reveal that even if a washing station could only produce 25 tons of parchment coffee in a year it would still be able to realize a positive financial NPV of $24,981 over its 10-year lifetime. This positive NPV and the internal rate of return of 14.80% at a production level of 25 tons are consistent with field observations. In fact, several CWS in Rwanda operate at a capacity of 25 tons of parchment production per year [7] As the level of outputs increases, we observe that the NPV rises to $398,764 for a production of 50 tons and finally reaches $2,687,016 for an output level of 200 tons per season.

The NPV results indicate that under the current operating regulations, an investment in a coffee washing station is potentially a very lucrative endeavor. This profitability is contingent, however, on three important conditions: First, the CWS must be able to secure financing to cover its working capital needs prior to the beginning of the season. Second, the station must be able to purchase enough cherries within its zone 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 at all, the owner of the CWS would be forced to sell its output domestically to another exporter for a much lower price.

3.1.9. Average Variable and Long Run Costs

The PV of costs and the PV of the outputs of parchment produced as reported in table 2 will be used in the computation of average short-run and long run average costs per KG of parchment production at each of the four production levels of CWS.

In our analysis, we use the term short run average cost to refer to the seasonal cost per KG of processing parchment. 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 estimates of total variable costs are presented in table 2, row 6. The long-term total cost on the other hand includes the initial investment cost as reported in table 2, row 8. Hence, the average total financial cost of processing a KG of parchment must also include the cost of the initial capital investment. 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 table 4 from row 1 to row 7 report the various average cost variables. They are derived by dividing the PV of the cost of different input categories from table 2 (table 2 to row 2 to 8) by the PV of the quantities of parchment production from row 1 of table 2, as estimated by equation 6. Table 4, row 5 reports the estimated average total seasonal costs of processing 1 KG of parchment coffee by a washing station of the four levels of production scale. This cost includes the financing costs of cherry that is purchased at 410 RwF/KG. This seasonal processing cost is a gauge of the cost efficiency of the CWS for a season. As shown in table 4 row 5, it falls from $1.46/KG When we assume a production scale of 25 tons, to $0.33/KG when the CWS processes 200 tons of parchment coffee

Table 4. Financial average short run and long run unit processing costs in USD per KG of parchment coffee

Row	Average short run and long run unit processing costs	25 tons	50 tons	100 tons	200 tons
1	Average seasonal variable labor production costs per KG	0.40	0.28	0.18	0.15
2	Average transportation costs and others costs per KG	0.06	0.06	0.06	0.06
3	**Average Seasonal Variable Costs per KG**	**0.45**	**0.34**	**0.24**	**0.20**
4	Average seasonal fixed labor costs and others per KG	1.01	0.50	0.25	0.13
5	**Average Total Seasonal Costs per KG (r3+r4)**	**1.46**	**0.84**	**0.49**	**0.33**
6	Average Total Investment Costs per KG	1.67	0.83	0.42	0.21
7	**Average Total Cost/ KG of parchment (r7+r8)**	**3.13**	**1.67**	**0.91**	**0.54**

This seasonal processing cost is a key parameter when determining the size of the incentive a CWS owner faces to expand production within a season given the purchasing price of cherry coffee and the parchment coffee selling price. Of course, in a competitive situation where the CWS owner could purchase cherry coffee outside of its designated zones, it would be expected that transportation costs would increase and perhaps the price of cherry would be bid up. In this situation the marginal costs and average variable costs (including the costs of cherry input) would be expected to eventually increase as the scale of the CWS increased. When the average fixed cost of the initial investment reported in row 6 is added to seasonal costs the of row 5 one finds the estimated long run average total financial cost of processing a KG of parchment coffee at the CWS for the four different scales of operation this is found in row 7 of table 4. The average fixed investment cost reported in row 6 includes a real rate of return to the investor of 13%. It is estimated as the ratio of the cost of the initial investment costs divided by the present value of the quantity of parchment produced over the lifetime of the CWS.

From table 4 row 7, a CWS that produces only 25 tons of parchment coffee, the long run average total cost is $3.13. If a CWS produces 50 tons of parchment coffee each season, its average total cost is $1.67 per KG of parchment coffee produced. When the CWS produces 100 tons of parchment coffee, its long run average total cost per KG falls to $0.91 per KG and is reduced further to $0.54 per KG when the CWS achieves a production level of 200 tons. The fall in the average total costs arises because both the average fixed capital cost as well as the average fixed seasonal costs decrease as the volume of parchment coffee produced by a CWS increases. There are also some economies of scale with respect to the seasonal variable costs.

3.1.10. Producer Surplus and Profit Margins with Regulated Cherry Prices

The short run and long run average costs computed in table 4 can now be used to compute the producer surplus and profit margins when the net export price of parchment coffee averages 5.50 USD per KG. Table 5 row 6 shows the profit margins a typical CWS would realize per KG of parchment coffee for the respective production levels. In these calculations, the current price of cherry of 410 RwF/KG is used. We notice that when the station processes 25 tons of parchment coffee it enjoys a net profit of $0.46 per KG. If on the other hand it achieves a production volume of 100 tons, the profit margin climbs to 2.69 USD per KG finally, the profit per KG soars to 3.05 KG if the CWS can process 200 tons of cherry. Those significant profits margins unveil one of the reasons why investments in CWS were attractive to business to investors and why there has been a surge of investments in CWS in Rwanda since 2003. However, the results also testify to the fact that the ability to purchase larger volumes of cherry coffee from farmers is of critical importance to a CWS owner.

When one considers the situation where CWS owner has invested in a CWS then the short run surplus to be gained from obtaining additional cherry is even greater. Table 5, row 4 reports the margin or contribution to producer surplus. For the existing owners of CWS who are operating below their capacity, the incentive is much greater for them to purchase cherries at a higher price than it would be for someone who is contemplating investing in a new CWS. The margin of producer surplus per KG of additional parchment production starts at $2.12/KG for a CWS now producing 25 tons/year to $2.74, $3.09 and $3.25/KG for CWS producing 50, 100 and 200 tons/year, respectively, of parchment coffee.

If the industry were allowed to operate and to purchase cherries coffee competitively, these very large margins would result in the individual CWS being willing to pay higher prices for cherry to expand production. As a tree crop, the supply response of cherry supply is small to the short run increases in its price. Without the zoning policy, the competition for cherry will likely be more intense. It would be expected that only those organizations that were financially secure enough to obtain t financing for their working capital will remain in business.

Table 5. Financial Profits per KG of Parchment Produced in (USD per KG)

Row	Average Profit per KG	25 tons	50 tons	100 tons	200 tons
1	Net export price	**5.5**	**5.5**	**5.5**	**5.5**
2	Cost of Cherry input per KG of parchment if cherry price is 410 RwF/KG	1.92	1.92	1.92	1.92
3	Average Total Seasonal Production Costs per KG	1.46	0.84	0.49	0.33
4	**Producer Surplus ($/KG) (r1-r2-r3)**	**2.12**	**2.74**	**3.09**	**3.25**
5	Average Total Financial Cost of Processing a KG of parchment	**3.13**	**1.67**	**0.91**	**0.54**
6	**Profit ($/ KG) of Parchment Coffee if Cherry is 410 RwF/KG (r1-r2-r5)**	**0.45**	**1.91**	**2.67**	**3.04**

3.1.11. Equilibrium Cherry Prices in a Competitive Industry

The next step in this analysis is to estimate what would be the price of cherry if it were increased to the point where the industry was earning only a rate of return sufficient to attract investors into the CWS sector. For this analysis we are assuming that a 13 percent real rate of return would be sufficient to attract investors into the CWS sector. This will be carried out under two situations. First, the long run equilibrium price of cherry is estimated for alternative long run selling prices 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 inelastic.

The second case considers the short-term situation where a surplus of processing capacity 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 inelastic. In each of these two cases the analysis is carried out under four different assumptions about the scale of production of a representative CWS.

To find the break-even price of cherry coffee (RwF / KG) of table 6 and table 7, one first needs to find the margin per KG available for the CWS to purchase cherry in these two situations. This is 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. The margin available for the purchase of cherry in the long run $M_{\widetilde{LB}}$ is found using equation 8). Where $ap_{M_{\tilde{B}}}$ denotes the average total seasonal costs per KG table 4, row 5 excluding the financing costs associated with the purchase of cherry. The long run margin is further reduced by the deduction of the average fixed investment costs per KG denoted by $ap_{I_{\bar{k}t}}$ as reported in row 6 of table 4.

$$M_{\widetilde{LB}} = \left[P_i^{\,F} - \; ap_{M_{\tilde{B}}} - \; ap_{I_{\bar{k}t}} \right] (8)$$

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 us estimated using equation (10),

$$M_{\widetilde{SB}} = \left[P_i^{\,F} - ap_{M_{\tilde{B}}} \right] \qquad (9)$$

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 11.

The maximum price of cherry coffee that the CWS could potentially be offered $P_{\widetilde{LB}}$ is estimated for the four chosen scales 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. $\bar{\bar{q}}$ is the number of KG of cherry coffee needed to produce a KG of parchment coffee.

$$P_{\widetilde{LB}} = \frac{M_{\widetilde{LB}}}{\bar{\bar{q}}} * E_{\tilde{x}} \qquad (10)$$

The estimates of the competitive prices of cherry that could be paid at the site of the CWS are presented in table 6 for situations where the industry was characterized by firms of an average production of 25, 50, 100 and 200 tons of parchment coffee and facing average 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 6 and table 7, the per KG cherry prices 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 13 percent.

Table 6. Long run break-even price of cherry coffee (RwF / KG)

Row	Net Export price (USD per KG) Parchment Coffee	Annual Production 25 tons	50 tons	100 tons	200 tons
1	**5.00**	400	713	875	954
2	**5.50**	**507**	**820**	**982**	**1,061**
3	**6.00**	614	927	1,089	1,168
4	**6.50**	721	1,034	1,196	1,275
5	**7.00**	828	1141	1303	1382

At the present time in Rwanda, the average annual production is 50 tons/year and the average output price was $5.50/KG during the last coffee season. At an output price of $5.50/KG, a CWS producing 50 tons could pay up to 820 RwF/KG (table 6, row 2) for cherry. This price is the double of the current regulated cherry coffee price of 410 RwF/KG. If the industry were operating efficiently with all CWS operating with an annual production of 200 tons/year or larger, the long run equilibrium price of cherry earned by the farmers could be as high as 1,061 RwF/KG. 1061 RwF/KG is 158.78 % above the current regulated price of 410 RwF/KG. 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 cherry coffee in any given season, one needs to compare the short run cost with the selling price of parchment. The per KG price of cherry that would result in a zero profit, is found by replacing the numerator of equation (10) by $M_{\widetilde{SB}}$. The maximum cherry prices in the short run are presented in table 7. In the short run, the capital investment in the CWS can be considered a sunk cost. 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 997 RwF/KG. This price for a KG of cherry is 143.2% greater than the current price of 410 RwF /KG being paid to farmers. For a CWS operator who wishes to get production to a level of 200 tons/year, they would be willing to pay up to 1106 RwF/KG for cherry, or 169.8 %, above the current regulated cherry price.

From this analysis, it is clear why it is important for owners of CWS to seek to expand their production volume of parchment coffee by purchasing additional quantity of cherry coffee. With the government mandated cherry price of 410 RwF/KG, there is a high incentive to engage in the illicit purchase cherry coffee by offering higher per KG prices despite the risk of punishment. 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 aera in which of individual CWS can legally buy cherry coffee.

Table 7. Short run break-even price of cherry coffee (RwF / KG)

Row	**Net Export price (USD per KG) Parchment Coffee**	**Annual Production**			
		25 tons	**50 tons**	**100 tons**	**200 tons**
1	**5.00**	758	890	965	999
2	**5.50**	**865**	**997**	**1,072**	**1,106**
3	**6.00**	972	1,104	1,179	1,213
4	**6.50**	1,079	1,211	1,286	1,320
5	**7.00**	1,186	1,318	1,393	1,427

3.1.12. 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 Annual Report (2021-2022) [5, 15, 16]. The country exported around 15000 tons of fully washed coffee in 2022. The production of coffee in Rwanda usually oscillates between 18,000 tons to 23,000 tons per year. We will therefore use the figure of 15000 tons or 15 million KG of parchment as the production benchmark level for Rwanda to evaluate the cost of the inefficiencies of the CWS sector 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 6 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 zoning policy designed by the government for this sector. In table 8 estimates of these annual losses are presented for the case where with an annual quantity of exports of processed coffee exported of 15,000 tons, and the average long run price of parchment coffee is $5.50/ KG.

Table 8 row 1 col 3 reports that for a CWS owner producing 50 ton of parchment coffee a year to earn a real rate of 13 percent the breakeven price for cherry is 820 RwF. This means that the farmers are potentially losing 410 RwF/KG of cherry they sell to the CWS (table 8 row 3). Considering that 15,000 tons of parchment coffee are exported, the financial loss to the Rwandan coffee farmers is 30.75 billion RwF or $28,738,318 per year. This is the financial loss resulting from the restriction on the selling price of cherry. 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 CWS owners to compensate them for the higher costs they incur because of the inefficient investment and operations of the CWS.

Table 8. Annual Aggregate Long Run Losses to Rwandese farmers who are selling cherry coffee at $!) RwF parchment coffee at Due to Low Regulated Cherry Price

	Col 1	Col 2	Col 3	Col 4	Col 5
Row		**25 tons**	**50 tons**	**100 tons**	**200 tons**
1	Long run of cherry price if parchment price at $5.50/KG	**507**	**820**	**982**	**1,061**
2	Fixed cherry price 410 RwF/KG	410	410	410	410
3	Difference per RwF/KG	97	410	572	651

4	Annual Loss to coffee growers in **Million RwF**	**7,275**	**30,750**	**42,900**	**48,825**
5	Annual Loss to coffee growers in **USD**	**6,799,065**	**28,738,318**	**40,093,458**	**45,630,841**
6	PV of Aggregate Loss over 10 years in **USD**	**36,893,382**	**155,941,111**	**217,556,865**	**247,604,053**

From table 8 row 5 col 5 we observe that if the coffee industry had been more efficient with only 25% as many CWS and each producing on average 200 tons/year of parchment coffee, then the annual loss to the coffee growers would have been $45,630,841. The difference between the annual loss of $45,630,841 and $28,738,318 or $16,892,523 is the excess financial costs created by the greater investment and operating costs incurred by the owners and operators of CWSs because of excess number of CWS that has emerged as a response to the policy framework.

This analysis is being carried out in a static framework where the amount of parchment coffee exported is fixed at 15,000 tons/ year. A major current problem with the sector is that with the existing price structure farmers have been unwilling to invest in replanting and expanding their coffee trees [17]. 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.

3.2. Economics Analysis

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. The economics analysis is based on economic costs rather than financial ones. The goal of an economic analysis is to assess the impact that a given project has on the whole society. We proceed by repeating the same equations we previously used, however this time we use economics prices and economics costs instead of financial ones. Economics prices and costs 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 [13, 18].

The divergence between the economics and the financial evaluation are referred to as externalities. Externalities can be either positive or negative. The economics analysis uses as discount rate an economic opportunity cost of capital ($EOCK$) of 13%. This EOCK is the discount rate recommended by the Government of Rwanda to conduct an economics appraisal [18]. Equation 12 describes the calculation of the present value of the quantity of parchment coffee in KG produced by CWS over a period of 10 years.

$$PV(\tilde{Q}_t{}^{E}) = \sum_{t=0}^{T=11} \frac{(\tilde{Q}_t * 1000)}{(1 + EOCK)^t} \quad (12)$$

The total economics variable costs for a season $TV(\tilde{Q})_{\widehat{J.t}}{}^{E}$ are given by equation (13)

$$TV(\tilde{Q})_{\widehat{J.t}}{}^{E} = [(n(\tilde{Q}_t) * D_{op} * D_{\widehat{lab}\tilde{q}}{}^{E}) + (\tilde{Q}_t * 1000 * (c_{\widehat{trans}\tilde{q}}{}^{E}) + T(\tilde{Q}_t)^{E}{}_{\widehat{oth}}] \quad (13)$$

Where the variables of the right-hand side of equation (13) and equation (14) have the same interpretation as in the financial analysis. The Total Economics Seasonal Fixed Cost ($TFC_{\overline{f.t}}{}^{E}$) is given by:

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

(14)

3.2.1. The Economics Present values of Total Costs of processing Parchment.

The present value of the total economics cost of processing parchment coffee is the sum of the economics PV of Seasonal Variable Costs $TV(\tilde{Q})_{\widehat{J.t}}{}^{E}$, the economics PV of total seasonal fixed cost $TFC_{\overline{f.t}}{}^{E}$, and the initial investment cost $I_{\overline{k.t}}{}^{E}$. The total economics cost of processing is expressed by equation (15).

$$PV_T C_{\tilde{q}}{}^E = \sum_{t=0}^{T=10} \frac{TV(\tilde{Q})_{\widehat{J.t}}{}^E + TFC_{\overline{f.t}}{}^E + I_{\overline{k.t}}{}^E}{(1+EOCK)^t} \quad (15)$$

The average economics cost of processing a KG $ap_{c_{\tilde{q}}}{}^E$ of parchment coffee is given by (16). It is the ratio of the PV of Total Economics Processing Cost of parchment coffee $PV_T C_{\tilde{q}}{}^E$ to the PV of the total volume of parchment $PV\left(\tilde{Q}_t{}^E\right)$.

$$ap_{c_{\tilde{q}}}{}^E = \frac{PV_T C_{\tilde{q}}{}^E}{PV\left(\tilde{Q}_t{}^E\right)} \quad (16)$$

The results from the economics analysis for the present values of costs and outputs at a CWS are reported in the table 9 for the four scales of parchment production volumes.

Table 9. Economics Present value at EOCK 13% of the outputs and costs for the 04 production levels of a single 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**
5					
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 Economics 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**

Table 9, row 10 shows 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 the values of the PV of total economic cost in Table 9, row 9 to the PVs of quantities produced as reported in row 1 of table 9. We see that when a washing station produces 50 tons of parchment coffee annually, the long run average economics cost per KG of parchment to Rwanda is \$1.51 per Kilo. Similarly, the total the long run average economics cost of a CWS processing 100 of parchment coffee a year is \$0.82 per KG. Finally, the long run average economics cost per KG falls to \$0.49 per KG when the CWS achieves an annual production level of 200 tons of parchment coffee. As 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 economics 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 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 counted as economic costs.

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

The following analysis estimates the economic cost to Rwanda of processing the annual production of 15,000 tons of parchment coffee. We will compare the economics cost bore by the current number of CWS in Rwanda which stands at 300 to the what would the economic cost have been if the number of CWS were reduced to 150 CWS and 75 CWS. The difference between the total cost incurred at the moment by 300 CWS during a season and a 150 CWS and 75 CWS with each producing respectively 100 or 200 tons on average per year represents the losses Rwanda suffers for a coffee season as a result of overinvestments in the CWS sector.

3.2.2.1. Rwanda's Potential Yearly Economics Costs Saving

From table 9 we find that the average total long run average economics cost of producing parchment coffee with a CWS producing 50 tons a year ($ap_{c_{\widetilde{50t}}}{}^{E}$) is $1.51/KG. Using the country's assumed annual production of parchment coffee $\tilde{Q}_{AGG}$. The total annual production costs are estimated to be $19,987,109 . Similarly, with a CWS producing 100 tons, the average total long run economics cost of producing parchment coffee ($ap_{c_{\widetilde{100t}}}{}^{E}$) is $0.82/KG. The total annual production costs are estimated in this case would be $10,869,885 and 150 CWS would be needed to maintain the contry's annual production of parchment coffee. The annual saving on Economics costs to Rwanda if the number of CWS were reduced from 300 CWS to 150 CWS is given by equation (17)

$$\tilde{Q}_{AGG} * \left[ap_{c\widetilde{50t}}{}^{E} - ap_{c\widetilde{100t}}{}^{E} \right] \quad (17)$$

Similarly, the annual saving on Economics costs to Rwanda if the number of CWS reduces from 300 CWS to 75 CWS is given by equation (18)

$$\tilde{Q}_{AGG} * \left[ap_{c\widetilde{50t}}{}^{E} - ap_{c\widetilde{200t}}{}^{E} \right] \quad (18)$$

While the amount of parchmant coffee produced is assumed to be 15 million kg in a year, the value of $\tilde{Q}_{AGG}$ used in the calculation of 17 and 18 is discounted by one year at 13% to be consistent with the way the average costs in both situations were estimated.

Table 10. Rwanda's Potential Yearly Economics Costs Savings

Row	Col 1	Col 2
1	Yearly Saving on Economics costs to Rwanda from 300 CWS to 150 CWS	**$9,117,224**
2	Yearly Saving on Economics costs to Rwanda from 300 CWS to 75 CWS	**$13,484,295**

If the number of washing stations is greater than what would be optimal, it implies that the industry has wasted economic resources that could have been better employed elsewhere. From table 10 row 1, we see that reducing the number of CWS by half would result in a total welfare saving of $9,117,224 per year to Rwanda. This amount is substantial and could potentially be used to offer higher prices to farmers for their cherry coffee instead of mandating a fixed price.

If the number of CWS could be reduced further to 75 CWS by having each producing on average 200 tons of parchment coffee/year, the economic resource savings as compared to the current situation would be $13,484,295 per year. From table 8 we found that the financial cost per year of the inefficiencies of overinvestment was $16,892,523. The difference between these two values is caused by the fact that the economic costs of the excess CWSs is slightly lower due to input taxes than is part of the financial costs, but not an economic cost.

3.2.2.2. Total Economics Welfare loss to Rwanda due to the Oversupply of CWS

To evaluate the overall economic losses created by the excessive number of CWS we need to compute these costs over the 10 years life of CWS. In the current situation, we have 300 CWS that process parchment coffee each at a present value ($PV_T C_{\widetilde{300}}{}^{E}$) of $361,516 so the total processing cost incurred by 300 CWS producing on average 50 tons each is therefore $108,454,800 over 10 years. The estimated present values of the processing costs are also estimated for the situation where all the parchment coffee is produced by plants producing 100 tons per year and 200 tons per year. These estimates of PV of costs are reported in table 11, col. 2 rows 1, 2, and 3, respectively. The total economics welfare Rwanda could have saved if only 150 CWS were operating instead of 300 is given by equation (19).

$$\left[\left(300cws * PV_T C_{\widetilde{300}}{}^{E}\right) - \left(150cws * PV_T C_{\widetilde{150}}{}^{E}\right)\right] \quad (19)$$

Similarly, the total economics welfare Rwanda could have saved if only 75 CWS were operating is given by equation (20):

$$[(300cws * PV_T C_{\widetilde{300}}{}^{E}) - 75cws * PV_T C_{\widetilde{75}}{}^{E})] \quad (20)$$

The combined results of the welfare loss to Rwanda are presented in table 11, col 2, rows 4 and 5.

Table 11. Total Economics Welfare loss to Rwanda due to the Oversupply of CWS

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

These estimates indicate that Rwanda would have saved over $49,472,100 (table 11 row 4 col 2) if only 150 CWS were built instead of 300 CWS. Furthermore, if only 75 CWS were built to produce annually the 15,000 tons of parchment coffee then Rwanda could have saved up to approximately $73,168,950 over a 10-years period (table 11 row 5 col 2). Those figures further confirm that the oversupply of CWS in Rwanda has come in at a large economic cost to the country.

3.2.3. Stakeholder Analysis of Policies Reforms

With the results of the financial analysis from Table 8 and the economic analysis reported on tables 10 and 11, one can assess the impacts of this policy on the various affected stakeholders in the economy. In what follows, the comparison is carried out between the current situation with 300 washing stations producing 15,000 tons of parchment per year and a situation where there were only 75 CWS with each producing 200 tons per year.

From the overall Rwandan economies point of view, we report in Table 12 col 2 the annual and PV of 10 years of economic losses caused by the excessive investment and operating costs in CWS. The annual loss to the economy is estimated to be equal to $13,484,295 with a PV of economic loss over 10 years of $73,168,950. In breaking down this loss into its various components it is the coffee farmers who are bearing the brunt of these policies with current annual financial losses of $45,630,841 or a PV of financial losses of $247,604,053 as compared to what their situation could be if the CWS sector were operating efficiently and they rather than the CWS owners were receiving the surplus income from increasing the coffee quality, Table 12, col 3.

Because of the increased investment and operating costs, the government is receiving more sales taxes and excise tax revenues than they otherwise would have amounted annually to $3,408,228 or a PV over 10 years of $18,493,874, Table 12, col 4. Finally, it is the owners of the existing CWS, even if they are operating inefficiently who are the main beneficiaries of the current policies. On an annual basis they have been gaining income more than a real rate of return of 13% equal to $28,738,318 per annum. Evaluated as a PV over a period of 10 years the amount of financial income (rents) gained is equal to $155,941,111.

Table 12: Stakeholder Analysis of Impacts of Policies Leading to Excessive Investments in CWS in Rwanda

	Col 1	Col 2	Col 3	Col 4	Col 5
Row		**Rwandan Economy**	**Farmers**	**Government**	**CWS Owners**
1	Potential annual Impacts USD	-$13,484,295	-$45,630,841	+$3,408,228	+28,738,318
2	PV Potential impacts over 10 years USD	-$73,168,950	-$247,604,053	+$18,493,874	+$155,941,111

The stakeholder analysis uses the information derived throughout this study and it reconciles exactly. The loss to the economy is exactly equal to the sum of the stakeholder impacts on the affected groups in society. The loss to the farmers, partially offset by the gain to the government in taxes and to the excess profits of the CWS is exactly equal to the overall economic cost of this policy to the economy of Rwanda**.**

4. Discussion and Conclusion

Rwanda is facing serious threats to the sustainability of its coffee industry in the long run 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, a large number of 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 [17]. 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 a lot of 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 fueled 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 large 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 cherry coffee within the confines of a specific geographic area thereby guaranteeing to some extent the availability of cherry coffee to washing stations within that zone. The government also maintained the long-standing policy of setting a fixed per kg price for cherry coffee at the beginning of each harvest season. Infringing on these rules was a sanctionable offense in Rwanda. The combined effect of the oversupply of CWS, the zoning policy, and the fixed per KG cherry coffee price gave rise to substantial inefficiencies with coffee farmers bearing the brunt of the cost of theses inefficiencies through being paid a lower price for cherry coffee 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 cherry coffee. 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 were 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 article 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 cherry coffee 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 cherry coffee 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 necessary investments required on their plantations to increase their production of cherry coffee. 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.

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Appendixes

Table A1. Initial Investment Costs for a Coffee washing station in Rwanda with a Capacity of 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 A2. Variable and Fixed Costs of a standard CWS

Seasonal Variable Costs	Seasonal 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 Administrative head
Materials costs	Security during the season
Seasonal Workers	Security for the rest of the year
Cherries Selection-Reception-Floatation	**Operating Costs**
Tank- Fermentation - Grading	Office supplies
Drying team	Communication expenses
Seasonal Variable Cost Without Financing	Printing expenses
	Mechanic Repair and maintenance
Interest on Working Capital	Spare parts
	Advertising
	Lubricants and greases
	Insurances
	Seasonal Fixed Costs

Table A3. Seasonal variable Labor 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 A4. Seasonal Fixed Labor Assumptions based on a station producing 200 tons of Parchment Coffee.

Permanent labor	**# of employees**	**# of months**	**Monthly Salary in RwF 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 A5. Table of parameters used in analysis in Equations

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
$\tilde{Q}_t$	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 $\tilde{q}$
$TV(\tilde{Q})_{\widehat{f.t}}^{\ F}$	Total Financial variable cost of processing parchment for a season
r	Real Financial discount rate
r_s	The real interest rate on the working capital loan
$TFC_{\overline{f.t}}^{\ F}$	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.

Parameters	Definition
	Financial Analysis
$WC_{p.t}$	Working capital per season
${c_{\ddot{q}}}^F$	Average Financial Cherry cost per KG of parchment coffee produced
$M_{\tilde{B}}$	The total margin in USD available to the CWS for the purchase of cherry
$\tilde{\iota}_b$	The interest paid on the working capital excluding on in the interest paid on the cost of cherry purchase.
$\overline{\overline{q}}$	The conversion ratio between Cherry coffee and parchment coffee (It is set at 5 KG of cherry = 1KG of parchment)
$(I_{\bar{k}_t})$	Total Financial Initial capital cost for a washing station
	Economics Analysis
EOCK	Economics opportunity cost of capital
$NPV_{\tilde{q}}^E$	Economics net present value, as of year t= 0 (2022)
${PV_T C_{\tilde{q}}}^E$	PV of Total Economics Processing Cost of parchment coffee
${ap_{c_{\tilde{q}}}}^E$	The Average Economics cost of processing a KG of parchment coffee
${ap_{c_{\widetilde{100t}}}}^E$	The average total long run economics cost of producing parchment coffee by a CWS producing 100 tons
${ap_{c_{\widetilde{200t}}}}^E$	The average total long run economics cost of producing parchment coffee by a CWS producing 200 tons
${P_i}^E$	Parchment Coffee Economics Selling price per KG
$TV(\tilde{Q})_{\widetilde{f.t}}$	Total Economics Variable Cost
${TFC_{\overline{f.t}}}^E$	Total Economics Seasonal Fixed cost
${P_{\ddot{C}}}^E$	Economics Floor Price for 1 KG of cherry set by Government at the beginning of each season
$PV_T C_{\widetilde{150}}$	PV of Total Economics Cost of Processing by 150 CWS each processing 100 tons on average
$PV_T C_{\widetilde{300}}$	PV of Total Economics Cost of Processing by 300 CWS each processing 50 tons on average
${I_{\overline{k.t}}}^E$	Total Economics Initial capital cost for a washing station

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