Impact Evaluation of the Rwanda Green Leaf Tea Pricing Reform

Final Report

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Executive Summary

The green leaf tea pricing reform, introduced by the government of Rwanda in 2012, linked farmers directly to the international tea market through a 30% price share of the international tea price, as determined at the Mombasa tea auction. The impact evaluation finds that the average nominal **price for green leaf tea in Rwanda rose sharply (by about 40%) as a result of the pricing reform**. This confirms the existence of a pass-through from international tea prices to farm-gate prices as anticipated by the policy, though there remains a wedge of 25% between what the factories pay co-operatives, on average, and what farmers actually receive.

The pricing reform led **20% of farmers to expand tea cultivation**. On average, female and older headed households were found to be less likely to expand cultivation, as were households headed by those with no reading or writing skills. A lack of land holdings, rather than land quality, is the primary constraint to expansion.

There is suggestive evidence that the reform positively impacted productivity, but increases are not statistically significant. In contrast, annual tea farmer revenues did significantly increase post-reform and the empirical analysis also detects a **significant increase in farm-related investments**, which suggests the possibility of future productivity enhancements. To date, price reforms have not resulted in statistically observable impacts on household food expenditure patterns, livestock asset profiles of tea farmers, or subjective household welfare.

Knowledge of the tea reforms is poor among non-tea farmers, and most remain reluctant to engage in tea production. The survey responses suggest non-tea farmers view the tea prices as significantly below the reservation prices that would stimulate their entry. In addition, a majority cite access to land as an impediment, and close to one-fifth also cite a lack of expertise as a key constraint. In general, non-tea farmers have less land, own fewer assets, and have lower levels of household welfare.

The 2016 follow-on survey was complemented by an additional survey of tea-pluckers, a critical element in tea production, and one largely neglected to date in terms of analysis. Our analysis provides evidence that pluckers have benefitted from the 2012 price reform with an uplift in their pay rates, comparable in percentage terms to the price increases enjoyed by tea farmers. Thus, there is evidence of a 'trickle-down' of the tea price reform benefits to the tea-pluckers themselves, though the degree of pass-through from the tea price to plucker-pay appears to have remained constant in the wake of the price reform. The overwhelming majority of tea-pluckers report improvements in work conditions since the reforms, indicating that **the policy has improved the quality of these rural jobs**.

Using administrative data drawn from the Asopthé cooperative, our analysis points to a **positive effect on gross production after the reform**. There is also evidence of an increase in tea farmer net earnings, complementing the findings from the household survey data. Some caution, however, is required in interpretation. In particular, the positive effects observed from the Asopthé are certainly correlated with the introduction of the reform, but may not be causally linked. Furthermore, the cooperative is viewed within the tea sector as well-managed and high-performing, so results may not be generalizable for the sector as a whole.

Therefore, the evidence from this case study portion is best interpreted as suggestive, rather than compelling.

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Introduction

This report provides findings from the impact evaluation of the green leaf tea pricing reforms in Rwanda. The evaluation measured whether, and to what extent, the pricing reforms impacted tea revenues, farmer incomes, agricultural assets, investments, and tea cultivation decisions.

The Ministry of Agriculture and Animal Resources (MINAGRI), through the National Agricultural Export Board (NAEB), undertook to reform the pricing mechanism for green leaf in 2012. Up to that time, the price for green leaf was determined annually, and the amount paid to farmers for their green leaf tea was based on the self-declared costs of a factory. The system was generally viewed as cumbersome and opaque. Furthermore, under this system, the price paid to farmers was not linked to the market price, and was low by comparison to the benchmark provided by other tea-producing countries. This had the effect of discouraging farmers from planting and harvesting tea and investing in their plots and in the quality of their output, given higher returns could be obtained from cultivating alternative crops.

The GoR requested technical assistance from the World Bank Group's IFC Advisory Services to both inform and structure the reform of the green leaf pricing mechanism. In July 2012, the GoR introduced a radical reform to the pricing mechanism with this technical support, which became effective in late 2012. The reform consists of a more transparent pricing mechanism that directly links the prices paid to farmers to the market price for (factory) "made tea." The "made-tea" price is now based on a weighted average price of all Rwandan tea sales on the market, of which farmers receive a fixed percentage (currently 30 percent), as opposed to the factory-cost model described above. These prices were designed to be set every six months rather than, as previously, on an annual basis. In addition, in order to encourage farmers to improve the quality of their harvested green leaves, farmers were also to receive a bonus depending on whether or not their tea exceeds a quality threshold. Thus, the policy is designed to increase both the quantity and quality of tea produced by farmers. The key implementers are the MINAGRI and NAEB.

The structure of the report is as follows. The next section reprises the impact evaluation design and data. Section 2 provides descriptive statistics of tea prices, tea quality, tea production and tea revenue changes in Rwanda before and after the initial price reform in 2012. Section 3 reviews the empirical methodology in detail and reports the results for the impact evaluation of the 2012 tea price reform on selected household expenditures, subjective welfare measures, farm investments, and livestock asset measures. Section 4 examines the key factors that have driven the expansion in tea cultivation since the 2012 reform, again using the household panel data. Section 5 provides a descriptive review of farmer knowledge of the reforms and the savings intentions of tea farmers in the light of potential tea price increases. Section 6 provides a profile of non-tea farmers, their attitude to tea production, and perceived potential barriers that inhibit their engagement in tea cultivation. Section 7 provides an analysis of the tea-plucker survey with a particular emphasis

on changes in pay rates, workplace conditions, and the key determinants of plucker earnings. A penultimate section 8 uses the Asopthé administrative data to provide a case study to investigate the impact of the tea reforms on gross production and the net payments of its members. A final section concludes.

1. Impact Evaluation Overview

Objectives

The objectives of the impact evaluation are linked to the objectives of the reform. The green leaf price reform was undertaken by the GoR with the intention of increasing farmers' incomes and enhancing their incentives to raise the productivity and the quality of the raw material utilized by the tea factories. In addition to the government's rural poverty alleviation objectives, price reform was seen as critical to improving the efficiency and competitiveness of Rwandan tea factories and increasing export revenues (MINAGRI, 2012).[1]

The purpose of this study is to evaluate the impact of tea price reform measures on tea production, tea quality, farmer tea revenues, and a range of farmer welfare metrics. The focus is on the market-based green leaf pricing mechanism for farmers, which was passed in Cabinet in July 2012 and became effective in late 2012 after clearing the legislative process. The reform was expected to have the intermediate outcomes of improving prices, quality, productivity, and output. The intermediate outcomes in turn were expected to lead to higher farmer revenues, growth in exports, growth in jobs, and greater food security (see Figure 1).

Figure 1: Theory of Change for Rwanda's Tea Sector Price Reform

Direct impact: Assuming that the price reform is implemented as planned, it will directly impact farmer revenues by raising the prices received by farmers. The assumption is that the old factory-cost model suppressed farmer returns and insulated farmers from market signals. The pass through from factories to farmers (whether through a cooperative[2] or directly) is also assumed in the Government's theory of change (Figure 1).

[1] MINAGRI. 2012. Cabinet Briefing Paper: *New Green Leaf Tea Pricing Model to Tea Farmers in Rwanda*.

[2] That is, the Government's theory of change does not explicitly address the role of co-operatives in the Rwanda tea sector. These provide an important medium through which the internationally determined

Indirect impacts: Increased tea prices following the reform are expected to affect revenue indirectly through the incentive effect, encouraging greater on-farm investment. Investments in tea farms (for example, in labor, land husbandry, improved inputs) are in turn anticipated to improve farm productivity, thereby impacting farmer revenues through the increased quantities produced. Furthermore, the fact that prices now also reflect differences in quality is expected to incentivize farmers to invest more in quality improvement. This in turn is expected to yield additional higher prices for farmers, thus providing a third channel through which to increase farmer revenues. The final channel is through the incentive effect that higher prices will induce new farmers to engage in tea production.

The impact evaluation study aimed to inform the following specific questions:

- Are farmers actually being paid higher prices compared to the price levels before the reform, and to what extent have these raised household revenues?
- Are there any changes in production levels before and after the reform? Are these due to improvements in productivity or expansion in cultivation, or both?
- Did the price reform lead to improvements in productivity?
- Did the price reform lead to increases in on-farm investments?

As with the introduction of all new policies, the practical implementation of the price reform did not occur as originally envisaged. Therefore, it is worth reviewing the key elements of policy implementation over the period of analysis. As discussed, the new pricing system connected the price of the raw material (green leaves[3]) with the price of the finished product (made tea) through a price share formula, using a conversion factor of 4.5 (i.e., 4.5 kilograms of leaves = 1 kilogram of made tea). After consultation with industry stakeholders, the Cabinet of Rwanda issued a directive in October 2012, introducing a price-share of 30% for 2012 and directing the Ministry of Agriculture to implement annual increases in the formula with a target set to reach a 50% price-share by 2017. Contrary to Cabinet instructions, however, no annual increments in the share were implemented in 2013 or 2014, and the price-share remained at 30%. As made-tea prices declined in 2014 (back to levels not seen since 2008), and farmer real incomes risked contracting to below their 2011 levels, the NAEB intervened and asked factories to retain their 2014 green leaf prices during 2015.

factory prices are converted into the prices paid to tea farmers. This then raises the issue whether, in the light of say favourable international tea price movements, there may be rent-seeking on the part of cooperatives that would distort the transmission mechanism from international tea price signals to tea farmers. Such a change in cooperative behaviour is deemed unlikely to have occurred over the analytical period with the introduction of the new pricing mechanism for a number of reasons. First, the policy implementation occurred fairly rapidly, so rule-bound institutions like cooperatives are unlikely to respond to such change with equal rapidity. Second, the new pricing mechanism introduced a greater degree of transparency into the prices paid to factories. Third, the tentative evidence we find in this report suggests the share of the made tea price absorbed by cooperatives appears to have remained stable over the period before and after the price reform, which is suggestive that cooperative behaviour has not altered in the wake of the price reform.

[3] As is true for all tea production, green leaf tea production in Rwanda is sold domestically, given that the leaves must be processed within hours of harvesting.

Econometric Methodology for the Impact Evaluation

Our impact evaluation methodology is based on the propensity score matching (PSM) technique. The approach exploits the idea of 'matching' individual units from a treatment and a control group on the basis of their propensity scores. In the current application, we characterise the treatment group as tea farmers subject to the price reform with the control group comprised of the non-tea farmers who were not subject to the treatment of the price reform. Thus, the treatment of the price reform is captured through the propensity of being in the group subject to the treatment (i.e., the tea farmer group). We believe this to be a sufficiently plausible characterisation in the current context.

The first thing this framework requires is the specification of a treatment assignment equation. This is provided by a probability model for whether the unit is in the treatment group or not. The probability model is used to obtain the propensity scores. These propensity scores provide the basis for the matching, which is done using a kernel density matching approach. In determining the variables to be included in the probability (or treatment assignment) model, particular care should be exercised in ensuring they influence the treatment and the outcome variable at the same time, but are not influenced by the treatment. Time invariant and pre-treatment variables are generally optimal in this context.

The assumption that is crucial for the application of the PSM is the conditional (mean) independence assumption (CIA). The CIA implies that any systematic differences in outcomes between the 'treated' and 'control' groups with the same covariate values is attributable to the treatment. This means that, given a set of observable covariates unaffected by the treatment like the ones included below, potential outcomes are independent of treatment assignment. Therefore, although the outcomes of interest for the treated and control group might be correlated with the assignment (i.e., being a tea-farmer), once we partial out the effects of the explanatory variables by using the treatment assignment equation, the two outcomes are assumed to be independent of the treatment assignment. This has prompted some in the literature to classify this type of approach as selection on observables. It is also commonly known as the 'ignorability' of the treatment assumption.

After specifying and estimating the probability model for the propensity scores, we need to establish where the common support lies. The technique requires a substantial degree of overlap in the propensity scores between the treated and the control groups. The assumption, which is also known as the overlap condition, ensures there is sufficient overlap in the characteristics of the treated and untreated to determine adequate matches.

After establishing common support, to ensure the quality of the matches, the mean outcomes of the covariates used in the probability model must be in balance within the common support in the sense that there are no statistical differences in their mean or variance values. This is known as the balancing property and an array of techniques and diagnostics can be used to inform whether or not this property has been satisfied. If no differences are found between covariates within the common support, the balancing property is said to be satisfied. This property will be subject to detailed testing in the subsequent analysis.

If no important covariate has been omitted from the analysis and the balancing property is satisfied, it is plausible to assume that any difference in the responses of any paired match,

where one within the pair received the treatment and the other (i.e., the control unit) did not, represents the treatment effect plus a random error. If we average over the full set of paired differences this should yield an unbiased estimate of the average treatment effect on the treated (ATT) with the effect of unobservables averaging to zero. Therefore, our approach will be to obtain an ATT at baseline (pre-reform) for our different outcome measures and a corresponding ATT at follow-up (post-reform) for the same outcome measures. The difference between these two ATT estimates provides our difference-in-difference estimator and, under certain assumptions and conditions, is interpreted as providing the causative impact of the tea reform on these selected outcomes.

The validity of the PSM in the current application will be discussed in more detail in section 3 below.

Data Sources

The evaluation relies on a number of different data sources to inform household-level and individual-level outcomes. The primary data source is a follow-up survey conducted in early 2016, complementing a baseline survey completed in 2012/2013. In addition, we also exploit a survey of tea-pluckers, conducted alongside the follow-up survey, to inform the impact of the reforms on a set of workers that are key to tea production. Finally, we use extensive administrative data from the Asopthé co-operative that spans a time period before and after the introduction of the first price reform to investigate the impact of the reform on gross production and farmer net payments.

Figure 2: Timeline of Price Reform and Survey Implementation

The baseline survey collected data from a random sample of households within the tea-growing areas of Rwanda. As each household within the target population had an equal chance of selection, the sample was thus representative of the underlying population of both tea and non-tea producers in the tea-growing areas of Rwanda.

The study used the 2004 Rwanda tea sector survey *Enquête Quantitative de Base auprès des Ménages des zones Théicole* (EQBT) as the template in designing the sampling strategy for the 2013 baseline survey. The baseline closely follows the geographic coverage, sample size, and sampling strategy of the earlier survey. The target population is all rural households (both tea-producing and non-tea producing) in the tea-growing areas within the production radius of Rwanda's 14 tea factories. The EQBT covered 12 of these 14 factories. The new tea-growing

areas added are within the production radius of two new tea factories, which opened after 2004.

Multi-stage cluster sampling was used to randomly select 2,062 households. All tea-growing administrative sectors corresponding to each of the 14 tea factories were purposively selected, based on a list compiled by NEAB, and providing a total of 71 sectors from which 63 were drawn randomly.[4] Within each of these sectors, cells, villages and households were selected using multi-stage randomization. In the first stage of the randomization, administrative cells were selected randomly from each sector, such that the number of cells was proportionate to the size of the sector (on average, two cells were selected from each sector). In the second stage, two villages were randomly selected from each of the selected cells. In the third stage, eight households were selected randomly from each village.

Given the clustered sampling design described above, a random sample of 2,000 households was sufficiently powered to statistically identify the empirical effects of the key outcomes of interest for the impact evaluation. The final sample included 1,716 randomly selected farming households, 429 of which were tea farmers. This represents a 1% random sample of the population of tea farmers in Rwanda. Given the sampling design, we believe our estimates should provide unbiased estimates of the key parameters of interest.

The primary objective of the follow-up survey was to re-interview the same farmers as in the baseline survey. However, given a need to conduct a more detailed analysis of tea pluckers as part of the follow-up survey within the existing budget, the research team purposively reduced the sample of non-tea growers compared to the baseline survey. Thus, the original sample size of non-tea growers in the baseline survey was reduced by approximately 600. This was done through the random exclusion of non-tea households in proportion to the population size of such households across all relevant administrative sectors. The implications of this in terms of the representativeness of the reduced sample are discussed below

In addition to the modification of the sampling size, modest changes were made to the questionnaire for the follow-up survey. This comprised dropping questions no longer viewed as relevant and adding new questions to evaluate more recent policy changes. Most notable among the latter were additional questions to assess farmer preferences for a savings scheme that the Government of Rwanda intends to implement to smooth tea farmer incomes in the face of potential tea price fluctuations on the international market.

The follow-up survey also provided the opportunity to undertake a study on the living standards, pay and work conditions of tea pluckers, viewed as an integral though sometimes overlooked, part of the tea industry in Rwanda. A statistical power calculation, using as a sampling frame the database of all tea-pluckers hired by tea co-operatives, determined the sample size to be 600. The specified sample was randomly drawn in proportion to the population size of tea-pluckers hired across all tea co-operatives. A total of 520 tea-pluckers

[4] The original plan was to cover the entire list of 71 tea-growing sectors provided by NEAB. However, the size had to be reduced to 63 (89%) to accommodate logistical considerations.

were successfully interviewed, and these data are subsequently used in the conduct of our empirical analysis.

There may be some concern that the random exclusion of approximately 500 non-tea farmers from the sample in the follow-up survey will have implications for the representativeness of the reduced sample. Table A1 of the appendix reports the sample averages for the household and individual level characteristics and the outcome variables of interest in this study using the original baseline data and the baseline data for the respondents in the follow-up survey. As is evident from this table, there are no material differences in the mean values for the variables reported. None of the mean differences is found to be statistically significant at a conventional level. Overall, the data in the follow-up survey based on a reduced sample appear to be drawn from the same population as the data reported in the original baseline survey.

In total, 1,348 households were located for re-interview in the 2016 follow-up household survey and, of these, 1,062 were categorized as farmers. However, for some key variables missing data presented an issue for this panel given problems encountered in the baseline survey. In particular, accurate information on the size of landing holdings is not available for all farming households. Specifically, 172 farmers failed to report any information on the size of their land holdings. Table A2 of the appendix separates the overall sample by whether the land holdings data are available or not and reports sample means for these two sub-samples. Although there are some individual and household-level variables for which the mean values are not statistically different, the overall pattern is that those farmers not reporting land holdings (compared to those that do) are younger, less likely to be tea farmers, do not own their property, reside further from public transportation and road networks, have not experienced improved road infrastructure in the last five years, have poorer livestock asset profiles, and are less satisfied with their standard of living.

It is acknowledged that the reduction in the sample size, largely attributable to the absence of land data, potentially weakens the power of the statistical analysis undertaken and this may have implications for our empirical findings. The selective nature of some of the data also raises implications for the randomness of the samples used. We believe that an adequate specification of the treatment assignment equation mitigates this problem. Nevertheless, in order to assess the robustness of our key estimates, we present estimates that match with and without the land holding variable included in the treatment assignment equation. This allows us to compare whether key estimates of the ATT are materially affected by exclusion of those farmers for which no land holdings data are available. It is acknowledged that this robustness check represents a trade-off as it excludes from the treatment assignment equation a potentially important variable for the purposes of matching.

For the purposes of the primary household panel empirical analysis reported in section 3 below, useable data with land holdings information are available for 293 tea farmers and 588 non-tea farmers. The exclusion of the land holding variable from the treatment assignment equation provides additional observations for both the tea farmers and the non-tea farmers.

The former increases to 317, while the latter increases to 693 when the land variable is excluded from the analysis.

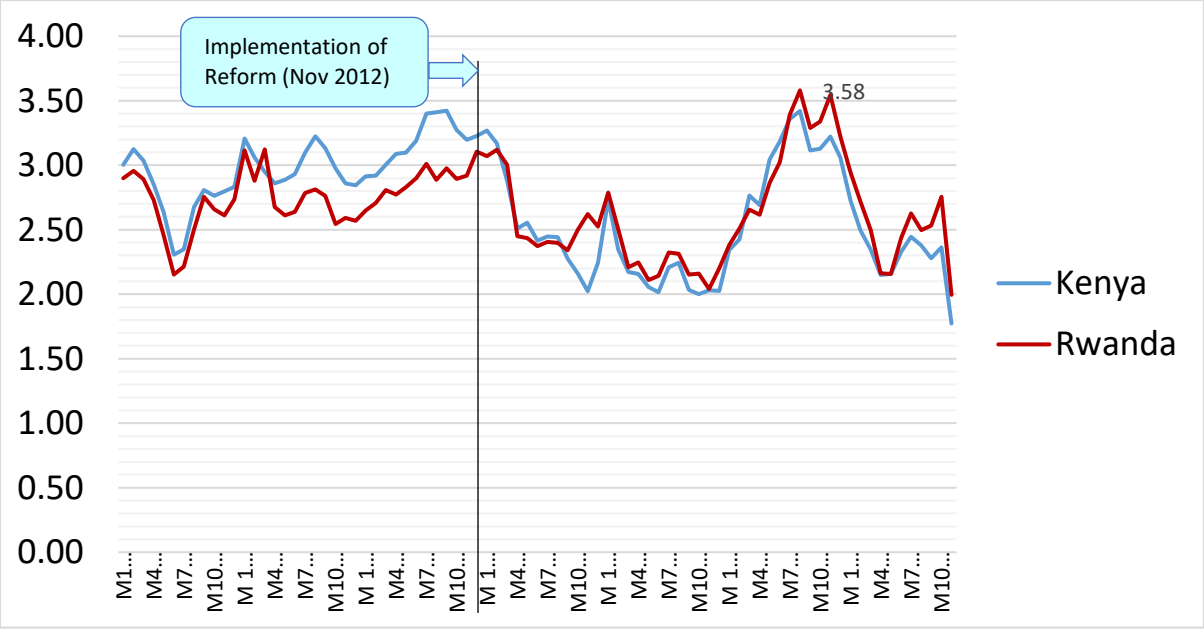
Finally, there may also be a concern that unobservable selection effects, associated with the loss of observations through key missing data, may also bias estimates. However, the use of an extensive array of relevant observable characteristics in our econometric specifications mitigates these selection effects for the impact evaluation.

2. Tea Prices, Tea Quality, Tea Production & Tea Revenues

The panel data of small tea farmers, based on two rounds of the Rwanda Tea Sector survey, are used here to provide, *inter alia*, a descriptive account of how the net prices received by tea farmers have changed in light of the 2012 Government of Rwanda pricing policy—a policy which linked farmer tea prices to movements in international tea market prices. The first round covers the time period from October 2012 to September 2013, while the second round spans a period from April 2015 to March 2016 (well after the introduction of the price reform). The baseline took place after the reform was implemented, but given that farmers respond to the price signal with a lag of one year and, although retrospective payments were made in 2012, any alteration in production behaviour is only likely to be evident in the subsequent years of 2013 and 2014.

The impact evaluation focuses on the 2012 price reform, which linked the prices paid to farmers to the international prices through a 30% price-share formula.

Figure 3: Monthly price of tea at Mombasa Auction (2010-16)



The 30% price-share formula was used in 2012 but no increments were made to this share in either 2013 or 2014. Given the sharp decline in international tea prices in 2014 (see figure 1 above), NAEB asked tea factories to retain their 2014 price levels for 2015. Table A3 in the appendix reports the price per kilogram paid to tea farmers by individual factories over the period covering 2012 and early 2015. The data are available for 11 of Rwanda's tea factories over the full period, and for two newly established factories from 2014 onwards. Immediately prior to the price reform in 2012 all factories paid tea farmers, through their cooperatives, 100 RWF per kilogram. The post-reform prices are generally revised on a six-monthly basis to

reflect international market conditions, though this has not occurred on a systematic basis to date. In the wake of the price reform and its linkage to the international tea market, there is a sharp rise evident in the prices paid to farmers, with prices peaking in late 2013. However, subsequent to that, prices reduced marginally in response to a fall in market prices but remained well above the levels that prevailed under the pre-reform factory cost pricing system. An interesting feature of table A3 is the degree of variation in prices paid across tea factories. This reflects the fact that some factories pay prices above the base price determined by the tea pricing formula incorporating a 30% share of the international price. Overall, the data reported here confirm the sharp price increases emerging with linking tea prices paid to farmers to international tea prices in 2013. There are modest reductions evident in 2014, but prices hold their 2014 levels in early 2015 providing evidence that tea factories actually responded to NAEB's request for pricing stability for 2015.

The data from the panel household confirm the above pattern and reveal that the price received in Rwandan Francs (RWF) by tea farmers has risen sharply subsequent to the pricing reform. The average rose from 72 RWF to 101 RWF (see table 1) representing an increase of about 40%. The median price change is of similar magnitude. The average differential is found to be well determined on the basis of a conventional t-test (|t| = 8.9; prob-value=0.00). It is acknowledged that the number of tea farmers providing information on the prices they receive is fewer than the full sample of tea farmers in the data. This may reflect the fact that tea farmers are more concerned with the amount they receive from the cooperative rather than the rate per kilogram, hence the incomplete set of responses reported in this table from the tea farmers in our dataset. In addition, given the extensive role cooperatives play in the management and distribution of income earned from tea production, some tea farmers tend to be remote from the pricing process.

Table 1: Average and Median Price (RWF) Received per Kilogram Before and After Price Reforms

	Nov.2012 – Sept.2013	**Feb.2015 – March 2016**
Average Price Received	72.3 (23.5)	101.1 (37.9)
Median Price Received	70.0	100.8
Sample Size	171	201

Notes to table 1: Standard deviations are reported in parentheses

On the basis of the foregoing, there is strong evidence that the reform over this period substantially enhanced the prices received with clear evidence of a pass-through from international prices to those received at the farmgate by small tea farmers in Rwanda. There remains, however, a wedge between what the factories pay for green leaf and what farmers receive in net terms from their co-operatives. For instance, at the end of 2015 the average price paid per kilogram of green leaf by factories was about 133 RWF. The gross prices paid by 13 factories for which data are available ranged from 120 RWF to 158 RWF, with four factories paying the lower bound figure which actually represents the 2015 rate based on the

green leaf price-share formula. Thus, using the average net price of RWF 101 reported in table 1 above, the co-operatives retain, on average, about 24% of the per unit gross price in return for payment for an array of services provided.

The share of the price retained by cooperatives can be as source of tension between farmers and some cooperatives. Our data do not allow an empirical interrogation of the uses to which the cooperative is putting the retained share. The services provided generally include the provision of fertilizers, extension services, and technical advice. It is worth noting that almost 80% of tea-farmers in our follow-up survey reported either an 'improvement' or a 'significant improvement' in the profitability of their cooperative after the introduction of the 2012 price reform. However, 42% of tea farmers did not feel they were getting a fair share of the improved profitability, reflecting the tension noted above.

We now examine whether the recent price reforms have exerted any demonstrable effect on the quality of leaves produced. A motivation for the introduction of the pricing policy, aside from stimulating tea farmer production activity, was to incentivize farmers to enhance the quality of such production. Unfortunately, less than 100 farmers reported the quality grade (expressed in percentages) assigned to their tea by factory officials in responses to survey questions in the first round, while only 69 reported these figures for the more recent round. Therefore, the responses should be interpreted suggestive rather than definitive indications of the trends in quality in the aftermath of the price reforms. The average quality reported for the former round was 77.1%, while for the latter, the average rose to 77.9% (see table 2). However, given the modest nature of the increase, the differential is not found to be statistically significant at any reasonable level. Median quality for the same sub-samples is found to rise by almost four percentage points between the earlier and later rounds (see table 2), but again there is no evidence here that the introduction of the price reforms has induced a statistically significant increase in the green leaf quality produced.

It is extremely important to caveat the foregoing findings on quality. First, only about one-quarter to one-third of tea farmers reported the quality of their tea across the two rounds. Thus, they may represent a selective rather than a random sample of the tea farmers, and ones who were potentially producing high quality leaves over both periods in the first instance. Second, tea farmers may be too remote from the quality assessment process, given most of the harvesting is undertaken by pluckers, and so have poor knowledge of the actual quality assigned to their tea to provide accurate responses. Therefore, there may be noise inherent in the responses provided. Third, and separate from the concerns noted above, it may be the case that the small sample sizes compromise the power of the statistical tests used to test for differences in table 2. This may be particularly apposite for the differentials notes for the median values, the point estimates for which suggested an increase in graded quality of about four percentage points.

Table 2: Average and Median Tea Leaf Quality Grade Before and After Price Reforms

	Nov.2012 – Sept.2013	**Feb.2015 – Jan. 2016**
Average Quality Grade (%)	77.1 (13.3)	77.9 (13.8)
Median Quality Grade (%)	75.0	79.0
Sample Size	94	69

Notes to table 2: Standard deviations in parentheses

Given missing data on the size of land holdings, we focus our attention on the leaf production levels of the farmers in the panel prior, and subsequent, to the introduction of the first tea price reform in 2012. Table 3 reports the average annual production levels in kilograms for the same farmers across a pre-reform and a post-reform period. In addition, the analysis is broken down between those farmers who expanded their tea cultivation area after the introduction of the price reform, and those that did not. This permits us to isolate the change in production for those farmers whose tea land holdings have remained constant over these two periods. A more detailed analysis of tea cultivation expansion is confined to section 4 below.

In the case of the sample of all farmers, an average increase in production of about 13% is recorded between the two periods. However, the point estimate for the differential corresponding to this percentage change is not found to be statistically significant at a conventional level. The corresponding estimate for the sub-sample of farmers who did not expand tea cultivation is closer to 16% but again the point estimate for the differential is not found to be well determined at a reasonable level of statistical significance. The small sample size for the sub-sample of farmers who expanded their tea cultivation area demands interpretational caution as the information content in these estimates may be relatively noisy.

It is acknowledged that the split between those who did and did not expand area under cultivation is clearly endogenous, and so it is very difficult to interpret any changes in production conditional on these endogenous decisions to expand. Therefore, the descriptive findings reported here should be interpreted as suggestive. We will return to the issue of the impact of the price reform on tea production in the context of our case study in section 8 below.

Table 3: Annual Average Green Leaf Production in Kilograms by Tea Farmers

	All Farmers	Farmers who did not Expand Tea Cultivation Area Post-reform	Farmers who did Expand Tea Cultivation Area Post-reform
Pre-Reform (Baseline)	1844.1 (2864.5)	1577.0 (1824.1)	3133.9 (5511.4)
Post-Reform (Follow-up)	2081.6 (2802.5)	1826.3 (2164.6)	2941.1 (4226.8)
Sample Size	239	198	41
|t|-test [prob-value]	0.92 [0.36]	1.24 [0.21]	0.18 [0.86]

Notes to table 3:

(a) Standard deviations in parentheses;
(b) The pre-reform period is Nov.2012 to Sept.2013; the post-reform period is Mar. 2015 to Feb. 2016;
(c) The absolute t-test is a test of the difference in means between the post-reform and pre-reform periods.

Given the steep rise in tea prices over the two periods (and a perhaps very modest increase in production), there has also been a sharp increase noted in nominal tea revenues. We were able to obtain meaningful responses from 176 farmers matched across the two periods (see table 4). These farmers reported an increase in average revenues over the three-year period of about 80%, which does appear higher than that anticipated given the price increases alone. The increase in median revenues was closer to 70%.

Table 4: Average Annual Tea Revenues (RWF) Before and After Price Reforms – All Tea Farmers

	Nov.2012 – Sept.2013	Feb.2015 – March 2016
Average Annual Tea Revenues	143361.4 (186834.2)	264203.8 (413900.3)
Median Annual Tea Revenues	87135.0	147245.0
Sample Size	176	176

Notes to table 4: Standard deviations in parentheses

Although the evidence supporting an increase in tea revenues appears persuasive in light of the price increases (see table 1) and production increases (see table 2), the magnitude of the revenue increase is somewhat larger than anticipated. This may be attributable to the characteristics of the sub-sample of tea farmers that have provided useable responses to these particular questions across the two periods. Nevertheless, this issue clearly merits a more detailed interrogation and it is one to which attention returns to below using administrative data from a tea growers' cooperative (see section 8).

3. Price Reform Impact on Household Welfare, Farm Investments & Livestock Assets

In this section, we explore the impact of the price reform on an array of household level outcomes using the propensity score matching (PSM) technique. These outcome variables include household expenditures on food, a number of subjective welfare measures, a binary variable for whether or not any farm-related investments were undertaken in the last four months, and five different livestock types. The purpose of this exercise is to determine whether the tea price reform, and the increased prices associated with such reforms, impacted these measures in a statistically significant manner.

Prior to proceeding to a discussion of the empirical analysis, it is worthwhile providing a justification for the use of this procedure in the current application, paying particular attention to the assumptions being made in its implementation. For the purpose of the analysis, all tea farmers are assumed subject to the treatment of the price reform. The propensity of interest is the propensity to be a tea farmer. Ideally, it would be better characterised by the propensity to be affected by the reform. Fortunately, since all tea farmers are subject to the price reform, the two concepts are coterminous in the current context.

The use of the tea farmer as the treatment could be interpreted as problematic given non-tea farmers could respond to the reforms by engaging in tea production. However, it can take between three to four years for the necessary investments in tea production to yield. Therefore, over the time period covered by our analysis, it is not feasible to argue that non-tea farmers could respond to the price reforms and change their existing production activities. There is no evidence of this behaviour in our data and, as noted in subsequent sections 5 and 6 below, an overwhelming majority of non-tea farmers remain reluctant to engage in tea production for a variety of different reasons. Therefore, we believe that measuring the treatment through the farmer being a tea farmer provides a reasonable approach in this case.

There are other issues relating to the stable unit treatment value assumption (SUTVA), which we need to acknowledge. In particular, there may be other spill-over effects that are difficult to control in the current quasi-experimental framework. There are obvious general equilibrium effects that are potentially induced with the introduction of the price reform. These include the potential effects of the reforms on those product, input and labour markets shared by tea and non-tea farmers. Unfortunately, these types of spill-over effects are difficult to address given our data, but we appreciate their potential relevance for our analysis in the current setting but provide some tentative evidence that such spill-overs are unlikely to be prevalent in the data.

The approach adopted here is also implicitly situated within a difference-in-difference framework. The key assumption in using this approach is that the outcomes in the treatment and control groups follow the same time trend in the absence of the policy intervention. This

is known as the common trends assumption. This does not imply, of course, that the mean outcomes pre-intervention are the same for both the treatment and control groups only that the time trends governing the evolution of these outcomes are the same.

This assumption is extremely difficult to verify and the issue is particularly acute in the current context where data are only available for two points in time. However, we can point to a number of factors that could be taken tentatively to support the notion of common trends pre-policy in our application. First, for a protracted period of time prior to the price reform, tea prices paid to farmers were modest in nature and predictably stable as they were based on a self-declared factory costs pricing model. Thus, there was no tendency, prior to the price reform, for the returns to tea production to diverge relative to other crop activities prevalent in tea-growing areas. Second, the price reform was implemented so rapidly by the Government of Rwanda that there was no scope for its anticipation by farmers. The absence of anticipatory effects provides some support for the common trends assumption. Third, since the introduction of the price reform in late 2012 there have been sharp increases in tea prices paid to tea farmers, as already noted from table 1. Similar price increases, in the wake of the tea price reform, have not been evident in the competitor crops produced by non-tea farmers. For example, as noted below in table 15, the two key crops produced by non-tea farmers in the tea growing areas are haricot beans and maize. Neither of these report substantial price increases over the same period. For example, between 2013 and 2014 the price increases were of the order of 1% and 5% respectively.[5] The sharp divergence in tea prices relative to these other crops could be taken to reflect a changing trend in tea prices consequent on the introduction of the reform policy. Of course, even if pre-trends are indeed the same, there may be policies other than the tea price reform policy introduced over the same period. However, there is no evidence that these key competitor crops have been affected by specific policy interventions on the part of the Government of Rwanda over this time period.

In implementing the PSM approach, as noted earlier, it is important that the input variables should influence the treatment and the outcome variables, but are not themselves influenced by the treatment. In particular, time invariant and pre-treatment variables are standard in this type of application. In the current case, we use only baseline characteristics to forge the match. Of course, it could be argued that the optimal set of baseline characteristics to use should be those that actually pre-date the event of tea production itself. This is infeasible as such variables are not easily accessible given tea production in Rwanda dates back to the 1960s. We argue that the most feasible baseline characteristics for the impact evaluation relate to those time-invariant characteristics that prevailed prior to the introduction of the price reform rather than prior to introduction of tea.

Specifically, these comprise the characteristics for the head of household, information about the household itself and its location, a baseline physical assets index to capture baseline household wealth, and total land holdings. Given all the variables used in this assignment

[5] See Quarterly Price Monitoring Bulletin, July-Sept (2014), Ministry of Trade and Industry, Republic of Rwanda.

equation reflect realizations at the baseline prior to the tea price reform (i.e., the treatment), it is difficult to argue that the variables included in the treatment assignment equation are influenced by the treatment itself in this case. We believe the use of measures calibrated at the baseline only and not at follow-up, as in this case, provide the most sensible approach in the current context. These are arguably exogenous variables in the current setting. The inclusion of time-varying variables that may have been potentially contaminated by the policy change is likely to undermine the identification strategy.

Table A4 of the Appendix reports the probit estimates for the treatment assignment equation. The dependent variable in this case (whether the farmer is a tea-farmer or not) represents the treatment. This probability model provides the propensity scores to be subsequently used for matching purposes. The matching approach exploits the Epanechnikov density, which has become one of the most popular kernel densities in the matching literature. A bandwidth of 0.06 is used in estimation, which is the conventionally used parameter value for this density. The computed standard errors for the ATT estimates are based on bootstrapping with 100 replications (see below).

In most cases, both the treated and control units are found to be on the common support. We now turn to examine the 'balancing property' of the covariates on the common support. Once the match on the basis of the propensity scores is made, we need to explore whether the distribution of covariates is the same across the treatment and control groups. There are a couple of measures that are useful for this purpose. A popular one that determines the distance in the marginal distributions of the covariates is the standardized bias (SB) measure suggested by Rosenbaum and Rubin (1985). This is computed for each covariate in the treatment assignment equation and is defined as the difference in sample means between the treated and the control groups as a percentage of the square root of the average of the sample variances in both groups. The computation of this statistic is undertaken prior to the matching and then again after the matching. As a 'rule-of-thumb', we would generally expect the SB to lie between 3% and 5% after a successful matching exercise.

In addition to this statistic, a common procedure is to conduct t-tests of differences in means on the matched samples. For the match to be good, the mean differences should not be statistically significant. The t-tests should be conducted individually. In addition, it is also recommended to investigate for any differences in the sampling variances of the continuous covariates after matching using F-tests. Finally, another diagnostic that can be examined to determine the quality of the match is to re-run the treatment assignment equation using the matched data only. If the matching has been effective, we would expect the pseudo-R^2 from this equation to be considerably lower (close to zero) than that from the original sample. This is because after matching there should be no systematic difference in the distribution of covariates across the two groups – hence no variation – and so the pseudo-R^2 should be fairly low. In addition, the Likelihood Ratio Test (LRT) for the overall significance of the estimated relationship should now be statistically insignificant.[6]

[6] A good explanation of the PSM technique and balancing property issues is provided by M.Caliendo and S. Kopeinig (2008), Some practical guidance for the implementation of propensity score matching, *Journal of Economic Surveys*, Vol. 22, No.1, pp. 31-72.

Table A5 of the appendix summarises the key findings in regard to the balancing property. Only the land holdings variable exhibits a SB value that is in double-digits. Importantly, none of the individual t-ratios is found to be statistically significant, so this suggests that the mean values between the matched treated and control groups are the same. The variance ratios follow the F-distribution and for the null hypothesis of common sample variances to be upheld at the 5% level of statistical significance, the ratio should lie between 0.79 and 1.26. In the current application, there is only one variable ('hsize') that falls outside that range. However, it is only marginally outside the range (at 1.30) and is thus not viewed as troublesome in the current case. The pseudo-R^2 obtained for the probit regression treatment assignment model fitted to the matched data is close to zero (0.004) having fallen from 0.1042 in the original treatment assignment model (see table A6), while the corresponding LRT is 0.49 compared to 116.6 (see table A6 again) from the unmatched sample. In addition, the B estimate reported here is Rubin's B, which is the absolute standardized percentage difference of the means of the linear index of the propensity score in the treated and the non-treated (matched) group. The R estimated here is Rubin's R, which is the ratio of the treated to the non-treated (matched) variances of the propensity score index. The general recommendation is if B is less than 25% and R lies between 0.5 and 2, so the two samples are considered to be sufficiently balanced. Overall, the evidence reported here suggests that the quality of the match is good and that the 'balancing property' is satisfied.

Finally, table A6 provides a summary of the mean differences in variables before and after the matching. Prior to matching, there is statistically significant evidence that tea farmers are, on average, older and better educated than non-tea farmers (i.e., significantly more tea farmers can read or write). In addition, the average household size is statistically higher at the 10% level for tea farmers compared to non-tea farmers, and tea farmer land holdings are almost twice those of the non-tea farmers. Furthermore, tea farmers have a statistically higher level of physical assets as captured by the principal components measure. Finally, tea farmers appear to be located further from the nearest local market than non-tea farmers, and further from the nearest main road too. Overall, there appears to be some significant differences in the distribution of many of these characteristics between the treatment and control groups prior to matching. Therefore, a simple comparison of the outcome variables across these two groups would be confounded by sharp underlying differences in the distribution of covariates across the two sub-samples. However, after matching has occurred all these differences disappear reflecting the effective nature and quality of the match in this application. This is particularly evident from the sharp percentage reductions in the standardized bias measures reported in table A6.

We now turn attention to the ATT estimates. As noted earlier our analysis will focus on 880 farmers of which 292 are tea farmers and 588 are non-tea farmers. The mean values for the treatment and outcome determining variables for the treated (i.e., tea farmers) and the control groups (i.e., non-tea farmers) are reported in the table below. The realizations of

these variables relate to the baseline prior to the introduction of the tea price reform in late 2012.

It should be stressed here that matching only occurs at the baseline. Therefore, we examine variable outcomes at both the baseline (pre-reform) and the follow-up surveys (post-reform) for tea and non-tea farmer pairs matched using the array of baseline characteristics discussed above. Thus, the sample used is identical for the baseline calculations of the treatment effects as it is for the calculations for the outcomes from the follow-up survey. Thus, our approach computes an average treatment effect for the treated (ATT_0) at the baseline (pre-reform) and an average treatment effect for the treated (ATT_1) at the follow-up (post-reform). The difference between these two ATT estimates (i.e., $\Delta = ATT_1 - ATT_0$) provides, under certain assumptions already discussed above, the causal impact of the treatment (i.e., the tea price reform) on the outcomes of interest. In addition, as noted above, the standard errors for the ATT estimates are computed using a bootstrapped approach with 100 replications.[7]

Table 5 reports the ATT estimates at baseline and follow-up, and the difference-in-difference estimates. The baseline (or pre-reform) differences reveal sizeable advantages to tea farmers relative to non-tea farmers in terms of average food expenditures. However, there are no statistical differences in livestock ownership levels, with the exception of sheep. A broadly similar pattern emerges in terms of the follow-up survey's differentials but there are no individual cases where the difference-in-difference estimate for these measures is found to be statistically significant. There is tentative evidence that the incidence of farm-related investments by tea farmers has increased in the wake of the price reform compared to the rate for the non-tea farmer control group. This category of expenditure includes investments in equipment for processing crops etc. Prior to the tea reforms the rates for this expenditure category were broadly comparable between the two groups. The rate of farm-related investments increased between the baseline and the follow-up surveys.

Overall, we do not find statistically significant evidence of impact for the majority of the objective outcome measures explored here. The increased prices (and hence revenues) have not found their way into enhanced levels of household food expenditures or livestock asset levels. It may be that tea farmers' savings ratios have increased in response to the price increases but this is not something we can inform on directly with the data. Importantly, there is evidence that the incidence of farm-related investments undertaken by tea-farmers has increased in response to the reform. This may ultimately lead to enhancements in productivity as the effects of these investments yield over time.

As a robustness check we re-specified the treatment assignment equation to exclude the land size variable. This provided additional observations for both the tea farmers and the non-tea farmers. The former increased to 317, while the latter increased to 693. However, none of the difference-in-difference ATT estimates reported in table 5, or the conclusions drawn from,

[7] We do not cluster the standard errors by village or use wild-cluster bootstrapped standard errors given the relevant policy intervention was at the national level and the impacts are at the farmer level (not the village level).

these are materially affected by this re-specification. However, given the large difference in land holding sizes between the two farmer types prior to matching (see table A6), our preferred approach remains using the land size variable in the treatment assignment equation.

It has become common in the economics literature to use subjective measures of welfare to inform on household welfare status. In particular, subjective well-being measures tend to be highly correlated with objective measures like poverty and household income. The relevant ATT estimates are reported in table 5. At baseline, tea farmers registered statistically significant higher levels of satisfaction than non-tea-farmers, and were also ten percentage points less dissatisfied than this same comparator (or control) group. The satisfaction gap between tea and non-tea farmers widened marginally in the aftermath of the reforms. However, neither of the difference-in-difference estimates is found to be statistically distinguishable from zero. Therefore, in comport with our analysis on the more objective outcome measures like the log of food expenditures and livestock assets, our empirical analysis suggests that the price reforms exerted no impact on the subjective welfare of tea farmers. Again, these ATT estimates are invariant to the exclusion of the land size variable from the treatment assignment equation.[8]

[8] We attempted to explore for the presence of spill-overs (i.e., the SUTVA) by examining the mean changes in the control group's outcomes as reported in table 5. The argument being that the absence of such changes for the non-treated group provides evidence in support of no spill-overs. We found little evidence of statistically significant changes for the control group's variables. However, this was also the case for all but one of the categories (i.e., farm investments) for the treatment group. Therefore, it is not entirely obvious how valid this is as a test for no spill-overs in the current case.

Table 5: Impact of Tea Price Reform on Welfare Outcomes, Investment & Asset Ownership

Outcome Measure	**Difference between Treatment and Control Groups at Baseline (ATT_0)**	**Difference between Treatment and Control Groups at Follow-up (ATT_1)**	**Difference-in-Difference ($\Delta = ATT_1 - ATT_0$)**
Log of Food Expenditure	0.1758** (0.0928)	0.3099*** (0.0830)	0.1341 (0.1245)
Investments in farm in the last four months	-0.0182 (0.0284)	0.0636*** (0.0350)	0.0818* (0.0451)
Number of Cattle	0.0659 (0.1073)	-0.0122 (0.0869)	-0.0781 (0.1381)
Number of Goats	0.1297 (0.1197)	0.0483 (0.1039)	-0.0814 (0.1527)
Number of Sheep	0.1787* (0.0935)	0.0019 (0.0626)	-0.1768 (0.1125)
Number of Pigs	0.0266 (0.0883)	0.0433 (0.0765)	0.0167 (0.1168)
Number of Poultry	0.0399 (0.1371)	-0.0254 (0.1336)	-0.0653 (0.1914)
Satisfaction Score	0.2180** (0.0812)	0.1847** (0.0776)	-0.0333 (0.1123)
Dissatisfied	-0.1045** (0.0433)	-0.0855** (0.0433)	0.0190 (0.0612)

Notes to Table 5

(a) ***, **,* denote statistical significance at the 1%, 5% and 10% levels respectively using two-tailed tests.
(b) The satisfaction score is based on: 'very dissatisfied' = 1; 'dissatisfied' = 2; 'neutral' =3; 'satisfied' = 4; 'very satisfied' = 5.
(c) 'Dissatisfied' =1 if individuals reported themselves as either 'dissatisfied' or 'very dissatisfied', and = 0 otherwise.
(d) Bootstrapped standard errors are used based on 100 replications.

4 Tea Cultivation Expansion

We now explore the evidence on expansion in the tea cultivation area in the period since the initial price reform. It should be stressed that the empirical analysis reported here is descriptive in nature and not intended to provide any causal evidence given the absence of data from the non-tea farming control group.

The household panel data suggest that tea farmers have expanded their area of tea cultivation within the last three years. Specifically, almost one-fifth of tea farmers have reported expanding their area under tea production since the introduction of the original price reform (see table 6 below). The average increase was about 0.334 of a hectare relative to an unconditional average of 0.577 hectares at baseline. However, this is inflated by a small number of very large expansions over this period. The median expansion has been a more modest 0.014 hectares relative the unconditional median of 0.268 hectares at the baseline. However, given that land purchase and tea bush investment decisions operate with a long lag (of between three to four years), it is not clear that the expansion documented here is linked exclusively or entirely to the price reforms. Therefore, a high degree of interpretational caution is required here.

Table 6: Expansion of Cultivation by Tea Farmers

Question	**% Yes**
'Have you expanded tea cultivation since the first survey in November 2013'	19.0
Sample Size	**293**

The key determinants of tea cultivation expansion are now investigated using a probit model. Again, it is stressed that the effects discussed here are correlations and no causative effects are inferred. The estimated effects are either marginal or impact effects depending on the nature of the explanatory variables used. The covariates are all defined at baseline and reflect the gender, age and literacy of the head of household, the number who work in the household, a household agricultural wealth measure in the form of a livestock asset index, and the log of the household's total land holdings. About one-quarter of the farmers are female with nearly 60% aged 50 or more years. In addition, close to one-third of tea farmers cannot read or write.

The probit marginal/impact effects are reported in table 7. All but one of the estimates is found to be statistically significant at conventional levels. On average and *ceteris paribus*, both female and older headed households are almost 10 percentage points less likely to expand cultivation, as are those whose heads cannot read or write. Better-off households, as measured by their livestock asset profile, are more likely to have expanded cultivation. The only estimate that fails to register as statistically significant here is land size. Thus, the quantity of land available, *ceteris paribus*, appears to be uncorrelated with the expansion decision.

It is worth noting the narratives provided by tea farmers, as part of the survey, emphasized a lack of land as the key constraint to expanding tea cultivation area. About 60% of those who responded cited this as a constraint rather than land quality. This appears somewhat at odds with the econometric findings in table 7, where the effect of land was not found to be statistically significant. It is also noteworthy that a lack of access to either credit markets or product markets was not identified by many respondents as representing a barrier to tea cultivation expansion.

Table 7: Marginal/Impact Effects for Determinants of Tea Cultivation Expansion

Variables	**Sample Means**	**Coefficient Estimates**
Female Head of Household (1/0) (at baseline)	0.2584	-0.0964* (0.0454)
Head of Household Aged 50+ (1/0) (at baseline)	0.5653	-0.0893** (0.0211)
Head of Household can't read or write (1/0) (at baseline)	0.3009	-0.1051*** (0.0452)
Number in the Household who work (at baseline)	0.7386	-0.0441* (0.0270)
Livestock PCA Index (at baseline)	0.3046	0.0363** (0.0162)
Log of total land holdings (at baseline)	-0.3380	0.0259 (0.0237)
Sample Size	293	293
Pseudo-R^2	n/a	0.0932

Notes to table 7:

(a) ***, **,* denote statistical significance at the 1%, 5% and 10% levels respectively using two-tailed tests.

5. Knowledge of Price Reforms & Savings Intentions

Table 8 below confirms a widespread knowledge among tea farmers of the most recent green leaf tea pricing policy initiative introduced in January 2016, which raised the share of the international price paid to farmers from 30% to 40%. In contrast, knowledge of the two earlier reforms appears less entrenched. However, a feature of this table is the general lack of awareness of these policy reforms among non-tea farmers, particularly the most recent one. This re-affirms findings from the baseline survey in 2012/13, where only about 18% of non-tea farmers were aware of the green leaf price reform. This lack of knowledge, other things equal, may represent an important constraint in encouraging non-tea farmers to engage in tea production though it is acknowledged that many of these farmers may have land that is not entirely suitable for such cultivation or are not sufficiently incentivized by the prices available. These issues are examined in more detail in section 6 below.

Table 8: Knowledge of Tea Reforms among Farmers (% Yes)

Question	**Tea Farmers**	**Non-tea Farmers**
'Are you aware that tea factories were recently transferred to private ownership?'	66.4	17.9
'Are you aware of the government's November 2012 original green leaf price reform?'	62.2	12.6
'Are you aware of the government's January 2016 green leaf price reform that gives famers 40% rather than 30% of the international price?'	87.3	19.9
Sample Size	**283**	**532**

Notes to table 8: The original reform was scheduled for introduction in November 2012 but was applied retrospectively from June/July 2012

The Government of Rwanda is committed to introducing a savings scheme for tea farmers. In particular, given the potential volatility in international prices, encouraging farmers to save part of the revenues from prices in 'good times' provides one way to mitigate the effects of lower prices in 'bad times'. Our follow-up survey asked whether farmers would be willing to save a share of the price they received in a dedicated savings account. Specifically, we asked tea farmers whether they would be willing to save a share of their tea earnings when prices were favourable. As revealed in table 9, 90% of farmers responded that they would be willing to do so under such circumstances. In addition, our survey also asked what share of the price would they be willing to save and the average response was about 36% (see table 10). Finally, over two-thirds of respondents expressed a preference to save using a microfinance savings account rather than any other type of financial facility (see table 11). Interestingly, almost all respondents wished to control access to their account and not have it managed by a third party (e.g., government, factory or cooperative).

Table 9: Percent of Tea Farmers Willing to Save

Response	**%**
'No'	9.9
'Yes'	90.1
Sample Size	**434**

Notes to table 9: Exact phrasing of survey question: 'The price you receive for your tea is directly linked to international markets. As a result, it goes up and down. Would you be willing to save a certain amount of money during good price seasons to support your income during bad price seasons?'

Table 10: Average Percent of Price Tea Farmers would be Willing to Save

Response	**%**
Average Response	35.9
Sample Size	**391**

Table 11: Tea Farmers Preferences on Where to Save

Response	**%**
Bank Account	31.0
Microfinance Savings Account	67.8
Other	1.2
Sample Size	**391**

6. Profile of the Non-tea Farmers in the Tea-growing Areas

We now examine the profile of non-tea farmers and review their attitude to the tea reforms and tea production activity. Using the responses from the follow-up Survey in 2016, Table 12 reports the number of plots and the size of land holdings for all farmers, and also broken down by tea and non-tea farmers. It should again be emphasized that there are a significant number of missing values for the size of land holdings. Hence, the reduced sample sizes. The average number of plots owned by tea farmers is slightly higher than that for non-tea farmers. Both the average and median tea farmer plot sizes are almost twice the corresponding figures for the sample of non-tea farmers.

Table 13 summarizes livestock ownership for all farmers and separately by farmer type. The table reports the ownership rate and means for five common livestock categories in Rwanda. The point estimates suggest that tea farmers enjoy higher rates of ownership of cattle, goats, pigs and poultry and higher average numbers of goats and sheep compared to their non-tea farmer counterparts. The four most popular crops cultivated are climbing beans, maize, sweet potato and Irish potato. In general, tea farmers appear to be as engaged in the cultivation of these other crops as non-tea farmers (see table 14).

Table 6: Profile of Landholdings

	All Farmers	**Tea Farmers**	**Non-tea Farmers**
Average Number of Cultivated Plots	3.01 (1.44)	3.34 (1.44)	2.79 (1.39)
Average Total Land Holdings (Hectares)	1.016 (5.223)	1.565 (6.519)	0.622 (4.001)
Median Land Holdings (Hectares)	0.265	0.443	0.188
Sample Size	**651**	**248**	**403**

Notes to table 12: The data used are based on those who own their own land and where households where farming is the main activity. Standard deviations are reported in parentheses.

Table 7: Livestock Ownership

	All Farmers	Tea Farmers	Non-tea Farmers
Own Cattle (=1)	0.519	0.562	0.491
Average Number of Cattle (conditional on ownership)	1.39 (0.90)	1.37 (0.63)	1.41 (1.06)
Own Goats (=1)	0.276	0.288	0.268
Average Number of Goats (conditional on ownership)	2.02 (1.19)	2.12 (1.23)	1.95 (1.16)
Own Sheep (=1)	0.180	0.174	0.184
Average Number of Sheep (conditional on ownership)	1.85 (1.05)	1.97 (1.13)	1.76 (1.00)
Own Pigs (=1)	0.236	0.275	0.209
Average Number of Pigs (conditional on ownership)	1.43 (1.39)	1.33 (0.64)	1.52 (1.80)
Own Poultry (=1)	0.225	0.251	0.208
Average Number of Poultry (conditional on ownership)	2.79 (1.96)	2.73 (1.91)	2.83 (2.01)

Notes to Table 13: Standard deviations are reported in parentheses for continuous variables

Table 14: Crop Cultivation

	All Farmers	Tea Farmers	Non-tea Farmers
Most Popular Crop Type			
Climbing Beans (Haricot)	0.830	0.769	0.869
Maize	0.634	0.687	0.599
Sweet Potato	0.700	0.697	0.703
Irish Potato	0.300	0.311	0.294
Sorghum	0.286	0.261	0.302
Peas	0.108	0.140	0.088
Sample Size	**968**	**386**	**582**

Notes to Table 14: The numbers report the rates of crop activity across these six crop types.

Our survey data suggest that about 5% of the current sample of non-tea farmers had engaged in tea production sometime in the past. However, the majority had abandoned such activity before the 2012 price reforms were introduced. Table 8 above revealed poor knowledge of the price reforms among tea farmers. The follow-up survey asked non-tea farmers what minimum price per kilogram of tea would incentivize them to engage in tea production. Over 60% of respondents reported that no price would induce them to engage in tea production. In other words, their reservation price to engage in such an activity is infinity. One-third of the non-tea farmer respondents who expressed a price, specified one in excess of 230 RWF – a lower bound that is almost 70% higher than the average gross price paid by factories in 2015. Thus, price remains an important incentive but current prices are seen as far too low to

encourage the overwhelming majority of non-tea farmers to consider engagement in tea production.

The non-tea farmers were also asked to state any other factors that inhibit their engagement in tea production. Table 15 reports the most significant barriers. The most cited non-price constraint, as with tea farmers who wished to expand cultivation, is inadequate land size. Indeed, the percentage registering this constraint is broadly similar across both farmer types. The other factors deemed of some importance are soil quality and a limited expertise in tea cultivation.

The foregoing is redolent of the findings reported for the baseline survey and it appears from the analysis of the follow-up survey that the negative perceptions among non-tea farmers regarding engaging in tea production have changed little since the price reform. A more detailed piece of empirical analysis that interrogated the reluctance of non-tea farmers to engage in tea production more thoroughly is reported in the 2015 Baseline Report.[9]

Table 8: Reasons for non-tea farmers not engaging in tea production

Response	**% Yes**
Inadequate Land Size	63.9
Limited Expertise	16.0
Unsuitability of Soil	13.7
Limited Access to Credit	2.2
Sample Size	**577**

7. An Empirical Analysis of Tea Pluckers in Rwanda

As noted earlier, the primary objective of the follow-up survey was to re-interview tea-growers and non-tea growers originally interviewed in the baseline survey in 2012/13. However, the follow-up survey was also used to undertake a study on the work conditions and living standards of tea-pluckers, who represent an integral part of the tea sector in Rwanda. In particular, the quality of tea harvested is inextricably linked to training and experience of the tea pluckers. The tea pluckers are employed by both the tea factories and the cooperatives, but mostly by the latter. In general, they are paid on a piece-meal basis related to the volume of green leaves harvested. The employment activity is all year round given tea harvesting is not seasonal in nature and is plucking is undertaken throughout the year, though its intensity might vary from season to season.

[9] See *Rwanda Green Leaf Price Reform Impact Evaluation Baseline Report*, March 2015, World Bank Group.

In order to facilitate an investigation of tea-pluckers within the existing budget, the research team decided, as already noted in the data section, to reduce the number of non-tea growers re-interviewed. The survey of tea-pluckers was conducted in the early months of 2016 and surveyed over 500 pluckers. For purposes of an initial comparison, we draw on data from the follow-up household survey, conducted over the same period, to provide the basis for summary comparisons between the tea-pluckers and both tea farmers and non-tea farmers along a number of different dimensions. The analysis reported here should be interpreted as representing a purely descriptive exercise given the data are cross-section in nature and were collected post-reform, although with some retrospective questions asked of tea pluckers.

Table 16 provides a comparison of the physical and livestock assets profiles across these three types. In general, and as anticipated, tea-pluckers have inferior asset profiles compared to either of the two farmer types. However, one notable feature is that the average level of tea-plucker satisfaction with their standard of living is broadly comparable with that of tea farmers but higher than that reported by non-tea farmers. There is also some evidence, not reported here, that tea pluckers are as knowledgeable as tea farmers regarding the price reforms with over 70% reporting knowledge and awareness of these.

Table 17 reports the average and median prices received by tea-pluckers for the periods before and after the 2012 price reform. On average, the price paid per kilogram plucked rose by about 37% in the wake of the 2012 reform, though the median increase is more modest in magnitude. Thus, there is evidence that the tea-pluckers have benefitted from the price reforms with average increases comparable in magnitude to those received by the tea farmers themselves (see table 1 above). It is also noteworthy that nearly 80% of all tea-pluckers report either an improvement or a significant improvement in their work conditions since the introduction of the price reforms (see table 18). In addition, the majority of tea-pluckers (58%) appear satisfied with their current work conditions (see table 19), which is higher than those (43%) expressing themselves satisfied with their current living standards (see also table 19).

The share of the tea-plucker take as a percentage of the tea farmer price received has remained relatively stable over the period prior to the price reform and subsequent to it. Using the estimates reported in tables 1 and 17, the percentage take is approximately 35% for the two years. This suggests that tea-pluckers have benefitted proportionately from the tea price reforms. In other words, the pass-through from higher tea prices to plucker pay has remained fairly constant subsequent to the price reform.

As noted earlier, our data do not permit an empirical investigation into what the share of the price retained by the co-operatives is used for. In addition, we only have limited data on inputs for the cooperatives. However, using data for the Asopthé cooperative, we note that deductions for one key input provided by cooperatives to tea farmer, fertilizers, rose marginally by about 4% between the period prior to the firm price reform and 2014. Overall, there does not appear strong evidence that the price reforms have been associated with changes in the underlying relationships between tea farmers, tea pluckers and the cooperatives in such a way as to distort the impact of the price reform on farmer behaviour.

We now turn our attention to an econometric analysis of the factors determining tea-plucker monthly earnings. We have a useable sample of 446 tea-pluckers for this analysis and we focus on the role of eight different variables, almost all of which are found to be statistically significant. About two-thirds of the sample is male, close to 40% are aged 40 years or more, 90% are cooperative employees, the average work experience is close to 12 years in duration, 18% are entitled to workplace breaks, about 13% had a workplace injury in the previous month, and over 27% had dedicated training in recent times to enhance their plucking skills.

The estimation technique used is OLS and the coefficient estimates are reported in table 20. On average and *ceteris paribus*, a sizeable premium is attached to being a male tea-plucker with male monthly earnings 65% higher than those for females. Older pluckers earn less than younger ones with those aged over 40 years earning 53% less than their younger counterparts. An additional year of work experience raises monthly earnings by about 1.8%, on average and *ceteris paribus*. Pluckers employed by a cooperative secure a sizeable pay advantage compared to those not so employed but the availability of workplace breaks exerts no independent effect on earnings. The provision of training is found to enhance earnings. The OLS estimate suggests that pluckers who have had recent training enjoy increased monthly earnings of about 60%, presumably because of the improvements in the quality of tea plucked. Finally, we noted above that a sizeable number of tea-pluckers in the sample had incurred a work-related injury in the previous month. The estimates suggest that a significant penalty attaches to such injuries with monthly earnings reduced by over 46% for those subject to injury compared to those that were not.

Table 9: Living Standards and Asset Profiles of Tea Farmers Non-tea Farmers and Tea Pluckers

	Tea Farmers	**Non-Tea Farmers**	**Tea Pluckers**
Asset Ownership Rate:			
Bicycle	0.0969	0.0633	0.0405
Radio	0.5812	0.4992	0.4451
TV	0.0344	0.0332	0.0038
Mobile Phone	0.7125	0.6621	0.5298
Livestock Numbers:			
Cattle	0.7531	0.5973	0.4136
Goats	0.6000	0.4585	0.4451
Sheep	0.3438	0.2760	0.3584
Pigs	0.3844	0.3182	0.1060
Poultry	0.6938	0.5023	0.3275
Satisfaction with Living Standards	2.8801 (0.8777)	2.6371 (0.9696)	2.8921 (0.9382)
Sample Size	**320**	**663**	**519**

Notes to table 16:

(a) The satisfaction score is based on: 'very dissatisfied' = 1; 'dissatisfied' = 2; 'neutral' =3; 'satisfied' = 4; ''very satisfied' = 5.

(b) Standard deviations in parentheses.

Table 10: Prices Received by Tea Pluckers

	Pre-Reform	**Post-Reform**
Average Rate per Kilogram (RWF)	25.65 (6.694)	35.10 (8.081)
Median Rate per Kilogram (RWF)	27.0	33.0
Sample	**426**	**476**

Notes to table 17: Standard deviations reported in parentheses.

Table 11: Perceived Improvements to Working Conditions Post-Reform

Response	**%**
'Improved significantly'	17.7
'Improved somewhat'	60.7
'Same as before the reform'	18.9
'Deteriorated somewhat'	2.1
'Deteriorated significantly'	0.6
Sample Size	**519**

Table 19: Subjective Well-Being

Response	**Current Work Conditions (%)**	**Current Standard of Living? (%)**
'Very Satisfied'	5.1	2.1
'Satisfied'	53.0	40.5
'Neutral'	25.1	26.6
'Dissatisfied'	15.7	27.8
'Very Dissatisfied'	1.1	3.0
Sample Size	**511**	**519**

Table 12: Determinants of Tea Plucker Log Monthly Earnings

Variables	**Sample Means**	**OLS Estimates**
Constant	1.000	8.2838*** (0.4291)
Male (1/0)	0.646	0.5037*** (0.1660)
Aged 40+ (1/0)	0.360	-0.7460** (0.1651)
Work Experience as Tea Plucker (years)	11.990 (11.301)	0.0176** (0.0077)
Coop Employee (1/0)	0.899	0.6025** (0.2646)
Log of Tea Quantity Plucked in last week	3.667 (0.844)	0.3252*** (0.0936)
Workday Break(s) Available (1/0)	0.179	-0.2930 (0.1946)

Injuries Suffered in last Month (1/0)	0.134	-0.6249*** (0.2174)
Received Training (1/0)	0.275	0.4647*** (0.1732)
Sample Size	**446**	**446**
Adjusted-R^2	**n/a**	**0.1286**

Notes to Table 20: (a) Standard deviations are reported in parentheses for continuous variables only in the sample means column. (b)***, **,* denote statistical significance at the 1%, 5% and 10% levels respectively using two-tailed tests. (c) Given the presence of heteroscedasticity, robust standard errors are reported for the OLS estimates in parentheses.

8. A Case Study: the Asopthé Co-operative

We now focus on a case study of a single co-operative (Asopthé) to explore the potential impact of the tea price reform on production and the net earnings of its members. We do this by exploiting administrative data held at the level of the co-operative.[10] These data comprise monthly data for each individual member covering the period from 2010 to 2014 inclusive. The data comprise, *inter alia*, production data, plot size information, plot location, the price per kilogram paid, and net payments to members. The data span a period prior and subsequent to the price reforms and contains information on 815 individual members.

Asopthé co-operative members produced about 9.5% of total green leaf production in Rwanda in 2014 and is generally regarded as a well-managed and high-performing cooperative. Table 21 reports the average prices paid (in RWF) per kilogram. These show a sharp rise in 2012 given the retrospective payments applied with the implementation of the price reform policy at the end of 2012. In addition, the slight 'dip' in the price paid in 2014 reflects the downward movement in international prices at the Mombasa auction over the relevant calculation period. It is worth noting that, compared to the other co-operatives in Rwanda, the average price paid per kilogram is actually at the lower end of the scale.

Table 131: Price Paid per Kilogram in Asopthé (2010 – 2014)

Year	**2010**	**2011**	**2012**	**2013**	**2014**
Price per Kilogram (RWF)	52	59	106	125	119

Our analysis examines the relationship between the price reform and gross production at the farmer level, as well as the relationship with net payments. We construct a post-reform dummy variable equal to 1 if the data are in the years 2013 and 2014 and 0 otherwise. This is intended to capture the effect of the price reform. The motivation for this is based on the consideration that farmers respond to price signals with a lag of one year and, although

[10] We attempted to obtain comparable data from other cooperatives to broaden the analysis reported here. However, none was available to the detail reported here or over a time period prior to and post the introduction of the price reform.

retrospective payments were made in 2012, any alteration in production behaviour is only likely to be evident in the subsequent years of 2013 and 2014.

The empirical modelling approach exploits a fixed effects estimator with the individual tea farmer household providing the fixed effect. This is included to control for farmer heterogeneity, which is assumed to remain constant over the five-year period under analysis. In addition, the gross production specification included controls for log plot size, growing season (i.e., A, B or C seasons), plucking area location, and a dummy for whether or not the transportation and plucking activities are organized.

It is acknowledged that, in spite of the rich set of controls included in the specifications, we are not in a position to identify with complete confidence the causal effect of the price reform on either of the two measures subject to analysis here. This follows from the fact that there may be other trends in production activity, and hence the net payments to farmers, that are not controlled for in the current specifications. The empirical analysis will, however, provide some insights on the impact of the price reforms on production and net payments.

Table 22 reports the estimates for the policy dummy for the fixed effects models. In the post-reform period, there is evidence of a sharp increase in production activity compared to the three previous years. Specifically, average gross production appears to have increased by 35%, *ceteris paribus*, in the two post-reform years relative to the base (pre-reform) period. The magnitude of the estimate does appear on the high side, though the average increase in net payments to farmers (24.2% *ceteris paribus*) is more modest in nature. This measure is defined as income net of payments for cooperative dues, fertilizer, pluckers, and taxes etc. Furthermore, if we re-do the analysis with plots providing the fixed effects rather than the tea farmers, none of the estimates reported in table 22 is materially altered.

Overall, there is some suggestive evidence that the price reforms have exerted a positive impact on tea farmer production and net incomes.

Table 22: Impact of Tea Price Reform on Production and Net Payments 2010 - 2014

Policy Variable	**Log Production**	**Log Net Payments**
Post-Reform	0.3033***	0.2167***
	(0.0249)	(0.0084)
Sample Size	7,181	6,899

Notes to Table 22:

(a) The data are administrative data from the Asopthé Cooperative.
(b) The Post-Reform variable is a dummy =1 if in years 2013 and 2014, and = 0 otherwise.
(c) Specifications for log production model also include controls for log plot size, season, plucking area location, and a dummy for whether the transportation and plucking activities are organized.
(d) Specifications for log net payments model also include controls for log yield, season, plucking area location, and a dummy for whether the transportation and plucking activities are organized.
(e) There are 815 individual fixed effects included for each of the tea farmer households.
(f) The standard errors are clustered at the level of the farmer.

Conclusions

This section reviews some key findings. The **average net price for green leaf tea for Rwandan tea farmers rose sharply** (by about 40%) after the introduction of the pricing reform. This confirms the existence of a pass-through from international tea prices to farmgate prices as anticipated by the policy. There remains a wedge of about 25% between what the factories pay the co-operatives, on average, and what the farmers actually receive. Given the increase in green leaf prices received by farmers, there has been a sharp increase in annual tea revenues generated. The average quality of the green leaf produced appears to have remained stable over the period before and after the price reform.

Our empirical analysis, which relied on the use of Propensity Score Matching (PSM) technique, does not find statistically significant impacts on either household food expenditures (an informative objective measure of household welfare), or on the physical or livestock asset profiles of tea farmers. One area where a statistically significant increase is, however, detected is in terms of the incidence of **increased farm-related investments**. Specifically, there does appear modest evidence that the benefits of the price reform have found their way into farm-related investment expenditures, which suggests that income and productivity gains would be forthcoming once the effects of such investments are realised. The impacts of these on factory competitiveness is an important area of further research.

Our panel data descriptive analysis indicates that about one-fifth of tea farmers have expanded their tea cultivation since the introduction of the price reforms. Although the average expansion was about one-third of a hectare, the median was a more modest 140 square metres. On average, female and older headed households are found to be less likely to expand cultivation, as are households headed by those with no literacy skills. In addition, tea farmers with superior livestock asset profiles are found to be more likely to engage in expansion, *ceteris paribus*. **A lack of land holdings rather than land quality remains the primary constraint to expansion** according to the narrative responses provided by tea farmers from the 2016 survey. There also remains limited knowledge about the nature of the reforms among non-tea farmers in the tea-growing areas of Rwanda and this lack of information may constrain existing non-tea farmers from engaging in tea cultivation. Furthermore, the prices that would induce non-tea farmers to engage in tea production are significantly beyond the upper boundaries of current prices available suggesting it will be extremely difficult to incentivize this group along the dimension of price alone.

A novel feature of our follow-up survey analysis has been the focus on tea-pluckers, an occupational activity central to the tea sector in Rwanda, and one largely neglected in any tea sector analysis to date. Our analysis provides evidence that **pluckers have benefitted from the 2012 price reform** with an uplift in their pay rates comparable in percentage terms to the price increases enjoyed by tea farmers. There is thus evidence of a 'trickle-down' of the tea price benefits to the tea-pluckers, though the pass-through share from tea price to plucker pay has not altered in the light of the reform. There is also evidence among an overwhelming majority of tea-pluckers that work conditions are perceived to have improved either

'somewhat' or 'significantly' since the introduction of the initial price reform. The descriptive analysis of tea-plucker earnings yielded a number of additional insights. Earnings are related to gender and age with men earning a premium and older pluckers incurring an earnings penalty. However, there are returns to both experience and training. About 13% of pluckers reported incurring injuries in the previous month, and this was found to reduce monthly earnings by about 46%, emphasizing the importance of health and safety measures within the tea harvesting workplace.

Our final piece of analysis provided evidence from a case study to focus on the effects of the tea reforms on production. Using administrative data drawn from the Asopthé cooperative, a tea farmer fixed effects model was estimated. Our estimates point to a **positive effect on gross production in the post-reform era, with additional evidence of an increase in tea farmer net earnings.** However, some circumspection is required in interpreting these results. First, the empirical identification of the reform effect on production is not entirely persuasive. Second, our analysis focused on just one co-operative that is viewed in the sector as extremely well managed, and therefore may not be fully generalizable to the Rwanda tea sector at large.

APPENDIX

Table A1: Comparison of Variable Outcomes from Baseline & Follow-up Samples

Variable	**Original Baseline Outcomes**	**Follow-up Baseline Outcomes**
Tea Farmer (1/0)	0.272 (0.445)	0.375 (0.484)
Age of Head of Household (years)	48.46 (14.96)	48.95 (14.93)
Female Head of Household (1/0)	0.257 (0.445)	0.256 (0.437)
Farmer can't read or write (1/0)	0.339 (0.474)	0.346 (0.476)
Household Size (number)	5.460 (2.229)	5.562 (2.262)
Own House (1/0)	0.977 (0.150)	0.978 (0.145)
Number of Rooms	2.799 (0.993)	2.791 (0.971)
Electricity (1/0)	0.081 (0273)	0.076 (0.266)
Minutes to market	53.25 (45.84)	55.40 (47.49)
Minutes to road	75.91 (65.78)	75.32 (64.98)
Minutes to public transport	65.96 (59.16)	64.27 (57.37)
Roads Improved in last five years	0.702 (0.457)	0.670 (0.470)
Investments in Farm Business (1/0)	0.138 (0.345)	0.155 (0.362)
Number of Cattle	0.928 (1.136)	0.962 (1.141)
Number of Goats	0.759 (1.309)	0.758 (1.344)
Number of Sheep	0.443 (0.987)	0.453 (1.002)
Number of Pigs	0.431 (1.121)	0.475 (1.174)
Number of Poultry	1.104 (2.741)	0.929 (1.796)
Average Satisfaction Score with Standard of Living	3.043 (0.973)	2.994 (0.971)
Land Holdings (hectares)	0.749 (1.247)	0.813 (1.326)
Sample Size	**1484**	**1022**

Table A2: Comparison of Variable Outcomes for sub-samples with and without Land Holdings Data

Variable	**Baseline Panel (sub-sample with land data reported)**	**Baseline Panel (sub-sample without land data reported)**	**t-test/z-score Prob-value**
Tea Farmer (1/0)	0.331 (0.471)	0.215 (0.412)	0.002
Age of Head of Household (years)	48.58 (14.71)	46.07 (15.00)	0.042
Female Head of Household (1/0)	0.260 (0.439)	0.250 (0.434)	0.793
Farmer can't read or write (1/0)	0.343 (0.475)	0.372 (0.485)	0.460
Number in Household Working	0.837 (0.906)	0.855 (0.941)	0.817
Household Size (number)	5.605 (2.237)	5.285 (2.137)	0.083
Own House (1/0)	0.981 (0.150)	0.878 (0.145)	0.000
Number of Rooms	2.790 (0.993)	2.983 (1.079)	0.020
Electricity (1/0)	0.072 (0.258)	0.046 (0.266)	0.225
Minutes to market	54.79 (46.71)	48.02 (43.28)	0.079
Minutes to road	76.32 (66.37)	103.80 (71.83)	0.000
Minutes to public transport	65.26 (58.90)	83.02 (69.79)	0.000
Roads improved in the last five years (1/0)	0.700 (0.459)	0.523 (0.501)	0.000
Investments in Farm Business (1/0)	0.155 (0.362)	0.105 (0.362)	0.087
Number of Cattle	0.949 (0.993)	0.628 (1.043)	0.000
Number of Goats	0.735 (1.292)	0.593 (1.168)	0.181
Number of Sheep	0.453 (1.192)	0.326 (0.816)	0.112
Number of Pigs	0.485 (1.192)	0.174 (0.625)	0.000
Number of Poultry	0.908 (1.790)	0.488 (1.843)	0.005
Average Satisfaction Score with standard of living	2.980 (0.973)	2.564 (1.087)	0.000
Dissatisfied with living standards (1/0)	0.357 (0.479)	0.570 (0.497)	0.000
Land Holdings (Hectares)	0.799 (1.355)	n/a	n/a
Sample Size	**890**	**172**	

Table A3: Rwanda Green Leaf Price Movements over time by Cooperative

	Green Leaf price (RWF/KG)													
FACTORY	**2012 Previous price**	**July 2012**	**Aug-12**	**Sep-12**	**Oct-Dec 2012**	**Jan-March 2013**	**April-June 2013**	**July-Sept 2013**	**Oct-Dec 2013**	**Jan-march 2014**	**April-June 2014**	**July-Sept 2014**	**Oct-Dec 2014**	**Jan-March 2015**
Gisovu	100	143	143	144	143	155	156	157	160	153	156	157	158	158
Kitabi	100	134	135	136	135	149	150	152	154	141	143	145	146	146
Nshili	100	134	134	135	134	146	147	148	151	124	126	127	128	128
Nyabihu	100	132	132	133	132	146	147	149	151	132	134	135	136	136
pfunda	100	123	123	124	123	137	138	139	142	117	119	120	120	120
Rubaya	100	123	123	124	123	138	139	140	142	134	136	137	138	138
Mata	100	112	112	113	112	123	124	125	127	117	119	120	120	120
Sorwathe	100	112	112	113	112	123	124	125	127	117	119	120	120	120
Gisakura	100	112	112	113	112	123	124	125	127	117	119	120	120	120
Shagasha	100	112	112	113	112	123	124	125	127	127	127	127	127	127
Mulindi	100	112	112	113	112	123	124	125	127	127	127	127	127	127
Karongi										122	124	125	126	126
Mushubi										149	149	149	149	149

NOTES:

For Shagasha and Mulindi cooperatives, from 2014 where the prices started to fall down, the investor decided to maintain the 2013 price.

Due to conflict of interest, Karongi tea factory decided to pay their farmers at the same price as Gisovu because they tended to supply their GL to Gisovu.

From 2015, the prices remained the same as for last quarter 2014.

Table A4: Probit Estimates for Treatment Assignment Equation

Variables	**Coefficient Estimates**
Constant	-2.2974*** (0.5898)
Female Head of Household	0.0077 (0.1145)
Head of Household Age	0.0648** (0.0211)
Head of Household Age-squared	-0.0004* (0.0002)
Head of Household can't read or write	-0.2657** (0.1100)
Household Size	0.0042 (0.0241)
Number in the Household who work	-0.0733 (0.0514)
Own Residence	-0.3725 (0.3417)
Number of Rooms in Residence	0.0175 (0.0515)
Electricity in Residence	-0.5325** (0.1992)
Minutes to walk to market	0.0018** (0.0011)
Minutes to walk to public transportation	-0.0022** (0.0011)
Minutes to walk to road	0.0026*** (0.0010)
Roads have improved in last five years	-0.1155 (0.1035)
Total land size holdings (Hectares)	0.1598*** (0.0384)
PCA – Physical Assets	0.1353*** (0.0478)
Sample Size	815
Pseudo-R^2	0.1042
LRT (Overall Significance)	116.6

Notes to Table A1:

(a) Standard errors are reported in parentheses.

(b)***, **,* denote statistical significance at the 1%, 5% and 10% levels respectively using two-tailed tests.

(c) All explanatory variables are specified at their baseline realisations.

(d) The PCA for the household physical assets comprises whether or not the household has a mobile, radio, tv, bike, or motorbike.

Table A5: Balancing Property Tests After Matching

Variable	Mean Treated	Mean Control	%bias	t-test t	t-test p>|t|	V(T)/ V(C)
HoH_fem	.2646	.26301	0.4	0.04	0.965	.
h_age	52.921	53.465	-3.8	-0.46	0.645	0.91
h_agesq	2993.3	3069.7	-5.0	-0.58	0.565	0.84
nolit	.2921	.28588	1.3	0.17	0.869	.
num_work	.76289	.74981	1.4	0.17	0.863	1.22
hsize	5.8522	5.7085	6.2	0.74	0.459	1.30*
own_house	.97938	.9827	-2.4	-0.29	0.770	.
rooms	2.8797	2.8931	-1.4	-0.17	0.869	0.89
electric	.05498	.04529	3.8	0.53	0.593	.
mins_market	61.649	65.342	-7.8	-0.88	0.378	0.93
mins_trans	67.127	69.36	-3.8	-0.45	0.650	0.99
mins_road	84.155	86.266	-3.2	-0.37	0.712	1.06
roads_imp	.67354	.67716	-0.8	-0.09	0.926	.
bl_tot_land_size	1.1336	.98352	10.4	1.20	0.230	0.81
pca_physical_bl	.17385	.15074	2.1	0.25	0.806	0.92

* if variance ratio outside [0.79; 1.26]

Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
0.005	4.09	0.997	3.6	3.2	16.8	0.92	10

* if B>25%, R outside [0.5; 2]

Table A6: Balancing Property Tests Before and After Matching

Variable	Unmatched / Matched	Mean Treated	Mean Control	%reduct %bias	%reduct |bias|	t-test t	t-test p>|t|	V(T)/ V(C)
HoH_fem	U	.2637	.2568	1.6		0.22	0.826	.
	M	.2646	.26301	0.4	76.9	0.04	0.965	.
h_age	U	52.894	46.42	45.3		6.28	0.000	0.90
	M	52.921	53.465	-3.8	91.6	-0.46	0.645	0.91
h_agesq	U	2990	2369.2	40.9		5.73	0.000	1.03
	M	2993.3	3069.7	-5.0	87.7	-0.58	0.565	0.84
nolit	U	.2911	.35884	-14.5		-2.01	0.045	.
	M	.2921	.28588	1.3	90.8	0.17	0.869	.
num_work	U	.76027	.87925	-12.9		-1.83	0.067	1.17
	M	.76289	.74981	1.4	89.0	0.17	0.863	1.22
hsize	U	5.8699	5.4762	17.1		2.46	0.014	1.44*
	M	5.8522	5.7085	6.2	63.5	0.74	0.459	1.30*
own_house	U	.97945	.98129	-1.3		-0.19	0.852	.
	M	.97938	.9827	-2.4	-80.3	-0.29	0.770	.
rooms	U	2.8767	2.7602	12.0		1.67	0.095	0.92
	M	2.8797	2.8931	-1.4	88.5	-0.17	0.869	0.89
electric	U	.05479	.08163	-10.6		-1.44	0.149	.
	M	.05498	.04529	3.8	63.9	0.53	0.593	.
mins_market	U	61.849	51.551	21.7		3.08	0.002	1.21
	M	61.649	65.342	-7.8	64.1	-0.88	0.378	0.93
mins_trans	U	67	64.083	5.0		0.70	0.487	1.03
	M	67.127	69.36	-3.8	23.4	-0.45	0.650	0.99
mins_road	U	84.38	71.41	19.5		2.76	0.006	1.22
	M	84.155	86.266	-3.2	83.7	-0.37	0.712	1.06
roads_imp	U	.67466	.71429	-8.6		-1.21	0.227	.
	M	.67354	.67716	-0.8	90.9	-0.09	0.926	.
bl_tot_land_size	U	1.1932	.60571	40.5		6.15	0.000	2.67*
	M	1.1336	.98352	10.4	74.4	1.20	0.230	0.81
pca_physical_bl	U	.1714	-.07588	22.1		3.07	0.002	0.97
	M	.17385	.15074	2.1	90.7	0.25	0.806	0.92

* if variance ratio outside [0.79; 1.26] for U and [0.79; 1.26] for M

Sample	Ps R2	LR chi2	p>chi2	MeanBias	MedBias	B	R	%Var
Unmatched	0.104	116.59	0.000	18.2	14.5	78.8*	1.10	20
Matched	0.005	4.09	0.997	3.6	3.2	16.8	0.92	10

* if B>25%, R outside [0.5; 2]