IMPACT ASSESSMENT REPORT

Republic of Rwanda

Project for Rural Income Through Exports (PRICE)

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IFAD
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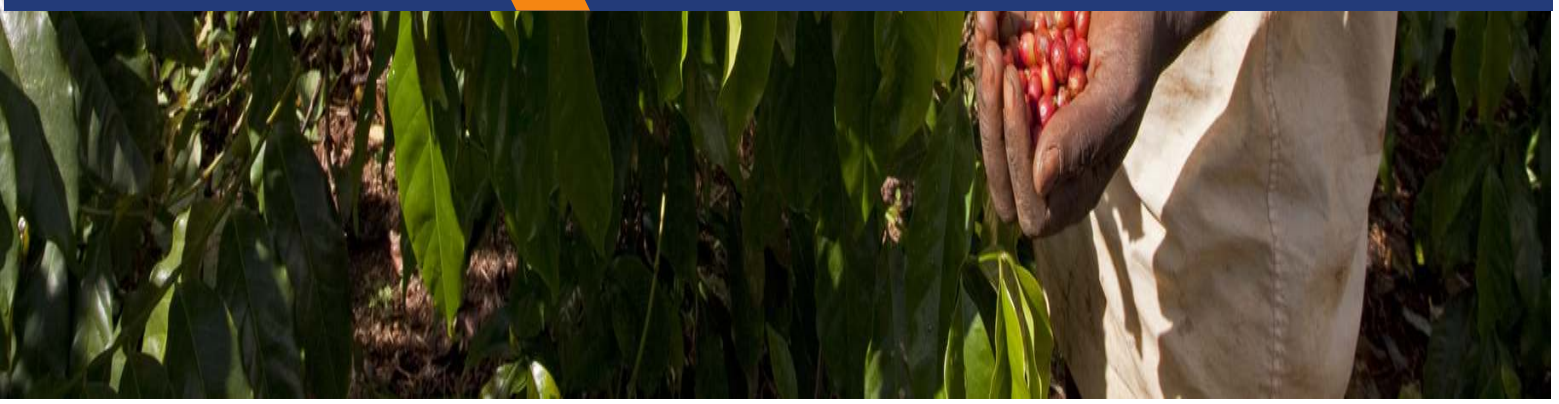

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Executive summary

Agricultural commercialization is one of the cornerstones of rural poverty reduction for smallholder farmers in developing countries (Dixon, Gulliver and Gibbon 2001). This development approach seeks to strengthen farmers' positions in selected value chains through the production and marketing of a sizable amount of cash crops. Commercialization can be achieved by allocating sufficient resources and specific interventions toward the cash crops, both for production and marketing activities (Jaleta, Gebremedhin and Hoekstra 2009).

The Rural Income through Exports (PRICE) project in Rwanda is a rural agricultural commercialization project that aimed to achieve sustainable increased returns to farmers from increased participation in export-driven value chains. This goal[1] was to be accomplished by increasing production volumes and quality of cash crops, including coffee and horticulture, through a variety of interventions. The PRICE interventions included providing technical training on coffee processing, and providing support to horticulture farmers to develop business plans and access financial capital, both loans and matching grants, for their respective enterprises.

This report presents results of an ex-post impact assessment (IA) of select components of the PRICE project relating to coffee, horticulture and financial services. The IA was conducted between May 2017 and July 2018 and used both qualitative and quantitative research methods. The current report mainly focuses on the quantitative results, while drawing on some of the insights from the qualitative survey. The quantitative results are based on secondary panel data of 85 coffee cooperatives observed over six years between 2012 and 2017 (510 observations) and two cross-sectional primary datasets collected using household surveys in 2018: (i) a sample of 2894 coffee farmers who are members of the coffee cooperatives observed over six years and (ii) 1584 horticulture farmers for the horticulture-finance component. We used a variety of quasi-experimental and non-experimental design methods to estimate our results, namely difference-in-difference estimations for the cooperative-level panel data, inverse probability weight matching and entropy balancing approaches for the coffee household data, and regression discontinuity design for the horticulture-finance data.

Key findings from the IA show that at the cooperative level, the coffee-related PRICE interventions increased the price of coffee offered by cooperatives to farmers as well as the utilization rate of coffee washing stations (CWS). In fact, more farmers who were members of cooperatives that received the PRICE interventions delivered all their coffee output to the cooperative, compared to farmers who were members of cooperatives that did not receive the interventions. Evidence of the effectiveness of PRICE at the cooperative level is corroborated by qualitative findings – farmers who were members of coffee cooperatives that received PRICE interventions reported increased satisfaction with their cooperative leadership as well as increased overall satisfaction with the performance of their cooperative.

At the household level, on average, PRICE had a positive impact on farmers' household assets and incomes sourced from coffee. This was especially the case for farmers whose cooperatives received

[1] This goal is in line with IFAD's overarching goal of economic mobility and IFAD's strategic objectives of increasing poor rural people's productive capacities, benfits from market participation and strengthened environmental sustainability and climate resilience (IFAD, 2016a).

the Turnaround Programme 2 (TAP2) intervention. While farmers that benefited from the Turnaround Programme 1 (TAP1) also experienced significant increases in their household assets, we did not find a significant impact of TAP1 on general household income or income from coffee sales. TAP2 appears to have had a greater impact, potentially as a result of incorporating both administrative and technical lessons learned from TAP1.

With regards to the horticulture-financial services components of the PRICE project, which vetted farmer's horticulture business ideas provided endorsement letters for use in accessing loans and performance-based grants to horticulture farmers, our findings show mixed results. Although no significant impact was registered for farmers' total income or crop income, farmers whose business plans were selected for consideration for either a loan or the performance-based grant ended up with more horticulture income and household assets on average. We also found productive assets being significantly higher for PRICE beneficiaries than non-beneficiaries.

One of our key takeaways from the PRICE IA centre on the effectiveness of integrating learning and adapting interventions based on lessons from earlier stages of project implementation. We found TAP2 to have had a greater impact on farmers largely due to its flexibility and adjustments made to the programme design based on lessons learned from TAP1.

Our second lesson learned from the PRICE IA focuses on the importance of developing good selection criteria that ensure appropriate beneficiaries selection. This lesson is drawn from the results of the horticulture-finance intervention, where the farmers selected to participate in the intervention appear to have been relatively better off from the beginning than non-beneficiaries, limiting the detectable impact of the intervention. In addition, the design of the horticulture-finance intervention did not account for the fungibility of financial loans and grants, which may be used for things other than those proposed in the business plan. Therefore, in future designs, it would be useful to either allow beneficiaries to invest in any chosen venture or to put in place mechanisms that ensure that the beneficiaries invest in the planned business enterprise.

Our final insight is on the high demand for finance by farmers in Rwanda. The design of the horticulture-finance intervention did not account for the overwhelming demand for the financial loans and matching grant, such that most of the applicants whose business proposals were selected did not receive the expected financing. It is nonetheless encouraging to find that a large number of the farmers not selected went on to finance their business plans by other means. Future projects may consider supporting farmers to develop business plans and then officially vetting them, which could motivate farmers to implement their business idea through personal savings and external financing. Our results demonstrate the plausibility of this approach, which could create significant developmental impacts while drastically decreasing the capital required to implement the intervention. This is especially important in contexts with limited resources, since the mere process of helping farmers to develop and vet their proposals seems to have had a positive impact on household assets.

1. Introduction

Agricultural development projects that focus on cash crops, especially export crops, in developing countries are often designed to increase smallholder farm incomes in rural areas (Maertens, Minten and Swinnen 2012); (McCulloch and Otta 2002). In many cases, these projects support smallholder farmers to increase the quantity and quality of their crop production through the provision of agricultural extension services and support for access to farm inputs, such as quality seed, fertilisers, pesticides and herbicides. These projects tend to work through local organisations such as cooperatives, often in partnership with government departments, and can provide important mechanisms for investing in marketing infrastructure. For example, cooperatives have been instrumental in providing post-harvest handling and processing facilities in rural communities to address the challenge of low produce quality and low value addition among smallholder farmers (Markelova, et al. 2009). Working through cooperatives, agricultural projects can also enhance smallholder farmers' marketing capabilities and access to lucrative export markets (Mojo, Fischer and Degefa 2017); (Verhofstadt and Maertens 2015); (Wollni and Zeller 2007). Given that smallholder farmers often lack financial capital, it is not uncommon for these projects to also provide agricultural finance to farmers for investment in their cash crop enterprises.

In the case of Rwanda, the Rural Income through Exports (PRICE) project aimed to achieve sustainable increased returns to farmers through export-driven value chains. The project was designed to increase production volumes and quality of cash crops among the beneficiary smallholder farmers. PRICE consisted of five components, namely coffee development, tea development, silk development (sericulture), horticulture, and financial services. The project was approved in December 2011 for a total amount of US$ 56 million, of which IFAD initially committed to financing US$ 37.4 million. IFAD later approved a top-up of US$ 11.3 million to fill a financing gap of an unidentified co-financier (IFAD, 2015). In April 2018 the project received approval for a second additional financing of US$8.5 million plus an 18-month extension, making the total financial investment US$ 65.8 million. By August 2018, PRICE had reached approximately 125,824 households and 174 cooperatives. The project is in line with the Government of Rwanda's Economic Development and Poverty Reduction Strategy 2 (EDPRS2) and the Transformation of Agricultural Sector Program Phase III (PSTA III) (MINECOFIN - Ministry of Finance and Economic Planning 2013); (MINAGRI - Ministry of Agriculture and Animal Resources 2009) and the National Agricultural Export Development Board (NAEB) is the lead implementing agency.

The main objective of this report is to present results of an IA of key activities implemented under three components of the PRICE project in Rwanda, namely the coffee development, horticulture development and financial services components. Together, these three components account for the majority of the planned total project cost. We selected these components of PRICE for an ex post IA, which fit into the broader set of IAs being conducted globally as part of the IFAD10 Impact Assessment Agenda (IFAD10 IAA). IFAD10 IAA aims to provide lessons for improving the design of rural poverty reduction programmes and to measure the impact of IFAD-supported programmes on enhancing rural people's economic mobility, agricultural productive capacity, market participation, and resilience.

The PRICE IA was conducted between May 2017 and August 2018, and used a combination of qualitative and quantitative methods. Our mixed method approach allowed us to understand the context of the intervention and accurately capture the effects of PRICE.

We started and finished the fieldwork with qualitative analysis. Our qualitative approach included a scoping mission, focus group discussions and key informant interviews with relevant stakeholders. We used the results of these efforts to inform the design of the quantitative impact assessment and to better interpret the quantitative results presented in this report.

In this IA, we mainly report on our quantitative findings. Our quantitative approach included two farm household surveys. The first survey covered 2,894 smallholder coffee farmers in Rwanda, of which 1450 belonged to coffee cooperatives that received support under PRICE. The second survey was administered to 1,600 horticulture farmers, of which 359 received support under PRICE, specifically, vetting and endorsement letters for their business idea and performance-based matching grant. In addition, we incorporated into our analysis a secondary panel data set of 85 coffee cooperatives, observed on a yearly basis from 2012 to 2017. We analysed these quantitative data using a combination of quasi-experimental and non-experimental design methods, including regression discontinuity design, difference-in-difference, and propensity score matching.

The rest of this report is organized as follow: in the next section we develop our theory of change as well as outline the selection criteria for the PRICE interventions. We then present our research questions along with a brief description of the project coverage and targeting approach. In the third section, we outline our methodology approach, as well as the data and analytical methods we used to answer the research questions. We next review the results section, where we present our main findings. Finally we conclude the study, including a summary of the main findings and policy recommendations for improving future designs of similar projects.

2. Theory of change and main research questions

2.1 PRICE's theory of change

PRICE's theory of change is built on the development paradigm that smallholder farm incomes can be increased through commercialization of high-value cash crops. Agricultural commercialization is seen as a cornerstone of rural poverty reduction for smallholder farmers in developing countries (Dixon, Gulliver and Gibbon 2001). The approach seeks to strengthen farmers' positions in selected value chains through the production and marketing of cash crops. Smallholder income is increased by allocating sufficient resources to the cash crops, both for production and marketing activities (Jaleta, Gebremedhin and Hoekstra 2009).

The process of strengthening the position of smallholder farmers along the value chain often entails addressing numerous constraints. For example, smallholder Rwandan coffee farmers experience several agricultural constraints such as lack of knowledge and management capacities and limited access to capital and inputs, which hinder them from attaining high yields and quality outputs. Thus, by providing training through farmer field schools (FFS) linked with the provision of quality planting materials and agricultural research, PRICE sought to enable smallholder farmers to overcome the abovementioned production constraints.

At the market level, addressing binding constraints within the chosen value chains and organizing and training farmers into effective commodity groups or cooperatives, is likely to increase farmers' market access, output prices, and incomes. CWS in Rwanda, which were designed to be a mechanism for increasing coffee quality, value addition, and market access, were often improperly managed. This dysfunction prevented smallholders from processing their coffee into quality cherries or accessing lucrative export markets. Due to weak governance structures, lack of financial controls, and inadequate transparency requirements, many of the coffee cooperatives had previously experienced financial losses.

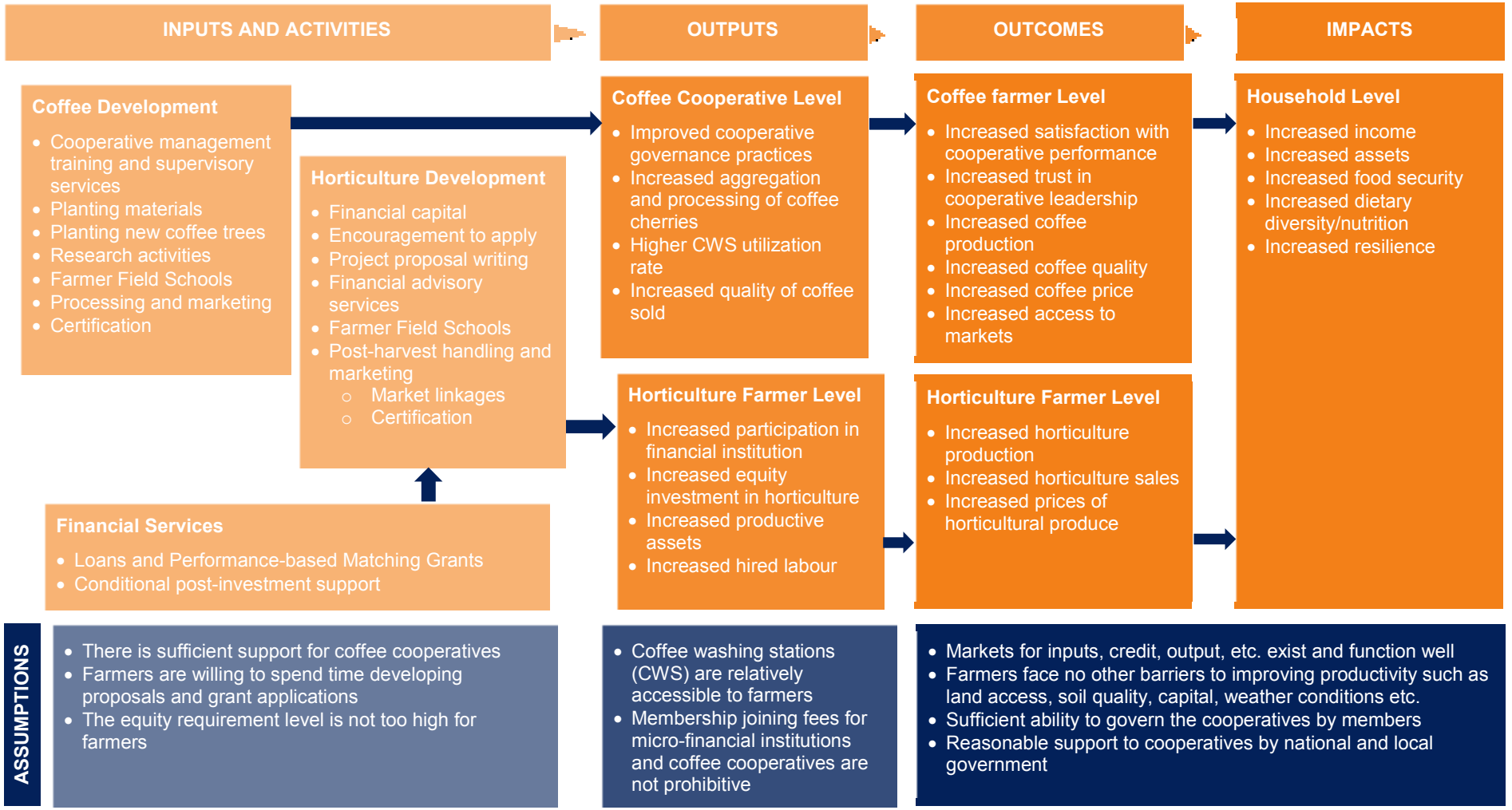
PRICE targeted these cooperatives with the aim of increasing profitability by training them on cooperative and financial management combined with provision of supervisory services. As part of the TAP intervention, NAEB contracted SNV-Rwanda to new and pre-existing coffee cooperatives. SNV-Rwanda's technical trainings covered many topics including coffee processing, CWS maintenance, and good planting processes. NAEB chose these trainings to improve the CWS processing practices and the overall operations of the cooperatives.

For horticulture, PRICE sought to address restricted access to capital and limited horticulture investments through its matching grants.. In 2001, 73% of the total horticulture production in Rwanda was dedicated to consumption and sales in local informal markets, while only 3% was sold in more formal regional and international markets. It was noted that there were high levels of informal business arrangements in the horticulture sector, which were believed to disadvantage horticulture farmers, particularly in the credit markets (IFAD 2011a, IFAD 2011b).

The lack of formal sales history limited formal lending to Rwandan horticulture farmers, despite a growing domestic and international demand for horticulture products. Therefore, PRICE incentivized financial institutions to lend to horticulture smallholder farmers at competitive rates. At the same time, PRICE used performance-based matching grants to leverage its finances to raise equity

investments from the farmers. Figure 1 depicts the theory of change for the related activities of PRICE, and the intended outputs, outcomes and impacts. It also shows the assumptions upon which the project relies.

Figure 1: PRICE's theory of change



2.2 Selection of PRICE Beneficiaries

Turnaround Programme - Coffee Intervention

The PRICE Turnaround Programme consisted of two rounds of interventions, TAP1 and TAP2, each lasting two years. TAP1 was implemented from 2014-2015, and TAP2 took place from 2016-2017. TAP1 and TAP2 targeted 50 existing coffee cooperatives in total, focusing on 25 in each round. The Turnaround Programme built the capacity of coffee cooperatives through improved governance, financial management, and operational support. TAP1 and TAP2 also enhanced the operations of the cooperatives' coffee washing stations (CWS) and marketing activities. The Turnaround Programme aimed to enable coffee cooperatives to recover from their previous losses and transform them into profitable cooperatives.. TAP1 and TAP2 were ultimately designed to improve the lives of the cooperatives' smallholder farmers.

SNV-Rwanda[2] conducted and NAEB/PRICE[3] validated the coffee cooperatives selection process for both rounds of the Turnaround Programme. However, the process slightly differed for each round. For TAP1, the SNV-Rwanda pre-screening cooperatives by reviewing: 1) the cooperatives' losses over the previous 3 years; 2) the functioning of the cooperatives since 2010; and 3) the rental status of the CWS for the 2014 coffee season. SNV-Rwanda found 52 coffee cooperatives eligible for second stage scoring, which they conducted according to the cooperatives' performance in the three dimensions shown in Table 1: cooperative governance, financial profile, and technical potential. After excluding 8 cooperatives due to insufficient information, the selection team ultimately considered a pool of 44 coffee cooperatives, of which 25 were selected to receive TAP1.

Table 1: Selection Criteria for the TAP1

Dimension	Sub-Dimension	Maximum scores
Cooperative Governance	Availability of documents as required by the law	5
	Cooperative organization	4
Financial Profile	Profitability	4
	Financial potentiality	4
	Debts status	4
Technical Potential	Coffee washing station (CWS) area productivity	4
	CWS performance	4
	CWS status	4
	Management team	4
	Provision of premium price and/or second payment to the farmers	4
Total		**41**

Note: There are some sub-components under each sub-dimension, upon which the scores were given.

For TAP2, the selection team pre-screened 89 coffee cooperatives using the following criteria: 1) CWS losses in previous years and profitability potential; 2) CWS management's commitment to high governance, accountability and transparency standards ; and 3) CWS' willingness to pass on premium prices to farmers.

[2] SNV-Rwanda is a development organization, founded in the Netherlands in 1965 to equip communities, businesses and organisations with the tools, knowledge and connections they need so that they are empowered to break the cycle of poverty and guide their own development. They have been engaged in strengthening the coffee sector in Rwanda jointly with national Agricultural Export Development Board.

[3] NAEB/PRICE is the National Agricultural Export Development Board, which is responsible for guiding and managing all activities of the PRICE project implementation.

SNV-Rwanda additionally considered the cooperative's governance structure, financial profile, and technical potentiality during the selection process. They excluded inoperative, rented-out, and bankrupt coffee cooperatives from the selections. Out of the pre-screened 89 coffee cooperatives, SNV and NAEB/PRICE shortlisted 64 coffee cooperatives, of which they selected the 25 cooperatives with the highest potential for viability and sustainability to receive TAP2.

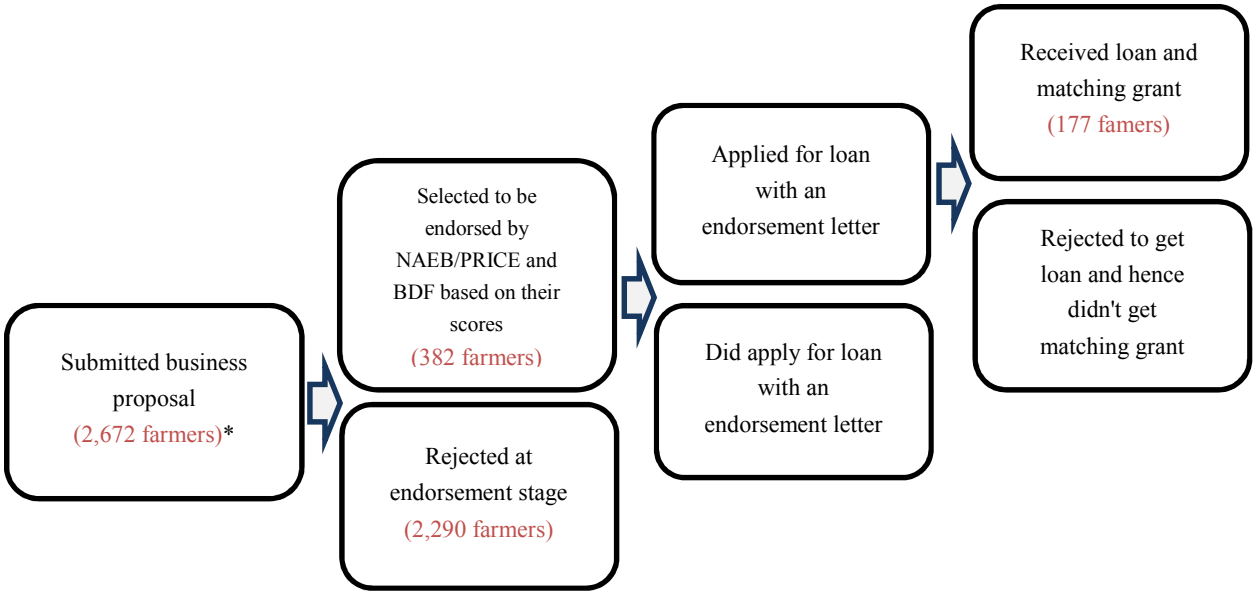
Horticulture-Finance Intervention

The PRICE designers focused the horticulture activities on a business partnership approach. Performance-based matching grants were the main vehicle to facilitate access to financial services for horticulture farmers. PRICE matching grants for horticulture farmers consisted of 50% grant and 50% loan as follows:

1) The PRICE project deposited 50% of the grant in an interest-bearing account opened at the lending bank/institution as soon as a financial institution approved the investment.
2) One third of this 50% loan would be used to reduce the project investment cost..
3) The financial institution lent the borrower the remainder of the investment cost.
4) The borrower completed the loan after paying pack 50% of the investment cost.
5) The bank would offset the outstanding loan principal with PRICE funds.

To implement the matching grants in the horticulture sector, NAEB/PRICE launched an open call for proposals for horticulture farmers to submit business ideas on October 1st, 2013. After submission of prospective business ideas, NAEB/PRICE selected projects based on a set of specific criteria as explained later. The selected projects were submitted to Bank of Rwanda Development Fund (BDF)[4] for technical assistance with the business plans before the applicants could apply for loans from the financial institutions. Figure 2 illustrates the different applicant pathways.

Figure 2: Stages of the selection process for farmers applying for horticulture-matching grants



[4] BDF was established in 2011 as a wholly owned subsidiary of the Development Bank of Rwanda. It assists SMEs to access finance, particularly those insufficient collateral to obtain credit from traditional financial institutions.

To check the eligibility of the business proposals to be endorsed for the matching grant, NAEB and BDF staff evaluated and scored each proposal based on the selection criteria shown in Table 2.

Table 2: Selection criteria used for scoring horticulture applicants

Dimensions	Score
Market and export potential/differentiation opportunity/value-adding capacity	20
Ensured markets	15
Project feasibility - experience and interest of applicant	15
Project feasibility - business idea/impact	25
Project feasibility - investment cost and financing	15
Sustainability	5
PRICE criteria	5
Total	**100**

(MINAGRI 2014)

Addition prerequisites for project eligibility included: 1) Rwandan implementation; 2) a focus on primary production or post-harvest/marketing activities; and 3) the growing of pineapple, onions, hot peppers, tamarillo, passion fruits, tomato, apple banana, carrots, eggplants, French beans, cabbage, flowers, essential oils crops, avocado, avocado, mango, or citrus. Our analysis assesses two levels of treatment impact, receiving an endorsement letter and receiving the matching grant. We assess the impact of receiving an endorsement letter, even if the farmer did not receive a matching grant from PRICE, because our qualitative research revealed that many farmers who received the endorsement letter secured financing from another source, either through an alternative financial mechanism or through equity financing.

Table 3: Pass Marks for different horticulture crop types

Activity sector	Crops	Required pass mark
Value-added sectors	All crops that involved processing, post-harvest, packaging, transport and marketing	50%
Primary production	Essential oils & flowers	
Primary production	Onions & passion fruit	75%
Primary production	Apple banana & pineapple	
Primary production	Other vegetables & fruits	80%

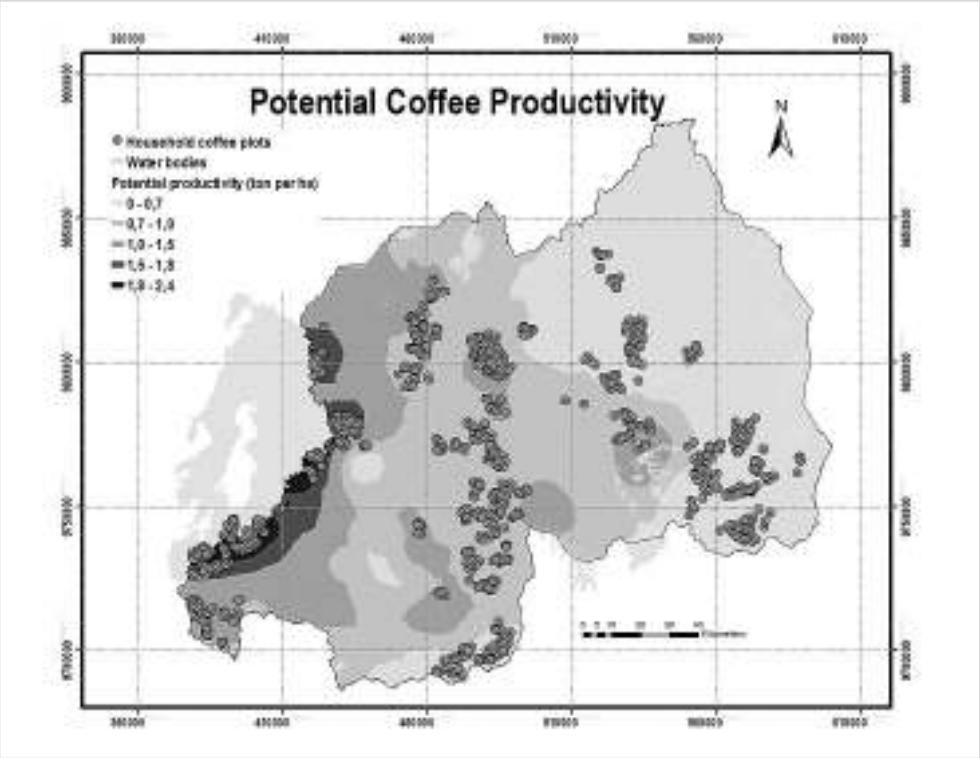
(NAEB - National Agricultural Export Development Board 2014)

The NAEB/BDF proposal selection team highlighted crops with greater value, thus the differing required pass marks outlined in Table 3. For example, they deemed other vegetables and fruits of lower value, and therefore set the highest score requirement for this crop type. The selection team received a total of 2,673 applications, out of which NAEB/PRICE and BDF endorsed only 382 proposals. BDF supported 177 applicants with the matching grants, due to limited PRICE funding.

2.3 Project coverage and targeting

PRICE targeted relatively poor smallholder farmers, with limited assets but a willing to commercialize their crop production. Low-income farmers account for 24 percent of Rwanda's population. The project also included farmers with higher income levels, particularly horticulture farmers who had to capacity to raise capital for the matching grants. TAP targeted farmers through struggling coffee cooperatives. Geographically, PRICE covered farmers across Rwanda's rural areas, including all twelve districts and all four provinces of Rwanda except the city of Kigali (Figure 3).

Figure 3. Characteristics of geographic areas targeted by the Turnaround Programme



2.4 Research questions

Following Gertler, et al. (2016), we based our research question on the causal logic embedded in the project's theory of change.. As shown in Figure 1, our research questions directly relate to the theory of change's causal pathways, from inputs/activities, outputs, and outcomes to expected impacts,.

For coffee, our quantitative impact assessment focuses the Turnaround Programme's impact on cooperative members. Specifically, we assess how TAP1 and TAP2 separately affect farmers' incomes and assets. We unpack the causal chain by examining the coffee prices received by cooperative members, the coffee volumes they produced, and the coffee they sold to their respective cooperatives. In addition, we assess the impact of TAP on cooperative governance, perceived performance, and technical outcomes. We use active cooperative participation, social capital, and perceived cooperative performance as measures of cooperative. For the technical outcomes, we review the volume of coffee aggregated by the cooperatives and the level of CWS utilization, which is the share of total CWS capacity being used by the individual cooperatives.

Regarding the financial intervention of PRICE for horticulture farmers, we assess the impact on horticulture farmer production, sales, incomes and assets. Our evaluation examines how being selected for the PRICE financial intervention affected the farmers' likelihood to invest in their horticulture enterprises using their own

equity or other sources of finance. We also consider other dimensions of potential impact, encompassing food security, dietary diversity, and resilience. Our research question include:

Cooperative level:

1. Does the Turnaround programme improve coffee cooperatives' governance, CWS utilization rate and coffee prices paid to cooperative members?

Farmer level:

2. Does the Turnaround programme and the horticulture-financial intervention increase farmers' market access, income or assets?
3. Does the Turnaround programme and the horticulture-financial intervention increase farmers' household level food security, dietary diversity and resilience?

3. Impact assessment design: Data and methodology

3.1 Data

In our impact assessment we implement a mixed methods approach that employs both qualitative and quantitative analysis to answer our research questions. We pre-registered our assessment on the International Initiative for Impact Evaluation's Registry for International Development Impact Evaluations.[5] Our data collection efforts follow our pre-registration plan.

Qualitative data

Prior to collecting the quantitative data, we collected qualitative data through focus group discussions (FGDs) and key informant interviews (KIIs) with randomly selected coffee cooperatives and Savings and Credit Cooperatives (SACCOs). These included four FGDs with coffee cooperative leaders and members from TAP1, TAP2, and the respective control groups; four KIIs with SACCOs with members who applied for the matching grant, and; a KII with a representative from BDF. We aimed to understand how the coffee cooperatives worked, the context and mechanics of the TAP interventions, as they relate to the operations of the cooperatives, and linkages between the coffee cooperatives, their members, and other coffee market stakeholders. We also gained an understanding of the matching grant implementation process for the horticulture farmers, and obtained insights on the matching grant selection criteria.

We later conducted an additional set of KIIs, after collecting the quantitative data, to glean insights on the results that emerged from our analysis. In this round, we conducted two KIIs with coffee cooperatives that received TAP1 and two that received TAP2. We additionally conducted another KII with a BDF staff member to obtain further insights on the results of our horticulture-finance analysis.

Quantitative data

Cooperative-level coffee secondary data

For the coffee cooperative level, we obtained secondary data on CWS owned by all coffee cooperatives from the Rwanda Cooperatives Authority (RCA) and NAEB. As aforementioned described in Figure 1,, our variables of interest at the cooperative level include: (i) volume of green coffee (cherries) aggregated and processed, (ii) coffee prices received by farmers in the cooperatives, and (iii) CWS capacity utilization rate. The latter is defined as the ratio of cherries received and processed by the cooperative to the theoretical capacity of the CWS. These panel data span the years 2012-2017 and allowed us to estimate difference-in-difference econometric models to assess the impact of TAP interventions on the three cooperative-level outcome variables of interest. In total, the secondary panel dataset consisted of 85 coffee cooperatives observed over the six years, for a total of 510 observations.

Household-level coffee quantitative data

Prior to collecting the household level data, we conducted power calculations that indicated a required sample size of 2800 coffee farmers, equally divided between the treatment and control groups for both TAP1 and TAP2. Our final sample size was 2894 coffee farmers who were members of cooperatives included in the panel data obtained from RCA and NAEB. This final sample includes 728 and 714 coffee farmers representing the

[5] See (Wood and Balint 2018) to review our pre-registration plan.

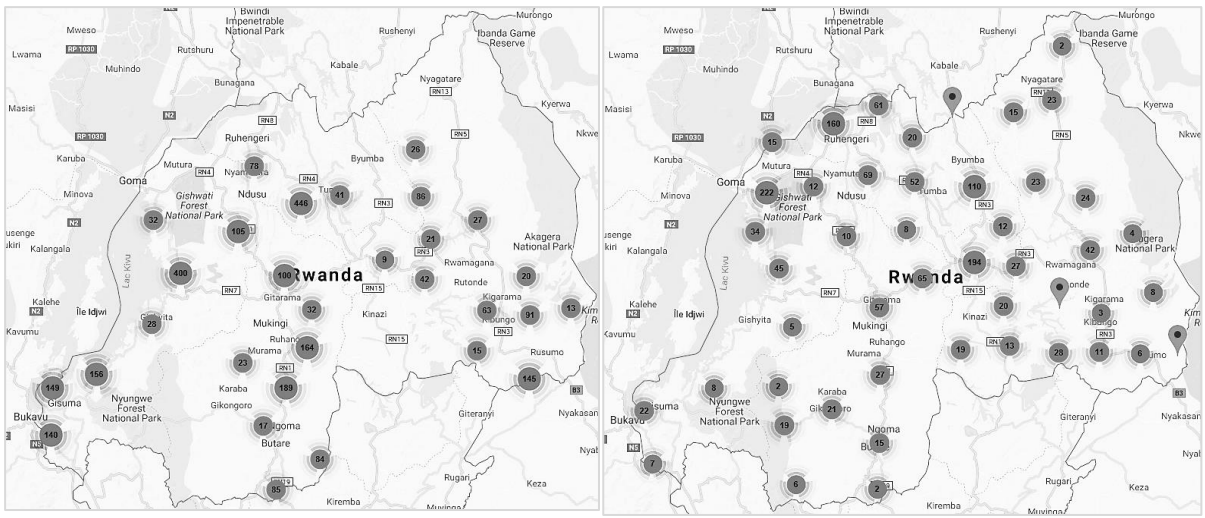
treatment groups for TAP1 and TAP2, respectively. The control group includes 1438 farmers representing the control group for both rounds of TAP. Within each cooperative, members were randomly selected proportional to cooperative size. Members not sampled in each cooperative were randomly listed as replacements, in the case that the sampled farmers proved inaccessible. Geographically, our sample covered almost all rural areas of Rwanda, as depicted in Figure 4.

Horticulture-finance quantitative data

The horticulture development component of PRICE contained multiple interventions. It mainly provided loans and matching grants to farmers growing horticultural crops for sale. These farmers grew a wide array of crops and varieties, including garlic, onions, beans, carrots, tamarillo, passion fruit, and flowers. This funding mechanism provided smallholder farmers with access to capital through bank loans. Financial institutions previously overlooked these horticulture farmers, as they typically focused on large-scale commercial farmers. As a result, the matching grants were heavily oversubscribed, with over 3,000 applications for approximately 170 grants. Our total sample size for the horticulture-finance component encompasses1,578 horticulture farmers, including 358 farmers with selected business ideas and 1,220 farmers with rejected applications. Out of the 358 selected farmers in our sample, 322 of them applied for a loan, 162 received a loan, and only 130 received a matching grant. Figure 4 demonstrates the geographic coverage of our sample area.

Figure 4: Geographic distribution of household data collected

Coffee sample *Horticulture sample*



Note: number in each circle reflects how many farmers in each area were interviewed.

Constructing the counterfactual for TAP-coffee intervention

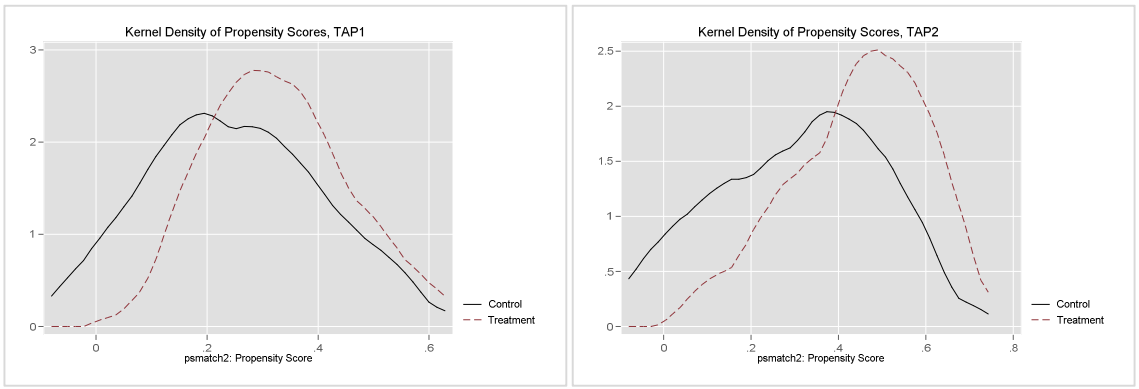
To assess impact of the TAP coffee interventions we implement a two-stage matching procedure. In the first stage, we compare the treatment and control cooperatives. In the second stage, we match at the household level. This two-stage approach ensures that our analysis captures both similar cooperatives and similar households. In our coffee analysis, we use propensity score matching to create counterfactuals at both the cooperative and household levels. We implement our analyses separately for TAP1 and TAP2 because the timing of implementation differed for the two interventions and the implementers used lessons learned from TAP1 to inform TAP2.

Prior to data collection, we conducted the first stage of matching at cooperative level to ensure comparability between the treatment and control cooperatives. We use data on the cooperatives and regional levels to ensure

statistical comparability between the treatment and control groups. We rely on two data sources to validate our matching results, namely 1) the SNV-Rwanda's official scores based on the cooperative's governance, financial and technical indicators; 2) expert judgment by key informants involved in the implementation of the TAP interventions.

We rely on the official scores to corroborate the propensity score matches because SNV-Rwanda's findings represent an independent assessment of each coffee cooperatives. We assume similar scores for cooperatives in the control and the treatment groups would indicate a similar level of performance for these cooperatives at the baseline. We also validated our matching results with expert judgment from the project team, to ensure sound comparability. We present our propensity score matching results in Figure 5.

Figure 5: Propensity score matching results at the coffee cooperative level



Given that our ultimate interest is in assessing impacts of the coffee intervention at the household level, we implemented another level of matching at the household level. Our household-level matching procedure includes variables at both the household and cooperative levels shown in Table 4.

Table 4: Matching variables

Matching variables	Definition	Unit of measurement	Data source
Membership years	Number of years as a cooperative member in farmer's current cooperative	Years	Household data
Coffee experience	Number of years cultivating coffee	Years	Household data
Number of rooms	Number of rooms a household had 5 years ago	Rooms	Household data
Time to water (5 years ago)	Time take a household to arrive to their main water source	Minutes	Household data
Electricity (5 years ago)	Dummy variables equals 1 if a household had electricity 5 years ago, and 0 otherwise	Dummy variable	Household data
Age of household's head	Household age	Years	Household data
Household size	Number of household members	Members	Household data
Distance between farmers and their cooperative	Distance between farmers and their cooperatives	Kilometres	Household data and cooperative data
Distance between cooperatives and Kigali	Distance between cooperatives and Kigali	Kilometres	Cooperative data
Households' average schooling years	Household average years of schooling	Years	Household data
Numbers of household members who get involved in agricultural activities	Number of household members actively involved in agricultural activities	Members	Household data

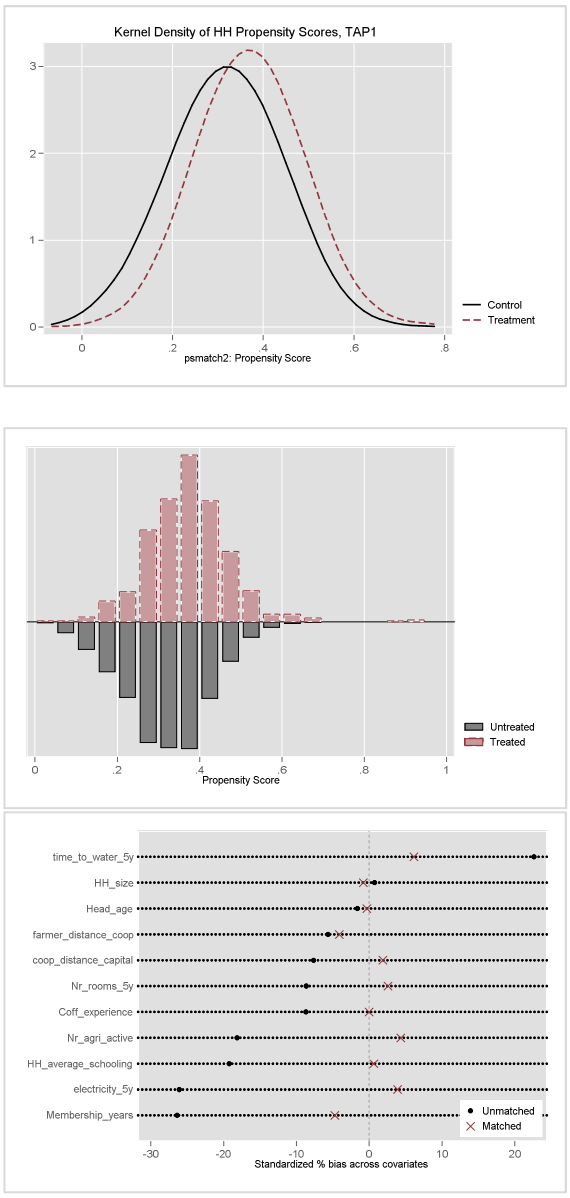
We present our matching results in

Figure 6. Our results show all observations are located within the common support, with the different weights for each observation reflecting its importance in the matching procedure. Our matching results also significantly reduce the standardized percent of bias across all matching covariates. That is reflected in a reduction in Rubin's Bias[6] from 50.3 per cent to 9per cent for TAP1 and from 59.9 per cent to 13.8 per cent for TAP2. In addition, the Rubin's Ratio[7] is 1.13 for TAP1 and 0.71 for TAP2, both of which are within the recommended range of 0.5-2 (Rosenbaum and Rubin 1985, Rubin 2001).

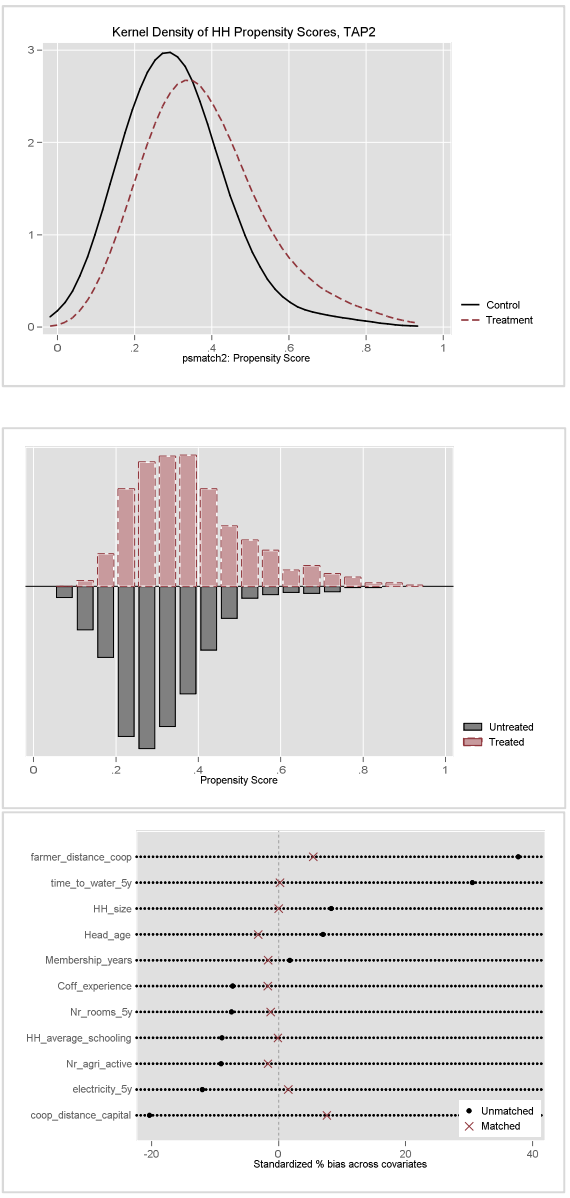
[6] Rubin's Bias is the absolute standardized difference of the means of the linear index of the propensity score in the treated and (matched) non-treated group.
[7] Rubin's Ratio is the ratio of treated to (matched) non-treated variances of the propensity score index.

Figure 6: Propensity score matching results at the coffee household level

TAP1



TAP2



We detail the descriptive statistics for all of the matching covariates we used for the TAP1 and TAP2 matches in Table 5 and Table 6, respectively. Our results demonstrate an improvement in the balance of the matching covariates after matching using the matching weight for each observation within the control group. Only one variable on the cooperative level, the distance between the cooperative and Kigali, remains statistically different between the treatment and control group for TAP2 after matching.

Table 5. Summary statistics before and after matching for TAP1

TAP1	Before matching				After matching				Reduction in Bias (percent)
	Treat. Mean/SE	Control Mean/SE	p-value	Bias	Treat Mean/SE	Control Mean/SE	p-value	Bias	
Membership years	8.37	9.76	0.000***	26.51	8.37	8.50	0.615	2.37	91.07
	(0.19)	(0.14)			(0.19)	(0.14)			
Coffee experience	27.75	29.06	0.054*	8.69	27.75	27.93	0.818	1.19	86.26
	(0.58)	(0.39)			(0.58)	(0.43)			
Number of rooms (5 years ago)	3.42	3.53	0.058*	8.66	3.42	3.41	0.894	0.67	92.28
	(0.05)	(0.03)			(0.05)	(0.04)			
Time to water (5 years ago)	21.94	17.22	0.000***	22.62	21.94	20.85	0.369	5.26	76.74
	(0.94)	(0.40)			(0.94)	(0.53)			
Electricity (5 years ago)	0.06	0.13	0.000***	26.16	0.06	0.05	0.379	3.03	88.40
	(0.01)	(0.01)			(0.01)	(0.01)			
Age of household's head	54.63	54.87	0.701	1.73	54.63	54.57	0.935	0.44	74.72
	(0.53)	(0.36)			(0.53)	(0.41)			
Household size	4.92	4.90	0.859	0.81	4.92	4.92	0.990	0.07	91.92
	(0.08)	(0.06)			(0.08)	(0.06)			
Distance between farmers and their cooperative	3.56	3.88	0.239	5.68	3.56	3.71	0.596	2.60	54.31
	(0.17)	(0.18)			(0.17)	(0.18)			
Distance between cooperatives and Kigali	68.99	71.63	0.110	7.62	68.99	68.64	0.828	1.01	86.68

TAP1	Before matching				After matching				Reduction in Bias (percent)
	Treat. Mean/SE	Control Mean/SE	p-value	Bias	Treat Mean/SE	Control Mean/SE	p-value	Bias	
	(1.07)	(1.04)			(1.07)	(1.07)			
Households' average schooling years	5.67	6.12	0.000***	19.15	5.67	5.62	0.667	2.14	88.81
	(0.09)	(0.06)			(0.09)	(0.07)			
Numbers of household members who get involved in agricultural activities	2.39	2.61	0.000***	18.04	2.39	2.36	0.531	2.86	84.15
	(0.04)	(0.04)			(0.04)	(0.03)			
No. of observations	728	1 438			728	1 438			

Standard errors are shown in parentheses
Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 6. Summary statistics before and after matching for TAP2

TAP2	Before matching				After matching				Reduction
	Treat. Mean/SE	Control Mean/SE	p-value	Bias	Treat Mean/SE	Control Mean/SE	p-value	Bias	in Bias (percent)
Membership years	9.85	9.76	0.707	1.75	9.85	9.95	0.732	1.77	-0.90
	(0.18)	(0.14)			(0.18)	(0.16)			
Coffee experience	27.98	29.06	0.109	7.32	27.98	27.59	0.620	2.62	64.18
	(0.56)	(0.39)			(0.56)	(0.43)			
Number of rooms (5 years ago)	3.44	3.53	0.111	7.35	3.44	3.51	0.240	6.24	15.18
	(0.04)	(0.03)			(0.04)	(0.04)			
Time to water (5 years ago)	22.69	17.22	0.000***	30.32	22.69	22.84	0.902	0.79	97.38
	(0.77)	(0.40)			(0.77)	(0.57)			
Electricity (5 years ago)	0.09	0.13	0.010***	12.11	0.09	0.10	0.896	0.62	94.88
	(0.01)	(0.01)			(0.01)	(0.01)			
Age of household's head	55.76	54.87	0.147	6.69	55.76	55.44	0.653	2.39	64.32
	(0.49)	(0.36)			(0.49)	(0.40)			
Household size	5.08	4.90	0.068*	8.29	5.08	5.07	0.936	0.44	94.69
	(0.08)	(0.06)			(0.08)	(0.06)			
Distance between farmers and their cooperative	4.47	3.13	0.000***	37.86	4.47	4.30	0.476	4.79	87.35
	(0.15)	(0.08)			(0.15)	(0.13)			
Distance between cooperatives and Kigali	65.03	71.82	0.000***	20.16	65.03	62.24	0.060*	8.30	58.84
	(1.01)	(1.03)			(1.01)	(0.97)			

TAP2	Before matching				After matching				Reduction
	Treat. Mean/SE	Control Mean/SE	p-value	Bias	Treat Mean/SE	Control Mean/SE	p-value	Bias	in Bias (percent)
Households' average schooling years	5.90	6.12	0.049**	8.94	5.90	5.92	0.859	0.91	89.82
	(0.09)	(0.06)			(0.09)	(0.07)			
Numbers of household members who get involved in agricultural activities	2.49	2.61	0.053*	9.02	2.49	2.49	0.953	0.29	96.81
	(0.04)	(0.04)			(0.04)	(0.04)			
No. of observations	714	1 438			714	1 438			

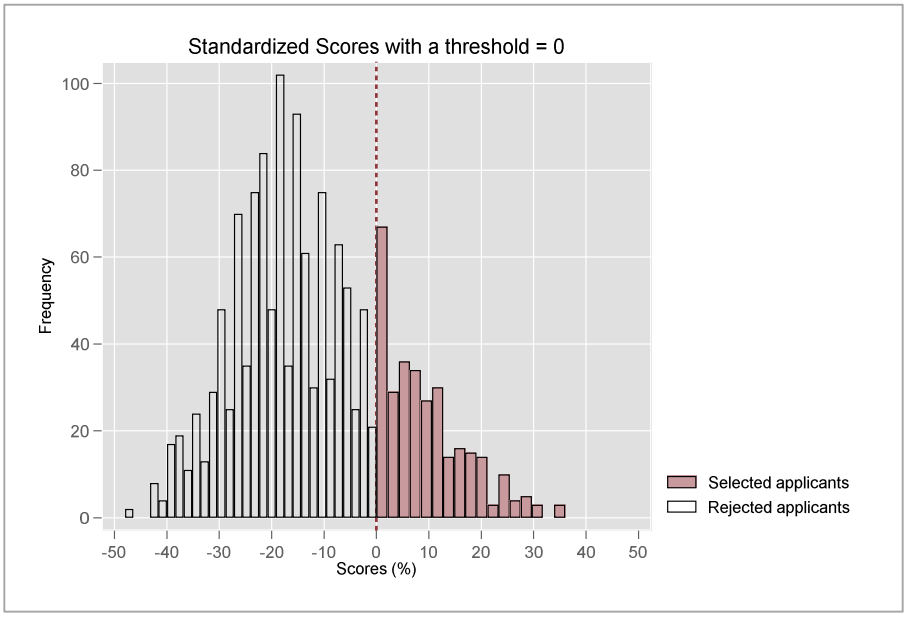
Standard errors are shown in parentheses
Significance levels: *** p<0.01, **p<0.05, *p<0.1

Constructing counterfactual for the horticulture intervention

Our analysis focuses on evaluating two levels of treatment, namely being selected to get the endorsement letter (T1 group) and getting the matching grant (T2 group). We encountered a challenge in using the rejected applicants as a counterfactual group for the T1 group, as the applicants differed based on their assigned scores. Therefore we use those who received the loan but did not receive the matching grant as our counterfactual for the T2 group, because limited funding introduced a randomized element to the selection. Nevertheless, limited observations in this counterfactual group prevent us from detecting some potential impacts of the matching grant.

The horticulture-finance selection team varied their selection thresholds, 50, 75 and 80 percent depending on the horticulture crop groups as described earlier in Table 3. We followed common practice by standardizing the thresholds around zero for comparability purposes. In our sample, we interviewed 1,220 rejected applicants and all 358 selected applicants (T1 group), along with 130 applicants who received the matching grant (T2 group).

Figure 7: Standardized scores for the matching grant business proposals

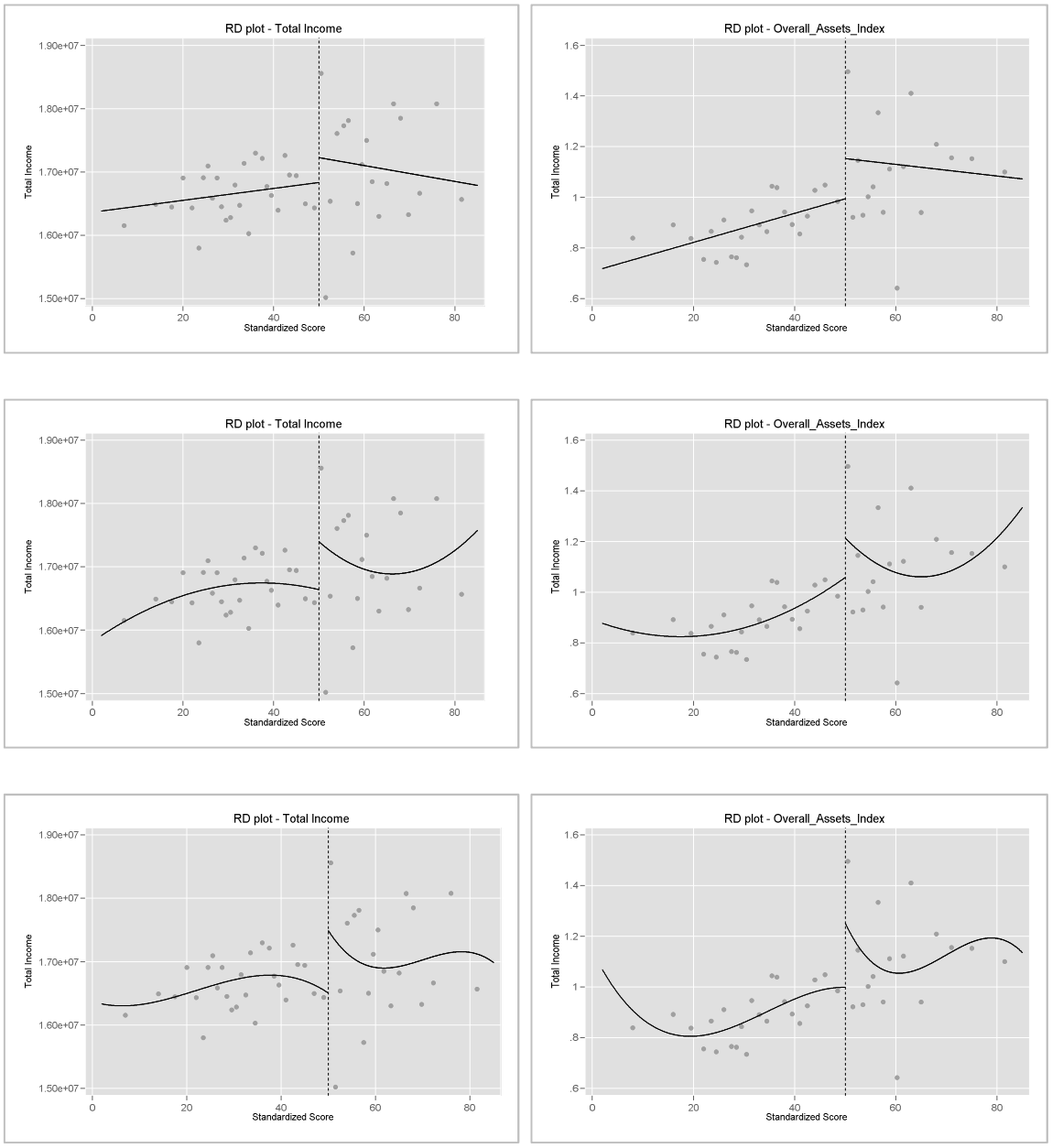


We evaluate the impact of the two levels of treatment in a regression discontinuity design (RDD) framework. Our design exploits the arbitrary thresholds used to select farmers to receive an endorsement letter and the matching grant. Based on the assumption that farmers cannot manipulate their scores with precision around the pre-determined thresholds, we use the rejected applicants near to the thresholds as a local counterfactual to the treated applicants. Our "as if random" experimental design assumes that farmers had the same probability of having a score just below or just above the threshold (Lee and Lemieux 2010). We support this assumption by noting that all farmers in our sample did not know the scoring criteria or thresholds, and thus we confidently assume that farmers did not have any manipulation power around the thresholds. We also show the results of the McCrary (2008) manipulation test, as a falsification of the RDD, to corroborate the evidence that of no self-selection sorting of farmers into the control and treatment groups. The lynchpin to our approach is the discontinuity of the density of the scores near to the thresholds (Cattaneo, Jansson and Ma 2018).

Another assumption embedded in the RD framework is the continuity restriction, meaning there is no observed discontinuity in any potential explanatory variables. If not, we would be unable to attribute the jump in outcomes to the treatment of interest and the estimate. We tested this assumption on observable characteristics to exclude the possibility of confounding discontinuities in other explanatory variables.

We graphically depict the discontinuity in the main outcomes of interest, income and assets in Figure 8. As shown in this figure, we observe a discontinuity at the standardized threshold for both income and assets. The discontinuity is consistent irrespective of the different polynomial orders (linear, quadratic and cubic) we use. The graphical representation provides suggestive evidence for the treatment effect, but cannot be used to quantify impacts.

Figure 8: Regression Discontinuity Plots by Income and Asset variables



3.2 Questionnaire and impact indicators

We developed a detailed household survey instrument to assess the impact of TAP on coffee cooperatives and matching grant on horticulture farmers. Our questionnaire collected data on agriculture production by parcel, plot and crop over the past three agricultural seasons in Rwanda.[8] The questionnaire also gathered information on perennial crops grown, demographic characteristics, food related questions, shocks, and external financial support.

Based on the household questionnaire, we calculated outcome indicators at both the cooperative and household levels. At the cooperative level, our indicators include mean coffee prices received by cooperative members, cooperative member trust in management and other cooperative members, and cooperative member level of subjective satisfaction in the cooperatives' performance. We used official cooperative level data to assess the impact of TAP on the amount of coffee cherries cooperatives received from farmers, coffee washing station (CWS) utilization rate, and average coffee price at the cooperative level. At the household level, our outcome indicators include total household income, total crop income, income from coffee sales, assets, resilience, food security, and dietary diversity.

Cooperative-level indicators

We measure changes in cooperative outcomes by using variables both at the cooperative and the household level. At the cooperative level, our indicators include volume of green coffee aggregated, mean coffee price per KG given to member farmers, and CWS capacity utilization rate. At the household level, our variables include coffee price per KG received by famers, whether farmers deliver all harvested coffee cherries to their cooperative, intention to leave their cooperative, whether they trust their cooperative and other cooperatives, their opinion on the transparency of their cooperative's, whether they intend to expand their coffee plantation, and whether they had a chance to attend their cooperative's annual meeting.

Economic mobility indicators

The economic mobility indicators measure both income and assets. Given the export value-chain focus of the PRICE project, these are our main outcome indicators at the household level. We used the Rural Income Generating Activities (RIGA) methodology to compute the total income indicator (Carletto, et al. 2006). We measure income at the household level, as the sum of the value of crop production after subtracting the value of inputs, livestock income, employment income, enterprise income, and other income including transfers. As PRICE targeted coffee and horticulture crops, we focused on total crop income, and income from coffee and horticulture to evaluate how the project influence household income.

We compliment the income indicators with overall asset index, which may provide a more stable measure of household economic status (Filmer and Scott 2012). Our overall asset index encompasses four assets indices to give a comprehensive picture of household financial status. These indices include a durable asset index, a productive asset index, a livestock asset index, and a housing asset index. We use principal components analysis (PCA) to compute the first three indices, as we calculate them based on continuous variables. Alternatively, as we base the household asset index on categorical questions, we use a multiple correspondence analysis (MCA) to compute this index. For the overall asset index, we implement a PCA based on the polychoric correlation, which allows us to combine both continuous-based indices with categorical-based ones (Kolenikov and Angeles 2004).

[8] Our survey collected data on three Rwandan seasons including season A from September 2017 to February 2018, season B from March 2017 to June 2017, and Season C from July 2017 to September 2017.

Poverty reduction indicators

IFAD strives to help households out of poverty. To understand how this project influenced poverty levels in Rwanda, we compiled a number of poverty reduction indicators based on our income and assets indices. We compare our income-based poverty indicators against both the international and local poverty lines, whereas we only calculate our assets-based poverty indicators against the local poverty level (Booysen, et al. 2008). For income, different international poverty lines (USD1.90, USD1.25 and USD1), as well as local thresholds (the 40^{th} and 60^{th} percentiles of control households' incomes), were used to measure whether a household is above the poverty line. For assets, we set local thresholds, the 40^{th} and 60^{th} percentiles of control households' asset distribution based on the aforementioned overall asset index, to assess the poverty status of a household.

Resilience, dietary diversity, and food security

In an increasingly volatile world, one of IFAD's focuses is on helping households become more resilient against shocks. As a proxy for resilience, we use household's ability to recover from the top three significant shocks encountered over the last 12 months since the start of the data collection. The resilience index is adjusted by the severity of each shock to allocate different weights depending on shock severity. In addition to the overall resilience index for the top three significant shocks that were encountered by most coffee and horticulture farmers in Rwanda during 2017, we calculate the index for each of these shocks to check for household reactions. The top three significant shocks used for the overall resilience index may differ from one farmer to another. For the one-shock resilience indices, we focus on the top three shocks most encountered by Rwandan farmers: drought, irregular rains, and crop pests or diseases.

Regarding, dietary diversity, this is measured at household level following the FAO's guidelines, which reflect household ability to access 18 food groups. We use two reference periods namely, the previous 24 hours and last week. The latter is weighted with how many times a food item was consumed during last week. Having both timeframes helps us mitigate potential recall errors (FAO 2010). Along with dietary diversity indices, we measured the Food Insecurity Experience index following the FAO's guidelines, which is based on eight questions that reflect household's access to adequate food.

3.3 Impact estimation

Impact of TAP1 and TAP2 at cooperative level

We evaluate the impact of TAP at the cooperative level using a difference-in-difference (DID) identification strategy. We have two similar interventions of TAP- over 2014-2015 for the first round (TAP1) and 2016-2017 for the second round (TAP2). Therefore, we use 2013 and 2015 data as baselines for TAP1 and TAP2, respectively. For TAP1, we show how the impacts evolve over 3 years after the intervention. The situation differs for TAP2, given that we only have data for a year after the intervention. Accordingly, the following two equations estimated for each impact indicator: volume of green coffee aggregated, average coffee prices given to member farmers, CWS and capacity utilization rate. We estimate the first equation to evaluate the impact of TAP1, and the second equation to evaluate TAP2.

$$y_{it} = \alpha + \beta_1 TAP_1 + \beta_{2i} \sum_{i=2015}^{2017} Year_i + \beta_{3i} \sum_{i=2015}^{2017} TAP_1 * Year_i + \varepsilon_{it} \quad (1)$$

$$y_{it} = \alpha + \beta_1 TAP_2 + \beta_2 Year2017 + \beta_3 TAP_2 * Year2017 + \varepsilon_{it} \quad (2)$$

where, y_{it} is the impact indicator of interest: volume of green coffee aggregated and processed by the CWS, the price offered to cooperative members by the cooperative and the CWS capacity utilization. TAP_1 is the

treatment variable for a cooperative having received the first round of the turnaround programme, TAP_2 is the treatment variable for a cooperative having received the second round of the turnaround programme.

Estimation approach for TAP1 and TAP2 household-level results

We use an Inverse Probability Weighted Regression Adjustment (IPWRA) matching approach to estimate the impact of TAP1 and TAP2 on our indicators of interest. IPWRA matching assigns a weight for each observation based on the probability of receiving the treatment. After determining these weights, we use them in the regression analysis to estimate the impact of our treatment. Under this approach, observation with higher probabilities of treatment will have higher weights in the regression estimation, contributing more to estimating the impact.

Estimation approach for the horticulture-finance household-level results

As described previously, we use a RDD to assess the impacts of the PRICE horticulture-finance interventions. Our RDD exploits the proposal score as the forcing variable. We use only those farmers who were rejected and did not implement their business idea as our main control group.

Table 7. Share of rejected applicants who still implemented their business proposal

Rejected applicants	Number of applicants (% of total rejected applicants)	Financing the implementation
Implemented their business idea	856 applicants (70%)	Personal savings (644 applicants- 75%) Loan from your SACCO (98 applicants- 12%) Loan from another financial institution (46 applicants- 5%) Partnership with other farmer(s) (15 applicants- 2%) Others (53 applicants-6%)
Did not implement their business idea (pure control)	364 applicants (30%)	

We evaluate the impact of the T1 (selection of business idea) and T2 (matching grant) treatment in an RD framework, but we assess the former using a sharp RDD and the latter using a fuzzy RDD. Unlike sharp RD, where the probability jumps from 0 to 1 at the threshold, it jumps to less than 1 in the fuzzy RD. As the eligibility for a treatment does not necessarily determine receiving it in T2, we end up with a lower number of treated farmers than eligible ones.

Denote **S** the Standardized score (assignment/forcing variable) and **T1** is the treatment variable as follows:

$$T1 = \begin{cases} 0 \; if \quad S < 0 \\ 1 \; if \quad S > 0 \end{cases} \qquad (3)$$

Also,

$$T2 = \begin{cases} 0 & if \quad received \; the \; matching \; grant \\ 1 & otherwise \end{cases} \qquad (4)$$

We estimate the impact of the T1 treatment using the following equation in one stage:

$$y_i = f(s) + \beta T1_i + \gamma X + \varepsilon_i \quad (5)$$

where y_i is the indicator of interest, $f(s)$ is a smooth function of the standardized score and β is the parameter of interest. X is a set of explanatory variables γ is a set of their corresponding parameters. ε_i is the unobserved error component. Other control variables include province fixed effect, household size, land area, family head's years of education, SACCOs membership years and number of waged family members.

For the impact of the T2 treatment, we use the discontinuity as an instrument for the T2 treatment, so we implemented the estimation in two stages. As shown in the following, the first stage links the assignment variable to the T2 (matching grant) and the second stage links the T2 treatment to the indicator of interest y_i. Following Lee & Card (2008), we cluster the standard errors by crops groups to account for common characteristics within each group when estimating the impacts of both T1 and T2.

$$y_i = f(s) + \beta T2_i + \gamma X + \varepsilon_i \quad (6)$$

$$T2_i = f(s) + \beta T1_i + \gamma X + v_i \quad (7)$$

We use different specifications to check the sensitivity our results. Our robustness checks include different levels of polynomial of the standardized score (linear, quadratic and cubic), as well as different methods to determine the optimal bandwidths. Given that T1 treatment includes farmers who received T2, we exclude the latter when estimating the impact of the former to prevent potential confoundedness.

4. Profile of the project area and sample

As alluded to earlier, the PRICE project was implemented across all rural provinces of Rwanda, where agriculture is the main economic activity for most households. At the national level, agriculture accounts for 29 percent of total GDP and the estimated poverty headcount ratio, using the national per capita per day poverty line, was 39.1 percent ((World Bank 2018). The World Bank also estimates that 94.6 percent of the population resides in rural areas and that rural areas are characterized by a high population density of approximately 483 people per square kilometre of land. An important feature of the rural population is that the majority is young, with an estimated median age of 19 years and the rural population aged 15-24 years accounts for 21.1 percent of the total rural population (UNDESA - United Nations Department of Economic and Social Affairs, Population Division 2017).

The topography of the areas where PRICE was implemented include hillside cropland, marshlands, and extensive cropland. Most of the agricultural cultivation takes place on the hills and valleys of the hillsides, which are dependent on rain-fed agriculture with very little irrigation. Rwanda typically has three farming seasons, including: Season A: September-February, Season B: March-July, and Season C: August-September. Agricultural GDP growth in Rwanda has consistently been above six percent for the past 12 years, which implies that Rwanda has consistently met the African Union/CAADP growth target and is among the African countries with the fastest agricultural growth .

The majority of households in PRICE areas engage in production of a select few cash crops, including: coffee, horticulture, cereals, roots and tubers. Coffee and tea are the main export cash crops, while horticulture is typically limited to the domestic market. Some horticulture farmers export to regional markets, in the eastern parts of The Democratic Republic of Congo, southwestern Uganda, and northern Burundi. Seasonal crops making up these regional markets include: tomato, eggplant, garlic, onion, carrots, and. International horticulture exports to lucrative markets are also emerging, most notably fresh cut flowers for export to Europe.

Our Turnaround Programme impact assessment sample focuses on coffee cooperatives members registered with the Rwanda Cooperatives Agency (RCA). Some farmers were initially part of unregistered associations. PRICE support promoted improved governance and organizational performance, thus eventually allowing these groups to register legally as cooperatives.

Our horticulture sample captures farmers growing a wide array of crops. The majority grew seasonal crops that permitted at least two harvests per year. While the horticulture-finance component also supported cooperatives, few cooperatives received the intervention; hence we excluded them from the analysis. We focused on individual horticulture farmers, some of whom had both sizeable land areas and involvement in other business enterprises. Overall, the PRICE implementation areas exhibited great potential for growth in crop production, domestic marketing, and exports.

5 Results

5.1 Overall impacts of PRICE: Coffee

Overall, we found statistically significant results at both the cooperative and household levels. The results varied both between the TAP round recipients and the household beneficiaries. As the Turnaround Programme targeted cooperatives, we first present our cooperative-level results. In Table 8, we compare cooperative-level difference-in-difference (DID) results to test the impact of the two TAP interventions on the volume of coffee cherries processed, coffee washing station capacity utilization rates, and the coffee prices received by farmers. As the TAP1 intervention ran from 2014-2015, and TAP2 from 2016-2017, we present the results from the years relevant to each intervention. These results provide insights on the mechanisms and channels through which impacts on different indicators were achieved at the household level.

We next present detailed household-level results. Our household-level analyses use several matching and propensity score methods, but we only report results from the IPWRA estimation model. Results from the other model estimations are presented in the appendix to showcase consistency and robustness of results.

Impact on cooperative-level indicators

We find mixed results at the cooperative-level. Looking first at TAP1, Table 8 shows weak effects on the volume of coffee cherries processed and CWS utilization rates for 2014. However, the results demonstrate a clear, and statistically significant, steady increase in coffee prices received by cooperative members over time: a 4.7% increase in both 2015 and 2016, as well as a 5% increase in 2017. The TAP2 cooperative-level results demonstrate comparable findings in this respect: a 3.3% increase in price for 2016 and a 3.4% increase in price for 2017. Coffee farmers that belonged to cooperatives that received either TAP1 or TAP2 show a statistically significant increase in coffee prices received, once the project is implemented as well as after the project is completed.

While TAP beneficiary farmers consistently received higher coffee prices and supplied more coffee cherries for processing by the cooperatives' CWS, TAP's influence on CWS utilization rates appear to be more temporary. Our qualitative evidence suggests a variety of reasons for our utilization rate findings, from difficulty with maintaining equipment to a lack of after project follow-up training to reinforce the new techniques. The main channel of impact, however, continues to be the impact on coffee prices after project closure.

Table 8: Impact of the TAP1 and TAP2 interventions at the cooperative level

TAP 1	(1) Log (Cherries quantity)	(2) Log (coffee price)	(3) CWS Utilization Rate	TAP 2	(1) Log (Cherries quantity)	(2) Log (coffee price)	(3) CWS Utilization Rate
TAP_1	-0.421	-0.0379**	-0.712	TAP_2	-0.831*	-0.0129	-23.85**
	(0.319)	(0.0168)	(13.57)		(0.456)	(0.0147)	(10.09)
YEAR2014	-0.743**	0.345***	-25.36***				
	(0.307)	(0.0328)	(6.598)				
TAP_1#1.YEAR2014	0.626*	-0.0296	20.15*				
	(0.328)	(0.0425)	(11.69)				
YEAR2015	-0.244	0.172***	-1.347				
	(0.352)	(0.0157)	(9.438)				
TAP_1#1.YEAR2015	0.493	0.0474***	13.53				
	(0.392)	(0.0170)	(14.86)				
YEAR2016	-0.0374	0.162***	-16.70	YEAR2016	0.209	0.0323***	-10.02
	(0.214)	(0.0154)	(10.30)		(0.220)	(0.0107)	(8.309)
TAP_1#1.YEAR2016	0.0339	0.0469***	13.09	**TAP_2#1.YEAR2016**	0.453	0.0328**	24.50**
	(0.346)	(0.0173)	(15.18)		(0.292)	(0.0136)	(10.21)
1.YEAR2017	0.0848	0.158***	-2.813	YEAR2017	0.332	0.0287***	3.864
	(0.222)	(0.0151)	(12.13)		(0.208)	(0.00977)	(11.32)
TAP_1#1.YEAR2017	0.111	0.0504***	3.207	**TAP_2#1.YEAR2017**	0.182	0.0340***	11.75
	(0.255)	(0.0171)	(18.31)		(0.298)	(0.0127)	(13.73)
TAP_OTHER	-0.972*	-0.0299	-20.84*	TAP_OTHER	-0.819	-0.0332*	-16.42
	(0.502)	(0.0195)	(11.06)		(0.544)	(0.0170)	(11.45)
Distance to Kigali	0.00544	6.00e-05	0.420***	Distance to Kigali	0.00245	0.000176	0.251**
	(0.00518)	(0.000140)	(0.110)		(0.00511)	(0.000142)	(0.0997)
Constant	5.208***	5.124***	53.69***	Constant	5.144***	5.245***	58.78***
	(0.644)	(0.0235)	(12.75)		(0.711)	(0.0200)	(11.93)
Observations	246	246	246	Observations	264	264	264
Number of cooperatives	41	41	41	Number of cooperatives	44	44	44

Standard errors are shown in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

To gain a better understanding of the cooperative-level impacts,, we also analysed data from the household surveys. In our household survey instrument, we asked coffee cooperative members to rate the performance of their cooperatives and their overall satisfaction with their cooperatives. Table 9 presents our results, which vary by TAP programme.

Our TAP1 results are mostly inconclusive. As we only have ex-post data from 2017 at the household-level, and given that TAP1 occurred over 3 years ago, it is perhaps not surprising that our TAP1 results are not statistically significant.

In comparison, our TAP2 findings generally show statistically significant increases in annual meeting attendance, cooperative transparency, cooperative's expansion plans, and the price per kilogram of coffee. Importantly, we also find that TAP2 causes an increase, on average, of the likelihood that households sell all of their coffee through the cooperative. Our findings suggest that TAP2 cooperatives were more likely to cause greater household-level impacts. Higher coffee prices are a likely cause for the increased likelihood of TAP2 farmers delivering all of their coffee to the cooperative. In fact, TAP2 cooperatives' coffee cherry prices were generally 10% higher, than control-group cooperatives. Another aspect is that TAP2 members were more likely to report that their cooperatives were transparent, and more likely to attend their cooperative annual meeting..

Interestingly, both TAP1 and TAP2 showed positive impacts on farmers' intentions to expand their coffee plantation. The magnitude of TAP1 is even stronger compared to the one of TAP2. On average, TAP1 farmers owned 792 coffee trees, while TAP2 farmers had 1,100 coffee trees. The coffee tree imbalance between TAP1 and TAP2 might translate into increased potential gains for TAP1 farmers to expand their coffee plantations.

To further understand the TAP1 and TAP2 impacts, we examine the household-level results both at the output and outcome levels. By testing the intervention effects along the theory of change, our analysis unpacks the casual chain and allows us to explain how the intervention at cooperative-level affected household-level outcomes. Our cooperative-level results are promising in that treated cooperative members are, on average, seeing an increase in the price they receive for their coffee. The TAP interventions centred on cooperative governance, but, as described earlier, our ultimate interests lie in household-level outcomes.

Table 9: The impact of TAP1 and TAP2 on the cooperative variables measured at the household level

Cooperative -related variables	TAP_1	TAP_2
	N = 2,093	*N = 2,094*
Price per kg of coffee (log)	-0.0839	0.0860**
	(0.0635)	(0.0358)
Deliver all coffee (yes=1)	-0.00563	0.0456***
	(0.0163)	(0.00913)
Management trust (yes=1)	-0.0415	0.0191
	(0.0278)	(0.0348)
Members trust (yes=1)	-0.0619	-0.0228
	(0.0400)	(0.0309)
Cooperative transparency (yes=1)	-0.0618	0.0622*
	(0.0404)	(0.0360)

Cooperative -related variables		TAP_1	TAP_2	
		N = 2,093	*N = 2,094*	
Expansion plan (yes=1)		0.105***	0.0614**	
		(0.0245)	(0.0285)	
Annual meetings attendance (yes=1)		-0.0308	0.110***	
		(0.0460)	(0.0226)	

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

Coffee impact on economic mobility

When looking at household-level outcomes, we mainly focused on income and assets. For income, we start with overall income, then examine total crop income and coffee income. On average, total crop income represented about 88% of total household income in our sample, and income from coffee sales represented nearly 58% of crop income and 51% of total income, underscoring the importance of coffee among the households analysed.

Table 10: Income shares by TAP treatment households

	As % of total income	As % of crop income
Annual wage	1%	
Annual enterprise	4%	
Livestock income	5%	
Other income	2%	
Crop income	**88%**	
Crop income season 1	11%	12%
Crop income season 2	5%	6%
Crop income season 3	0%	1%
Crop income perennial	57%	64%
Coffee income	**51%**	**58%**

We examine a few additional income-related variables, including marketing cost for all crops, coffee marketing costs, and the cost of inputs. We also explore different asset indices impacts, starting with an overall asset index, then dividing the asset results along durable, productive, livestock, and household lines.

TAP1 generally had no effect on income and moderate effect on assets. As shown in Table 11, across all our different estimation matching strategies, consistently, there were no effects on the 2017 income for TAP1 households. In contrast, TAP1 appears to have had an effect on household assets, particularly housing and durable assets. Table 11 shows that on average, households that were members of TAP1 cooperatives had 16% more durable assets and 5% more housing assets as measured by the respective asset and housing indexes.

Possible explanations for why we do not find an impact on income for TAP1 include the lack of sustained impact on income, given that our estimations only measured recent income two years after the project ended for

these cooperatives. This might also explain why we observe impacts on household assets for TAP1, especially on durable assets and the housing index. This suggests that TAP1 may have influenced income in previous years, and households transformed that income into household and durable assets.

Table 11: The impact of TAP1 and TAP2 on the income and assets-related variables

Income-related variables	TAP_1	TAP_2
	N = 2093	*N = 2094*
Log (income)	0.000529	0.00279
	(0.0114)	(0.0256)
Log (crop income)	0.0492	0.324***
	(0.105)	(0.0854)
Log (coffee income)	-0.0969	0.343***
	(0.141)	(0.0868)
Log (coffee harvest)	0.0937	0.738***
	(0.163)	(0.143)
Log (coffee sales)	0.279	1.129***
	(0.287)	(0.234)
Log (coffee home consumption)	-0.0801	0.0610
	(0.0631)	(0.0482)
Log (coffee inputs costs)	-0.217	0.807**
	(0.457)	(0.408)
Log (marketing costs)	0.673	0.798**
	(0.419)	(0.405)
Assets-related variables		
Overall asset index	0.123**	0.109**
	(0.0548)	(0.0465)
Durable asset index	0.164**	0.166**
	(0.0729)	(0.0687)
Productive asset index	0.0377	-0.0154
	(0.0916)	(0.0745)
Livestock asset index	0.182*	0.206**
	(0.0958)	(0.0911)
Housing	0.0514***	0.0371***
	(0.0170)	(0.0137)

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

We find stronger results at the TAP2 household-level. While TAP2 did not have a statistically significant impact on total income, our results show statistically significant impacts across almost all of our other income and assets indicators. Most notably, TAP2 farmers show average increases in their crop and coffee income by 32% and 34%, respectively. The latter is attributed to increases in coffee harvests and coffee sales. Corresponding increases in input and marketing costs appear to prevent these household-level gains from transferring to net income. Descriptive analysis of the input and marketing costs revealed that hired labour represents the main source of higher inputs cost for the beneficiary farmers. At the same time, this reflects positive spillover impacts in the form of job creation.

Assets also increased, on average, by about 11% for TAP2 recipient households. Livestock assets increased by 21% while housing assets increased by approximately 4%. These findings suggest TAP2 recipients found alternatives to cash for storing their wealth. Qualitative insights from focus group discussions and key informant interviews corroborate these findings, with some TAP2 cooperatives reporting they created livestock pass-on programs from coffee profits. Some TAP2 farmers highlighted their newfound access to capital from their cooperatives, which allowed them to pay health expenses.

Qualitative results also show that there were differences between the TAP1 and TAP2 interventions, which may explain why we observe stronger quantitative impacts from TAP2 compared to TAP1. The implementers of both turnaround programmes noted that they incorporated changes into TAP2 based on their experience from TAP1 (IFAD 2015). From our discussions with the implementing partners, we understand that these differences included both revising the training materials and selection of different types of cooperatives. SNV Rwanda (2016) describes the TAP2 selection procedure in some detail, explaining how the implementers and the sub-contractors worked together to identify the strongest 25 existing cooperatives in need of governance training and support associated with the TAP interventions. In contrast, TAP1 focused on the neediest cooperatives, meaning that TAP2 cooperatives were, by definition, healthier before the intervention. Analysis of secondary data and qualitative information on pre-intervention variables that we obtained from the project implementation team help us interpret and explain the differences found in the effects between TAP1 and TAP2. In general, the secondary datasets indicate pre-intervention differences between the cooperatives selected for TAP1 and TAP2.

Table 12: Pre-intervention characteristics of coffee cooperatives that received TAP1 and TAP2

Variables		Mean	Median
TAP1 (n = 18 cooperatives)			
Age of cooperative (years)		7.85	7.80
Distance from cooperative to capital city (Km)		75.08	68.48
CWS Utilization rate (%)		86.06	75.50
Theoretical coffee cherries (tons)		230.6	150.00
TAP2 (n = 23 cooperatives)			
Age of cooperative (years)		6.58	6.60
Distance from cooperative to capital city (Km)		61.30	55.39
CWS Utilization rate (%)		48.89	40.00
Theoretical coffee cherries (tons)		321.70	250.00

Note: Data on 7 TAP1 cooperatives and 2 TAP2 cooperatives are missing.
Source: Authors calculations using NAEB (2012) data.

As shown in Table 12, the TAP1 cooperatives were slightly older and located farther from Kigali than those selected for TAP 2. Also, the TAP 1 cooperatives had lower theoretical cherry-processing capacity compared to the cooperatives that received the TAP2 intervention. The lower pre-intervention utilization rates for TAP2 cooperatives also translated into a greater coffee cherry processing potential.

The annual report from SNV Rwanda (2016) corroborates the finding that TAP1 cooperatives had been, on average, registered longer than TAP2 cooperatives. This report also suggests that TAP2 cooperatives typically had less members than TAP1 cooperatives, which might make the TAP 2 interventions goals of improved cooperative transparency and governance for the cooperatives easier to implement. Evidence around group collective action suggests it is easier to increase trust and improve cooperative level outcomes in smaller groups ((Coulter 2007); (Markelova, et al. 2009)). The secondary data from NAEB and literature support our impact assessment results, which show larger TAP2 impacts compared to TAP1.

Impact on poverty

Our results on the poverty indicators reveal consistent income and assets patterns. Unsurprisingly given our previous findings; TAP2 shows significant impacts on both income-based and assets-based poverty indicators while TAP1 farmers do not. According to our sample, 77% of the coffee farmers are below US$ 1.90 per day, 52% are below US$ 1.25 per day and 43% are below US$ 1.00 per day poverty line). Based on total income and overall assets, TAP2 increased the likelihood of impoverished farmers to move out of poverty by about 10%. Our income-based poverty indicators are stable across poverty lines. Table 13 shows the results of the impact estimation on poverty reduction indicators and demonstrates that TAP2 had a greater and significant poverty reducing effect compared to TAP1.

Table 13: The impact of TAP1 and TAP2 on poverty reduction indicators

	Poverty-related variables		TAP_1		TAP_2
			IPWRA		*IPWRA*
Income based indicators	Above poverty line (1.9 $)		0.0494		0.0969**
			(0.0414)		(0.0416)
	Above poverty line (1.25 $)		0.0128		0.0913**
			(0.0426)		(0.0408)
	Above poverty line (1 $)		-0.00173		0.122***
			(0.0437)		(0.0373)
	Above 40th percentile (Total income)		0.00629		0.118***
			(0.0435)		(0.0378)
	Above 60th percentile (Total income)		0.0416		0.124***
			(0.0416)		(0.0415)
Asset based indicator	Above 40th percentile (Overall asset index)		0.0905**		0.0955***
			(0.0427)		(0.0367)
	Above 60th percentile (Overall asset index)		0.0479		0.0376

Poverty-related variables	TAP_1	TAP_2
	IPWRA	*IPWRA*
	(0.0457)	(0.0397)
Above 40th percentile (Durable asset index)	0.0678	0.0665
	(0.0419)	(0.0423)
Above 60th percentile (Durable asset index)	0.0923**	0.0683*
	(0.0436)	(0.0407)
Above 40th percentile (Productive asset index)	0.0171	0.0381
	(0.0468)	(0.0401)
Above 60th percentile (Productive asset index)	0.0348	0.0556
	(0.0463)	(0.0407)
Above 40th percentile (Livestock asset index)	0.0331	0.0975**
	(0.0466)	(0.0400)
Above 60th percentile (Livestock asset index)	0.0681	0.135***
	(0.0490)	(0.0422)
Above 40th percentile (Housing asset index)	0.0990**	0.0815**
	(0.0452)	(0.0415)
Above 60th percentile (Housing asset index)	0.105**	0.107**
	(0.0455)	(0.0419)
Observations	2,093	2,094

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

Impact on resilience

Looking at the aggregate resilience index, we did not find a consistent impact of both TAP1 and TAP2 based on different matching techniques. Nonetheless, our results differ in terms of significance and magnitude once we disaggregate the resilience index by the type of significant shocks that coffee farmers encountered during 2017, which include drought (40% of the households), irregular rains (27% of the households), and crop diseases (7% of the households). Both TAP1 and TAP2 households showed a significant positive impact on the ability of households to recover from drought, but no impact on both ability to recover from irregular rains and ability to recover from crop disease. Given that the TAP projects were mostly commercial in nature and not necessarily designed to address issues of resilience to weather shocks or pests and diseases of crops, it is perhaps not surprising that the project did not generate huge impacts on resilience to such shocks. Table 14 show results of the estimated impact of TAP interventions on overall resilience and resilience categorized by type of shock.

Table 14: The impact of TAP1 and TAP2 on resilience indicators

	Resilience -related variables	TAP_1	TAP_2
		IPWRA	*IPWRA*
Overall	Resilience index 1	0.0219***	0.0104*
		(0.00629)	(0.00595)
	Resilience index 2	0.0251***	0.0141**
		(0.00596)	(0.00568)
	Ability to recover (total)	0.460***	0.217*
		(0.132)	(0.125)
	Ability to recover (mean)	0.0219***	0.0103*
		(0.00629)	(0.00595)
Drought	Resilience index 1	0.628***	0.257***
		(0.0785)	(0.0782)
	Resilience index 2	0.594***	0.260***
		(0.0786)	(0.0761)
	Ability to recover	0.629***	0.257***
		(0.0785)	(0.0782)
Irregular Rains	Resilience index1	0.0832	0.0949
		(0.0710)	(0.0701)
	Resilience index 2	0.0743	0.0981
		(0.0692)	(0.0698)
	Ability to recover	0.0833	0.0949
		(0.0711)	(0.0701)
Crop Pests or Disease	Resilience index 1	-0.0200	-0.0418
		(0.0406)	(0.0354)
	Resilience index 2	0.00444	-0.0379
		(0.0396)	(0.0353)
	Ability to recover	-0.0202	-0.0418
		(0.0406)	(0.0354)
	Observations	2,093	2,094

Dietary diversity scores are weighted on the basis of the number of times the food group was consumed in the last seven days Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

Impact on food insecurity and dietary diversity

Regarding food security and dietary diversity, TAP1 households do not show any impacts, while TAP2 households shows positive results only on the dietary diversity index. Yet, the different dietary diversity indices in our analysis do not present consistent results. The results of the analysis on food security indicators and dietary diversity are presented in Table 15.

Table 15: The impact of TAP1 and TAP2 on dietary diversity and food security

Food -related variables	TAP_1	TAP_2
	IPWRA	*IPWRA*
FIES index	0.220	0.0249
	(0.275)	(0.250)
Dietary diversity index (7 days)	-0.00825	0.459**
	(0.203)	(0.207)
Dietary diversity index weighted† (7 days)	1.461	0.347
	(1.000)	(0.953)
Dietary diversity index (24 hours)	0.405**	0.206
	(0.172)	(0.164)
Observations	2,093	2,094

† Dietary diversity scores are weighted on the basis of the number of times the food group was consumed in the last seven days Standard errors in parentheses
Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

Given that the TAP interventions were targeting coffee processing cooperatives with washing stations, it is also perhaps not surprising that there were limited impacts on food security and nutrition indicators. Firstly, coffee is for the most part a commercial crop in that when farmers increase its production it is unlikely that they would keep some of the output for household consumption. Secondly, even if they kept some coffee for household consumption, the crop is not particularly a nutrition dense food and would not necessarily increase diversity of the food crops consumed. On the other hand, coffee could be expected to increase food security and nutrition through the income channel. As coffee farmers grow more and sell more coffee, with the result of increasing their incomes, they could be expected to then begin buying more food and more diverse sets of foods for household consumption. This may have happened though to a limited extent and may be the reason why some measures of dietary diversity showed an impact of the TAP interventions on them.

5.2 Heterogeneous impacts of PRICE: Coffee

While treatment effects may vary given a number of factors, we focus our heterogeneous analysis on cooperative size and household's land size, since previous research suggests that larger cooperatives are likely to experience high coordination costs, which may impede transfer of benefits to individual members ((Fischer and Qaim 2012); (Markelova, et al. 2009)). Moreover, we are interested in testing the likelihood of unequal benefits or discrimination within cooperatives on the basis of farm size. We also limit this analysis to TAP2 households, as our results show the strongest average impacts for these farmers. Given IFAD's institutional goals, we additionally conducted heterogeneous analysis on youth and impacts on assets- and cooperative-related variables.

Our results in Table 16 reveal heterogeneity of impacts with respect to cooperative size but not farmers' land size For the majority of our indicators, the magnitude of TAP2 effects diminish with cooperative size, indicating a negative association between these two variables. This diminishing impact with respect to cooperative size, while statistically significant, was however not large in magnitude. One possible explanation for the diminishing impacts with cooperative size could be that smaller cooperatives are easier to manage, and as a result, these cooperatives have an easier time of passing positive impacts down to members. Another possible explanation is that larger cooperatives may be more likely to reinvest profits in expansion or diversify

cooperative activities, while smaller ones might be inclined to demonstrate benefits to their members by passing on the profits.

Table 16: Heterogeneous impacts of TAP2 – cooperative size and land size

Indicators	TAP_2	TAP2*Cooperative Size	TAP_2	TAP2*Land Size
Log (crop income)	0.133	-0.000704***	0.0513	0.000239
	(0.106)	(0.000203)	(0.0637)	(0.00139)
Log (coffee income)	0.297***	-0.00118***	0.108*	0.00186
	(0.106)	(0.000211)	(0.0651)	(0.00151)
Log (coffee harvest)	0.860***	-0.00216***	0.460***	-0.00194
	(0.204)	(0.000500)	(0.130)	(0.00204)
Log (coffee sales)	1.571***	-0.00359***	0.809***	-0.00238
	(0.362)	(0.000888)	(0.229)	(0.00281)
Log (coffee inputs costs)	-1.027**	0.00132	0.404	-0.00630
	(0.447)	(0.00102)	(0.302)	(0.00604)
Overall asset index	0.0517	-0.000305***	0.0446	-0.00115
	(0.0490)	(0.000117)	(0.0313)	(0.000814)
Durable asset index	0.0645	-0.000498***	0.0547	-0.000384
	(0.0623)	(0.000151)	(0.0411)	(0.00149)
Livestock asset index	0.0962	0.000240	0.177***	-0.00203**
	(0.0962)	(0.000223)	(0.0671)	(0.000923)
Log (Price per kg of coffee)	0.203**	-0.000462**	0.0721	0.000259
	(0.0974)	(0.000205)	(0.0575)	(0.000532)
Deliver all coffee (yes=1)	0.122***	-8.15e-05	0.0932***	-5.94e-05
	(0.0295)	(6.03e-05)	(0.0200)	(0.000162)
Observations	2,094	2,094	2,094	2,094

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

The lack of heterogeneity in impact with respect to farmers' land size suggests that cooperatives do not discriminate between members with small or large farms. Coffee farmers with different land sizes equally benefit from TAP2.

We also assessed the extent to which TAP2 affected youth, by comparing the impact on households with more versus fewer youth. To do this, we interacted the TAP2 treatment variable with the number of youth within each household. We defined youth as household members between the ages of 15-24 years inclusive. As part of this analysis, we also defined a separate category of young adults (household members between the ages of 15 and 34 inclusive) thereby assessing if there were heterogeneous impacts of TAP2 with respect to young adults as well.

Results reveal that the TAP2 households with more youth or more young adults have stronger impacts, especially on coffee income and assets. As shown in Table 17, having an extra youth member in a household generally increases the impact of TAP on coffee income by 7% and on overall assets by 5%. This implies that TAP2 leverages youth labour well to generate higher incomes and assets Also, it is likely that younger coffee farmers are more apt to learn and better implement the TAP2 trainings.

Table 17: Impacts of TAP2 on youth

Indicators	TAP_2	TAP2*Number of Youth (15-24)	TAP_2	TAP2*Number of Youth (15-34)
Log (crop income)	0.0452	0.0350	0.00597	0.0425
	(0.0846)	(0.0327)	(0.106)	(0.0290)
Log (coffee income)	**0.0459**	**0.0720****	**0.0487**	**0.0652*****
	(0.0867)	**(0.0290)**	**(0.109)**	**(0.0225)**
Log (coffee harvest)	0.497***	0.0465	0.503***	0.0509
	(0.158)	(0.0524)	(0.172)	(0.0480)
Log (coffee sales)	0.951***	-0.0629	0.945***	-0.0316
	(0.276)	(0.0890)	(0.299)	(0.0794)
Log (coffee input costs)	0.0649	0.121	0.128	0.101
	(0.378)	(0.123)	(0.414)	(0.111)
Overall asset index	**0.0443**	**0.0418*****	**0.0431**	**0.0529*****
	(0.0414)	**(0.0147)**	**(0.0476)**	**(0.0147)**
Durable asset index	**0.0427**	**0.0383****	**0.0547**	**0.0505*****
	(0.0546)	**(0.0187)**	**(0.0615)**	**(0.0183)**
Livestock asset index	**0.189****	**0.0835*****	**0.138**	**0.104*****
	(0.0860)	**(0.0284)**	**(0.0899)**	**(0.0272)**
Log (price per kg of coffee)	0.0485	0.00307	0.0606	-0.00187
	(0.0764)	(0.0156)	(0.0868)	(0.0169)
Deliver all coffee (yes=1)	0.103***	-0.00336	0.106***	-0.00339
	(0.0254)	(0.00518)	(0.0275)	(0.00493)
Observations	2,094	2,094	2,094	2,094

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

To further investigate the heterogeneous impacts of TAP2, we assess whether the intervention had more impact among the poor coffee farmers versus those who were above our three poverty lines. Table 18 shows that TAP2 impacts on the quantity of coffee harvested, coffee sales, and livestock assets, diminished with the farmer's poverty status. These findings suggest that special attention may be needed for the poorer coffee farmers for them to reap equal benefits from TAP2.

Table 18: Impacts of TAP2 on coffee farmers below poverty lines

Indicators	TAP_2	TAP2*Poverty Gap Below 1 US$	TAP_2	TAP2*Poverty Gap Below 1.25 US$	TAP_2	TAP2*Poverty Gap Below 1.9 US$
Log (crop income)	-0.178*	-0.236*	-0.159	-0.233*	-0.0297	-0.218*
	(0.104)	(0.131)	(0.0977)	(0.129)	(0.0636)	(0.113)
Log (coffee income)	-0.101	-0.250**	-0.0834	-0.248**	0.0333	-0.235**
	(0.109)	(0.120)	(0.102)	(0.119)	(0.0665)	(0.105)
Log (coffee harvest)	0.336**	-0.332**	0.351**	-0.327**	0.415***	-0.329**
	(0.141)	(0.167)	(0.139)	(0.164)	(0.126)	(0.152)
Log (coffee sales)	0.652***	-0.498*	0.673***	-0.491*	0.756***	-0.507**
	(0.238)	(0.262)	(0.235)	(0.257)	(0.219)	(0.244)
Log (coffee input costs)	0.340	-0.0561	0.365	-0.0540	0.368	-0.0255
	(0.315)	(0.183)	(0.313)	(0.181)	(0.302)	(0.167)
Overall asset index	-0.00347	-0.0111	-0.000266	-0.00956	0.0175	-0.00797
	(0.0322)	(0.0233)	(0.0318)	(0.0228)	(0.0306)	(0.0214)
Durable asset index	-0.00549	0.0440	-0.00246	0.0455	0.0225	0.0458
	(0.0434)	(0.0331)	(0.0430)	(0.0325)	(0.0411)	(0.0308)
Livestock asset index	0.147**	-0.0952***	0.151**	-0.0927***	0.166**	-0.0900***
	(0.0710)	(0.0318)	(0.0704)	(0.0312)	(0.0680)	(0.0305)
Log (price per kg of coffee)	0.0689	-0.0348**	0.0699	-0.0344**	0.0704	-0.0352**
	(0.0538)	(0.0165)	(0.0538)	(0.0166)	(0.0529)	(0.0169)
Deliver all coffee (yes=1)	0.0910***	-0.00604	0.0906***	-0.00645	0.0902***	-0.00728
	(0.0196)	(0.00553)	(0.0195)	(0.00566)	(0.0190)	(0.00578)
Observations	2,094	2,094	2,094	2,094	2,094	2,094

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

5.3 Overall impacts of PRICE: Horticulture-Finance

Horticulture: Impact on Economic mobility indicators

When looking at the horticulture-finance interventions, we start by examining the project's impact on overall income and then move to crop income. Given that both treatments centred on horticulture crops, we mainly focus on assessing the horticulture income impact. Horticulture income represents 40% of total income and 70% of the crop income on average for these farmers. We divide our horticulture income results into income from seasonal horticulture crops and from perennial horticulture crops. In addition to income-related indicators, we present our results on assets indices to show how horticulture farmers used their matching grant.

Table 19: Income shares by horticulture farmers

	% of total income	% of crop income
Annual Wage	15%	
Annual Enterprise	17%	
Livestock Income	6%	
Other Income	3%	
Crop Income	**57%**	
Crop_Income_season 1	20%	35%
Crop_Income_season 2	14%	26%
Crop_Income_season 3	4%	8%
Perennial Crop_Income	18%	31%
Horticulture Income	**40%**	**70%**

Looking at the income indicators, our results demonstrate a significant impact on horticulture for both the selection and endorsement of business idea treatment (T1) and the matching grant treatment (T2), while the magnitude is considerably higher for the latter. We expected these results, given that T2 did not repay the full amount of their loans. In fact, those who received the matching grant received 50% of their project funding for free once they paid 50% of their loan. If T1 farmers wanted to implement their plans, they had to finance the entirety of their idea through savings, external loans, or other financial capital sources.

One mechanism through which farmers achieved higher income is increased harvest and sales. Harvest and sales for NAEB-endorsed farmers generally increased significantly, and as expected, with greater magnitude for T2 farmers. Given that horticulture crops can be seasonal or perennial crops, we analysed both types of horticultural crops. Based on our sample, on average, perennial and seasonal crops contribute nearly equally to farmers' horticulture income. Results reveal that the impact on horticulture income stems mainly from the seasonal crops. This is consistent with our qualitative results that reported seasonal horticulture crops to be more profitable compared to the perennial crops. Perennial crops need a longer period of time for production before harvest returns can be realized.

Our assets indicator impacts fall in-line with our income findings. Horticulture farmers generally invested in productive assets to cultivate and harvest more, regardless of their T1 or T2 status. Our results show positive impacts on productive assets and T2 farmer continue to show greater magnitudes of impact. We also find a positive impact on farmers' durable assets, yet it is not significant across all specifications. These results support the argument that the matching grants were used in horticulture-related investments.

As we previously reported, our horticulture-finance results provide evidence of spillover impacts in the form of job creation through an increased demand for hired labour. Our results indicate that amount of hired labour for horticulture-related activities increased considerably during the project. In addition, consistently with the harvest and income results, seasonal crops drive the findings and the T2 treatment had a larger impact compared to T1.

The positive impact we find in T1 on horticulture income and assets reflect the possibility of highly cost-effective future projects. Although T1 horticulture farmers did not receive the matching grant, just giving them official documents from NAEB validating their business idea appears to motivate them to finance and implement their ideas. According to our qualitative results, relevant stakeholders confirmed that such documents were of a great support to farmers' loan applications.

Table 20: Impact of the horticulture-finance interventions on income-related variables

	Income-related Indicators	Treatment 1: Selected Idea (sharp RRD)	Treatment 2: Matching Grant (fuzzy RRD)
	Log (total income)	-1.222**	-6.091*
	Log (crop income)	0.598	3.679
	Log (horticulture income)	0.933***	5.401**
	Log (horticulture harvest)	4.244*	32.38*
	Log (horticulture sales and home consumption)	4.257*	32.71*
	Log (horticulture sales)	4.839**	32.22*
	Log (horticulture home consumption)	4.491***	30.69**
	Log (horticulture hired labour)	1.446***	9.008**
Seasonal	Log (horticulture income)	0.691**	4.174*
	Log (horticulture harvest)	2.255	16.17*
	Log (horticulture sales and home consumption)	2.356	16.57*
	Log (horticulture sales)	2.554	19.79*
	Log (horticulture home consumption)	2.251**	17.72**
	Log (horticulture hired labour)	0.793*	5.467*
Perennial	Log (horticulture income)	0.426	4.073**
	Log (horticulture harvest)	1.875	11.79
	Log (horticulture sales and home consumption)	2.048	13.17
	Log (horticulture sales)	3.034	21.23
	Log (horticulture home consumption)	2.348	16.03
	Log (horticulture hired labour)	0.576	3.889

Significance levels: *** p<0.01, **p<0.05, *p<0.1.

Table 21: Impact of the horticulture-finance interventions on household assets

Assets-related Indicators		Treatment 1: Selected Idea (sharp RRD)	Treatment 2: Matching Grant (fuzzy RRD)
Overall assets index	1	0.32	1.925
Durable assets index	1	0.834***	2.295
Housing index	1	0.016	0.272
Livestock assets index	1	0.0825	1.493
Productive assets index	1	0.492**	2.927*

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Poverty reduction indicators

Although the significant impact of both T1 and T2 treatment on horticulture income, we do not find evidence that they had an impact on the poverty indicators based on their income. This is unsurprising, given that most of horticulture farmers were already above the international poverty line thresholds. In fact, according to our sample, 70% of horticulture farmers are above US$ 1.90 per day poverty line, 77% are above the US$ 1.25 per day poverty line and 80% are above the US$ 1.00 per day poverty line. We do find in Table 23 that the horticulture-finance interventions had a positive and significant impact on durable and productive assets..

Table 22: Impact of the horticulture-finance interventions on poverty measures

	Poverty-related Indicators	Treatment 1: Selected Idea (sharp RRD)	Treatment 2: Matching Grant (fuzzy RRD)
Income based indicators	Above poverty line (1.9 $)	0.0399	0.548
	Above poverty line (1.25 $)	0.0423	0.433
	Above poverty line (1 $)	0.015	0.0849
	Above 40th percentile (Total Income)	-0.0172	-0.541
	Above 60th percentile (Total Income)	-0.14	-0.645
Income based indicators	Above 40th percentile (Overall asset index)	0.244	1.871
	Above 60th percentile (Overall asset index)	0.137	0.905
	Above 40th percentile (Durable asset index)	0.231	1.332
	Above 60th percentile (Durable asset index)	0.417***	1.906*
	Above 40th percentile (Productive asset index)	0.366*	2.011
	Above 60th percentile (Productive asset index)	0.456***	2.505**
	Above 40th percentile (Livestock asset index)	-0.12	-0.394
	Above 60th percentile (Livestock asset index)	-0.256	-0.798
	Above 60th percentile (Housing asset index)	-0.0406	-0.153

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Resilience, dietary diversity, and food security

Our results reveal no significant impact of both T1 and T2 on resilience, dietary diversity, and food security. This is in line with our previous poverty findings. By targeting wealthier horticulture farmers we do not expect to see strong changes in resilience, dietary diversity, or food security as these farmers would already have enhanced resilience food security and dietary diversity beforehand. According to our sample, around 93% of those who encountered shocks reported that they were able to recover from their shocks. In addition, the average dietary diversity score is 9 different food groups consumed, with a maximum of 18 different food groups consumed.

Table 23: Impact of the horticulture-finance interventions on resilience measures

	Resilience-related Indicators	Treatment 1: Selected Idea (sharp RRD)	Treatment 2: Matching Grant (fuzzy RRD)
Overall	Resilience index 1	-0.0116	-0.0204
	Resilience index 2	-0.0205	-0.0201
	Ability to recover (total)	-0.277	-0.365
	Ability to recover (mean)	-0.0116	-0.0204
Drought	Resilience index 1	-0.321	-0.0344
	Ability to recover	-0.331	-0.0405
Irregular Rains	Resilience index 1	0.00191	-0.0674
	Ability to recover	-0.006	-0.0823
Crop Pests or Disease	Resilience index 1	0.0285	0.131
	Ability to recover	0.0282	0.135

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table 24: Horticulture-finance impacts on household food insecurity and household dietary diversity

Food-related Indicators	Treatment 1: Selected Idea (sharp RRD)	Treatment 2: Matching Grant (fuzzy RRD)
FIES Index	-0.608	-4.349
Dietary Diversity Score (7 days)	2.075	13.56
Dietary Diversity Score adjusted (7 days)	8.107	51.78
Dietary Diversity Score (24 hours)	0.432	2.85

Significance levels: *** p<0.01, **p<0.05, *p<0.1

5.4 Horticulture-finance heterogeneous impacts

Based on the qualitative interviews, horticulture farmers with more than 5 hectares are regarded as large-scale commercial producers that consist an entirely different category of horticulture farming. Therefore, we assessed heterogeneity of impacts of the horticulture-finance treatments on small farmers (with at most 5 hectares of land) versus large farmers (with more than 5 hectares) as the project may have affected them differently. We only report results on the indicators that showed significant impacts.

For T1, our results in Table 25 show that large farmers generally benefited more compared to small ones This result follows logically from the fact that T1 farmers needed savings or an ability to access finance, which is more likely for larger farmers. Our results show that simply vetting the horticulture business idea and providing a NAEB endorsement letter for large farmers resulted in an average increase of 230% in horticulture income and about 222% increase in total income. In addition, T1 generally led to an increase of about 157% in productive assets and 90% in overall assets. These results demonstrate the ability to increase income and assets for larger farmers without providing financing.

Table 25: Heterogeneous impacts of the horticulture-finance interventions (by land size)

Treatment 1: Selected Idea (sharp RRD)	<= 5 Hectares (68 percent of the sample)	> 5 Hectares (32 percent of the sample)
Log (horticulture income)	0.24	2.222***
Log (horticulture harvest)	-0.718	14.68***
Log (horticulture sales and home consumption)	-0.772	14.81***
Log (horticulture sales)	-0.592	15.45***
Log (horticulture home consumption)	0.898	11.59***
Log (seasonal horticulture income)	0.111	2.318***
Log (seasonal horticulture harvest)	-0.615	12.03***
Log (seasonal horticulture sales and home consumption)	-0.641	12.22***
Log (seasonal horticulture sales)	-0.231	11.54***
Log (seasonal horticulture home consumption)	1.355	9.553***
Overall asset index	-0.257	0.896***
Durable asset index	-0.414	1.304**
Productive asset index	-0.0241	1.566**

Significance levels: *** p<0.01, **p<0.05, *p<0.1

T1 also resulted in heterogeneous impacts on the value of total horticulture produce harvested, value of horticulture sales (revenues), and horticulture produce consumed at the household level. In all instances, large farmers experienced greater impacts, on average, as a result of T1. As shown in Table 25, we find large farmers generally recorded very large increases, of more than 1000%, for horticulture harvest and horticulture sales. At first glance, these results seem astounding, but when one looks at the types of crops that the farmers produced the magnitudes are as expected. The crops produced were mostly seasonal horticultural crops with a short production cycle of between 3 to 6 months, implying that in a single year the farmers could produce at least two

batches of output. Moreover, we expect the scale of production generated economies of scale for these crops. Based on qualitative insights we understand that most large-scale T1 farmers experienced large income increases as they managed to acquire more land and increase their scale of production through their own savings or alternative financing options..

For T2, our results, presented in Table 26, do not show statistically different impacts for almost any indicators Nevertheless, the magnitude of impact for the T2 beneficiaries appears to be greater for large farmers compared to small farmers. In addition to being able to secure loans, the average dollar value of loans and matching grant received by large farmers was almost double that of small farmers. Based on quantitative analysis of our sample and qualitative reports from farmer interviews, the average value of loans for small famers was about US$5000 compared to US$8000 for large famers. This highlights that in absolute dollar terms, larger farmers received more money per household in the T2 group, yet it did not yield statistically significant impacts. Overall, we observe impacts for all farm sizes, implying that offering smaller absolute sizes of matching grants even to the larger farmers would likely generate impacts, while allowing the intervention to reach even more farmers.

Table 26: Heterogeneous impacts of the matching grant by land size

Treatment 2: Grant (fuzzy RRD)	<= 5 Hectares (68 percent of the sample)	> 5 Hectares (32 percent of the sample)
Log (horticulture income)	2.411	17.68
Log (horticulture harvest)	-0.384	93.71
Log (horticulture sales and home consumption)	0.694	99.79
Log (horticulture sales)	-1.021	101
Log (horticulture home consumption)	8.93	67.72*
Log (seasonal horticulture income)	0.211	25.28
Log (seasonal horticulture harvest)	0.535	72.41
Log (seasonal horticulture sales and home consumption)	0.113	76.13
Log (seasonal horticulture sales)	0.286	65.89
Log (seasonal horticulture home consumption)	11.19*	60.36
Overall asset index	-1.139	7.601
Durable asset index	-1.993	9.073
Productive asset index	0.0373	9.482*

Significance levels: *** p<0.01, **p<0.05, *p<0.1

We also analysed heterogeneity of impacts by poverty status to test if the treatments classified as pro-poor. Here, it is important to understand that the analysis is not to see if the treatments reduced poverty but rather whether they generated greater impacts among the poor versus those above the poverty line. Table 27 shows that, in fact, larger impacts on horticulture sales and income indicators for households above the poverty line, which is consistent with the results that the horticulture-finance impacts were greater among those who had larger land areas.

Table 27: Heterogeneous impacts of the horticulture-finance interventions (by poverty status)

Treatment 1: Selected Idea (sharp RRD)	Below poverty line (1.25 US$)	Above poverty line (1.25 US$)
Log (Horticulture Income)	-0.117	1.430***
Log (Horticulture Harvest)	-1.706	8.351***
Log (Horticulture Sales and Home Consumption)	-1.73	8.296***
Log (Horticulture Sales)	-1.783	8.426***
Log (Horticulture Home Consumption)	2.179	5.376**
Log (Horticulture Income)- seasonal	-0.238*	1.064***
Log (Horticulture Harvest) - seasonal	-3.414*	4.475**
Log (Horticulture Sales and Home Consumption)- seasonal	-3.094	4.441*
Log (Horticulture Sales))- seasonal	-2.211	4.051*
Log (Horticulture Home Consumption))- seasonal	-2.112	3.679***
Overall Assets Index	0.956***	0.101
Durable Assets Index	1.916**	0.158
Productive Assets Index	0.785***	0.369

Significance levels: *** p<0.01, **p<0.05, *p<0.1

However, impacts on consumption of horticultural crops is found for both farmers below and above the $1.25 per day poverty line, implying that for those who were poor and were somehow able to invest in their selected business idea, the intervention allowed them to start consuming more horticultural crops at home. In terms of assets, we find T1 on average increases durable assets by about 200% and productive assets by about 79% for farmers below the poverty threshold of $1.25 per day.

Qualitative reports from the field support these findings. SACCO leaders and horticulture farmers interviewed indicated that once farmers received financing, after obtaining the NAEB endorsement letter, they purchased productive assets, mainly land. However, poorer farmers also purchased durable assets, especially after receiving increased incomes from their seasonal horticultural crop sales.

In contrast, wealthier farmers were said to already own a number of durable assets, such that they channelled financing or profits from their horticulture business into alternative businesses or additional productive assets such as land and farming implements. Thus, farmers above the poverty line were more likely to further diversify their livelihoods by investing in things like a small enterprise or shop, a lorry or ferry, or an agro-processing facility. Our qualitative insights shed light on the positive multiplier effects of supporting wealthier horticulture farmers to expand their business.

The finding that merely receiving a NEAB endorsement letter for the business idea would more likely benefit those who are able to either invest their own money in the proposed horticulture business idea or raise capital from other sources is an important finding. By default, these farmers are likely to be non-poor and have larger farm sizes, and as a result would likely hire more people as well as diversify their livelihoods by investing in

other businesses. This suggests that greater spillover effects are likely to be realized by simple support interventions for larger and wealthier farmers.

Results of the analysis of heterogeneity impacts in the matching grant treatment are shown in Table 28. We find that the matching grant also mostly positively impacted the non-poor farmers.

Table 28: Heterogeneous impacts of the matching grant (poverty status)

Above poverty line (1.25 US$)	Below poverty line (1.25 US$)	Above poverty line (1.25 US$)
Log (Horticulture Income)	0.852	6.992**
Log (Horticulture Harvest)	-6.015	42.20**
Log (Horticulture Sales and Home Consumption)	-3.698	41.38*
Log (Horticulture Sales)	-4.256	43.33**
Log (Horticulture Home Consumption)	14.66	32.48*
Log (Horticulture Income)- seasonal	0.794	4.262
Log (Horticulture Harvest) - seasonal	-13.41	24.65
Log (Horticulture Sales and Home Consumption)- seasonal	0.128	24.4
Log (Horticulture Sales))- seasonal	5.759	24.64
Log (Horticulture Home Consumption))- seasonal	2.716	19.68**
Overall Assets Index	313.6	0.764
Durable Assets Index	227.4	0.527
Productive Assets Index	6.46	2.086

Significance levels: *** p<0.01, **p<0.05, *p<0.1

6 Conclusion and lessons learnt

This study set out to assess the impacts of two sub-components of the PRICE project in Rwanda: (i) the coffee turnaround programmes, and (ii) the horticulture-finance interventions. In both sub-components, the study found positive impacts as measured against a number of indicators, including economic mobility, crop production, and market access. Assessment of impacts on other indicators of interest, including resilience, food security, and dietary diversity),showed mixed results. The targeting of the PRICE, particularly for the horticulture-finance component, suggests that this project was not specifically designed to address these indicators.

Given that PRICE mainly sought to increase rural incomes of farmers through export-driven value chains, we mainly assess impact on income indicators such as crop-specific income and total income. We find positive impacts, largely focused on crop-specific income. These results show that the coffee and horticulture-finance PRICE components accomplished their objective of increasing farmers' incomes. Our results add to the evidence base demonstrating that agricultural commercialization projects, especially those focusing on high-value export crops, can have significant positive impacts on farmers' incomes.

In the case of coffee, the turnaround programme, particularly TAP2, on average led to a 34 percent increase in coffee incomes and 32 percent increase in total crop income. Our findings highlight differences between the implementation of TAP1 and TAP2, which resulted in more significant results in the second round of the turnaround programme. Our cooperative level results show consistent cooperative-level increases, on average, for coffee prices received by the TAP1 and TAP2 cooperatives. This is in line with the increases in income realized by the coffee farmers, as measured using the household level-data.

Regarding the horticulture-finance intervention, very large increases in income of more than 500 percent were recorded. Our horticulture-finance results showcase the strong potential for high-value horticulture crops, which can be harvested at least twice within a year. This was especially the case among large-scale farmers with more than 5 hectares of land, who managed to capitalize on economies of scale as well as the short production cycles of the seasonal horticulture crops they grew. Moreover, most horticulture farmers paid off their loans within a year\, suggesting high profitability of their horticulture businesses. Qualitative interviews conducted by the authors also show that some of these farmers borrowed additional capital for further investment in their businesses after receiving PRICE funds.

For the horticulture farmers with more than 5 hectares of land, the impact assessment found that merely vetting their business ideas and issuing an official NAEB endorsement letter generated huge income and asset impacts. This was the case, even though they did not receive the performance-based matching grant in the end. In addition, we found evidence of spillover impacts in the form of job creation in the form of hired labour by the large farmers. Our qualitative interviews with these large farmers revealed that, afterward receiving the PRICE funds, they invested in other enterprises such as local shops, processing facilities, and local transport businesses.

When we assess impact of T2, those who received the performance-based grant, we generally find significant increases in incomes and assets. However, the impacts were more pronounced among non-poor farmers, i.e. farmers above the $1.25 per day poverty line. This implies that matching grants are more likely to generate greater impacts on incomes for the non-poor as opposed to poor farmers. Thus, if the intended impact is to increase incomes and not necessarily to reduce poverty, poverty status of farmers could be used as selection criteria for allocating performance-based grants. Our results on poverty reduction confirm that the performance-based grant did not reduce poverty by any significant means.

Whom to target for performance-based matching grants is an open question. We recommend that a different set of interventions that focus on supporting development of business ideas and accessing loans from formal financial institutions may be more apposite to large-scale farmers. However, if performance-based grants are to

be given to large farmers it may be prudent to set a cap on the absolute amount awarded as a grant rather than using a percentage of the total loan amount. As found in the impact assessment, the average loan amount for large farmers was almost double that of smaller farmers, and the program was heavily oversubscribed. Thus, for future performance-based grants to reach more farmers, we suggest setting a cap on the maximum absolute award any one farmer can receive. Moreover, qualitative interviews indicated that BDF changed the rules midway, by requiring applicant farmers to submit additional documentation, thus making it more difficult for those farmers who submitted business ideas later in the business cycle.

A separate recommendation pertains to offering different calls for proposals for the performance-based grants, depending on the types of farmers and intended project objectives. This could be on the basis of farm size, poverty status, whether or not the farmers have previously obtained loans, their experience in horticulture farming, or the type of crops they produce. As observed in the PRICE performance-based matching grants assessed in this report, an open call forces small farmers who have never engaged with a SACCO or other financial lender to compete with the larger farmers who oftentimes have more familiarity with accessing capital Therefore, we recommend offering different calls for proposals, each with different selection criteria, to achieve different objectives. Or simply focusing on one objective for one type of sub-group of farmers, for example financial inclusion for smaller farmers who have less experience with the financial sector.

It is still important to recognize that positive spillover effects are likely to arise from interventions given to large-scale farmers, as they employ more labour and invest in other enterprises that generate positive multiplier effects. Moreover, these larger farmers are better positioned to access export markets than smaller farmers and boosting their production can positively impact the national export earnings from horticulture. Thus, while performance-based grants may screen away smaller farmers who fail to meet the eligibility criteria or compete with larger farmers, they still generate indirect economic impacts that positively affect the poor. Hence, our recommendation of not excluding larger farmers from participating in future grant opportunities but to provide a different mechanism that better suits them.

The qualitative insights we gleaned from the impact assessment highlight issues with the process used to administer the performance-based grants. Many farmers that the authors interacted with complained about the lengthy and cumbersome process involved to apply for the grants, from submitting their business ideas to finally receiving the loan. And receiving the grant itself proved difficult, with some farmers thinking the received the grant but ultimately only received the loan. We suggest future designs consult relevant experts and stakeholders to see if the process can be improved and made less cumbersome, to reduce what some SACCO leaders termed as red tape in the process.

Another issue from the qualitative discussions is the interest rate. While the farmers that received the performance matching grants would only pay 50 percent of the loan, they had to pay interest on the full amount of the loan, implying that SACCOs and other participating lenders were charging interest to the farmer on the 50 percent that BDF eventually repaid to the SACCO or lender. Here we recommend to either have BDF recoup the interest on the 50 percent or to find a way to negotiate the interest rate so that farmers can access the loan at a more favourable rate.

A separate suggestion, which may be explored, is making the performance-based matching grant a revolving grant fund. The fact that few farmers were able to access the loans and/or grants could be addressed by ensuring that loans that are repaid can then be made available for additional rounds of loans and performance-based grants. Thus, SACCOs and other lending financial intuitions could be given an incentive to provide additional loans out of the repaid funds.

Regarding the coffee turnaround programmes, one key lesson learned from the impact assessment is the importance of learning by doing. TAP2 incorporated adjustments in the design and implementation based on lessons learned from TAP1. This is likely to have contributed to the higher impacts observed, on income indicators for TAP2 compared to TAP1. Another lesson is on the importance of ensuring sustainability of impacts through provision of multiple and coordinated interventions to the same beneficiaries. In the case of

TAP1, impacts were found for assets but not on incomes of year 2017, probably due to lack of sustainability. In contrast, TAP2 cooperatives had received other support from NAEB prior to receiving the TAP2 intervention in 2016/17, which likely enabled them to generate greater income impacts in 2017.

Qualitative key informant interviews with stakeholders raised the issue that the TAP programmes only lasted for only one year. It may take more time, plus supplementary interventions, to turnaround an unprofitable coffee cooperative. Thus, offering a more complete set of interventions, and for a longer period of time, may promote long-term cooperative sustainability.

Positive impacts on assets for both TAP1 and TAP2, especially on livestock assets, potentially offer a window of opportunity to generate spillover effects from cooperative interventions in areas beyond the focus of the intervention. This implies that broader impacts are likely realized from interventions that improve coffee cooperative governance. While the impact pathway may be long and likely weaker, incorporating support for diversification into other livelihoods for the coffee cooperatives may create larger impacts beyond the increases in coffee income.

Finally, it is clear from this impact assessment that the PRICE sub-components evaluated had positive impacts on their respective beneficiary farmers in multiple ways. We find it encouraging to see that agricultural commercialization projects, designed to increase production volumes and quality of high-value export crops, go beyond increasing farmers' incomes to also positively impact various other indicators and create positive spillover effects. These interventions ultimately had a positive influence on transforming the lives of the beneficiary families and others in their communities.

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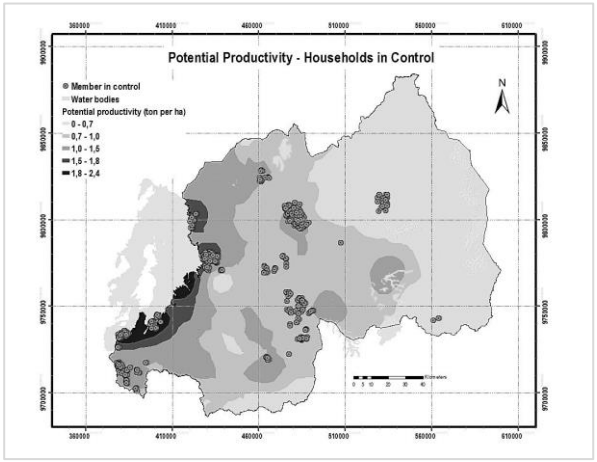
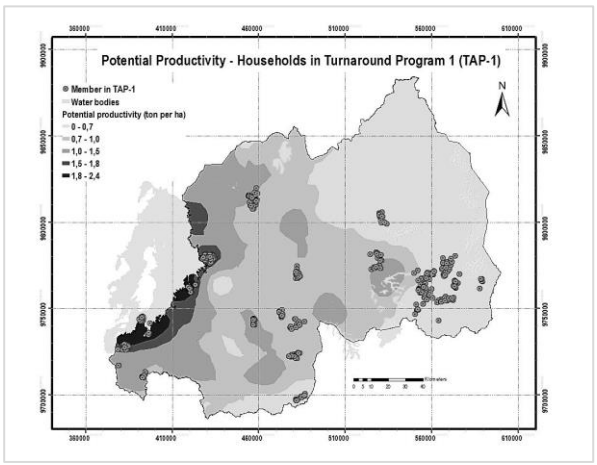
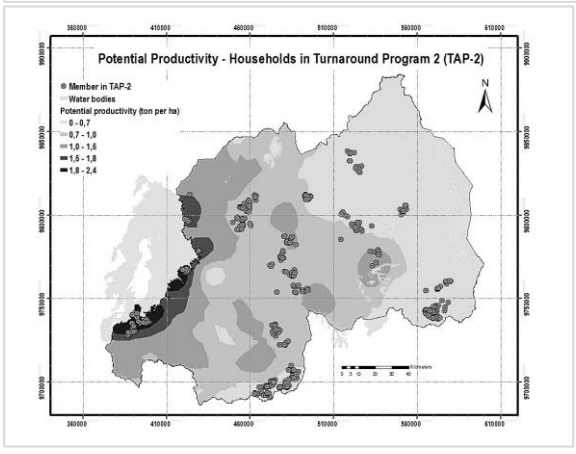
Appendix

Maps of Rwanda showing coffee productivity potential by location of control, TAP1 and TAP2 households







Source: (Nzeyimana, Hartemink and Geissen 2014)

Table A1. List of main impact indicators

	Indicator	Definition	Data source
Cooperative Level	Cherries	Volume of green coffee delivered to a cooperative by members and non-members	Cooperative
	Coffee Price	Average coffee price per KG at the cooperative level to those who deliver their coffee to cooperatives	Cooperative
	CWS Utilization Rate	The percentage of your current production compared to the highest level the CWS would achieve if working on full capacity	Cooperative
	Price per kg of coffee	Price per KG of coffee cherries in the previous harvest season (2017)	Household
	Deliver all coffee (yes=1)	Dummy variables that takes 1 if a household usually deliver all of their coffee cherries, and 0 otherwise	Household
	Intention leave (yes=1)	Dummy variables that takes 1 if a household has intention to leave his cooperative, and 0 otherwise	Household
	Management trust (yes=1)	Dummy variables that takes 1 if a household trust their cooperative management, and 0 otherwise	Household
	Members trust (yes=1)	Dummy variables that takes 1 if a household trust their cooperative members, and 0 otherwise	Household
	Cooperative transparency (yes=1)	Dummy variables that takes 1 if a household think that their cooperative is transparent, and 0 otherwise	Household
	Expansion plan (yes=1)	Dummy variables that takes 1 if a household has a plan to expand their coffee plantation, and 0 otherwise	Household
	Annual Meetings attendance (yes=1)	Dummy variables that takes 1 if a household has a plan to expand their coffee plantation, and 0 otherwise	Household
Economic Mobility	Income	Sum of crop income after subtracting inputs and marketing costs, employment income, enterprise profit, livestock sales and other income sources including transfers	Household
	Crop Income	The value of sales after subtracting inputs and marketing costs	Household
	Coffee (horticulture) Income	The value of sales from coffee (horticulture crops) after subtracting inputs and marketing costs	Household
	Durable Assets	It is an index of household's durable assets using the principal components analysis	Household
	Productive Assets	It is an index of household's productive assets using the principal components analysis	Household
	Livestock Assets	It is an index of household's livestock and livestock products using the principal components analysis	Household
	Housing	It is an index of household's housing characteristics using the multiple correspondence analysis	Household
	Overall Assets Index	It is a combined index of four indices (durable assets, productive assets, livestock assets, and housing) using the principal	Household

	Indicator	Definition	Data source
		components analysis based on the polychoric correlation	
Poverty	Above poverty line (1.9 $)	Dummy variables that takes 1 if a household above poverty line of 1.9 US$	Household[1]
	Above poverty line (1.25 $)	Dummy variables that takes 1 if a household above poverty line of 1.25 US$	Household[1]
	Above poverty line (1 $)	Dummy variables that takes 1 if a household above poverty line of 1. US$	Household[1]
	Above 40th percentile (X)	Dummy variables that takes 1 if a household above poverty line of the 40th percentile of X. This variable is created for both income and assets' indices	Household
	Above 60th percentile (X)	Dummy variables that takes 1 if a household above poverty line of the 60th percentile of X. This variable is created for both income and assets' indices	Household
Resilience	Ability to recover (mean)	The average of a household's perceived ability to recover from a shock, measured on a scale of 1 if a household didn't recover from a shock at all, 2 if a household somewhat recovered from a shock, and 3 if a household fully recovered from a shock	Household
	Ability to recover (total)	The sum total of a household's perceived ability to recover from a shock	Household
	Resilience Index 1	Average of perceived ability to recover for a household + the slope of ability to recover on severity of a shock*100 (ability to recover of all households- average ability to recover for a household)	Household
	Resilience Index 2	Average of perceived ability to recover for a household + the slope of ability to recover on severity of a shock (ability to recover of all households- average ability to recover for a household)	Household
Food	FIES Index	Food Insecurity Experience index following the FAO's guidelines, which is based on eight questions that reflect household's access to adequate food	Household
	Dietary Diversity index (7 days)	It is measured at household level following the FAO's guidelines, which measure household ability to access 18 food groups. It is the sum of dummy variables that reflect whether a household had access to each food group in the last week.	Household
	Dietary Diversity index adjusted (7 days)	It is measured at household level following the FAO's guidelines, which measure household ability to access 18 food groups. It is the sum of dummy variables that reflect whether a household had access to each food group in the last week, weighted by number of times a household consumed a specific item within each food category.	Household
	Dietary Diversity index (24 hours)	It is measured at household level following the FAO's guidelines, which measure household ability to access 18 food groups. It is the sum of dummy variables that reflect whether a household had access to each food group in the last 24 hours.	Household

[1]We use a 2013 exchange rate of RWF to the dollar (646.6 RWF/1US$), which we base on the last available official Rwandan figures for world development indicators...

Table A10. The impact of TAP1 and TAP2 on the cooperative-related variables measured at the household level

Cooperative -related variables		TAP_1				TAP_2		
		IPWRA	*AIPW*	*Entropy Balancing*		*IPWRA*	*AIPW*	*Entropy Balancing*
Price per kg of coffee (log)		-0.0839	-0.259	0.0214		0.0860**	0.0944**	0.0791
		(0.0635)	(0.199)	(0.0513)		(0.0358)	(0.0393)	(0.0483)
Deliver all coffee (yes=1)		-0.00563	-0.00945	0.196		0.0456***	0.0477***	1.240***
		(0.0163)	(0.0179)	(0.235)		(0.00913)	(0.00934)	(0.274)
Intention leave (yes=1)		0.0170	-0.00124	-0.490		-0.00192	-0.00666	-0.0922
		(0.0403)	(0.0258)	(0.359)		(0.0151)	(0.0103)	(0.349)
Management trust (yes=1)		-0.0415	0.0150	-0.198		0.0191	0.0143	0.403**
		(0.0278)	(0.0539)	(0.142)		(0.0348)	(0.0348)	(0.179)
Members trust (yes=1)		-0.0619	-0.0464	-0.0747		-0.0228	-0.0328	0.0355
		(0.0400)	(0.0399)	(0.239)		(0.0309)	(0.0365)	(0.277)
Cooperative transparency (yes=1)		-0.0618	0.0220	0.0872		0.0622*	0.0690**	0.803***
		(0.0404)	(0.0721)	(0.134)		(0.0360)	(0.0352)	(0.169)
Expansion plan (yes=1)		0.105***	0.181**	0.602***		0.0614**	0.0597**	0.402***
		(0.0245)	(0.0860)	(0.145)		(0.0285)	(0.0285)	(0.150)
Annual meetings attendance (yes=1)		-0.0308	-0.00146	0.337**		0.110***	0.112***	0.679***
		(0.0460)	(0.0517)	(0.159)		(0.0226)	(0.0218)	(0.192)
Observations		2,093	2,093	2,093		2,094	2,094	2,094

Table A11: The impact of TAP1 and TAP2 on the income and assets-related variables

Income-related variables	**TAP_1**			**TAP_2**		
	IPWRA	***AIPW***	***Entropy Balancing***	***IPWRA***	***AIPW***	***Entropy Balancing***
Log (income)	0.000529	-0.0491	0.00858	0.00279	-0.00740	-0.0145
	(0.0114)	(0.0494)	(0.00684)	(0.0256)	(0.0299)	(0.0198)
Log (crop income)	0.0492	-0.499	-0.0154	0.324***	0.281***	0.0746
	(0.105)	(0.535)	(0.0674)	(0.0854)	(0.0933)	(0.0603)
Log (coffee income)	-0.0969	-1.115	-0.0781	0.343***	0.324***	0.131**
	(0.141)	(1.038)	(0.0743)	(0.0868)	(0.0917)	(0.0614)
Log (coffee harvest)	0.0937	-0.417	0.211*	0.738***	0.714***	0.468***
	(0.163)	(0.561)	(0.116)	(0.143)	(0.150)	(0.128)
Log (coffee sales)	0.279	-1.554	0.461**	1.129***	1.056***	0.831***
	(0.287)	(1.896)	(0.202)	(0.234)	(0.248)	(0.225)
Log (coffee home consumption)	-0.0801	-0.0419	-0.0168	0.0610	0.0673	0.0557
	(0.0631)	(0.0498)	(0.0138)	(0.0482)	(0.0521)	(0.0407)
Log (coffee inputs costs)	-0.217	0.668	0.494*	0.807**	0.785*	0.420
	(0.457)	(1.021)	(0.259)	(0.408)	(0.407)	(0.295)
Log (marketing costs)	0.673	-0.899	0.240	0.798**	0.596	1.033***
	(0.419)	(1.386)	(0.261)	(0.405)	(0.403)	(0.276)
Assets-related variables	*IPWRA*	*AIPW*	*Entropy Balancing*	*IPWRA*	*AIPW*	*Entropy Balancing*
Overall asset index	0.123**	0.0891	0.00913	0.109**	0.115**	0.0305
	(0.0548)	(0.0610)	(0.0288)	(0.0465)	(0.0450)	(0.0298)
Durable asset index	0.164**	0.147*	0.0201	0.166**	0.178***	0.0482

Income-related variables	TAP_1			TAP_2		
	IPWRA	*AIPW*	*Entropy Balancing*	*IPWRA*	*AIPW*	*Entropy Balancing*
	(0.0729)	(0.0855)	(0.0370)	(0.0687)	(0.0669)	(0.0396)
Productive asset index	0.0377	0.0514	-0.0796*	-0.0154	-0.00630	-0.0793
	(0.0916)	(0.104)	(0.0456)	(0.0745)	(0.0717)	(0.0495)
Livestock asset index	0.182*	0.0180	0.127**	0.206**	0.198**	0.160**
	(0.0958)	(0.203)	(0.0546)	(0.0911)	(0.0843)	(0.0657)
Housing	0.0514***	0.0473**	0.00320	0.0371***	0.0350***	0.0194*
	(0.0170)	(0.0192)	(0.00975)	(0.0137)	(0.0134)	(0.0101)
Observations	2,093	2,093	2,093	2,094	2,094	2,094

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A13: The impact of TAP1 and TAP2 on poverty reduction indicators

	Poverty-related variables	TAP_1			TAP_2		
		IPWRA	*AIPW*	*Entropy Balancing*	*IPWRA*	*AIPW*	*Entropy Balancing*
Income based indicators	Above poverty line (1.9 $)	0.0494	-0.153	0.0205	0.0969**	0.0891**	0.0369
		(0.0414)	(0.213)	(0.0241)	(0.0416)	(0.0410)	(0.0270)
	Above poverty line (1.25 $)	0.0128	-0.291	0.0256	0.0913**	0.0684*	0.0217
		(0.0426)	(0.305)	(0.0264)	(0.0408)	(0.0409)	(0.0296)
	Above poverty line (1 $)	-0.00173	-0.324	0.0189	0.122***	0.108***	0.0296
		(0.0437)	(0.324)	(0.0271)	(0.0373)	(0.0369)	(0.0290)
	Above 40th percentile (Total income)	0.00629	-0.309	0.0292	0.118***	0.0969**	0.0280
		(0.0435)	(0.319)	(0.0269)	(0.0378)	(0.0380)	(0.0290)
	Above 60th percentile (Total income)	0.0416	-0.168	0.0241	0.124***	0.105**	0.0343
		(0.0416)	(0.217)	(0.0246)	(0.0415)	(0.0415)	(0.0272)
Assets based indicators	Above 40th percentile (Overall asset index)	0.0905**	0.256	0.0146	0.0955***	0.0879**	0.0358
		(0.0427)	(0.196)	(0.0264)	(0.0367)	(0.0370)	(0.0273)
	Above 60th percentile (Overall asset index)	0.0479	-0.141	-0.0224	0.0376	0.0395	-0.00886
		(0.0457)	(0.187)	(0.0238)	(0.0397)	(0.0384)	(0.0266)
	Above 40th percentile (Durable asset index)	0.0678	0.239	-0.0104	0.0665	0.0731*	0.0204
		(0.0419)	(0.199)	(0.0269)	(0.0423)	(0.0410)	(0.0294)
	Above 60th percentile (Durable asset index)	0.0923**	0.277	-0.00853	0.0683*	0.0756*	0.0167
		(0.0436)	(0.218)	(0.0246)	(0.0407)	(0.0394)	(0.0259)
	Above 40th percentile (Productive asset index)	0.0171	0.181	0.0131	0.0381	0.0402	-0.0142
		(0.0468)	(0.187)	(0.0267)	(0.0401)	(0.0400)	(0.0287)
	Above 60th percentile (Productive asset index)	0.0348	0.332	-0.0321	0.0556	0.0556	-0.0278

Poverty-related variables	TAP_1			TAP_2		
	IPWRA	*AIPW*	*Entropy Balancing*	*IPWRA*	*AIPW*	*Entropy Balancing*
	(0.0463)	(0.318)	(0.0240)	(0.0407)	(0.0401)	(0.0284)
Above 40th percentile (Livestock asset index)	0.0331	0.185	0.0428	0.0975**	0.0869**	0.101***
	(0.0466)	(0.153)	(0.0277)	(0.0400)	(0.0397)	(0.0294)
Above 60th percentile (Livestock asset index)	0.0681	-0.0780	0.0818***	0.135***	0.126***	0.119***
	(0.0490)	(0.174)	(0.0260)	(0.0422)	(0.0414)	(0.0284)
Above 40th percentile (Housing asset index)	0.0990**	0.220	-0.0232	0.0815**	0.0749*	0.0487
	(0.0452)	(0.137)	(0.0284)	(0.0415)	(0.0403)	(0.0297)
Above 60th percentile (Housing asset index)	0.105**	0.291	0.00780	0.107**	0.111***	0.0522*
	(0.0455)	(0.206)	(0.0261)	(0.0419)	(0.0414)	(0.0268)
Observations	2,093	2,093	2,093	2,094	2,094	2,094

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A14: The impact of TAP1 and TAP2 on resilience indicators

	Resilience -related variables	TAP_1			TAP_2		
		IPWRA	*AIPW*	*Entropy Balancing*	*IPWRA*	*AIPW*	*Entropy Balancing*
Overall	Resilience index 1	0.0219***	0.0114	0.0192***	0.0104*	0.00929	0.00396
		(0.00629)	(0.0170)	(0.00442)	(0.00595)	(0.00587)	(0.00510)
	Resilience index 2	0.0251***	0.00846	0.0242***	0.0141**	0.0129**	0.00903*
		(0.00596)	(0.0225)	(0.00431)	(0.00568)	(0.00559)	(0.00489)
	Ability to recover (total)	0.460***	0.240	0.403***	0.217*	0.194	0.0822
		(0.132)	(0.356)	(0.0928)	(0.125)	(0.123)	(0.107)
	Ability to recover (mean)	0.0219***	0.0114	0.0192***	0.0103*	0.00925	0.00391
		(0.00629)	(0.0170)	(0.00442)	(0.00595)	(0.00587)	(0.00510)
Drought	Resilience index 1	0.628***	0.940***	0.400***	0.257***	0.215***	0.0838
		(0.0785)	(0.303)	(0.0575)	(0.0782)	(0.0771)	(0.0663)
	Resilience index 2	0.594***	0.884***	0.384***	0.260***	0.221***	0.0921
		(0.0786)	(0.284)	(0.0574)	(0.0761)	(0.0754)	(0.0656)
	Ability to recover	0.629***	0.940***	0.400***	0.257***	0.215***	0.0837
		(0.0785)	(0.303)	(0.0575)	(0.0782)	(0.0771)	(0.0664)
Irregular Rains	Resilience index1	0.0832	-0.157	0.165***	0.0949	0.0600	0.127**
		(0.0710)	(0.328)	(0.0524)	(0.0701)	(0.0697)	(0.0644)
	Resilience index 2	0.0743	-0.141	0.176***	0.0981	0.0648	0.147**
		(0.0692)	(0.301)	(0.0527)	(0.0698)	(0.0691)	(0.0645)
	Ability to recover	0.0833	-0.158	0.165***	0.0949	0.0600	0.126**
		(0.0711)	(0.328)	(0.0524)	(0.0701)	(0.0697)	(0.0644)
s o	Resilience index 1	-0.0200	-0.0873	0.0448	-0.0418	-0.0418	-0.00359

	Resilience -related variables		TAP_1				TAP_2		
			IPWRA	*AIPW*	*Entropy Balancing*		*IPWRA*	*AIPW*	*Entropy Balancing*
			(0.0406)	(0.0899)	(0.0301)		(0.0354)	(0.0399)	(0.0305)
	Resilience index 2		0.00444	-0.0539	0.0650**		-0.0379	-0.0359	0.00904
			(0.0396)	(0.0792)	(0.0307)		(0.0353)	(0.0393)	(0.0307)
	Ability to recover		-0.0202	-0.0876	0.0446		-0.0418	-0.0418	-0.00372
			(0.0406)	(0.0900)	(0.0301)		(0.0354)	(0.0399)	(0.0306)
	Observations		2,093	2,093	2,093		2,094	2,094	2,094

Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A15: The impact of TAP1 and TAP2 on food security and dietary diversity

Food -related variables	TAP_1			TAP_2		
	IPWRA	*AIPW*	*Entropy Balancing*	*IPWRA*	*AIPW*	*Entropy Balancing*
FIES index	0.220	-0.0760	-0.276	0.0249	0.0229	-0.341*
	(0.275)	(0.604)	(0.171)	(0.250)	(0.238)	(0.176)
Dietary diversity index (7 days)	-0.00825	-0.966	-0.0775	0.459**	0.489**	0.119
	(0.203)	(1.077)	(0.122)	(0.207)	(0.197)	(0.135)
Dietary diversity index weighted† (7 days)	1.461	-4.387	-0.147	0.347	0.689	-0.321
	(1.000)	(6.370)	(0.604)	(0.953)	(0.913)	(0.608)
Dietary diversity index (24 hours)	0.405**	-0.631	0.162	0.206	0.291*	0.239**
	(0.172)	(1.076)	(0.103)	(0.164)	(0.157)	(0.108)
Observations	2,093	2,093	2,093	2,094	2,094	2,094

† Dietary diversity scores are weighted on the basis of the number of times the food group was consumed in the last seven days
Standard errors in parentheses; Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A20: Impact of the horticulture-finance interventions on income-related variables

	Income-related Indicators	polynomial order	Treatment 1: Selected Idea (sharp RRD)			Treatment 2: Matching Grant (fuzzy RRD)		
			Bandwidth			Bandwidth		
			mserd	msecomb2	cercomb2	mserd	msecomb2	cercomb2
	Log (total income)	1	-1.222**	-1.135**	-1.412**	-6.091*	-5.789*	-6.611*
		2	-0.996*	-0.978*	-1.260**	-7.334	-7.133	-7.924
	Log (crop income)	1	0.598	0.598	0.685	3.679	3.635	3.658
		2	0.639	0.664	0.719	4.039	4.025	8.114
	Log (horticulture income)	1	0.933***	0.931***	0.937***	5.401**	5.570**	6.264**
		2	1.133***	1.125***	1.015**	13.01	12.76	18.51
	Log (horticulture harvest)	1	4.244*	4.231*	4.449**	32.38*	27.33*	26.14*
		2	5.952*	6.076*	4.928	41.16*	39.06*	52.9
	Log (horticulture sales and home consumption)	1	4.257*	4.245*	4.443**	32.71*	25.40*	24.72*
		2	5.929*	6.088*	5.01	39.82	34.36	39.07
	Log (horticulture sales)	1	4.839**	4.855**	4.827**	32.22*	30.89*	28.09*
		2	5.983*	6.004*	5.138	39.23*	39.85*	52.86
	Log (horticulture home consumption)	1	4.491***	4.475***	4.834***	30.69**	28.37**	29.61**
		2	6.452***	6.640***	5.394**	69.25	64.62*	87.56
	Log (horticulture hired labour)	1	1.446***	1.436***	1.497***	9.008**	8.897**	9.732**
		2	1.722**	1.720***	2.193***	12.20**	12.13**	20.59
Seasonal	Log (horticulture income)	1	0.691**	0.671**	0.700**	4.174*	4.026*	4.918
		2	0.823*	0.828*	0.363	12.24	12.25	-0.14
	Log (horticulture harvest)	1	2.255	2.24	2.9	16.17*	15.9	16.65*
		2	4.716**	3.899*	4.293*	35.58	26.01*	47.36
	Log (horticulture sales and home consumption)	1	2.356	2.344	2.939	16.57*	16.29	16.89*
		2	4.702**	3.913*	4.242*	35.52	25.97	46.44
	Log (horticulture sales)	1	2.554	2.853*	2.949*	19.79*	20.07*	18.74*
		2	4.149*	4.149*	3.117	30.37	28.96	39.37
	Log (horticulture home consumption)	1	2.251**	2.242**	2.746**	17.72**	17.72**	18.58**
		2	3.983**	4.039***	-0.725	47.59	56.61	-3.64
	Log (horticulture hired	1	0.793*	0.783*	0.907*	5.467*	5.411*	5.837

	Income-related Indicators	polynomial order	Treatment 1: Selected Idea (sharp RRD)			Treatment 2: Matching Grant (fuzzy RRD)		
			Bandwidth			Bandwidth		
			mserd	msecomb2	cercomb2	mserd	msecomb2	cercomb2
	labour)	2	1.112*	1.036	1.109*	7.561	7.394*	13.35
Perennial	**Log (horticulture income)**	1	0.426	0.425	0.553*	4.073**	3.924**	5.990**
		2	0.416	0.412	0.462	6.666*	5.771*	15.17
	Log (horticulture harvest)	1	1.875	1.872	1.087	11.79	11.47	10.29
		2	2.386	2.379	1.208	14.9	14.46	13.28
	Log (horticulture sales and home consumption)	1	2.048	2.041	1.444	13.17	12.99	12.14
		2	2.489	2.478	1.348	16.95	14.41	15.71
	Log (horticulture sales)	1	3.034	2.989	2.871	21.23	17.32	16.68
		2	3.002	2.976	3.11	24.11	22.67	22.82
	Log (horticulture home consumption)	1	2.348	2.459*	2.536	16.03	17.18	15.77
		2	2.471	3.108*	2.834	20.79	22.48	26.17
	Log (horticulture hired labour)	1	0.576	0.574	0.583	3.889	3.893	3.664
		2	0.625	0.627	0.802	5.201	4.875	9.519

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A21: Impact of the horticulture-finance interventions on household assets

Assets-related Indicators	polynomial order	Treatment 1: Selected Idea (sharp RRD)			Treatment 2: Matching Grant (fuzzy RRD)		
		Bandwidth			Bandwidth		
		mserd	msecomb2	cercomb2	mserd	msecomb2	cercomb 2
Overall assets index	1	0.32	0.249	0.346*	1.925	1.552	2.151*
	2	0.410*	0.417*	0.659***	2.142	2.14	5.435
Durable assets index	1	0.834***	0.382	0.737***	2.295	1.868	3.348
	2	0.946**	0.959**	1.708***	2.59	2.563	8.512
Housing index	1	0.016	0.0167	0.0669	0.272	0.299	0.456
	2	0.0244	0.0192	0.199	0.151	0.159	1.214
Livestock assets index	1	0.0825	0.103	-0.00253	1.493	1.478	1.079
	2	-0.072	-0.0719	-0.249	2.206	2.298	0.616
Productive assets index	1	0.492**	0.544**	0.576**	2.927*	3.208*	3.300*
	2	0.717**	0.620**	0.711**	4.669*	4.180*	7.001

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A22: Impact of the horticulture-finance interventions on poverty measures

	Resilience-related Indicators	polynomial order	Treatment 1: Selected Idea (sharp RRD)			Treatment 2: Matching Grant (fuzzy RRD)		
			Bandwidth			Bandwidth		
			mserd	msecomb2	cercomb2	mserd	msecomb 2	cercomb 2
Income based indicators	Above poverty line (1.9 $)	1	0.0399	0.0374	0.0338	0.548	0.401	0.289
		2	0.0366	0.0458	-0.156	0.444	0.454	-0.649
	Above poverty line (1.25 $)	1	0.0423	0.0444	0.0332	0.433	0.308	0.22
		2	0.0803	0.0811	-0.0791	0.499	0.465	-0.213
	Above poverty line (1 $)	1	0.015	0.00761	-0.00792	0.0849	0.0829	0.0288
		2	0.0254	0.0219	-0.17	0.144	0.122	-1.411
	Above 40th percentile (Total Income)	1	-0.0172	-0.0431	-0.113	-0.541	-0.544	-0.665
		2	-0.206	-0.205	-0.204	-1.037	-1.01	-1.645
	Above 60th percentile (Total	1	-0.14	-0.138	-0.207	-0.645	-0.57	-0.956

	Resilience-related Indicators	polynomial order	Treatment 1: Selected Idea (sharp RRD)			Treatment 2: Matching Grant (fuzzy RRD)		
			Bandwidth			Bandwidth		
			mserd	msecomb2	cercomb2	mserd	msecomb 2	cercomb 2
	Income)	2	-0.326	-0.312	-0.531	-1.607	-1.471	-4.365
Income based indicators	Above 40th percentile (Overall asset index)	1	0.244	0.283	0.298	1.871	1.654	1.811
		2	0.306	0.313	0.257	3.264	3.139	3.848
	Above 60th percentile (Overall asset index)	1	0.137	0.12	0.186	0.905	0.69	0.95
		2	0.218	0.218	0.349	1.366	1.385	4.247
	Above 40th percentile (Durable asset index)	1	0.231	0.184	0.272	1.332	0.886	1.249
		2	0.342	0.344	0.387	2.886	2.713	4.989
	Above 60th percentile (Durable asset index)	1	0.417***	0.322**	0.537***	1.906 *	1.486*	2.086**
		2	0.716***	0.722***	1.091***	3.997	3.923	10.08
	Above 40th percentile (Productive asset index)	1	0.366*	0.336*	0.361*	2.011	1.884	2.05
		2	0.404	0.404	0.0231	3.679	3.792	1.088
	Above 60th percentile (Productive asset index)	1	0.456***	0.455***	0.396***	2.505 **	2.267*	2.404*
		2	0.560***	0.525***	0.545***	3.257 *	2.494*	3.713
	Above 40th percentile (Livestock asset index)	1	-0.12	-0.0467	-0.138	-0.394	-0.223	-0.832
		2	-0.108	-0.0876	-0.259	-0.434	-0.458	-1.667
	Above 60th percentile (Livestock asset index)	1	-0.256	-0.227	-0.339	-0.798	-0.686	-1.342
		2	-0.353	-0.349	-0.560*	-1.798	-1.349	-5.781
	Above 40th percentile (Housing asset index)	1	-0.0534	-0.0322	-0.0586	-0.052 5	-0.0162	-0.123
		2	-0.313	-0.282	-0.268	-1.706	-1.709	-2.287
	Above 60th percentile (Housing asset index)	1	-0.0406	-0.0369	-0.0666	-0.153	-0.0654	0.152
		2	-0.111	-0.111	-0.0723	-0.602	-0.526	-0.155

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A23: Impact of the horticulture-finance interventions on resilience measures

	Resilience-related Indicators	polynomial order	Treatment 1: Selected Idea (sharp RRD)			Treatment 2: Matching Grant (fuzzy RRD)		
			Bandwidth			Bandwidth		
			mserd	msecomb2	cercomb 2	mserd	msecomb2	cercomb 2
	Resilience index 1	1	-0.0116	-0.0204	-0.0201	-0.0204	-0.0198	-0.0118
Overall		2	-0.0274	-0.0271	-0.0196	-0.0139	-0.0144	-0.0009
	Resilience index 2	1	-0.0205	-0.0314	-0.0324	-0.0201	-0.0239	-0.0159
		2	-0.0373	-0.037	-0.0326	-0.0216	-0.0234	-0.0043
	Ability to recover (total)	1	-0.277	-0.399	-0.376	-0.365	-0.340	-0.217
		2	-0.517	-0.513	-0.356	-0.200	-0.209	0.00668
	Ability to recover (mean)	1	-0.0116	-0.0204	-0.0201	-0.0204	-0.0198	-0.0118
		2	-0.0274	-0.0271	-0.0196	-0.0139	-0.0144	-0.0009
Drought	Resilience index 1	1	-0.321	-0.297	-0.285	-0.0344	-0.0385	-0.0372
		2	-0.346	-0.341	-0.298	-0.0901	-0.0998	0.00109
	Ability to recover	1	-0.331	-0.307	-0.280	-0.0405	-0.0438	-0.0296
		2	-0.354	-0.35	-0.304	-0.0772	-0.0851	0.0148
Irregular Rains	Resilience index 1	1	0.00191	7.56E-05	-0.0458	-0.0674	-0.0658	-0.0511
		2	-0.0928	-0.093	-0.181	-0.0537	-0.0971	-0.0637
	Ability to recover	1	-0.006	-0.00862	-0.0442	-0.0823	-0.0808	-0.0512
		2	-0.0981	-0.0982	-0.176	-0.0676	-0.11	-0.0503
Crop Pests or Disease	Resilience index 1	1	0.0285	3.16E-02	0.0457	0.131	0.102	0.159
		2	0.06	0.0645	0.0832	0.141	0.153	0.168
	Ability to recover	1	0.0282	0.0312	0.0458	0.135	0.101	0.161
		2	0.0601	0.0645	0.0834	0.134	0.148	0.171

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A24: Horticulture-finance impacts on household food insecurity and household dietary diversity

Food-related Indicators	polynomial order	Treatment 1: Selected Idea (sharp RRD)			Treatment 2: Matching Grant (fuzzy RRD)		
		Bandwidth			Bandwidth		
		mserd	msecomb2	cercomb 2	mserd	msecomb2	cercomb 2
FIES Index	1	-0.608	-0.617	-1.127	-4.349	-4.412	-5.528
	2	-1.024	-1.036	-2.213	-5.436	-4.555	-6.689
Dietary Diversity Score (7 days)	1	2.075	2.378*	2.542*	13.56	12.67	13.84
	2	2.092	2.121	2.364	15.32	15.47	33.79
Dietary Diversity Score adjusted (7 days)	1	8.107	8.201	9.592	51.78	52.08	42.99
	2	7.493	7.541	9.542	60.11	67.65	48.77
Dietary Diversity Score (24 hours)	1	0.432	0.43	1.208	2.85	2.744	5.316
	2	1.232	1.239	2.002	4.275	4.475	18.47

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A25: Heterogeneous impacts of the horticulture-finance interventions (by land size)

Treatment 1: Selected Idea (sharp RRD)	polynomial order	<= 5 Hectares (68 percent of the sample)			> 5 Hectares (32 percent of the sample)		
		Bandwidth			Bandwidth		
		mserd	msecomb2	cercomb2	mserd	msecomb2	cercomb2
Log (horticulture income)	1	0.24	0.214	0.0387	2.222***	2.218***	2.420***
	2	0.0351	0.0356	0.0464	2.866***	2.930***	2.134***
Log (horticulture harvest)	1	-0.718	-0.815	-2.564	14.68***	13.87***	14.95***
	2	-2.04	-2.024	-1.601	16.50***	16.54***	17.79***
Log (horticulture sales and home consumption)	1	-0.772	-0.822	-2.979	14.81***	14.41***	15.25***
	2	-2.071	-2.06	-1.998	16.62***	16.65***	17.48***
Log (horticulture sales)	1	-0.592	-0.678	-2.203	15.45***	13.91***	14.89***
	2	-2.154	-2.146	-1.063	16.84***	16.85***	17.55***
Log (horticulture home consumption)	1	0.898	0.844	-0.13	11.59***	11.60***	11.72***
	2	2.093	2.177	4.343*	11.81***	13.28***	11.85**
Log (seasonal horticulture income)	1	0.111	0.113	0.0193	2.318***	2.312***	2.370***
	2	0.198	0.2	0.0602	2.783***	2.785***	2.588**

Treatment 1: Selected Idea (sharp RRD)	polynomial order	<= 5 Hectares (68 percent of the sample)			> 5 Hectares (32 percent of the sample)		
		Bandwidth			Bandwidth		
		mserd	msecomb2	cercomb2	mserd	msecomb2	cercomb2
Log (seasonal horticulture harvest)	1	-0.615	-1.091	-0.699	12.03***	11.87***	13.12***
	2	2.692	2.715	2.955	14.35***	13.31***	17.43***
Log (seasonal horticulture sales and home consumption)	1	-0.641	-1.071	-0.701	12.22***	12.13***	13.64***
	2	2.352	2.366	2.746	14.43***	14.50***	14.88***
Log (seasonal horticulture sales)	1	-0.231	-0.72	-0.56	11.54***	11.45***	12.17***
	2	1.909	1.923	1.947	14.71***	14.60***	13.64***
Log (seasonal horticulture home consumption)	1	1.355	1.464	1.669	9.553***	9.557***	9.771***
	2	3.474*	3.477*	0.597	9.045***	9.043***	9.192***
Overall asset index	1	-0.257	-0.272	-0.153	0.896***	0.886***	0.994***
	2	0.212	0.219	0.649	0.987***	0.969***	1.175***
Durable asset index	1	-0.414	-0.469	-0.228	1.304**	1.250**	1.298**
	2	0.578	0.592	1.494	1.102*	1.120*	1.248*
Productive asset index	1	-0.0241	-0.0448	-0.105	1.566**	1.560**	1.628***
	2	0.253	0.245	0.151	1.864**	1.903**	2.259*

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A26: Heterogeneous impacts of the matching grant by land size

Treatment 2: Grant (fuzzy RRD)	polynomial order	<= 5 Hectares (68 percent of the sample)			> 5 Hectares (32 percent of the sample)		
		Bandwidth			Bandwidth		
		mserd	msecomb2	cercomb2	mserd	msecomb2	cercomb2
Log (horticulture income)	1	2.411	2.241	2.258	17.68	14.46	18.67
	2	7.695	7.694	5.105	44.26	23.65	23.35
Log (horticulture harvest)	1	-0.384	-0.802	-3.587	93.71	79.01	114.7
	2	2.461	2.613	4.59	88.96	81.07	314.7
Log (horticulture sales and home consumption)	1	0.694	0.521	-5.499	99.79	80.44	111.8
	2	4.478	4.714	-1.053	86.84	80.99	314.2

Treatment 2: Grant (fuzzy RRD)	polynomial order	<= 5 Hectares (68 percent of the sample)			> 5 Hectares (32 percent of the sample)		
		Bandwidth			Bandwidth		
		mserd	msecomb2	cercomb2	mserd	msecomb2	cercomb2
Log (horticulture sales)	1	-1.021	-1.768	-3.614	101	84.92	119.4
	2	2.329	2.527	3.692	91.45	84.28	323.9
Log (horticulture home consumption)	1	8.93	9.421	6.456	67.72*	67.81*	81.18
	2	31.31	30.16	34.63	104.2	69.62	232.4
Log (seasonal horticulture income)	1	0.211	0.85	0.318	25.28	18.76	25.72
	2	1.589	1.623	0.892	50.12	50.49	108.6
Log (seasonal horticulture harvest)	1	0.535	-5.552	-1.894	72.41	65.52*	85.09
	2	20.03	20.29	14.68	75.19	88.28	306.9
Log (seasonal horticulture sales and home consumption)	1	0.113	-6.03	-2.302	76.13	69.12*	87
	2	14.27	14.42	14.4	74.77	84	311.3
Log (seasonal horticulture sales)	1	0.286	-3.386	-1.635	65.89	61.10**	78.93
	2	11.27	11.45	8.346	76.85	102.7	126.1
Log (seasonal horticulture home consumption)	1	11.19*	11.03*	9.118	60.36	57.45	66.23
	2	30.51	30.29	3.374	70.96	70.34	74.23
Overall asset index	1	-1.139	-1.29	-0.712	7.601	7.475	9.364
	2	-0.656	-0.553	1.435	6.537	6.526	22.42
Durable asset index	1	-1.993	-2.111	-0.788	9.073	7.946	9.226
	2	0.169	0.199	4.446	7.375	7.249	25.71
Productive asset index	1	0.0373	-0.109	-0.375	9.482*	9.554*	10.12
	2	1.61	1.693	0.38	11.05	13.05	31.14

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A27: Heterogeneous impacts of the horticulture-finance interventions (by poverty status)

Treatment 1: Selected Idea (sharp RRD)	polynomial order	Below poverty line (1.25 US$)			Above poverty line (1.25 US$)		
		Bandwidth			Bandwidth		
		mserd	msecomb2	cercomb2	mserd	msecomb2	cercomb2
Log (Horticulture Income)	1	-0.117	-0.0669	0.154	1.430***	1.392***	1.497***
	2	0.0117	0.00896	0.0751	1.804***	1.807***	1.790***
Log (Horticulture Harvest)	1	-1.706	-2.287	-0.501	8.351***	8.346***	8.158***
	2	-0.159	-0.06	-2.046	9.432**	9.449**	8.596*
Log (Horticulture Sales and Home Consumption)	1	-1.73	-2.25	-0.57	8.296***	8.287***	7.997***
	2	-2.398	-0.105	-1.327	9.377**	9.392**	8.644**
Log (Horticulture Sales)	1	-1.783	-2.196	-0.575	8.426***	8.418***	8.159***
	2	-0.677	-0.0178	-1.344	8.971**	8.996**	9.010**
Log (Horticulture Home Consumption)	1	2.179	1.999	2.255	5.376**	5.400**	5.838***
	2	6.413**	6.027**	6.121**	7.728**	7.740**	4.927
Log (Horticulture Income)-seasonal	1	-0.238*	-0.0691	0.149	1.064***	1.063***	1.042***
	2	0.405	0.416	0.446	1.203**	1.203**	0.91
Log (Horticulture Harvest) -seasonal	1	-3.414*	0.631	0.105	4.475**	4.471**	4.441**
	2	4.061	4.097	2.218	4.898	4.898	5.235
Log (Horticulture Sales and Home Consumption)-seasonal	1	-3.094	0.167	0.316	4.441*	4.439*	4.378*
	2	4.47	4.493	2.104	4.96	4.96	5.259
Log (Horticulture Sales))-seasonal	1	-2.211	0.501	0.693	4.051*	4.278*	3.705*
	2	6.044	6.04	3.947	4.45	4.46	5.401*
Log (Horticulture Home Consumption))- seasonal	1	-2.112	-1.043	-0.0348	3.679***	3.349**	3.665***
	2	0.694	4.587*	1.043	4.154	4.155	0.261
Overall Assets Index	1	0.956***	0.837***	1.220***	0.101	0.00449	0.144
	2	1.173***	1.102***	1.492***	0.0837	0.0858	0.508
Durable Assets Index	1	1.916**	1.356**	1.778**	0.158	-0.00624	0.423
	2	2.238**	1.989**	2.745***	0.00754	0.0215	0.69
Productive Assets Index	1	0.785***	0.777***	0.910***	0.369	0.395	0.535*
	2	0.787*	0.792*	0.727*	0.824*	0.637*	0.955**

Significance levels: *** p<0.01, **p<0.05, *p<0.1

Table A28: Heterogeneous impacts of the matching grant (poverty status)

Treatment 2: Grant (fuzzy RRD)	polynomial order	Below poverty line (1.25 US$)			Above poverty line (1.25 US$)		
		Bandwidth			Bandwidth		
		mserd	msecomb2	cercomb2	Mserd	msecomb2	cercomb2
Log (Horticulture Income)	1	0.852	0.904	5.364	6.992**	6.911**	6.139**
	2	14.29	14.82	-1.038	10.20*	10.32*	8.249
Log (Horticulture Harvest)	1	-6.015	-2.809	1.601	42.20**	42.36**	38.20**
	2	0.641	-0.162	21.13**	59.26	58.84	50.63*
Log (Horticulture Sales and Home Consumption)	1	-3.698	-3.978	29.33	41.38*	41.82*	37.63**
	2	-0.629	-4.995	22.64**	59.24	58.6	51.82
Log (Horticulture Sales)	1	-4.256	-4.542	24.92	43.33**	43.60**	38.15**
	2	-0.891	-3.697	21.77**	60.45*	59.83	49.65
Log (Horticulture Home Consumption)	1	14.66	14.91	18.73	32.48*	29.73*	28.07**
	2	457.8	289.5	-6.805	48.06*	48.50*	27.66
Log (Horticulture Income)-seasonal	1	0.794	1.585	-0.259	4.262	4.371	2.473
	2	76.41	81.99	-1.749	6.866	6.867	1.182
Log (Horticulture Harvest) -seasonal	1	-13.41	15	14.15	24.65	24.59	20.18
	2	5,743	130.4	10.17	28.56	28.4	29.12
Log (Horticulture Sales and Home Consumption)-seasonal	1	0.128	14.59	10.47	24.4	24.02	19.55
	2	69,814	77.97	8.482	28.42	28.32	28.81
Log (Horticulture Sales))-seasonal	1	5.759	13.03	15.38	24.64	24.97	19.19
	2	282.5	212.6	8.822	25.87	25.87	26.49
Log (Horticulture Home Consumption))- seasonal	1	2.716	8.895	-0.037	19.68**	21.22**	15.34*
	2	406.9	220.6	4.213	28.41	28.52	5.967
Overall Assets Index	1	313.6	7.509	-11.52	0.764	0.677	1.267
	2	1.196	32.21	-1.542	1.12	0.952	1.148
Durable Assets Index	1	227.4	10.07	-28.36	0.527	0.415	1.42
	2	-0.409	37.08	-3.233	0.675	0.726	1.63
Productive Assets Index	1	6.46	6.485	-45.07	2.086	2.222	2.715
	2	8.516	8.425	-0.526	2.973	3.019	4.184

Significance levels: *** p<0.01, **p<0.05, *p<0.1

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