An Assessment of Experimental Evidence in the Coffee Sector*

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Abstract

Most coffee farmers are smallholders and about half of them live below the international poverty line of US$3.20 a day. These farmers are highly reliant on coffee as a source of primary income but face unique challenges in improving production and productivity. Several interventions and programs, aimed at enhancing productivity, profitability, and farmers' income, have been rolled-out in agriculture, in general, and in the coffee sector, in particular. However, very few of these have been rigorously evaluated. This paper aims to provide a comprehensive assessment of the effects of different interventions, primarily from field experiments, and highlight under which conditions and where these have been most successful in improving coffee farmer productivity and income. The paper concludes with policy implications and some potential directions for future research.

Keywords: coffee, evaluations, RCTs, natural experiments, economic development

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1. Introduction

Agricultural development remains the cornerstone of the fight against global poverty (Caldwell et al., 2019). Among the agricultural products, coffee is one of the most important, being the most valuable agricultural export for several developing countries and the primary source of income for approximately 12.5 million farmers worldwide. At least 5.5 million of these farmers live however below the international poverty line of $3.20[4] a day, with the highest levels of poverty observed in Africa and Oceania, and about 95% of coffee farmers are "smallholder."[5] Most of these rely heavily on coffee for their livelihoods but face unique challenges in improving production and productivity.

Several interventions and programs—such as extension services, fertilizer subsidies, and training—have been rolled-out in agriculture, in general, and in the coffee sector, in particular. However, very few of these have been rigorously evaluated. Recent literature has already attempted to document whether and how, and under which conditions, these can enhance productivity, profitability, and eventually farmers' income (Magruder, 2018). Evidence from field experiments in Kenya, for example, finds that following the official seed and fertilizer recommendations from the Ministry of Agriculture would maximize yields, but may not be profitable for many of the country's maize farmers (Duflo et al. 2008). Also, experiments on the impact of a microcredit program in Morocco find that when given access to micro-loans farmers increase their investment in self-employment activities and see an increase in profits, but they do not see any effect on overall income and the take-up of the program was quite low (Crepon et al., 2015).

Despite its relevance, to date, there is a lack of a systematic review of the programs and interventions in the coffee sector. The paper aims to fill this gap and provide a comprehensive assessment of the experimental, namely randomized controlled trials (RCTs), and quasi-experimental studies along the coffee value chain.[6] When it comes to impact evaluation techniques, RCTs are considered the gold standard. This is a type of experimental design where individuals or units are randomly assigned to treatment and control groups. The effect of the intervention can then be measured by comparing the outcomes of the treatment group to the control group. However, since these controlled experiments are not always possible, researchers often resort to the use of a quasi-experimental design, which attempts to mimic an experimental research design to estimate the causal impact of an intervention but without random assignment, as it relies

[4] Publisher's Note: All dollar amounts referenced in this report are for US dollars unless otherwise noted.
[5] According to Enveritas, 21% of the world's coffee is produced on estates and large farms over 50 hectares, 19% comes from estates and farms between 5 and 50 hectares, and the remaining 60% comes from smallholder coffee farmers with less than 5 hectares.
[6] We exclusively focus on quasi-experimental studies and RCTs to guarantee a minimum level of rigorousness.

on observational data. Two such main techniques are widely used. First, Difference-in-Differences (DiD), which is a method that compares the change in outcomes for the treatment group to the change in outcomes for a control group over time (Card and Krueger, 1994). Intuitively, absent treatment, groups receiving treatment would have experienced the same changes in outcomes that groups receiving control actually experienced. This is a cost-effective approach for evaluating the impact of interventions, as it does not require randomization or the collection of pre-intervention data, but it is limited to interventions that have a pre-post design, where the intervention occurs at a specific point in time. Second, Regression Discontinuity Design (RDD), is a quasi-experimental design that aims to determine the causal effects of interventions by assigning a cutoff or threshold above or below which an intervention is assigned. By comparing observations lying closely on either side of the threshold, it is possible to estimate the average treatment effect in environments in which randomization is unfeasible. RDDs offer the key advantages that the identifying assumptions can be especially transparently tested and arguments can be visibly supported by informative plots of the data. The main drawback of the design is a potentially low external validity because causal identification is highly local (Abadie and Cattaneo, 2018).

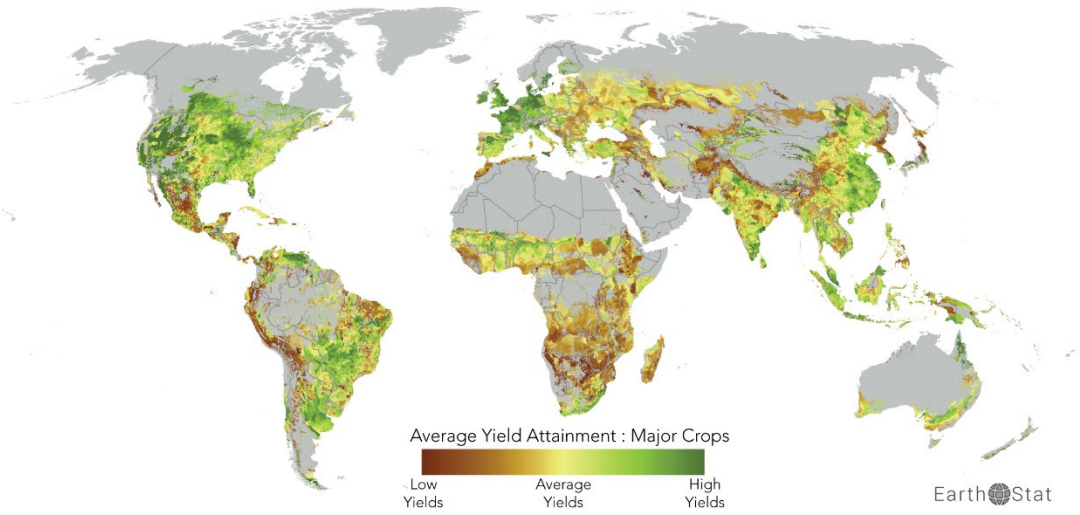
To build the largest possible database of existing evidence, we rely on two main sources: EconLit, which provides a comprehensive library of economics literature, covering all research articles published over the last 130 years from leading institutions in 74 countries, and the American Economic Association's (AEA) RCTs registry, which is a central registry established in April 2012 on which trials are recorded according to their status, i.e., as on-going, complete, or withdrawn. We also source documents from the ATAI policy insights, the J-PAL, and the International Growth Centre.

In this paper, we provide a background on productivity and income in Section 2. Section 3 reviews recent results, with experimental or quasi-experimental designs, on the effects of different interventions in the coffee sector. Section 4 expands and reviews programs and interventions in the agricultural sector, and highlight under which conditions and where these have been most successful in improving farmer productivity and income. Finally, Section 5 concludes with some policy recommendations and potential directions for future research.

2. Background: Agricultural Productivity and Income

Agricultural productivity differences are large. Figure 1 shows the map of average aggregate yield attainment for 17 major world crops. By measuring, on average, how crop yields compare to other regions growing that same crop under similar climatic conditions, it shows that there are enormous productivity differences, both across and within countries.

Figure 1. Global productivity differences



Note: Attainable yields are derived from comparison to other farmers growing that crop in areas of similar climate. For each crop, individual climate bins cover equal harvested areas (Mueller et al., 2012).

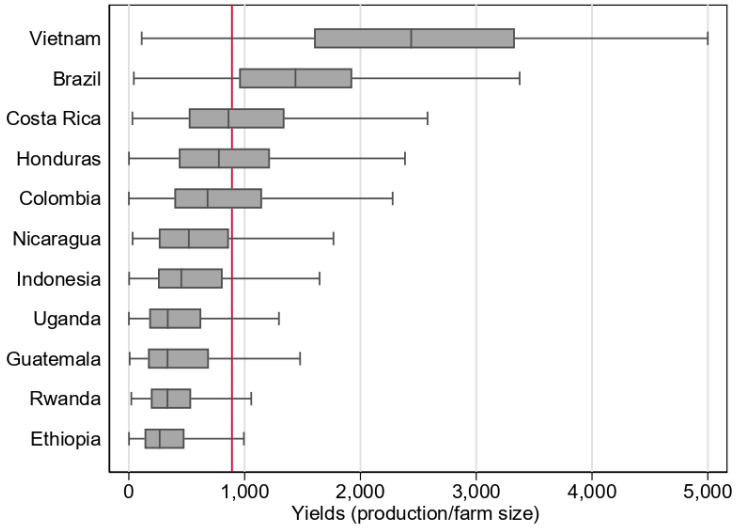
Global agricultural productivity can vary greatly due to several factors, such as climate, soil quality, technological advancements, and access to resources like water and fertilizers. There are two possible broad explanations for the large agricultural productivity dispersion across countries. The first is the economic choices made by countries in agriculture, which can be influenced by a range of institutions, constraints, frictions, and policies. The second is the natural endowments of a country, such as land quality, geography, and climate, which can affect its potential for agricultural productivity. While there is evidence of considerable heterogeneity in land quality, even within narrow geographic regions, recent literature has shown that low agricultural productivity is not due to unfavorable geographic endowments but, rather, to economic choices made by farmers (Adamopoulos and Restuccia, 2022). As a consequence, to address these differences and promote sustainable agriculture, countries need to invest in practices that can improve yield, as well as support the development and adoption of modern farming technologies.

More importantly, there is ample evidence that agricultural productivity differences can largely explain the cross-country income per capita dispersion (Caselli 2005, Restuccia and Rogerson, 2017). Poverty reduction, where it has happened, has been more effective through productivity growth where the poor work (in agriculture and rural areas) than through structural transformation (de Jainvry and Saudolet, 2020). Therefore, understanding this is a fundamental issue on both the policy and the research agenda.

Within these broader patterns, coffee is no exception. Thus, there is significant yields dispersion both *across* and *within* coffee-producing countries. Figure 2 shows coffee productivity, measured as the production in kilos of green coffee over farm size in hectare,

in eleven coffee-producing countries, that account for about 85% of the world's coffee production for 2018 and 2019 (ICO, 2019).[7]

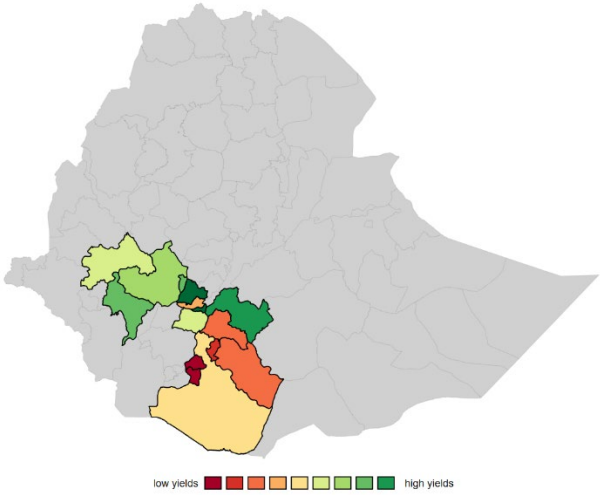
Figure 2. Coffee productivity by country



Source: Blouin, Cervone, Del Prete, and Macchiavello (2022) based on Enveritas data

Ethiopia is the least productive country in this sample, with only an average of 250 kg of green coffee per hectare, and yet, even within this country, some farmers produce 100 kg and others 500 kg of green coffee per hectare (Figure 3). Therefore, there are large benefits to increase productivity even within the least productive countries.

Figure 3. Coffee productivity dispersion in Ethiopia



[7] These data are sourced from Enveritas, which employs a statistically robust approach to sampling and data quality monitoring - from geospatial analysis to on-the-ground observations – to collect large nationally representative repeated cross-sectional farmers' surveys, providing detailed geo-referenced information on farm-gate prices, quantities, type of coffee sold, inputs, farm size, ownership, and a large array of managerial/technical practices.

Source: Blouin, Cervone, Del Prete, and Macchiavello (2022) based on Enveritas data

3. Evidence in the Coffee Sector

In this section, we review the literature that was conducted specifically in the coffee sector. As mentioned before, to ensure a minimum level of rigor in our analysis, the studies reviewed here are either experimental or quasi-experimental studies. It is important to note first that such studies are limited. We were able to identify only eight studies in the sector that meet our criteria. Of the studies that were conducted, each one aims to establish the effect or the lack-of of different types of interventions such as information and training, cash transfers, Voluntary Sustainability Standards (VSS), and bundled programs. Table 1 provides a summary of the eight studies reviewed in this paper.

Table 1. Studies on Coffee Sector

S.No	Author	Title	Year	Country	Intervention	Method	Outcome
1	Abate, G. T., Bernard, T., Regassa, M. D., & Minten, B.	Improving coffee productivity in Ethiopia: The impact of a coffee tree rejuvenation training program on stumping	2021	Ethiopia	training program	DiD	•stumping increased
2	Duflo, E., Keniston, D., Suri, T., Zipfel, C.	Chat Over Coffee? Technology Diffusion Through Social and Geographic Networks in Rwanda	2020	Rwanda	training program	RCT	•increased knowledge of ag practices • no effect on adoption of practices •no evidence of information diffusion
3	Harigaya, T., V. Hoffmann and Kremer M.	UgandaCoffee Agronomy Training Impact Evaluation	2022	Uganda	mobile phone-based extension service	RCT	Study ongoing
4	GiveDirectly	Cash crop: evaluating large cash transfers to coffee farming communities in Uganda	2019	Uganda	cash transfer	RCT	•higher consumption • higher revenues driven by non-coffee sources
5	Neilson, J., Toth, R., Sari, N., Bray, J., Donoghue, M., Arifin, B., & Ismono, H.	Evaluation of the Impacts of Sustainability Standards on Smallholder Coffee Farmers in Southern Sumatra, Indonesia.	2019	Indonesia	4C certification	DiD	•higher income level •no effect on mgt practices and yield
6	Dragusanu, R., Montero, E., & Nunn, N.	The effects of Fair Trade certification: evidence from coffee producers in Costa Rica.	2022	Costa Rica	fair trade certification	DiD	•higher prices, sales and revenues at mill level •higher income to farm owners - redistribution of rents capttured by intemediaries
7	Macchiavello, R., & Miquel-Florensa, J.	Buyer-Driven Upgrading in GVCs: The Sustainable QualityProgram in Colombia.	2019	Colombia	Sustainable Quality Program		•upgrade plantations •increase quality •higher price
8	Abouaziza, M., Macchiavello, R. and Steenkamp, I.	Building and Managing Relationships with Farmers: Evidence from the Rwanda Coffee Sector	2022	Rwanda	farmer development programme	RCT	Study ongoing

In the following subsections, we will dive into the details of each of these studies to understand what worked, what didn't, and why. Programs and interventions are classified into four groups: training, cash transfer, certification, and buyer-driven programs. The review will be structured such that each section tackles one of the four intervention groups.

3.1. Training

Information and communication are crucial to agriculture. Timely and accurate information on good agricultural practices, planting strategies, inputs, and prices can help farmers maximize yields and profits, and cope with changes in weather and soil conditions or pest and disease epidemics (Deichmann et al., (2016)). The value of information and techniques for information diffusion are, therefore, widely studied in the context of agriculture. Two such studies assess the role of information, particularly in the adoption of good agriculture practices in coffee cultivation these are Abate et al. (2021) and Duflo et al. (2020). In both studies, the authors collaborate with a private partner called TechnoServe to deliver training sessions to farmers.

In Abate et al. (2021) the training program is rolled out to farmers in five districts of Ethiopia over two cohorts. All coffee farmers were eligible to participate in the program and the participation itself was voluntary. To assess the impact of the training program the authors adopt two identification strategies. The first is a DiD estimate that compares participating and non-participating farmers pre- and post-treatment. This, however, does not control for selection bias. To address the bias, the second analysis adopted by the authors compares the participating farmers' post-treatment outcomes in cohort 1 to the pre-treatment variables of the participating farmers in cohort 2. Since the latter analysis cannot account for program placement bias, the two analyses are complementary to each other. The authors find that just one year after the training, there was a 15-19 pp in the share of farmers adopting stumping and a 3 pp increase in stumped trees. The authors however only study the short-term impacts of the program and do not study the potential effects on the yields.

While the above result seems positive, Duflo et al. (2020) who study the impact of TechnoServe trainings on coffee farmers in Rwanda, find more tempered results. In this study, 50% of all farmers who applied to be a part of the training program were randomly selected into the program and considered the treatment group. The 50% of farmers who applied but were not trained formed the control group. The authors also vary treatment intensity by village – in a third of the villages 25% of the farmers are treated, in a third 50%, and the rest 75%. As opposed to Abate et al (2021), the authors here test for a broader range of agricultural practices including pruning, mulching, and pest and disease management among other things. The authors find that the training improved the knowledge and self-reported adoption of agricultural practices significantly,

and improved the use of fertilizers and higher investments in labor. However, there was no statistically significant impact on the adoption rates of agricultural practices when measured through plot visits. Additionally, though yields improved by 7%, the authors speculate that this may be due to negative spillovers on control group farmers discussed below.

The discussed results in both studies measure the direct impact of the training program on the treated group. However, even when it leads to positive outcomes in adoption, conducting training sessions may prove to be quite an expensive way to provide information to farmers and therefore, has limited scalability. Casaburi et al., 2019, for example, note that not only is hiring extension workers to train farmers expensive, but high farmer-worker ratios and the difficulty in monitoring workers make it particularly inefficient for information dissemination. Therefore, the question of whether the effect of training has spillovers to non-treated farmers has implications for the cost-effectiveness of training programs. In other words, if farmers who are not-trained learn from trainings attended by other farmers in their network, even training a few farmers could lead to significant positive impacts on even the non-treated farmers.

In Duflo et al. (2020), the authors answer exactly this question. They study whether there is any diffusion of the training from treated to control farmers and spillovers. Firstly, through a social networks analysis, the authors find that having more treated friends at baseline did not generate any effect on the adoption rates of control group farmers. Similarly, they find no effects along geographic networks. Comparing the control group farmers in villages with different treatment concentrations, the authors find evidence of negative spillovers to farmers in high-treatment concentration villages. Two explanations are given for these results. The first is that when the information delivered is complex, not only is it harder to pass on, but the knowledge does not translate into adoption either. Further, when treated farmers do not see big returns to adoption, they are less likely to pass on the information to others and in fact might even spread the word that the practices did not work, leading to negative spillovers in the control group. The second explanation is that the increase in fertilizer and hired labor use among treated farmers led to lower access of these for control group farmers in a resource-constrained setting. The authors conclude that in such settings, it is input and labor that is the binding factor in the take-up of adoption practices rather than information.

To summarise, we saw that training sessions led to increased adoption of stumping in Ethiopia. In Rwanda, however, the training sessions did not lead to increased adoption of rates of various practices like pruning, mulching, and stumping. Further, the evidence from Duflo et al. (2020), suggests that complex information—such as about agricultural practices—does not diffuse to farmers who are not directly trained. Finally, in the latter study, the authors also highlight that information by itself would not lead to improved outcomes when farmers face other binding constraints such as resources and labor.

Given these mixed results of training on the adoption of yield-enhancing practices and yields, it would be interesting to see the outcomes of the ongoing experiment in Uganda being conducted by Harigaya et al. (2022). They study the effects of in-person and mobile phone-based training on coffee yield per tree. The effect on coffee agronomy knowledge, gross coffee profit, household labor days spent on coffee, non-coffee income, income controlled by women, and the diversity and amount of food crops grown will also be studied as secondary outcomes.

3.2. Cash Transfer

As seen in the previous section, farmers face multiple binding constraints, including resource constraints. When addressing resource constraints, direct cash transfers to recipients rather than in-kind offerings or subsidies have proved to be quite impactful. An ODI report (2016) reviews a large literature on cash transfers and finds that cash transfers have wide-ranging impacts on reducing monetary poverty, improving education, health, and women's empowerment. More relevant to our study, the ODI report highlights that several studies have found positive impacts of cash transfers on agricultural investments towards inputs as well as the accumulation of agricultural productive assets.

Whether the benefits of cash transfer apply to coffee cultivation is the question answered in the impact evaluation study by GiveDirectly (2019). They study the effects of an unconditional cash transfer program in Uganda. GiveDirectly enrolled 3,415 households in 44 villages across four sub-counties in Iganga District. Households were targeted based on poverty, using an index relying on households' land and asset ownership. About 30% of the recipients reported before transfers that they had harvested coffee in one of the two previous harvest seasons. The bottom 20 percentile were automatically eligible for the program while those falling in the 20-64th percentile were randomized into treatment or control groups using matched pair randomization based on their ownership of coffee trees and level of coffee production. Each of the eligible households was given a $1000 cash transfer over three installments. The authors found that overall consumption and welfare measures improved with no significant differences between coffee and non-coffee farmers. For coffee farmers, investments improved (ag practices like pruning (+25%), stumping (+47%), mulching (+100% from a low base), and weeding (+23%) coffee trees. Investment in new land, sacks, pesticide, fertilizer, and coffee transportation all rose but – except for investment in new land (+$56 PPP) – these statistically significant changes were small in absolute magnitude: all were under $1 PPP per coffee farming household showing that farmers chose to spend the majority of the cash transfer on investments that were not coffee-specific.

Further, cash transfers boosted coffee sales revenue with an increase of 138% (+$17 PPP) supported by an increase in the number of coffee trees owned (likely through purchasing land with mature coffee trees) and achieving a slightly higher price for their coffee. However, the earning gains from non-coffee sources saw a greater improvement in

absolute terms for treated farmers. For example, enterprise income increased by +$235 on an annualized basis for treated coffee farmers; sales of own-produced crops per month yielded +$155 on an annualized basis; but coffee income increased only by +$33 PPP.

Therefore, the majority of investments and income gains from the GiveDirectly cash transfer program seem to be driven by non-coffee sources than coffee. This could suggest that rather than a resource constraint, it may be the lack of demand for coffee that led to low investments in this context. This is further supported by the finding from the authors that even in the treatment group, only 54% of the coffee farmers sold coffee at the endline (as opposed to just 45% in the control group).

Additionally, this type of highly subsidized intervention is quite expensive and therefore may not be scalable and sustainable. Further, even when successfully implemented, it may not lead to a proportionate increase in investment in coffee in the absence of demand as argued in the previous paragraph.

3.3. Certification

The evidence on cash transfers in the previous subsection leads us to conclude that while easing resource constraints may improve the welfare of coffee farmers, the mechanism for this improvement need not be through increased investment or productivity in coffee cultivation. This signals that even resource constraints are not binding when there is a lack of demand for the crop.

This finding resonated with the study by Neilson et al., (2020) where coffee is perceived as a resilience crop rather than a poverty alleviation investment and therefore, not a primary livelihood strategy. The authors here evaluate the effects of VSS (particularly 4C and Rainforest Alliance) adopted by producer organizations in Semendo, Indonesia. They use propensity score matching and a DiD strategy to compare treated and control farmer groups. Here, treated farmer groups were those who worked with an exporter that implemented and therefore, received 4C certification and access to a new supply chain. 4C certification implied farmers received up to 10 training sessions a year on good agricultural practices, updates on market prices, access to the supply chain, and eligibility to sell at a premium. Therefore, this program did address multiple constraints that small-holder farmers face. Control groups on the other hand comprised of farmer groups in the same region who have not received any form of exporter training or certification.

The authors find that certification led to slightly higher investment in coffee and a weakly significant positive effect of certification on coffee income mainly due to price improvements. Adoption of coffee management practices and average yields on the other hand, actually reduced among treated farmer groups.

Despite lukewarm effects on coffee outcomes, the authors find a significant increase in time invested in productive activities and total household income of treated farmer groups. Presenting evidence from ethnographic case studies, the authors argue that the income increase does not happen through the expected channel of productivity improvement of coffee cultivation. Rather, certification seemed to have increased firms' investment in training programs. These training sessions offer farmers a market channel providing farmers with avenues for social and knowledge exchange networks. The development of social capital thus seemed to reduce cash risk and enabled farmers to diversify into higher earning (but perhaps riskier) economic activities. Here, the authors highlight that for farmers in the study context, coffee is a low-input and low-risk resilience crop rather than a poverty alleviation investment. Therefore, VSS that envision coffee cultivation as high input-focused production activities are in this case at odds with the local context of farmers and do not capture what sustainability would mean in this context

However, even in contexts such as Costa Rica where coffee is an important source of livelihood, Dragusanu et al., (2022), find mixed effects of VSS—Fairtrade (FT) certification in this case. Under the Fairtrade certification program, coffee that is sold as Fairtrade certified is entitled to a guaranteed price floor—Fair Trade minimum price. Authors find that in the years where the FT minimum price is binding, FT certified mills receive higher prices for the exported coffee. They find that when the international price of regular coffee per pound is $1 lower than the FT minimum price, FT certified mills receive an export price that is 11 cents higher. If all FT coffee was sold as FT certified coffee, a price differential of $1 would give mills a $1 premium as well. The authors argue that only 11% of the price is passed on as premium shows that not all but only 11% of FT certified coffee is sold as FT. Through an event study analysis, they find positive effects of certification on prices, the quantity of coffee received, exports, sales and revenues of mills, and a decrease in the likelihood of mill exits.

The effects on farmers and households of the FT certification are more heterogeneous. Using detailed administration data on the price and premiums given to farmers by mills, the authors find a significant price transmission to coffee farm owners. They show that the income (from the higher prices alone) gains to skilled coffee workers (mainly farm owners) is significant and amounts to an average increase of 2.2% of the farmer owners' income which estimates to be about $50 - $124 per farmer. However, they find no effect on the incomes of unskilled coffee workers who tend to be hired laborers.

Non-farm workers primarily those involved in the sales, storage, transport, or processing of coffee (e.g., intermediaries, mills, and their employees) on the other hand are found to have negative impacts on their income. While not all of these non-farm workers are intermediaries, the authors show that the average income in this group is 40% greater than that of skilled coffee workers. The authors argue that the gains to skilled coffee

workers therefore are due to a redistribution from intermediaries who had previously captured rents.

While in this case, the absolute gain to farmers was sizable, this may not be true in all contexts. Running certification programs comes with several implementational challenges. As already noted by Dragusanu et al., (2022), the demand for certified coffee may not be high enough to capture all the supply or the mills may not have the required capacity to find buyers. This would mean mills have to sell certified coffee at normal market prices below the Fair Trade minimum price—89% in the case of Dragusanu et al., (2022). The amount of coffee that can be sold as FT certified coffee may be smaller in other contexts (eg., Minten et al., (2018)). Further, the operation costs of running certification programs may be sizeable, meaning that even when mills realize a premium, these do not trickle down to the farmers.

To conclude, this raises a few questions about the value and viability of VSS programs. Firstly, for it to directly boost coffee productivity, the social context needs to be such that coffee cultivation is perceived as a stable livelihood strategy worthy of investment rather than as a resilience crop. Secondly, even when it is considered a livelihood strategy if there is not enough demand for certified coffee or if mills do not have the capacity or know-how to access buyers of certified coffee then the gains of certification are reduced. Thirdly, implementing certification programs comes with significant operational costs that often erode the premiums that mills capture, resulting in meager trickledown to the producers. Buyer-driven programs reviewed in the next sub-section tackle these challenges by design by assuring demand and covering program implementation costs for mills.

3.4. Buyer-driven Programs

As discussed, buyer-driven programs might be able to tackle some of the challenges that are not addressed by certification programs. Macchiavello and Miquel-Florensa (2019) evaluate one such program—the Sustainable Quality Program rolled out by a large buyer in Colombia. The main difference between the Program here and the VSS programs like Fairtrade discussed above is that in addition to quality requirements, the Sustainable Quality Program involves contractual agreements between stakeholders at all levels along the supply chain. These contractual agreements between the exporter and buyer included provisions on protocols: a) the export gate price premium; b) the farm gate price premium; and c) a lump-sum contribution to cover the Program implementation costs. Those include costs for training, extension services, and plot renewal support offered to eligible farmers as well as to inspect farms' conditions and compliance with the Program requirements. Towards the farmer, the Program offered a fixed price at which all of the qualifying coffee would be bought.

The authors find that the Program resulted in a massive quality improvement, prices at farm-gate, labor, and land expansion. While the authors cannot unbundle the different

components of the program, comparing it to the effects of VSS, the farmers attribute the massive upgradation and efficient price transmissions to the contractual arrangements. The latter not only resolved demand with the price guarantee but also eliminate market inefficiency by creating vertical integration in the supply chain and removing double-marginalization. To establish such a program it was important for the buyer to have good relationships with the exporter and exporter to have capacity and relationships locally for implementation of the program.

In ongoing work, Abouaziza et al., (2022) delve into the latter, i.e., the relationships of the exporter with the producers. The authors study the effect of a Farmer Development Program (FDP) run by a large exporter in Rwanda. Through the FDP, the authors operationalize relationship contracts between farmers and the exporter at a large scale. The Program gives farmers clarity sessions on the two-way expectations associated with the relationship, relationship management, and access to a call center. The authors find that the FDP had positive effects on the awareness and take-up of agricultural practices, training session attendance, trust towards the Partner, and coffee deliveries.

The main emerging insights are that small-holder coffee farmers face multiple constraints, and interventions that only partially address the constraints faced by farmers do not seem to have the intended magnitude of effects. Adhering to VSS forces producer organizations to adhere to standards that may lead to productivity improvements, but the premiums realized by these standards are often too low to drive transformative outcomes. This as we have seen, is mainly due to high operational costs of compliance and demand uncertainty. Buyer-driven programs may then be the answer to make sure quality premiums are realized at all levels.

4. Evidence in the Agricultural Sector

Considering the limited research in the coffee sector, and that the few existing studies evaluate very different objects with quite mixed results, we will now broaden our search to any experimental or quasi-experimental studies in agriculture. Many of the constraints faced in coffee cultivation have been studied in the context of other crops. Therefore, the learnings from these studies may provide insights into how agricultural transformation can be driven in the coffee sector. We review 27 studies and six academic reviews. Different studies address specific constraints that farmers face. We will structure the review in this section by the type of constraint that the study addresses, namely capital and risk, information constraints, and bundles.

4.1. Capital Constraints and Risk

4.1.1. Capital

Yield-enhancing technologies such as agricultural practices and inputs like seeds, fertilizers, and pesticides could prove to be detrimental in boosting agriculture production for farmers. Despite the obvious benefits, the take-up of these technologies remains low in many developing country contexts. Various studies argue that one of the hindrances to agricultural transformation and the adoption of yield-enhancing technologies is the lack of capital and credit constraints for farmers (Beaman et al., 2015; Carter et al., 2013). Many researchers have therefore investigated the effectiveness of interventions that ease capital constraints in different contexts. The studies reviewed in this sub-section are summarised in Table 2.

Table 2. Studies addressing Capital Constraint

S.No	Author	Title	Year	Country	Crop	Intervention	Method	Outcome
1	Crépon, B., Devoto, F., Duflo, E., & Pariente, W.	Estimating the Impact of Microcredit on Those Who Take It Up: Evidence from a Randomized Experiment in Morocco	2015	Morocco		microcredit access	RCT	•increase investment and assets •increase profit •low uptake: 13%
2	Tarozzi, A., Desai, J., & Johnson, K.	The Impacts of Microcredit: Evidence from Ethiopia	2015	Ethiopia		microcredit	RCT	•increase agri investment •no effect on agri outcomes •low uptake: 36%
3	Burke, M., Bergquist, L. F., & Miguel, E.	Sell Low And Buy High: An Arbitrage puzzle.	2019	Kenya	Grain	credit	RCT	•increase profits •no effect on inputs adoption •uptake: 64%
4	Carter, M., Laajaj, R., & Yang, D	The impact of voucher coupons on the uptake of fertilizer and improved seeds: Evidence from a randomized trial in Mozambique.	2013	Mozambique	Maize	Voucher	RCT	•increase use of seeds and fertilizers •low uptake: 28%
5	Beaman, L., Karlan, D., Thuysbaert, B., & Udry, C.	Self-selection into credit markets: evidence from agriculture in Mali	2015	Mali		loan and grant	RCT	•heterogenous returns to capital •positive investment responses •returns to grants •low uptake: 21%

The first study, by Crepon et al., (2015) assesses the impact of a microcredit program in Morocco. This is a context where the access to credit was very poor at baseline and microlending hadn't penetrated either. At the village level, the authors randomize whether a microlending program will be launched or not. They find that when given access to

micro-loans clients increase their investment in self-employment activities like agriculture and animal husbandry. They also see an increase in profits from self-employment but they do not see any effect on the overall income of the farmer. They estimate a return to the capital of 140%. Despite these high returns to capital, the authors note that the take-up of the credit program was quite low at only 13%.

Similarly, Tarozzi et al., (2015) study a microcredit program in Ethiopia where access to credit was low at baseline. The program take-up was somewhat better in this setting but still low. The treatment group borrowing increased in the extensive margin by only about 25% but the outstanding borrowing doubled. Further, through surveys, they find that most of the capital was used for investments in crop cultivation and livestock activities. However, unlike Crepon et al., (2015), the authors here do not find any major impact on farmer agricultural outcomes.

The mixed results and striking low take-up rates in both studies warrant more investigation. One reason for this could be that the financial product offered in the program was poorly adapted to the needs of the agriculture sector. Agriculture is typically characterized by a lumpy initial investment for inputs and lumped pay-outs once or twice a year corresponding to the harvest seasons. This makes microloans and micro repayments a bad fit. Burke et al., (2019) in a study with small-scale farmers in Kenya address a challenge unique to agriculture – as more time progress from the post-harvest season, farmers face more liquidity constraints. They address this temporal constraint by giving loans in the post-harvest season when prices are usually low to allow farmers to save their produce for later in the year when prices are high. The take-up for this program was quite high at 64% in the first year. They find that farmers made significant profits by arbitrage but find no effect on inputs adoption, probably due to already high adoption rates at the baseline.

Therefore, in a lot of settings, farmers face severe credit constraints. Interventions reviewed above that provide credit to farmers have shown that returns to capital are high for farmers. However, the take-up of such credit interventions is low unless the financial instrument is tailored to the specific needs of the agricultural sector characterized by income flows influenced by harvest seasons.

The timing of loans is also critical for boosting input uses. In the above study—Burke et al., (2019)—ease liquidity constraints in the post-harvest season, this yields no effects on inputs adoption. This could be due to another feature of agriculture—the need for a lumpy capital prior to planting to buy inputs. Carter et al., (2013) studies the impact of an intervention that specifically alleviates the credit constraint required for inputs. The intervention here is a voucher-based subsidy for fertilizers and seeds to poor maize farmers in Mozambique. Authors find positive effects on seed and fertilizer use for maize production. But the co-pay for subsidy was still too high and affected the take-up of the program, showing that farmers often face severe liquidity constraints. Offering such

subsidies at scale might prove to be quite expensive and still may not be enough to ease the liquidity constraints of farmers enough to result in agricultural transformation. Considering this, targeting credit to farmers who are most likely to benefit from it may be a useful strategy.

Beaman et al., (2015) provide support for the targeted supply of credit as a strategy by showing that there are heterogenous returns to capital. They perform an experiment where in 88 out of 189 randomly selected villages in Mali, farmers were given access to loans. Only 21% of farmers in the loan villages actually took up a loan. More interestingly, 50% of the farmers in the no-loan villages and 50% of the farmers who did not borrow in the loan villages were randomly selected and given cash grants. In no-loan villages, agriculture investments and profits improved significantly more for farmers who received the grant than those who didn't. However, in loan villages, farmers who received the grant were no different than farmers who didn't. The authors argue that in the loan villages, farmers who had high returns to capital self-selected themselves into borrowing. Those who did not borrow, therefore, did not have high returns to capital and even when given grants did not improve their productivity.

Therefore, it is important to identify which farmers are capital constrained. Directing credit to such farmers would yield productivity gains and enable agricultural transformation. Further, from the earlier papers discussed in this subsection, the credit instrument needs to suit the particular needs of agriculture.

4.1.2. Risk

For those farmers who have lower returns to capital and investment in agriculture, any investment including in technology adoption becomes risky as it may not lead to commensurate gains. For example, Crepon et al., (2015) discussed earlier, finds that despite the overall positive outcomes mentioned before, the lower quartile of treated farmers saw negative returns to capital. This heterogeneity in returns makes investments in agriculture risky and could explain the muted effects on input adoption in the studies discussed so far. Therefore, for many farmers—particularly the smaller farmers—credit may be too risky. In such cases, it is the risk that is the binding constraint rather than the lack of credit. The studies that address risk are reviewed in this subsection and are summarized in Table 3.

Table 3. Studies addressing Risk

S.No	Author	Title	Year	Country	Crop	Intervention	Method	Outcome
1	Cai, J.	The impact of insurance provision on households' production and financial decisions.	2016	China	Tobacco	weather insurance	DiD	•increase production: 16% •increase borrowing: 29%
2	Emerick, K., de Janvry, A., Sadoulet, E., & Dar, M.	Technological innovations, downside risk, and the modernization of agriculture.	2016	India	Rice	flood resilient variety	RCT	•labor-intensive planting method •area cultivated •fertilizer usage •credit utilisation
3	Mobarak, M., & Rosenzweig, M	Risk, insurance and wages in general equilibrium	2014	India	Rice	rainfall index insurance	RCT	• increased risk taking - high yield varieties • increased labour

Cai (2016) takes this up by arguing that one of the reasons for low investments in agriculture and productivity-enhancing technologies is the risk associated with it. They study the role of a mandatory weather insurance policy for tobacco farmers in China. They find that insurance resulted in greater investments in the insured crop as well as higher production.

Emerick et al., (2016) also alleviate risk by introducing a flood-resistant seed variety to farmers. They find that alleviating the risk of flooding led to a crowd in effect on inputs such that there was an improvement in the adoption of labor-intensive but high-yielding methods, area cultivated, fertilizer usage, and credit utilization.

Finally, Rosensweig and Mobarak (2013) also find improvement in wages due to weather-based insurance. They find that insurance led cultivators to take more risk by investing in high-yielding varieties and hiring more labor. During years that saw good rainfall, the wages increased in treated villages where the insurance program was launched. However, the authors caution us against extending insurance to landowning cultivators while excluding landless laborers. They argue that while the cultivators would benefit from this, it would make wages more sensitive to weather and thereby, increase the vulnerability of wages.

However, in general, demand for index insurance has been low, particularly at near-market prices. with a take-up rate of 6–18%. Only when these index insurance schemes are heavily subsidized the uptake is high and farmers replace traditional low return-low risk crops/varieties with higher yielding and risky crops/varieties. Due to the heavy subsidies, these schemes do not seem to be financially sustainable.

4.2. Information

4.2.1. Analog

Another key constraint to agricultural transformation as noted by Abate et al., (2021) and Duflo et al., (2020) discussed in the previous section, are information constraints. Lack of awareness and correct information prevent farmers from adopting and harnessing the right tools and strategies to improve their agricultural productivity even when capital is available. A large body of literature studies the role of social networks and information and communication technologies (ICTs) in addressing informational failures in the agriculture sector. In this section, we will review analog interventions for information diffusion.

Table 4. Studies addressing Information Constraint - Analog

S.No	Author	Title	Year	Country	Crop	Intervention	Method	Outcome
1	Beaman, L., BenYishay, A., Magruder, J., & Mobarak, A. M.	Can network theory-based targeting increase technology adoption?	2021	Malawi	Maize	social network	RCT	•high diffusion by complex contagion •improved adoption
2	BenYishay, A., & Mobarak, A. M.	Social learning and incentives for experimentation and communication.	2019	Malawi		peer farmers	RCT	•high diffusion by incentivizing peer farmers •improved adoption
3	Dar, M., de Janvry, A., Emerick, K., Kelley, E., & Sadoulet, E.	Inducing demand for information in social networks to promote technology adoption: An alternative approach to extension.	2019	Bangladesh	Rice	side-by-side demonstration plots	RCT	•high diffusion by demonstration plots to outgroup farmers •improved awareness

As highlighted in section 3.1, the dissemination of yield-enhancing technologies has proved challenging. The traditionally adopted method of dissemination through hired extension workers has particularly been disappointing, because of the high costs involved, the difficulty in monitoring extension workers, and the high farmer-worker ratios (Casaburi et al., 2019). It is, therefore, not efficient to use extension workers to train farmers directly. A lot of work has been done in the most effective and efficient ways to spread information to farmers.

The first category of work relies on physical training targeted through social networks. Beaman et al., (2021) test such network-based targeting for effectiveness in information dissemination. They perform an RCT in Malawi to launch a new agricultural technology called "pit planting" for maize farmers. They test different strategies to select the candidates who will be taught the technology and serve as the entry points of the technology in the villages. The selection criteria were based on different network theories of information diffusion. In the first group of the sample villages, the status-quo selection process i.e., picking by experts was maintained—this formed the control group. The second group received treatment 1—the entry points were two knowledgeable farmers, centrally located in the village social networks. This selection was based on the theory of complex contagion—wherein technology only diffuses when individuals are connected to at least two knowledgeable farmers. The third group received treatment 2—one of the entry points was centrally located while the other was peripheral. This is based on a model of simple contagion where farmers only need to know one knowledgeable farmer. To identify the central and peripheral farmers in groups 2 and 3, rich data was collected to map out the social networks in the villages. In the fourth treatment group, the complex contagion model of group 2 was replicated, but geographical proxies were used in place of the network data.

The authors find that the status-quo model of expert selection posed a critical failure, such that three years after the intervention, no farmers had adopted the technology. Treatment 1 however, proved much more effectively such that after three years, there was a 56% greater likelihood of adoption by at least one farmer in these villages. However, they find no effect of treatments 2 and 3. The authors argue that for this technology, which was completely new and in this context the threshold for adoption was quite high, the underlying model of diffusion followed the complex contagion i.e. technology diffusion when individuals are connected to at least two knowledgeable farmers. For every technology, it is therefore important to identify the complexity and challenges to adoption to predict which model would work. A drawback of this method of using networks, however, is its limited scalability due to the need for expensive network mapping. This is especially true since the authors find that the effect cannot be replicated by using easily identifiable geographical proxies as in treatment 3. Geographic networks need not represent social networks in all contexts.

BenYishay and Mobarak (2019) add perspective to this by saying that social networks give us a sense of the passive flow of information, while for policy intervention a more active approach is needed to trigger diffusion. They study the role of incentives in triggering this active flow of information. They test the utility of three selection criteria of entry points, each with or without incentives. The first criterion is one government-employed extension agent. The second is the village lead farmer who is considered an opinion leader. The third is five peer farmers who are selected to represent the general population of the village and similar to the conditions of the recipient farmers. The authors find that when no incentives are given the most effect on adoption is generated by extension agents (3pp), then lead farmers (2pp), and almost no effect by peer farmers. The fact that lead farmers perform better than the peer farmers group reinforces the importance of the centrality of entry points flagged by Beaman (2021). However, things turn around when small incentives are given to the lead farmer or peer farmers to adopt the technology themself. Authors find that the peer farmers are much more responsive to this incentive than the lead farmers. The former exerts more effort in communicating the technology to others and also adopting the practice themself. Farmers too respond more to peer farmers than lead farmers such that there is 14pp more adoption in the peer farmers group. Here, the authors conclude that a small incentive is a cost-effective way to spark information diffusion. Further, they argue that incentives work best and recipient farmers respond more when the entry points are people they consider credible, namely their peers who are more similar to them in terms of characteristics like land size, risk appetite, credit situation, access to resources, etc.

While the above approaches rely on exploiting the existing social structures, Dar et al., (2019) test for diffusion by sparking interest and communication beyond existing network ties in rural Bangladesh. Here, they use three selection criteria. In the first group, the entry points are five randomly selected farmers. The second group consists of the five largest farmers in the village. The third group of five farmers was selected as per the recommendation of local agricultural extension officers. The selected farmers in the second and third group, the authors notes, were more central in the village networks. The effectiveness of each of these selections was tested and the authors found that groups 2 and 3 were about 7 pp more effective in increasing awareness about the new seed variety being launched.

Further, each of the three groups in the above study was cross-randomized and half the treatment group was asked to use demonstration plots for the agricultural practice. These demonstration plots were comparison plots where half of the plot was cultivated with a new seed variety and the other half with an old seed variety the farmer normally cultivates. Each of the plots had a marker that named the seed variety cultivated. The authors find that randomly selected farmers who used demonstration plots were as effective as groups 2 and 3 without demonstration plots. However, demonstration plots led to no additional effect in groups 2 and 3. The authors conclude that demonstration

plots are a cost-effective way for information diffusion that can be used with minimal investment in the selection of farmers.

Dar et al., (2019) additionally highlight an important consideration. They show that their method of demonstration plots with random farmers diffused the information to farmers with below-median treatment returns. This is because the information diffusion in this group did not rely on peer effects while the other groups did. Being connected to one of the selected farmers did not improve the likelihood of awareness of the seed variety. Rather, the mechanism for diffusion here relied on making ties outside the networks and therefore, was taken up more by less connected and more isolated farmers who also tend to be more vulnerable. This is explained by the phenomenon wherein information seeking reveals the low skill and therefore, has some stigma attached to it.

The main insight from these studies is then that diffusion through social networks might work when the right targeting strategy is used but such diffusion is slow and the mapping of social networks is quite expensive. This reduces the cost-effectiveness of the strategy. We saw above that in such situations small incentives—particularly to peer farmers can really boost diffusion. Further, more salient signaling such as demonstrative plots can also be used as an inexpensive strategy to disburse information, particularly to farmers outside of peer networks.

4.2.2. Digital

Going a step beyond such personal forms of information sharing, in today's day and age there is a multitude of digital tools and technologies that can be leveraged for information dissemination at a much cheaper cost. As a result, ICT has been harnessed in various contexts. There is also a large body of literature on how effective these tools have been.

Table 5. Studies addressing Information Constraint – Digital

S.No	Author	Title	Year	Country	Crop	Intervention	Method	Outcome
1	Casaburi, L., Kremer, M., Mullainathan, S., & Ramrattan, R.	Harnessing ICT to increase agricultural production: Evidence from Kenya	2019	Kenya	Sugarcane	SMS messages with agricultural advice	RCT	•increased yields by 8% •no increase in yields in the follow-up
2	Jensen, R.	The digital provide: Information (technology), market performance, and welfare in the South Indian fisheries sector	2007	India	Fisheries	mobile phone service	DiD	•reduction in price dispersion
3	Fafchamps, M., B. Minten	Impact of SMS-Based Agricultural Information on Indian Farmers.	2012	India		SMS market, quality premium, and weather information	RCT	•no price effect •increased efforts in quality upgradation among youth
4	Mitra, S., Mookherjee, D., Torero, M., & Visaria, S.	Asymmetric information and middleman margins: An experiment with Indian potato farmers	2018	India	Potato	SMS with price info	RCT	•no sales and price effect •increase pass-through
5	Deichmann, U., Goyal, A., & Mishra, D.	Will digital technologies transform agriculture in developing countries?	2016				Review	Limitations to ICT impacts
6	Nakasone, E., M. Torero, B. Minten,	The power of information: The ICT revolution in agricultural development	2014				Review	Existence of multiple constraints

Casaburi et al., (2019) for example test an SMS-based information intervention through an RCT with sugar cane farmer in Kenya. As a treatment, farmers receive a set of text messages that inform them about agricultural tasks to be performed right around the time they need to complete such tasks on the plot. In the first round, access to the SMS

project raises yields by around 3.3 tons per hectare or 8% of the control group average. They estimate that this reflects a $54 increase in income for the farmer at $0.30 cost per farmer. However, they do not find a significant yield improvement in the second year.

In addition to information on agricultural practices, price information is critical for farmers to engage in optimal trade and arbitrage (Jensen, 2007). But in reality, there is an imperfect flow of information in the market leading to price dispersion. Several studies have tested the utility of improved information on prices by leveraging digital technologies. Jensen (2007), for example, studies the effect of mobile phones on price dispersion in the fish markets of Kerala. The author finds that there is an improvement in earnings and a reduction in price distribution and waste. The patterns in the data suggest that these impacts are explained by improved price information and consequently improved spatial arbitrage.

Although we see positive results above, Fafchamps and Minten (2012) and Mitra et al., (2018) find no effects for SMS-based services that provide regular price updates for farmers in two different states in India. While Mitra et al., (2018) do find some evidence for spatial arbitrage as a result of this price information, both studies find no effect on price gains by farmers. Both papers find that this is due to the local market structure. Thus, the market structure in both study contexts was such that high transport costs and fragmented markets resulted in farmers not having an outside option to sell to. In the absence of outside options, knowing the market price was not enough for the farmers to engage in arbitrage. This was different from the context studied by Jensen (2007) where the markets were less fragmented.

However, Fafchamps and Minten, (2012) do find some suggestive evidence that relaying information to farmers about the quality grading of crops, led to farmers—particularly young farmers—reporting more efforts in grading and sorting of the products and higher returns although the latter is not a very precise estimate.

The evidence on ICT has, therefore, been mixed and rarely successful in scaling up. Deichmann et al., (2016) review the evidence on ICT interventions and provide a neat summary of the major challenges that prevent ICT interventions from achieving the intended results: 1) while there has been an increase in the penetration of mobile phones, access to mobile phones and the internet remains quite low in rural economies of the developing world, 2) price information can improve efficiency, but often the novelty of this information is not very high. Additionally, farmers cannot act upon information even if novel due to imperfectly competitive market structures as evidenced by Jensen (2007) and Mitra et al., (2018); 3) for ICT interventions to be effective, complementary investments need to be made in education, electricity, and infrastructure. These might be more important for welfare in resource-constrained environments; 4) the broader regulatory frameworks need to be conducive to business models that enable sustained investments in technology and the internet.

Nakasone et al., (2014) also review the evidence on ICT interventions for agriculture and emphasizes the point on multiple constraints—information alone may not be enough to lead to technology adoption or transform the production of farmers who face multiple constraints including imperfect competition in markets. Therefore, a more holistic approach is required leading researchers to an approach of bundled interventions we see in the next subsection.

4.3. Bundles

The evidence on interventions that ease only one constraint for farmers has been mixed. In many of the studies, such designs did not lead to commensurate outcomes toward agricultural transformation. The existence of multiple constraints on farmers motivates bundled interventions that relax various constraints simultaneously. An increasing body of literature studies the effectiveness of such bundled interventions.

Table 6. Studies with Bundles

S.No	Author	Title	Year	Country	Crop	Intervention	Method	Outcome
1	Casaburi, L., & Willis	Time versus state in insurance: Experimental evidence from contract farming in Kenya.	2018	Kenya	Sugarcane	Bundle-index insurance and contract-farming	RCT	•increase demand: 67 p.p. •high uptake: 72%
2	Deutschmann, J. W., Duru, M., Siegal, K., & Tjernström, E.	Can Smallholder Extension Transform African Agriculture?	2019	Kenya	Maize	Bundle – input loans, insurance, and training	RCT	•increase maize production by 26% and profits by 16%

Casaburi and Willis (2018) highlight the constraints of contract farmers in Kenya—liquidity constraints, present bias, and contractual risk. Poor farmers have the most gains from risk reduction through insurance that smooths income over states. However, despite the gains, there is often a low take-up of insurance programs. Insurance programs often require the clients to pay the premiums upfront, therefore, insurance also shifts income across time. The authors hypothesize that the cyclical nature of income from agriculture, and the transfer of income across time makes insurance premiums additionally costly for poor farmers who need it the most. The authors test for this through a pay-at-harvest insurance product in an RCT. The pay-at-harvest model negates the insurance's income shift across time, by allowing farmers to pay the insurance premiums as a deduction from their harvest sales. Each farmer associated with the contract farming company is randomly offered either a regular insurance product (premium paid upfront) or pay-at-harvest insurance. The authors find that the pay-at-harvest product increases the take-

up of insurance by 67 percentage points. Through further experiments, the authors find that the pay-at-harvest product is effective not only because it addresses liquidity constraints faced by farmers but also tackles present bias and negates contractual risk.

In yet another RCT with farmers in Kenya, Deutschmann et al., (2019), study the effectiveness of a bundled program by One Acre Fund. The program aims to ease credit, risk, and information constraints by giving participating farmers input loans for high-quality seeds and fertilizer, crop insurance, and training on improved farming practices. The authors find that program participation causes statistically and economically significant increases in output, yields, and profits with total maize output increasing by 26% and profits by 16%. Further, the authors find homogenous and consistent treatment effects across the sample. The authors also highlight that enrolled farmers, if at all, enroll more land in the program in the second year. This reinforces the idea that participation in the 1AF program relaxes participants' credit constraints, or it may help farmers learn about the returns to program participation and agricultural intensification.

Therefore, in both cases above, the takeup and agriculture outcomes were more positive when the intervention offered to farmers was carefully designed to tackle several constraints faced by farmers. However, such bundled interventions might be expensive. It might be fruitful for future research to investigate the cost-effectiveness and feasibility of offering such interventions. In addition, research into what combination of constraints needs to be addressed to drive agricultural transformation and how this may be influenced by context is a potential avenue for future investigations.

5. Conclusions

Differences in productivity are remarkable, both across and within countries, in the agricultural sector, in general, and in the coffee sector, in particular. These differences have been found to explain most of the cross-country income per capita dispersion. As a result, several interventions, and programs, aimed at narrowing these gaps and eventually enhancing productivity, and farmers' income, have already been rolled out in the primary sector. However, very few of these have been rigorously evaluated.

In this paper we reviewed the literature on experimental studies along the coffee value chain, providing a comprehensive assessment of the effects of different interventions, and highlighting under which conditions and where these have been most successful in improving coffee farmer productivity and income. Specifically, despite the limited research in the coffee sector, training, certification, and cash transfer programs show very mixed results. This is likely due to the simultaneous constraints farmers face, both on the supply and demand side. Thus, an intervention that only provides training or information may not be sufficient to raise productivity and income in a significant way. Accordingly, more promising seems to be the results from bundled interventions, i.e.,

programs that target multiple constraints to productivity at once. These seem to be effective in improving quality, yields, and profits both in the agricultural and coffee sector.

One open question is whether these bundles offer good value for money. Previous research has not been able to identify the effects of individual components of these programs, so it is possible that simpler programs with fewer components could be just as effective at a lower cost. On one hand, standardized bundled programs can be expensive, but they may allow an organization to implement its program in different locations without having to customize it for each new context. On the other hand, it could be expensive to tailor simpler programs to each new context. The cost-effectiveness of these bundled programs, therefore, depends on the balance between the cost of including too many components and the cost of adapting the program to each new context through market research. We believe this is a potentially interesting avenue for future research.

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