THE
ECONOMIC
JOURNAL

The Economic Journal, 1–33 https://doi.org/10.1093/ej/ueac018

TRANSFERS, DIVERSIFICATION AND HOUSEHOLD RISK STRATEGIES: CAN PRODUCTIVE SAFETY NETS HELP HOUSEHOLDS MANAGE CLIMATIC VARIABILITY?*

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We present experimental evidence on a programme aimed at improving households' risk management through income diversification. The intervention targeted rural Nicaraguan households exposed to weather variability and combined a one-year conditional cash transfer with vocational training or a productive investment grant. Both complementary interventions provided protection against weather shocks two years after the programme ended. Households that received the productive investment grant also had higher average consumption levels. The complementary interventions facilitated income smoothing and diversification of economic activities. Relaxing capital constraints induced investments in non-agricultural businesses, while relaxing skills constraints increased wage work and migration in response to shocks.

Poor households in the developing world are often highly exposed to risk, which contributes to consumption volatility, high welfare costs and low productivity. In many countries, safety net programmes have been put in place to provide welfare support and relief from shocks to poor households. The debate is still open, however, on how to design policies, productive safety nets or graduation strategies to enhance households' risk-management capacities and promote resilience and opportunities beyond the short term (Barrett, *et al.*, 2019; Bowen *et al.*, 2020). The combination of cash transfers with productive interventions is often seen as particularly promising (Andrews *et al.*, 2021). This debate has gained prominence with changes in weather patterns and higher weather variability, which increase agricultural households' risk exposure, particularly

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This paper was received on 30 July 2019 and accepted on 16 February 2022. The Editor was Nezih Guner.

The data and codes for this paper are available on the Journal repository. They were checked for their ability to reproduce the results presented in the paper. The replication package for this paper is available at the following address: https://zenodo.org/record/5933958.

We are grateful to Ximena Del Carpio and Fernando Galeana for countless contributions during data collection and preparation, the programme team at the Ministerio de la Familia, in particular Teresa Suazo and Carold Herrera for their collaboration during the design of the randomised control trial, and the Centro de Investigación de Estudios Rurales y Urbanos de Nicaragua (in particular Verónica Aguilera, Enoe Moncada and the entire field team) for excellent data collection. We also thank Wolfram Schlenker for many discussions on climate change and Edgar Misael Uribe, Nicos Vakis and Pablo Valdivia for their guidance with the rainfall data and agronomical insights. We thank the editor and referees, Harold Alderman, Luc Behaghel, Diego Arias Carballo, Stefan Dercon, Marcel Fafchamps, Nathan Fiala, Chrysanthi Hatzimasoura, John Nash, Norbert Schady, seminar participants at Clermont Ferrand, Columbia University, DFID, Grenoble (INRA-GAEL), Oxford, the Paris School of Economics, Paris I, the World Bank, Zürich as well as ASSA, BASIS, CEPR and NEUDC conferences for providing us with additional comments and suggestions. The study is registered in the AEA RCT registry under AEARCTR-0001794, and received IRB approval from Johns Hopkins Homewood IRB: No 2008062. The views expressed in this paper are those of the authors and do not necessarily reflect those of the World Bank, or any of its affiliated organisations. All errors and omissions are our own.

Financial support for this research was received from the World Bank (ESSD: SP-TF053795-TF055540 and P064906, RSB grant: RF-P109212-RESE, the Government of the Netherlands through the BNPP programme as well as the Spanish Impact Evaluation Fund: P119232, BASIS: USAID Agreement No. EDH-A-00-06-0003-00 awarded to the Assets and Market Access Collaborative Research Support Programme, and the Agence Nationale de la Recherche under grant ANR-17-EURE-0001.

for poor rural households highly specialised in rain-fed agriculture. Policy discussions consider a range of adaptation options, often starting with agricultural adaptation, though the potential of livelihood or economic diversification outside agriculture has also been noted (IPCC, 2014; 2018). To date, there is little experimental evidence on interventions that foster diversification and facilitate risk management.

Households can use a wide range of strategies to manage risks ex ante and cope with shocks ex post. The reliance on adverse coping mechanisms can have long-run welfare effects (Fafchamps *et al.*, 1998; Hoddinott and Kinsey, 2001). Poor households with limited ability to smooth consumption ex post may reduce the variability of their income portfolio ex ante. Income or consumption smoothing can also occur through off-farm labour supply (Rose, 2001) or migration (Stark and Bloom, 1985; Morten, 2019). Even so, the ex ante welfare cost of risk has been shown to be high (Elbers *et al.*, 2007). This implies that risk hampers households' productivity and upward mobility.

Theoretically, diversification can help households manage risk by making income less sensitive to shocks, as such also facilitating consumption smoothing. However, it can be costly if expected profits are sacrificed for lower risk and the implicit insurance premium related to choosing low-risk, low-return strategies can be substantial (Rosenzweig and Binswanger, 1993; Dercon, 1996). At the same time, a variety of constraints can hinder households' entry in high-return activities, including capital or skills constraints. A risk-return trade-off might not exist if such constraints to higher-return non-agricultural activities can be lifted. There are several open questions on the scope for diversification to improve risk management in practice, including whether, how and to what extent interventions aimed at facilitating economic diversification can contribute to help households manage risk.

This paper provides experimental evidence on interventions delivering a productive investment grant and vocational training to facilitate diversification and their impact on consumption and income smoothing. The productive interventions were combined with a traditional safety net providing conditional cash transfers. The programme targeted agricultural households in Nicaragua who faced increased exposure to weather shocks linked to changes in rainfall and temperature patterns. The complementary interventions were designed to relax capital and skills constraints to diversification into non-agricultural activities such as small businesses or wage jobs. They were also labelled as such. They aimed to strengthen poor households' risk management through income smoothing, as such facilitating consumption smoothing and decreasing reliance on adverse coping mechanisms. Identification relies on the randomised assignment of the different treatment packages, and on local weather variability that provides exogenous variation in the intensity of seasonal shocks.

Despite the high frequency of droughts in the study region, most households primarily depend on semi-subsistence rain-fed agriculture. Diversification into non-agricultural activities is limited. In this context, a one-year basic conditional cash transfer (CCT) was introduced to provide short-term relief through cash, conditional on human capital investments.[1] During the same year, two complementary interventions were implemented with the objective to help households diversify income and protect themselves against future shocks. A first group of beneficiaries

[1] The short-run impacts of the programme were consistent with the safety net objective by increasing school enrolment and consumption, improving nutrition and reducing delays in early childhood cognitive development (see the supplementary material online, Macours *et al.*, 2012, and Macours and Vakis, 2014). Similar results have been shown for CCTs in other countries (Fiszbein and Schady, 2009).

received only the traditional CCT, a second group received the traditional CCT and a vocational training, and a third group received the traditional CCT and a productive investment grant. Households were assigned to one of the three groups based on a lottery in each treatment community. Treatment communities were themselves randomly selected, so that each of the intervention groups can also be compared to an experimental control group. The complementary interventions increased participation in non-agricultural activities, as well as returns from such activities.

We take advantage of local variations in weather shocks across micro-climatic zones within which treatment assignment was stratified. Agronomical models provide insights on which weather variables contribute to drought conditions, and these variables are indeed good predictors of both self-reported drought shock intensity and yield losses. These predictions allow isolating the exogenous variation in shock and yield measures through Two-Stage Least Squares (2SLS). We then examine how the impact of exogenous shocks on consumption and income varies across the different randomised treatment and control groups. The estimation strategy passes placebo tests. Results are also similar when using either self-reported shock intensity or yield losses and are robust to alternative specifications. Hence, as in much of the literature on risk, shocks and welfare, we rely on cross-sectional variation on the incidence of weather shocks (Karlan *et al.*, 2014; Emerick *et al.*, 2016). To be clear, this also implies that the paper does not directly address adaptation to long-term climate change. Instead, it focuses on households' resilience through their ability to manage short-term climatic shocks, in a context where the increased occurrence of such shocks can be linked to climatic changes.

The results show that, two years after the end of the programme, both consumption and income of households eligible for the complementary interventions were better protected against the negative impact of weather variability. This holds for households provided with a productive grant to invest in a non-agricultural self-employment activity, as well as for beneficiaries of the intervention aimed at building skills through vocational training. These results differ significantly from those of the basic CCT, indicating that the protection against shocks comes from the complementary interventions. In addition, for households eligible for the productive investment grant, there is a significant positive impact on consumption and income at average shock intensity. This intervention hence helped to increase and smooth both consumption and income. The mechanisms and behavioural responses vary between the two productive interventions. Relaxing capital constraints facilitated income diversification through the creation of more productive small non-agricultural businesses, which contribute to raising average earnings while also smoothing income when drought shocks occur. Relaxing skills constraints, on the other hand, allowed households to respond to shocks by increasing their ability to shift into non-agricultural wage work or migration.

The paper contributes to the thin literature on effective interventions to promote risk management and resilience. Evidence has shown that interventions facilitating ex post coping, such as cash transfers or saving groups, can provide protection against shocks (de Janvry *et al.*, 2006; Karlan *et al.*, 2017; Adhvaryu *et al.*, 2018). Less evidence exists, however, regarding policies aimed at improving households' ex ante risk strategies. An important contribution of this paper is hence to show impacts on income smoothing and to document specific mechanisms through which a safety net programme and its complementary productive interventions help households manage weather shocks, even after these programmes have ended. This is particularly relevant given that the literature on weather insurance interventions shows mixed results, in part due to low take-up (Cole *et al.*, 2013; Karlan *et al.*, 2014; Carter *et al.*, 2017). Empirical evidence on risk management through adoption of drought and heat resistant crop varieties, shifting of planting dates, changes in crop mix or expansion of irrigation has started to emerge (Olmstead and Rhode, 2011; Hornbeck and Keskin, 2014), but results on such agricultural adaptation strategies point to many remaining challenges (Burke and Emerick, 2016; Fishman, 2018; Dar *et al.*, 2019; van Etten *et al.*, 2019).

The paper also relates to the literature analysing the impacts of cash grants on small business development (De Mel *et al.*, 2008; 2012; Blattman *et al.*, 2014; Haushofer and Shapiro, 2016) and the impacts of vocational training on employment outcomes (McKenzie, 2017; Card *et al.*, 2018). There is active research on the relative effectiveness of interventions providing capital or skills, for instance in the context of micro-entrepreneurship support interventions (see Cho and Honarati, 2014 for a review). We show that capital and skill interventions can facilitate households' income diversification, which in turn provides protection against subsequent weather variability. To our knowledge, these results constitute unique evidence that productive transfers aimed at diversifying economic activities can lead to improved protection against shocks two years after the end of an intervention.

We also contribute to the broader literature on cash transfers, social safety nets and poverty reduction interventions. We compare the outcomes of households who received a CCT together with a capital or skill intervention, both with households in the same communities that only received the CCT, and with pure control households in other communities. This helps to disentangle the contribution of the 'productive' component of the productive safety net. Indeed, as shown by Gertler *et al.* (2012) for Mexico, a CCT programme alone can increase investments in non-agricultural activities and lead to higher longer-term consumption levels. While cash transfers have been shown to impact savings and investments in the short term (Alderman and Yemtsov, 2013; Davis *et al.*, 2016; Handa *et al.*, 2018), combining cash transfers with complementary interventions can strengthen programme impacts. Our study complements findings on multi-faceted programmes aiming to improve livelihoods among the poor through a comprehensive package combining cash transfers, assets, training, coaching and savings facilitation (Banerjee *et al.*, 2015; Bandiera *et al.*, 2017). Specifically, we disentangle the effects of cash transfers from those of alternative complementary productive packages composed mostly of skills, and mostly of capital. Our comparisons with households that receive the same CCT without additional capital or skills hence allow separating the impact of the productive interventions.

The next section provides more details on the intervention, the experimental design, the timing and the data. Section 2 first shows the results of each treatment on participation and returns to non-agricultural activities. Section 3 then discusses climatic changes in the study region, and insights from agronomical models that allow identifying meaningful exogenous variation in shocks. In Section 4 we further discuss the empirical strategy and outline the main hypotheses to be tested. Section 5 presents the main results on consumption and income smoothing, as well as robustness and placebo tests in support of the empirical strategy. Section 6 delves into the mechanisms behind the results, their interpretation, and the role of diversification, showing that the two productive interventions fostered income smoothing and diversification in off-farm activities through markedly different pathways. Section 7 concludes.

1. The Experimental Design, Timing and Data

1.1. *Description of the Programme and the Three Transfer Packages*[2]

The *Atención a Crisis* programme was a one-year pilot implemented between November 2005 and December 2006 by the Ministry of the Family. The programme targeted six municipalities in the Northwest of Nicaragua because they had been affected by a drought the previous year and had high prevalence of rural extreme poverty. To stratify, all communities in the six municipalities were grouped in blocks based on micro-climates, similarity in road access and infrastructure. Through a public lottery, forty-four blocks were selected and half of the communities in each block were randomly assigned to treatment, and the other half to the control.

Baseline data were collected in the fifty-six treatment and fifty control communities. These data were used to define households' eligibility for the programme based on a proxy means test. Around 10% of households in treatment and control communities were ineligible for the programme because their estimated baseline expenditures, as determined by the proxy means, were above the pre-defined threshold. This process resulted in the identification of 3,002 households to participate in the programme. In a next step, 3.7% of households that had originally been deemed eligible by the proxy means were reclassified as ineligible after a process of consultation with community leaders, and a corresponding 3.7% that had originally been deemed ineligible were reclassified as eligible. To avoid selection bias from these choices, we use the *original* proxy-means eligibility as the intent to treat (ITT). There were no other eligibility conditions.

In the treatment communities, the main caregiver in each eligible household (typically a woman) was invited to a registration assembly, where the programme objectives and various components were explained. At the end of the assembly, a second public lottery took place in each community. Participation in the assemblies and lotteries was close to 100%. The lottery assigned all eligible households within each community to one of three treatment packages: (1) a basic CCT; (2) a basic CCT plus a scholarship for a vocational training and (3) a basic CCT plus a productive investment grant. The costs of the second and third packages were approximately the same. While the basic CCT's aim was to protect investments in human capital, the two complementary interventions aimed at strengthening households' ex ante risk management via income diversification in non-agricultural activities.

All selected households were eligible for the basic CCT, which included cash transfers, paid to the children's main caregiver, conditional on children's primary school and health service attendance during the one-year time period. Households received a transfer of US$145 even if they did not have children. Households with children between seven and fifteen enrolled and attending primary school received an additional US$90 per household and an additional US$25 per child (with amounts referring to the total transfer received over the year). For an average household in the sample, the basic CCT transfers represented 18% of annual household expenditures at baseline.

In addition to the CCT, one-third of the beneficiary households in each community received a scholarship that paid for one household member to choose among a number of vocational training courses offered in the main town of the municipality. The person identified as the main caregiver (who also received the basic CCT) was asked to select one person among the adults and teenagers in the household to attend the training course, with (soft) guidelines to prioritise a

[2] More detailed information about the programme and its different components is provided in the Online Appendix.

young adult with sufficient literacy skills to benefit from the training.[3] In 35% of cases, this led to the main caregiver herself taking the course, while in 21% of cases it was her spouse, and in the remaining cases one of her children (or other younger household members). The scholarship was conditional on regular attendance to the course, and most (though not all) of the training courses required basic literacy skills for participation. The programme paid the course fees directly to the training providers, so that the scholarship was not a cash transfer to the beneficiaries. The courses aimed at providing participants with new skills for income diversification and participants received a certificate after completing the training. The beneficiaries were also offered labour-market and business-skill training workshops organised in their own communities and received a small monetary compensation to offset income losses from the time spent in the course (paid to the main caregiver like the other transfers).

Finally, another third of the beneficiary households in each community received, in addition to the basic CCT, a US$200 grant for productive investments aimed at encouraging recipients to start a small non-agricultural activity. This grant was paid to the same person as the basic CCT (i.e., in most cases a woman). It was conditional on the household developing a simple business development plan, outlining the proposed investments in new livestock or non-agricultural income generating activities. Beneficiaries participated in light training workshops organised in their own communities, receiving technical assistance for the initial choice of business as well as to develop the business plan. Technical staff made two to three visits to monitor the implementation of the business plan. In total, the average household in this treatment group received transfers corresponding to 34% of annual household expenditures at baseline.

Programme take-up was high. More than 95% of all households randomised into the three treatment groups received the basic cash transfer. A small fraction of those households (less than 5%) did not collect the full amount of the transfer they were eligible for because they had not complied with the school enrolment and attendance requirements. Take-up of the productive packages was also high—89% for those offered vocational training, and close to 100% for the productive investment grant.[4] Programme take-up (contamination) in the control group was negligible (one household).

1.2. *Timing and Data Collection*

Baseline data for the evaluation were collected in April–May 2005. The sample included the 3,002 eligible households in the treatment communities, and a random sample of 1,019 eligible households in the control communities. The first payments were made in November 2005 and the selection of the vocational training courses as well as the preparation of the business plans for productive grant recipients started shortly thereafter. A first follow-up survey was collected in July–August 2006, nine months after the households had started receiving payments. Because of implementation delays, the productive investment grant had been fully disbursed only two to three months prior to this survey; and while households had signed up for the vocational training

[3] When asked in a first follow-up survey in 2006, about half of the main caregivers indicated that they decided on the course, about one-third said another household member decided, while in the remaining the main caregiver indicated that it was a joint decision.

[4] About 10% of the business development plans were initially turned down by the ministry. These proposals were sent back to the households and virtually all of them received technical assistance and developed a new plan that was ultimately approved (the few exceptions being households that had migrated). The most common reason for incomplete take-up of the vocational training was the absence of an interested household member with sufficient literacy skills to participate in the training.

courses, the courses started after the end of this survey round. Programme activities ended by December 2006. A second follow-up survey was collected between August 2008 and May 2009 (henceforth referred to as 2008). At this point, households had stopped receiving transfers, as well as any programme benefits related to the productive investment grant or the training for an average of two years. Because of thorough tracking, attrition compared to the baseline was less than 2.4% in 2008 (3.5 years after the baseline) and is uncorrelated with treatment status (p-value = 0.54). Differences in attrition rates between treatments are also small and not significant (p-value = 0.67). As the first follow-up survey was done while the productive components were being implemented, it does not allow observing impacts on the returns to income diversification. This paper therefore uses mainly the second follow-up, with the first follow-up being used for placebo tests and to provide short-term process indicators on business start-up.

The surveys included comprehensive information on household socioeconomic status, including detailed modules for expenditures and economic activities.[5] All surveys also contained a module on shocks, including a question on whether the household's income had been affected by a drought shock in the last twelve months. For the 2008 follow-up survey, an extended agricultural module allows calculating maize and bean yields in the first agricultural season. We use two alternative shock measures throughout the paper. The first shock measure is the share of households in each block having reported a drought shock in the first season of 2008. This variable has a mean of 0.35, a standard deviation of 0.15, and ranges between 0.03 and 0.69. Hence, the average shock intensity is high, and there is substantial variation in shock intensity. The second shock measure is based on the block-level averages of maize yields in the first season of 2008, which varies from 619 to 2330 kg per manzana, with a mean of 1,242 and a standard deviation of 421.[6] We focus on the first season of 2008, when self-reported shock and yield data are available for all households.[7] The majority of all self-reported shocks in the survey refer to that season. We use both self-reported shock and yield data to show the robustness of the results and to facilitate comparisons with different literatures. The self-reported weather shocks allow for comparison with the existing micro-empirical literature on the impact of shocks on household welfare. On the other hand, yield data are commonly used in the climate change literature, and our measure of yield losses that captures deviations from average yields may have a more intuitive quantitative interpretation.

Online Appendix Table A.1 provides descriptive statistics of some key variables at baseline. It documents the low levels of education (2.6 years for household heads), and a high dependency on agriculture with 90% of households involved in self-employment agriculture. About half the households are engaged in livestock activities and temporary migration. On the other hand,

[5] The expenditure modules were taken from the 2001 Nicaragua Living Standards Measurement Study survey and include detailed information on various expenditure categories. For example, food expenditures are based on questions about sixty-three food items, asked separately for actual expenditures, home production and food consumed outside the home. The income module was designed specifically for this study with the objective to capture all household members' economic activities.

[6] To calculate the block-level share of households reporting drought and the average yield, self-report measures of households in the control are over-weighted with a factor three compared to those in the treatment. This accounts for the fact that we sample three times more households in the treatment than in the control. Only households still living in their baseline block are used for the calculation of these block-level variables. All households (including those that moved) are assigned the block-level variables of the block where they lived at baseline. For the yield measure, we focus on maize yields as maize is the most common crop during the first agricultural season. Using a weighted average of maize and bean yields gives similar results.

[7] For the second agricultural season, we do not have yield data. Also, data on shocks in the second season refer to 2007 for some of the households in the sample, but to 2008 for other households, making it more difficult to map the self-reported data to the available weather data.

non-agricultural self-employment or wage employment is much less prevalent. Table A.1 also establishes that the randomisation resulted in balanced samples in the treatment and control communities as well as between treatment groups. The results of balance tests are shown using asymptotic and exact p-values (Young, 2019). Differences are generally small and the number of significant differences is not larger than expected. Considering some of the few significant differences, treatment households, and in particular those with the basic CCT package, are more likely to engage in non-agricultural wage work in the public sector (i.e., professional jobs such as teachers or nurses), but the shares for all groups are very small. To account for this, the impact estimates control for baseline activities. The main outcome variables (total consumption and income) are balanced between all groups. The self-reported drought shock at baseline is also balanced. In fact, almost all households reported having been affected by drought at baseline. This is consistent with the occurrence of a major drought in 2004 in the region—the event that triggered the design of the programme. Additional information on weather data, changes in weather patterns and agronomical droughts are provided in Section 3.

In addition to the quantitative data, qualitative work preceded each round of data collection. The qualitative work, conducted by the authors, in collaboration with local research organisations (CIASES and CIERUNIC), consisted of focus groups and semi-structured interviews with a wide set of beneficiaries and other local actors in treatment and control communities, and in the main town of the municipalities. It explored households' perceptions about weather patterns, qualitative evidence of the programme's impacts, as well as questions related to programme implementation.

2. Impacts on Non-Agricultural Economic Activities

The productive interventions aimed at improving households' risk management strategies by facilitating income diversification. Therefore, prior to analysing whether these interventions helped households manage weather variability, this section first establishes that they indeed had impacts on households' economic activities. The productive investment grant provided financial support and (limited) technical assistance for households to start a non-agricultural self-employment activity. The vocational training intervention aimed at increasing households' skill base, to be applied either in a non-agricultural wage job or by providing services (such as masonry or sewing) as self-employed.

Table 1 shows the impact of the three treatments on households' participation in non-agricultural activities.[8] Compared to the control group, households that were eligible for the productive investment grant are 13 percentage points (p.p.) more likely to engage in non-agricultural self-employment, while impact of the basic and training packages is about 4 p.p. (significant at 10%). In contrast, there is no significant average impact of any of the treatment packages on participation in non-agricultural wage employment.[9] The right panel of the table unpacks the impact of non-agricultural self-employment. Households can be engaged in more than one non-agricultural self-employment activity. The productive investment grant leads to significant increases in both food production (such as small bakeries or cheese production) and small commerce (such as corner stores or roaming sellers of clothes). These are activities for which an

[8] There is no significant impact on participation in agricultural activities, possibly because almost all households have some self-employment in agriculture, and the programme is unlikely to move households completely away from agriculture.

[9] We focus on non-professional wage employment, as the training did not provide skills for professional jobs.

Table 1. *Impact on Households' Participation in Non-Agricultural Economic Activities.*

				By type of non-agricultural self-employment			
		Non-agr. wage employment	Non-agr. self-employment	Food production	Manu-facturing	Commerce	Services
CCT + grant (T3)	α_3	−0.0271	0.126***	0.0636***	0.0048	0.107***	0.0112
		(0.022)	(0.019)	(0.017)	(0.010)	(0.013)	(0.014)
CCT + training (T2)	α_2	0.0204	0.0399*	0.0166	0.0115	0.0105	0.0352***
		(0.022)	(0.020)	(0.017)	(0.011)	(0.011)	(0.013)
CCT (T1)	α_1	0.0174	0.0400*	0.0255	0.0023	0.0293**	0.0332**
		(0.022)	(0.021)	(0.017)	(0.010)	(0.014)	(0.014)
Mean in control		0.317	0.381	0.207	0.039	0.138	0.105
R^2		0.114	0.112	0.083	0.086	0.139	0.063
p-value $\alpha_3 = \alpha_2$		0.011**	0.001***	0.021**	0.479	0.000***	0.125
p-value $\alpha_3 = \alpha_1$		0.040	0.001***	0.034**	0.768	0.000***	0.153
p-value $\alpha_2 = \alpha_1$		0.878	0.996	0.624	0.381	0.196	0.891

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$; SEs clustered by community are given in parentheses. The table shows intent-to-treat (ITT) estimates, including household controls and block fixed effects; $n = 3{,}918$. Non-agricultural wage employment excludes public sector professional employment. Controls include age, gender and literacy of the household head, number of household members in different age groups by gender, land ownership, participation in different non-agricultural self-employment and wage employment activities, distances to school and the health centre.

initial capital investment likely was important to overcome liquidity constraints and cover start-up costs. The increases are significantly larger than for the training and the basic package (with the latter showing a small but significant increase in commerce, too). The increase in non-agricultural self-employment for households eligible for the vocational training is significant but smaller and is driven by an increase in services. There is also a small increase in service participation for beneficiaries of the basic CCT.

Complementing the evidence of impacts on the extensive margin in Table 1, Table 2 presents indicators of economic returns. Households eligible for the training have significantly higher non-agricultural wage earnings, while households with the productive investment package have higher earnings from non-agricultural self-employment. The increases are similar in size, a 30% and 43% increase, respectively, compared to the control. Households eligible for the productive investment grant also have higher profits from non-agricultural self-employment activities, and higher values of sale or self-consumption of livestock products. Impacts are not only significant but also substantial. Two years after the end of the intervention, average annual profits of non-agricultural self-employment are 603 Cordobas (about US$30) higher than in the control while the return on livestock adds another 221 Cordobas. These numbers hence imply a 15% to 20% annual return to the initial grant of US$200. Households that were eligible for the productive investment grant also report higher levels of business assets compared to the control, and those with businesses expect profits to further increase in the future. For beneficiaries of the basic cash transfer, the smaller increase in participation in non-agricultural activities does not translate in higher returns.

Comparing Tables 1 and 2 indicates that the training was effective in increasing returns to participation in non-agricultural wage jobs—possibly by allowing those beneficiaries already working in non-agricultural jobs to switch jobs—but that it did not increase such participation. The results also indicate no increased returns in non-agricultural self-employment for the training. These results are consistent with findings of the qualitative work that preceded the quantitative data collection, which pointed to low local labour demand, labour market imperfections and

Table 2. *Impact on Different Indicators of Economic Returns.*

		Non-agr. wage income	Gross income in non-agr. self-employment	Profits of non-agr. business	Value livestock sold or self-consumed	Value business assets	Exp. increase in profits in twelve months
CCT + grant (T3)	α_3	−179.3	1216***	603.1***	220.7***	233.1***	178.4***
		(454)	(268)	(156)	(46.6)	(83.2)	(65.6)
CCT + training (T2)	α_2	1061**	−88.67	−286.8*	−32.66	−22.12	−54.91
		(490)	(264)	(156)	(38.5)	(90.8)	(53.3)
CCT (T1)	α_1	241.8	213.5	98.03	−2.467	−88.13	78.76
		(414)	(270)	(166)	(41.6)	(98.9)	(67.4)
Mean in control		3,559	2,820	1,579	836	606	345
Observations		3,880	3,879	3,878	3,880	3,882	1,204
R^2		0.123	0.143	0.130	0.084	0.103	0.080
p-value $\alpha_3 = \alpha_2$		0.016**	0.000***	0.000***	0.000***	0.001***	0.000***
p-value $\alpha_3 = \alpha_1$		0.374	0.000***	0.003***	0.000***	0.002***	0.247
p-value $\alpha_2 = \alpha_1$		0.071*	0.151	0.013**	0.455	0.559	0.028**

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$; SEs clustered by community are given in parentheses; dependent variables trimmed for 1% highest outliers. The table shows ITT estimates, including all household controls (see the notes to Table 1) and block fixed effects, and the expected increase in profits conditional on having non-agricultural self-employment. Non-agricultural wage income excludes public sector professional jobs.

remoteness, together with the relatively short duration of the training, as potential factors limiting the impact of the training. Remaining transaction costs related to wage employment (which, given the remoteness of the region, often implies temporary migration, or long commutes) might have limited the average impact.

Overall, the results indicate that the complementary interventions helped diversify households' income portfolios. The shift is particularly strong for the households eligible to receive the productive investment grant. Smaller impacts on diversification are found for those eligible for training. Having established that the skill and capital interventions indeed affected households' non-agricultural activities, we turn to the main question of this paper and analyse whether these interventions helped households to manage weather variability by smoothing their income and consumption. To do so, we exploit exogenous weather variation.

3. Changes in Weather Patterns, Agronomical Droughts and Welfare Losses

3.1. *Climatic Changes and Agronomical Droughts*

Farmers in the study region report a high incidence of drought shocks. Despite the frequency of droughts, they remain strongly dependent on self-employment agriculture, with almost no irrigation, low adoption of drought resistant varieties or crops, and little diversification into non-agricultural activities. When droughts occur, harvests are often completely lost. Not surprisingly then, households consider agricultural activities riskier than other economic activities.[10] During qualitative interviews, farmers conveyed their strong perception that drought shocks had become more frequent and that changes in weather patterns were interfering with the traditional agricultural seasons. Longitudinal rainfall and temperature data from 1979–2008, obtained from Uribe (2011), confirm these perceptions. Online Appendix Table A.2 and Online Appendix B contain more information on changes in rainfall and temperature patterns during key months for planting and harvesting of the main crops (maize and beans).[11] Changes in rainfall patterns have shortened the overall time window for the two crop cycles by delaying the start of the main agricultural season and shortening the second season. Rainfall is also more irregular. Consistent with the literature on Central America (Schmidt, *et al.*, 2012; FAO, 2019) as well as a wider set of countries and using longer time series (Lobell *et al.*, 2011; IPCC, 2018), increases in temperature are equally drastic.

Our empirical strategy relies on insights from the agronomical literature regarding the role of temperature and rainfall shocks during critical windows in the growth cycles of the main crops (see the Online Appendix), together with substantial variation within the region in terms of rainfall and temperature, as well as in the timing and duration of hot and dry spells. Indeed, even if the 106 communities are located in a relatively small geographical area, the area contains many different micro-climates. As a result, in any given year, weather shocks are more severe for some communities than for others. We exploit this variation to shed light on the relationship between weather shocks and household welfare, and to analyse to what extent the different interventions help households protect themselves against such shocks. In particular, we define

[10] Ninety-three percent of households report agricultural activities to be riskier than wage employment, and 77% consider it riskier than non-agricultural self-employment.

[11] We document shifts in weather patterns using 1998 as a cut-off to compute historical averages. Locally, 1998 is a reference year as it was marked by hurricane Mitch, one of the largest hurricanes to ever hit the region. We also show that (as expected with gradual weather changes) similar shifts are found when using other cut-off years. The main findings of the paper are robust when using 1997, 1996, 1995 or 1994 as the cut-off year for historical averages.

several temperature and rainfall variables based on the agronomical models and aggregate them in two separate shock indices. The key properties of these shock variables is that they only capture exogenous weather variation (due to a 2SLS approach), that they are uncorrelated with treatment status (due to stratification and because they are defined at the block level) and not auto-correlated (as all weather variables capture time-variant shocks).

Specifically, we use the longitudinal information on rainfall and temperature, available for a grid of 0.075° (seventeen nodes across the study region) and 0.15° (eight nodes across the study region), respectively, to calculate indicators capturing rainfall and temperature during critical phases in the crop growth cycles for each year. These variables are then used to predict the block-level intensity of self-reported drought shocks and yield losses in 2008. Instead of estimating the impact of each weather variable separately, we use 2SLS to estimate how treatment effects differ depending on a weather index, predicted based on the exogenous weather variables in the first stage. We use the coefficients of these prediction estimates as weights to construct the shock indices.[12] Specifically, we use either the block-level self-reported shock intensity or the deviation from average yield in the block as first stage outcomes in a 2SLS estimate. Recall that, for stratification, neighbouring communities were grouped into blocks based on local micro-climates prior to randomisation. Hence, all blocks by construction include treatment and control communities, and the block-level measures are orthogonal to treatment (including each treatment package). Block-level shock intensity and yield loss measures capture weather variation across the different micro-climates (see Online Appendix Table A.3).

3.2. *First-Stage Specification*

We first analyse how the block-level averages of the self-reported shocks and yield losses correlate with the exogenous weather variables. To facilitate interpretation, we normalise the self-reported block-level shocks so that a value of 0 describes an average shock intensity, and the estimates correspond to a one standard deviation change in shock intensity (corresponding to a 15% change in the share of households affected by drought in a block). The yield variable is standardised, and, to facilitate comparability with the shock variable, multiplied by −1. Hence, a one standard deviation change in yield corresponds to a yield loss of about one-third when starting from the average yield (421 compared to 1,242). Online Appendix Table A.4 shows the association between these shock measures and welfare in 2008 for households in the control group. The drought shock intensity is strongly negatively correlated with household welfare. A one standard deviation increase in the intensity of shock is related to a 9.7% reduction in total consumption, and a 12.6% reduction in total income.[13] This suggests that income is slightly more sensitive to shocks than consumption. The relationships with yield loss follow a similar pattern.

[12] We need to construct an index as existing aggregate indices are not available for sufficiently small grids. For instance, the Standardized Precipitation-Evapotranspiration Index, a multi-scalar drought index accounting for temperature, rainfall and other factors, is calculated for grids that are much larger (Vicente-Serrano *et al.*, 2010).

[13] These results, and the other results in the paper, are very similar when using only the average shocks of the control households in each block. We prefer the specification with the average of treatment and control because only using the control might lead mechanically to smaller impacts of weather variability in the treatment if it measures shocks less accurately for the treatment.

Table 3. *Relationship between Weather Variables in the First Season and Block Averages of Self-Reported Shocks and Yield Loss.*

	Block-level regressions		Household-level regressions			
	Drought shock in first season		Drought shock in first season		Yield loss in first season	
	(1)	(2)	(3)	(4)	(5)	(6)
Length of the longest dry spell	0.500***	0.305**	0.352***	0.278***	0.430***	0.495***
	(0.11)	(0.11)	(0.075)	(0.082)	(0.086)	(0.083)
Number of days delay in the rains	0.0530***	0.0262	0.0371***	–	–	–
	(0.019)	(0.019)	(0.013)	–	–	–
Number of degree days	0.0867***	0.104	0.120*	0.126*	0.248***	0.143***
	(0.018)	(0.10)	(0.065)	(0.066)	(0.074)	(0.040)
Length of the longest hot spell	−0.249	−1.783***	−0.976***	−1.158***	−0.691**	–
	(0.18)	(0.55)	(0.244)	(0.241)	(0.328)	–
Altitude × number of degree days	–	0.0000	0.0000	0.0000	−0.0003***	−0.0002***
	–	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Altitude × length of the longest hot spell	–	0.0031***	0.0013***	0.0018***	0.0014***	–
	–	(0.001)	(0.000)	(0.000)	(0.000)	–
Altitude	–	−0.0199***	−0.0073***	−0.0104***	−0.0039**	0.0024**
	–	(0.005)	(0.002)	(0.002)	(0.002)	(0.001)
Observations	44	44	3,918	3,918	3,918	3,918
R^2	0.50	0.65	0.51	0.46	0.54	0.49
F-statistic weather variables	–	–	14.56	19.53	23.33	31.00

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$. For household-level regressions (in columns (3)–(6)), SEs are clustered by community. The length of the longest dry spell is defined as the largest number of consecutive dry days in a window of fifteen to sixty days after the start of the rainy season. The start of the rainy season is defined as the first five days with consecutive rain and at least 15 mm cumulative rainfall. The number of days delay in the rains measures how many days this start of the season comes compared to the pre-1998 median start day. The number of degree days in June and July is calculated as a deviation from the pre-1998 average. The longest hot spell is defined as the longest stretch of consecutive days in June–July with temperatures larger than the median pre-1998 daily temperature. See also Section 3, Online Appendix B and Online Appendix Table A.3. Drought intensity measures the normalised share of households in a block reporting a drought shock. Yield loss measures the normalised average maize yields in the block, multiplied by −1. Household-level regressions include controls as in Table 1.

The independent variables for the first-stage regression capture rainfall and temperature during critical phases in the crop growth cycles. All the weather variables are defined to capture time-variant shocks, rather than more permanent changes in climate. Dry spells are defined for the critical window in 2008, which itself depends on the year and location-specific start of the rainy season. The temperature variables (growing degree days and hot spells) are defined as deviations from historical averages.[14] As a result, an important property of the weather variables is that they are not significantly correlated to the same measures for earlier years (see the notes to Table 3 for definitions of each variable).

Table 3 shows that the length of dry spells, the growing degree days and the delay in the start of the rains are all positively and significantly correlated with block-level average of self-reported shocks in the first season (column (1)). Given the variation in altitude and given that water evaporates faster with high temperatures when altitude is higher, we interact the temperature measures with altitude. Column (2) shows that these interactions explain additional variation,

[14] Growing degree days is the summation of a function of temperature $D(T)$ reflecting the ability of crops to absorb heat between 8°C and 32°C, with $D(T) = 0$ for temperatures lower than 8°C, $D(T) = T - 8$ for temperatures between 8°C and 32°C, and $D(T) = 24$ for temperatures higher than 32°C. It is a measure of heat exposure widely used to predict crop yields in the agronomical and climate change literature (Schlenker *et al.*, 2006).

consistent with agronomical models.[15] The weather and altitude variables together capture up to 65% of the variation in the self-reported shocks.

As the main regressions are estimated at the household level, the next two columns show the same relationship using household-level data. The regression also includes the household control variables of the main regression (see Section 4). The dependent variable is the normalised block-level average shock reported for the first season (columns (3) and (4)). These regressions confirm that the exogenous weather variables are strong predictors for the self-reported shock measures. The F-test for joint significance of the weather variables is up to 14.56. Taking out the variable capturing the delay in the start of the season increases the F-statistic to 19.53 (column (4)). Columns (5) and (6) confirm that the weather variables also have good explanatory power for average yield losses in the first season (F-statistics up to 31).

4. Main Empirical Specification and Hypotheses

We estimate the following intent-to-treat (ITT) household-level regressions:

$$Y = \alpha_1 T_1 + \alpha_2 T_2 + \alpha_3 T_3 + \beta S + \gamma_1 T_1 \times S + \gamma_2 T_2 \times S + \gamma_3 T_3 \times S + \delta \boldsymbol{X} + \varepsilon. \quad (1)$$

Here Y denotes household per capita consumption or income; T_1, T_2 and T_3 correspond to the intent-to-treat indicators taking the value of one for households randomly assigned to receive the basic CCT, the CCT plus training and the CCT plus productive investment grant, respectively; S represents one of two shock variables, shock intensity or yield loss, normalised so that they have the value of 0 at average shock intensity or yield loss; $T_1 \times S$, $T_2 \times S$ and $T_3 \times S$ are interaction terms between each treatment package and the shock; and $\boldsymbol{X}$ includes an intercept, altitude and a set of baseline control variables.[16] Given the stratification, our main specification includes block fixed effects. (The value of β cannot be estimated, but other coefficients are estimated with more precision.)

The specification in (1) separates programme effects depending on the intensity of the exposure to shocks or the magnitude of the yield loss, and by treatment. The estimates of α_1, α_2 and α_3 give the intent-to-treat effect at an average level of shocks for each of the interventions.[17] And γ_1, γ_2 and γ_3 show how the impact of the programme changes as the shock intensity or yield loss increases by one standard deviation. We estimate (1) by Ordinary Least Squares (OLS) and 2SLS.

While the block-level shock variables are by construction uncorrelated with treatment status, we cannot rule out that they are correlated with block-level unobservables that might be driving potential heterogeneity in treatment effects. This would bias the OLS estimates. A potential concern is that the survey question asks whether income was affected by the weather shock, making the self-reported variable an imperfect measure of the exogenous weather shock. In

[15] The interaction terms suggest that hot spells are more strongly correlated with reported weather shocks at higher altitudes, as is to be expected since evaporation increases with altitudes due to low atmospheric pressure (see Allen *et al.*, 1998). Adding interactions between altitude and dry spells does not add further explanatory power, but 2SLS results are qualitatively similar with such an alternative specification for the first stage.

[16] Controls include the few variables that showed imbalances in Online Appendix Table A.1, as well as household demographics and assets: the baseline value of the outcome variable, as well as baseline values for age, gender and literacy of the household head, the number of household members in different age groups by gender, distances to school and the health centre, land ownership and dummy variables for baseline participation in different non-agricultural self-employment and wage employment activities.

[17] Since averages are calculated at the block level, while the estimates are at the household level, the point estimates of α_1, α_2 and α_3 vary slightly from the average treatment effects (reported in Online Appendix Table A.5).

particular, it is likely to already capture the income effects of risk management and coping strategies that households used even in absence of the programme. It is also possible that blocks where households tend to have a larger dependence on crop income might on average have more households reporting such shocks, but also might have reacted differently to treatment than more diversified places. Similarly, yield data capture many other factors in addition to weather conditions, which in turn could be correlated to other sources of heterogeneity. By using 2SLS, identification stems from the variation in the block-level average shocks or yields that is due to the exogenous weather shocks. We predict the shock variable as well as the shock variable interacted with the treatment dummies, using the combination of weather variables that result in the highest F-statistics in the first stage (see column (4) of Table 3 for the shock intensity, and column (6) for the yield).

Given that treatment was assigned at the community level (with additional variation within the community), and shocks are measured at the block level, but predicted with weather and altitude variables at the community level, SEs are either clustered at the community or the block level. The F-statistics for the joint significance of the instruments are high (19.53 and 31.00 with clustering at the community level, 14.66 and 18.12 with clustering at the block level). All results are very similar when estimating the same model using limited information maximum likelihood instead of 2SLS.

The exogenous weather variation together with the experimental variation in treatments allow testing four main hypotheses.

(H1) First, we test whether eligibility for the productive investment grant or vocational training protects households' consumption from the negative impact of shocks, two years after the end of the interventions. Hence, we hypothesise that we can reject[18]

$$\gamma_i = 0 \quad \text{for } i = 2, 3.$$

(H2) Second, we test whether at average shock intensity or yield, and two years after the end of the programme, households eligible for the productive investment grant or training have different consumption levels than households in the control group. Hence, we hypothesise that we can reject

$$\alpha_i = 0 \quad \text{for } i = 2, 3.$$

(H3) Third, to shed light on the relative effectiveness of interventions aimed at different types of income diversification, we test whether the capital or skill interventions are equally effective in limiting the negative impact of shocks, and whether the average programme impacts are the same. We test the hypotheses

$$\gamma_3 = \gamma_2 \quad \text{and} \quad \alpha_3 = \alpha_2.$$

(H4) Fourth, we test whether some of the impacts could be related to the longer-term impacts of the conditional cash transfer alone, rather than the complementary productive components. To do so, we hypothesise that we cannot reject

$$\alpha_1 = 0 \quad \text{and} \quad \gamma_1 = 0.$$

[18] While a one-sided test is sufficient to test whether the interventions helped smooth consumption, we report the more conservative two-sided test to ensure consistency with the tests for other hypotheses.

We also compare the impact of the productive investment grant and training packages to the basic package, and test

$$\alpha_1 = \alpha_i \quad \text{and} \quad \gamma_1 = \gamma_i \quad \text{for } i = 2, 3.$$

The analysis of the difference between the three different treatment variations draws on the large statistical power obtained from the individual randomisation of treatments within communities. An obvious caveat with this design, however, is that differences between treatment groups can only be estimated net of intra-community spillovers. For instance, displacement of existing businesses with new ones, or lower ability to seize new business opportunities resulting from the cash flow into the community, could have negatively affected households with the basic package. At the same time, positive spillovers could arise if new businesses increase the availability of products in the communities, the cash influx increases prices, knowledge obtained through training courses is passed on to other households in the community, capital grants are shared to start joint non-agricultural activities with others or positive examples of non-agricultural investment inspire other households. The comparison between treatment variations should hence be interpreted as possibly incorporating any of these positive or negative spillovers. Section 5 therefore analyses the intra-community spillover effects along a number of dimensions, with results showing that, if any, spillovers might have been (net) positive. Differences between households that only received the basic package and control households (captured by the estimates of α_1 and γ_1) help to assess to what extent such potential spillovers contributed to risk management.

5. Impacts on Consumption and Income

5.1. *Consumption and Consumption Smoothing*

Table 4 presents the main results for total consumption per capita using shock intensity (columns (1)–(3)) and yield loss (columns (4)–(6)). The first column presents each time the OLS estimates, the next two the 2SLS estimates. The specification includes block fixed effects. Columns (1) and (2) (as well as columns (4) and (5)) have SEs clustered at the community level, and columns (3) and (6) at the block level. The p-values for tests of hypotheses (H3) and (H4) are reported at the bottom of the table. The estimate of β, i.e., the shock and yield coefficient from the estimation without block fixed effects, is also reported at the bottom of the table.

Turning to hypothesis (H1), the results in Table 4 show that both the vocational training and the productive investment grant help to protect against the negative impact of weather variability. In particular, the estimates of the interaction effect γ_2 and γ_3 show that the vocational training and productive investment grant significantly increase consumption by 7% and 10%, respectively, as shock intensity increases by one standard deviation (columns (2) and (3)). Similar results are found using yield loss (columns (5) and (6)).

With respect to hypothesis (H2), the results show a strong positive and significant impact of the productive investment grant package on consumption. At average shock intensity and yield loss, households that were eligible for this treatment have 8% higher consumption than control households. On the other hand, there is no significant impact of the vocational training package on consumption at an average level of shocks. Since the shock variable is normalised, the estimates of α_1, α_2 and α_3 are very close to the average intent-to-treat effect for each intervention.

Table 4. *Impact of Different Treatments on Consumption by Shock Intensity.*

		Log(total consumption per capita)			Log(total consumption per capita)		
		OLS (1)	2SLS (2)	2SLS (3)	OLS (4)	2SLS (5)	2SLS (6)
CCT + grant (T3)	α_3	0.0817***	0.0775***	0.0775**	0.0833***	0.0848***	0.0848***
		(0.023)	(0.025)	(0.031)	(0.023)	(0.024)	(0.030)
CCT + training (T2)	α_2	0.0255	0.0243	0.0243	0.0276	0.0290	0.0290
		(0.021)	(0.023)	(0.028)	(0.022)	(0.023)	(0.029)
CCT (T1)	α_1	0.0219	0.0222	0.0222	0.0201	0.0214	0.0214
		(0.023)	(0.024)	(0.027)	(0.023)	(0.024)	(0.027)
Shock × T3	γ_3	0.0248	0.100**	0.100**	–	–	–
		(0.023)	(0.039)	(0.047)	–	–	–
Shock × T2	γ_2	0.0302	0.0653**	0.0653*	–	–	–
		(0.023)	(0.032)	(0.038)	–	–	–
Shock × T1	γ_1	−0.0187	−0.0020	−0.0020	–	–	–
		(0.024)	(0.035)	(0.038)	–	–	–
Yield loss × T3	γ_3	–	–	–	0.0147	0.0764**	0.0764**
		–	–	–	(0.024)	(0.030)	(0.038)
Yield loss × T2	γ_2	–	–	–	0.0127	0.0724**	0.0724*
		–	–	–	(0.021)	(0.029)	(0.037)
Yield loss × T1	γ_1	–	–	–	−0.0209	0.0013	0.0013
		–	–	–	(0.021)	(0.029)	(0.033)
Level of clustering		Commun.	Commun.	Block	Commun.	Commun.	Block
Block fixed effects		Yes	Yes	Yes	Yes	Yes	Yes
Observations		3,918	3,918	3,918	3,918	3,918	3,918
R^2		0.32	–	–	0.32	–	–
β		−0.0749***	−0.114**	−0.114**	−0.0143	−0.0586**	−0.0586**
		(0.021)	(0.047)	(0.047)	(0.020)	(0.028)	(0.028)
(H3): p-value $\alpha_3 = \alpha_2$		0.007***	0.017**	0.020**	0.007***	0.007***	0.009***
p-value $\gamma_3 = \gamma_2$		0.792	0.382	0.392	0.932	0.904	0.903
(H4): p-value $\alpha_3 = \alpha_1$		0.011**	0.027**	0.035**	0.005***	0.005***	0.011**
p-value $\gamma_3 = \gamma_1$		0.057*	0.027**	0.036**	0.121	0.026**	0.036**
p-value $\alpha_2 = \alpha_1$		0.833	0.989	0.893	0.68	0.685	0.658
p-value $\gamma_2 = \gamma_1$		0.003***	0.015**	0.008***	0.053*	0.012**	0.007***

Notes: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$; SEs are given in parentheses. All regressions include household-level controls (see the notes to Table 1). Estimates of β derived from the specification without block fixed effects (see Online Appendix Table A.7).

Turning to hypothesis (H3), the impact at average shock intensity is significantly higher for the productive investment grant than for the vocational training (p-value between 0.01 and 0.02). By contrast, the estimates of the coefficient of the interaction terms are not significantly different (p-value 0.4 to 0.9 when testing $\gamma_3 = \gamma_2$). Households eligible for the productive investment grant have higher consumption levels at average shocks than households eligible for the vocational training, but both are equally protected against the negative impact of increased shock intensity on consumption. The results are similar when using yield loss.

Are households receiving the basic conditional cash transfer package also protected from shocks (hypothesis (H4))? The results in Table 4 show that households eligible for the basic package do not have significantly smoother nor significantly higher average consumption compared to control households. We cannot reject that $\gamma_1 = 0$ and $\alpha_1 = 0$. Moreover, at an average level of shocks, consumption is significantly lower than for households eligible for the productive investment package (p-value between 0.005 and 0.035). In addition, the coefficient of the interaction term is significantly different compared to both productive investment grant and vocational training packages (p-value between 0.007 and 0.036). Hence, in contrast with the complementary productive packages, the basic CCT package does not offer protection against the negative effect of shocks two years after the end of the intervention.

Taken together, these results show that the protection against shocks stems from the complementary interventions, not the basic CCT. Two years after the end of the programme, both productive packages lead to smoother consumption and protect against the negative welfare effects of weather shocks. In addition, households eligible for the productive investment grant also have higher average consumption compared to all other groups. Because we test all together six coefficients in each regression, possible concerns about multiple hypotheses are addressed following Young (2019) with a joint test of these different coefficients through randomisation inference.[19] Online Appendix Table A.6 (columns 1–2) shows exact p-values from a randomisation t-test for the main specification, showing similar results, and also confirms the joint significance of the coefficients.

The estimates of β at the bottom of the table provide a benchmark with which to compare the magnitude of the interaction coefficients. (The full estimation without block fixed effects can be found in Online Appendix Table A.7). The coefficients of the interaction terms are of the same magnitude as the shock coefficient β, suggesting that both complementary interventions fully offset the negative relationship between weather shocks and consumption. The estimate of β is also useful to understand the differences between the OLS and the 2SLS results. Notably, the estimated impacts of shocks are larger in the 2SLS than in the OLS, and consequently the interaction effects of the shock with the treatment variables are also larger in the 2SLS. The magnitude of the 2SLS shock coefficient indicates that an increase in shock intensity of one standard deviation (corresponding to 15% more households reporting a shock in a block) reduces per capita consumption by 11%, compared to only 8% in the OLS. Similarly, the 2SLS coefficient for yield is larger than the OLS. Using the weather-related exogenous variation in yield, a one standard deviation yield loss (corresponding to a yield loss of one-third when compared to the mean) reduces per capita consumption by 6%. The comparison between the OLS and 2SLS results suggests substantial bias in the former. This finding supports our estimation approach, and also more broadly sheds light on the potential bias of using self-reported weather shocks or yield data. While the 2SLS estimates reflect only exogenous weather variability, the OLS estimates likely also capture any risk management and coping practices that even control households might use. These in turn are likely to affect the way they might report shocks and yields ex post, leading to an underestimation of the impact of shocks. The OLS could further be affected by attenuation bias due to measurement error in both the shock and the yield variables.

5.2. *Income and Income Smoothing*

Table 5 presents the main results for total income per capita, using the same specifications as in Table 4. Here, again (and as expected), the β coefficient suggests a strong negative relationship between weather shocks and income in the control communities: a one standard deviation increase in shock intensity decreases per capita income by 14%, and a one standard deviation yield loss

[19] In terms of outcomes, the paper has only one main outcome (consumption per capita) and one main mechanism (income); hence, no further adjustment for hypotheses regarding multiple outcomes are made. Because the RCT pre-dates the introduction of pre-analysis plans, there is no pre-analysis plan specifying these outcome variables, or the focus on heterogeneity by weather variability. But, given that the primary objective of the intervention was to specifically help households manage weather shocks, (1) is the most natural specification to test whether the interventions reached that objective.

Table 5. *Impact of Different Treatments on Income by Shock Intensity.*

		Log(per capita income)			Log(per capita income)		
		OLS (1)	2SLS (2)	2SLS (3)	OLS (4)	2SLS (5)	2SLS (6)
CCT + grant (T3)	α_3	0.0423*	0.0374	0.0374	0.0438*	0.0453*	0.0453
		(0.025)	(0.026)	(0.032)	(0.024)	(0.025)	(0.030)
CCT + training (T2)	α_2	−0.0061	−0.0094	−0.0094	−0.0043	−0.0028	−0.0028
		(0.024)	(0.025)	(0.028)	(0.024)	(0.025)	(0.029)
CCT (T1)	α_1	−0.0201	−0.0205	−0.0205	−0.0210	−0.0194	−0.0194
		(0.024)	(0.026)	(0.027)	(0.024)	(0.025)	(0.026)
Shock × T3	γ_3	0.0129	0.108**	0.108*	–	–	–
		(0.023)	(0.044)	(0.055)	–	–	–
Shock × T2	γ_2	0.0173	0.0905**	0.0905**	–	–	–
		(0.023)	(0.039)	(0.038)	–	–	–
Shock × T1	γ_1	−0.0160	0.0220	0.0220	–	–	–
		(0.023)	(0.040)	(0.043)	–	–	–
Yield loss × T3	γ_3	–	–	–	0.0425*	0.0866**	0.0866**
		–	–	–	(0.024)	(0.033)	(0.039)
Yield loss × T2	γ_2	–	–	–	0.0211	0.104***	0.104**
		–	–	–	(0.024)	(0.038)	(0.040)
Yield loss × T1	γ_1	–	–	–	−0.0062	0.0143	0.0143
		–	–	–	(0.024)	(0.033)	(0.037)
Level of clustering		Commun.	Commun.	Block	Commun.	Commun.	Block
Block fixed effects		Yes	Yes	Yes	Yes	Yes	Yes
Observations		3,892	3,892	3,892	3,892	3,892	3,892
R^2		0.27	–	–	0.27	–	–
β		−0.100***	−0.138***	−0.138***	−0.0370	−0.0748**	−0.0748**
		(0.023)	(0.050)	(0.049)	(0.023)	(0.037)	(0.031)
(H3): p-value $\alpha_3 = \alpha_2$		0.069**	0.086*	0.087*	0.066*	0.076*	0.082*
p-value $\gamma_3 = \gamma_2$		0.860	0.738	0.740	0.481	0.721	0.715
(H4): p-value $\alpha_3 = \alpha_1$		0.002***	0.007***	0.012**	0.001***	0.001***	0.002***
p-value $\gamma_3 = \gamma_1$		0.171	0.042**	0.051*	0.030**	0.010***	0.016**
p-value $\alpha_2 = \alpha_1$		0.579	0.671	0.671	0.507	0.531	0.548
p-value $\gamma_2 = \gamma_1$		0.149	0.141	0.139	0.351	0.055*	0.055*

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$; SEs are given in parentheses. All regressions include household-level controls (see the notes to Table 1). Income trimmed for 1% highest outliers. Estimates of β derived from the specification without block fixed effects (see Online Appendix Table A.8).

decreases per capita income by 7%. Income is hence slightly more sensitive to adverse weather conditions than consumption.

The results for the average effects of the different interventions and the interactions with the shock variables are very consistent with the consumption results for both shock measures. Income of households eligible for either complementary intervention is protected against the negative effect of higher shock intensity. The interaction effects in columns (2), (3), (5) and (6) are significant and large, indicating income is 9%–11% higher than in the control when shock intensity (yield loss) increases by one standard deviation. The magnitude of the interaction terms suggests that both complementary interventions protect income from the negative effect of increased shock intensity. In addition, there is a positive average impact of the productive investment grant package on income, significant at 10%. At average yield loss, households eligible for this treatment have 4% higher income than control households. Hence, the productive investment grant increases average income while also making income less sensitive to weather variability. As with the consumption results, being eligible for training does not lead to higher average income but does lead to less variable income. Online Appendix Table A.6 (columns 3–4) shows exact *p*-values from a randomisation *t*-test (Young, 2019) for the main specification and shows similar results. Online Appendix Table A.8 shows results without block fixed effects.

For both vocational training and the productive investment grant, the coefficients of the interaction effects with shocks are similar for consumption and income, suggesting that smoother income contributed to protecting consumption from shocks. For the productive investment grant, the average impact is smaller for income than for consumption (though not significantly so). This may stem from attenuation bias (income being notably noisier), but may also indicate that the intervention contributed to higher consumption through other channels as well. For instance, beneficiary households may have resorted to inter-temporal consumption smoothing by using savings from earlier periods or, related, part of the average consumption gains may have resulted from a (slow) depletion of some of the business assets, store inventory or livestock.

5.3. *Alternative Specifications*

A first important indication of the robustness of the results is that they are highly consistent between the specifications using the reported weather shocks and yields, as well as across income and consumption outcomes. In addition, Online Appendix Tables A.9 and A.10 show the results of various alternative specifications for per capita consumption and income. Results are robust to (*i*) limiting controls to the baseline outcome and altitude, (*ii*) calculating the block-level average weather shock and yield loss with all observations in the block except for the data from the household itself; (*iii*) including interaction effects of baseline consumption with each of the treatments, in addition to the shock interaction effects shown earlier; and (*iv*) replacing the 2SLS with an alternative two-step method to analyse the treatment heterogeneity, similar to the approach used by Giné *et al.* (2012). The first-step estimation is done using the community-level information for the fifty control communities, regressing average yields on the exogenous weather variables and their interaction with altitude and then using coefficients of these estimations to obtain predicted yields for the treatment and the control communities, and using bootstrapped SEs to account for the two-step procedure. Findings are also robust to the introduction of sampling weights (Online Appendix Table A.11). and alternative definitions of weather shocks (Online Appendix Tables A.12 and A.13).

5.4. *Placebo Tests*

The empirical strategy is further tested through a series of placebo specifications in Table 6. Re-estimating (1) using baseline (2005) per capita consumption measures shows small and insignificant coefficients for the impacts at average levels of shocks and yield loss (columns (1) and (2)), consistent with the randomised assignment. The coefficients of the interaction effects have the opposite sign to those found for 2008 and are mostly not significant, confirming that the positive findings in 2008 are unlikely to be driven by a spurious positive correlation between the predicted shock variable and baseline measures of per capita consumption.[20] A similar test using the 2006 per capita consumption also shows small and insignificant interactions between the treatment variables and the predicted shock and yield variables for 2008 (columns (3) and (4)). As expected, for 2006, the coefficients of the average impacts of the three experimental variations

[20] For consumption, γ_3 is significant at 10% but points in the opposite direction than the 2008 result, indicating that, if anything, the latter is slightly underestimated.

Table 6. *Placebo Tests with Baseline and Midline Data.*

	Log(consumption p.c. 2005)		Log(consumption p.c. 2006)		
	(1)	(2)	(3)	(4)	(5)
CCT + grant (T3)	0.0272	0.0212	0.299***	0.301***	0.302***
	(0.027)	(0.026)	(0.027)	(0.027)	(0.029)
CCT + training (T2)	0.0256	0.0222	0.254***	0.254***	0.250***
	(0.026)	(0.025)	(0.027)	(0.027)	(0.028)
CCT (T1)	0.0429	0.0405	0.259***	0.257***	0.252***
	(0.026)	(0.025)	(0.026)	(0.026)	(0.027)
Shock × T3	−0.0852*	–	0.0111	–	–
	(0.044)	–	(0.041)	–	–
Shock × T2	−0.0544	–	−0.0235	–	–
	(0.048)	–	(0.039)	–	–
Shock × T1	−0.0432	–	−0.0424	–	–
	(0.048)	–	(0.039)	–	–
Yield loss × T3	–	−0.0762*	–	0.0281	–
	–	(0.040)	–	(0.037)	–
Yield loss × T2	–	−0.0430	–	0.0195	–
	–	(0.040)	–	(0.038)	–
Yield loss × T1	–	−0.0294	–	0.0116	–
	–	(0.040)	–	(0.037)	–
Shock in 06 × T3	–	–	–	–	0.0294
	–	–	–	–	(0.056)
Shock in 06 × T2	–	–	–	–	−0.0362
	–	–	–	–	(0.056)
Shock in 06 × T1	–	–	–	–	−0.0565
	–	–	–	–	(0.051)
Observations	3,918	3,918	3,880	3,880	3,880

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$; SEs are given in parentheses, clustered at the community level. All regressions include block fixed effects and household-level controls as in Table 1.

are large, reflecting the direct impact of the CCT on consumption; see the supplementary material online for a more detailed discussion.

Finally, in column (5) we regress 2006 per capita consumption on the treatments and the predicted shock for 2006 interacted with the experimental treatments (we cannot perform this placebo test for yields due to lack of data for 2006). At the time of the 2006 survey, the training had not yet started and hence could not yet have led to consumption smoothing, and the productive investment grant had only recently been disbursed, limiting its potential to reduce impacts of shocks that occurred in the first season of 2006. This is confirmed by column (5), showing no significant interaction effects.

5.5. *Spillovers within Treatment Communities*

As mentioned in Section 4, the comparison between treatment variations should be interpreted as possibly incorporating any positive and negative intra-village spillovers. Besides capturing any longer-term effects of the CCT itself, the comparisons between households assigned to the basic package and control households who reside in other communities can help shed some light on these potential intra-community spillover effects. This comparison suggests that net spillovers may have been positive: beneficiaries of the basic package are slightly more active in non-agricultural activities than control households, but consumption and earnings are not significantly higher. Data from community surveys further show that the availability of food and non-food items remained higher in the treatment communities two years after the end of the intervention, consistent with a net increase in small businesses at the community level (Online Appendix Table A.14).[21] The scope for negative spillovers and displacement effects was arguably limited as there were few existing businesses at baseline. Online Appendix Table A.15 further shows that, two years after the intervention, there were no significant price differences between treatment and control, and prices also do not vary differentially with the intensity of shocks, indicating that results are not driven by general equilibrium price effects.

6. Mechanisms

Section 2 showed that the productive interventions increased households' participation in non-agricultural activities, as well as returns from such activities. Section 5 then showed that both productive interventions provided protection against climatic shocks through income and consumption smoothing. Is it the programme's focus on economic diversification that offered this protection, or could the results be driven by the overall higher value (hence higher implicit overall transfers) of the training and the productive investment packages? An exploratory heterogeneity analysis provides empirical support for the role of diversification in facilitating consumption and income smoothing. If diversification is driving the results, and given the change in participation in different economic activities along the extensive margin documented in Table 1, one could expect the productive interventions to be less impactful for households that were already diversified at baseline. Table 7 confirms that consumption smoothing results are indeed stronger for households that were not diversified at baseline (columns (1)–(2) and (5)–(6)) compared to those that were (columns (3)–(4) and (7)–(8)). Online Appendix Table A.16 shows similar results for income smoothing.

To further disentangle the mechanisms, this section focuses on the contrast between the two productive packages. Importantly, results show that the productive interventions led to markedly different changes in economic activities and related diversification, in line with their differential emphasis on capital versus skills. This goes against an interpretation that it is solely the overall value of the package that matters. Specifically, we first analyse labour re-allocation across different economic activities in response to shocks, which helps to unpack the mechanisms through which the productive investment package and the training package helped smooth income and consumption. We also present various additional results on skills, capital investments and diversification, together with direct evidence on shifts in attitudes toward diversification. While it is hard to fully rule out that the impact of the productive investment grant is merely the result of receiving more money two years earlier, taken together these findings strongly suggest that the programme's emphasis on income diversification, and the distinct components of the two packages, were instrumental in achieving consumption and income smoothing.

6.1. *Labour Allocation across Economic Activities*

Table 8 (panel A) presents changes in time allocation of all adult household members by type of economic activity. We measured the number of days in the last twelve months each adult in the household had been engaged in various off-farm economic activities. Consistent with the results

[21] Based on a listing of small businesses at the community level, Online Appendix Table A.14 documents that there is a larger number of small businesses in treatment communities compared to control communities. In particular, there are more local convenience stores, cereal traders, bakeries and hairdresser. Differences in some other types of business (e.g., butcher's shop, shoe traders, shops or mechanics) are suggestive, though not statistically significant.

Table 7. *Impact on (Log per Capita) Consumption for Subgroups of Households (by Baseline Diversification).*

	Without non-agr. activity		With non-agr. activity		With ≤ 2 activities		With > 2 activities	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CCT + grant (T3)	0.116***	0.129***	0.0141	0.0160	0.122***	0.139***	0.0351	0.0358
	(0.026)	(0.026)	(0.037)	(0.036)	(0.032)	(0.031)	(0.029)	(0.029)
CCT + training (T2)	0.0294	0.0355	0.0278	0.0333	0.0167	0.0221	0.0351	0.0372
	(0.025)	(0.026)	(0.036)	(0.035)	(0.027)	(0.028)	(0.028)	(0.028)
CCT (T1)	0.0389	0.0428*	−0.0088	−0.0121	0.0464	0.0480	−0.0183	−0.0220
	(0.025)	(0.026)	(0.037)	(0.035)	(0.029)	(0.030)	(0.033)	(0.033)
Shock × T3	0.123***	–	0.0763	–	0.159***	–	−0.0121	–
	(0.041)	–	(0.075)	–	(0.047)	–	(0.062)	–
Shock × T2	0.0690*	–	0.111	–	0.0841**	–	0.0133	–
	(0.036)	–	(0.077)	–	(0.036)	–	(0.069)	–
Shock × T1	0.0330	–	−0.159*	–	0.0424	–	−0.0730	–
	(0.035)	–	(0.087)	–	(0.037)	–	(0.071)	–
Yield loss × T3	–	0.129***	–	0.0004	–	0.173***	–	−0.0424
	–	(0.036)	–	(0.043)	–	(0.043)	–	(0.036)
Yield loss × T2	–	0.0954**	–	0.0235	–	0.108**	–	−0.0066
	–	(0.041)	–	(0.045)	–	(0.042)	–	(0.035)
Yield loss × T1	–	0.0416	–	−0.0834*	–	0.0607	–	−0.0849**
	–	(0.035)	–	(0.047)	–	(0.040)	–	(0.038)
Observations	2,535	2,535	1,383	1,383	2,248	2,248	1,670	1,670

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$; SEs are given in parentheses, clustered at the community level. Columns (1)–(4) divide households based on whether they had at least one member working in a non-agricultural activity at baseline, while columns (5)–(8) distinguish between households with at least two versus more than two different economic activities (out of a list of nine: agricultural self-employment, agricultural day labour, livestock, self-employment in commerce, services, manufacturing or food production, non-agricultural wage work and professional jobs).

in Table 1, there is a large increase in time allocated to non-agricultural self-employment for the households that were eligible for the productive investment grant, suggesting crowding in of labour effort. We cannot directly observe whether the increase in labour days in non-agricultural self-employment is matched with a decrease in agricultural self-employment. However, Online Appendix Table A.17 shows that most of the increase in non-agricultural self-employment comes from adult women (the target beneficiaries of the productive investment package). As women in this setting have limited engagement in agricultural self-employment, it is likely that this represents an overall increase in labour effort. This is consistent with the review by Banerjee *et al.* (2017) on cash transfers not dis-incentivising work, and on asset transfers often leading to increased labour effort.

Households eligible for the training, in contrast, do not increase time allocated to self-employment or wage activities on average, but notably change their time allocation towards wage employment when shocks occur. This result suggests that having benefited from the vocational training equipped those households with skills they could use to obtain wage work when shocks hit. The finding that they only decide to use those skills at times of need is consistent with a low reported willingness to accept employment outside the municipality of origin. When asked how much they would need to be paid in order to accept a job in the closest city, respondents indicate much higher salaries than those being actually paid, pointing to a very high reservation wage (suggestive of the perceived mobility costs associated with taking these jobs). When shocks occur, the increased wage work for households from the vocational training group is mostly in the non-agricultural sector. In contrast, households eligible for investment grants do not increase wage work in response to shocks, though they do seem to reallocate from agricultural to

Table 8. *Time Worked (per Activity) and Migration in Response to Shocks.*

	Panel A: total number of days worked (per activity) by all household members								*Panel B: individuals who permanently left the household*			
	Non-agr. self-employment		All wage employment		Non-agr. wage employment		Agr. wage employment		All migration		Migration for work	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
CCT + grant (T3)	82.16***	81.45***	−15.79	−17.00	−10.20	−9.148	−6.751	−9.000	−0.009	−0.008	−0.004	−0.003
	(11.1)	(11.5)	(11.5)	(11.4)	(6.94)	(6.82)	(9.72)	(9.63)	(0.020)	(0.019)	(0.009)	(0.009)
CCT + training (T2)	5.677	4.212	−12.85	−9.893	0.864	2.744	−14.52	−13.38	−0.037*	−0.030	−0.009	−0.004
	(9.66)	(9.81)	(12.9)	(12.9)	(7.26)	(7.07)	(11.3)	(11.7)	(0.020)	(0.019)	(0.009)	(0.010)
CCT (T1)	21.67*	21.42*	−12.79	−11.81	4.313	4.883	−18.52*	−17.99*	−0.030*	−0.030*	−0.006	−0.006
	(12.0)	(11.7)	(11.1)	(10.8)	(6.44)	(6.28)	(9.85)	(9.89)	(0.017)	(0.016)	(0.008)	(0.008)
Shock × T3	−13.13	–	−18.04	–	15.45	–	−32.34**	–	0.034	–	0.014	–
	(17.0)	–	(18.2)	–	(12.6)	–	(16.2)	–	(0.035)	–	(0.015)	–
Shock × T2	−23.16	–	32.47	–	25.36*	–	8.551	–	0.107***	–	0.068***	–
	(16.7)	–	(19.8)	–	(13.6)	–	(17.1)	–	(0.034)	–	(0.017)	–
Shock × T1	−7.017	–	8.949	–	9.398	–	2.109	–	0.016	–	0.002	–
	(17.3)	–	(17.6)	–	(12.2)	–	(16.8)	–	(0.029)	–	(0.013)	–
Yield loss × T3	–	−12.61	–	−12.25	–	13.17	–	−24.94*	–	−0.021	–	0.001
	–	(15.2)	–	(15.4)	–	(9.61)	–	(13.4)	–	(0.026)	–	(0.012)
Yield loss × T2	–	−6.269	–	38.84**	–	21.77**	–	18.22	–	0.053**	–	0.042***
	–	(13.4)	–	(16.7)	–	(10.8)	–	(14.5)	–	(0.027)	–	(0.013)
Yield loss × T1	–	8.122	–	16.87	–	8.053	–	10.41	–	−0.010	–	−0.004
	–	(15.5)	–	(14.4)	–	(9.70)	–	(14.3)	–	(0.024)	–	(0.011)
Mean in control	112.72	112.72	257.58	257.58	81.57	81.57	176.01	176.01	0.16	0.16	0.05	0.05
Observations	3,916	3,916	3,916	3,916	3,916	3,916	3,916	3,916	3,918	3,918	3,918	3,918

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$; SEs are given in parentheses, clustered at the community level. All regressions include block fixed effect and household-level controls as in Table 1.

non-agricultural work. Finally, households only assigned to the regular cash transfers do not appear to reallocate labour in response to shocks, but do, on average, reallocate some agricultural wage work to non-agricultural self-employment.

These results suggest that households eligible for productive investment grants are able to smooth consumption directly through increased activity in the non-agricultural sector. With a higher income share coming from non-agricultural activities, these households are (almost mechanically) less vulnerable when weather shocks affect their agricultural income.[22] In contrast, households eligible for vocational training seem able to smooth income and consumption through behavioural changes when shocks occur: the training provided skills that helped them react to shocks by shifting labour effort. This mechanism is further confirmed when considering migration for work. While the average treatment effect for all treatment groups suggests (if anything) a reduction of outmigration, households assigned to vocational skills training are more likely to have members emigrate when shocks occur (Table 8, panel B).

To confirm that the skills training facilitated a shift in labour allocation in response to shocks, one ideally would like to know whether results are driven by the person in the household who participated in the course. Since beneficiaries could decide which household member participated in the training, we cannot directly estimate impacts for the selected member (as it is not possible to know who would have been selected in the other treatment and control groups). Still, we can predict who the skill training participant was likely to be and obtain ITT estimates for these predicted members. To make this prediction for each household, we consider the education levels of all teenage and adult members, accounting for the fact that the main beneficiary was the person asked to choose, and that she was encouraged to prioritise young adult household members with sufficient literacy.[23] Table 9 shows ITT estimates for these predicted training participants. Results confirm that predicted participants in training treatment households are more likely to move to wage work and migrate when shocks occur (columns (1)–(2) and (5)–(6)). The results are noteworthy as the coefficients likely underestimate average treatment effects on actual training participants. The results are further confirmed when focusing on household members more likely to be mobile: coefficients are larger on the sub-sample of households for which the prediction points to a child or other household member that is not the main beneficiary or her spouse (columns (3)–(4) and (6)–(7)). As columns (1)–(4) do not account for permanent migrants' labour (since there is no detailed time use data for them), columns (9)–(12) present an alternative estimate that includes household members reported as permanently migrating for work as having a full-time wage job. Overall, the results in Table 9 are consistent with the labour response in reaction to shocks being driven by individuals most likely to have participated in the training course.

[22] Note that beneficiaries who diversified into non-agricultural small businesses and mainly supply local markets could suffer from low demand at times of drought. But weather variability across communities helps explains why non-agricultural activities could nevertheless contribute to income and consumption smoothing. Exploiting local variation in shocks, Online Appendix Table A.18 shows that the consumption and income smoothing results are stronger when neighbouring blocks are less affected by shocks.

[23] On average, there are 3.5 teenagers and adults in a household. For the prediction, we select the person with the highest education, reflecting the guidelines for choosing educated younger members (and given secular trends in education). If there are multiple people with the same level of education, we prioritise the main caregiver (reflecting she was the one choosing), her spouse and then her children. We predict the correct household member to participate in the training for 52% of the households (with the proportion of main caregivers, spouses and younger members in the prediction being similar to the reality). The main reason for incorrect predictions is that many households have multiple younger household members with similar education levels, and each household has discretion to choose based on characteristics or preferences we do not necessarily observe.

Table 9. *Time Worked in Wage Employment and Migration in Response to Shocks—Household Member Predicted to Participate in Training.*

	# days worked in wage employment				Permanently left the household				# days worked in wage empl. (incl. work migration)			
	Any member		Child of main beneficiary		Any member		Child of main beneficiary		Any member		Child of main beneficiary	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
CCT + grant (T3)	−2.694	−2.463	2.947	3.382	−0.007	−0.007	−0.003	−0.003	−2.946	−2.753	2.358	2.683
	(5.15)	(5.04)	(6.52)	(6.62)	(0.009)	(0.008)	(0.018)	(0.017)	(5.10)	(5.07)	(6.52)	(6.75)
CCT + training (T2)	−0.751	1.145	4.621	7.019	−0.006	−0.002	−0.004	0.001	−1.121	1.074	3.946	6.635
	(5.57)	(5.63)	(8.06)	(8.13)	(0.009)	(0.008)	(0.017)	(0.017)	(5.60)	(5.67)	(7.98)	(8.06)
CCT (T1)	2.526	2.902	10.17	10.19	−0.019**	−0.018**	−0.024*	−0.023	1.598	1.963	7.944	8.004
	(5.89)	(6.18)	(8.81)	(9.39)	(0.008)	(0.007)	(0.015)	(0.014)	(5.96)	(6.26)	(8.79)	(9.36)
Shock × T3	1.653	–	4.234	–	0.005	–	0.017	–	0.981	–	3.059	–
	(8.73)	–	(12.4)	–	(0.015)	–	(0.028)	–	(8.84)	–	(12.5)	–
Shock × T2	20.02*	–	30.90	–	0.045***	–	0.092***	–	23.81**	–	37.07*	–
	(11.7)	–	(19.6)	–	(0.016)	–	(0.031)	–	(12.0)	–	(19.6)	–
Shock × T1	2.540	–	2.697	–	0.009	–	0.029	–	2.473	–	2.874	–
	(11.3)	–	(14.7)	–	(0.015)	–	(0.027)	–	(11.7)	–	(15.2)	–
Yield loss × T3	–	9.097	–	7.454	–	−0.003	–	−0.002	–	8.768	–	6.423
	–	(7.35)	–	(9.80)	–	(0.012)	–	(0.022)	–	(7.42)	–	(9.91)
Yield loss × T2	–	25.84***	–	34.70**	–	0.040***	–	0.065***	–	29.38***	–	39.82***
	–	(9.60)	–	(14.1)	–	(0.012)	–	(0.022)	–	(9.93)	–	(14.4)
Yield loss × T1	–	3.587	–	−2.970	–	0.007	–	0.012	–	4.303	–	−1.556
	–	(9.82)	–	(13.1)	–	(0.011)	–	(0.018)	–	(10.0)	–	(13.2)
Mean control	83.33	83.33	90.25	90.25	0.05	0.05	0.08	0.08	86.53	86.53	95.34	95.34
Observations	3,402	3,402	1,735	1,735	3,555	3,555	1,868	1,868	3,439	3,439	1,768	1,768

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$; SEs are given in parentheses, clustered at the community level. All regressions include block fixed effects and household-level controls as in Table 1.

6.2. *Further Interpretation on Investments, Skills and Economic Diversification*

Results so far are consistent with the productive interventions making households more economically resilient to weather shocks by addressing constraints to income diversification. The differences in the pathways through which the productive investment grant and training interventions appear to have facilitated consumption smoothing can be interpreted as highlighting the relative role of addressing constraints related to capital or skills for households' risk management.

Indeed, while both interventions provided a mix of capital and training, the productive investment grant mostly constituted capital. The technical assistance was limited and primarily involved monitoring of the business plan implementation, rather than actual skill transfers. Columns (1)–(2) of Table 10 provide empirical support for this interpretation. Data from the survey collected a few months after the business grant payment (in 2006) confirm that a vast majority of households selected for the productive investment grant reported having started a new business (increase of 61 p.p.), with a lower increase in reported expansion of an existing business (18 p.p.). As shown in Table 1, two years later this still translated to more capital-intensive self-employment activities. This points to diversification through investment of the productive grant in the creation of new activities. In addition, the business skills training did not lead to changes in business knowledge, as proxied by the number of business practices beneficiaries report knowing. Neither did it change answers on vignettes (small fictional stories measured at endline and designed to capture shifts in knowledge) regarding business practices related to consumer credit or price setting (Table 10, columns (3)–(5)). This is consistent with the limited business skill training offered to productive grant beneficiaries, and the fact that technical assistance focused on monitoring of the business investment plan implementation.

In contrast, the training intervention was designed to mostly provide skills and not transfer capital. The scholarship to cover course fees was not paid to households, but directly to training providers. There was limited access to vocational training courses other than those organised for the programme, so that paying for training was not a realistic option for most control households. (Only 5% of individuals aged fifteen or older in the control report any past participation in training and almost all of this as part of other programmes). The monetary compensation for time spent in class was relatively small and was intended to cover foregone income and transportation costs. During qualitative work, beneficiaries also indicated they faced liquidity constraints to buy tools to practice their newly learned skills. The training focused on acquiring technical skills, but participants received a certificate upon completion and were given basic advice on job search in the labour market workshops. It is possible that this helped them obtain jobs in times of need, by increasing their ability to signal skills. A broader interpretation therefore would be that the estimated impacts of training capture a return to individuals' ability to find wage jobs in times of need, through a combination of increased skills and signalling. Even so, among those who took a course, 61% claimed they had put in practice what they learned, and 73% of them felt very comfortable applying the technical skills learned. This suggests that technical skill acquisition did take place, though possibly not for everyone. At the same time, about half of the respondents indicated only using the skills at home, while 33% had used the skills for a job or business, consistent with the limited increase in wage employment in the absence of shocks. The potential of the skills acquired in the training to contribute to income diversification was further confirmed by insights from the qualitative work, through several success stories of respondents explaining, for instance, how they used their newly acquired masonry skills to find temporary employment

Table 10. *Impact on New Business Creation, Business Knowledge and Attitudes about Diversification.*

	Business creation or expansion during the programme		Self-reported knowledge on business practices			Attitudes towards diversification		
	Household created a new business in 2006 (1)	Household expanded a business in 2006 (2)	Number of business practices known (max 3) (3)	Vignette: would give credit to customers (4)	Vignette: would increase price if input costs increase (5)	Vignette: HH would invest an inheritance to buy sewing machine over buying land (6)	Vignette: a HH member would migrate after losing harvest (7)	Vignette: HH would start a non-agr. business after losing harvest (8)
CCT + grant (T3)	0.613***	0.178***	0.0382	−0.0232	−0.0115	0.0912***	−0.0418***	0.0676***
	(0.019)	(0.020)	(0.028)	(0.019)	(0.020)	(0.017)	(0.014)	(0.023)
CCT + training (T2)	−0.00238	0.0236	−0.0360	0.0095	−0.0161	0.106***	−0.0161	0.0591**
	(0.014)	(0.018)	(0.029)	(0.020)	(0.020)	(0.017)	(0.014)	(0.023)
CCT (T1)	0.000307	0.0259	−0.0049	0.0285	−0.0134	0.0538***	−0.0286*	0.0619***
	(0.014)	(0.019)	(0.027)	(0.019)	(0.021)	(0.017)	(0.015)	(0.023)
Mean in control	0.11	0.16	2.25	0.31	0.60	0.50	0.88	0.48
Observations	3,877	3,875	3,918	3,917	3,914	3,917	3,910	3,910

Notes: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$; SEs clustered by community are given in parentheses. All regressions include household-level controls and block fixed effects (see the notes to Table 1).

abroad to help address hardship at home, or used their new computing skills to get a part-time clerical job.

Overall, the clear differences in mechanisms between productive interventions show that households used the additional resources in remarkably different ways and support our interpretation that the intended productive use of either skills or the investment grant, rather than only the monetary value of these interventions, are important to understand the documented impacts. We find substantial differences in behavioural response between treatments, including involvement in different types of economic activities and related diversification. There are also clear differences with households receiving the CCT alone, which allows ruling out that the results are driven by long-term impacts of the CCT itself. The CCT combined with productive interventions was hence more effective than the basic CCT in helping households protect themselves against future shocks. More specifically, the results suggest that interventions aiming to provide (mostly) either capital or skills were effective in lifting constraints to income and consumption smoothing. In addition, the capital-intensive intervention also resulted in higher average consumption levels.[24]

6.3. *Beliefs and Attitudes about Diversification*

The potential of labelled cash transfers to nudge households towards certain types of intended investments more than they would have done with cash alone has been demonstrated by Benhassine *et al.* (2015). As in their analysis, an additional piece of evidence regarding mechanisms comes from observed shifts in beneficiaries' beliefs about diversification. We measured beliefs through a number of vignettes, short fictional stories that respondents were asked to complete or opine about during the follow-up survey. Table 10 shows that beneficiaries shifted beliefs towards the importance of diversification (columns (6)–(8)). When asked to make a choice for a fictional agricultural household on how to invest an inheritance, treated households are more likely to choose investing in a business asset than in agricultural land. The increase is significant for all treatment arms, but significantly larger for beneficiaries of the productive interventions. (The particular business asset used as an example in the vignette was a sewing machine, and hence complementary to skills acquired in training for a subset of the households). A second story asked how households would cope with agricultural losses. While 88% of the control households report they would migrate (corresponding to the most common coping strategy in the study setting, which is to seek work as an agricultural day labourer in another part of the country), this answer is significantly less common for the productive investment grant recipients. All treatment households also report being more likely to start a non-agricultural business, further suggestive of a shift in attitudes towards diversification. Finally, note that some shifts in attitudes are also observed for beneficiaries only of CCT, possibly explaining the positive but smaller changes in economic activity observed for them in Table 1. These beneficiaries could have been influenced by the general promotion of diversification, but without the complementary interventions may have been more constrained to act on it.

[24] The overall impact of the productive investment grant is positive for almost the entire range of shock intensities and yield losses in the data, and this mostly holds also for the vocational training package (see Online Appendix C), indicating that there was no implicit insurance premium. Hence, in this context, and given the intervention, consumption smoothing did not come at the cost of lower consumption at low shock intensity. By addressing the capital and skill constraints, the interventions likely allowed households to diversify income without resorting to lower-return activities.

7. Conclusion

This paper presents experimental evidence on a productive safety net implemented in a region of rural Nicaragua where households report an increased incidence of drought shocks. Self-reported shocks and yields are highly correlated with weather data, consistent with agronomical definitions of drought. These shocks have large welfare effects. We document the impact of a cash transfer programme expanded to include two complementary interventions: vocational training and a productive investment grant. The productive interventions induce households to diversify economic activities and increase participation and returns to non-agricultural and livestock activities. Households eligible for the productive investment grant are 13 p.p. more likely to be self-employed in non-agricultural activities and have higher profits from non-agricultural self-employment. The impacts on returns are large and amount to a 15% to 20% annual return on the initial investment of US$200, two years after the programme ended.

Using the randomised assignment of the interventions, exogenous local variation in weather shocks and follow-up data collected two years after the end of the programme, we show that both productive packages reduce the sensitivity of consumption and income to weather variability. These results differ significantly from the basic CCT, indicating that the protection against shocks comes from the complementary productive interventions. Being eligible for the productive investment grant also increases average consumption by 8%, and income by 4%. Hence, while the grant increases average consumption and also reduces its sensitivity to weather variability, the training only achieves the latter. Results further show that the two productive interventions lead to income smoothing and facilitate diversification in economic activities through clearly distinct mechanisms. The productive investment package mostly addresses capital constraints and induces investments in non-agricultural businesses. The training mostly addresses skill constraints, giving households (and in particular the individuals most likely to have taken the training) the ability to shift into non-agricultural wage work and migration in response to shocks. The difference in the mechanisms through which the training and investment grants affect diversification, together with the results on income smoothing as well as evidence of shifts in beneficiaries' beliefs about the importance of diversification, are indicative that it is not solely the extra value of these productive packages that protected households' consumption from negative weather shocks. Combined with evidence showing that the protective effects of the productive interventions are the strongest among the least diversified households at baseline, these results suggest that interventions promoting income diversification by increasing capital or skills can be effective in lifting constraints to income and consumption smoothing.

The basic CCT does not lead to higher or smoother consumption two years after the end of the transfers—even if of course it had increased consumption while the programme was in place. The significant contrast in outcomes between households that only received the basic CCT compared to those that also received a productive intervention allows ruling out that our findings are driven by the longer-term impact of the CCT alone. That said, the experimental design does not allow identifying whether the impacts of the training and the productive investment grant would have been similar in the absence of the CCT component. It is possible that the productive interventions were more effective in the longer run because they were given to households that had also received the CCT at the same time. Perhaps, for instance, having a temporary safety net in place might have been important for households to take the risk related to starting up a new activity, might have made it easier to attend courses, might have further motivated households, or even provided additional resources to pool with the productive grant or the skills. Future research that compares training or a productive grant only with a package containing a CCT together with such productive interventions could shed light on potential complementarities.

Several factors are worth considering in terms of the broader relevance and external validity of the paper. First, public programmes combining cash transfers with productive interventions are rapidly spreading around the world as part of efforts to expand poor households' economic opportunities and strengthen resilience. Second, the study setting in rural Nicaragua is not unlike those in many poor rural communities in different parts of the developing world. The setting is characterised by widespread poverty, high concentration of employment in rainfed agriculture and limited off-farm diversification. The relatively low levels of education and the remoteness of the study area are also noteworthy. Finally, this is a context with high exposure to climatic shocks, with substantial cross-sectional variation in weather conditions. Results may however not generalise to permanent changes in weather, or different distributions of shocks (Rosenzweig and Udry, 2020). Diversification based on non-agricultural self-employment may be less successful if a very large aggregate shock were to affect all households in a region at once. As such, productive transfers should not be seen as a substitute for relief through social safety nets when low-probability shocks with very large welfare effects (including pandemics) occur.

To our knowledge, this is the first paper providing experimental evidence on an intervention that is effective in promoting income diversification to mitigate the welfare effects of weather shocks. As such, our results go beyond the existing literature documenting short-term protection from cash transfers against shocks as well as average productive impacts of safety net programmes. Results show that the combination of short-term social safety nets with productive interventions can help households manage risk after the programme end and smooth both income and consumption when subsequent shocks occur. This generates lasting impacts two years after a one-year intervention. Overall, these results contribute to the ongoing debates on productive safety nets, adaptive social protection and resilience by providing empirical evidence on an intervention that successfully promoted livelihood diversification and helped to facilitate households' resilience to weather shocks. They also show that productive interventions such as vocational training can have social protection benefits beyond impacts on average outcomes.

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Additional Supporting Information may be found in the online version of this article:

Online Appendix
Replication Package

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