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Mediation analysis of the impact of the Zimbabwe Harmonized Social Cash Transfer Programme on food security and nutrition

Noemi Pace [a,b,*], Ashwini Sebastian [c], Silvio Daidone [b], Ervin Prifti [d], Benjamin Davis [b]

[a] Faculty of Political Science, University of Teramo, Via Renato Balzarini, 1 - 64100 Teramo, Italy
[b] Inclusive Rural Transformation and Gender Equality (ESP), FAO of the United Nations, Viale delle Terme di Caracalla, 00153 Rome, Italy
[c] The World Bank, Washington, DC, United States
[d] International Monetary Fund, United States

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ABSTRACT

This paper analyses the causal effects of the Zimbabwe Harmonized Social Cash Transfer (HSCT) programme on food security and nutrition after 12 months of implementation. Through mediation analysis, we disentangle the total effect of the programme on its direct effect due to the greater liquidity of beneficiary households, which increases the affordability of food, and its indirect effect mediated by an increase in agricultural activities. We find a total effect of cash transfers on food security and nutrition ranging between a 11 and 16 percent increase with respect to the baseline comparison mean for the household dietary diversity score and number of food items consumed, respectively. Causal mediation analysis shows that most of the effects are driven by the increased liquidity of HSCT beneficiaries. However, approximately between 10 and 21 percent of the total effect is mediated by agricultural activities, suggesting that cash transfer programmes not only play a protective role against food insecurity but also a promoting role towards more diversified nutrition.

1. Introduction

This paper aims to understand how an increase in exogenous income from an unconditional cash transfer programme in Zimbabwe impacts the food security and nutrition (FSN) of beneficiaries through its effect on agricultural activities.

Food security is defined as the circumstance "*when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*" (FAO, 2009). Four dimensions characterize food security: *i)* availability of food; *ii)* access to food; *iii)* utilization of food; and *iv)* stability, which is the ability of households to withstand risks and shocks that erode any of the other three dimensions (Webb et al., 2006). The first component can be defined as a supply-driven component of food security and refers to the total food stock available from the market or from home production. The second component is a demand-driven component of food security and refers to the ability of households to obtain food from a market. The two components are strictly linked because the availability of food supplies in a country or region is not a sufficient condition to reach food security because it does not guarantee that people have the ability to access this food. Moreover, for the rural poor in many Sub-Saharan African countries, agricultural production is inextricably linked to household consumption and therefore to FSN. For 80 percent of the global poor, agricultural production is the primary source of income and the main source of calories and essential nutrients (Hoddinott, 2011).

In 2012, Zimbabwe launched the Harmonized Social Cash Transfer Programme (HSCT), an unconditional cash transfer targeted to ultra-poor households with high dependency ratios, with the overarching purpose of protecting their food security and minimizing the fluctuations in their consumption associated with shocks. In this paper, we disentangle the total effect of the HSCT on FSN on its direct effect due to an increase in the purchasing power of households – which increases affordability of food – and its indirect effect mediated by an increase in agricultural production (availability of food increases). Understanding whether household improvements in FSN, resulting from cash transfers, stem from changes in household agricultural production rather than increased purchasing power is important from a policy perspective for several reasons. If the cash is used not only for consumption purposes, but also for agricultural investments and improved livelihoods, this may

* Corresponding author.
E-mail addresses: npace@unite.it, noemi.pace@fao.org (N. Pace), ashwini.sebastian@gmail.com (A. Sebastian), Silvio.daidone@fao.org (S. Daidone), eprifti@imf.org (E. Prifti), benjamin.davis@fao.org (B. Davis).

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reduce concerns frequently expressed by policy makers and the public more in general over the possible dependency induced by the cash transfers. This issue is particularly relevant for unconditional social cash transfers, which are provided to targeted beneficiaries without any strings attached to their receipt. Further, governments of developing countries very often support their farmers via input subsidies, which are often very inefficiently distributed and can lead to market distortions. If cash transfers can obtain similar results on food security at a lower administrative cost, this may lead to more cost-effective government spending. Moreover, if cash transfers induces greater diversification of production, for example, through increased variety of crops planted, they can also increase diversification of diet, which is likely to improve the quality of nutrition.

In this paper we hypothesize that if the unconditional cash transfer is sufficiently large to impact agricultural activities, through greater output and diversity, then at least part of the observed impact on household investments in more and better-quality food should come from increases in own production. It is expected that among the food-poor and labour-constrained target group of the HSCT programme the hypothesis is likely to hold, as most households in this group are smallholder farmers. We test our hypothesis using longitudinal data from an impact evaluation conducted as part of the initial scale-up of the programme. Data were collected from 2,360 programme-eligible households across 90 wards in six districts. Households in three districts were randomly selected to immediately enter the programme, while households in the other three districts were selected to enter the programme in a later phase. The impact evaluation data contain a large set of information on agricultural activities, household food and non-food consumption and several indicators of FSN accounting for the quantity and diversity of food.

The emerging literature linking the composition of agricultural production to dietary diversity has either exploited exogenous variations in rainfall and temperature on planting decisions (Dillon et al., 2014) or utilized a reduced form of identification strategies (Muller, 2009; Zezza and Tasciotti, 2010). Muller (2009) links lagged agricultural production to health and nutritional status indicators in Rwanda, finding that income alone cannot account for the quality and quantity impacts of food output on FSN. The findings of that paper indicate that the production of food rich in nutrients, including beans and tubers, which also comprise a large share of household food consumption, has significant positive impacts on nutrition. Zezza and Tasciotti (2010) regress a dummy variable for household participation in urban agriculture on dietary diversity and total calorie consumption, including household demographic and socio-economic controls and geographic controls, for a set of 15 countries. They find that engagement in urban agriculture can be associated with improved household FSN via dietary diversity and caloric availability. Dillon et al. (2014) link agricultural revenue and crop diversity to dietary diversity and instrumenting for planting season production decisions with weather variability. Their findings indicate a 10 percent increase in agricultural revenue and an increase of dietary diversity of 1.8 percent and 2.4 percent due to crop diversity, respectively. The low elasticities of these impacts (Dillon et al., 2014) suggest a potentially limited role for agricultural interventions designed to increase revenues. A special issue of the *Journal of Development Studies* is devoted to systematically and empirically testing the relationship between household agricultural production and nutrition in a variety of settings and types of data, including nationally representative data and detailed case studies (Carletto et al. 2015). The eight studies in this issue examine the relationship between crop and livestock production, household dietary diversity, and children's diet and anthropometric outcomes across countries in Sub-Saharan Africa and South Asia, two regions where undernutrition remains a major concern.

A thriving emerging literature links cash transfer programmes to agricultural production (Daidone et al. 2019; Prifti et al. 2019; Romeo et al., 2013) and consumption from production (Todd et al., 2010; Boone et al., 2012; Maluccio, 2010; Gertler et al., 2012). Independently, a strand of the literature linking cash transfers to household food security and nutrition has also emerged. Among these studies, some assess the role of transfers in affecting caloric intake via purchases and consumption of high calorie food (Rubalcava et al., 2009; Hidrobo et al., 2014), and several study improvements to household dietary diversity and food security (see Tiwari et al. 2016, Miller et al., 2011; OPM, 2013 for evidence in Africa, and Olinto et al., 2003, Paxson and Shady, 2007, and Maluccio and Flores, 2005).

This paper aims to contribute to the existing literature by merging these two strands of the literature. Indeed, this paper disentangles the total impact of the HSCT programme on FSN from its direct impact due to an increase in the purchasing power of households and its indirect effect mediated through an increase in agricultural activities. Given the nature and the target population of the programme, we expect that, at the initial stage, beneficiaries will tend to spend money mostly to meet basic needs, such as food, clothing and shelter. This initial increase of spending on food is expected to affect the quantity and quality of the nutrition of beneficiary households. We measure FSN in three ways. First, we consider a basic measure of diet quality based on the count of distinct food items consumed. Second, we consider the Household Dietary Diversity Score (HDDS), which is a count of the number of food groups consumed (Swindale and Bilinsky, 2005).[1] A score of one indicates that a household consumed a less diverse diet of only one food group, while a score of 12 indicates that it consumed a diverse set of food groups. Lastly, we consider the household Food Insecurity Experience Scale (FIES). FIES is an experience-based metric of food insecurity severity. It relies on people's direct responses to questions about their experiences facing constrained access to food (Ballard et al. 2013). Based on the answers to these questions, households are classified along a spectrum of food insecurity classes, ranging from 'no food insecure' (value of zero) to 'severely food insecure' (value of three).

Once immediate basic needs are met, the additional liquidity brought about by the programme may trigger further responses within the household by providing money for investment in productive activities. The investment in productive activities may take different forms. In this paper, we explore the mediating role of crop production, namely, the number of different crops produced and household engagement in kitchen gardening. As additional potential mediators, we consider livestock activities, which are measured as the number of livestock purchased and expenditure on livestock (this part of the analysis is reported in Appendix B). To take into account the potential reverse causality between food security and nutrition and our indicators of agricultural activities, we also adopt a two-stage least squares estimation approach to the causal mediation effects (Imai et al. 2011). Indeed, evidence from the literature (Strauss and Duncan, 1998, and Croppenstedt and Muller, 2000, among others) suggests that better nutrition and more solid food security are likely to be positively correlated with individuals' productivity in agriculture. Therefore, to obtain consistent estimates of the mediation effect, we included indicators of weather anomalies (i.e., temperature and rainfall anomalies) as an exclusion restriction in the mediation equation.

We find that the programme positively affects all indicators of FSN considered but FIES. Most of the total effect is due to the direct impact of the programme on the purchasing power of beneficiary households: transfer money is used to purchase more diversified food, increasing the consumption of fruits and vegetables as well as the consumption of animal-based food. The indirect mediation effect of agricultural activities plays a minor but meaningful role.

The paper comprises six sections. Section 2 and 3 present the main characteristics of the HSCT programme and the conceptual framework

[1] Food items are categorized into 12 food groups: 1) cereals, 2) roots and tubers, 3) pulses, legumes and nuts, 4) meat/poultry, 5) vegetables, 6) fruits, 7) eggs, 8) fish and seafood, 9) milk and milk products, 10) oil and fat, 11) sugar and honey, and 12) miscellaneous.

of the study, respectively. Section 4 describes the data used and the empirical strategy adopted for the analysis. The results are reported in section 5. Lastly, section 6 provides our conclusions and the discussion of the main policy implications.

2. The Zimbabwe Harmonized Social Cash Transfer Programme (HSCT)

The Zimbabwe HSCT programme is an unconditional cash transfer programme introduced in 2012 and implemented by the Ministry of Public Service, Labour and Social Welfare of the Government (MPSLSW) of Zimbabwe with the goal of fostering the well-being of poor and vulnerable rural households. The programme targets labour-constrained households that are also food-poor. Eligible households are identified through a detailed targeting census conducted by ZIMSTAT, the national statistical agency. Households are considered labour-constrained if they (i) have no able-bodied member aged 18–59; (ii) have one able-bodied member aged 18–59 but must care for more than three dependents; or (iii) have a dependency ratio between 2 and 3 but a severely disabled or chronically sick household member requiring intensive care (American Institute of Research – AIR, 2014).

In addition, households are defined as food-poor when they live below the food poverty line[2] and are unable to meet the most basic needs of their members. A list of ten indicators measuring the ability of a household to meet basic needs is outlined in the Operations Manual of the programme.[3] At least three of these must be met for the household to be eligible for the HSCT.

Eligible households receive bi-monthly cash payments ranging from USD 10 to USD 25 per month based on household size: a one-person household gets USD 10, a two-person gets USD 15, a three-person gets USD 20, and a household comprising four or more persons gets USD 25. Transfer amounts correspond to approximately 20 percent of the sample median total household consumption expenditure.

Programme implementation is carried out in a phased manner and was originally planned to be extended nationwide. In 2012, the MPSLSW chose to begin a first rollout of the HSCT in three districts: Binga, Mwenzi, and Mudzi. Households in these three districts are compared with eligible households in three districts (Uzumba-Maramba-Pfungwe (UMP), Chiredzi, and Hwange) that did not receive the transfers during the period of the study, 2013–2014, and were scheduled to be included into the programme in a subsequent rollout. The comparison districts were selected by the Ministry and a research team at the AIR to match the treatment districts by agro-ecological characteristics, culture, and level of development. Section 4.1 provides a detailed explanation of the sampling, selection of treatment and comparison groups and data collected for the analysis. In January 2015, the HSCT covered 52,500 households. Approximately 250,000 households in 65 districts are expected to be in the programme at full-scale, but the expansion plans have been delayed.

3. Conceptual framework

When markets function perfectly, the provision of cash should have no impact on household decisions with respect to production. Under such conditions, production and consumption decisions can be viewed as “separable” in that households first maximize profit/income from production decisions and then use the income generated from these decisions to maximize utility from consumption (Singh et al. 1986). A cash transfer should influence consumption by relaxing a household’s budget constraint, but not production. Therefore, if markets function perfectly, cash transfers given to labour-constrained and food-poor households should increase food and non-food consumption, with the former directly affecting food security and nutrition. However, poor rural households in developing countries face missing or poorly functioning markets. In the credit markets, poor households have difficulty borrowing due to a lack of sufficient collateral and may face credit rationing due to asymmetric information (Feder et al. 1990). Similarly, insurance markets are plagued by issues of adverse selection and moral hazards and are also located in settings where the availability of information might allow for the enforcement of mutual insurance arrangements when only partial insurance is possible (Deaton, 1992; Townsend 1994; Jalan and Ravallion, 1999). With missing or partial insurance, poor households manage risk through *ex-ante* strategies such as precautionary savings or diversification of crops and income-generating activities that allow for hedging against risk.

If multiple market failures exist, the production and consumption decisions of households can be viewed as “non-separable”, i.e., they are jointly determined (Singh et al. 1986). The choice of which crops to produce is not necessarily what would be the most profitable, but it may ensure that households have enough food to eat. In the same way, livestock activities might not be the most profitable, but they ensure by-products to fill and possibly enrich individual diet. Under conditions of market imperfections and non-separability of consumption and production decisions, an infusion of cash into a household can alter household decision-making. The HSCT provides liquidity to labour-constrained and food-poor households characterized by a low level of consumption expenditure. We therefore expect that at the initial stage of the programme, beneficiaries tend to spend money mostly to meet basic needs such as food, clothing and shelter. This initial increase of spending on food is expected to affect the quantity and quality of nutrition of beneficiary households. Once immediate basic needs are met, the additional liquidity brought about by the programme may trigger further responses within the household by providing money for investment in productive activities.

The investment in productive activities may take different forms: investment in crop production, investment in livestock and investment in non-farm businesses. Leaving out the investment in non-farm businesses, investments in crop production and in livestock are expected to indirectly affect food security and nutrition through greater own production of food (fruits, vegetables, meat and livestock by-products) and greater diversification of products. Production diversification might be oriented to market sales or to own consumption and both of them are expected to improve FSN. The HSCT can affect agricultural production through different channels: *i)* increased use of agricultural inputs (organic or chemical fertilizer, seeds, pesticides); *ii)* increased use of agricultural assets (hoe, axe, chicken house, ox plough, livestock corral, sickle, yokes, chains, rope, granary and ox cart); *iii)* increased family labour ; and *iv)* increased hired labour. Our data show that the third and fourth channels can be excluded. Indeed, beneficiary households do not seem to have increased hiring labour. On the contrary, there is evidence of increase of agricultural inputs (organic and chemical fertilizer) and asset (sickles). The results are reported in Table A4 in Appendix A.

3.1. Existing evidence of the impact of the HSCT programme on productive activities and FSN

Previous studies have investigated the impact of the HSCT on agricultural production and food security. Using the same study sample adopted for this paper, Daidone et al. (2018) and AIR (2014) document a significant impact of the HSCT on beneficiaries’ agricultural activities. The programme led to crop production diversification; households

[2] The food poverty line is the threshold where total household expenditure is below what is required to meet the food energy requirement for each household member, set at 2,100 kcal/day/person.

[3] The indicators are: only one or no meals per day; grains lasted for less than 3 months last harvest season; no/minimal livestock; no blankets; no rooms/huts for sleeping; rudimentary house material; members live on begging or some piece work; no/minimal regular support from relatives or others; no valuable assets, e.g., animal-drawn cart, vehicle; and the household is landless or owns less than one acre.

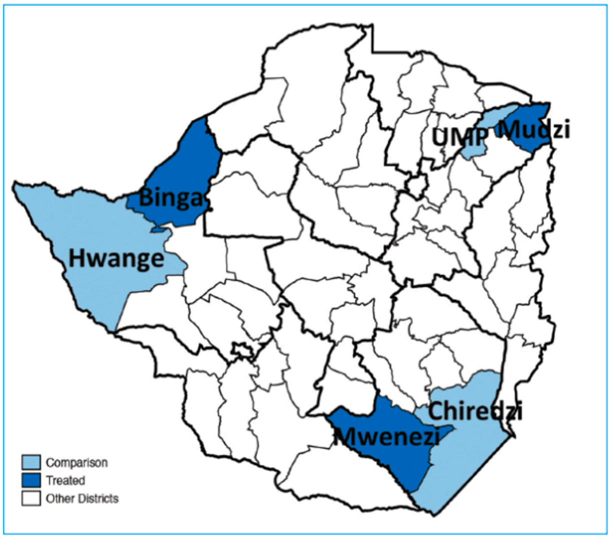

Fig. 1. Map of Zimbabwe. Source: Shape files obtained from http://www.gadm.org/. The darker outlines in the map are province boundaries.

moved away from traditional crops such as maize and sorghum to groundnuts, roundnuts, and finger and pearl millet. Moreover, they find a positive impact on food security and nutrition. Households diversified their source of calories with shifts from cereal to richer nutrient foods such as legumes. Similar findings are shown in AIR (2014), with impact results of higher magnitude on groundnuts and roundnuts for smaller households. Bhalla et al. (2018) focus on food security indicators and find impacts ranging from null to low on aggregate food expenditure but large programme impacts on the household food insecurity access scale (HFIAS) and on dietary diversity. Lastly, OPM (2013), adopting a qualitative approach, finds that the HSCT enabled beneficiaries to increase the quantity and variety of the food they consumed. For the most vulnerable and food-insecure beneficiary households, this has meant purchasing more staple food (maize), and for those better able to meet their staple food requirements from own harvest, this has meant increased purchases of other food items such as salt, sugar and cooking oil.

This paper adds to the existing evidence an analysis of the channels through which a cash transfer intervention affects FSN. Indeed, all extant studies focus on the total impact of the HSCT programme, while the current paper disentangles the direct impact on FSN due to an increase in purchasing power of households from the indirect impact mediated through an increase in agricultural production. The current analysis is meant to shed light on how the HSCT can affect FSN by increasing both access to food and availability of food, playing not only a protective function but also allowing households to invest in their primary livelihood activity. If some of the impacts on FSN are through own agricultural activities, there is room for further improvements by providing training, information and services aimed at raising productivity and/or diversifying the crops that are grown. To the best of our knowledge, this is the first study to conduct this kind of analysis.

4. Data and empirical strategy

4.1. Data for the HSCT impact evaluation

We use data collected in 2013 and 2014 for the impact evaluation of the HSCT programme conducted by the AIR (2014). The phased roll out of the HSCT allowed the AIR evaluation team to use households considered eligible to enter the programme at a later stage as a potential comparison group. The primary sampling unit for the sample design was the ward, an administrative unit below districts.

Phase 1 of the HSCT expansion occurred in 2011–12 and covered ten districts. Wards for the treatment group of the evaluation were selected from Phase 2 areas, which entered the program in 2013. Wards for the comparison group were selected from areas that were slotted for Phase 4 expansion and that were geographically close to Phase 2 areas. Treatment wards were stratified across the three treatment districts (Mudzi, Mwenezi and Binga), and comparison wards (UMP, Chiredzi and Hwange) were likewise stratified to areas adjacent to the three treatment districts. The location of the study sites is shown in Fig. 1. All wards were given a point score from 1 (low vulnerability) to 3 (high vulnerability) based on five characteristics: forest cover, nearness to main roads, resistance to shocks, nearness to business centers, and water sources.

Power calculations based on the expected number of households per ward indicated that a total of 60 Treatment and 30 Comparison Wards were necessary for the study.[4] Wards in treatment areas were ranked from highest point score (most vulnerable) to lowest and paired within each stratum. Then, for each treatment ward pair with a given score, a comparison ward with the same score in the same stratum was selected to serve as the 'matched' comparison ward.

Programme targeting in the selected study wards was conducted by the Zimbabwe Department of Social Services which adopted strictly the programme operation guidelines. Homogeneity in targeting guarantees that all households in comparison wards in the study sample are actual eligible households who will receive benefits once the programme reaches their area. Since, eligibility criteria are the same across the country and there is universal programme take-up, these households thus serve as a close approximation of the perfect counterfactual for treatment households. In the HSCT, programme operations called for complete scale-up in a district once that district entered the programme, thus there was no possibility of drawing control wards from the same district. However if the eligibility criteria are applied uniformly, targeting is supply-driven, and take-up is universal, then the only threat to internal validity is the geographical differences across Phase 2 and Phase 4 areas. The stratified matched design was chosen to minimize geographical differences. Out of the identified eligible households, the evaluation team randomly selected 34–60 households in each ward. This generated a sample of 3,063 households across 90 wards. However, due to missing responses in the follow-up sample, the final sample used in the current study comprises 2,628 households, interviewed both at baseline and follow-up.[5] Data were collected through a detailed household survey, conducted at baseline (in 2013) and 12-month follow-up. The data allow us to generate several indicators of FSN.

First, we consider the raw number of household items consumed. Second, we combine the different items into 12 food groups and generated the Household Dietary Diversity Score (HDDS), which measures the number of groups of food items consumed.[6] Third, from the HDDS, we generated two sub-indicators of dietary diversity, the HDDS – fruits-and-vegetables and the HDDS – animal-based food groups. The former includes only food groups produced through harvesting and

[4] Details on the power calculation are in Handa et al. 2013.

[5] AIR (2014) investigate attrition at the 12-month follow-up by testing for similarities at baseline between (1) treatment and control groups for all households included in both the baseline and follow-up surveys (differential attrition) and, (2) all remaining households at the 12-month follow-up and the households who were missing in the follow-up survey (overall attrition). There is no evidence of differential attrition at the 12-month follow-up, meaning that the similarity of the treatment and control groups found in the baseline survey are preserved. However, there is some evidence of overall attrition. About 86 percent of the households from baseline remain in the 12-month follow-up sample. In order to deal with this problem, we used an Inverse Probability Weighting (IPW) procedure to correct the sampling weights for overall attrition and we also added control variables in the regressions.

[6] The food groups are 1) cereals, 2) roots and tubers, 3) vegetables, 4) fruits, 5) legumes, nuts and seeds, 6) meat and poultry, 7) eggs, 8) fish and seafood, 9) milk and milk products, 10) oils and fats, 11) sweets, and 12) miscellaneous.

home gardening, namely, cereals, roots and tubers, pulses, legumes and nuts, and fruits. The latter includes only food groups that are animal based and livestock by-products, namely, meat/poultry, eggs, milk and milk products, and fish and seafood (these results are reported in Appendix B). Lastly, we generated the Food Insecurity Experience Scale (FIES), which is based on answers to eight questions capturing a range of food insecurity severity and classifies households along a spectrum of four food insecurity classes, ranging from 'no food insecure', FIES equal to zero, to 'severely food insecure', FIES equal to three (Smith et al. 2017a; 2017b).[7] All these indicators have advantages and disadvantages in measuring FSN. One shortcoming of both the number of food items consumed and the HDDS is that they do not capture the quality of diversity both within and across food groups through some form of weighting. On the contrary, the FIES accounts for quality, quantity and diversity but is a more subjective measure with respect the other two indicators, and as with most experience-based scales, it is subject to response bias (Jones et al., 2013).

4.2. Empirical strategy

4.2.1. Total effects of the HSCT programme on FSN

We use the panel sample of households to conduct a difference-in-difference (DID) analysis to estimate the total causal effect of the programme on FSN.[8] The unit of analysis is the household, and we control for household as well as household head characteristics.

$$Y_{ht} = \beta_0 + \beta_1 d2014_{ht} + \beta_2 CT_{ht} + \beta_3 CT^{*}d2014_{ht} + \beta_4^{\intercal} HH\_demographic_{ht} + \beta_5^{\intercal} HH\_characthead_{ht} + \beta_6^{\intercal} HH\_charactplots_{ht} + \varepsilon_{h1} \quad (1)$$

where

Y_{ht} is a proxy of FSN for household *h* at time *t*; *d2014* is an indicator that equals 1 if the time period is 2014 (12 month follow-up); *CT* is an indicator that equals 1 if household *h* is a beneficiary of the programme; *HH_demographics* is a vector of the household demographic characteristics, such as the household composition (number of members below age 5, between ages 6–17, between ages 18–59, 60 +); *HH_characthead* is a vector of the characteristics of the household head; and *HH_charactplots* is a vector of the characteristics of the soil of the household's plots (plot subject to erosion, plot sloped, and soil composed of loam, clay, sand or other).

Standard errors were adjusted for clustering at the ward level, and weights adjusted for attrition and the probability of selection were used to provide population-level estimates of the impacts of the programme.

4.2.2. Direct and indirect-mediated effects

We are interested in analysing whether the effects of the HSCT programme on FSN are mediated by its causal effect on agricultural activities. To analyse the mediation of the impact of the cash transfer through these pathways, we follow the approach proposed by Baron and Kenny (1986) and Imai et al. (2010) and further developed by Imai et al. (2011) and Hicks and Tingley (2011). Baron and Kenny (1986) propose a linear structural equation model that estimates causal mediation effects by decomposing the total treatment effect into indirect-mediated and direct effects. The indirect-mediated effect provides one explanation of why the treatment works through the mediators under analysis, and the direct effect represents all the other channels (increase in purchasing power) that improves food affordability. Fig. 2 disentangles the direct effect (solid arrow) from the indirect effects: the dashed lines and the dotted lines represent the causal mediation effect of crop production, namely the number of crops produced and household engagement in kitchen gardening.

Imai et al. (2011) formalize the assumption necessary to identify the causal mediation effect and the direct effect, which is known as the "sequential ignorability" assumption. Let CT_h be the treatment indicator, i.e. the cash transfers, M_h the mediator indicator, and X_h be a vector of the observed pre-treatment confounders for household *h.*

5. Ignorability assumption:

$$\{Y_h(ct^{'}, m), M_h(ct)\} \perp\!\!\!\perp CT_h | X_h = x, \quad (2)$$

$$Y_h(ct^{'}, m) \perp\!\!\!\perp M_h(ct) | CT_h = ct, X_h = x \quad (3)$$

where $0 < \Pr(CT_h = ct | X_h = x)$ and $0 < \Pr(M_h = m | CT_h = ct, X_h = x)$ for $ct = 0,1$ and all × and *m* in the support for X_h and M_h, respectively.

The assumption is called *sequential ignorability* because two ignorability assumptions are made sequentially. First, given the observed pre-treatment confounders, the treatment assignment is assumed to be ignorable (Equation (2)), i.e., statistically independent of potential outcomes and potential mediators. The second part of the assumption (Equation (3)) implies that there are no unmeasured pre-treatment or post-treatment covariates that confound the relationship between the outcome indicators and the mediators.

When both parts of the ignorability assumptions hold, we can estimate the average causal direct effect and the mediation effect through the following set of linear equations:

$$Mediator_{ht} = \alpha_0 + \alpha_1 d2014_{ht} + \alpha_2 CT_{ht} + \alpha_3 CT_{ht}^{*} d2014_{ht} + \alpha_4^{\intercal} HH.demographic_{ht} + \alpha_5^{\intercal} HH.Characthead_{ht} + \alpha_6^{\intercal} HH.Charactplots_{ht} + \varepsilon_{h2} \quad (4)$$

$$Y_{ht} = \gamma_0 + \gamma_1 d2014_{ht} + \gamma_2 CT_{ht} + \gamma_3 CT_{ht}^{*} d2014_{ht} + \gamma_4^{\intercal} HH\_demographic_{ht} + \gamma_5^{\intercal} HH\_Characthead_{ht} + \gamma_6^{\intercal} HH\_Charactplots_{ht} + \gamma_7 Mediator_{ht} + \varepsilon_{h3} \quad (5)$$

In this setup, the total effect of the treatment ($\widehat{\beta}_3$ from Equation (1)) comprises

1. Direct effect: $\widehat{\gamma}_3$ from Equation (5). This is the partial causal effect of the cash transfer on *Y* controlling for the mediator variable as well as a set of confounding factors (household demographic characteristics, characteristics of the household head, characteristics of soil of the household's plots).
2. Mediation effect: $\widehat{\alpha}_3 * \widehat{\gamma}_7$. This is the effect of the cash transfer on the mediator ($\widehat{\alpha}_3$ from Equation (4)) multiplied by the partial effect of the mediator on *Y* ($\widehat{\gamma}_7$ from Equation (5)) controlling for the cash transfer and the same set of confounding factors.

The second part of the sequential ignorability assumption, i.e., the exogeneity of the mediator with respect to the final outcomes, must hold for $\widehat{\alpha}_3 * \widehat{\gamma}_7$ to be a valid estimate of the mediation effect. However, in the context of this paper, the second part of the sequential ignorability assumption may not hold. Indeed, agricultural production may not be exogenous because better nutrition and more solid food security are likely to be positively correlated with productivity in agriculture (Strauss and Duncan, 1998; Croppenstedt and Muller, 2000). In other words, there may be a problem of reverse causality of the outcome (FSN) on agricultural activities. The task is, therefore, to identify how

[7] The questions used to construct the FIES index are formulated as follows: "During the last 4 weeks, was there a time when, because of lack of money or other resources: 1. Were you worried you would not have enough food to eat? 2. Were you unable to eat healthy and nutritious food? 3. Did you eat only a few kinds of foods? 4. Did you have to skip a meal? 5. Did you eat less than you thought you should? 6. Did you household run out of food? 7. Were you hungry but did not eat? 8. Did you go out without eating for a whole day?

[8] Even though the common trend assumption cannot be proved, its validity can be assessed. Given the lack of data on comparison and treatment households collected before the baseline, we performed a placebo test considering several community level variables as fake outcomes, i.e., variables that should not be affected by the programme (negative and positive shocks at community level, presence in the communities of different NGOs, and access to markets and access to main services). The results are reported in Tables A1, A2 and A3 in Appendix A. More discussion is reported in section 5.1.

variations in the mediation variable, induced only by the treatment and not due to potential reverse causality, impact variations in the outcome. The inclusion of the characteristics of soil of the household's plots partially solve this issue because better quality soil is likely to affect plots' yields and it is not affected by the household food security and nutrition. However, there might be other confounders, such as risk preferences or household's effort that might invalidate the second part of the sequential ignorability assumption.

When the second part of the sequential ignorability assumption does not hold, Imai et al. (2011) suggest implementing a two-stage least squares estimation of the mediation effects, where the first-stage model is given by Equation (6).

$$Mediator_{ht} = \alpha_0 + \alpha_1 d2014_{ht} + \alpha_2 CT_{ht} + \alpha_3 CT_{ht} * d2014_{ht} + \alpha_4^{\intercal} HH.demographic_h + \alpha_5^{\intercal} HH.Charactead_h + \alpha_6^{\intercal} HH.Charactplots_h + \varphi^{\intercal} WA_{hjt} + \varepsilon_{h2} \quad (6)$$

where WA_{hjt} represents temperature and rainfall anomalies at time t for household h in ward j, which is used as exclusion restriction in the mediation equation. Weather anomalies are appropriate exclusion restrictions if two basic conditions are satisfied: *exogeneity*, i.e they do not directly affect the outcomes of interest, and *relevance*, i.e. they have to be significantly correlated with the endogenous variable, which is the mediator in the context of this paper. Relevance is supported by the rejection of the null hypothesis of the weather anomalies regression coefficients and by the F-test of joint significance of the coefficients of both temperature and rainfall anomalies. Exogeneity cannot be tested empirically but we performed the Sargan-Hansen test of overidentifying restrictions. The joint null hypothesis is that the instruments are valid instruments, i.e., uncorrelated with the error term and correctly excluded from the estimated equation. A rejection of the test casts doubt on the validity of the instruments. As shown in the section Results, the selection of robust instruments is not an easy task. In our empirical analysis we selected several proxies of weather anomalies that were shown to be i) more correlated with the mediators and, at the same time, ii) uncorrelated with the error term of the outcome equation. As discussed later, we succeeded more in point *i)* than *ii)* and we acknowledge the limitation of this approach.

Following the work of Marchiori et al. (2012), data of weather anomalies are extrapolated from the Prediction of Worldwide Energy Resource (POWER) project of the National Aeronautics and Space Administration (NASA) for years 1981–2014 (US National Aeronautics and Space Administration, 2014).[9] Climate variability plays an important role in determining planting and harvesting season decision-making and agricultural production. Several studies examine the effects of seasonal precipitation and temperature on agricultural production (Rowhani et al., 2011; Bilham, 2011; Lobell, 2010; Schlenker and Lobell, 2010; Tao et al., 2008; Jayachandran, 2006).[10]

In this paper, temperature anomalies are defined as the grid-specific deviation of the current season's total rainfall (planting and harvesting season) from the long-term mean divided by its long-run standard deviation. Similarly, rainfall anomalies are the grid-specific deviation of current season's mean temperature degree (planting and harvesting season) from the long-term mean divided by the long-run temperature standard deviation.[11] We match climate data to wards using the nearest grid-to district centroid, similar to Jayachandran (2006).[12]

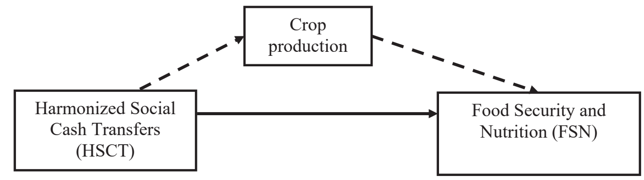

Fig. 2. Direct and indirect-mediated effects.

Formally, the rainfall and temperature weather anomalies (WA) are defined as

$$WA_{j,t} = \frac{W_{j,t} - \mu^{LR}(W_j)}{\sigma^{LR}(W_j)}$$

WA_{jt} is the weather condition (rainfall or temperature) in ward j and year t. μ^{LR} and σ^{LR} are the ward mean and standard deviation of rainfall and temperature over the long run from 1981 to 2014, respectively. These anomalies provide a statistical measure of the degree of deviation from the norm for ward-level seasonal weather conditions.

6. Results

6.1. Summary statistics

Table 1 provides baseline summary statistics for household-level food security indicators (panel A), crop production (panel B), livestock activities (panel C), proxies of weather anomalies (panel D), set of control variables at household level (panel E), and the soil characteristics of the household's plots by treatment status.

Panel A shows no statistically significant differences in the number of household items, on the HDDS-fruits and vegetables and FIES. Treatment households consume, on average, 10.4 food items, belonging, on average, to 6 groups of food, 3 from harvesting and home gardening and only 1.38 from animal and livestock by-products. In addition, regardless of treatment status, households have a FIES score equal to 2.3. The overall HDDS and the HDDS-animal-based food are slightly and marginally better in the control group (P-value 010 and 0.06, respectively).

Panel B shows that for the majority of indicators of crop production, the differences between treatment and comparison households are not statistically significant.

The only exceptions are the share of households engaged in the production of finger millet and pearl millet, which is significantly greater in the treatment group, and the share of households engaged in kitchen gardening, which is significantly greater in the control group.

The number of different crops grown is, on average, 1.51, suggesting a scarce diversification in crop production at baseline. The majority of households are engaged in the production of maize and sorghum at 58 and 41 percent.

Panel C shows that for the majority of the indicators of livestock activities, the differences between treatment and comparison households are not statistically significant. The number of animals purchased in the past 12 months is an exception: treatment households purchased a quantity of livestock significantly greater than comparison households, although the difference is very small.

[9] POWER data: https://power.larc.nasa.gov/

[10] Both temperature and rainfall deviations from historical means are important for determining agricultural production. Rowhani et al. (2011) examine the relationship between seasonal precipitation and temperature on crop yields in Tanzania. The authors find seasonal temperatures to have the largest impact on yields with a 2-degree Celsius increase leading to reductions in yields of 13, 8.8 and 7.6 percent for maize, sorghum and rice, respectively. Similarly, using a larger cross-country panel for sub-Saharan Africa, Schlenker and Lobell (2010) also find that anomalies in temperature have an impact on yields for several crops.

[11] The POWER grid-specific rainfall is taken from daily precipitation (mm/day) and the temperature of the air 2 m above the surface of the earth (degrees C).

[12] Matching is done using the *distmath* command in STATA to implement the Harvesine formula for distance.

Table 1
Summary statistics: baseline characteristics by treatment status.

	2013 (Baseline)					
	Control (n = 813)		Treatment (n = 1621)			
	Mean	Std. error	Mean	Std. error	Difference	P-value
PANEL A						
Food Security and Nutrition Indicators						
Number of household items	11.00	(5.34)	10.40	(5.25)	0.60	0.27
Household Dietary Diversity Score (HDDS)	6.33	(2.09)	6.00	(2.13)	0.33	0.10
HDDS – Fruits and Vegetables	3.12	(0.89)	2.99	(0.85)	0.13	0.16
HDDS – Animal-based food	1.54	(1.05)	1.38	(1.07)	0.16	0.06
Food Insecurity Experience Scale (FIES)	2.25	(0.71)	2.26	(0.68)	−0.01	0.77
PANEL B						
Crop production and gardening						
Number of different crops grown by HH*	1.47	(0.78)	1.51	(0.78)	−0.04	0.54
Share of households in kitchen gardening	0.50	(0.50)	0.37	(0.48)	0.13	0.00
Share of households producing:						
Maize	0.63	(0.48)	0.58	(0.49)	0.05	0.38
Sorghum	0.47	(0.50)	0.41	(0.49)	0.07	0.26
Groundnut	0.15	(0.36)	0.16	(0.36)	−0.01	0.92
Finger Millet	0.12	(0.32)	0.21	(0.41)	−0.09	0.00
Pearl Millet	0.06	(0.24)	0.11	(0.31)	−0.05	0.04
Roundnuts	0.02	(0.14)	0.03	(0.18)	−0.01	0.23
Cowpeas	0.02	(0.14)	0.03	(0.16)	−0.00	0.62
HH Production (quantity, kg)						
Maize	100.59	(230.63)	111.47	(424.96)	−10.88	0.60
Sorghum	74.86	(219.0)	62.50	(184.97)	12.37	0.41
Groundnut	35.44	(181.12)	28.23	(154.30)	7.20	0.62
Finger Millet	15.84	(63.05)	29.33	(116.77)	−13.49	0.03
Pearl Millet	7.43	(39.98)	15.98	(66.14)	−8.55	0.09
Roundnuts	4.50	(56.99)	2.06	(18.56)	2.44	0.40
Cowpeas	1.58	(18.50)	1.59	(19.76)	−0.01	0.99
Total household land holdings (hectares)	1.55	(2.00)	1.90	(9.80)	−0.35	0.24
PANEL C						
Livestock activities						
TLU Total	1.45	(2.16)	1.34	(2.06)	0.12	0.43
Number of different animals owned	2.70	(2.38)	2.61	(2.30)	0.09	0.55
Number of animals purchased	0.11	(0.52)	0.20	(1.14)	−0.09	0.03
Expenses for livestock	3.99	(33.61)	5.43	(40.02)	−1.44	0.42
HH producing livestock by-products	0.34	(0.47)	0.34	(0.48)	−0.01	0.84
PANEL D						
Climate Shocks (1981–2014)						
Rainfall anomaly: planting season	−0.34	(0.14)	−0.33	(0.23)	0.00	0.95
Temperature anomaly: planting season	0.97	(0.07)	0.98	(0.11)	0.01	0.81
Rainfall anomaly: harvesting season	0.70	(0.33)	0.97	(0.36)	−0.27	0.00
Temperature anomaly: harvesting season	0.01	(0.12)	−0.09	(0.16)	0.11	0.00
PANEL E						
Household characteristics						
Household size	5.14	(2.88)	5.02	(2.82)	0.12	0.64
Number of members aged 0–5 in HH	0.80	(0.96)	0.76	(0.94)	0.04	0.62
Number of members aged 6–17 in HH	2.21	(1.75)	2.23	(1.78)	−0.01	0.94
Number of members 18–59 in HH	1.27	(1.19)	1.20	(1.18)	0.07	0.48
Number of members over 60 in HH	0.85	(0.74)	0.84	(0.75)	0.01	0.81
Age of the household head	56.68	(19.12)	56.27	(19.58)	0.40	0.81
Household head's years of education	3.47	(3.65)	3.30	(3.69)	0.18	0.33
Marital status: widow	0.37	(0.48)	0.37	(0.48)	0.00	0.94
PANEL F						
Soil characteristics						
Erosion	0.53	(0.50)	0.60	(0.49)	−0.07	0.17
Slope	0.46	(0.50)	0.50	(0.50)	−0.04	0.42
Soil type: loam	0.49	(0.50)	0.34	(0.48)	0.14	0.01
Soil type: clay	0.20	(0.40)	0.22	(0.41)	−0.02	0.48
Soil type: sand	0.31	(0.46)	0.44	(0.50)	−0.12	0.04
Soil type: other	0.01	(0.08)	0.00	(0.06)	0.00	0.64

Notes: Mean difference test with clustered standard errors. P-values less than 0.05 are highlighted in bold.
*Production from kitchen gardening is actually included in the count of the different crops grown. In the "Land" section of the questionnaire, the enumerators were instructed to "Ask for up to three plots of land. If more than three, report largest first. In addition, ask about their kitchen/garden plot". However, the count of the different crops grown might have been underestimated. Indeed, in the "Crop production" section of the questionnaire, the enumerators were instructed to list up to two crops for each plot and kitchen/garden plot listed in the "Land" section.

Rainfall and temperature weather anomalies in the planting and harvesting season are shown in Panel D. The differences are statistically significant for rainfall and temperature anomalies in the harvesting season.

Panel E presents the baseline household characteristics, which are used as control variables in the empirical analysis. None of these differences in household characteristics are statistically significant. On average, households comprise five members, mainly in the 6–17-year-old and 18–59-year-old age groups, and have a fifty-six-year old household head with only 3 years of education.

Table 2
Total Impact Estimates of cash transfers on FSN.

	(1) # food items consumed	(2) HDDS	(3) HDDS – fruits and vegetables	(4) HDDS – animal based food items	(5) FIES
CT*d2014	1.74***	0.70***	0.41***	0.15*	−0.02
	(0.50)	(0.19)	(0.08)	(0.08)	(0.07)
CT	−0.46	−0.28	−0.15*	−0.11	0.00
	(0.51)	(0.18)	(0.09)	(0.08)	(0.04)
d2014	1.58	0.34	−0.06	0.07	−0.53***
	(1.01)	(0.39)	(0.16)	(0.22)	(0.16)
Constant	5.26***	4.29***	2.67***	0.66**	2.48***
	(1.21)	(0.49)	(0.18)	(0.26)	(0.16)
Observations	4,865	4,865	4,865	4,865	4,866
R-squared	0.084	0.104	0.086	0.062	0.093

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for household demographic composition, characteristics of the household head, and characteristics of the soil of household's plots.

Panel F shows the characteristics of the soil of the household's plots. We find some statistically significant differences in the soil type, mainly loam in comparison wards and mainly sandy in treatment wards.

Overall, the non-random selection between treatment and control group and the non-trivial number of variables for which we observe statistically significant differences between the two groups might cast doubt on the correct identification of the impacts of the programme. However, the implementation of a DID estimation method addresses this issue. Indeed, under the *common trend* assumption between the treatment and control group, the DID method allows to obtain consistent estimates even when the two groups are on average not equal at baseline. The DID method compares trends between the treatment and comparison groups, i.e. the difference in outcome for that individual before and after the programme. By subtracting the before outcome situation from the after situation, DID allows to cancel out the effect of all of the characteristics (observed and unobserved) that are unique to that individual and that do not change over time. The *common trend* assumption guarantees the correct identification of the impact of the programme. Given the lack of data on comparison and treatment households collected before the baseline, we performed a placebo test considering several community level variables as fake outcomes, i.e., variables that should not be affected by the programme but likely to affect agricultural activities and FSN (negative and positive shocks at community level, presence in the communities of different NGOs, and access to markets and access to main services). Although these tests cannot be considered conclusive, the lack of significance of the DID estimator would suggest that the common trend assumption hold. The results are reported in Tables A1, A2 and A3 in Appendix A. Out of 52 tests performed, 7 tests (13 percent) do not support the common trend assumption. In particular, the tests shows that *i)* treated communities experienced significantly more droughts than comparison communities (table A1), ii) treated communities are significantly more exposed to the activities of World Vision, World Food Programme (WFP) and Development and Aid from People to People (DAPP) (table A2), and *iii)* treated communities are significantly further away to health care facilities, are less likely to have a health clinic, and less likely to have secondary schools electricity-endowed than comparison communities (table A3). Despite these differences, 45 placebo tests (87 percent) seem to suggest that community level variables follow a common trend in the treatment and comparison groups.

6.2. Results of the total effects of the HSCT programme

Table 2 provides the results of the total effects of the HSCT programme on five indicators of FSN: number of food items consumed (column 1), Household Dietary Diversity Score (HDDS) (column 2), HDDS – fruits and vegetables (column 3), HDDS – animal-based food items (column 4), and Food Insecurity Experience Score (FIES) (column 5). All the regressions include a large set of control variables: household demographic composition (number of members aged 0–5, 6–17, 18–59, 60 +), characteristics of the household head (age, marital status and education), and characteristics of the soil of the household's plots (plot subject to erosion, plot sloped, and soil composed of loam, clay, sand or other).

The table shows five main results:

- a significant increase in the number of food items consumed (1.74), corresponding to an increase of 16 percent with respect to the baseline comparison mean;

- a significant increase in the HDDS (0.70), corresponding to an

Table 3
Total Impact Estimates of cash transfers on agricultural production.

PANEL A	Kitchen gardening	Number of different crops produced	HH produced maize	HH produced sorghum	HH produced groundnut	HH produced finger millet	HH produced pearl millet	HH produced roundnuts	HH produced cowpeas
CT*d2014	0.21***	0.15**	0.02	−0.01	0.07***	−0.05**	0.08***	0.04***	−0.00
	(0.07)	(0.07)	(0.05)	(0.03)	(0.02)	(0.02)	(0.03)	(0.01)	(0.01)
CT	−0.27***	0.00	−0.07	−0.07	−0.01	0.08**	0.06**	0.01	0.00
	(0.07)	(0.05)	(0.05)	(0.06)	(0.05)	(0.03)	(0.03)	(0.01)	(0.01)
d2014	−0.23*	−0.03	0.16	−0.05	−0.02	−0.16**	0.07	−0.08*	0.05*
	(0.13)	(0.16)	(0.11)	(0.09)	(0.07)	(0.06)	(0.06)	(0.05)	(0.03)
Constant	0.58***	1.34***	0.48***	0.73***	0.01	0.08	−0.02	0.04	0.01
	(0.12)	(0.15)	(0.14)	(0.12)	(0.07)	(0.07)	(0.11)	(0.03)	(0.03)
Observations	4,868	4,868	4,868	4,868	4,868	4,868	4,868	4,868	4,868
PANEL B		Crop production (kg)	Maize (kg)	Sorghum (kg)	Groundnut (kg)	Finger millet (kg)	Pearl millet (kg)	Roundnuts (kg)	Cowpeas (kg)
CT*d2014		−55.64	−81.25	−97.48	18.33**	−8.62	56.86***	8.96***	0.08
		(98.72)	(54.50)	(63.51)	(8.25)	(6.34)	(19.92)	(3.31)	(1.00)
CT		35.62	46.30**	6.87	5.03	12.03*	14.61**	−1.57	0.09
		(35.13)	(20.43)	(13.69)	(8.71)	(6.82)	(6.14)	(2.51)	(0.79)
d2014		163.30	119.04	68.60	8.63	9.89	26.36	−14.29	3.61
		(174.15)	(77.97)	(150.28)	(22.57)	(26.44)	(28.60)	(8.92)	(2.31)
Constant		−27.27	21.63	3.51	−43.18**	−39.41	−4.50	8.78	−0.33
		(93.85)	(78.18)	(39.64)	(19.16)	(26.85)	(31.08)	(7.13)	(2.06)
Observations		4,868	4,864	4,863	4,866	4,868	4,868	4,868	4,868

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for household demographic composition, characteristics of the household head, and characteristics of the soil of household's plots.

Table 4
Impact Estimates of cash transfers on livestock activities.

	TLU total	Number of different livestock purchased	Number of livestock purchased	Amount spent for livestock	HH produced livestock by-products
CT*d2014	0.05	0.19	0.46***	7.54*	−0.00
	(0.12)	(0.14)	(0.07)	(4.36)	(0.04)
CT	−0.06	−0.05	0.10**	2.20	0.00
	(0.15)	(0.14)	(0.05)	(2.02)	(0.04)
d2014	0.20	0.28	0.72**	9.82	0.92***
	(0.37)	(0.43)	(0.29)	(8.64)	(0.07)
Constant	−0.81**	0.20	−0.11	−6.42	0.08
	(0.37)	(0.49)	(0.23)	(7.68)	(0.09)
Observations	4,868	4,868	4,868	4,868	4,868

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for household demographic composition, characteristics of the household head, and characteristics of the soil of household's plots.

Table 5
Causal Mediation Analysis on FSN. Mediator: number of different crops produced (SI assumption holds).

	Regression on mediator:	Regression on main outcome:		
	(1)	(2)	(3)	(4)
	Number of different crops produced	Number of different food items eaten	HDDS	HDDS – Fruits and Vegetables
Number of different crops produced		1.82***	0.71***	0.30***
		(0.15)	(0.06)	(0.03)
CT*d2014	0.15**	1.47***	0.60***	0.37***
	(0.07)	(0.52)	(0.19)	(0.08)
CT	0.01	−0.47	−0.29*	−0.15*
	(0.05)	(0.48)	(0.17)	(0.08)
d2014	−0.02	1.62*	0.36	−0.05
	(0.16)	(0.92)	(0.37)	(0.15)
Constant	1.34***	2.84**	3.35***	2.27***
	(0.15)	(1.16)	(0.47)	(0.18)
Observations	4,865	4,865	4,865	4,865
SI assumption holds				
Mediation Effect: $\widehat{\alpha}_3$ (Eq. (4)) *$\widehat{\gamma}_7$ (Eq. (5))		0.26***	0.10**	0.04**
Direct Effect: $\widehat{\gamma}_3$ (Eq. (5))		1.48***	0.60**	0.37**
Total Effect		1.74***	0.70**	0.41**

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for the household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots. Columns (1) shows the estimates for the mediator as described in Equations (4). Columns (2), (3) and (4) show the estimates for the number of different food items consumed, the households dietary diversity score (HDDS) and the HDDS for fruits and vegetables, respectively.

increase of 11 percent with respect to the baseline comparison mean;

- a significant increase in the HDDS – fruits and vegetables (0.41), corresponding to a 13 percent increase with respect to the baseline comparison mean;

- a significant increase in the HDDS – animal-based food items (0.15), corresponding to a 10 percent increase with respect to the baseline comparison mean;

- no impact on FIES[13].

Before proceeding to the mediation analysis, we present the results of the impact of the programme on the agricultural production and livestock activities considered to be potential mediators in the mediation analysis. Table 3 shows a positive and significant impact of the programme on the share of households engaged in kitchen gardening (a 42 percent increase with respect to the baseline comparison mean) and the number of different crops grown (a 10 percent increase with respect to the baseline comparison mean) in columns 1 and 2, respectively. The rest of Table 3 shows that the programme also affected the composition of the production basket, reducing the quantity of finger millet produced in favour of a greater quantity of groundnut, pearl millet and roundnuts. However, no impact is detected for the total quantity produced. Table 4 presents the impact of the programme on livestock activities and shows a positive and significant impact on the number of livestock purchased and on the amount spent on livestock. No impacts are detected for Tropical Livestock Units (TLU), the number of different kinds of livestock purchased and household engagement in the production of livestock by-products.

6.3. Mediation results

The analysis of the causal effect of the HSCT programme on agricultural production and livestock activities presented in section 5.2 allows us to restrict the set of options for the mediation analysis to four mediators, namely, the number of different crops produced, engagement in kitchen gardening, the number of livestock purchased and the amount spent for livestock. The results for these latter two mediators are reported in Appendix B. In this section, we present the results of the causal mediation analysis focusing on the number of different crops produced and engagement in kitchen gardening as potential mediators. We investigate the effect of each mediator in separate tables and estimate the mediation effect, the direct effect and the total effect in two different scenarios: first, we assume that the sequential ignorability assumption (Equations (2) and (3)) holds (Table 5), and second, we assume that the exogeneity of the mediator does not hold and thus only the first part of the ignorability assumption (Equation (2)) holds (Table 6).

The first approach is based on the assumption that no other confounding factors can affect agricultural production and food security and nutrition at the same time. The second approach is valid only if the exclusion restrictions are shown to be at the same time relevant and exogenous, which we show, it is not always the case with the set of instruments available. Both approaches have limitations and our analysis does not allow to address this methodological and empirical issue in a conclusive manner. However, has it is shown below, the two approaches lead to coherent and robust conclusions regarding the direct effect of the HSCT on food security and nutrition and its mediating effect via agricultural production activities.

Table 5 presents the results of the causal mediation analysis on FSN

[13] With respect to the other FSN indicators, the FIES is a more subjective measure and suffers from several other weaknesses. First, as with most experience-based scales, the FIES is subject to response bias (Jones et al., 2013). Moreover, as data are collected at the household level, further biases may derive from the fact that the selected respondent's perception of their household's experience is not representative of all other household members (Jones et al., 2013). Lastly, the FIES does not quantify food consumption or directly assess diet quality.

Table 6
Mediation Analysis on FSN. Mediator: number of different crops produced (SI does not hold).

	Regression on mediator Number of different crops produced	Regression on main outcome: Number of different food items eaten	HDDS	HDDS-Fruits and Vegetables
Number of different crops produced		1.84***	0.70***	0.29***
		(0.15)	(0.06)	(0.03)
CT*d2014	0.14**	1.44***	0.59***	0.37***
	(0.07)	(0.52)	(0.20)	(0.08)
CT	0.03	−0.53	−0.32*	−0.15
	(0.07)	−0.47	(0.17)	(0.08)
d2014	−0.02	1.60*	0.35	−0.05
	(0.16)	−0.92	(0.36)	(0.15)
Rainfall anomalies planting season	−0.57***			
	(0.11)			
Temperature anomalies planting season	−0.83			
	(0.19)			
Rainfall anomalies harvesting season	0.09			
	(0.08)			
Temperature anomalies harvesting season	0.52***			
	(0.13)			
Constant	0.45**	4.19***	4.06***	2.49***
	(0.21)	−0.92	(0.36)	(0.14)
Observations		4,865	4,865	4,865
F-test excluded instruments	F(4, 92) = 35.10			
	P-value = 0.0000			
SI assumption does not hold				
Mediation Effect: $\hat{\alpha}_3$ (Eq. (6)) *$\hat{\gamma}_7$ (Eq. (5))		0.26**	0.10**	0.04**
Direct Effect: $\hat{\gamma}_3$ (Eq. (5))		1.44**	0.59***	0.37**
Total Effect		1.69**	0.69**	0.41**

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for the household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots. Columns (1) shows the estimates for the mediator as described in Equations (6). Columns (2), (3) and (4) show the estimates for the number of different food items consumed, the households dietary diversity score (HDDS) and the HDDS for fruits and vegetables, respectively.

considering the number of different crops produced as the mediator, assuming that the sequential ignorability assumption holds. Columns 1 shows the results of the regression on the mediator as in Equations (4). The impact of the programme on the number of different crops produced is 0.15. Columns 2, 3 and 4 show the results of three main FSN outcomes for the number of different food items eaten, HDDS, and HDDS – fruits and vegetables, respectively. The direct effect is given by coefficient $\gamma_3$in Equation (5). The causal mediation effect is given by the impact of the programme on the mediator (α_3 in Equation (4)) multiplied by the impact of the mediator on the final outcome (γ_7 in Equation (5)).

Table 7
Causal Mediation Analysis on FSN. Mediator: kitchen gardening (SI assumption holds).

	Regression on mediator: (1) Household in Kitchen Gardening	Regression on main outcome: (2) Number of different food items eaten	(3) HDDS	(4) HDDS – Fruits and Vegetables
Household in Kitchen Gardening		1.65***	0.61***	0.22***
		(0.26)	(0.09)	(0.04)
CT*d2014	0.21***	1.39***	0.57***	0.37***
	(0.07)	(0.49)	(0.18)	(0.07)
CT	−0.27***	−0.02	−0.12	−0.09
	(0.07)	(0.57)	(0.20)	(0.10)
d2014	−0.23*	1.95*	0.48	−0.01
	(0.13)	(0.98)	(0.38)	(0.15)
Constant	0.58	4.31***	3.94***	2.55***
	(0.12)	(1.27)	(0.51)	(0.19)
Observations	4,865	4,865	4,865	4,865
SI assumption holds				
Mediation Effect: $\hat{\alpha}_3$ (Eq. (4)) *$\hat{\gamma}_7$ (Eq. (5))		0.35**	0.12**	0.05
Direct Effect: $\hat{\gamma}_3$ (Eq. (5))		1.39**	0.58**	0.37
Total Effect		1.74**	0.70**	0.41

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for the household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots. Columns (1) shows the estimates for the mediator as described in Equations (4). Columns (2), (3) and (4) show the estimates for the number of different food items consumed, the households dietary diversity score (HDDS) and the HDDS for fruits and vegetables, respectively.

Looking at the number of different food items consumed (column 2), the results show that the total effect of the programme is 1.74, corresponding to an approximate 16 percent increase with respect to the baseline comparison mean. Most of the total effect is due to the direct effect of the programme, 85 percent, while the effect due to an increased number of different crops produced represents 15 percent of the total effect.

Similar results are obtained for the HDDS and HDDS – fruits and vegetables (columns 3 and 4). The total effect of the programme on HDDS is 0.70, corresponding to an approximate 11 percent increase with respect to the baseline mean. The direct effect corresponds to 86 percent of the total effect, while the number of different crops produced accounts for the residual 14 percent of the total effect. The total effect of the programme on HDDS – fruits and vegetables is 0.41, corresponding to a 13 percent increase with respect to the baseline comparison mean. The direct effect of the programme represents 90 percent of the total impact, while the mediation effect is the residual 10%.

Table 6 presents the results of the causal mediation analysis on FSN considering the number of different crops produced as the mediator, assuming that the sequential ignorability assumption does not hold. Column 1 shows the results of the regression on the mediator as in Equation (6). Weather anomalies during the planting season are negative, meaning that they reduce the number of different crops produced, while weather anomalies during the harvesting season seem to have the opposite effect. The F-test of joint significance of the excluded instruments shows that weather anomalies are relevant instruments, i.e. correlated with the mediator (F-test of excluded instruments = 35.10, P-value = 0.000). We perform a Sargan-Hansen test of overidentifying restrictions which tests the null hypothesis that the excluded instruments (weather anomalies) are valid instruments, i.e., uncorrelated

Table 8
Causal Mediation Analysis on FSN. Mediator: kitchen gardening (SI assumption does not hold).

	Regression on mediator	Regression on main outcome:		
	Household in kitchen gardening	Number of different food items eaten	HDDS	HDDS - Fruits and Vegetables
Household in kitchen gardening		1.68***	0.63***	0.22***
		(0.26)	(0.09)	−0.04
CT*d2014	0.20***	1.35***	0.56***	0.36***
	(0.07)	(0.50)	(0.18)	−0.07
CT	−0.03	−0.06	−0.14	−0.08
	(0.07)	(0.56)	(0.20)	−0.1
d2014	−0.22*	1.93*	0.48	−0.01
	(0.12)	(0.98)	(0.37)	−0.15
Rainfall anomalies planting season	−0.30***			
	(0.08)			
Temperature anomalies planting season	−0.26**			
	(0.12)			
Rainfall anomalies harvesting season	0.01			
	(0.07)			
Temperature anomalies harvesting season	0.21**			
	(0.09)			
Constant	0.32***	5.83***	4.72***	2.80***
	(0.14)	(1.07)	(0.39)	−0.16
Observations	4,865	4,865	4,865	4,865
F-test excluded instruments	F(4, 92) = 17.43 P-value = 0.000			
SI assumption does not hold				
Mediation Effect: $\hat{\alpha}_3$ (Eq. (6)) *$\hat{\gamma}_7$ (Eq. (5))		0.35**	0.13***	0.04**
Direct Effect: $\hat{\gamma}_3$ (Eq. (5))		1.34***	0.56***	0.36***
Total Effect		1.69**	0.69***	0.40**

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for the household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots. Columns (1) shows the estimates for the mediator as described in Equations (6). Columns (2), (3) and (4) show the estimates for the number of different food items consumed, the households dietary diversity score (HDDS) and the HDDS for fruits and vegetables, respectively.

with the error term, and are correctly excluded from the estimated equation. Unfortunately, the null hypothesis cannot be rejected only for the number of food items eaten as main outcome variable (P-value = 0.1611), while it can be rejected for HDDS and HDDS-fruits and vegetables as main outcome variables (respectively, P-value = 0.0228 and 0.0011). The results of the Sargan-Hansen test cast doubts on the exogeneity of the instruments which might bias the estimates. Despite this limitation, the results obtained for the main indicators of FSN considered in this paper are consistent with the approach presented in Table 5.

Columns 2, 3 and 4 show the results for the number of different food items eaten, HDDS, and HDDS – fruits and vegetables, respectively. The direct effect is given by coefficient $\gamma_3$in Equation (5). The causal mediation effect is given by the impact of the programme on the mediator (α_3 in Equation (6)) multiplied by the impact of the mediator on the final outcome (γ_7 in Equation (5)). Looking at the number of different food items consumed (column 2), the results show that the total effect of the programme is 1.69, slightly lower than the total effect reported in Table 5. Most of the total effect is due to the direct effect of the programme, 84 percent, while the effect due to an increased number of different crops produced represents 16 percent of the total effect.

Similar results are obtained for the HDDS and HDDS – fruits and vegetables (columns 3 and 4). The total effect of the programme on HDDS is 0.69. The direct effect corresponds to 85 percent of the total effect, while the number of different crops produced accounts for 15 percent of the total effect. The total effect of the programme on HDDS – fruits and vegetables is 0.40. The direct effect of the programme represents 89 percent of the total impact, while the mediation effect is the residual 11%.

Table 7 presents the results of the causal mediation analysis on FSN considering the engagement in kitchen gardening as a potential mediator, assuming that the sequential ignorability assumption holds. The HSCT programme increases the probability that a household engages in kitchen gardening by 21 percent (column 1). As in the previous table, columns 2, 3 and 4 show the results for three main FSN outcomes: the number of different food items eaten, HDDS, and HDDS – fruits and vegetables, respectively. The total effects of the number of different food items, HDDS and HDDS – fruits and vegetables are very close to those presented in the previous tables. What changes the most here is the share of the total effect, which is direct, i.e., due to the increased liquidity provided by the programme, and mediated, due to the effect on the mediator. Indeed, when we consider engagement in kitchen gardening as the mediator, the mediation effect is larger, is 20 percent of the total effect for the number of different food items eaten, 18 percent of the total effect for the HDDS.

Table 8 presents the results of the causal mediation analysis on FSN considering the engagement in kitchen gardening as a potential mediator, assuming that the sequential ignorability assumption does not hold. The HSCT programme increases the probability that a household engages in kitchen gardening by 20 percent (column 1). Weather anomalies during the planting season are negative and statistically significant, meaning that they reduce the probability of a household engaging in kitchen gardening. The F-test of joint significance of the excluded instruments shows that weather anomalies are relevant instruments, i.e. correlated with the mediator (F-test = 17.43, P-value = 0.000). We perform a Sargan-Hansen test of overidentifying restrictions. The null hypothesis cannot be rejected for the number of food items eaten and for the HDDS as main outcome variables (respectively, P-value = 0.1611, 0.212) while it can be rejected for HDDS-fruits and vegetables as main outcome variable (P-value = 0.0221). As highlighted for Table 6, the results of the Sargan-Hansen test cast doubts on the exogeneity of the instruments. Despite this limitation, the results obtained for the main indicators of FSN considered in this paper are consistent with the approach presented in Table 7.

7. Conclusions and discussion

This paper analyses the impact of the Zimbabwe Harmonized Social Cash Transfer (HSCT) programme on the food security and nutrition of beneficiaries through its impact on agricultural activities after 12 months of implementation. Cash transfers directly increase the household purchasing power, leading recipients to purchase goods from local markets and thereby improving household FSN. Moreover, cash transfers increase household agricultural activities and crop diversity, which in turn, improves dietary diversity from household production or increased revenue from agricultural sales. In this paper, we conduct a causal mediation analysis enabling us to disentangle the total effect of cash transfers on direct effect due to an increase in purchasing power of households and indirect effect mediated by a change in agricultural activities, namely, crop production and livestock. The analysis focuses on three indicators of FSN, namely, the number of different food items eaten, the HDDS, the HDDS for fruits and vegetables, and two main potential mediators accounting for crop production (number of different crops produced and household engagement in kitchen gardening).

We investigate the effect of each mediator separately and estimate the mediation effect, the direct effect and the total effect in two different scenarios. First, we assume that the sequential ignorability assumption (Equations (2) and (3)) holds. This approach is based on the assumption that no other confounding factors can affect agricultural production and food security and nutrition at the same time. The inclusion of the characteristics of soil of the household's plots partially address this issue because better quality soil is likely to affect plots' yields and it is not affected by the household food security and nutrition. Second, we assume that the exogeneity of the mediator does not hold and thus only the first part of the ignorability assumption (Equation (2)) holds. Indeed, agricultural production may not be exogenous because better nutrition and more solid food security are likely to be positively correlated with productivity in agriculture (Strauss and Duncan, 1998; Croppenstedt and Muller, 2000). In other words, there may be a problem of reverse causality of the outcome (FSN) on agricultural activities. The task is, therefore, to identify how variations in the mediation variable, induced only by the treatment and not due to potential reverse causality, impact variations in the outcome. This second approach is valid only if the exclusion restrictions are shown to be at the same time relevant and exogenous, which we show, it is not always the case with the set of instruments available. Both approaches have limitations and our analysis does not allow to address this methodological and empirical issue in a conclusive manner. However the two approaches lead to coherent and robust conclusions regarding the direct effect of the HSCT on food security and nutrition and its mediating effect via agricultural production activities.

Our analysis finds that the programme positively affects the three indicators of FNS considered. Most of the total effects are due to the direct effect of the programme on the purchasing power of beneficiary households: transferred money is used to purchase more diversified food, increasing the consumption of fruits and vegetables as well as the consumption of animal-based food. The indirect mediation effect of agricultural activities plays a minor role, although they are more relevant in the case of crop production used as the mediator. Indeed, the indirect mediation effect of the number of different crops produced, which is a proxy of diversification in production, ranges between 15 and 16 percent of the total effect of the programme on the number of different food items eaten and between 14 and 16 percent of the total effect of the programme on the HDDS. The indirect mediation effect ranges between 10 and 11 percent of the total effect on the HDDS for fruits and vegetables. The results are stronger for household engagement when kitchen gardening is used as the mediator. In this case, the indirect mediation effect ranges between 20 and 21 percent of the total effect on the number of different food items eaten and between 18 and 19 percent of the total effect on the HDDS. The indirect mediation effect on HDDS for fruits and vegetables is slightly weaker, ranging between 11 and 10 percent of the total effect.

The analysis conducted in this paper supports the view that a social protection intervention such as the HSCT programme positively contributes to household welfare not only by guaranteeing beneficiaries a higher purchasing power but also by boosting their agricultural activities. From a policy perspective, the analysis conducted in this paper is relevant primarily for two reasons.

First, the mediation analysis contributes to shedding light on the channels through which a social protection programme, such as the HSCT programme in Zimbabwe, affects food security and nutrition. Since the main objective of the programme is to protect the food security of ultra-poor households and minimize the fluctuations in their consumption associated with shocks, it is extremely relevant to understand whether the potentially induced changes in agricultural activities also play a role. From a policy perspective, the role of cash transfers in subsistence agriculture as a pathway to improving household food security and nutrition can be viewed as a critical component to improving household welfare.

Second, the results of the mediation analysis show a strong linkage between diversification in production and diversification in consumption: households that produce more diversified food also enjoyed a more diversified diet. These results are consistent with Jones et al. (2014), Romeo et al. (2013), Ecker (2018) and Bellon et al. (2020), among others.[14] Jones et al. (2014) use cross-sectional data from a large, nationally representative sample of farming households in Malawi to determine the relationship between farm production diversity and household dietary diversity. They find that the diversity of farm production is consistently positively associated with the diversity of household diets. Ecker (2018) and Bellon et al. (2020) both show that farm production diversity matters for household dietary diversity in the context of rural Ghana. Using impact evaluation data of the Kenya Cash Transfer for Orphans and Vulnerable Children, Romeo et al. (2013), find that "on-farm production diversification correlates with household diet diversification and some production activities have stronger association with diet diversification than others in the context of ultra-poor, labor constrained families living in rural Kenya". This suggests that government policies that affect diversification in crop production have great potential for improving household dietary diversity.

These findings are clearly more relevant for the sub-population of ultra-poor smallholders, who live in a context of subsistence agriculture, with limited access to credit and input and output markets. For these farmers, crop diversification represents a risk management strategy to protect them against weather and market shocks. As shown by the mediation analysis, cash transfers may represent a powerful tool for poor households' resilience to help them bouncing back.

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Data

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Data are not currently publicly available, but the authors will facilitate access to estimation, raw data and code in a timely and effective way, if necessary under license to the ultimate owner.

CRediT authorship contribution statement

Noemi Pace: Conceptualization, Resources, Methodology, Software, Validation, Formal analysis, Writing – original draft, Writing – review & editing. **Silvio Daidone:** Conceptualization, Methodology, Software, Formal analysis, Writing – original draft, Writing – review & editing. **Ashwini Sebastian:** Conceptualization, Software, Formal analysis, Writing – original draft. **Ervin Prifti:** Resources, Methodology, Writing – review & editing. **Benjamin Davis:** Conceptualization, Investigation, Writing – review & editing, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

[14] Evidence of the linkage between diversity in production and diversity in consumption is also documented in Herforth (2010), Remans et al. (2011), Hirvonen and Hoddinott (2017), Sibhatu et al. (2015), and Bellon et al. (2016).

Table A1
Test of common trend assumption of community-level shocks.

	Drought	Flood	Crop diseases	Livestock disease	Human epidemic disease	Changes in prices
CT*d2014	0.23***	−0.17	0.17	−0.17	−0.10	−0.10
	(0.08)	(0.14)	(0.16)	(0.12)	(0.12)	(0.16)
Obs.	178	178	178	178	178	178
	Massive jobs lay offs	Loss of key social services	Power Outage	Improved transportation	Development project	New employment opportunities
CT*d2014	−0.08	−0.17	0.02	0.09	−0.09	−0.01
	(0.18)	(0.19)	(0.14)	(0.14)	(0.14)	(0.05)
Obs.	178	178	178	178	178	178
	New health facility	New road	New school	On-grid electricity	Off-grid electricity	
CT*d2014	−0.01	−0.02	0.07	−0.07	0.10	
	(0.10)	(0.01)	(0.11)	(0.08)	(0.06)	
Obs.	178	178	178	178	178	

Notes: *** indicates significance at 1%. The table reports only the DID coefficient (CT*d2014).

Table A2
Test of common trend assumption of presence of international organization and NGO in the community.

	CARE	OXFAM	PRIZE	World Vision	WFP	CADS
CT*d2014	−0.08	−0.04	−0.02	0.17**	0.25*	0.09
	(0.12)	(0.05)	(0.03)	(0.08)	(0.14)	(0.07)
Obs.	178	178	178	178	178	178
	MOTSRUD	CRS	DAPP	ADAF	FACT	Mercy Corps
CT*d2014	−0.01	0.00	0.20**	−0.00	−0.03	−0.02
	(0.05)	(0.09)	(0.09)	(0.10)	(0.09)	(0.02)
Obs.	178	178	178	178	178	178
	Save the Children	BEAM	AIDS Council	GOAL	Basilizwi Trust	
CT*d2014	0.09	−0.23	0.23	0.01	−0.04	
	(0.11)	(0.14)	(0.16)	(0.03)	(0.03)	
Obs.	178	178	178	178	178	

Notes: *** indicates significance at 1%. The table reports only the DID coefficient (CT*d2014).

Table A3
Test of common trend assumption of access to services at community level.

	Distance to nearest road	Distance to the nearest bus station	Distance to the nearest permanent market	Distance to nearest drug shop	Distance to the nearest clinic	Distance to the nearest health facility
CT*d2014	−10.75	−3.26	−7.67	2.67	−1.04	26.08**
	(7.87)	(3.48)	(10.80)	(21.29)	(7.36)	(12.54)
Obs.	178	178	178	178	178	164
	Private vehicles pass on the main road?	Public buses or regular Khombi stop in this community?	Market in the village?	Does the village have a clinic	Is there a health worker in the village	Microfinance institution in the community?
CT*d2014	0.18	−0.07	−0.06	−0.37*	0.04	−0.19
	(0.20)	(0.13)	(0.10)	(0.20)	(0.15)	(0.15)
Obs.	178	178	178	178	171	178
	Nearest primary school electrified	Nearest secondary school electrified	Number of private primary schools	Number of private secondary schools	Groups or programmes providing insecticide	Groups or programmes providing support
CT*d2014	0.04	−0.35**	1.02	−0.00	0.13	−0.06
	(0.12)	(0.16)	(0.841	(0.27)	(0.19)	(0.13)
Obs.	178	178	178	178	177	178

Notes: ** and * indicate significance at 5% and 10%. The table reports only the DID coefficient (CT*d2014).

Appendix A

The regressions also control for the treatment indicator (CT equal to one for treatment, zero otherwise) and the time indicator (d2014 equal to one for followup, equal to zero otherwise). Tables A1-A4

List of acronyms: CARE: Cooperative for Assistance and Relief Everywhere; OXFAM: Oxford Committee for Famine Relief; PRIZE: Promoting Recovery in Zimbabwe; WFP: World Food Programme; CADS: Cluster Agriculture Development Services; MOTSRUD: Management Outreach Training Services for Rural and Urban Services; CRS: Catholic Relief Services; DAPP: Development Aid from People to People; ADAF: Agricultural Development Assistance Fund; FACT: Family Aids Caring Trust; BEAM: Basic Education Assistance Module.

The regressions also control for the treatment indicator (CT equal to one for treatment, zero otherwise) and the time indicator (d2014 equal to one for followup, equal to zero otherwise).

Table A4
Table impact of cash transfers on agricultural inputs and assets.

PANEL A	Chemical fertilizer	Organic fertilizer	Pesticide	Fodder	Manufactured feeds	Vet services
Agr Inputs: HH used						
CT*d2014	0.01	0.05*	−0.02	0.02	0.01	0.02**
	(0.03)	(0.03)	(0.02)	(0.01)	(0.01)	(0.01)
Agr Inputs: HH purchased						
CT*d2014	0.04**	0.00	−0.01	−0.00	0.00	0.01
	(0.02)	(0.01)	(0.01)	(0.00)	(0.01)	(0.01)
Agr Inputs: expenses						
CT*d2014	2.13**	0.17	−0.37	−0.01	0.10	0.43
	(0.93)	(0.11)	(0.64)	(0.02)	(0.09)	(0.33)
PANEL B	Hoe	Axe	Sickle	Machete	Watering can	Sprayer
Agr Assets: HH used						
CT*d2014	−0.01	0.01	0.08*	0.05	−0.00	−0.01
	(0.02)	(0.04)	(0.04)	(0.05)	(0.04)	(0.02)
Agr Assets: number of						
CT*d2014	0.13	0.04	0.11**	0.04	0.09	−0.03
	(0.09)	(0.05)	(0.05)	(0.06)	(0.15)	(0.03)
PANEL C	Hired Labour	Days of labour	Hired men labour	Days of hired men	Hired women labour	Days of hired women
Hired Labour						
CT*d2014	0.04	−2.04	0.02	−1.14	0.01	−0.44
	(0.02)	(1.89)	(0.02)	(1.38)	(0.02)	(0.86)

Notes: ** and * indicate significance at 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. The table reports only the DID coefficient (CT*d2014). All regressions control for household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots.

Appendix B

Table B1 presents the results of the causal mediation analysis on FSN considering the number of livestock purchased as a potential mediator, assuming that the sequential ignorability assumption holds. Looking at the regressions for FSN, columns 2 and 3 show that the programme total effects on the number of different food items eaten and the HDDS are almost identical to those presented in Tables 4 and 6. However, the causal mediation effect represents a smaller share of the total effect, namely, only 4 percent of the total effect for both number of different food item eaten and HDDS. Column 4 reports the estimates of the regression for HDDS – animal-based food. The total effect of the programme is 0.15, corresponding to an approximate 10 percent improvement in HDDS – animal based food with respect to the comparison baseline mean. The direct effect of the programme accounts for 91 percent of the total impact, while only the residual 9 percent is due to the effect of the mediator.

Table B2 presents the results of the causal mediation analysis on FSN considering the number of livestock purchased as a potential mediator, assuming that the sequential ignorability assumption does not hold. In this case, weather anomalies do not seem to be appropriate exclusion restrictions since they are uncorrelated with the mediator. The causal mediation effect represents a small share of the total effect, namely, only 4 percent of the total effect for both number of different food item eaten and HDDS, and 8 percent of the total effect for HDDS – animal-based food.

Table B3 shows the results of the causal mediation analysis on FSN considering expenditure on livestock as a potential mediator, assuming that the sequential ignorability assumption holds. The results are consistent with those reported in Table B1: i) the causal mediation effect on the number of different food items and HDDS only accounts for a very small percentage of the total effect (2 percent). For HDDS – animal-based food groups, 95 percent of the total effect is due to direct effect of increased liquidity, while the remaining 5 percent is mediated by an

Table B1
Causal Mediation Analysis on FSN. Mediator: number of livestock purchased (SI assumption holds).

	Regression on mediator:	Regression on main outcome:		
	(1) Number of livestock purchased	(2) Number of different food items eaten	(3) HDDS	(4) HDDS – Animal-Based
Number of livestock purchased		0.15**	0.06**	0.03***
		(0.07)	(0.03)	(0.01)
CT*d2014	0.46***	1.67***	0.68***	0.14
	(0.07)	(0.50)	(0.1)9	(0.09)
CT	0.10**	−0.48	−0.29	−0.11
	(0.05)	(0.51)	(0.18)	(0.08)
d2014	0.72	1.47	0.30	0.05
	(0.29)	(1.02)	(0.39)	(0.22)
Constant	−0.11	5.28***	4.30***	0.66**
	(0.23)	(1.22)	(0.50)	(0.26)
Observations	4,865	4,865	4,865	4,865
SI assumption holds				
Mediation Effect: $\widehat{\alpha}_3$ (Eq. (4)) *$\widehat{\gamma}_7$ (Eq. (5))		0.07**	0.03**	0.01**
Direct Effect: $\widehat{\gamma}_3$ (Eq. (5))		1.67***	0.68**	0.14
Total Effect		1.74**	0.71**	0.15

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for the household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots. Columns (1) shows the estimates for the mediator as described in Equations (4). Columns (2), (3) and (4) show the estimates for the number of different food items consumed, the households dietary diversity score (HDDS) and the HDDS for animal-based food groups, respectively.

Table B2
Causal Mediation Analysis on FSN. Mediator: number of livestock purchased (SI assumption does not hold).

	Regression on mediator	Regression on main outcome:		
	(1) Number of livestock purchased	(2) Number of different food items eaten	(3) HDDS	(4) HDDS - Animal Based food
Number of livestock purchased		0.15**	0.06**	0.04***
		(0.07)	(0.03)	(0.01)
CT*d2014	0.44***	1.63***	0.67***	0.13
	(0.07)	(0.50)	(0.19)	(0.09)
CT	0.21**	−0.53	−0.32*	−0.14*
	(0.10)	(0.51)	(0.18)	(0.08)
d2014	0.73**	1.45	0.29	0.05
	(0.30)	(1.02)	(0.39)	(0.21)
Rainfall anomalies planting season	0.20			
	(0.16)			
Temperature anomalies planting season	0.51*			
	(0.27)			
Rainfall anomalies harvesting season	−0.42			
	(0.25)			
Temperature anomalies harvesting season	−0.02			
	(0.13)			
Constant	−0.31	6.99***	5.15***	1.03***
	(0.23)	(1.00)	(0.37)	(0.18)
Observations	4,865	4,865	4,865	4,865
F-test excluded instruments	F(4, 92) = 0.61			
	P-value = 0.6558			
SI assumption does not hold				
Mediation Effect: $\hat{\alpha}_3$ (Eq. (6)) *$\hat{\gamma}_7$ (Eq. (5))		0.07	0.03*	0.02*
Direct Effect: $\hat{\gamma}_3$ (Eq. (5))		1.63***	0.66**	0.13
Total Effect		1.69**	0.69**	0.14

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for the household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots. Columns (1) shows the estimates for the mediator as described in Equations (6). Columns (2), (3) and (4) show the estimates for the number of different food items consumed, the households dietary diversity score (HDDS) and the HDDS for animal-based food groups, respectively.

Table B3
Causal Mediation Analysis on FSN. Mediator: amount spent to purchase livestock (SI assumption holds).

	Regression on mediator:	Regression on main outcome:		
	(1) Expenditure for Livestock	(2) Number of different food items eaten	(3) HDDS	(4) HDDS – Animal-Based
Expenditure on livestock		0.01*	0.00*	0.00**
		(0.00)	(0.00)	(0.00)
CT*d2014	7.54*	1.69***	0.69***	0.14*
	(4.36)	(0.49)	(0.19)	(0.08)
CT	2.19	−0.47	−0.29	−0.11
	(2.02)	(0.51)	(0.18)	(0.08)
d2014	9.75	1.53	0.33	0.06
	(8.65)	(1.01)	(0.39)	(0.22)
Constant	−6.38	5.30***	4.30***	0.67**
	(7.69)	(1.22)	(0.50)	(0.26)
Observations	4,865	4,865	4,865	4,865
SI assumption holds				
Mediation Effect: $\hat{\alpha}_3$ (Eq. (4)) *$\hat{\gamma}_7$ (Eq. (5))		0.04*	0.01*	0.01
Direct Effect: $\hat{\gamma}_3$ (Eq. (5))		1.69***	0.69**	0.14*
Total Effect		1.74**	0.71**	0.15*

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for the household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots. Columns (1) shows the estimates for the mediator as described in Equations (4). Columns (2), (3) and (4) show the estimates for the number of different food items consumed, the households dietary diversity score (HDDS) and the HDDS for animal-based food groups, respectively.

Table B4
Causal Mediation Analysis on FSN. Mediator: amount spent to purchase livestock (SI assumption does not hold).

	Regression on mediator	Regression on main outcome:		
	(1)	(2)	(3)	(4)
	Expenditure on Livestock	Number of different food items eaten	HDDS	HDDS-Animal Based food
Expenditure on livestock		0.01*	0.00	0.00**
		(0.00)	(0.00)	(0.00)
CT*d2014	7.59*	1.66***	0.68***	0.14
	(4.32)	(0.50)	(0.19)	(0.09)
CT	4.26**	−0.53	−0.32*	−0.14*
	(2.08)	(0.50)	(0.18)	(0.08)
d2014	9.92	1.50	0.32	0.06
	(8.62)	(1.01)	(0.39)	(0.21)
Rainfall anomalies planting season	0.47			
	(4.56)			
Temperature anomalies planting season	7.02			
	(9.31)			
Rainfall anomalies harvesting season	−4.92			
	(3.82)			
Temperature anomalies harvesting season	11.04			
	(6.05)			
Constant	−8.27	6.99***	5.15***	1.04**
	(11.16)	(0.99)	(0.37)	(0.18)
Observations	4,865	4,865	4,865	4,865
F-test excluded instruments	$F(4, 92) = 2.48$			
	P-value = 0.0497			
SI assumption does not hold				
Mediation Effect: $\hat{\alpha}_3$ (Eq. (6)) *$\hat{\gamma}_7$ (Eq. (5))		0.03	0.01	0.01
Direct Effect: $\hat{\gamma}_3$ (Eq. (5))		1.66***	0.68***	0.14
Total Effect		1.69**	0.69**	0.14

Notes: ***, ** and * indicate significance at 1%, 5% and 10%. Heteroskedasticity robust standard errors, clustered at ward level, in parentheses. All regressions control for the household demographic composition, characteristics of the household head, and characteristics of the soil of the household's plots. Columns (1) shows the estimates for the mediator as described in Equations (6). Columns (2), (3) and (4) show the estimates for the number of different food items consumed, the households dietary diversity score (HDDS) and the HDDS for animal-based food groups, respectively.

increase in expenditure in livestock.

Table B4 presents the results of the causal mediation analysis on FSN considering expenditure on livestock as a potential mediator, assuming that the sequential ignorability assumption does not hold. The results are consistent with those reported in Table B2: i) weather anomalies do not seem to be appropriate exclusion restrictions for the regression on the mediator; ii) the causal mediation effect on the number of different food items and HDDS only accounts for a very small percentage of the total effect (2 percent). For HDDS – animal-based food groups, 95 percent of the total effect is due to direct effect of increased liquidity, while the remaining 5 percent is mediated by an increase in expenditure in livestock.

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