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RESEARCH PAPER

Participation in social safety net programs and household agricultural performance in Mali

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Abstract
This paper analyzes the impact of social safety net programs on the agricultural performance of households in Mali by identifying the determinants of program participation and agricultural income and the effect of this participation on agricultural income per hectare. The endogenous switching regression (ESR) model is applied to data from 2284 households drawn from Mali's 2014 Living Standards Measurement Survey (LSMS). The results show a positive effect of program participation on agricultural income per hectare among households. Indeed, unlike nonparticipants, the beneficiaries of social safety net programs have additional agricultural income of 57,125 FCFA per hectare, with a less significant causal effect for nonparticipant households, which indicates a certain efficiency in targeting beneficiaries. Therefore, continuation of the program in its current form and its expansion will help enhance the effectiveness of agricultural development policies toward achieving food security and poverty reduction in furtherance of national development objectives.

Keywords Welfare programs · Social protection · Financial constraints · Work incentives · Agricultural performance · Mali

JEL Classification C31 · I38 · Q12

Introduction

Faced with persistent poverty and weak progress in implementing poverty reduction strategies, many countries in sub-Saharan African (SSA) are increasingly turning to social transfer programs (FAO 2017). These transfer programs, designed as tools to reduce poverty and inequality and promote food security of the poor, mainly target the most vulnerable households. Often promoted by various stakeholders as key instruments

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of social protection, these transfers may be conditional or otherwise, for example, conditional on attendance at school or clinics or participation in public works (Slater 2011). In addition to reducing poverty and inequality, they promote food security and enable poor households to strengthen their human and physical capital, as well as participate in markets and improve their productive performance (Slater 2011; Bastagli et al. 2018).

The government of Mali, following the country's socio-economic instability and its negative impact on food security and household poverty, initiated a social safety net program dubbed 'JigisemeJiri' (tree of hope) in 2013 with support from the World Bank. This program provides regular support to chronically poor households, thereby protecting them against shocks and promoting human development through child health and the adoption of model nutrition and hygiene practices. Additionally, in April 2014, the 'Common Framework on Seasonal Social Safety Nets (CCFS)' was launched with the financial support of the European Commission. The objective of CCFS was to lay the foundations for the resilience of more than 40,000 poor households hardest hit by the food and politico-military crises. In October 2016, the program was strengthened through the development of a national social protection policy with a component on (a non-contributory) social assistance scheme. The latter involves regular cash or in-kind transfers from governmental and nongovernmental entities to individuals or households.

In the context of perfect markets, transfers, regardless of their nature, should not affect the productive activities of beneficiaries with separability (Singh et al. 1986). Owing to market imperfections, however, these social transfers could help recipient (poor) households overcome market failures by allowing better access to inputs, increased investment and higher productive spending with the effect of increasing production (Stiglitz and Weiss 1981; Ali et al. 2014; Daidone et al. 2019). Transfers ease the credit constraint of beneficiaries and help them overcome imperfections of the insurance market for managing large risks (Boucher et al. 2008). This is often the case in rural areas where most households depend on agricultural production and income, which are inherently highly uncertain due to climatic hazards, diseases, low yields and price volatility (Deaton 1992). In addition, transfers create an incentive for recipient households to use more productive family labor because of the supervision costs of hired labor (Dasgupta 1993). Indeed, Tirivayi et al. (2016) reported, from a comprehensive review of the empirical literature, evidence of the benefits of transfers and public works programs through a reduction in uncertainty and the alleviation of credit and liquidity constraints, which encourages optimal use of resources.

However, whereas many authors argue that participation in these programs improves the performance and income of recipients (for example, Asfaw et al. 2014), others observe otherwise (Moffitt 2002; Saez 2002). The latter group argues that by reducing the use of family labor, transfer programs reduce the performance and agricultural income of recipient households, making the farm-level productivity impact of such programs an empirical question. In addition, Tirivayi et al. (2016) observed the need for impact evaluations of transfer programs in other regions outside of Latin America, especially in agricultural research using more rigorous methodological standards. Within this context, the current study raises the empirical question of whether Mali's programs improve the agricultural performance of farm households. Its objective is to estimate the effect of transfer program participation on the value of agricultural production per hectare among recipient households. Our hypothesis is that social transfers to households ease their financial constraints and improve use of farm inputs, thereby improving agricultural performance. Previous studies that support this hypothesis include Boone et al. (2013) and Bastagli et al. (2018). The paper contributes to the current discourse on fighting poverty and food insecurity in

sub-Saharan Africa through social protection and agricultural transformation under the Comprehensive Africa Agriculture Development Programme (CAADP).

Several previous studies on impact estimation, especially on transfers and agricultural performance, have identified various nonexperimental methods (e.g., Asfaw et al. 2014; Boone et al. 2013). These are usually methods of matching, double difference, or instrumental variables (IVs). Unlike matching methods, others explicitly address selection on unobservables as well (Caliendo and Hujer 2006), and recent studies seem to favor alternatives that explicitly allow selection on both observables and unobservables. Diamoutene and Jatoe (2021) reviewed some of the reasons for this apparent shift toward instrumental variable techniques and associated limitations, encouraging the use of the endogenous switching regression (ESR) method to correct endogeneity bias. The challenge in estimating IVs is to find a good instrument, as it must predict the treatment but not the outcome (Caliendo and Hujer 2006). The ESR has challenges similar to those of the IVs, but it remedies unobserved heterogeneity (Khonje et al. 2015) and hence is the choice in this article. Second section reviews literature, and next is third section with the methodology. The fourth section presents the results and discussion, and fifth section concludes.

Conceptual, theoretical and empirical framework

Concepts

At the end of the 1980s, in response to the negative effects of structural adjustment programs (Paitoonpong and Abe 2008), social protection emerged and consisted of social safety nets, social insurance and labor market protection. The definitions of safety nets differ, but many emphasize that social transfers are non-contributory, regular and predictable, and intended to reduce food consumption deficits (Commission-Européenne 2012). In this paper, we follow FAO (2015) that the poor receive support in cash or in kind, vulnerable people are protected from risk, and marginalized persons enjoy a better social situation and recognition of their rights, with the goal of reducing poverty and vulnerability. These are mechanisms put in place by the government to protect the poor and vulnerable groups in society (Grosh et al. 2008).

Social assistance programs consist of the provisions by the state of aid, with or without conditions. Social insurance programs are contributory and grant coverage for certain risks or situations affecting living conditions or household incomes. Labor market programs provide for the payment of unemployment benefits, skills enhancement, improved worker productivity and professional integration. Safety net programs are part of social assistance programs and are defined as cash or in-kind transfer programs; thus, the aim is to fight against poverty through the redistribution of wealth and to protect households from income shocks (FAO 2003).

Related theoretical literature

In the context of perfect markets, social transfers should not affect household production and consumption decisions even if some face an infinite supply of prices (Singh et al. 1986). Indeed, perfect markets exclude all the problems and difficulties in accessing various markets. This lack of difficulty allows all actors, especially poor households, to access the labor force, credit, agricultural land and other resources essential for production and the improvement in their well-being. They can participate in all markets at specific and

competitive market prices and rates (Daidone et al. 2019). Since the objective is to maximize production or well-being, actors make decisions to achieve maximum results. In the conditions of perfect market operation, production and consumption decisions are therefore separable and sequential. Producer households first make the decision to maximize production/ profit and then use the resulting income for consumption maximization (Singh et al. 1986). Under these circumstances, social transfers, by easing the budgetary constraints, influence not only production but also consumption (Daidone et al. 2019).

Transfers, access to agricultural inputs, assets and farm investment

Agriculture is characterized by a production cycle that results in a lag of several months between expenditure (preparation, planting) and harvest. Until the sale of the harvested produce, actors earn very little cash income, while material, input and communication expenses are incurred in cash (Feder et al. 1990). This situation increases the farmer's enormous need for working capital, which should in no way be a problem in the context of perfect and complete markets (Singh et al. 1986). However, in poor countries, especially in rural areas, poor producers face difficulties in accessing the main resources for agricultural production (Stiglitz and Weiss 1981; Daidone et al. 2019) because of market imperfections related to information asymmetry or public policies (Feder et al. 1990).

In addition to imperfections in resource and factor markets, the insurance market for managing large risks is non-existent in developing countries (Stiglitz and Weiss 1981). Even if the latter exists, it is often much localized where the availability of information could allow the application of mutual insurance agreements where only partial insurance is possible (Deaton 1992). Also, by limiting producers' access to markets as sellers or purchasers, market imperfections generate transaction costs that create differences between selling and buying prices. These costs, which are generally high in the commodity market, lead poor households to make self-sufficiency the goal, with the result that households often tend to choose low productivity options (Singh et al. 1986; Key et al. 2000; Karlan et al. 2014).

Households in SSA, especially the poor, face challenges with access to credit due to credit rationing (Binswanger and Khandker 1995; Boucher et al. 2008), thus tightening their funding constraints, which limits their investments in activities with high expected profits (Feder et al. 1990; Ali et al. 2014). In addition, in agriculture, yields are uncertain (Dasgupta 1993), the transaction costs linked to market access are often very high for poor households (Key et al. 2000), and revenues are received after the harvest. Under these circumstances, the deprivation of poor households of resources negatively affects the allocation of agricultural resources, as well as productivity (Boucher et al. 2008).

With imperfect markets and non-separability, direct public intervention, whether monetary or not, toward a household eases the financial constraints of poor households. Consequently, any such intervention offers poor farm households the possibility of accessing more inputs and making more productive investments (Bastagli, et al. 2018), which in turn changes their production possibilities (Daidone et al. 2019). Within this framework, social transfers, on the one hand, make liquidity or assets in kind directly available to households (Phimister 1995; Karlan et al. 2014), allowing them to acquire agricultural assets, make more investments and increase the land area cultivated (Asfaw et al. 2014; Todd et al. 2009). On the other hand, social transfers help beneficiaries improve their credit rating (Karlan et al. 2014). Social transfers therefore have the advantage of bringing input use closer to its optimal levels, leading to increased productivity and output (Todd et al. 2009).

Moreover, if the transfers are clearly sufficient, they offer households the possibility of saving for investment and future consumption (Daidone et al. 2019).

Transfers, work and farm risk management

Since the 1960s, the effects of social transfer programs on poor households' incentives to work have attracted the interest of researchers and policy makers. In fact, although these programs improve the income of poor households (Asfaw et al. 2014), some authors stress that they reduce the incentives for actors to work and make them live off cash transfers. For these households, transfers make work less attractive compared to leisure and therefore entail significant efficiency costs, which could outweigh the effect of credit gains (Moffitt 2002; Saez 2002). In addition, in areas where child labor is more prevalent, transfers reduce households' reliance on child labor as a strategy for coping with economic shocks. The result is a decrease in children's participation in child labor and working hours as a household adjustment strategy (de Hoop and Rosati 2014).

However, this view does not seem to be universally held, especially in the case of SSA. Indeed, far from discouraging working in low-income countries, transfers to poor households encourage people to work by giving them the means they need to invest and intensify agricultural production (FAO and UNICEF 2017). In addition, the uncertainty of agricultural yields and wage labor supervision requirements create incentives for households to make maximum use of family labor, making it a perfect substitute for paid work (Dasgupta 1993). Because of the incentive of family labor to work compared with hired labor, transfers encourage households to use their own labor force intensively, contributing to improved household agricultural production and productivity (Boone et al. 2013).

Although shocks are very common in agriculture, they affect the poorest deciles more than the richest households, whose consumption is at least 90% protected against these shocks (Jalan and Ravallion 1999). In this context, participation in paid agricultural activities and many other nonagricultural activities constitutes a strategy for poor households to survive and prevent these agricultural risks or obtain the liquidity they need. Such situations often lead these households to make less productive and less profitable crop choices, with their sole objective being to protect themselves against risk and to secure food. As Singh et al. (1986) note, these households often participate in the paid labor market to protect against risk. When transfers enable households to protect themselves against risk, they devote themselves fully to the activities of their holdings (Daidone et al. 2019; FAO and UNICEF 2017), leading to the intensification of their own production (Hennessy 1998).

Related empirical literature

The extractive orientation of colonial rule led to the disintegration of indigenous social systems amidst unequal development and gave rise to the need for formal state social welfare services in many African countries (Patel et al. 2012). In the face of failure of structural adjustment programs to generate the desired economic recovery, calls for 'pro-poor' and 'transformative development' emerged among major development agencies and institutions, giving impetus to more developmental social policies (Surrender and Walker 2013). Social protection and public works programs (PWPs), which often require beneficiaries to work, are recent but very fast-growing social policy instruments (Patel 2018; Grosh et al. 2008) widely used across Africa, which are part of changing trends. Spurred by globalization and other transformative forces, social protection policies have experienced

exponential growth in the developing world (Patel 2018). Indeed, over 50 countries with such programs in Africa have also established formal institutions for social protection, often backed by necessary legislation. Thus, research on their nature and effectiveness in delivering more balanced and broad-based or inclusive economic and social development is of enduring importance and interest. However, others such as Mkandawire (2004) argue that 'social policies need to work in tandem with economic policy to ensure equitable and socially sustainable development' and thus 'safety nets' alone will not suffice.

The empirical question of the impact of social safety net programs on the agricultural performance of households is not new. Heath et al. (2020) reported from a randomized control trial that cash transfers had significant impacts on intimate partner violence, reduced physical and emotional violence and controlling behaviors in polygamous households but had limited effects in monogamous households and no effect on women's bargaining power. Additionally, cash transfers cause opportunity-led diversification among poor households (Pace et al. 2022) and reduce child labor but have no significant effects on agricultural production (Asfaw et al. 2014). Weldegebriel and Prowse (2013) reported results contrary to the expectation that the program would encourage or promote autonomous climate change adaptation in Ethiopia. In Rwanda, cash transfers had significant poverty reduction benefits, although their effects on both total and food consumption were minimal. Indeed, Habimana et al. (2021) concluded that the program allowed some subsistence households to partly retire.

Cash transfers have positive effects on time spent working on family farms, farm assets and household dietary diversity and reduce their use of hired labor (Boone et al. 2013). In Lesotho, transfers increased farm output through improvements in the use of crop inputs and related expenses, resulting in increased sorghum production and the frequency of harvests from vegetable gardens among households with limited working capacity. Other results include increased spending on seed in Ghana but a decline in Kenya, although in both cases, transfers did not result in an increase in farm output. Daidone et al. (2019) noted that beneficiaries avoid low-earning wage labor and invest in productive small assets such as farm tools and inputs, as well as small animals and livestock. Handa et al. (2018) reported sizeable multiplier effects of unconditional cash transfers among beneficiaries. Todd et al. (2009) analyzed the impact of money transfers, conditioned on human capital, on agricultural production and reported positive effects on land use, livestock ownership, and agricultural spending and production.

Nilsson et al. (2019) reported that an in-kind transfer program increased both consumption and farm productivity among beneficiaries, with a significant role for knowledge and experience. Unlike India and Ethiopia, Beegle et al. (2017) found no evidence that Malawi's labor-intensive public works program had the desired effect. Berhane et al. (2014) assessed Ethiopia's program and reported increased food security of participant households as well as their livestock holdings and no crowding-out of private transfers.

Materials and methods

Social assistance programs in Mali

Although some progress has been made in reducing poverty, Mali still has a high level of poverty, with an estimated poverty head count ratio of 49.7% in 2009, and 42.7% of the population in 2017 lived in extreme poverty (World Bank 2019). Cherrier et al. (2011)

reported that most of the population is highly vulnerable, and that the country has relied on various strategies and programs, including social assistance, in pursuit of reducing both poverty and food insecurity. In Mali, 'social safety nets' come in various forms, but it is important to note that most, if not all, of these programs only ran on a pilot basis, and had very limited geographical coverage (see Cherrier et al. 2011). In addition, these programs were run mainly by development partners, including UNICEF, Catholic Relief Services and WFP, over relatively short time periods. In the cash transfer category, Oxfam GB and Save the Children US targeted approximately 7000 households in Gao and Sikasso in 2010–2011. UNICEF, working with local NGOs, ran a pilot, 'Bourse Maman,' in selected basic schools targeting boys and girls in the first cycle from 2002 to 2007 in Kayes and Mopti; it reached approximately 500 mothers per year. Similarly, World Education, along with three local NGOs, ran a girls' scholarship program in Gao, Kidal and Timbuktu from 2003 to 2008. This program targeted all girls in upper primary segment in 109 schools and reached approximately 7000 girls per year.

While food transfer and nutrition programs appear to be common, these programs were mostly short duration interventions lasting one year or two years. Largely with the support of external partners, Mali runs various food security-themed programs, including a school feeding program with support from the WFP and CRS. Cherrier et al. (2011) provide a comprehensive discussion of social safety net programs in Mali. Whereas there is a multiplicity of social safety net interventions, there is not proper coordination in the design and implementation of these interventions, which may hamper their effectiveness.

Consequently, the World Bank (2013), at the request of the Malian government, supported a 'systemic' approach that provides coordinated support under the Emergency Safety Net Project code-named 'Jigisemejiri' or (Tree of Hope), which aims to fight against extreme poverty. It originally targeted 62,000 households and planned to add 60,000 more by the end of its fifth year as part of an expanded unified register. Although it has a national scope, it initially covered, for the period 2013–2018, only the Bamako district and the five southern regions. The medium- and long-term objective of the cash transfer component was to reduce the intergenerational transmission of poverty by improving human capital outcomes. Following a systematic diagnostic study of the country in 2015, Mali expanded the project with additional funding to include a subcomponent on income-generating activities, with at least 65% of these activities in the areas of subsistence or smallholder agriculture, trade, poultry farming and processing (World Bank 2018). In 2023, Mali restructured the project to help address various challenges (World Bank 2023).

Today, the 'jigisemejiri' has established itself as a flagship program in the fight against poverty in Mali. In 2017, the program began its expansion phase with additional funding of 10 million US dollars from the World Bank. This enabled the implementation of 10,000 income-generating activities (IGAs) and the installation of one hundred labor-intensive microprojects (HIMs) in the form of public works. The Malian government and the World Bank added 25 and 54 million US dollars, respectively, to ensure the extension of the program to additional households across the country, including the northern regions.

During the Covid-19 pandemic, the government used 'jigisemejiri' for the implementation of the Government Emergency Transfer Program (PGTU). This enabled, at the end of 2022, 412,935 households to benefit, with each receiving an allocation of 90,000 FCFA linked to the Covid-19 disease. At the end of 2022, the 'jigisemejiri' program was able to mobilize 70 billion FCFA including 60 billion FCFA World Bank contributions. This made it possible to allocate more than 40 billion FCFA in the form of monetary transfers to 103,000 households, and more than 280,000 households received support measures in the form of strengthening human capital. In addition, preventive nutritional packages were

distributed to more than 150,000 breast-feeding women and children under the age of five (5) and 34,000 income-generating activities were implemented.

Data and data sources

This work uses data from the Agricultural Survey of Integrated Household Living Conditions (EAC-I) of 2014. The survey is part of the Living Standards Measurement Survey (LSMS), which was conducted in two stages with family farms or households during the sowing and harvesting seasons. In addition to data on the characteristics of households, production and various factors of production, the EAC-I allows the collection of several other types of data, including those relating to the participation of households in a social transfer program. With a focus on households involved in agricultural production, 2284 households were retained after data cleaning as part of this work, of which 7.27% benefited from a social safety net program.

Descriptive analysis and average characteristics by social transfer program participation

On average, households obtain 365,116 FCFA per hectare, with a range of 1,786,885 FCFA (Table 1). They cultivate an average of 5.72 hectares, ranging from 0.05 to 132.12 ha. The seed expenditure ranges from 150 to 63,200 FCFA, and its mean is 12,432 FCFA. On average, they spend 68,518 FCFA per hectare on the purchase of chemical fertilizers, with a minimum of 0 and a maximum of 314,605 FCFA. Only 1% of households have an internet connection at home, whereas 2.15% of households have a landline telephone at home. The proportion of households experiencing a shock is 73.86%. Households headed by a woman account for 2.45%, and 4.38% for single-person households. Approximately 26% of the households received training support in relation to production; only 6.82% of households live in urban areas, 13% grew cotton and 24.52% grew rice.

The participants and nonparticipants differ in their access to the internet, number of shocks, and involvement in cotton and rice. Compared with participants, nonparticipants in a social safety net program have more large ruminants and more assets relative to their household size (Table 2). In addition, they are relatively more involved in the cultivation of cotton and rice. In contrast, participants experienced more shocks than nonparticipants did.

Modeling the impact of cash transfers on agricultural performance

The estimation of the effect of participation in social transfer programs on agricultural performance is subject to endogeneity bias (Boone et al. 2013). Although, on average, the focus is on targeting beneficiary households, there is the potential bias of self-selection in observational data, which requires consideration to allow unbiased estimates of program effects. Among several methods developed to correct potential selection biases, Lokshin and Sajaia (2004) found ESR suitable. In addition to the impact on beneficiaries, the ESR also allows the calculation of the conditional effect on nonparticipants, that is, supposing they benefit (Läpple et al. 2013). Unlike the propensity score matching technique, the ESR explicitly tests for and incorporates the effect of unobservables, through the inverse Mills ratio term, and thus controls both observable and unobservable selection bias (Heckman and Navarro-Lozano 2004). Indeed, it is also possible to simulate farmer outcomes if they were placed in another scenario

Table 1 Definition and description of variables. *Source*: Authors' estimates from base LSMS (2014)

Variables	Mean	SD	Min	Max	*N* (# cases)
Cropvp: production value per hectare (CFA)	365,115.9	358,012.4	1002	1,787,887	2202
Crop_area: cultivated area (ha)	5.717945.64	6.905128	0.05	132.124	2256
Seedexp: total expenditure on seed (FCFA)	12,432.4	11,533.51	150	63,200	951
Chemexp: total expenditure on chemical fertilizers (FCFA)	68,518.13	61,445.27	0	314,604.7	795
Laborexp: total labor expenditure (FCFA)	53,363.11	136,955.2	1000	1,147,176	1587
Largerum: total number of large ruminants	4.983758	9.56462	0	72	2278
Ratio: (active number/household size)	.4958075	.1628254	0.1	1	2284
Age: age of household head	51.75	14.26392	17	94	2284
Disease: household experienced crop and livestock pests or disease (%)	Binary ('1 yes; 0 no')			20.18	2284
Shocks: the household has suffered a shock (climate, market, etc.) (%)	Binary ('1 yes; 0 no')			73.86	2284
Single: the householder is single (%)	Binary ('1 yes; 0 no')			4.38	2284
Femhead: the head of household is a woman (%)	Binary ('1 yes; 0 no')			2.45	2284
Dtrain_ext_crop: benefit from production training (%)	Binary ('1 yes; 0 no')			25.67	2263
Telephon: having a home phone (%)	Binary ('1 yes; 0 no')			2.15	2284
Internet: having an internet connection at home (%)	Binary ('1 yes; 0 no')			0.96	2284
Urban: residing in an urban environment (%)	Binary ('1 yes; 0 no')			6.82	2284
Conflict: household residing in the area affected by the security crisis (%)	Binary ('1 yes; 0 no')			11.47	2284
Cotton: cultivate cotton (%)	Binary ('1 yes; 0 no')			13.00	2284
Rice: cultivate rice (%)	Binary ('1 yes; 0 no')			24.52	2284
Maize: cultivate maize (%)	Binary ('1 yes; 0 no')			36.43	2284

Table 2 Average characteristics according to the status of participation in a social transfer program. *Source*: Authors' estimates from base LSMS (2014)

Variables	Participation in a social transfer program				Diff	T_stat
	Non-beneficiaries	Sample size (*N*)	Beneficiaries	Sample size (*N*)		
Crop_area	5.751	2093	5.293	163	.458	0.81
Seedexp	12,569.62	878	10,782.05	73	1787.56	1.27
Chemexp	69,046	749	59,923.07	46	9122.93	0.98
Laborexp	54,113.73	1475	43,477.73	112	10,636	0.79
Largerum	5.445	2112	4.20	166	1.250**	1.99
Ratio	.498	2118	.462	166	.036 ***	2.78
Shocks	.732	2118	.831	166	− .100***	− 2.83
Age	52.10	2118	50.5	166	1.66	1.44
Single	.042	2118	.060	166	− .018	− 1.07
Femhead	.025	2118	.024	166	.000	0.04
Disease	.20	2118	.21	166	− .01	− 0.30
Dtrain_ext_crop	.259	2100	.227	163	.032	0.90
Telephone	.021	2118	.024	166	− .003	− 0.24
Internet	.009	2118	.012	166	− .003	− 0.33
Conflict	.11	2118	.19	166	− .08***	− 3.28
Urban	.058	2118	.060	166	− .002	− 0.11
Cotton	.130	2118	.127	166	.004*	1.82
Rice	.271	2118	.243	166	.028*	1.92
Maize	.37	2118	.35	166	.02	0.41

(Mare and Winship 1987), hence the choice of the ESR model. The ESR specifies a binary treatment model (participation in social transfer programs) and a separate equation for the outcome, the value of agricultural production per hectare in our case, according to treatment status.

Participation in social transfer programs and agricultural performance

This research models a household's participation in social transfer programs as the binary expected utility of agricultural performance via a random utility model. A household participates in transfer programs if it expects to derive higher utility from participation (P_1^*) than otherwise (P_0^*). If $P = U_{iT} - U_{iN}$ is the difference in expected utility from participation, a household will participate if $U_{iT} - U_{iN} > 0$. Unlike participation, the expected usefulness of the programs is not observable. A household's decision to participate (P) can be modeled as a dichotomous choice as follows:

$$P_i^* = Z\alpha + \varepsilon; \text{with } P_i = \begin{cases} 1 & \text{if } P_i^* > 0 \\ 0 & \text{otherwise} \end{cases} \quad (1)$$

where P is a dichotomous variable representing participation. $P=1$ if the household participated in a program and $P=0$ if not; Z is the matrix of the explanatory variables, α is the

vector of parameters to estimate and ε is the error term of the normal distribution with zero mean and variance σ_{ε}^2. Assuming that the value of agricultural output per hectare is linear in participation in a transfer program, then:

$$Y_i = \gamma X_i + \delta P_i + u_i \tag{2}$$

describes the outcome as a function of participation and other explanatory variables (X). In Eq. 2, Y_i represents the value of agricultural production per hectare of household i, P is a latent variable of program participation, γ and δ are parameters to be estimated, and u is a term for error. In this function, δ captures the impact of the transfer program on agricultural performance. Accurately measuring the impact of participation on agricultural performance requires random assignment of households to participating or nonparticipant groups.

The endogenous switching regression (ESR) model

The ESR framework models program impact in two steps by specifying a probit model for participation and then an OLS, with correction for self-selection, for agricultural performance contingent on participation in social transfer programs. Since the choice of the household to participate in social transfer programs affects its agricultural performance, the two performance regression equations (participants or not) may be expressed as follows:

$$\text{Plan 1 (participants)}: \; Y_{1i} = X_{1i}\beta_1 + w_{1i} \quad \text{if} \quad P = 1 \tag{3a}$$

$$\text{Plan 2 (nonparticipants)}: \; Y_{0i} = X_{0i}\beta_0 + w_{0i} \quad \text{if} \quad P = 0 \tag{3b}$$

where Y_{1i} and Y_{0i} represent the agricultural output per hectare of households in the respective schemes. X_{1i} and X_{0i} represent vectors of exogenous influences on agricultural performance, β_1 and β_0 represent vectors of parameters to be estimated, and w_{1i} and w_{0i} are random errors.

Shiferaw et al. (2014) noted that the expected values of $w_{1i} and w_{0i}$ are not null; hence, OLS estimates of β_1 and β_0 are biased. Other details of this framework can be found in Diamoutene and Jatoe (2021). For brevity, upon the assumption of a tri-variate normal distribution of the error terms in Eqs. (1) and (3) and a unit variance for the errors in (1), the covariance between w_1 and w_0 is not defined (Läpple et al. 2013; Maddalla 1983). This is because Y_{1i} and Y_{0i} are not observed simultaneously. Continuing by computing the inverse Mills ratios from the selection equation and including them in Eqs. (3a) and (3b) correct selection bias. The inverse Mills ratios are given as $\lambda_0 = \frac{-\emptyset(Z_{i\alpha})}{1-\Phi(Z_{i\alpha})}$ and $\lambda_1 = \frac{\emptyset(Z_{i\alpha})}{\Phi(Z_{i\alpha})}$, where $\emptyset$ is the probability density and Φ is the cumulative density function of the standard normal distribution. By replacing $\lambda_1 = \frac{\emptyset(Z_{i\alpha})}{\Phi(Z_{i\alpha})}$ and $\lambda_0 = \frac{-\emptyset(Z_{i\alpha})}{1-\Phi(Z_{i\alpha})}$, and following Maddalla (1983), the agricultural performance Eqs. (3a and 3b) become:

$$Y_1 = X_1\beta_1 + \sigma_{w_1\varepsilon}\lambda_1 + u_1 \quad \text{if} \quad P = 1 \tag{4a}$$

$$Y_0 = X_1\beta_0 + \sigma_{w_0\varepsilon}\lambda_0 + u_1 \quad \text{if} \quad P = 0 \tag{4b}$$

Clearly, OLS estimates of β_j from (3a) and (3b) will be biased and inconsistent due to omission of the $\sigma_{w_j\varepsilon}\lambda_j$[1] terms. Only if the covariance between the error terms in (1) and (3) is nonzero does this bias appear. Additionally, owing to the heteroscedastic u_j terms OLS estimates from 4a and 4b will be ineffective. Lokshin and Sajaia (2004) proposed full information maximum likelihood estimation as an effective method for adjusting the ESR model. It allows both treatment and outcome equations (agricultural performance) to be estimated simultaneously to produce consistent parameter estimates.

In the implementation of support programs, one of the difficulties lies in the targeting of beneficiaries. The choice is usually not the result of a random process, as beneficiary targeting is performed by local officials, including mayors, village chiefs, councilors, youth and women leaders. In such situations, belonging to a local network or the possession of a real power of influence could affect a household's participation in such programs. Without network variables or this local influence, we took interest in a household's possession of an internet connection at home. We chose this variable because it can well reflect power, networks and the ability to influence actors at the local level. We therefore created an 'Internet' variable which captures whether a household has an internet network at home. Thus, this variable could serve as an instrument for the variable of participation in a social safety net program. We assessed the admissibility of having internet connections following Di Falco et al. (2011). The test results show that the internet variable is a good instrument; it is not a predictor in the model of agricultural performance (see 'Appendix').

Using the ESR is appropriate when model estimates for $\sigma_{w_1\varepsilon}$ and $\sigma_{w_0\varepsilon}$ are statistically significant, indicating sample selection bias. In other words, some unobservable variables, such as household capacity and motivation, influence both program participation and performance. When $\sigma_{w_1\varepsilon}>$ and $\sigma_{w_0\varepsilon} < 0$, both groups show positive selection, suggesting that participating farmers do so because of the expected benefits and are ones with above-average returns. With $\sigma_{w_1\varepsilon} > 0$ and $\sigma_{w_0\varepsilon} > 0$, there is positive selection in group one and negative selection in the other. This implies that the members of the beneficiary group have higher farm returns either way but are better able to participate (see Maddalla 1983 for other cases). Khonje et al. (2015), Shiferaw et al. (2014), Di Falco et al. (2011), and Maddalla (1983) provide detailed expositions of how the ESR model allows for comparisons of the expected farm incomes of household with their counterfactuals. Of interest in this study is how program participation affects the performance (farm income per hectare) of beneficiary households.

Results and discussion

Agricultural performance, measured as the logarithm of the value of production per hectare, is the dependent variable. The treatment, 'transfer', assumes a value of 1 if at least one member of the household is a beneficiary of a transfer program, and 0 if not. With a Wald test χ^2 (11) 300.88 (Table 3), we conclude that ESR model has good fit. The estimated values for both $\sigma_{\epsilon_1}\varepsilon$ and $\sigma_{\epsilon_0}\varepsilon$ are statistically significant, indicating the presence of sample selection bias. Thus, using an endogenous switching regression model is appropriate. We reject the null hypothesis that participation and agricultural performance are not correlated given the significant likelihood ratio test statistic for independence of the two equations.

[1] $\sigma_{w_j\varepsilon}$ is the covariance between the error terms in (1) and (3).

Table 3 Determinants of transfer program participation and agricultural performance. *Source*: Authors' estimates from the LSMS database (2014)

Participation in the transfer program			Agricultural performance			
			Beneficiairies		Non-beneficiairies	
Variable	Coef	SE	Coef	SE	Coef	SE
Crop_land			− 0.434***	.026	− 0.338***	.098
Seedexp			− 0.002	.036	0.019**	.008
Chemexp			0.055***	.021	0.048***	.005
Laborexp			0.011	.019	0.018***	.005
Dtrain_Ext_Crop			0.429*	.223	0.118**	.059
Disease			− 0.410*	.230	− 0.116*	.064
Shocks	0.313***	.107	− 0.459*	.254	− 0.152**	.068
Age	− 0.110	.122	0.015	.307	0.014	.087
Single	− 0.053	.162	− 0.009	.522	− 0.239	.181
Femhead			− 0.545	.924	− 0.016	.217
Internet	0.299**	.004				
Telephon	− 0.285	.227				
Cons	− .809	.463	11.368	.402	13.553	1.458
/lns_1	.288	.017				
/lns_2	.874	.092				
/r_1	2.044	.124				
/r_2	− 2.326	.213				
Sigma_1	1.334	.022				
Sigma_2	2.396	.220				
Rho_1	.967	.008				
Rho_2	− .981	.008				
Log likelihood	− 3918.044					
Wald test χ^2 (11)	300.88					
LR test of indep. eqns	224.50***					
N	2173					

Determinants of participation in the transfer program and agricultural performance

Two variables are significant in the modeling of participation in the transfer program: shocks and having an internet connection at home. Both variables positively affect participation in the transfer program, which implies that households that suffer shocks and/or have internet connection at home are more likely to benefit from a transfer program. Approximately 70% of Malian population is rural and relies heavily on agriculture. However, agriculture is still highly exposed to shocks, including natural hazards and uncertainty about the quantities and prices in both factor and commodity markets. As poverty is a rural phenomenon, the advent of a shock deteriorates the state of poverty of households and makes them eligible for social safety net programs. This explains the positive relationship between shocks and a household's participation in a transfer program. Since it is the local officials (both elected and otherwise) and the chiefs who are often involved in the process

of choosing beneficiaries, the latter are likely to be people with real connections in local networks. This may explain the positive sign of the internet variable, which is used as a proxy for the networking capacity and influence of the household.

For recipients of a social transfer program, five variables were found to significantly influence the agricultural performance of households. These are the areas cultivated, diseases and shocks, with negative effects, and then fertilizer and access to support services had positive effects. For those not benefiting from a transfer program, crop area, crop diseases and shocks had significant negative effects on agricultural performance. The variables that have positive effects among nonparticipants are seeds, fertilizers, labor and agricultural production support services. The negative sign of the area cultivated suggests an inverse relationship of productivity in agriculture in Mali due to imperfections (see Lamb 2003; Larson et al. 2014). The positive relationship of access to seeds, fertilizers and support services is consistent with the observation that a key difference between wealthier and poorer households in Mali lies less in how much land they possess but rather more in how much land they can cultivate; this difference is often driven by the poor's limited access to labor, agricultural inputs and productive assets (World Bank 2015).

Effect of transfer program on agricultural performance

Estimates of both ATT and ATU show a positive impact of social safety net programs on agricultural performance. While the effect is positive for both groups, the results show a greater effect on beneficiaries than the potential effect on nonparticipants. Indeed, the effect of social safety net programs on recipient households is an increase in agricultural income per hectare of 57,125 FCFA, whereas the potential effect on nonparticipant households would be 34,136 FCFA per hectare (Table 4). The greater impact on participants reflects a good level of effectiveness in targeting beneficiary households. The positive effect of the transfer programs may be much more related to the effect on the use of household labor. This is because in the context of agricultural shocks (Jalan and Ravallion 1999) and poverty, social transfers from social safety net programs allow households to protect themselves against risk, reduce the use of paid employment and fully intensify the use of more productive family labor on their own farms (Singh et al. 1986; Daidone et al. 2019; FAO and UNICEF 2017).

In Mali, various transfer programs are based on in-kind aid. Indeed, 98% of transfers received by households under social safety net programs are in-kind, whereas only 2% is cash. Donations of treated nets (35%), free care for children (27%) and cereal rations (23%) are the main components of these programs. Our results suggest that these transfers allow households to maintain their consumption and human capital and to devote the few resources at their disposal to agricultural production. In this way, transfers give agricultural households the means and incentives to improve productivity and agricultural income.

Table 4 Result of estimating the effect of the transfer program on agricultural performance. *Source*: Authors' estimates from the LSMS database (2014)

	Coef	T. Stat
ATT (beneficiaries)	57,125***	15.17
ATU (non-beneficiaries)	34,136***	89.59

In addition, the fact that most transfers are in-kind reduces the risk of diversion for other purposes, making them more efficient. One implication of our findings is that the transfer program could be an effective tool for fighting poverty. In Mali, an increase in cereal production is strongly linked to poverty reduction, and the areas with good potential for cereal production are those with the bulk of the poor (World Bank 2015). Therefore, programs that increase households' capacity to work and expand their access to productive assets can prove effective tools for poverty reduction. Indeed, there is evidence that rapid reductions in poverty and inequality in Mali are closely associated with increases in the production of maize and rice.

Conclusion

This study analyzed the impact of social safety net programs on the value of agricultural production per hectare among households in Mali. The endogenous switching regression (ESR) model was used to correct for endogeneity and selection biases related to household participation in the programs on survey data, and positive and significant effects of participation on income per hectare were found. The smaller impact estimate for nonparticipant households suggests the effectiveness of the policy of targeting the selection of participating households.

Exposure to shocks, an important factor influencing participation in Mali's 'tree of hope' program, is of national concern as the country has not only high levels of poverty but also that most of its population remains rather vulnerable, and a variety of shocks are too prevalent. Thus, the program is benefiting the intended group. Additionally, internet connection at home, used as a proxy for a household's connectedness in the community, is also an important factor influencing participation in the safety net program. Hence, the reliance on local officials for the selection of program participants is having the desired effect of ensuring that deserving individuals (vulnerable individuals) are targeted as beneficiaries.

In Mali, area cultivated, diseases and shocks have negative effects on agricultural performance, and fertilizer and access to support services have positive effects. In addition, agricultural performance among nonparticipants is positively influenced by household expenditures on seed and farm labor. These results support the continuation of 'Jigisemejiri' in its current form and its expansion to benefit more households. Additionally, adding productivity-enhancing components such as access to improved seed to the program can enhance program impacts. These actions will improve farm households' access to the factors of production and contribute to the achievement of the objectives of improving the agricultural performance of family farms in Mali under the Law of Agricultural Orientation (LOA) and the Agricultural Development Policy (PDA). Expansion of the current social transfer program is likely to contribute to improved household food security and faster reductions in poverty and inequality through pro-poor growth.

Appendix

See Table 5.

Table 5 Instrument validation test results (simple falsification test). *Source:* Authors' estimates from the LSMS database (2014)

Participation in the transfer program			Agricultural performance non- participants	
Variable	Coef	SE	Coef	SE
Lsup			− 0.335***	.023
Lseed			0.019**	.008
Leng			0.048***	.005
Llabor			0.018***	.005
Dtrain_ext_crop		.118**	.059	
Disease			− 0.116*	.064
Shocks	0.313***	.011	− 0.152**	.068
Lage	− 0.110	0.122	0.014	.087
Single	− 0.053	.162	− 0.239	.181
Femhead			− 0.016	.217
Telephon	− 0.285	.227	− .212	.188
Internet	0.299**	.004	.005	.276

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Declarations

Conflict of interest The authors have no conflict of interests to declare.

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