Can a Social Safety Net Affect Farmers' Crop Portfolios? A Study of the Productive Safety Net Programme in Ethiopia*

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* The author acknowledge with thanks the financial support received for this work from the Environment for Development (EfD) Initiative at the University of Gothenburg, Sweden, financed by the Swedish International Development Cooperation Agency, as well as from the Jan Wallander and Tom Hedelius Foundation. She thanks the following institutions for access to the data used for this study: the Department of Economics, Addis Ababa University; the Environmental Economics Policy Forum for Ethiopia, Ethiopian Development Research Institute; the Department of Economics and the EfD Initiative, University of Gothenburg; and the World Bank. Finally, she thanks Alemu Mekonnen at the Ethiopian Development Research Institute; Jesper Stage, Menale Kassie, Yonas Alem and Haileselassie Medhin at the University of Gothenburg; Karl-Gustaf Löfgren, Kurt Brännäs and Andrea Mannberg at the Department of Economics, Umeå University; and Johan Kiessling at the Swedish International Development Cooperation Agency. The usual disclaimers apply.

Abstract

In this paper, we examine whether a minimum level of ensured consumption from a social safety net has the potential of breaking the vicious circle of risk avoidance and low return in African agriculture. We study how the implementation of a social safety net programme in Ethiopia has affected the value, risk and composition of farmers' crop portfolios. The effects of programme participation on the value and risk of the crop portfolio are examined in a Just-Pope production function, and the effects of programme participation on composition of the crop portfolio are tested in a set of acreage response models. The empirical analysis is based on unique household panel data that allow us to control for unobserved heterogeneity. No significant effect on the value and risk of the crop portfolio could be found. However, the programme seems to have brought about some changes in the land allocated to different crops. The greatest effect is towards increased cultivation of perennials, which are high-value, high-risk crops in this part of Ethiopia.

Keywords: Crop choice, Social safety nets, Food-for-work programmes, PSNP, Ethiopia

JEL classification: Q12, Q18, O22

1 Introduction

In this paper we examine whether a minimum level of ensured consumption from a social safety net has the potential of breaking the vicious circle of risk avoidance and low productivity in African agriculture. We study how the implementation of the Productive Safety Net Programme, a social safety net programme in Ethiopia, has affected the value, risk and composition of farmers' crop portfolios.

In the development debate, it is often emphasised that the difficulties of managing risk are an important reason for the low productivity in African agriculture (see e.g. World Bank, 2007). The argument put forward is that, since unexpected shortfalls in income cannot be handled through credit or insurance markets, farmers are often forced to opt for strategies that reduce the risk of starvation but may trap them in poverty.

A number of previous studies have found that farmers who have access to consumption credit, liquid assets or off-farm income that can be used to maintain a certain level of consumption during negative income shocks are more likely to choose an income portfolio with higher average risk and higher average return, while farmers without these opportunities are more likely to resort to income activities with low risk and low average return.[1]

[1] See e.g. Eswaran and Kotwal (1990), Morduch (1990), Rosenzweig and Binswanger (1993), Dercon (1996) and Lamb (2002) and Wadood and Lamb (2006).

A social safety net is likely to have a similar effect on the production pattern. If farmers know that they will at least reach the subsistence level of consumption – even if there is a bad year in production – they may be more willing to engage in activities with a higher average return and higher risk. However, few, if any, studies have been made in this field.

The effects of a social safety net on crop production are, however, ambiguous and are likely to depend on how that net is designed. In many developing countries, especially in sub-Saharan Africa, safety nets are designed so that participants in programmes are assured of a minimum level of food or money in exchange for work in social programmes during a given period – which is the case with the programme studied in this paper. When the safety net is designed in this manner, a number of possible effects it may have on the value, risk and composition of farmers' crop portfolios can be identified.

The insurance function of such programmes may not only lead farmers to choose a crop portfolio that contains a larger share of crops with higher value and risk (which in turn affect the value and risk of the total crop portfolio), it can also increase labour productivity by ensuring that household members have adequate food and nutrition throughout the year. The increased labour productivity can directly increase the output (and, hence, the total value of the crop portfolio) and reduce the variation in output at the same time.

The safety net can also affect the availability of inputs by reducing liquidity constraints (so that farmers can more easily purchase inputs), but also by competing with labour use in own farming. These changes in input availability can directly affect both the output and variation in it. For example, if more capital is available to make investments at the beginning of the season, it may increase the output and reduce the variation; on the other hand, if farmers are employed in public work during times that are critical for crop production on the farmer's own farm, there is a risk of reduced output and increased variation in output. The availability of inputs may also affect the relative attractiveness of growing different crops, depending on their relative input intensities. It is, for example, likely that crops that are more capital-intensive but less labour-intensive become more attractive. Again, the resulting reallocation of land to different crops can indirectly affect the value and variation of the total crop portfolio.

Another possible effect of the safety net is that, if workers are paid in food, it can crowd out local food production by increasing the supply of food and suppressing the prices of food crops.

Thus, depending on the design of the programme, there can be several different types of effects on agricultural production, and the net impact is not clear.

The effect of food-for-work (FFW) programmes on agricultural production is an ongoing debate and the empirical results are mixed (see e.g. Bezu and Holden (2008) and Barrett et al. (2004)). The main focus in the literature has been on the effects of these programmes on output and input usage, while less attention has been given to the effects on risk and composition of the crop portfolio. Bezuneh et al. (1988) is an exception: they use linear programming to study the effects of FFW on agricultural production in rural Kenya. Their results indicate that participation in FFW programmes can shift agricultural production from maize to millet, where millet is the more profitable crop. However, to our knowledge, there has been no study to date of how FFW programmes affect risk in crop portfolios. This paper is an attempt to fill that gap.

The rest of the paper is organised as follows: section 2 describes the programme studied in this paper. Section 3 outlines a brief theoretical model of how the programme studied can affect the riskiness of and return to the total crop portfolio and the composition of the crop portfolio. Section 4 presents the empirical models. Section 5 describes the data. Section 6 presents the results and section 7 sets out the conclusions for the study.

2 The Productive Safety Net Programme

The safety net programme of interest in this paper is the Productive Safety Net Programme (PSNP) in Ethiopia. It is the largest social protection programme in the history of sub-Saharan Africa, with the exception of South Africa. The annual budget is near US$500 million, and it reaches more than 7 million Ethiopians (Gilligan et al. 2008). The programme was launched by the government and a number of donors[2] in 2005 with the aim of combating the persistent problem of food insecurity in Ethiopia. The general idea of the programme is to provide food-insecure people with public works that will generate a small but secure income. Such works differ from region to region, but it aims at generating public goods such as roads and stone terraces. The extra income generated from these works is intended to ensure that the participants can maintain at least a minimum level of consumption, and enable them to keep their productive assets in times of income shocks rather than selling them. It should be emphasised that the main purpose of the programme is not to affect the value, risk or composition of the crop portfolio. Even though such impacts are not an explicit programme goal, impacts on the crop portfolio will, of course, matter in respect of the programme's overarching aims and deserve to be studied, therefore.

The basic targeting criteria for eligibility to the PSNP are that –

- the household should have faced continuous food shortages during the most recent three years
- have suddenly become food insecure, and/or
- lack family support or other means of social protection or support.

[2] Including the World Bank, the United States Agency for International Development, the Canadian International Development Agency, and several European donors.

Factors that are mentioned as indicators are –[3]

- "status of households' assets; land holdings, quality of land, food stock, etc
- income from non-agricultural activities and alternative employment[, and]
- support/remittances from relatives or community".

There are two previous comprehensive studies of effects of the PSNP: Gilligan and Hoddinott (2008) and Andersson et al. (2010). Andersson et al. (2010) study the effects of the programme on asset holdings. They find that the programme increases investment in tree holdings, which are less liquid assets, while no effects on livestock holdings are found. Gilligan and Hoddinott (2008) study the effect of the programme on a number of variables. Of special interest for this study are the variables related to agricultural production. They find no significant effect of the PSNP alone on the use of improved seed or fertiliser, but report a significant increase in the usage of the two inputs when the joint impact of PSNP and other food security programmes (where the major part is provision of credit) are considered.

Section 3 presents a theoretical framework for how the PSNP can affect the composition of the crop portfolio, on the one hand, and the mean and variability of the total crop portfolio on the other.

[3] MoARD (2006).

3 Theoretical background

The theoretical framework in this paper is mainly based on the model presented by Rosenzweig and Binswanger (1993), but includes some minor extensions to fit the current context. The PSNP has two features that are important to incorporate in the model. The first is that the programme can reduce how much of the variation in profit spills over to variation in consumption. This will happen if the programme acts as a safety net and ensures that consumption never falls below a level derived from the incomes from the programme – even if there is a bad year in agricultural production. The implication of this feature is the same as that derived by Rosenzweig and Binswanger (1993), although they consider the impact of wealth rather than the impact of participation in a social protection programme. The second feature, which represents an extension of the original model, is that the programme can affect the availability of inputs. It is assumed that the programme can either increase or decrease input availability, depending on whether it reduces liquidity constraints (which would increase input availability) or competes for labour (which would reduce input availability).[4]

The farmer's expected utility is assumed to depend on the first two moments of consumption, according to –

[4] In reality there are, of course, a number of additional factors that affect the mean and variance of profit, such as input and output price variability. We abstract from this in order to keep the model as simple as possible.

$$V = V(\mu_c, \sigma_c^2) \tag{1}$$

where μ_c is mean consumption and σ_c^2 is the variation in consumption, and where $V_\mu > 0$ and $V_\sigma < 0$. Consumption is assumed to be derived from profits in crop production and income from the PSNP. The relationship between consumption and profit is determined in the following way:

$$\mu_c = \mu_\pi + c(P) \tag{2}$$

$$\sigma_c^2 = k(P)\sigma_\pi^2 \tag{3}$$

Here, μ_π and σ_π^2 are the mean and variation in profit. *P* is participation in the PSNP, and is here seen as a continuous variable to simplify the analysis. c is consumption-derived from the income received from the work in the programme. k can be seen as a measure of how much of the variation in profit spills over in variation in consumption with $0 \leq k \leq 1$. Furthermore, it is assumed that $k_p < 0$. This means that programme participation is assumed to act as a buffer and reduce the transmission of variation in profit to variation in consumption. The mean and variation in profit is assumed to be determined according to the following:

$$\mu_\pi = f(\tilde{L}; X(P)) \tag{4}$$

$$\sigma_\pi^2 = \Gamma(\tilde{L}; X(P)) \tag{5}$$

where $\tilde{L} = [L_1, \ldots, L_N]$ is a vector of crop composition, and L_i is the share of land devoted to crop i . X is the availability of inputs which is assumed to be exogenously determined and depends on programme participation.

To derive the effects of the programme on the crop portfolio we assume, for the sake of simplicity, that the expected utility function is additively separable in μ_c and σ_c^2. This implies that the farmers' expected utility can be written as follows:

$$V(\tilde{L}; P) = f(\tilde{L}; X(P)) + c(P) - \Gamma(\tilde{L}; X(P))k(P) \tag{6}$$

Again for the sake of simplicity, it is assumed that there are only two types of crops, *1* and *2*. The total amount of land is assumed to be fixed and is set to unity, so that $L_1 + L_2 = 1$. This means that the Lagrange function can be written as:

$$\mathcal{L}(\tilde{L}; P, \lambda) = f(L_1, L_2; X(P)) + c(P) - \Gamma(L_1, L_2; X(P))k(P) + \lambda(1 - L_1 - L_2) \tag{7}$$

The first-order conditions are given by –

$$\begin{aligned} \mathcal{L}_{L_1} &= f_{L_1}(L_1, L_2; X(P)) - \Gamma_{L_1}(L_1, L_2; X(P))k(P) - \lambda = 0 \\ \mathcal{L}_{L_2} &= f_{L_2}(L_1, L_2; X(P)) - \Gamma_{L_2}(L_1, L_2; X(P))k(P) - \lambda = 0 \\ \mathcal{L}_{\lambda} &= 1 - L_1 - L_2 = 0 \end{aligned} \tag{8}$$

From these first-order conditions, it follows that –

$$f_{L_1} - f_{L_2} = (\Gamma_{L_1} - \Gamma_{L_2})k(P) \quad (9)$$

Here, f_{L_j} and Γ_{L_j} are the marginal contribution from land allocated to crop *j* to the mean and variability of profit, respectively. From equation (9) it can be seen that, if crop *1* has a relatively higher return in optimum, i.e. $f_{L_1} - f_{L_2} > 0$, then it also has a relatively high risk, i.e. $\Gamma_{L_1} - \Gamma_{L_2} > 0$. Hence, there is a positive relationship between a crop's marginal contribution to the mean profit and its marginal contribution to the variability in profit.

The effects of programme participation on the share of land allocated to the relatively more profitable and risky crop, L_1, is obtained by total differentiation of (8), and the use of Cramer's rule. This produces –

$$\frac{dL_1}{dP} = \frac{(f_{L_1x} - f_{L_2x})X_P - (\Gamma_{L_1x} - \Gamma_{L_2x})X_P k - (\Gamma_{L_1} - \Gamma_{L_2})k_P}{-f_{L_1L_1} - f_{L_2L_2} + 2f_{L_1L_2} + (\Gamma_{L_1L_1} + \Gamma_{L_2L_2} - 2\Gamma_{L_1L_2})k} \quad (10)$$

The denominator is positive from the second order condition for maximisation. Hence, how a change in programme participation will alter the amount of land allocated to the more profitable and more risky crop will depend on –

- how the programme affects availability of inputs, which in turn affects the marginal profitability and risk of land devoted to each crop, and

- how much the programme reduces the transmission of profit variation to consumption variation.

In other words, if the programme only smoothes variation in consumption, increased programme participation would lead to an increase in the production of high-return, high-risk crops, and would thereby increase the average value and risk of the crop portfolio. However, programme participation can also alter the composition of the crop portfolio by altering the differences in marginal return and risk between crops. In this case, the PSNP's effect on the composition of the crop portfolio and on its average return and risk is ambiguous, and is likely to depend on the relative input intensities of different crops.

The effects of the PSNP on the mean and risk of the total crop portfolio are given by total differentiation of (4) and (5). This gives the following:

$$\frac{\partial \mu_\pi}{\partial P} = \frac{\partial f}{\partial X}\frac{\partial X}{\partial P} + \sum_i \frac{\partial f}{\partial L_i}\frac{\partial L_i}{\partial P} \tag{11}$$

$$\frac{\partial \sigma_\pi}{\partial P} = \frac{\partial \Gamma}{\partial X}\frac{\partial X}{\partial P} + \sum_i \frac{\partial \Gamma}{\partial L_i}\frac{\partial L_i}{\partial P} \tag{12}$$

The sign of $\partial f/\partial X \cdot \partial X/\partial P$ depends on whether the programme increases or decreases the availability of inputs, and the sign of $\partial \Gamma/\partial X \cdot \partial X/\partial P$ depends on whether the resulting changes in inputs are risk-increasing or risk-decreasing. The signs of $\sum_i \partial f/\partial L_i \cdot \partial L_i/\partial P$ and $\sum_i \partial \Gamma/\partial L_i \cdot \partial \mathrm{L_i}/\partial P$

depend on how the programme alters the composition of the crop portfolio.

As can be seen from the brief theoretical exercise above, the overall effects of the PSNP on the composition of the crop portfolio and the average return and risk in crop production can go in either direction, and cannot be determined on theoretical grounds alone. Hence, empirical analysis is needed to determine the direction.

4 Empirical analysis

We use two empirical models to examine how farmers' crop portfolios have changed due to the PSNP. In the first model, we investigate whether the programme has altered the value and risk of the crop portfolio. In the second model, we investigate whether the programme has brought about changes in the land devoted to each crop. The two models are presented in detail below.

Before starting the empirical analysis, the inherent problem of evaluation studies should briefly be addressed. The problem arises from the fact that we can never know what the outcome would have been if the farmers had not participated in the programme. One way to approach this lack of information is to look at what has happened to farmers who did not participate in the programme. When one compares the two groups, it is important to control for variables that determine selection into the programme and that can, at the same time, affect the outcome; if one does not control for these variables, there is a risk that the difference in outcome between the groups is not due to programme participation but to differences in the characteristics of the households in the two groups. The rich data set that we have at hand (described in section 5) allows us to control for a wide range of variables such as household characteristics, plot characteristics, and input usage. In addition, the programme implementation manual is a good guide on what makes a household eligible for participation in the programme (see section 2). There is, however, still a risk that unobserved variables affect both programme participation and the outcome variables. To control for such unobserved effects, we make use of the panel data at hand. The panel data methods used to solve the problem differ somewhat between the two models, and are therefore presented as part of the description of each model.

It can be argued that there is a risk of simultaneity between composition, value and risk of the crop portfolio on the one hand, and PSNP participation on the other. For example, the farmer who has taken considerable risk in his crop portfolio and has suffered large losses in output might be more eligible for the programme than one who has not; or that households who have only undertaken low-risk, low-yield low return activities suffer from food shortages, and it is this that makes them eligible. However, this risk of simultaneity is unlikely because most of the participants were selected to the programme before the effects on the composition, value and risk of the crop portfolio were observed.

2.1 Model 1 – Mean and variance of crop yield in the total crop portfolio

In order to examine how the PSNP affects the value and risk of the crop portfolio, we follow the method suggested by Kumbhakar (1993) and specify a production function given by the following:

$$y_{ht} = f(x_{ht}; \alpha) exp^{g(x_{ht};\beta)^{1/2} e_{ht}} \tag{13}$$

where y is the total value of output per hectare produced by household *h* at time t; x is a vector of independent variables including a dummy variable indicating programme participation; α and β are parameter vectors; and e_{ht} is a random variable with mean *0* and variance *1*. This is an adaptation of a model originally attributed to Just and Pope (1978). These types of models have frequently been used in agricultural economics to study production risks[5] and they specifically encompass the possibility that an input can be both risk-increasing and risk-decreasing.

Equation (13) can be rewritten to yield the following:

$$ln\, y_{ht} = ln\, f(x_{ht}; \alpha) + g(x_{ht}; \beta)^{1/2} e_{ht} \tag{14}$$

[5] For later applications and extensions, see e.g. Wan et al. (1992), Kumbhakar (1993), Hurd (1994), Traxler et al. (1995), Battese et al. (1997), Tveterås (1999, 2000), Kumbhakar and Tsionas (2002), and Di Falco and Chavas (2006).

This implies that $E(\ln y_{ht}) = \ln f(\boldsymbol{x}_{ht};\alpha)$, and $V(\ln y_{ht}) = g(\boldsymbol{x}_{ht};\beta)$. Hence, by including PSNP participation as an explanatory variable, the effects of the PSNP on both the mean value and the variation in this value of can be estimated. Based on a number of tests, as described later, the final model considered in this paper is specified as follows (subscripts h and t are dropped for notational convenience):

$$\begin{aligned} \ln y = {} & \alpha_0 + \sum_k \alpha_k \ln x_k \\ & + \sum_k \sum_l \alpha_k \ln x_k \alpha_l \ln x_l + \sum_m \alpha_m z_m \\ & + \exp\left(\beta_0 + \sum_k \beta_k \ln x_k + \sum_m \beta_m z_m\right)^{1/2} e \end{aligned} \tag{15}$$

where x indicates inputs to production; z indicates other explanatory variables, including participation in PSNP; and k , l and m are indexes denoting the different inputs and other explanatory variables.

The model is estimated in two steps. In the first, the mean value function is estimated by regressing the logarithm of total value of output on the set of explanatory variables (ignoring the variance function). In the second step, the variance function is estimated by taking the logarithm of the squared residuals from the first step and regressing them on the same set of variables. The fact that that the error term is a function of the input variables implies that the regression is subject to heteroscedasticity. To deal with this problem, the mean function is estimated by weighted least squares, where $exp(\boldsymbol{x}_{ht}\hat{\beta})$ are used as weights and the variance function is estimated with robust standard errors.

To deal with the problem of selection into the PSNP on variables that are unobserved but are time-invariant, the production function can be estimated with a fixed effect approach (Tveterås, 1999). However, this method has the disadvantage that, when the data consist of only two time periods, then $e_{ht} = -e_{ht-1}$. This means that the variation in the dependent variable in the variance function, which is the natural logarithm of the squared residuals, is limited when one uses the fixed effect approach. Therefore, we chose to test only if the results in the mean value function were different when fixed effect was used, in comparison with using pooled Ordinary Least Squares (OLS). The explanatory variables used are described in section 5. These include variable inputs used in production, plot characteristics, and household characteristics. They are similar to the explanatory variables used by Kassie et al. (2008) when yield equations in rural Ethiopia were estimated.

2.2 Model 2: Acreage response of different crops

When one estimates the effects of PSNP on the land allocated to different crops, a number of issues need to be considered before choosing the econometric model. The first issue is that many farmers do not grow all the possible crops, which means that the dependent variable is zero for a large fraction of the population and continuous for the remaining fraction.

The second econometric issue, as discussed before, is that there is a risk that farmers are selected into the PSNP based on variables that are that are not observed (implying that there are unobserved variables that are correlated with the independent variables). If farmers that participate in the programme differ from those who do not in some aspect that we cannot observe, the estimated impact of participation may be biased.

The third econometric issue that arises is that there may be dynamic effects in the choice of crops. Dynamic effects can occur if, for example, a rotational crop system is used, which would imply that the probability of growing a specific crop during one year decreases if the same crop was grown during the previous season. Dynamic effects can also occur if there is some learning involved in the process which would imply a positive correlation between crop choices over the years.

To deal with the first issue, namely the truncated dependent variable, a number of different approaches have been suggested. These include the Type I Tobit Model (Tobin, 1956; Amemiya 1985), the Type II Tobit Model (Amemiya, 1985), and the Two-part Model (Cragg, 1971). The Type I Tobit Model has the disadvantage that the same mechanism that determines whether or not farmers grow a specific crop is also assumed to determine how much land they allocate to that crop. Both the Type II Tobit Model and the Two-part Model account for the fact that these decisions can actually be two separate mechanisms. The Type II Tobit Model, unlike the Two-part Model, accounts for the fact that there can be a problem of sample selection in the crop choice, i.e. some unobserved variables that affect the decision to grow a specific crop and that are correlated with determinants of how much land to allocate to that crop. However, the Type II Tobit Model has the disadvantage that it is often difficult to identify the parameters in the model. Therefore, we chose to use the Two-part Model and test for the existence of sample selection in crop choice (which would make the Type II Tobit Model preferable).

The Two-part Model is specified as a lognormal hurdle model (Cragg, 1971). This means that the decision whether or not to grow a specific crop is assumed to be governed by a Probit Model and the land allocated to a specific crop (conditional on the crop being grown by the farmer, and on a set of explanatory variables) are assumed to follow a lognormal distribution. The model can then be written as –

$$A_{cht} = s_{cht} * w_{cht} \tag{16}$$

where A_{cht} is the land allocated to crop c by household h at time t; s is a binary variable that is *1* if the crop was planted, and *0* if not; and w is a log normally distributed variable measuring the land allocated to that specific crop. As we assume that there may be unobserved variables (discussed as the second econometrical issue above) and that the probability of growing a specific crop may depend on whether or not it was grown during the previous season (discussed as the third econometrical issue above), the final model is specified as –

$$A_{cht} = 1[x_{cht}\gamma + \rho s_{cht-1} + u_{ch} + e_{cht} > 0] * exp\,(x_{cht}\beta + v_{ch} + \xi_{cht}) \quad (17)$$

where x is a set of explanatory variables; γ, ρ and β are parameters to be estimated; u_{ch} and v_{ch} are household-specific, time-invariant, unobserved effects; and e_{cht} and ξ_{cht} are error terms that are assumed to be independent of each other. e_{cht} is assumed to follow standard normal distribution, and ξ_{cht} is assumed to be normally distributed with mean *0* and variance σ^2.

To deal with the dynamic structure and unobserved effects that are potentially correlated with the independent variable in the first – or probit – part of the model, we use a method suggested by Wooldridge (2002). We assume that the unobserved effect is a function of the mean value of the independent variables and the initial value according to –

$$u_{ch} = \psi + \bar{x}_{ch}\xi + \zeta s_{ch0} + a_{ch} \quad (18)$$

where $\bar{x}_h$ is the average of x_{ht} over t; s_{ch0} is the observation of s_{ch} at time zero; and a_{ch} is assumed to be normally distributed with mean *0* and standard deviation σ_a^2. This implies that $u_{ch} \sim Normal(\psi + \bar{x}_h\xi + \zeta s_{ch0} + a_{ch}, \sigma_a^2)$ and the final Probit Model can then be written as follows:

$$s_{cht} = 1[\psi + x_{ht}\gamma + \rho s_{cht-1} + \bar{x}_h\xi + \zeta s_{ch0} + a_{ch} + e_{cht} > 0] \quad (19)$$

The model can now be estimated with the standard random effects probit estimation. The intuition behind this method is that the effect of a variable is estimated while holding the time average of the variable fixed. In the case of the PSNP variable used here, the time-averaged variable controls for the fact that it is a specific group of farmers who are participating in the programme, while the time-varying variable measures the effect of these farmers going from not participating in the programme to participating in it.

Average partial effects are obtained by first calculating –

$$N^{-1}\sum_{h=1}^{N}\Phi\left(\left(\hat{\psi}+x^{0}{}_{ht}\hat{\gamma}+\hat{\rho}s_{cht-1}+\bar{x}_{h}\hat{\xi}+\hat{\zeta}s_{ch0}\right)*\left(1+\hat{\sigma}_{a}^{2}\right)^{-1/2}\right) \quad (20)$$

for two different values of x^0, and then calculating the difference.

In the second part of the model, time-invariant unobserved effects are removed by the standard fixed-effects approach. Since the same variables are used for all the individual crops, efficiency could not be gained by estimating the equations simultaneously (see e.g. Greene, 2008:257). To test for unobserved variables that affect the decision to grow a specific crop, and that are correlated with determinants of how much land to allocate to that crop, we used a test suggested by Wooldridge (1995). This test can be seen as an extension to Heckman's (1976) test applied to a panel data context. The test is conducted by first estimating the inverse Mills lambda from the probability of growing a crop in each time period; the inverse Mills lambda is then used as an independent variable, after which the model is estimated with a fixed-effect estimation on the positive sample.

Both parts of the model, i.e. the probability of growing a specific crop and the land allocated to that crop, are assumed to depend on both household and farm characteristics. This is in line with Benin et al. (2004), who studied the economic determinants of crop diversity in the Ethiopian highlands. Crop choice is also likely to depend on the inputs available to the household. For example, if a household is abundant in family labour, it is more likely to plant a labour-intensive crop – especially if the labour market is not functioning perfectly. We chose to control for inputs employed in production at the household level, as we assume that inputs used in crop production are fixed in the short term at the household level, but flexible between plots.

Note that input prices are not included in the model, which is typically the case in supply functions. This is a limitation in our study and is due to lack of data. However, each farmer lives in one of three districts and prices do not normally differ much between farmers in the same district; hence, the regional dummies can be assumed to capture variation due to different prices.

5 Data

The data used in this paper were collected through four rounds of household surveys. These were conducted in 1999, 2002, 2005 and 2007 in 14 sites in East Gojam and South Wollo zones of the Amhara Region of Ethiopia. The surveys were performed in collaboration with the Departments of Economics at Addis Ababa University, the University of Gothenburg, and the World Bank. From these surveys we use data that contain information about crop production, input usage, plot characteristics, household characteristics, and regional dummies.

The larger household surveys were supplemented by a PSNP survey in 2008. In this latter survey, the farmers covered in the previous surveys were asked about their participation in the PSNP between 2005 – the year the PSNP was launched – and 2007. The PSNP survey only covered the sites in the South Wollo zone, as these were the only ones from the previous surveys that were covered by the PSNP. As the zones differ by agricultural conditions, we only make use of the South Wollo sample in our analysis.

In all models described above, we use the data from the PSNP survey and the 2005 and 2007 household surveys. In the acreage response models we also use data from the 1999 and 2002 surveys as lagged dependent variables.

Before the data were used in the analysis, some of the observations were removed from the sample. Plots that lacked information about the variables of interest and households that reported extreme outliers for one or more of the output or input variables used were not included in the analysis. The outliers were detected for each variable separately by using the test suggested by Hadi (1992, 1994). The original sample comprised 1,202 observations; after the outliers had been removed, the remaining sample consisted of 1,088 observations. The data set does not contain specific information about output prices; however, it does contain information about revenue from crop sales and quantities sold. By using this information, the price for each crop was calculated at the sample mean, after extreme outliers had been removed. Some of the crops were grown for own consumption only, and were not sold by any farmers in the sample; hence, price information for these crops is lacking. This problem concerns less than 0.5% of the plots in the final sample. Consequently, we only use plots that were planted with a crop that at least one farmer in the sample sold during the period.

Tables 1 and 2 in Appendix A present a description of the crop patterns in 2005 and 2007 for the sample used in the analysis. As can be seen in Table 1, *Cereals* was the crop category grown by most farmers, and to which most of the land was allocated during both years. The land share allocated to cereals was somewhat reduced in 2007. The crop category *Perennials* had the highest production value as well as standard deviation during both years, and showed a large increase in the number of growers from 2005 to 2007. As can be seen in Table 2, teff was the cereal grown by most farmers during both years. Zengada had the highest production value per hectare in 2005, while teff had the highest production value in 2007.

Table 3 in Appendix A describes the dependent variables in the different models. The dependent variable in the mean function in Model 1 is the value of production per household per hectare for the total crop portfolio. This is an aggregated measure of the value of all crops that a household produces. As mentioned above, the prices are calculated as the sample mean price received for the output sold. The prices are measured in nominal terms, but since a time dummy variable is included, inflation will not bias the results. As regards teff, the survey asked about three different varieties: white, black and mixed. As the three varieties generate different prices, the value of teff is the sum of price multiplied by the quantity for each of the three varieties. The dependent variable in the acreage response models is the land devoted to each crop.

Table 4 in Appendix A describes the independent variables used in the analysis. The variables are described for both PSNP participants and non-participants. The programme's launch in 2005 means that, by the time the last larger household survey was conducted in 2007, the households could potentially have participated for three years already: 2005, 2006 and 2007. In this paper, PSNP participation is defined as participation during 2006 and/or 2007. This is in order to make the PSNP variable correspond to the household survey data that were collected in May–June 2007, and that contain questions concerning production and household status during the last year. Although the 2005 survey was conducted during the first year of the PSNP, the programme began after farmers had already made their planting decisions for that season. For this reason, programme participation in 2005 was set to *0* for all households. The rest of the independent variables can be classified into three categories: *Family characteristics*, *Farm characteristics* and *Inputs in production*. All variables are measured at the household level. The family characteristics are straightforward. The dummy variables for farm characteristics (soil quality, slope and fertility) are set to *1* if the farm had any plot with the specified characteristics. The same applies to the dummy variables used for inputs in production, i.e. the dummy variables for manure, improved seeds, irrigation, and fertiliser are set to *1* if the household employed that specific input on the farm. The *Labour* variable is defined as the number of man days of family labour employed per hectare on the farmer's own land. *Traction* is defined as the number of days that some means of ploughing was used per hectare on the plot.[6] The other variables are self-explanatory.

As can be noted, there are many variables that can be important for the outcome. This is something that needs to be considered before specifying the models. The drawback of including too many variables in the empirical analysis is that the variance increases and, hence, there is a risk that a variable that actually affects the outcome becomes insignificant. However, if variables that are important for the outcome are omitted from the model, the estimated parameters will be biased. We therefore

[6] Ox, horse, donkey or human labour.

chose to report the regression results from the full model, including all of the variables, as our main results, while the results from models that include fewer variables are reported in footnotes.

6 Results

The results from estimations of the mean value and variance functions for the entire crop portfolio are presented in Table 5 in Appendix A. The results from the mean value function are based on pooled cross-section Weighted Least Squares (WLS) estimates of Translog mean value functions. This model specification is selected based on two sets of tests. Firstly, tests for functional form indicate that the Translog specification is preferred to the Cobb-Douglas specification, which in turn is preferred to the linear specification. Secondly, tests for unobserved effects indicate no significant fixed or random effects.[7] The results from the variance function are based on a model where the logged squared residuals from the mean value function are used as the dependent variable and the independent variables are the same as in the mean value function – with the exception of squared and cross-product of input variables.[8]

As can be seen in Table 5 in Appendix A, PSNP is insignificant in both the mean value function and in the variance function. This means that

[7] An F test where under H_0, all time invariant fixed effect = 0 gives F(556, 429) = 1.09 Prob > F = 0.1745. The Breusch and Pagan Lagrangian multiplier test for random effects gives chi2(1) = 0.28 Prob > chi2 = 0.5940.
[8] An F test where H_0 is that squared inputs and the cross-product of inputs = 0 gives F (6,983) = 1.24. Prob > F = 0.2827.

PSNP participation does not seem to significantly alter the mean value or risk in the total crop portfolio, which was one of the main questions of this paper.

In order to assess the validity of the model, it is also important to examine how other variables affect the mean value and variance. As can be seen, all variables that are used either have the signs expected from economic theory or are insignificant. In the mean value function, the production inputs *Labour* and *Traction* seem to significantly increase the value of production. In addition, as can be seen from the significant negative sign for squared labour and traction these inputs seem to increase the value of production at a decreasing rate. Furthermore, education seems to increase the value of production. All of these results are in line with what is normally expected from economic theory. The total number of livestock owned by the household, which can be seen as an indicator of wealth, also seems to significantly increase the value of production. From the time dummy variable, we see that the nominal value of production increased between the two years in question. There also seems to be a significant difference in production value between regions. Black soil seems to reduce the mean value of output, while flat land seems to increase it. It is also interesting to note that no significant effect from access to credit can be seen.[9]

[9] Exactly the same parameter estimates are significant when using a stepwise approach, where insignificant variables are removed backwards.

In the variance function, the number of hectares as well as the usage of manure seems to reduce the variation in output, while modern fertiliser seems to increase the variation.[10] These are standard results in the risk literature. In general, few variables are significant in the variance function, and the R^2 for this model is low.

The results from the acreage response models are presented through Table 6 to Table 10 in Appendix A. The test for the existence of sample selection in crop choice (some unobserved variables that affect the decision to grow a specific crop and that are correlated with determinants of how much land to allocate to that crop) indicates no such problem for any of the crops except pulses.[11] Hence, the Two-part Model is considered preferable.

The results from the first parts of the acreage response model, the Probit Models, are presented in Tables 6 and 7, while the average partial effects are presented in Table 8. The results suggest that the PSNP has significantly increased the probability of growing perennials and wheat, while it has decreased the probability of growing zengada.[12] Looking at the average partial effects, it can be seen that the effect of PSNP participation on the probability of growing perennials is the highest. The results from the second part of the acreage response model, i.e. the continuous part

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[10] ibid.
[11] The tests are available from the author upon request.
[12] For the crops for which PSNP is insignificant, Stepwise Probit Models – where insignificant variables are removed backwards – were also tested. The programme effect was still insignificant in all cases except for sorghum, where it was significantly negative.

that is estimated with a standard fixed effect approach, are presented in Table 9 and 10. These estimates reveal that the PSNP seems to have increased the land allocated to perennials, but reduced the land allocated to pulses and teff.

7 Discussion

The aim of this paper was to study the effects of a social safety net on the mean value and risk in agricultural production. This is an important question as it is often believed that a lack of opportunities to manage risk ex post traps farmers in low-risk, low-return activities.

In this paper, two questions have been raised:

- Has the PSNP altered the value and risk in the crop portfolio?
- Has there been a change in the composition of the crop portfolio toward higher-value and higher-risk crops?

The results suggest that the PSNP has brought about some changes in the farmers' choice of farming activities. The largest effect is found on the choice to grow perennials, and on the land allocated to them. Perennials have longer planning horizons, have a higher value, and have higher variability than other crops grown by the farmers in this sample. Hence, this result is in line with the findings in previous studies, namely that increased possibilities to ex-post smooth consumption in times of negative income shocks lead to less income skewing in favour of low-risk, low-return activities. The result is also in line with the results in Andersson et al. (2010), where it was found that the PSNP had increased the plantation of trees. The authors in the latter study conclude that the result can be ascribed to the programme giving farmers the option to forgo income from annual plants, and instead grow crops that take a longer time to mature. Perhaps the same effects are at work in the current study. There also seem to be some other minor changes in the probability of growing, and land allocated to, different crops that are not as easily traced back to any specific risk-return pattern.

No significant result could be found on the mean value and risk in the total crop portfolio. This lack of significant result can be explained by the programme not having any major influence on variables that are important for agricultural production. Another reason might be that there are effects that offset each other. In the theoretical model, a number of effects are seen to be at work. It is suggested that a change in mean value and risk in the crop portfolio could be brought about not only by changes in the composition of crop portfolio, but also through changes in the availability of inputs. In the empirical analysis, we control for input usage; hence, the results are for a given level of input. We cannot control for the timing or quality of input, however. The programme can either improve the timing of inputs (if it reduces liquidity constraints and makes it easier to buy the right inputs at the right time) or worsen the timing of inputs (if the farmers are stuck in public work when they are needed the most for on-farm work). It can also affect the quality of labour input by providing food during the lean season so that farmers are better fed when the sowing season begins.

Notably, the last of the main surveys on which this study was based was conducted after the programme had only been in operation for two years; hence, it may be too early to say much about the programme's longer-term effects. That farmers participating in the PSNP are growing more high-value perennials appears not to have had any impact on the overall value of their crop portfolios thus far; however, when the plants have had time to mature, the impact on the mean value may increase. The results of the PSNP that are already starting to show are interesting from a policy perspective, and point in a direction that is promising for the future.

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Appendix A. Tables

Table 1: Descriptive statistics by crop category

Crop category	**Number of growing households**		**Average share of land**		**Average production value in Birr per hectare**	
Year	2005	2007	2005	2007	2005	2007
Cereal	531	534	0.81	0.72	2,260	2,791
			(0.25)	(0.26)	(1,637)	(1,810)
Perennial	33	266	0.02	0.12	4,131	4,000
			(0.09)	(0.19)	(2,569)	(5,392)
Pulses	234	265	0.16	0.14	1,433	2,864
			(0.23)	(0.19)	(945)	(2,357)
Other (fruits, oilseed, spices)	44	79	0.01	0.02	1,407	3,710
			(0.06)	(0.06)	(1,184)	(2,405)

Note: Standard deviations are within parentheses.

Table 2: Descriptive statistics by cereal type

Cereal type	**Number of growing households**		**Average share of cereal land**		**Average production value in Birr per hectare**	
Year	2005	2007	2005	2007	2005	2007
Barley	95	127	0.06	0.07	1571	1751
			(0.18)	(0.17)	(1217)	(1401)
Maize	131	142	0.06	0.07	1155	1604
			(0.16)	(0.17)	(867)	(1515)
Sorghum	165	178	0.19	0.19	2500	2536
			(0.32)	(0.31)	(1603)	(1550)
Teff	380	404	0.37	0.38	2251	3880
			(0.32)	(0.31)	(1710)	(2666)
Wheat	151	187	0.14	0.14	2111	2409
			(0.27)	(0.24)	(1722)	(1701)
Zengada	149	125	0.15	0.12	3348	3170
			(0.28)	(0.26)	(2556)	(2911)
Other (dagussa, oats, sinnar)	85	88	0.02	0.02	10424	2193
			(0.07)	(0.07)	(40239)	(1433)

Note: Standard deviations are within parentheses.

Table 3: Descriptive statistics of the dependent variables

Variables	**Obs.**	**Mean**	**Std Dev.**	**Min.**	**Max.**
Value (in Birr per hectare) of total crop portfolio	1088	2184	1379	0	7462
Land (in hectares) allocated to: Cereals	1088	0.652	0.656	0	9.918
Perennials	1088	0.045	0.107	0	1.236
Pulses	1088	0.143	0.347	0	8.024
Other categories	1088	0.017	0.063	0	0.733
Barley	1088	0.042	0.120	0	2.000
Maize	1088	0.034	0.120	0	2.000
Sorghum	1088	0.158	0.330	0	4.000
Teff	1088	0.263	0.427	0	6.598
Wheat	1088	0.079	0.165	0	2.199
Zengada	1088	0.062	0.176	0	3.172
Other cereals	1088	0.014	0.093	0	2.500

Table 4: Descriptive statistics of the independent variables

Variable	***Non-participants***			***Participants***		
	Obs.	**Mean**	**Std Dev.**	**Obs.**	**Mean**	**Std Dev.**
Household characteristics						
Credit access	683	0.732	0.443	405	0.714	0.453
Family size	683	6.095	2.305	405	5.825	2.041
Sex of head of household	676	0.880	0.325	397	0.783	0.412
Education of head of household	682	1.233	2.755	405	1.274	2.632
Livestock	683	3.631	2.208	405	2.819	1.793
Remittance	683	0.141	0.348	405	0.151	0.358
Corrugated roof	683	0.625	0.484	405	0.383	0.487
No. of adult males	683	1.849	1.062	405	1.674	0.976
No. of adult females	683	1.647	0.903	405	1.546	0.771
Farm characteristics						
Fertile (soil quality)	683	0.763	0.426	405	0.840	0.368
Infertile (soil quality)	683	0.139	0.346	405	0.121	0.327
Black (soil colour)	683	0.767	0.423	405	0.778	0.416
Red (soil colour)	683	0.611	0.488	405	0.657	0.475
Flat (slope)	683	0.878	0.327	405	0.951	0.217
Steep (slope)	683	0.287	0.453	405	0.259	0.439
Inputs in production						
Labour per hectare	683	220.970	318.285	405	250.748	477.987
Traction per hectare	683	23.841	25.680	405	14.761	17.546
Manure	683	0.842	0.365	405	0.830	0.376
Improved seeds	683	0.057	0.232	405	0.074	0.262
Irrigation	683	0.182	0.386	405	0.099	0.299
Modern fertiliser	683	0.069	0.253	405	0.074	0.262
No. of hectares	683	0.811	0.728	405	0.935	0.899
Region						
Tenta	683	0.174	0.380	405	0.600	0.491

(Table 4 continued)

Variable	Non-participants			Participants		
	Obs.	Mean	Std Dev.	Obs.	Mean	Std Dev.
Theuldere	683	0.531	0.499	405	0.217	0.413
Time						
Time dummy	683	0.495	0.500	405	0.521	0.500
Crops grown in 2002						
Cereals	627	0.992	0.089	353	0.989	0.106
Perennials	627	0.051	0.220	353	0.023	0.149
Pulses	627	0.278	0.448	353	0.595	0.492
Other categories	627	0.094	0.292	353	0.198	0.399
Barley	627	0.150	0.357	353	0.354	0.479
Maize	627	0.279	0.449	353	0.130	0.337
Sorghum	627	0.356	0.479	353	0.210	0.408
Teff	627	0.802	0.399	353	0.819	0.386
Wheat	627	0.172	0.378	353	0.448	0.498
Zengada	627	0.408	0.492	353	0.173	0.379
Other cereals	627	0.091	0.288	353	0.184	0.388
Crops grown in 1999						
Cereals	643	0.970	0.169	380	0.979	0.144
Perennials	643	0.005	0.068	380	0.000	0.000
Pulses	643	0.300	0.459	380	0.521	0.500
Other categories	643	0.026	0.161	380	0.032	0.175
Barley	643	0.022	0.146	380	0.079	0.270
Maize	643	0.079	0.270	380	0.042	0.201
Sorghum	643	0.123	0.329	380	0.053	0.224
Teff	643	0.481	0.500	380	0.332	0.471
Wheat	643	0.059	0.236	380	0.168	0.375
Zengada	643	0.033	0.178	380	0.016	0.125
Other cereals	643	0.017	0.130	380	0.047	0.213

Table 5: Pooled WLS estimates of mean value function and pooled OLS estimates of the variance function

Explanatory variables	Mean value function	Variance function
PSNP	0.013	-0.023
	(0.056)	(0.219)
Family size (ln)	0.025	0.034
	(0.067)	(0.264)
Sex of head of household	-0.020	-0.357*
	(0.063)	(0.211)
Credit access	0.038	0.159
	(0.046)	(0.179)
Education of head of household	0.017**	-0.002
	(0.008)	(0.029)
Livestock (TLU)[13] (ln)	0.110***	-0.098
	(0.034)	(0.136)
Remittance	0.019	-0.031
	(0.052)	(0.228)
Corrugated roof	0.039	0.203
	(0.040)	(0.157)
No. of male adults	-0.024	-0.035
	(0.020)	(0.085)
No. of female adults	0.008	-0.033
	(0.024)	(0.103)
Fertile	0.042	-0.095
	(0.050)	(0.191)
Infertile	-0.043	0.240
	(0.060)	(0.203)

[13] Tropical livestock unit.

(Table 5 continued)

Explanatory variables	**Mean value function**	**Variance function**
Black	-0.094**	-0.040
	(0.045)	(0.188)
Red	-0.016	0.001
	(0.041)	(0.179)
Flat	0.163**	0.223
	(0.066)	(0.299)
Steep	-0.004	0.015
	(0.047)	(0.199)
Labour (ln)	0.578***	-0.055
	(0.186)	(0.106)
Traction (ln)	0.776***	-0.106
	(0.154)	(0.107)
No. of hectares (ln)	0.280	-0.237*
	(0.200)	(0.140)
Manure	-0.005	-0.517**
	(0.064)	(0.204)
Improved seed	-0.115	0.073
	(0.077)	(0.284)
Irrigation	-0.059	0.104
	(0.053)	(0.192)
Modern fertiliser	0.072	0.535**
	(0.090)	(0.251)
Theuldere	-0.290***	0.465**
	(0.054)	(0.204)
Tenta	-0.066	0.182
	(0.063)	(0.268)
Labour squared (ln)	-0.053***	
	(0.018)	

(Table 5 continued)

Explanatory variables	Mean value function	Variance function
Traction squared (ln)	-0.093***	
	(0.023)	
No. of hectares (ln) squared	-0.210***	
	(0.032)	
Labour (ln)*Traction (ln)	-0.019	
	(0.028)	
Labour (ln)*Land (ln)	-0.120***	
	(0.038)	
Traction (ln)*Land (ln)	-0.048	
	(0.044)	
Time dummy	0.276***	-0.197
	(0.053)	(0.206)
Constant	4.568***	-1.676***
	(0.500)	(0.635)
Observations[14]	1016	1016
R-squared	0.379	0.034

Note: The dependent variable in the mean value function is the log value of total production (in Birr per hectare). The dependent variable in the variance function is the log squared residuals from the predicted mean value function. Standard errors are reported in parentheses. In the variance function, robust standard errors are reported. ***, ** and * indicate significance at the 1, 5 and 10% level, respectively.

[14] The number of observations is less than the total sample as the value of production is 0 for some farmers – making the natural logarithm impossible.

Table 6: Random effects probit estimates by crop category

Explanatory variables	Perennials	Pulses	Other categories
PSNP	0.895**	-0.122	-0.056
	(0.350)	(0.211)	(0.255)
Basic controls	yes	yes	yes
Control for household characteristics	yes	yes	yes
Control for farm characteristics	yes	yes	yes
Control for inputs in production	yes	yes	yes
Control for previous production of crop category	no	yes	yes
Control for average value of independent variables	yes	yes	yes
Number of observations[15]	1073	970	970
Number of households	576	538	538
Percentage correctly predicted[16]	0.800	0.744	0.806
Log-likelihood value	-410.386	-442.535	-281.804
Pseudo *R*-squared[17]	0.359	0.369	0.262

Note: The dependent variable is dichotomous: it is 1 if the specific crop category was grown, and 0 otherwise. All regressions include a constant. Basic controls include time and regional dummies. *Control for household characteristics*, *Control for farm characteristics* and *Control for inputs in production* refer to the variables described in Table 4. *Control for previous production of crop category* is the lagged dependent variable (for the observation in 2007, the *lagged value* refers to an observation in 2005; and for the observation in 2005, the *lagged value* refers to an observation in 2002) and the dependent variable in 1999. *Control for average value of independent variables* is the average value for independent variables that have a correlation with the independent variable that is less than 0.8. The probability of growing cereal was not estimated, as almost all farmers grew some cereal.

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[15] The number of observations differs for perennials and the rest of the crop categories as too few households grew perennials in the first period; hence, the model could not be estimated when these variables were included. This means that a larger sample could be used in these estimations.

[16]An observation is calculated as correctly predicted if the dependent variable is 1 and the probability of a positive outcome > 0.5 or if the dependent variable is 0 and the probability of a positive outcome ≤ 0.5. The probability of a positive outcome is calculated assuming that the random effect for that observation's panel is 0.

[17] Calculated as (1-log-likelihood function for the full model/log-likelihood function for the model including only an intercept)

Table 7: Random effects probit estimates by cereal type

Explanatory variables	**Barley**	**Maize**	**Sorghum**	**Teff**	**Wheat**	**Zengada**	**Other cereals**
PSNP	0.257	0.095	-0.326	0.199	0.525*	-0.548*	-0.307
	(0.242)	(0.263)	(0.285)	(0.199)	(0.268)	(0.309)	(0.254)
Basic controls	yes	yes	yes	yes	yes	yes	yes
Control for household characteristics	yes	yes	yes	yes	yes	yes	yes
Control for farm characteristics	yes	yes	yes	yes	yes	yes	yes
Control for inputs in production	yes	yes	yes	yes	yes	yes	yes
Control for previous production of cereal type	yes	yes	yes	yes	yes	yes	yes
Control for average value of independent variables	yes	yes	yes	yes	yes	yes	yes
Number of observations	970	970	970	970	970	970	970
Number of households	538	538	538	538	538	538	538
Percentage correctly predicted[18]	0.780	0.730	0.823	0.777	0.781	0.818	0.791
Log-likelihood value	-305	-389	-272	-475	-364	-259	-289
Pseudo R-squared[19]	0.405	0.316	0.519	0.249	0.403	0.503	0.243

Note: The dependent variable is dichotomous: it is 1 if the specific crop category was grown, and 0 otherwise. All regressions include a constant. Basic controls include time and regional dummies. *Control for household characteristics*, *Control for farm characteristics* and *Control for inputs in production* refer to the variables described in Table 4. C*ontrol for previous production of cereal type* includes the lagged dependent variable (for the observation in 2007, the *lagged value* refers to an observation in 2005; and for the observation in 2005, the *lagged value* refers to the observation in 2002) and the dependent variable in 1999. *Control for average value of independent variables* is the average value for independent variables that have a correlation with the independent variable that is less than 0.8.

[18] See footnote 17
[19] See footnote 18

Table 8a: Average partial effect of PSNP on the probability of growing crop category

Crop category	Average partial effect of PSNP
Perennials	0.179
Pulses	-0.031
Other crop categories	-0.009

Table 8b: Average partial effect of PSNP on the probability of growing cereal type

Cereal type	Average partial effect of PSNP
Barley	0.047
Maize	0.020
Sorghum	-0.050
Teff	0.053
Wheat	0.093
Zengada	-0.079
Other cereals types	-0.046

Table 9: Fixed effect estimates by crop category

Explanatory variables	Cereals	Perennials	Pulses
PSNP	-0.028	2.926***	-0.315*
	(0.065)	(0.865)	(0.172)
Basic controls	yes	yes	yes
Control for household characteristics	yes	yes	yes
Control for farm characteristics	yes	yes	yes
Control for inputs in production	yes	yes	yes
Observations	1050	296	494
Number of hhid	573	271	335
R-squared	0.911	0.962	0.544

Note: The dependent variable is the log of the area (measured in hectares) planted with the specific crop category. Only samples with positive values on the dependent variables are used. All regressions include a constant. Basic controls include time and regional dummies. *Control for household characteristics*, *Control for farm characteristics* and *Control for inputs in production* refer to the variables described in Table 4. There were too few observations to estimate the area allocated to other crop categories.

Table 10: Fixed effect estimates by cereal type

Explanatory variables	Barley	Maize	Sorghum	Teff	Wheat	Zen-gada
PSNP	-0.268	0.384	0.142	-0.166*	-0.045	0.275
	(0.211)	(0.311)	(0.188)	(0.098)	(0.175)	(0.193)
Control for household characteristics	yes	yes	yes	yes	yes	- yes
Control for farm characteristics	yes	yes	yes	yes	yes	yes
Control for inputs in production	yes	yes	yes	yes	yes	yes
Observations	219	267	338	774	335	270
Number of hhid	165	195	215	494	231	182
R-squared	0.525	0.596	0.601	0.595	0.632	0.641

Note: The dependent variable is the log of the area (measured in hectares) planted with the specific cereal type. Only samples with positive values for the dependent variables are used. All regressions include a constant. Basic controls include time and regional dummies. *Control for household characteristics*, *Control for farm characteristics* and *Control for inputs in production* refer to the variables described in Table 4. There were too few observations to estimate the area allocated to other cereal types.