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Public Transfers and Subsistence Producer Disincentives in Botswana

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TABLE OF CONTENTS

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Abstract

This paper investigates the disincentive effects of public transfers on subsistence producers in Botswana. Comparative statics analyses indicate that public transfers would not affect farm production when profit and utility maximization decisions are recursive, with the profit maximization decision made first. However, when such decisions are interdependent, public transfers would lead to a reduction in farm output. Empirical results reveal that social pensions have impacted positively on cultivated area, but have had no impact on cereal yields and output. However, government food rations have impacted adversely on cultivated area, yields and output; they are a disincentive to crop production because they are relatively more sizable, consistent and certain. This, it is argued, is because food packages are directly substitutable for subsistence crop production. Therefore, public policy in Botswana should consider moving away from food to cash transfers to minimize such disincentive effects.

JEL classification: H55, I38, Q12, Q18

Keywords: Botswana; Public transfers; Safety nets; Subsistence agriculture; Welfare dependency, Work disincentives.

1. Introduction

It is becoming increasingly accepted that social safety nets should be considered an important part of broader socio-economic policy (Grosh, et al., 2008). Safety nets are beneficial in a number of ways, including the following. First, they reduce poverty and inequality directly. Second, they allow households to (re)build their productive assets and to invest in the future through, *inter alia*, human capital development. Third, they enhance the capacity of households to manage risk by minimizing the need to sell productive assets, reduce child feeding or withdraw children from school in the aftermath of a shock. Last, they may allow governments to implement beneficial economic reforms while managing adverse socio-economic impacts of such reforms.

Despite their positive contribution to wider socio-economic development, social safety nets, henceforth public transfers, have been criticized for their potential to induce work disincentives or welfare dependency at a household level (Grosh, et al., 2008). Theoretically, public transfers may create work disincentives by inducing households to consume more leisure, and, hence, reduce time devoted to economic activities. However, empirical evidence on work disincentive effects of these programs is scanty and mixed.

Studies on conditional cash transfer (CCT) programs in Latin America have found marginal or no work disincentive effects (Parker and Skoufias, 2000; Maluccio and Flores, 2004; Skoufias and Maro, 2006; Freije et al., 2006; Foguel and de Barros, 2010). Moreover, studies on Food Aid in Ethiopia have strongly refuted the existence of work disincentives (Gilligan et al., 2010; Little, 2008; Lentz and Barrett, 2005; Abdulai, Barrett and Hoddinott, 2005). However, it has also been revealed that food subsidies have created work disincentives in Sri Lanka, thus reducing labor supply (Sahn and Alderman, 1996).

This paper investigates the impact of public transfers (cash and food) on subsistence crop production in Botswana. The country has an extensive set of cash and food transfer programs, intended to primarily protect poor and vulnerable groups. Monthly food rations/packages are provided through the Destitute Persons Program, the Orphan Care Program, the Vulnerable Group Feeding Program and the Community Home Based Care Program (Seleka, et al., 2007). Cash transfers are also made on a monthly basis through the Old Age Pension scheme and the World War II Veterans Program. The Destitute Persons Program also has a meager cash component intended to allow beneficiaries to purchase personal items such as toiletry.

With the exception of the Destitute Persons and the Community Home Based Care Programs, public transfer programs in Botswana are not means tested, as eligibility is based on other criteria than income thresholds. The lack of poverty focus implies that the programs have also reached households who participate in the labor market or are self employed in agriculture, possibly creating work disincentives. Thus, while public transfer programs in Botswana have improved household welfare (Seleka et al., 2007), the question of whether they have also created work disincentives in agriculture is of paramount importance.

Whether or not work disincentives exist in Botswana's agriculture is therefore an important empirical question warranting further investigation, particularly in the subsistence economy where poverty is more widespread. Unlike food aid in Ethiopia, which is irregular and uncertain (Little, 2008), cash and food transfers in Botswana are regular, consistent and certain, implying that they may have caused households to modify their social and economic behavior.

The paper contributes in three ways. First, through comparative statics analysis, it provides an understanding of the theoretical assumptions under which fixed transfers would affect farm labor and output. Second, it provides empirical evidence useful to the design of public transfer programs in Botswana. Last, it adds to the current understanding of the work disincentive effects of public transfers in developing countries.

The rest of the paper is organized as follows. We begin with a brief overview of safety net programs in Botswana, followed by a brief review of existing empirical evidence on work disincentive effects of public transfer programs. We then conduct comparative statics analyses of two theoretical farm household models to investigate the theoretical impacts of changes in exogenous income (fixed public transfers) on endogenous variables, including farm labor and output. The first model assumes a recursive structure, with farm profit maximization being independent of utility maximization and utility maximization conditional on profit maximization. The second model assumes interdependence of profit and utility maximization.

Next, we specify an econometric model for investigating the effects of fixed public transfers on subsistence crop production in Botswana. This is done together with a discussion of data and descriptive statistics. We then present and discuss the empirical results. The paper then concludes and provides public policy implications.

2. Description of programs

Botswana has a number of safety net programs delivering food and cash to disadvantaged and vulnerable groups. Programs delivering monthly food baskets to the beneficiaries include the Destitute Persons Program (DPP), the Orphan Care Program (OCP), the Vulnerable Group Feeding Program (VGFP) and the Community Home Based Care (CHBC) Program (Seleka, et al., 2007; BIDPA, 2010a; RoB, 2010). The DPP was introduced in 1980 to ensure good health and welfare of the genuine destitute persons (MLG, 2002). The program classifies beneficiaries into permanent and temporary destitute persons. Permanent destitute persons are those that cannot be rehabilitated out of the program due to their physical condition, whereas temporary destitute persons are those that are temporarily incapacitated and can exit the program through rehabilitation.

The food basket for the DPP is intended to provide 1750 calories a day, which is sufficient to maintain health. However, on its own, it is not sufficient to allow the beneficiary to engage in sustained manual labor. The cost of the prescribed monthly food basket has varied depending on location, and it ranged from P450 to P700 in 2010 (RoB, 2010).

Eligibility is based on individual, rather than household-wide assessment (MLG, 2002). To be eligible, the individual should own no more than 4 livestock units or earn monthly cash income not exceeding P120 (without dependents) or P150 (with dependents).[1] Each eligible adult (aged 18 years or above) in the household receives a full package. Individuals under 18 years of age are treated as dependents to the destitute person. If a family consists of one destitute person and up to two dependents, it is entitled to a single food basket. A family which has one destitute person and three to four dependents is entitled to two food baskets. For families with over four dependents, an additional food basket is added for every two additional dependents.

While the main benefit of the DPP is the monthly food ration, the program also has a meager cash component, currently providing P90 to each beneficiary per month, to cover basic personal needs such as toiletry. The program may also provide shelter and cover the expenses related to school uniform, school fees, medical care, occasional fares, funeral, levies/taxes, water charges, and tools for rehabilitation projects. The number of registered destitute persons increased steadily from about 27 thousand in 2004-05 to 41 thousand in 2009-10 (RoB, 2010). Nominal program expenditure rose from P123 to P201 million during the same period.

The OCP was introduced in 1999 to provide food baskets, clothing, education, shelter, and protection and care to orphaned children under the age of 18 years. The program is intended to ensure that orphans remain in school, are nutritionally provided for at family level and that they deal with the trauma from the loss of parents. The program defines orphans as children who have lost both parents in the case of married families or one parent in the case of single parent families. Each orphan is entitled to a monthly food basket, which is provided to the foster family (usually an extended family to the orphan).

The number of registered orphans increased steadily from about 44 thousand in 2002 to 53 thousand in 2006. However, by 2010, it had fallen to 46 thousand. The decrease implies that the number of beneficiaries exiting the program has exceeded the number of entrants. The trend is likely a result of the reduction in HIV/AIDS related deaths due to the provision of life-saving antiretroviral therapy. Nominal expenditure in all programs for orphans and vulnerable children rose from P189 million in 2004-05 to P322 million in 2007-08, and was estimated at P258 million in 2008-09 (RoB, 2010).[2]

The VGFP was launched at Botswana's independence in 1966. It provides food rations to children under the age of five, medically selected pregnant and lactating mothers and TB and leprosy patients, through health facilities. The food packages provided to these vulnerable groups are meant to only meet their additional nutritional requirements. The number of children, aged 4 to 36 months, receiving Tsabana (Sorghum/Soya blend) increased from 64 thousand in 2006 to 91 thousand in 2009 (RoB, 2010). During the same period, the number of children aged 37 to 60 months, medically selected pregnant and lactating mothers and TB patients receiving enriched precooked maize meal dropped from 73 to 62 thousand, whereas those receiving vegetable oil declined from 137 to 57 thousand. However, total nominal expenditure for the VGFP increased from P156 million in 2004-05 to P195 million in 2010-11.

When it was launched in 1995, the CHBC Program was meant to provide food and care, at home, to terminally ill AIDS patients. The program was later extended to patients with other chronic illnesses such as diabetes and cardio vascular conditions. Eligibility into the program is based on referral by a medical doctor, although social workers have also played some role in this respect. Following the referral by a doctor, means testing is conducted by social workers based on the criteria for the DPP.

The CHBC Program provides food baskets to individuals who require special diets, based on the recommendation of a dietician. It also provides counseling and transport to facilities that undertake medical check-ups. In 2002-03, the program had about 6 thousand beneficiaries, which had increased to about 14 thousand by 2004-05 (RoB, 2010). Since then, enrolment has dropped because of the provision of antiretroviral therapy, reaching about 3 thousand in 2009-10. Similarly, nominal program expenditure dropped from P85 million in 2004-05 to P52 million in 2008-09, mainly because of declining enrolment.

Cash transfers are made through the Old Age Pension (OAP) scheme and the World War II (WW II) Veterans Program (Seleka et al., 2007; BIDPA, 2010a; RoB, 2010). The OAP Program was launched in 1996 to provide pension to all citizens aged 65 years and older. Currently, each beneficiary receives P250 per month, which is meant to only serve as recognition of the contribution of the elderly in the country's development– it does not fully meet their needs. The number of registered pensioners rose steadily from about 65 thousand in 2004-05 to 91 thousand in 2009-10 (RoB, 2010). By the same token, nominal program expenditure rose from P170 to P337 million during the same period.

Introduced in 1998, the WWII Veterans Program provides cash benefits to all WW II veterans, or either their surviving spouses or children under the age of 21. Each beneficiary currently receives P390 per month, which is higher than what is received under the OAP. Enrolment in the program remained more-or-less stable at around 3 thousand from 2004-05 to 2009-10 (RoB, 2010). However, nominal payouts to beneficiaries increased from P20 to P30 million during the same period.

3. Review of related literature

The literature on work disincentive effects of public transfers in developing economies has been geared at testing the hypothesis that food and cash transfers cause recipient families to increase leisure consumption and thereby reduce time devoted to work. Two strands of literature exist on work disincentive effects of public transfers. The first investigates the impact of cash transfers on labor force participation and labor supply, whereas the second examines work disincentives of food transfers, mainly food aid. Cash transfer studies have mainly focused on CCT programs in Latin America, which are conditional on school and health clinic attendance of children.

Parker and Skoufias (2000) found that a CCT program in Mexico, PROGRESA, had no effect on labor force participation among adults. With respect to labor supply, Parker and Skoufias (2000) concluded that "there is no significant impact of PROGRESA on leisure time of both male and female adults" (p. vi), providing evidence of the absence of work disincentive effects among adults. Skoufias and di Maro (2006) reached similar conclusions in their analysis of the work disincentive effects of PROGRESA. Freije et al. (2006) found that, at the current level of transfers, *oportunidades* (formerly known as PROGRESA), has negligible impacts on labor supply. They concluded that huge subsidies, which are unlikely, would be required to stimulate a change in labor supply among adults.

More recently, Foguel and de Barros (2010) revealed that CCT programs in Brazil had no impact on labor force participation rates of females. Moreover, while the programs positively affected labor force participation rates of males, the estimated coefficients were too small in magnitude to warrant any policy attention. These programs also reduced labor supply among females, but had no impact on labor supply among males. Overall, Foguel and de Barrios concluded that the results "do not show significant effects of the Brazilian CCT programs on either the labor market participation or the labor supply of hours of men and women" (p.291).

Food transfer studies have focused on country-wide impacts of food aid on the recipient countries, and only a few have conducted household level analysis.[3] Recent country-level studies have produced results indicating that disincentive effects do not exist in Ethiopia (Barrett, et al., 1999; Abdulai, et al., 2005; Little, 2008) and Sub-saharan Africa (Abdulai et al., 2005). Some of these studies have revealed that food aid has actually enhanced recipient countries' agricultural production (Lavy, 1990; Abdulai, et al., 2005). This, they concluded, could be that the negative impacts of food aid on agricultural production may have been offset by its favorable effects, such as improved human nutrition, food security and seasonal liquidity of famers, which enhance labor and farm productivity.

Household level analysis testing the work disincentive hypothesis has also produced mixed results. Sahn and Alderman (1996) revealed that rice subsidies in Sri Lanka had no significant effect on labor market participation, but negatively impacted labor supply. Recipients of a rice subsidy worked 2.4 to 3.2 fewer days per month than the non-recipients. The work disincentive effect, which corresponded to one-third of the value of the rice subsidy in rural areas, was found to be strong.

However, household-level studies on food aid in Ethiopia have generally refuted the work disincentive hypothesis. Abdulai et al. (2005) found no empirical evidence to suggest that food aid had caused work disincentives in Ethiopia. More recently, Little (2008) also found no significant difference in social and economic behavior of food aid recipients and non-recipients in South Wollo, Northeastern Ethiopia. Based on this finding, Little concludes that food aid does not cause households to modify their economic and social behavior.

According to Little, such lack of response is due to the fact that food aid deliveries in Ethiopia are usually irregular, inconsistent or uncertain.

In sum, the low disincentive effects of public cash and food transfers in developing countries are *inter alia* due to the fact that: (1) programs have generally been targeted at households without able-bodied adults or participants have been required to work as a condition for receiving the benefits (Grosh, et al., 2008), (2) benefits have been too small, irregular and uncertain to modify household behavior (Grosh, et al., 2008; Little, 2008), and (3) the negative effects have been offset by productivity enhancing effects such as improved human nutrition, food security and seasonal liquidity of farmers (Lavy, 1990; Abdulai, et al., 2005).

4. Theoretical framework

4.1 Separability

Separable (recursive) agricultural household models have been widely discussed in the farm household literature (Barnum and Squire, 1979; Nakajima, 1986; Singh, et al. (eds), 1986a; 1986b). Assumptions of these models are that farm and off-farm labor are perfect substitutes, and that labor markets are efficient and are without transaction costs (Jacoby, 1993). Therefore, the farm household may allocate its labor between own farm and off-farm wage work, or may choose to use both owned and hired labor on its farm at the prevailing market wage rate. These models are recursive in that the household first maximizes farm profits (makes production decisions) and uses the resulting information to maximize utility (to make consumption decisions).

Consider a household with utility function $U=U(L,M,X)$ and a farm production technology $Q=Q(\Gamma;\bar{A})$, where L is leisure, M denotes money income, X represents the agricultural commodity, Q represents farm output, Γ is time (owned and hired) devoted to farming, and $\bar{A}$ represents fixed acres of agricultural land. First-order partial derivatives are: $U_L, U_M, U_X, Q_\Gamma > 0$. Second-order partial derivatives are: $U_{LL}, U_{MM}, U_{XX}, Q_{\Gamma\Gamma} < 0$; $U_{LM}=U_{ML}>0$; $U_{MX}=U_{XM}>0$; and $U_{LX}=U_{XL}>0$. The household makes (spends) cash from (on) selling (buying) the agricultural commodity at a market price p, and received exogenous income V, henceforth fixed public transfers. The household may either hire-in or hire-out labor at a market wage rate w, to earn or pay-out wages.

Therefore, the household's money income constraint may be specified as:

$$M = p[Q(\Gamma;\bar{A}) - X] + w(T - L - \Gamma) + V$$

where T is the household's time endowment. $T-L-\Gamma=0$ implies that the household does not hire-in or hire-out labor and, hence, Γ represents owned labor devoted to farming. $T-L-\Gamma > 0$ means that the household hires-out labor to off-farm work at a market wage rate w and, hence, Γ represents owned labor devoted to own farm. $T-L-\Gamma < 0$ implies that the household hires-in labor and, hence, Γ represents both owned and hired farm labor. $Q > X$ $(Q < X)$ implies that the household is a net seller (net buyer) of the agricultural commodity. Q=X implies an autarkic situation where the household does not trade the agricultural commodity.

The household's objective function and the resulting first order conditions for an interior solution may be expressed as:

$$\underset{L,M,X,\Gamma,\lambda}{Maximize}\ [U(L,M,X) + \lambda(p(Q(\Gamma;\bar{A}) - X) + w(T - L - \Gamma) + V - M)]$$

$$U_L(L,M,X) - wU_M(L,M,X) = 0 \qquad [1]$$

$$U_X(L,M,X) - pU_M(L,M,X) = 0 \qquad [2]$$

$$\lambda[pQ_\Gamma(\Gamma;\bar{A}) - w] = 0 \qquad [3]$$

$$M - [pQ(\Gamma;\bar{A}) - w\Gamma] - w(T - L) - V + pX = 0 \qquad [4]$$

where λ is the Lagrangean multiplier. Equation 3 equates the value of marginal product of labor pQ_Γ to the market wage rate w and is a condition for farm profit maximization. Thus, profit maximization is made independently of utility maximization. Equation 1 equates the marginal rate of substitution of household time for money income U_L/U_M to the market wage rate w. Similarly, equation 2 equates the marginal rate of substitution of the agricultural commodity for money income U_X/U_M to the price of the agricultural commodity p.

Utility maximization is attained by simultaneously solving equations 1, 2 and 4. As seen, equation 4 contains information from profit maximization: $\pi^* = [pQ(\Gamma^*;\bar{A})\text{-}w\Gamma^*]$, where π^* denotes maximum profits (attained from equation 3). Thus, household decisions are recursive, with the farm profit maximization decision made independently (equation 3) and the utility maximization decision (equation 1, 2 and 4) made conditional on profit maximization.

A sufficient condition for constrained utility maximization is given as:

$$|\bar{Z}| = U_M PQ_{\Gamma\Gamma}[2wp\Theta + 2w\Phi + 2p\Psi + w^2\Omega + p^2\mathrm{K} + N] > 0 \qquad [5]$$

where $|\bar{Z}|$ is the determinant of the 5x5 bordered Hessian matrix of second order partial derivatives of the objective function, $\Theta = (U_{LX}U_{MM} - U_{LM}U_{MX}) < 0$, $\Phi = (U_{LM}U_{XX} - U_{MX}U_{LX}) < 0$, $\Psi = (U_{MX}U_{LL} - U_{LX}U_{LM}) < 0$, $\Omega = [(U_{MX})^2 - U_{MM}U_{XX}] < 0$, $K = [(U_{LM})^2 - U_{LL}U_{MM}] < 0$, and $N = [(U_{LX})^2 - U_{XX}U_{LL}] < 0$ (see Annex A).

The impact of fixed public transfers on the household may be examined through comparative statics analysis of the model to derive dL/dV, dM/dV, dX/dV, $d\Gamma/dV$, dQ/dV and dU/dV. First, we totally differentiate equations 1, 2 and 4 (with p, w, T and $\bar{A}$ held constant), use the fact that pQ_Γ-w =0 (equation 3), and simultaneously solve the resulting expressions to obtain:

$$dL/dV = U_M p Q_{\Gamma\Gamma} [\overbrace{p\Theta + w\Omega + \Phi}^{(-)}] \Big/ |\bar{Z}| > 0 \qquad [6]$$

$$dM/dV = U_M p Q_{\Gamma\Gamma} (\overbrace{w\Phi + p\Psi + N}^{(-)}) \Big/ |\bar{Z}| > 0 \qquad [7]$$

$$dX/dV = U_M p Q_{\Gamma\Gamma} (\overbrace{w\Theta + p\mathrm{K} + \Psi}^{(-)}) \Big/ |\bar{Z}| > 0 \qquad [8]$$

$$d\Gamma/dV = [\overbrace{|\bar{Z}|/|\bar{Z}| - 1}^{(0)}] \Big/ (\overbrace{pQ_{\Gamma} - w}^{(0)}) = 0 \qquad [9]$$

Next, we totally differentiate the farm production technology $Q=Q(\Gamma;\bar{A})$ and the utility function $U = U(L,M,X)$ and divide through by dV to obtain:

$$dQ/dV = Q_{\Gamma} (\overbrace{d\Gamma/dV}^{(0)}) = 0 \qquad [10]$$

$$dU/dV = \textstyle\sum_I U_I (\overbrace{dI/dV}^{(+)}) > 0, \; I = L, M, X \qquad [11]$$

The above results indicate that, under separability, the provision of fixed public transfers to agricultural households would lead to an increase in the consumption of leisure (equation 6), money income (equation 7) and the agricultural commodity (equation 8), and thereby an increase in household utility (equation 11). However, farm labor and output remain unchanged (equations 9 and 10). Thus, while the increase in leisure implies a reduction in household time devoted to farming, this is offset by the increase in hired labor, which is a perfect substitute for household labor. The conclusion is therefore that fixed public transfers would not affect total farm labor, output and productivity under separability, but they would yield an increase in household welfare.[4]

4.2 Nonseparability

To allow for comparative statics analysis of fixed public transfers under nonseparablity, we consider the basic agricultural household model similar to the one presented by Nakajima (1986). The model assumes that the household allocates its time only between farm work and leisure, implying that household members do not participate in off-farm wage work. Further, the household does not employ hired labor on its farm, or if it does, hired and owned labor are treated as imperfect substitutes; they enter the farm production technology as separate variables.

Nonseparability is premised on the assumption that the household's owned labor is an imperfect substitute to hired labor. Thus, changes in leisure consumption due to changes in economic fundamentals (such as a change in exogenous income) would cause the household to alter owned time devoted to farm work, leading to a change in farm output.

For a formal treatment, consider a household with utility function $U = U(H,M,X)$ and a farm production technology $Q = Q(H,\bar{A})$, where H is household labor devoted to own-farm work and other variables are as previously defined.[5] First order marginal effects are as follows: $U_M, U_X, Q_H > 0$; $U_H < 0$. Second order marginal effects are: $U_{MM}, U_{XX}, U_{HM}, U_{HX}, Q_{HH} < 0$; and U_{HH}, $U_{MX} > 0$. As before, the farm household derives cash income M from selling the agricultural commodity at a market price p and from fixed public transfers V. Thus, the household's money income constraint may be stated as:

$$M = p[Q(H;\bar{A}) - X] + V$$

The farm household's objective function and the first order conditions for an interior solution may be stated as follows:

$$\underset{H,M,X,\lambda}{Maximize} \; [U(H,M,X) + \lambda(p(Q(H;\bar{A}) - X) + V - M)]$$

$$U_H(H,M,X) + U_M(H,M,X)pQ_H(H;\bar{A}) = 0 \quad [12]$$

$$U_X(H,M,X) - pU_M(H,M,X) = 0 \quad [13]$$

$$M - p[Q(H;\bar{A}) - X] - V = 0 \quad [14]$$

Equation 12 equates the marginal rate of substitution of family time for money income U_H/U_M to the value of marginal product of owned farm labor pQ_H, implying interdependence of utility and profit maximization. Thus, the value of marginal product of labor represents the shadow wage rate under nonseparability. Equation 13 equates the marginal rate of substitution of the agricultural commodity for money income U_X/U_M to the price of the agricultural commodity p.

A sufficient condition for constrained utility maximization is given as:

$$|\bar{D}| = pQ_H(pQ_H\Omega + 2p\beta + 2\delta) + p(2U_{MX}\mathcal{L}_{HH} + p\eta - \mu) + \mho < 0 \quad [15]$$

where $|\bar{D}|$ is the determinant of the 4x4 bordered Hessian matrix of second order partial derivatives of the objective function with respect to the choice variables, $\Omega = ((U_{MX})^2 - U_{MM}U_{XX}) < 0$, $\beta = (U_{MH}U_{MX} - U_{HX}U_{MM}) < 0$, $\delta = (U_{MX}U_{HX} - U_{HM}U_{XX}) < 0$, $\mathcal{L}_{HH} = (U_{HH} + U_M pQ_{HH}) < 0$, $\eta = ((U_{HM})^2 - U_{HH}U_{MM}) < 0$, $\mu = (2U_{HX}U_{HM} + U_M U_{XX}Q_{HH} + p^2 U_M U_{MM} Q_{HH}) > 0$ and $\mho = ((U_{HX})^2 - U_{XX}U_{HH}) < 0$ (see Annex B).

The impact of fixed public transfers V on endogenous model variables is assessed through comparative statics analysis of the model to derive dH/dV, dM/dV, dX/dV, dQ/dV and dU/dV. Totally differentiating equations 12, 13 and 14, with p and $\bar{A}$ fixed, and simultaneously solving the resulting expressions yields:

$$dH/dV = -\,(\overbrace{pQ_H\Omega + p\beta + \delta}^{(-)})\Big/|\bar{D}| < 0 \quad [16]$$

$$dM/dV = (\overbrace{pQ_H\delta + \mho + pU_{MX}\mathcal{L}_{HH} - p\gamma}^{(-)})\Big/|\bar{D}| > 0 \quad [17]$$

$$dX/dV = (\overbrace{pQ_H\beta + U_{MX}\mathcal{L}_{HH} + p\eta - G}^{(-)})/|\bar{D}| > 0 \quad [18]$$

where $\gamma = (U_{MH}U_{XH} + U_M Q_{HH} U_{XX}) > 0$; $G = \mu - \gamma = (U_{HX}U_{HM} + p^2 U_M Q_{HH} U_{MM}) > 0$; $Q_H, U_{MX} > 0$; and $\Omega, \beta, \delta, \mho, \mathcal{L}_{HH}, |\bar{D}| < 0$.

Further totally differentiating the farm production function $Q=Q(H;\bar{A})$ and the utility function $U=U(H,M,X)$ and dividing through by dV yields:

$$dQ/dV = Q_H(\overbrace{dH/dV}^{(-)}) < 0 \quad [19]$$

$$dU/dV = U_H(\overbrace{dH/dV}^{(-)}) + \textstyle\sum_J U_J(\overbrace{dJ/dV}^{(+)}) > 0,\ J = M, X \quad [20]$$

where $U_H<0$ and Q_H, $U_J>0$.

Thus, under nonseparability, the provision of fixed public transfers would lead to a reduction in household time devoted to farm work (or an increase in leisure) (equation 16), and an increase in the consumption of money income (equation 17) and the agricultural commodity (equation 18). The reduction in household time devoted to farm work then leads to a reduction in farm output (equation 19). Household utility increases (equation 20) because H has declined and M and X have increased. Thus, when production and consumption decisions are interdependent, the provision of fixed public transfers to households would lead to a reduction in time devoted to farming and in agricultural output. Overall, however, household welfare increases.

5. Empirical strategy, data and descriptive statistics

As has been shown, from a theoretical perspective, public transfers would affect farm output only when profit and utility maximization decisions are interdependent. To allow for econometric estimation of the impact of public transfers on subsistence crop production, we need to extend the nonseparable model by making additional assumptions. First, household time devoted to farm work is split into two parts, H_1 and H_2; H_1 is time devoted to land cultivation (plowing), H_2 denotes time devoted to other crop production activities, and $H=H_1+H_2$.

Household preferences are now given as:

$$U = U(H_1, H_2, M, X; C) \quad [21]$$

where C represents household characteristics. While theoretical farm household models assume that cultivated land is exogenous, it has been treated as endogenous in some of the empirical models (see for example, Kimhi, 2006). We therefore relax the assumption that cultivated land is exogenous to allow it to now vary with H_1 and rainfall R. Thus, we define the acreage equation as:

$$A = A(H_1; R, F) \quad [22]$$

where F represents state of ownership of farm assets used in land cultivation, such as draught power. The farm production technology now becomes:

$$Q = Q(H_2, Y, A(H_1; R, F); R, T) \quad [23]$$

where Y denotes other variable inputs (for example, fertilizer) and T represents state of adoption of productivity enhancing technologies (not universally adopted by smallholders and assumed fixed at decision making).

The household's money income constraint may now be rewritten as:

$$M = p[Q(H_2, Y, A(H_1; R, F); R, T) - X\} - rY + V$$

where r is the market price of the purchased variable production factor.

The household's utility maximization problem may now be expressed as:

$$\underset{H_1, H_2, M, X, Y, \lambda}{Maximize} \ \{U(H_1, H_2, M, X; C) + \ \lambda(p(Q(H_2, Y, A(H_1; R, F); R_2, T) - X) + V - rY - M)\}$$

Deriving the first order conditions and simultaneously solving that for the endogenous variables yields:

$$\varphi^* = \varphi^*(p, r, V, C, R, F, T), \quad \varphi = H_1, H_2, M, X, Y \quad [24]$$

which represents the household's demand functions for consumption commodities and production inputs. Substituting [24] into [22] results in the reduced form acreage equation:

$$A^* = A^*(p, r, V, C, R, F, T) \quad [25]$$

Further substituting [25] into [23] yields the output supply equation:

$$Q^* = Q^*(p, r, V, C, R, F, T) \quad [26]$$

Equations 25 and 26 form the basis for econometric estimation of the impact of public transfers on the subsistence economy. These equations are easy to estimate since they are expressed in reduced form. Moreover, data needs are not that extensive. We estimate the acreage equation (25), the yield equation and the output equation (26).

Our empirical models are therefore stated as:

$$lnA_i = a_0 + \sum_{r=1}^{R} a_r S_{ri} + u_i \qquad [27]$$

$$ln(Q_i/A_i) = b_0 + \sum_{r=1}^{R} b_r S_{ri} + \varepsilon_i \qquad [28]$$

$$lnQ_i = (a_0 + b_0) + \sum_{r=1}^{R}(a_r + b_r)S_{ri} + (u_i + \varepsilon_i) \qquad [29]$$

where A_i, Q_i and (Q_i/A_i) respectively represent total (or cereal) cultivated area, cereal output and cereal yield for household i; S_r denotes explanatory variable r; a_0, a_r, b_0, and b_r are parameters to be estimated; u_i, ε_i and $(u_i + \varepsilon_i)$ represent error terms for the respective equations; and ln denotes natural logarithm. Specification 27 represents both total and cereal cultivated area equations. Total cultivated area represents the total amount of land planted by the household, covering all crops (sorghum, maize, millet, beans/pulses, groundnuts, melons and sweet-reed). Cereal cultivated area covers land devoted only to sorghum, maize and millet cultivation.

The model was estimated using the ordinary least squares estimation procedure. The estimated coefficients for continuous independent variables (household size, age of HH and cattle herd-size) represent the percentage changes in the dependent variables (acreage, yield or output) due to unit changes in the considered independent variables. For categorical (dummy) variables, the percentage change in the dependent variable due to the change, from a value of 0 to 1, in the respective independent variable was computed as: $100(e^{\tau} - 1)$, where τ represents the estimated coefficient for the considered independent variable. As seen from equation 29, the coefficient for a given variable in the cereal output equation is the sum of the coefficients for the cereal acreage and cereal yield equations for that particular variable. This is because the dependent variables have been transformed into natural logarithms and all explanatory variables are the same across the models.[6]

We used cross-sectional household level data for the 2004 Botswana Agricultural Census. The cleaned dataset contains a total of 7229 households practicing subsistence crop production. Table 1 provides a list of the variables used in model estimation. Given data limitations, we could not include all the explanatory variables stated in equations 25 and 26. This is for two reasons. First, input and output price data are unavailable at household level. Second, even if input and output price data were available, the respective variables may not have had an impact on subsistence crop production because a large majority of producers does not participate in the output market and has not adopted the fertilizer technology.[7] However, the inclusion of fertilizer adoption in the model should currently suffice.

Table 2 provides descriptive statistics for the variables. Average household size in the subsistence economy stands at 4 individuals. Average age of the household head was estimated at 55 years, implying the predominance of the elderly. About 63 percent of the households were male-headed, and 53 percent of the household heads were married. Average years of schooling (of the household head) were estimated at about 3 years, signifying low educational attainments in the subsistence economy. A large majority of subsistence farmers (84 percent) practiced farming as a fulltime activity.

Average cultivated area was estimated at 2.58 ha, implying the predominance of smallholders in the subsistence economy. Mean cereal output was estimated at 541 kilograms and yield at 249 kg/ha, signifying low output levels per farmer and low productivity. Mean cattle herd-size was estimated at about 39 heads, signifying the predominance of smallholder cattle herders. Donkey ownership was predominant with 59 percent of the households reporting ownership of donkeys, but only 6 percent owned tractors. Technology adoption was very low with only 9 percent of the households practicing row planting and only 4 percent using fertilizers.

Table 1: Description of variables used

Variable	Description of Variable
Total cultivated area	Total land planted to all crops (ha)
Cereal cultivated area	Land area planted to cereal crops only (ha)
Cereal output	Total cereal production (kg)
Cereal yield	Yield of cereals (sorghum, maize and millet) (kg/ha)
Household size	Number of household members
Age of HH	Age of household head
Gender	1=male household head; 0=female household head
Married	1=household head is married; 0=otherwise
Fulltime	1=household head is fulltime farmer; 0=household head is part-time farmers
Years schooling	Number of years of schooling of the head of household
Pension	1=household receives pensions; 0=household does not receive pensions
Nonfarm business income	1= household receives nonfarm business income; 0= household does not receive nonfarm income.
Remittances	1=household receives remittances; 0=household does not receive remittances.
Government rations	1=household receives government rations; 0=household does not receive government rations.
Supplies from relatives	1=household receives food from relatives and/or friends; 0 household does not receive food from relatives and/or friends
Cattle herd-size	Total livestock units
Tractor ownership	1=household owns a tractor; 0=household does not own a tractor
Donkey ownership	1=household owns donkeys; 0=household does not own donkeys.
Row planting	1=household used row planting method; 0=otherwise
Fertilizer use	1=household used a fertilizer; 0=otherwise
Rainfall for planting	Total rainfall for the months of October 2003 to February 2004 (mm)
Rainfall for the season	Total rainfall for the months of October 2003 to April 2004 (mm)

Table 2: Descriptive statistics†

Variables	Mean	Minimum	Maximum
Farm characteristics:			
Field size	3.43	0.01	169.55
Total cultivated area	3.03	0.01	88.57
Cereal cultivated area	2.58	0.01	46.43
Cereal output	540.60	2.5	36800
Cereal yield	249.01	1.62	1000
Household characteristics:			
Household size	4.40	1	30
Age of HH	54.90	12	99
Gender	0.63	0	1
Married	0.53	0	1
Fulltime	0.84	0	1
Years schooling	2.71	0	13
Farm assets and technology:			
Cattle herd-size	39.32	0	2074
Tractor ownership	0.06	0	1
Donkey ownership	0.59	0	1
Row planting	0.09	0	1
Fertilizer use	0.04	0	1
Exogenous income:			
Nonfarm business income	0.16	0	1
Pension	0.35	0	1
Remittances	0.36	0	1
Government rations	0.09	0	1
Supplies from relatives	0.02	0	1
Rainfall:			
Rainfall for planting	326.44	115	664.2
Rainfall for the season	444.77	194.1	1093.9

†: Descriptive statistics are based on 7229 observations.

Nonfarm business income was received by 16 percent of the households. About 35 percent of the households received pensions and only 9 percent received government food rations. Private transfers are also important, with 36 percent of households receiving remittances. But only 3 percent received *food from friends and relatives*. Thus, cash transfers, both public and private, are received by larger while food transfers are received by smaller fractions of subsistence households.

The agricultural census dataset used in this study does not contain rainfall data. Therefore, as an attempt to capture the impact of rainfall on cultivated acreage, yields and output, we computed farm-level rainfall estimates based on rainfall estimates at enumeration area level, using data obtained from the department of Meteorological Services in Botswana. Rainfall for the period from October 2003 to February 2004 (the planting season) was initially included in the acreage equations while rainfall for the period from October 2003 to April 2004 (the growing season) was initially included in the cereal yield and output equations. From Table 2, mean rainfall for the planting season was estimated at about 326 mm (millimeters) while that for the growing season was estimated at 445 mm. However, the estimated coefficients on rainfall were statistically insignificant, implying that enumeration area rainfall did not serve as a good proxy for farm-level rainfall, given spatial variability in annual rainfall in the country. Therefore, rainfall variables were excluded from the final models.

6. Empirical results

6.1 Farm and household characteristics

Table 3 reports the empirical results. The adjusted R^2 estimates for all the three equations, which range from 0.10 to 0.30, are small. However, this is normally expected for cross-sectional data. As stated in the previous section, the interpretations of the estimated coefficients differ depending on whether the regressors are continuous or dummy variables.

The results for total and cereal acreage equations are similar. Household size has positive effects on cultivated area and output, but has no effect on cereal yields. An increase in household size by one person would result in an increase of 1.3, 1.1 and 1.1 percent in total acreage, cereal acreage and cereal output, respectively. This may be reflective of the increased effort put into growing staples to feed larger families, and/or the increased availability of household labor, as family size increases, to devote to cropping activities. Cultivated area expands with the age of the head of household; a one year increase in the age of HH would yield a 0.3 percent increase in both total and cereal acreage. However, age of the head of household has no impact on cereal yields and output. Again, gender has no effect on cultivated acreage, cereal yields and cereal output.

Marital status has positive effects on crop area and cereal output, but has no effect on cereal yields. A household headed by a married individual devotes 25.6 (25.1) percent more land to total (cereal) crop cultivation and attains 26.6 percent more cereal output than a household headed by an unmarried individual. These results may reflect increased effort put into cereal production due to the need to provide for family.

Fulltime farming has no differential impact on land cultivation, cereal output and cereal yields. This is inconsistent with *a priori* expectation since one would expect full time

Table 3: Cross-sectional results for cultivated area, yields and output†

	Total cultivated area		Cereal cultivated area		Cereal yields		Cereal output	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
Intercept	0.502	0.067*	0.119	0.673	4.056	0.000***	4.176	0.000***
Household characteristics:								
Household size	0.013	0.000***	0.011	0.000***	-0.0002	0.954	0.011	0.014**
Age of HH	0.003	0.000***	0.003	0.000***	-0.001	0.151	0.001	0.174
Gender	-0.036	0.158	-0.034	0.188	0.042	0.232	0.008	0.841
Married	0.228	0.000***	0.224	0.000***	0.012	0.712	0.236	0.000***
Fulltime	-0.015	0.570	-0.005	0.862	-0.012	0.740	-0.017	0.666
Years schooling	0.008	0.007***	0.006	0.054*	0.012	0.003***	0.018	0.000***
Farm assets and technology:								
Cattle herd-size	0.001	0.000***	0.012	0.000***	0.001	0.018**	0.002	0.000***
Tractor ownership	0.680	0.000***	0.669	0.000***	-0.060	0.284	0.608	0.000***
Donkey ownership	0.143	0.000***	0.150	0.000***	0.035	0.211	0.185	0.000***
Row planting	0.283	0.000***	0.231	0.000***	0.103	0.040**	0.334	0.000***
Fertilizer use	0.268	0.000***	0.245	0.000***	0.236	0.001***	0.481	0.000***
Exogenous income:								
Nonfarm business income	0.050	0.051*	0.046	0.082*	0.068	0.053*	0.114	0.003***
Pension	0.036	0.097*	0.039	0.078*	-0.028	0.349	0.011	0.723
Remittances	0.043	0.029**	0.046	0.023**	0.018	0.509	0.065	0.027**
Government ration	-0.103	0.002***	-0.082	0.016**	-0.205	0.000***	-0.287	0.000***
Supplies from relatives	-0.114	0.064*	-0.111	0.080*	-0.156	0.068*	-0.267	0.003***
Number of observations	7229		7229		7229		7229	
R^2	0.294		0.268		0.107		0.171	
Adjusted R^2	0.290		0.264		0.102		0.166	
F-statistic	74.85	0.000***	65.75	0.000***	21.47	0.000***	37.01	0.000***

***, ** and *: statistically significant at 1, 5 and 10 percent, respectively.
†: Coefficients for 25 district dummies, which capture fixed regional effects, are not reported.

farmers to devote more time to farming than part-time farmers. Years of schooling (of the household head) has positive effects on land cultivation, cereal yields and cereal output; a one year increase in years of schooling results in a 0.8, 0.6, 1.2 and 1.8 percent increase in total acreage, cereal acreage, cereal yields and cereal output, respectively. The positive responses reflect that education enhances crop production and productivity in the subsistence economy.

6.2 Farm assets and technology

Cattle herd-size is positively related with cultivated acreage, cereal yields and cereal output. An increase in cattle herd-size by one animal (head) would yield a 0.1, 1.2, 0.1 and 0.2 percent increase in total acreage, cereal acreage, cereal yields and cereal output, respectively. The positive responses may reflect that cattle sales are used to finance investment in staple food production, particularly in hiring-in draught power for land cultivation. For example, in 2004, 52 percent of the households reported that they used hired draught power (tractors and/or donkeys) to cultivate the land, compared with only 37 percent who used owned draught power (BIDPA, 2010b). The remaining 11 percent used a combination of sources, including owned and borrowed.

Tractor ownership leads to increased land cultivation and cereal output, but has no effect on cereal yields. A family owning a tractor devotes 97.4 (95.2) percent more land to total (cereal) crop cultivation, and attains 83.7 percent more cereal output than a family that does not own a tractor. Since tractors are used to cultivate land, ownership implies increased access to draught power, which further implies increased land cultivation. Similarly, ownership of donkeys leads to increased land cultivation and cereal output, but has no impact on cereal yields. A household owning donkeys cultivates 15.4 (16.2) percent more total (cereal) cropland and attains 20.3 percent more cereal output than that which does not own donkeys, which captures the positive effect of access to draught power on crop production.

Consistent with *a priori* expectation, the adoption of row planting or fertilizer technologies has a positive impact on cereal yields and output. A household that has adopted row planting attains 10.8 (39.7) percent more cereal yields (output) than that which has not. Similarly, a household that has adopted fertilizers attains 26.6 (61.8) percent more cereal yields (output) than that which has not. However, adoption rates are very low (9 percent for row planting and 4 percent for fertilizer), implying that the overall impacts of these technologies on national output may be negligible.

Technology adoption also impacts positively on cultivated area. Households who have adopted row planting devote 32.7 (26.0) percent more land to total (cereal) crop production than those who have not adopted the technology. Similarly, households who use fertilizers devote 30.7 (27.8) percent more land to total (cereal) crop production than those who have not adopted the technology. This might reflect that technology adopters are relatively more commercialized and as such devote more land into crop production to produce marketable surplus. However, the inclusion of technology adoption variables in acreage equations could be questioned on grounds that technology adoption is perhaps endogenous, depending on household and farm characteristics. In this study, however, their exclusion did not alter the magnitudes of coefficients for the remaining variables that much, implying that the qualitative conclusions would have remained virtually the same if the variables were left out.

6.3 Exogenous income

Theoretically, exogenous income (public and private transfers, and property income) should cause households to consume more leisure and hence reduce time devoted to farming. This should further lead to a reduction in cultivated area, yields and output if profit and utility maximization decisions are interdependent. The empirical results show that social pensions have positive impacts on land cultivation, but have no impact on cereal yields and output; a household receiving a pension devotes 3.7 (4.0) percent more land to total (cereal) crop cultivation than that not receiving a pension.

Remittances and nonfarm business income impact positively on cultivated area and output. A family receiving remittances devotes 4.4 (4.7) percent more land on total (cereal) crop production than a non recipient family. A remittance recipient family also attains 6.7 percent more output than a non recipient family. Similarly, a household receiving nonfarm business income devotes 5.1 (4.7) more land on total (cereal) crop production and attains 12.1 percent more output than a non recipient family. However, while remittances have no impact of cereal yields, nonfarm business income positively influences cereal yields, with recipient households attaining 7.0 percent more yields than non recipients.

The positive effects of exogenous cash transfer variables on land cultivation appear to contradict economic theory. The possible explanation could be that cash income may ease credit (overcome liquidity) constraints at household level, further leading to increased investment in output enhancing activities (see, for example, Kilic, et al., 2009; Wouterse, 2010).[8] This is possible in Botswana where many households use hired draught power to cultivate land, implying that pensions and remittances enhance their capacity to procure hired draught power services to cultivate more land than they would in the absence of such transfers. Increased acquisition of hired draught power for land cultivation can occur without necessarily impacting significantly on household time allocation. The results further imply that while pensions and remittances are sufficient to enhance land cultivation, they may be insufficient to promote the adoption of productivity enhancing technologies (which would enhance yields) or to cause households to devote less time to crop production activities (which would have an adverse effect on cereal yields). However, nonfarm business income appears to be sufficient enough to allow households to invest in increasing yields as well.

Consistent with economic theory, food transfers (government and private) impact negatively on land cultivation, cereal yields and output. Thus, households receiving government and private food rations have less incentive to grow food crops due to the increased availability of food at family level; as food deliveries are directly substitutable for subsistence crop production. A household receiving government food rations devotes 9.8 (7.9) percent less acreage on total (cereal) crop cultivation and attains 18.5 (24.9) percent less cereal yields (output) than a household not receiving public food rations. Similarly, a household receiving private food rations devotes 10.8 (10.5) percent less land to total (cereal) crop production and attains 14.4 (23.4) percent less yields (output) than a non recipient household.

Thus, the impacts of food transfers on land cultivation at household level are relatively small, while those on cereal yields and output are substantial. The negative effects on land cultivation reflect less effort and time devoted to land cultivation while those on yields reflect reduced effort and time devoted to productivity enhancing activities such as weeding and bird-scaring. The findings suggest that, as is the case with government food transfers, private food transfers may be regular, consistent and sizeable enough to modify household behavior.

On balance, the analysis produced somewhat mixed results on the disincentive effects of public transfers on subsistence crop production. On the one hand, public cash transfers enhance crop acreage due to increased liquidity at family level while they have had no impact on cereal yields and output. On the other hand, public food transfers have had adverse household-level impacts on acreage and cereal yields. The combined effects are strong with cereal crop production declining by 24.9 percent amongst government food ration recipient families. However, the overall impact at national level may not be substantial since only a small fraction of subsistence households receives government food rations (9 percent).

7. Conclusions and policy implications

This paper conducted comparative statics analyses to investigate the theoretical impacts of fixed public transfers on agricultural households. The paper also empirically investigated the impacts of public transfers on Botswana's subsistence economy. Comparative statics analyses indicate that fixed public transfers would not affect farm production when profit and utility maximization decisions are recursive, with profit maximization made first. In such cases, labor markets are efficient and free of transaction costs and owned and hired labor are perfect substitutes. If these conditions prevail, a decrease in owned farm labor (increase in leisure) resulting from the provision of fixed (exogenous) income would not cause overall farm labor to fall. This is because households would hire-in more labor to just offset the reduction in own labor devoted to farming.

The above is less likely to prevail in developing economies where labor markets are more likely to be inefficient and not free of transaction costs, and where hired and owned farm labor are imperfect substitutes. Therefore, in developing countries, fixed income transfers would likely cause households to increase leisure and reduce owned time devoted to farming, which would further lead to a reduction in farm output. If these conditions hold, profit and utility maximization decisions are said to be interdependent.

Empirical results for Botswana's subsistence economy revealed that social pensions have had a positive impact on acreage but have had no impact on cereal yields and output. A household receiving a pension devotes 3.7 (4.0) percent more land on total (cereal) crop production than a non recipient household. Although the positive effects on acreage appear to contradict economic theory, it is argued (consistent with the empirical literature) that this may be because pensions overcome liquidity constraints at household level, increasing the capacity of families to employ hired draught power to expand land cultivation. The lack of impact on cereal yields appears to suggest that pensions may be too small to serve as a work disincentive or to allow households to invest in productivity enhancing technologies.

Government food rations have impacted adversely on acreage, cereal yields and cereal output. Thus, public food transfers are a disincentive to subsistence crop production. Specifically, a household receiving government food rations devotes 9.8 (7.9) percent less land to total (cereal) crop production and attains 18.5 (24.9) percent less cereal yields (output) than a non recipient household. Thus, household level impacts on cereal yields and output are strong. However, since only a small fraction of households (9 percent) received government food rations, overall impacts at national level may be negligible.

The results have important policy implications. First, transfers need to be kept small to ensure that the disincentive effects at both household and national level are minimized. Second, it is important to ensure that transfers are targeted at those households who are in need of assistance, to minimize their potential adverse effects on subsistence crop production at both household and national levels. Last, since cash transfers positively influence cultivated acreage and food transfers have disincentive effects on food production, public policy in Botswana should consider moving away from food to cash transfers.

Notes

1. A livestock unit is equivalent to one head of cattle or 4 goats (sheep).

2. These include the orphans, needy students, and needy children programs. However, orphans dominate the program. For example, in 2009-10, there were 45,816 orphans, 33,661 needy students and 972 needy children.

3. Another strand of literature, which is also based on country-level analysis, can be traced back to Schultz (1960), Mann (1967) and Isenman and Singer (1977), who tested the hypothesis that food aid deliveries depress recipient country's food prices, further discouraging agricultural production. This strand of research, which continues to be pursued today (Tadesse and Shively, 2009), is not reviewed in this article (see Awokuse (2011) for a recent review).

4. It is worth highlighting that household labor supply would decrease in response to the provision of fixed public transfers because of the increase in leisure. Thus, in theory, public transfers should lead to a decrease in household labor supply even for recursive models, except that total farm labor remains unchanged as households use hired labor to just offset the decrease in owned labor. Therefore, in theory, studies investigating the impact of fixed public transfers on labor supply should obtain inverse relationships, even where separability prevails.

5. This model may be extended to include other variable factors of production, including hired labor, in the farm production technology. However, doing so would only make the comparative statics analysis more complex, without altering the qualitative conclusions. In addition, other interdependent models, with differing or additional assumptions on household behavior, have been proposed (for example, Lopez, 1984, 1986; Jacoby, 1993; Skoufias, 1994).

6. Since the dependent variables in equations 27 and 28 are expressed in their natural logarithms and because all explanatory variables are common to both equations, the latter may be rewritten as $lnQ\text{-}lnA=RHS(28)$, implying that $lnQ=RHS(28)+lnA = RHS(28)+RHS(27)$, where $RHS(28)$ and $RHS(27)$ denote right-hand-sides of equation 28 and 27, respectively.

7. As seen from the descriptive statistics, only 4 percent of families in the cleaned dataset had adopted fertilizer use. In 2004, only 6 percent of the families sold a part of their output (BIDPA, 2010b).

8. However, an inverse relationship between remittances and farm efficiency has also been observed (see Kilic, et al., 2009 for an elaborate discussion), which is consistent with comparative statics analysis under nonseparability.

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Annex: Comparative statics

A. Separability

The lagrangian function and the resulting first order conditions for an interior solution under separability may be expressed as:

$$\mathcal{L}(L,M,X,\Gamma,\lambda) = U(L,M,X) + \lambda[p(Q(\Gamma,\bar{A}) - X) + w(T - L - \Gamma) + V - M]$$

$$\mathcal{L}_L = U_L(L,M,X) - \lambda w = 0 \quad [A1]$$

$$\mathcal{L}_M = U_M(L,M,X) - \lambda = 0 \quad [A2]$$

$$\mathcal{L}_X = U_X(L,M,X) - \lambda P = 0 \quad [A3]$$

$$\mathcal{L}_\Gamma = \lambda[pQ_\Gamma(\Gamma;\bar{A}) - w] = 0 \quad [A4]$$

$$\mathcal{L}_\lambda = [pQ(\Gamma;\bar{A}) - w\Gamma] + w(T - L) + V - pX - M = 0 \quad [A5]$$

where $\mathcal{L}(.)$ is the lagrangian function and other variables are as defined in the paper.

The bordered Hessian matrix of second order conditions is given as:

$$[\bar{Z}] = \begin{bmatrix} \mathcal{L}_{LL} & \mathcal{L}_{LM} & \mathcal{L}_{LX} & \mathcal{L}_{L\Gamma} & \mathcal{L}_{L\lambda} \\ \mathcal{L}_{ML} & \mathcal{L}_{MM} & \mathcal{L}_{MX} & \mathcal{L}_{M\Gamma} & \mathcal{L}_{M\lambda} \\ \mathcal{L}_{XL} & \mathcal{L}_{XM} & \mathcal{L}_{XX} & \mathcal{L}_{X\Gamma} & \mathcal{L}_{X\lambda} \\ \mathcal{L}_{\Gamma L} & \mathcal{L}_{\Gamma M} & \mathcal{L}_{\Gamma X} & \mathcal{L}_{\Gamma\Gamma} & \mathcal{L}_{\Gamma\lambda} \\ \mathcal{L}_{\lambda L} & \mathcal{L}_{\lambda M} & \mathcal{L}_{\lambda X} & \mathcal{L}_{\lambda\Gamma} & \mathcal{L}_{\lambda\lambda} \end{bmatrix} = \begin{bmatrix} U_{LL} & U_{LM} & U_{LX} & 0 & -w \\ U_{ML} & U_{MM} & U_{MX} & 0 & -1 \\ U_{XL} & U_{XM} & U_{XX} & 0 & -p \\ 0 & 0 & 0 & \lambda pQ_{\Gamma\Gamma} & pQ_\Gamma - w \\ -w & -1 & -p & pQ_\Gamma - w & 0 \end{bmatrix}$$

where: $U_{LL}, U_{MM}, U_{XX}, U_{\Gamma\Gamma} < 0$; $U_{ML} = U_{LM} > 0$; $U_{XM} = U_{MX} > 0$; and $U_{XL} = U_{LX} > 0$.

Following Chiang and Wainwright (2005) and using the fact that $pQ_\Gamma - w = 0$ (from A4), the determinant of $[\bar{Z}]$ is given as:

$$|\bar{Z}| = U_M P Q_{\Gamma\Gamma}[2wp\Theta + 2w\Phi + 2p\Psi + w^2\Omega + p^2K + N] > 0 \quad [A6]$$

where $\Theta = (U_{LX}U_{MM} - U_{LM}U_{MX}) < 0$, $\Phi = (U_{LM}U_{XX} - U_{MX}U_{LX}) < 0$, $\Psi = (U_{MX}U_{LL} - U_{LX}U_{LM}) < 0$, $\Omega = [(U_{MX})^2 - U_{MM}U_{XX}] < 0$, $K = [(U_{LM})^2 - U_{LL}U_{MM}] < 0$, $N = [(U_{LX})^2 - U_{XX}U_{LL}] < 0$ and λ has been replaced with U_M as from A2.

Through substitution, A1 to A5 may be reduced to:

$$U_L(L,M,X) - wU_M(L,M,X) = 0 \quad [A7]$$

$$U_X(L,M,X) - pU_M(L,M,X) = 0 \quad [A8]$$

$$[pQ(\Gamma;\bar{A}) - w\Gamma] + w(T - L) + V - pX - M = 0 \quad [A9]$$

Totally differentiating expressions A7 to A9, with p, w, T and $\bar{A}$ held constant, and rearranging terms yields:

$$(U_{LL} - wU_{LM})dL + (U_{LM} - wU_{MM})dM + (U_{LX} - wU_{MX})dX = 0 \quad [A10]$$

$$(U_{XL} - pU_{ML})dL + (U_{XM} - pU_{MM})dM + (U_{XX} - pU_{MX})dX = 0 \quad [A11]$$

$$-wdL - dM - pdX + (pQ_{\Gamma} - w)d\Gamma + dV = 0 \quad [A12]$$

Using the fact that $pQ_{\Gamma}-w=0$ as per A4, substituting dM (from A12) into A10 and A11, and simultaneously solving the resulting two expressions yields:

$$dL/dV = U_M pQ_{\Gamma\Gamma}[\overbrace{p\Theta + w\Omega + \Phi}^{(-)}] \Big/ |\bar{Z}| > 0 \quad [A13]$$

where U_M, $|\bar{Z}|>0$; and $Q_{\Gamma\Gamma}$, Θ, Ω, $\Phi<0$.

Still using the fact that $pQ_{\Gamma}-w=0$, substituting dL (from A12) into A10 and A11, and simultaneously solving the resulting two expressions yields:

$$dM/dV = U_M pQ_{\Gamma\Gamma}(\overbrace{w\Phi + p\Psi + N}^{(-)}) \Big/ |\bar{Z}| > 0 \quad [A14]$$

where Ψ,$N<0$.

Substituting A13 and A14 into A12, using the fact that $pQ_{\Gamma}-w=0$ in A12 and rearranging terms yields:

$$dX/dV = U_M pQ_{\Gamma\Gamma}(\overbrace{w\Theta + pK + \Psi}^{(-)}) \Big/ |\bar{Z}| > 0 \quad [A15]$$

Further substituting A13, A14 and A15 into A12, with the term $pQ_{\Gamma}-w$ now retained, and rearranging terms yields:

$$d\Gamma/dV = [\overbrace{|\bar{Z}|/|\bar{Z}| - 1}^{(0)}] \Big/ (\overbrace{pQ_{\Gamma} - w}^{(0)}) = 0 \quad [A16]$$

Totally differentiating the farm production technology $Q=Q(\Gamma;\bar{A})$ and the utility function $U=U(L,M,X)$ and dividing through by dV yields:

$$dQ/dV = Q_{\Gamma}(\overbrace{d\Gamma/dV}^{(0)}) = 0 \quad [A17]$$

$$dU/dV = \textstyle\sum_I U_I(\overbrace{dI/dV}^{(+)}) > 0, \; I = L, M, X \quad [A18]$$

B. Nonseparability

The lagrangian function $\mathcal{L}(.)$ and the first order conditions for an interior solution under nonseparability may be expressed as:

$$\mathcal{L}(H,M,X,\lambda) = U(H,M,X) + \lambda[p(Q(H;\bar{A}) - X) + V - M] \quad \text{[B1]}$$

$$\mathcal{L}_H = U_H(H,M,X) + \lambda pQ_H(H;\bar{A}) = 0 \quad \text{[B2]}$$

$$\mathcal{L}_M = U_M(H,M,X) - \lambda = 0 \quad \text{[B3]}$$

$$\mathcal{L}_X = U_X(H,M,X) - \lambda p = 0 \quad \text{[B4]}$$

$$\mathcal{L}_\lambda = p[Q(H;\bar{A}) - X] + V - M = 0 \quad \text{[B5]}$$

where variables are as defined in the paper. The bordered Hessian matrix of second-order conditions is given as:

$$[\bar{D}] = \begin{bmatrix} \mathcal{L}_{HH} & \mathcal{L}_{HM} & \mathcal{L}_{HX} & \mathcal{L}_{H\lambda} \\ \mathcal{L}_{MH} & \mathcal{L}_{MM} & \mathcal{L}_{MX} & \mathcal{L}_{M\lambda} \\ \mathcal{L}_{XH} & \mathcal{L}_{XM} & \mathcal{L}_{XX} & \mathcal{L}_{X\lambda} \\ \mathcal{L}_{\lambda H} & \mathcal{L}_{\lambda M} & \mathcal{L}_{\lambda X} & \mathcal{L}_{\lambda\lambda} \end{bmatrix} = \begin{bmatrix} U_{HH} + U_M pQ_{HH} & U_{HM} & U_{HX} & pQ_H \\ U_{MH} & U_{MM} & U_{MX} & -1 \\ U_{XH} & U_{XM} & U_{XX} & -p \\ pQ_H & -1 & -p & 0 \end{bmatrix}$$

where, consistent with B3, λ has been replaced with U_M, $\mathcal{L}_{HH} = (U_{HH} + U_M pQ_{HH}) < 0$, $\mathcal{L}_{MM} = U_{MM} < 0$, $\mathcal{L}_{XX} = U_{XX} < 0$, $U_{MH} = U_{HM} < 0$, $U_{XH} = U_{HX} < 0$, and $U_{MX} = U_{XM} > 0$.

Following Chiang and Wainwright (2005), a sufficient condition for constrained utility maximization may be derived as the determinant of $[\bar{D}\,]$ to obtain:

$$|\bar{D}| = pQ_H(pQ_H\Omega + 2p\beta + 2\delta) + p(2U_{MX}\mathcal{L}_{HH} + p\eta - \mu) + \mho < 0 \quad \text{[B6]}$$

where $\Omega = ((U_{MX})^2 - U_{MM}U_{XX}) < 0$, $\beta = (U_{MH}U_{MX} - U_{HX}U_{MM}) < 0$, $\delta = (U_{MX}U_{HX} - U_{HM}U_{XX}) < 0$, $\mathcal{L}_{HH} = (U_{HH} + U_M pQ_{HH}) < 0$, $\eta = ((U_{HM})^2 - U_{HH}U_{MM}) < 0$, $\mu = (2U_{HX}U_{HM} + U_M U_{XX}Q_{HH} + p^2 U_M U_{MM}Q_{HH}) > 0$, and $\mho = ((U_{HX})^2 - U_{XX}U_{HH}) < 0$.

Through substitution, B2 through B5 may be reduced to:

$$U_H(H,M,X) + U_M(H,M,X)pQ_H(H;\bar{A}) = 0 \quad \text{[B7]}$$

$$U_X(H,M,X) - pU_M(H,M,X) = 0 \quad \text{[B8]}$$

$$M - p[Q(H;\bar{A}) - X] - V = 0 \quad \text{[B9]}$$

Totally differentiating B7 through B9, with p and $\bar{A}$ fixed, yields:

$$(U_{HH} + U_M PQ_{HH} + PQ_H U_{MH})dH + (U_{HM} + PQ_H U_{MM})dM + (U_{HX} + pQ_H U_{MX})dX = 0 \quad \text{[B10]}$$

$$(U_{HX} - pU_{MH})dH + (U_{MX} - pU_{MM})dM + (U_{XX} - pU_{MX})dX = 0 \quad \text{[B11]}$$

$$-pQ_H dH + dM + pdX - dV = 0 \quad \text{[B12]}$$

Substituting *dM* (from B12) into B10 and B11 and simultaneously solving the resulting two expressions yields:

$$dH/dV = -(\overbrace{pQ_H\Omega + p\beta + \delta}^{(-)})\Big/|\bar{D}| < 0 \qquad \text{[B13]}$$

where Ω, β, δ, $|\bar{D}|$ <0.

Similarly, substituting *dX* (from B12) into B10 and B11 and simultaneously solving the resulting expressions yields:

$$dM/dV = (\overbrace{pQ_H\delta + \mho + pU_{MX}\mathcal{L}_{HH} - p\gamma}^{(-)})\Big/|\bar{D}| > 0 \qquad \text{[B14]}$$

where $\gamma = (U_{MH}U_{HX} + U_M Q_{HH} U_{XX}) > 0$, and $\mathcal{L}_{HH} < 0$.

Substituting B13 and B14 into B12 and rearranging terms yields:

$$dX/dV = (\overbrace{pQ_H\beta + U_{MX}\mathcal{L}_{HH} + p\eta - G}^{(-)})/|\bar{D}| > 0 \qquad \text{[B15]}$$

where $G = \mu - \gamma = (U_{HM}U_{HX} + p^2 U_M Q_{HH} U_{MM}) > 0$.

Totally differentiating the farm production technology $Q = Q(H,\bar{A})$ and the utility function $U = U(H,M,X)$ and dividing through by dV yields:

$$dQ/dV = Q_H(\overbrace{dH/dV}^{(-)}) < 0 \qquad \text{[B16]}$$

$$dU/dV = U_H(\overbrace{dH/dV}^{(-)}) + \textstyle\sum_J U_J(\overbrace{dJ/dV}^{(+)}) > 0, \;\; J = M, X \qquad \text{[B17]}$$

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