



Income and welfare effects of input subsidies across representative agricultural households of rural Rwanda

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Abstract:

Subsidies for intermediate inputs represent considerable transfers from governments to farmers and, are implemented on a large scale in many developing countries to primarily achieve objectives of (1) national food security and (2) raising incomes for the poor and technology constrained farmers. Clearly, a trade-off exists between the two objectives whereby targeting beneficiaries for achieving pro-poor growth may lead to equity at the expense of efficiency. Nevertheless, knowing which group of farmers benefit more or less from these budgetary transfers is essential in order to re-allocate scarce budgetary resources more effectively. Taking the case of Rwanda as an example, this study uses an empirical modelling approach to assess the income and welfare effects of subsidies for intermediate inputs (i.e. fertilizers and improved seeds) across a heterogeneous set of agricultural households, under competitive and monopolistic input market structures. The results show positive policy outcomes for all representative households and these outcomes are twice higher when the input market structure is competitive. Although subsidies for inputs eventually help poor households to overcome cost burdens and participate in markets, a large share of the policy transfers is captured by large-scale producers who generally have the liquidity to purchase unsubsidized inputs.

Acknowledgment: This paper analyses the income and welfare effects of government subsidies for intermediate inputs across heterogeneous farmers' households in Rwanda. Authors wish to acknowledge that the analysis relies on the Development Policy Evaluation Model (DevPEM) developed by the OECD. The study was conducted as part of the Monitoring and Analysing Food and Agricultural Policy (MAFAP) program implemented in the Food and Agriculture Organization (FAO) and funded by the Bill and Melinda Gates Foundation, USAID, and the governments of the Netherlands and Germany.

JEL Codes: Q02, O55

#852



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January 2018

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Key words: income and welfare effects, agricultural household, input subsidy, competitive input market, monopolistic input market, Rwanda.

I. Introduction

The aim of transforming Rwanda's agriculture from a subsistence sector to market-oriented is paramount for stimulating economic growth and rising incomes of farm households, who make up more than a half of the rural population. Its transformative impact is largely dependent to the efficient and effective implementation of the sector's priority policies laid out in the medium-term Strategic Plans for the Transformation of Agriculture, currently in its third phase (PSTAIII 2013-2017). For a decade now, the country-wide Crop Intensification Programme (CIP 2007-present) has been a key intervention for the implementation of PSTAs, in response to agricultural intensification seen as priority policy on the broad structural transformation agenda. Its objective is to raise productivity for six priority food crops (maize, rice, beans, wheat, cassava and Irish potatoes) while simultaneously increasing incomes for farmers (MINAGRI, 2011). A bulk of CIP spending is allocated to subsidies for fertilizers and improved seeds and the hope is that subsidies help the predominant smallholder farmers overcome cost burdens and thereby shift focus from producing enough to producing surplus.

The earlier evaluations of CIP have primarily focused on measuring the average impacts on productivity and production for the targeted food crops. Although the mean impact of a policy is central in any cost-benefit analysis, policy makers usually need information on effects of a policy beyond it. This is because a positive average impact tells us about the total gains from the policy but not the distribution of the gains or whether some farmers are harmed by the policy or whether a particular structural group benefits (Bedoya et al., 2017). It is apparent from the implementation of CIP subsidies on a large scale that there is a need of achieving both objectives of (i) national food security – by considering in the programme even the most productive farmers, who may be somewhat less poor – and (ii) raising incomes for the poor and constrained farmers. Clearly, a trade-off exists between the two objectives whereby targeting beneficiaries of subsidies for achieving pro-poor growth may lead to equity at the expense of efficiency. However, subsidies represent considerable transfers from the government to farmers and, therefore, knowing which demographic group of farmers benefit more or less is essential in order to re-allocate scarce budgetary resources more effectively.

The objective of the present study is therefore to assess the income and welfare effects of agricultural input subsidies across a heterogeneous set of agricultural households, representative of the rural Rwanda. We use an empirical modelling approach drawing upon the Development Policy Evaluation Model (DEVPEM) of Brooks et al. (2010), which is tailored for policy analysis in developing countries by considering several sector-specific features more likely to affect the outcomes of policy interventions. One is the consideration of agricultural households in their structural diversity and in their dual nature as both producers and consumers, which is important in the context of developing countries where majority consume a significant share of their food production. Second is the consideration of high transaction costs, which compel some households in semi or pure (in the extreme case) subsistence rather than market participation. Third is the consideration of a monopolistic input market structure in which input suppliers may increase the price of inputs as their demand increases; a situation likely to happen in Rwanda since the subsidized agricultural inputs are imported from few suppliers in neighbouring countries.

With particular interest and for a heuristic comparison, the study further assesses the income and welfare effects of a staple price support and its efficiency at transferring welfare to agricultural households relative to subsidies for intermediate inputs. A growing tendency of improving incomes for farmers through regulated minimum price for staple crops, i.e. maize, has been observed in the past few years, and it seems that the government will proceed in the same direction with the new PSTA IV (2018-2024). Although a price support for food crops would generally stimulate producers to purchase more of the subsidized inputs and thereby raise productivity and incomes, the policy has a characteristic flaw of hurting some of the intended beneficiaries. Results from simulations are believed to enlighten on the effects of such a policy.

Overall findings are expected to provide insights on distributional implications of specified agricultural policies and to inform policy makers on necessary improvements which would ensure policy benefits are effected in the most efficient way possible

II. The Crop Intensification Program: rationale, targeting and delivery

2.1. Rationale

The Rwandan agriculture sector has experienced a period of stagnant growth and persistent underdevelopment prior to the inception of CIP in 2007. Most agricultural households practiced mixed farming of food crops, vegetables and traditional livestock rearing on small plots of less than one ha while few also produced traditional cash crops, namely tea and coffee, on a small portion of their land. Food crops were predominantly produced, however, for subsistence rather than commercial purposes (USAID, 2011). The cultivation was mainly rain fed dependent with little or no use of chemical fertilizers yet soils were less fertile and increasingly depleted of nutrients. The outcome has been low levels of on-farm productivity, less food surplus and thereby low levels of income (MINAGRI, 2007). Agricultural intensification therefore was recognized as a priority policy in the attempt to changing the sector's development stride from subsistence to market oriented agriculture. The use of fertilizers and improved seeds was apparent for raising agricultural productivity and for sustainable intensive agriculture without depleting soils. However, the high cost of inputs mainly following from market failures (i.e. poor infrastructure) was foreseen as a barrier for the majority of the poor smallholder farmers to demand and realize the economic potential of modern inputs (MINAGRI, 2004). The Ministry of Agriculture and Animal Resources (MINAGRI) therefore intervened through subsidies for fertilizers and improved seeds under CIP with the primary objective of helping smallholder farmers overcome cost burdens caused by market failures, and thereby increase agricultural productivity among them.

2.2. Targeting

The CIP input subsidy is implemented in the form of a voucher. Through extension service providers, vouchers are distributed to farmers who cultivate at least one hectare of land whereas those who cultivate less than this threshold of one ha have to participate in the land use consolidation – a component of CIP – and access a collective voucher. The land use consolidation plan has the objective of increasing agricultural productivity by encouraging groups of 20 to 25 farmers at the village level called “umudugudu” to organize attribution of their land to areas determined suitable for CIP priority crops based on the country's agro-ecological zones and on cultivated areas. Farmers keep their land property rights but must grow, in a synchronized manner, crops selected by authorities. Participating farmers are able to rationalize land use for profit maximization and oversee the supply as well as use of inputs (Cioffo, 2014). Participation in land use consolidation is voluntary; however, it is a pre-requisite for availing subsidies for intermediate inputs, extension services as well as other benefits foreseen in the programme (MINAGRI, 2012). Farmers acquire fertilizers and improved seeds at subsidized (fixed in percentage terms) prices by presenting vouchers to certified agro-dealers, who then redeem the vouchers directly with a financial bank outlet, which in turn collect money from MINAGRI or the Ministry of Trade and Industry (MINICOM).

2.3. Delivery

Almost all inorganic fertilizer and improved seed supplies in Rwanda are met through imports since the domestic input production is still nascent. At the inception of CIP in 2007, the government

embarked on bulk procurement of the modern inputs for the reason that private sector capacity was low to meet national input requirements for the targeted food crops (MINAGRI, 2007). The imported inputs were then auctioned, based on a quota system, to private companies for distribution to districts; and distribution to rural areas was covered by private distributors/agro-dealers.

In April 2013/14, the Government of Rwanda established a transition phase for the fertilizer importation to develop a private-led distribution system as it was stipulated in the action plan for the privatization of the fertilizer distribution (2010-2013). Initial engagements to import and distribute inputs to “assigned districts” were made with three local companies under Public Private Partnership (PPP). The distribution condition was soon relaxed to “any district in the country”, but through agro-dealers certified by MINAGRI and thereafter; five new entrants in the business were registered in 2015/16, summing up to eight companies including the regional (i.e. Balton and Export trading group from Kenya) and international (i.e. Yara)(MINAGRI, 2007).

III. Methodology

This study uses the Development Policy Evaluation Model (DEVPEM) set out in Brooks et al. (2010) for assessing the effects of input subsidy and market price support policies in Rwanda. The suitability of the model for assessing policy outcomes stems from its structure that integrates several specificities of developing countries. Specifically, it features:

- (i) a set of heterogeneous agricultural households and takes into account their dual nature, as both producers and consumers.
- (ii) a market failure situation in the form of transaction costs to represent the imperfect market environment under which agricultural households operate.
- (iii) an increasing function of the price of inputs to account for a market environment in which suppliers of inputs may exercise a monopoly power.
- (iv) a practicality of land re-allocation from one activity use to another.

3.1. Essence of the model

At the core of the DEVPEM is an agricultural household model in which the standard equations for consumption, production and factor endowments are defined. As a consumer, the household is assumed to maximize utility (U) from the consumption of goods (home produced or purchased) denoted by i subject to a budget constraint. The total consumption quantity (QC) of goods valued at their market price (P) must not be more than the income of the household (Y). For notation simplicity, we drop the subscript h for household. However, we keep in mind that the equations apply to each of the five representative agricultural household groups. The formal consumer problem is expressed as:

$$\text{Max}_{QC_i} U(QC_i) \text{ subject to } \sum_i QC_i \cdot P_i \leq Y \quad (1)$$

As a producer, the household is assumed to maximize profit (π_i) from the total production quantity (QP) of each good valued at market price, subject to a production technology that makes use of production factor and input demands (FD) (land, capital, family labour, hired labour, and intermediate inputs) denoted by f . Note that tradable factors (tf) (family labour, hired labour, and intermediate

inputs) are valued at market prices whereas non-tradable or fixed factors (ff) (land and capital) are valued at endogenous rents (R) because their value depends on the production activity in which they are applied, hence, there is no single market price. The formal producer problem is formulated as:

$$\begin{aligned} \text{Max } \pi_i &= QP_i \cdot P_i - \sum_{f \in tf} (FD_{i,f} \cdot P_{i,f}) + \sum_{f \in ff} FD_{i,f} \cdot R_{i,f} \\ \text{subject to:} \quad QP_i &= QP_i(FD_{i,f}) \end{aligned} \quad (2)$$

The producer and consumer problems are linked by the household's income, which is imposed on the consumer problem as a constraint. The level of income partly derives from expression (2) – by summing profits from output of each good. The remainder is obtained from the full income of the household, which is the total value of endowments, and equals to the sum of fixed (land and capital) factor demands (FD) used in the production of all goods and factor endowment (QE) of labour. It is expressed as:

$$Y = QE_f \cdot P_f + \sum_{f \in ff} \sum_i FD_{i,f} \cdot R_{i,f} \quad (2)$$

In order to derive analytical solutions, functional forms are imposed on equation (1) and (2). The assumption is that household utility follows a Linear Expenditure System (LES) and, that there is a minimum consumption quantity of staple goods, denoted by c_i , that the household needs to consume to survive irrespective of the price of the good or household's income. Since we lack authoritative data on this minimal consumption per household category, we equate it to zero, which reduces the functional form to a Cobb-Douglas. The household utility function is expressed as:

$$U = \prod_i (QC_i - c_i)^{\alpha_i} \quad (4)$$

And optimal consumption decisions are obtained by:

$$QC_i = \frac{\alpha_i}{P_i} \left(Y - \sum_i P_i c_i \right) + c_i \quad (5)$$

Where α_i is the share parameter.

The production function is characterized by a Cobb-Douglas and, is expressed as:

$$QP_i = b_i \prod_f (FD_{i,f})^{\beta_{i,f}} \quad (6)$$

Where b_i is the shift parameter, and $\beta_{i,f}$ is the input share in the production of good i .

The optimal factor allocations are obtained by:

$$FD_{i,f} = \frac{P_i \cdot QP_i \cdot \beta_{i,f}}{P_{i,f|f \in tf} + R_{i,f|f \in ff}} \quad (7)$$

Equations (1) through (7) describe the optimal behaviour of a representative agricultural household. Under the assumption that markets for all goods and inputs work perfectly, all prices are exogenous to agricultural households who participate in markets as either net sellers or net buyers of food and/or

labour. In this case, the consumption and production decisions are made separately and solved sequentially in the model; and the difference between the profit-maximizing production quantity [equation (6)] and its utility-maximizing consumption quantity [equation (5)] for each good equals excess supply.

In reality, a market (either formal or informal) exists for any good or factor, however, it may fail for particular households where for example transaction costs are important. In the model, the market for goods is assumed to fail for some households who face prohibitively high transaction costs caused by market failures such as poor infrastructure, long distances to markets, and high transportation costs. The transaction costs (TC) are modeled in a multiplicative form and create a wedge between market price, effective buying price and effective selling price. In the absence of transaction costs, all the representative agricultural households would face market price for goods and inputs, denoted by P^m , and engage in markets as net sellers or buyers. However, in the presence of transaction costs, a net buyer household facing buyer transaction costs (TC^b) values a good at effective buying price ($P^m \cdot TC^b$) $\geq P^m$ that is higher than market price and a net seller household facing seller transaction costs (TC^s) values good at effective selling price ($P^m \cdot TC^s$) $\leq P^m$ that is lower than the market price, and a subsistence household values a good at a shadow price determined by the intersection of household supply and demand (associated equations are expressed in Appendix Table A2). Under such market setting, the production decision of the household is determined simultaneously with its consumption decision. This requires an explicit expression of the cash constraint for households, whereby the total value of quantity bought (QB) of goods and tradable factors is constrained by household cash income, which is equal to excess supply or quantity sold (QS) of goods and tradable factors plus exogenous income (EI— include remittances and other cash transfers to the household):

While modelling for the input subsidy:

$$\sum_i QS_i \cdot P_i + \sum_{f \in tf} QS_f \cdot P_f + EI \geq \sum_i (QB_i \cdot P_i) + \sum_{f \in tf} (QB_f \cdot P_f) \cdot (1 - IS_f)$$

Where $QS_i = QP_i - QC_i$, and IS is input subsidy and,

$IS_f = 0.1$ (10% subsidy rate) for f =intermediate inputs

$IS_f = 0$ for f = other tradable inputs

(8)

While modelling for the market price support for maize:

$$\sum_i (QS_i \cdot P_i) \cdot (1 + MS) + \sum_{f \in tf} QS_f \cdot P_f + EI \geq \sum_i (QB_i \cdot P_i) + \sum_{f \in tf} (QB_f \cdot P_f)$$

Where MS is market price support and,

$MS_i = 0.1$ (10% price support) for i = maize

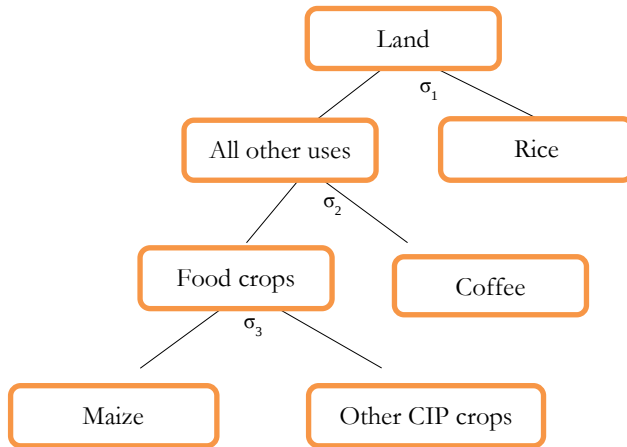
$MS_i = 0$ for i = other crops

Note: the prices for goods are exogenously fixed for agricultural households participating in markets and endogenously determined for remote agricultural households who face high transaction costs in the model.

3.1.1. Factor endowments

The household labour endowment is fixed. Labour is tradable and can either be drawn from household own endowment or hired from other households. Capital and land endowments are also fixed because the model is designed to show policy responses after households have been able to adjust the use of variable factors of production as well as consumption patterns in the short to medium run (Brooks et al. 2011). However, land has a special treatment whereby it is assumed to be fixed within each household but can be re-allocated between production activities. The land supply is therefore modelled with a nested Constant Elasticity of Transformation (CET) structure, which exhibits different elasticity of transformation (σ) depending on the ease of shift between activities at each level. The productions of goods considered in our application of the model are the six CIP food crops (maize, rice, beans, cassava, Irish potatoes and wheat) and one cash crop (coffee). Figure 1 illustrates the three levels of land re-allocation, whereby re-allocation becomes easier the more interchangeable are the pair of goods, such that the elasticity σ_1 ($=-0.1$ elasticity of transformation of land between rice and all other uses) is smaller than σ_2 ($=-0.15$ elasticity of transformation of land between food crops and coffee crop), which in turn is smaller than σ_3 ($=-0.4$ elasticity of transformation of land between maize and all other food crops). Re-allocation of land used for rice is assumed to be relatively difficult while it is assumed easier between land used for maize and the other four CIP crops. It is assumed moderate between land used for food crops and the cash crop coffee. The associated equations are provided in the Appendix, Table A2. The CET parameter values used in the DEVPEM are maintained due to lack of estimated elasticities of land transformation specific to Rwanda and are assumed to be same for all representative household groups

Figure 1. Land re-allocation between activities



Source: modified from Brooks et al. (2010)

3.1.2. Market assumptions and clearing

The supply of intermediate inputs, i.e. improved seeds and fertilizers, is assumed to be imperfectly elastic and the price of intermediate inputs is exogenously determined in the model. The supply of

inputs is however modelled as an increasing function of price, with constant price elasticity of supply, to allow modelling for cases where input suppliers may exercise a monopoly power. It is expressed as:

$$\frac{FD_f}{FD_{f0}} = \left(\frac{P_f}{P_{f0}} \right)^\varepsilon \text{ for } f = \text{intermediate inputs} \quad (9)$$

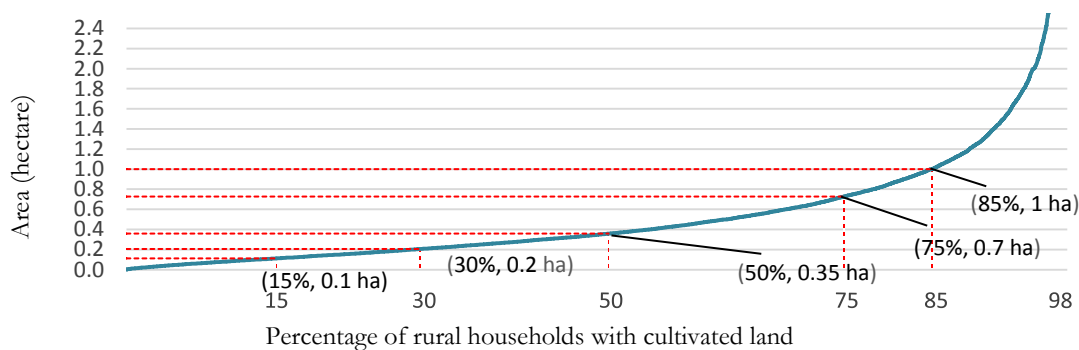
Where ε is the price elasticity of supply and subscript 0 is initial amounts and prices in the baseline dataset.

The market clearing for all goods and factors is ensured through a Social Accounting Matrix (SAM) – an accounting framework in which incomes equal expenditures for all accounts – constructed for each representative agricultural household. By this construction, the cash constraint and market clearing conditions are satisfied in the baseline model.

3.1.3. Household categorization

Land is a key structural endowment constraint in crop production for the majority of agricultural households in Rwanda. As illustrated in figure 2, about 15 per cent of rural households cultivate more than 1ha, whereas, a larger proportion of about 75 per cent cultivate less than 0.7 ha of land.

Figure 2. Distribution of rural households by cultivated land size in Rwanda



Source: IFPRI calculations, 2017 using EICV4 2013/2014 data.

The household's geographical location vis-à-vis local markets for outputs and inputs is another structural constraint pertinent to agricultural households in rural Rwanda, more importantly, to those located in remote areas. We therefore categorize households surveyed in the latest Rwandan integrated household living survey – Enquête Intégrale sur les Conditions de Vie des Ménages (EICV4 2013-14) – into five representative agricultural household groups based on the two constraints: “cultivated land size” and “remoteness to markets”. Agricultural households are first categorized based on cut-off percentiles of the cultivated land distribution such that households among “30% with least land-size” are defined as small holders, among “15% with largest land-size” are large holders, and among “rest of the distribution” are medium holders.

The small- and medium- holders are further categorized into remote and non-remote to markets. The EICV4 captures households' distance to nearest services (i.e. drinking water, school, hospital, food market). An average metric of all the services is computed for each household and cut-off percentiles, respectively, among “25% with large average distance to nearest services” and “rest of the

distribution” are used to categorize households in remote and non-remote. The sampling framework of the five representative agricultural household groups is illustrated in Table 1.

Table 1. Sampling framework for representative agricultural household groups

Categorisation of households by remoteness to markets	Categorisation of households by cultivated land size			
		among (30% with least “cultivated land size”)	among (rest of distribution for “cultivated land size”)	among 15% with largest “cultivated land size”.
	among (25% with large “average distance to nearest service”)	(1)Smallholder Remote Household (SRH)	(3)Medium holder Remote Household (MRH)	(5)Large holder farmers (LHF)
	among (rest of distribution for “average distance to nearest service”)	(2)Smallholder Non-remote Household (SNH)	(4)Medium holder Non-remote Household (MNH)	

Note: LHF are not categorized by remoteness to market because they are believed to be able to cover transaction costs given their scale of operation.

Source: sampling framework adapted from Brooks et al., 2010.

Given the dearth of literature on transaction costs estimates for remote rural Rwanda, agricultural households who are remote in our model are assumed to face an equivalent arbitrary transaction cost equal to 10% of all market transactions (selling and buying of goods and inputs). Furthermore, the quantity of goods produced is set equal to the quantity consumed for the remote households in the base model since they are modelled to represent self-sufficient households not participating in food markets due to prohibitively high transaction costs. The transaction costs for non-remote agricultural households as well as large scale producers are equal to zero.

3.2. Measures of welfare and policy efficiency transfer

Besides the change in nominal income, which only accounts for net policy gains from the production side, we also look at the change in household real income resulting from considered policy shocks. The real income accounts for both production and consumption side effects of a policy shock as well as additional effects from wage income changes. It therefore determines the household welfare change, which is measured in the model as a Compensating Variation (CV), *i.e. the amount of income that would have to be transferred to (or taken from) the household to leave it neither better nor worse off than before the policy shock (Brooks et al., 2010)*. Furthermore, a given policy efficiency in transferring welfare across heterogeneous agricultural households, and its overall efficiency relative to an alternative policy are measured in the model by a Generalized Transfer Efficiency (GTE) as follows

$$GTE = \frac{\text{change in agricultural household welfare (CV)}}{\text{total costs to urban consumers and taxpayers}} \quad (11)$$

For the input subsidies simulations, total costs to taxpayers are modelled as:

$$\sum_f (QB_f \cdot P_f) \cdot (IS_f)$$

for f is intermediate inputs and IS here is equal 0.1 (a 10% input subsidy)

For the market price support simulations, the total costs to urban consumers (in terms of consumer surplus losses) are modelled as:

$$\sum_i (QS_i \cdot P_i) \cdot (MS_i)$$

for i is maize and MS is equal to 0.1 (a 10 % price support)

The GTE of a policy can be measured independently for each representative household group given that each household has its specific supply and demand in the model. It is then equal to the net welfare change divided by the agricultural household's share in total policy costs. To compute the overall GTE, the welfare effects for all the representative agricultural household groups are summed and the total is divided by the total policy costs. The explicit costs (or transfers) of policies are assumed to be borne by taxpayers in the form of taxes, for the input subsidy, and by urban consumers for the price support. This means that the administrative or any other implicit costs are not taken into account. Rather we consider that every Rwandan francs cost to taxpayers translates in each Rwandan francs transferred by a policy.

3.3. Data sources

This study follows a pragmatic approach of using existing data at household level and gathering missing empirical information from previous studies. The fourth integrated household living survey (EICV4 2013-14) conducted by the National Institute of Statistic in Rwanda (NISR) is the main source of data used for our policy simulations. The values of production and consumption for different goods, expressed in currency unit (Rwandan francs) rather than quantities are extracted as well as exogenous income (remittances and other cash transfers) to feed into the SAM of each representative household group. Prices are therefore set to unity in order to convert the matrix into money-metric quantity units. The values for land, capital, own labour, hired labour, and intermediate inputs in the EICV4 database are recorded as aggregates; yet, the construction of the model requires disaggregated cost data for each input in the production of each good. Other country (Malawi, Ghana, Guatemala, Nicaragua, Bangladesh and Vietnam) applications of the DEVPEM have obtained the disaggregated value of inputs by using factor and input shares (that sum to 1) already estimated based on survey data on rural income generating activities. The shares are estimated by regressing agricultural income on the five factors of production for agricultural households specialised in one good. Given Malawi's economic similarity with Rwanda in terms of per capita GDP, agriculture % of GDP, and main food crops; we use its estimated factor and input shares as proxies for Rwanda and derive the value of factor and inputs in the production of each good under the assumption of zero economic profit. This means that the total value of production equals the total cost of inputs, including implicit costs of owned factors of production.

3.4. Model calibration

The overall model constructed in GAMS consists of a system of equations that define a set of relationships among variables through parameter values, of which some parameters are missing. The model is therefore calibrated to find the missing parameter values and make it functional. The calibration procedure consists of plugging observed variable values into the equations of the model to calculate the missing parameter values which would have led to those observed variable values as the equilibrium solution. All variables and parameters are shown in Appendix Table A.2.

IV. Results and discussion

4.1. Changes in income and welfare per representative household group

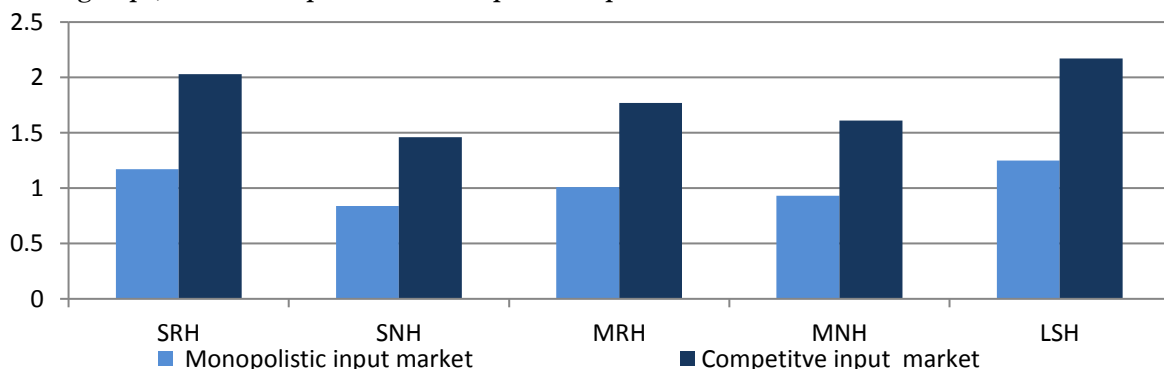
The changes in income and welfare are measured as the difference between the distribution of outcomes with and without the policy shock. Common to the two measures is that they both account for the net effect of gains on the production side and effects on wage income. Their difference however is that the welfare effect further considers losses that may occur on the consumption side due to the policy intervention.

➤ Input subsidies

The nominal income effects of a 10 per cent decrease in the price of intermediate inputs are assessed under two scenarios considering the market structure for inputs. The first scenario considers a monopolistic market structure whereby the few international (local) suppliers of inputs to Rwanda are able to raise the price as demand for inputs goes up. In this scenario, the input price is modelled with price elasticity equal to 2. The alternative scenario considers a competitive market structure in which there are no price distortions, meaning that the input price at the farm gate is fully aligned with the international (import price) price of imported seeds and fertilizers. Under this alternative scenario, the input price is modelled with price elasticity equal to infinite.

Figure 3 displays the nominal income effects of a 10 per cent input subsidy under competitive and monopolistic input market structures. As can be expected, the income changes are positive for all the representative agricultural household groups. Their magnitudes however differ, and are about twice larger for most household groups under the competitive input market, in which input price falls by the entire amount of the subsidy and all policy benefits accrue to agricultural households. Under monopolistic input market, the price of intermediate inputs falls with less than the entire amount of the subsidy resulting in relatively low changes in nominal income ranging between 0.8 and 1.2 per cent. The implication of this result is that a substantial proportion of policy transfers leak to unintended beneficiaries – input suppliers – when low competition in the supply of inputs creates favourable conditions for suppliers to exercise a monopoly power. It is therefore plausible to argue for such possibility in Rwanda given the high dependency on fertilizers and improved seed imports from few international suppliers. Such implication would also hold if the local distributors of intermediate inputs tend to charge higher prices in order to capture greater profits.

Figure 3. Nominal income effects (in % change) of a 10 per cent input subsidy across representative agricultural household groups, under monopolistic and competitive input markets.



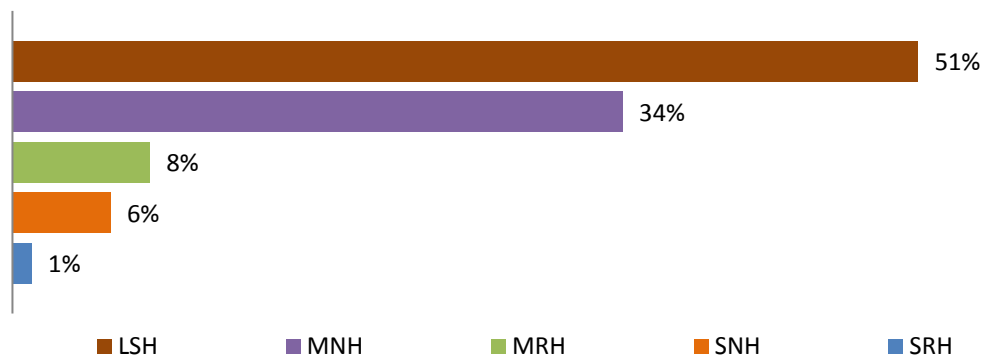
Source: authors, 2017

The welfare effects of the 10 per cent decrease in the price of intermediate inputs are identical with nominal income effects under both competitive and monopolistic input market structures. This is because an input subsidy does not create direct negative consumption cost effects and, therefore, each additional nominal income that agricultural households incur from subsidized inputs essentially translates into additional welfare. A highlight from the results however is the fact that the subsidy for intermediate inputs helps remote agricultural households to overcome cost burdens and, thereby obtain ample profit from sales. Nonetheless, as Taylor et al. (2012) argue, some agricultural households might not be able to take full advantage of the subsidized inputs if their use is still bound to other related constraints such as liquidity or seasonal cash. Although liquidity constraint is not explicitly modelled, it can indirectly be captured through the assumption of household fixed total land and capital endowments. Such limited financial resources stem from the lack of well-functioning financial institutions willing to issue micro-credits to potential agricultural households that are generally seen as defaulters. In practice, some of these agricultural households who already are market oriented would need liquidity to be able to pay even the subsidized prices while others would need the cash to expand their productive asset base, i.e. rent or buy more land, and thereby make effective use of the subsidized inputs. Although some studies (Banful, 2012b; Baltzer and Hansen, 2012) describe subsidies as efficient if to some extent they counteract distortions created by market failures, other authors (Timmer, 1988; Aparajita and Nash, 2017) describe the use of subsidies for inputs to correct market failures as treating symptoms rather than causes, and resulting impacts to be only temporary.

The subsidies for intermediate inputs are implemented on a large scale in Rwanda and represent significant amounts of agricultural budgetary resources. The analysis of the composition of public expenditures in support of food and agriculture in Rwanda for the 2011/12-2015/16 period indicate that about an average 35% of agriculture-specific expenditures (direct support to the agricultural sector) was spent on the category of “input subsidies and other payments to producers”; with most spending allocated to subsidies for seeds and fertilisers provided under the CIP (MAFAP, 2017). Therefore, knowing the repartition of policy transfers within agricultural household groups is deemed necessary. This is important to track whether policy transfers predominantly accrue to intended recipients, the smallholder producers.

The distribution of input subsidy transfers is the same under both competitive and monopolistic input markets. As illustrated in Figure 4, about 51 per cent of input subsidy transfers are absorbed by large scale producers, who represent 15% of rural households with more than 1ha and farm approximately 50% of national arable land as the previous Figure 2 displays with data from the latest integrated household living survey (EICV4 2013/2014). On the one hand, it could be viewed as rational to let the large scale producers benefit from subsidized inputs given the significant size of cultivated land and significant contribution to national food production. However, on the other hand and based on the literature, it appears inefficient since large scale producers generally have the liquidity to purchase unsubsidized inputs. What's more, the subsidies tend to crowd out their demand for commercial fertilizers, which in turn could discourage private sector investments in inputs supply.

Figure 4. Distribution of input subsidy transfers across representative agricultural household groups in Rwanda



Source: authors, 2017.

The results further indicate that the remainder, 49 per cent of input subsidy transfers, accrues to the small and medium holders. Only less than 10 per cent of the transfers accrue to smallholder agricultural households, who represent 30% of rural households with less than 0.2ha and farm approximately 5.4 per cent of national arable land. Majority of these smallholders are caught in a poverty trap, barely produce a marketable surplus and have no other non-farm income (Diao, 2017). These households absorb a smaller share of the transfers because their purchase of subsidized inputs is relatively small. Some households could also be of the type Baltzer and Hansen (2012) refer to as vulnerable to poor harvest, and thereby choose to apply little amounts of agricultural inputs, settling for smaller but more stable surplus.

The medium-scale holders, who represent 55% of rural households cultivating between 0.7ha and 1ha of land, purchase quite substantial amounts of the subsidized inputs resulting in the absorption of a moderate share of the input subsidy transfers. According to Diao (2017), most of the agricultural households with more than 0.7 ha of cultivated land size are already engaged in the market and have the potential to substantially contribute to food production in the country. The author therefore underlines that such particular households need incentives that go beyond targeting physical yields. In the same vein, other authors such as Izhar (2005) and Azariadis and Stachurski (2004) explain that input subsidies used to kick-start markets in the process of agricultural transformation generate progressive benefits to agricultural households trapped in poverty. Nevertheless, agricultural households who begin to make their way out of poverty by exhibiting increasing marginal returns may become risk averse during the process with the fear of falling back in low equilibrium levels. Support in the form of insurance, micro-credits as well as social transfers would therefore be helpful for them to move to the next level as supported by a number of studies that show beneficiary farmers to be highly efficient from an economic viewpoint (Carter and May, 1999; Devereux and Guenther, 2007).

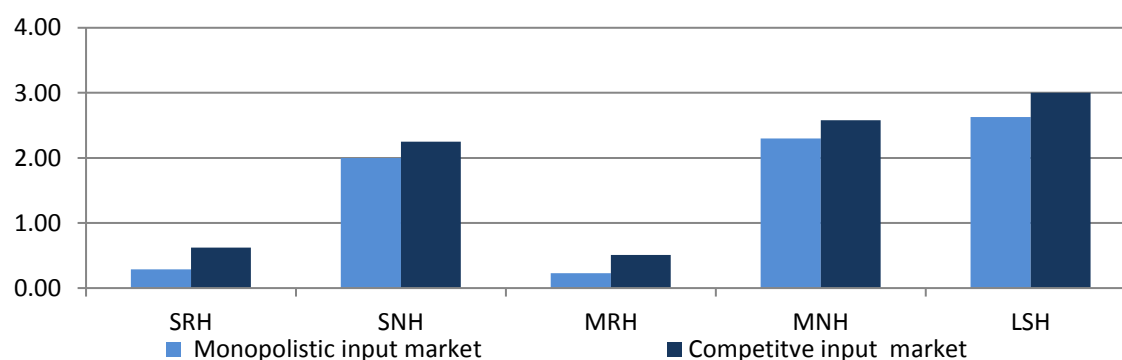
➤ **Market price support**

The market price support in our policy simulations is targeted at the main staple crop: maize, and considered to be implemented in the form of a regulated minimum price. Overall, the simulation results indicate that the nominal income effects of a 10 per cent increase in the price of maize are positive for all the representative household groups under both competitive and monopolistic input markets. They are concentrated among large scale producers and non-remote agricultural households who initially are net sellers of maize and respond to the policy by increasing production and sales.

Even more interesting is the fact that remote households who initially are subsistent enter into markets to commercialize their food surplus in response to the price increase, which helps them overcome high transaction costs.

As Figure 5 displays, under the competitive input market, the nominal income changes range between 2.2 and 3.0 per cent for the non-remote agricultural households and large scale producers, however, they are slightly more than 0.5 per cent for the remote agricultural households. Considering the monopolistic input market, the income effects are relatively lower ranging between 2.0 and 2.6 per cent for the non-remote agricultural households and large scale producers, whereas, they are less than 0.3 per cent for the remote agricultural households. The reduction in income effects under monopolistic input market stems from an increase in the cost of intermediate inputs which also induces a slight decrease in input demand. Some studies also find that a price increase for food crops, accompanied with high and volatile input prices as well as other relevant costs such as marketing margins, create substantial negative welfare consequences that are never counterbalanced by associated positive effects on producers; and even subsidies for inputs would only encourage scanty use of inputs due to unprofitable investments. In addition, although cereal price volatility is also found to be a significant problem, the negative welfare effects from price changes remain substantial relative to price volatility (Short et al., 2014; Baltzer and Hansen, 2012; Magrini et al., 2017).

Figure 5. Nominal income effects (in % change) of a 10 per cent increase in the price of maize across representative agricultural household groups, under competitive and monopolistic input markets.

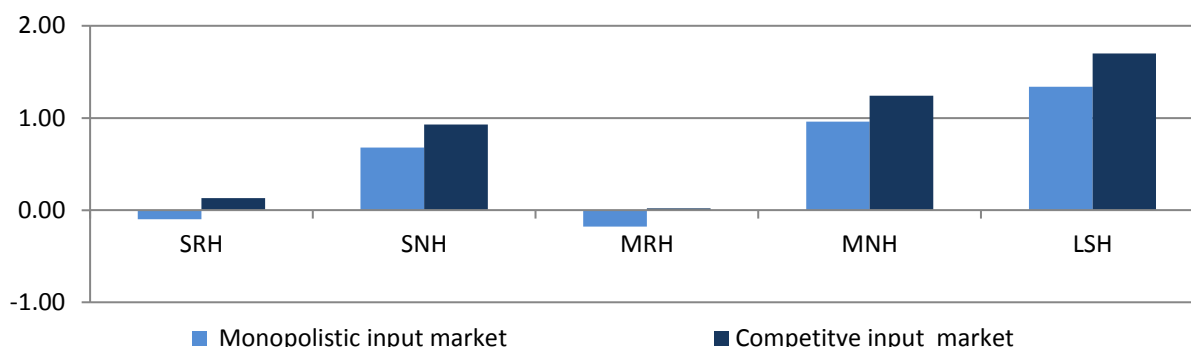


Source: authors, 2017.

The welfare effects of the 10 per cent increase in the price of maize are low than nominal income effects for all household groups under both monopolistic and competitive input markets, following from negative consumption cost effects created by the policy. As Figure 6 illustrates, the welfare effects are relatively high under competitive input market and remain positive for all agricultural households. Under monopolistic input market, the changes in welfare are positive, ranging between 0.6 and 1.3 per cent for the non-remote households and large scale producers, whereas, the effects turn negative -0.10 and -0.18 per cent for the small and medium remote households, respectively. The negative welfare results from the fact the price increase prompts agricultural households to increase the consumption of home produced maize (making the consumption bundle more expensive) – leaving little excess supply – and profit earned from the little market surplus turns out small to offset consumption expenditures, which are further made expensive by the price increase for intermediate inputs. Nonetheless, it is important to note that the staple price increase is more likely to harm, to a

larger extent, agricultural households who are net buyers as well as urban consumers (Magrini et al., 2017).

Figure 6. Welfare effects (in % change) of a 10 per cent increase in the price of maize across agricultural household groups, under monopolistic and competitive input markets.

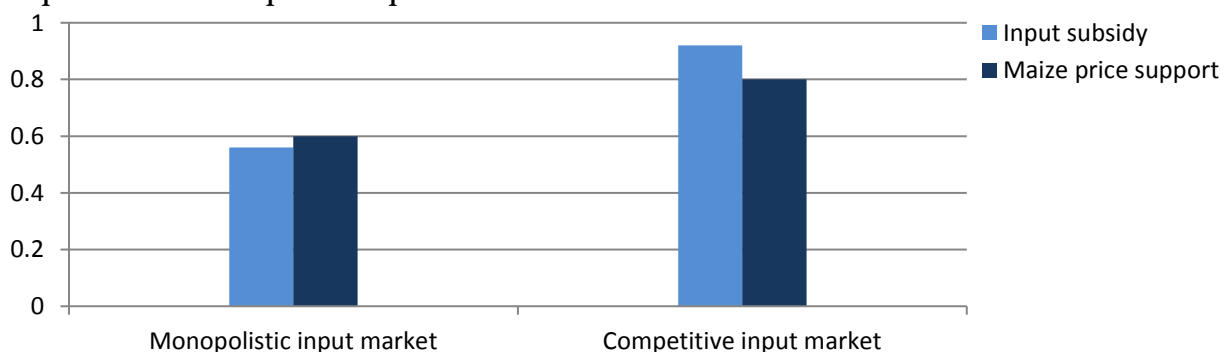


Source: authors, 2017.

4.2. Policy efficiency in transferring welfare to agricultural households

The policy efficiency is measured as the aggregate change in welfare for all representative household groups divided by the total policy costs (which are costs to taxpayers for the input subsidy policy and costs to urban consumers for the staple price support policy). Figure 7 illustrates the relative policy efficiency of an input subsidy and market price support, under competitive and monopolistic input markets. Under monopolistic input market, the input subsidy appears less efficient with an overall GTE of 0.5 relative to an overall GTE of 0.6 for the staple price support, whereas, it appears cost efficient (GTE=0.9) relative to the staple price support (GTE=0.8) under competitive input market. This is because a considerable share of the policy benefits leak to input supplier under monopolistic input market, therefore, making costs to taxpayers higher than benefits that accrue to intended beneficiaries: the agricultural households. At household level (see results in Appendix Table A3), we notice that the staple price support is cost efficient in transferring welfare to all agricultural households except the remote agricultural households who initially are self-sufficient in food because of high transaction costs caused by market failures; contrary to the input subsidy which is efficient at transferring welfare to all household groups, including the remote.

Figure 7. Relative policy efficiency of a 10 per cent input subsidy and market price support, under competitive and monopolistic input markets.



Source: authors, 2017.

V. Conclusions and recommendations

The agriculture sector remains the mainstay of the Rwandan economy. Its productive capacity therefore has to boost in order to meet expanding demand for food emerging from rapidly growing population and stimulate economic growth as well as reduce poverty (Diao, 2017). For this to materialize, agricultural producers – dominated by smallholders – need diverse incentives and support to enhance productivity as well as production of targeted staple food crops. We conclude by briefly reiterating the main findings.

-The input subsidy simulation results show positive nominal income and welfare effects under both competitive and monopolistic input markets. Nevertheless, the magnitudes are about twice higher when the input market structure is competitive, that is, if the few local input suppliers have no opportunity to raise the improved seeds and fertilizer prices above their import parity price and; if the few international suppliers do not take advantage of the high dependency on improved seeds and fertilizers to raise the price as demand for inputs goes up. The results further indicate that a large share of the input subsidy transfers is absorbed by the large-scale producers who purchase much of the intermediate inputs – an inefficient outcome based on literature since large-scale producers generally have the liquidity to purchase unsubsidized inputs. Less than a half of the policy transfers accrue to the small- and medium-scale holders whose purchase of intermediate inputs are relatively small and practically cash constrained.

-The maize price support simulation results show positive income effects for all agricultural households under both competitive and monopolistic input market, and are concentrated among the large- and medium-scale holders who initially are net sellers of maize and respond to the policy by increasing production and sales. The welfare effects are however small relative to nominal income effects because agricultural households are consumers of their own produce and their consumption side is therefore affected by high price for staple crops, more importantly if the crop is highly consumed within the household food basket. They are positive for all agricultural households under both input market structures, except for the remote agricultural households who incur negative welfare under monopolistic input market since profit earned from the little market surplus turns out small to offset consumption expenditures, which are further made expensive by the price increase for intermediate inputs.

-Input subsidies appear more efficient than staple price support at transferring welfare to agricultural households when the market for intermediate inputs is competitive and, more importantly, when some households are self-sufficient in food because of high transaction costs caused by market failures. Nevertheless, subsidies do not completely resolve their funding needs as poor agricultural households still need to pay a fraction of the subsidized inputs. Although the maize price support creates negative welfare for some household groups under monopolistic input market, it is found to be efficient at transferring welfare to agricultural households when they are already engaged with markets, are net sellers of the staple crop, and are able to supply substantial amounts of food crops at lower costs. It is nonetheless more likely to harm, to a larger extent, agricultural households who are net buyers as well as urban consumers.

Policy recommendations

(1) Reform the targeting of input subsidies beneficiaries in terms of withdrawing particular households, i.e. large scale producers, and therefore allow a channel of scarce public resources to agricultural households in need. Furthermore, assess and incorporate into the policy design a potential process of graduation from the subsidies to ensure the exit strategy is not only concerned with termination of the programme but an exit that leave supported beneficiaries able to pursue sustainable independent livelihoods. This will also allow reduction of costs over time (as beneficiaries graduate) and help in progressive as well as final impact evaluation of the programme.

(2) Promote a competitive input market structure to reduce policy benefits that leak away from agricultural households. This would require coming up with strategies that improve competition among input suppliers and improving rural infrastructure to lower the marginal cost of distributing inputs in rural areas. In the meantime, maintain regulatory measures in local supply of inputs to avoid uncompetitive business practices.

(3) Envisage channelling of public funds or support private sector investment in domestic production of improved seeds and fertilizers to diminish the heavy reliance on external markets for inputs. It could contribute to low costs of production through low input prices and thereby address both problems of affordability and profitability. This will nonetheless require complementary interventions such as access to credit in order to strengthen households' capabilities.

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Appendix

Table A1. Description of parameters and variables used in DEVPEM

<i>Subscript</i>	<i>Description</i>
i	Goods (maize, rice, other CIP crops, coffee and composite good)
f	Factors (land, capital, intermediate inputs, hired labour and own labour)
if	Goods and factors (maize, rice, other CIP crops, composite good, intermediate inputs, hired labour and own labour) considered in multiplicative transaction costs
tf	Tradable factors
ff	Non-tradable/fixed factors
η	Nodes in the CET land allocation (household-specific)
h	Households
<i>Parameters</i>	<i>Description</i>
P^m, P_i, P_f	Market prices
TC^s, TC^b	Multiplicative transaction costs (seller, buyer)
QE	Initial endowments (fixed in the case of capital and land)
EI	Exogenous income for household h
ε	Supply elasticity for intermediate inputs (imperfectly elastic)
c_i	Incompressible consumption level of good g for household h
α_i	Parameter of the utility function
$\beta_{i,f}$	Parameter of the production function
γ_i	CET share parameter of good i
ρ_h^η	CET parameter between goods production (household-specific, one for each node η)
<i>Variables</i>	<i>Description</i>
QP_i	Quantities produced of good i by household
QB_i, QB_f, QS_i, QS_f	Quantities of good i or factor f bought or sold by household
QC_i	Quantities of good i consumed by household h
$FD_{i,f}$	Input of factor f into production of good i
P_i, P_f	Prices of good i and tradable factors f for remote households
R_i	Land or capital rent in household-specific production of good i or CET node
Y	Shadow income

Source: adapted from Brooks et al., 2010

Table A2. Blocks of equations in DEVPEM

<i>Equations</i>	<i>Description</i>
Price bounds and complementary slackness	
$P_{if} \leq p_{if}^m \cdot TC_{if}^b \quad ; \quad P_{if} \geq p_{if}^m \cdot TC_{if}^s$ $QB_{if}(P_{if} - p_{if}^m \cdot t_{if}^b) = 0 \quad ; \quad QS_{if}(P_{if} - p_{if}^m \cdot t_{if}^s) = 0$	Price bands for the multiplicative transaction costs
Input supply block	
$\frac{FD_f}{FD_{f0}} = \left(\frac{P_f}{P_{f0}} \right)^\varepsilon$	Imperfectly elastic supply of input
Consumption block	
$QC_i = \frac{\alpha_i}{P_i} \left(Y - \sum_i P_i c_i \right) + c_i$	Demand from household b for good i
$Y = QE_{labour} \cdot P_{labour} + \sum_{f \in FF} \sum_i FD_{i,f} \cdot R_{i,f}$	Shadow income of household b
$\sum_i QS_i \cdot P_i + \sum_{f \in TF} QS_f \cdot P_f + EI \geq \sum_i (QB_i \cdot P_i) + \sum_{f \in TF} (QB_f \cdot P_f)$	Cash constraint of household b
Production block	
$QP_i = b_i \prod_f (FD_{i,f})^{\beta_{i,f}}$	Production function
$FD_{i,f} = \frac{P_i \cdot QP_i \cdot \beta_{i,f}}{P_{i,f f \in TF} + R_{i,f f \in FF}}$	Demand for tradable factor tf and non-tradable factor ff in the production of good g
$FD_{i,capital} = \overline{FD_{i,capital}}$	Fixed levels of capital
CET land allocation block	
$\overline{TLS}_h = \left(\sum_i \gamma_i \cdot (FD_{i,land})^{\rho_h^1} \right)^{1/\rho_h^1}$	CET land supply, top node ($\eta = 1$)
$FD_{node2,land} = \left(\sum_i \gamma_i \cdot (FD_{i,land})^{\rho_h^2} \right)^{1/\rho_h^2}$	CET land supply, middle node ($\eta = 2$)
$FD_{node3,land} = \left(\sum_i \gamma_i \cdot (FD_{i,land})^{\rho_h^3} \right)^{1/\rho_h^3}$	CET land supply, lower node ($\eta = 3$)
$\frac{R_{i,land}}{R_{i',land}} = \frac{\gamma_{h,i}}{\gamma_{h,i'}} \cdot \left(\frac{FD_{i,land}}{FD_{i',land}} \right)^{\rho_h^\eta - 1}$	CET optimality condition at every node η
$R_{\eta,land} = \left[\sum_{i \in l_\eta} \left(\gamma_i \right)^{\frac{1}{1-\rho_h^\eta}} \cdot (R_i)^{\frac{\rho_h^\eta}{\rho_h^\eta - 1}} \right]^{\frac{1-\rho_h^\eta}{\rho_h^\eta}}$	Implicit rent at CET node η
Market clearing constraints	
$\sum_i QP_i + QB_i + QB_f = QS_i + QS_f + QC_i + \sum_f FD_{i,f}$	Quantity balance at the household level for MAH
$QS_{if} \cdot QB_{if} = 0$	Households buy or sell, not both

Source: adapted from Brooks et al., 2010

Table A3. Simulations results of policy efficiency at transferring welfare at household and aggregate level

	Policy	GTE per household group					Overall GTE
		SRH	SNH	MRH	MNH	LSH	
Monopolistic input market	Input subsidy	0.78	0.75	0.60	0.58	0.52	0.56
	Market price support, maize	0	0.58	0	0.60	0.64	0.60
Competitive input market	Input subsidy	1.28	1.24	0.97	0.95	0.84	0.92
	Market price support, maize	0	0.79	0	0.77	0.81	0.80

Source: authors, 2017.