Rice Prices, Agricultural Input Subsidies, Transactions Costs and Seasonality:

A Multi-Market Model Poverty and Social Impact Analysis (PSIA) for Madagascar

by

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1. Introduction

The purpose of this study is to quantify the impact of alternative agricultural policies on the well-being of households in Madagascar. As part of a wider effort by the World Bank to conduct *ex-ante* Poverty and Social Impact Analyses (PSIA) of policy changes, we focus on income generating activities in the agricultural sector. With over 80 percent of all poor living in rural areas and the vast majority of them depending on agriculture for their livelihoods (Paternostro et al, 2001; INSTAT 2002), an increase in agricultural income is paramount to the development of any poverty reduction strategy for Madagascar. Further, since 90 percent of the rural poor are engaged in the production of rice, productivity in this sector as well as in agriculture in general, is an important element of income generation and poverty alleviation.

Although macroeconomic stability and growth of national income have ensued the economic reforms initiated in the latter half of the 1990s, the rural sector has been left behind (Paternostro, et al, 2001). Substantial increases in agricultural production have not been observed (Minten & Randrianarisoa, 2001) as the persistence of structural constraints hinder progress in this sector (World Bank, 2001). Productivity in Madagascar's agricultural sector has remained low and stagnant over the past 40 years, and the use of fertilizer is puzzlingly low (Stifel et al, 2003). This suggests that there are means through which growth of this sector can be kick-started, with positive repercussions for the rest of the economy. Naturally, as a recent World Bank study notes, there is "no silver bullet" that will simultaneously solve these problems (World Bank, 2003). Nonetheless, in an effort to better understand the set of instruments available to policy makers and what their effects might be, we develop a multi-market model that focuses on agriculture and the seasonal nature of the Malagasy economy. We then shock the model by experimenting with exogenous policy changes to assess their impacts on households in Madagascar.

The structure of the paper is as follows. We begin with a description of the model and in doing so, shed light on the character of the economy as well as the policy environment in which it functions. This is followed by a discussion of the data and the calibration of the model. The simulation results are then presented. The set of policies examined here include (1) rice trade liberalization, (2) reducing transaction costs and marketing margins, (3) reducing seasonal price variation, (4) fertilizer subsidies, and (5) increasing agricultural productivity. The paper concludes with remarks summarizing the simulations and discussing the policy implications.

2. The Model

The multi-market model used in this analysis extends Lundberg and Rich's (2002) generic model designed to facilitate analysis of agricultural policy reform issues in Africa. The purpose of this extension is to adjust the generic model to more accurately reflect the conditions in Madagascar, as well as to take advantage of recent household survey data to estimate supply response elasticities. Further, unlike the computable general equilibrium (CGE) model of Dorosh et al (2003), this multi-market model concentrates on the production relationships in the agricultural sector, and adds a seasonal component in a manner different from Dostie, et al's (2000) multi-market model.

We begin with a description of the product and household categories, before elaborating on the structure and the equations that make up the model.

2.1 Product Categories

The product categories are broadly broken down into (a) food items, (b) non-food consumption items, and (c) agricultural inputs. More specifically, the food items include:

1. Rice (RICE): As in many Asian economies, rice is the dominant crop in Madagascar. As such, it is given its own category in the model.

2. Course grains (CGRAIN): This group is comprised primarily of maize, sorghum and millet which are treated as non-tradables in this model. These commodities are an important source of livestock feed, and will frequently be referred to as "maize" given its dominance within this category.

3. Roots and tubers (ROOTTUB): Also an important source of livestock feed, roots and tubers such as cassava, sweet potatoes, and potatoes are used as food products of the poor and are non-tradables. In addition, cassava is the primary starchy staple consumed in southern Madagascar.

4. Cash crops (CASHCRP): Such crops as vanilla, coffee and cloves are produced primarily for export.

5. Livestock (LIVESTK): This is an aggregation of the various non-tradable meat products in Madagascar (e.g. cattle, pigs and poultry), but is primarily made up of cattle.

6. Other food products (OTHFOOD): This remaining food category captures a basket of miscellaneous non-tradable food crops and processed food products.

Non-food consumption items are aggregated into one product category since the emphasis of this model is the agricultural sector:

7. Non-agricultural production (NONFOOD): Such tradable products as manufactures, industrial products, oil, and forest products are included.

Two agricultural inputs are modeled explicitly:

8. Fertilizer (FERT): Given the potentially high returns and the extremely low levels of fertilizer use in Madagascar (Stifel, Minten and Dorosh, 2003), this imported input is the subject of policy considerations.

9. Animal and mechanical traction (TRACT): This non-tradable input is an aggregation of the use of cattle and tractors for plowing and other uses of traction.

The four other obvious agricultural inputs are land, labor, water and seed. Land is included as a variable input, but is not incorporated into the model as a traded commodity given the weakness of markets for land. Labor is not considered as a variable input in the multi-market model because it is better studied through the use of a CGE model. As such it is assumed to be supplied inelastically and allocated in fixed proportions to each of the production activities. Although water input is not entirely beyond the control of farming households – through development of irrigation systems – we assume it to be exogenous in the model since determining shadow prices is not possible given the lack of sufficient data. Finally, seed inputs are modeled as fixed proportion of output. These relationships are clarified below in the detailed discussion of the model.

2.2 Households

Production and consumption patterns are distinguished among four broad types of household groups: urban non-poor (URBRICH), urban poor (URBPOOR), rural non-poor (RURRICH), and rural poor (RURPOOR). Each of the household groups is assumed to be involved in all of the production activities, though to differing degrees. As such, these are representative agent households that may not correspond to any particular household within their groups, but rather embody the average activities of all the households in the group.

2.3 Structure of the Model

There are six blocks of equations in this multi-market model: prices, supply, input demand, consumption, income, and equilibrium conditions. (a) The price block defines the relationship between producer prices (*PP*) and consumer prices (*PC*) in the domestic economy based on the degree of transactions costs. For tradable goods, domestic prices are related to world prices, while prices of non-traded goods are determined by supply and demand conditions. (b) The supply block represents the domestic production of food crops, livestock, and non-agricultural production. (c) The input demand block describes the household demands for agricultural inputs. (d) The consumption block shows household demand for food and nonfood consumption items. (e) The income block describes household income as the sum of income derived from agricultural production and exogenous nonagricultural income. (f) Finally, the equilibrium condition block contains equations equating domestic supply and net imports to demand for each of the ten product categories.

Seasonality is incorporated into the model on the demand side for three "seasonal" consumption commodities – rice, maize and roots and tubers. This is done by allowing consumer prices to differ during the harvest (April - September) and the lean period (October - March) by the cost of storage for these products, as well as by seasonally variant urban-rural marketing margins. Production decisions for the seasonal products, however, are made based on prices expected to be received at the time of harvest. This is justified by conceptualizing the lean-period premium as storage costs (a leakage) which are not captured by the producers.[2]

2.3.1 Price Block

The price block is comprised of 111 equations that reflect the relationships between producer prices, consumer prices, international prices and transactions costs – including seasonal storage costs. These equations also reflect the laissez-faire approach of the government to transactions in the domestic economy. As Minten and Randrianarisoa (2001) describe:

> The current situation in agricultural markets can be described as one in which private traders have been given free reign to set prices and [to] move agricultural products around the country, and in which there is little state intervention.

In the presence of transactions costs due to distribution and transportation costs, producer (farmgate) prices for each household group (*h*) are lower than the harvest ($t = 1$) consumer (market) prices. The band between these prices is determined exogenously by commodity-specific (*c*) domestic marketing margins ($MARG_c$). Changes in the domestic marketing margins can proxy for changes in transportation costs that arise from improvements in infrastructure. The first 36 equations (9 x 4) in this block thus describe the relationship between producer and consumer prices during the harvest period for each commodity (*c*):

$$PP_{c,h} = \frac{PC_{c,h,1}}{1 + MARG_c} \qquad (1\text{-}36)$$

For non-tradable commodities, these prices adjust endogenously to equate supply and demand as described later in the discussion of the equilibrium conditions. For tradable

[2] This differs from Dostie et al's (2000) approach in which they solve sequentially for each season with six seasons linked by the previous season prices and levels. Their approach is appropriate in the context of their objective to study the seasonality of food consumption. Given the objective of this paper to analyze the second round income effects of agricultural policies, however, we prefer a more limited seasonal model that solves simultaneously. The rationale for this is that farmers make their major input decisions at the time of planting based on their ex ante expectations of producer prices that they receive for their crops at the time of harvest, as well as on current input prices. Since these prices – output and input – are realized during different seasons, we are more comfortable modeling production in a simultaneous model. (Note that this multi-market model exercise assumes that household consumption and production decisions are separable; Singh, Squire and Strauss, 1986). In the rice sector, Bockel (2002) finds a certain degree of producer price stability in the 1980s and 1990s, and more variation among consumer prices.

goods, however, prices are determined exogenously by fixed world prices, with net imports (imports less exports) clearing the domestic market (i.e. filling the gap between domestic demand and supply at the fixed prices). We first describe the relationship between world and border prices, and then clarify the distinction between border prices and consumer prices.

For exportable products (*ix*), the border price (*PX*) is linked to the world price (*PW*) by the exchange rate (*er*) and transactions costs – marketing margin – from the rest of the world to the border of Madagascar (*RMARG*). Given that cash crops are the sole exportable product category in this model, one equation is introduced:

$$PX_{ix} = \frac{\overline{PW_{ix}} * er}{(1 + RMARG_{ix})} \tag{37}$$

The prevailing producer price of exportables in the domestic market, however, is not equal to the border price since there also exist transactions costs that result in a marketing margin between the border and the domestic market. The domestic producer price of cash crops must then be adjusted downward to account for this margin (*IMARG*). Using the relationship between consumer prices and producer prices described in equations 1 through 10, we thus get the following relationship between domestic consumer price and the border export price for cash crops:

$$PC_{ix,urbrich,1} = PX_{ix} * \left(\frac{1 + MARG_{ix}}{1 + IMARG_{ix}} \right) \qquad (38)^{3}$$

Note that since consumer prices are defined for each household group for each season, the price described here is for urban non-poor households during the harvest ($t = 1$). The relationship between this price and the remaining consumer prices of exportables is described below.

The border prices of the three importable products (*im*) – food grains, non-agricultural products, and fertilizer – are similarly linked to the world price by the exchange rate, import tariffs (*tm*)[4], and the international marketing margin:

$$PM_{im} = \overline{PW_{im}} * er * (1 + RMARG_{im}) * (1 + tm_{im}) \qquad (39\text{-}41)$$

[3] An intuitive interpretation of this equation is based on understanding that the producer price is determine by the border price, and that the consumer price responds to adjustments in the producer price. For example, an decrease in the market-to-border marketing margin (*IMARG*) means that producers receive a higher price for exports even if the border price is unchanged, and consequently the domestic consumer price must also rise. While a fall in the domestic marketing margin (*MARG*) does not affect the producer price, it does reduce the band between the producer and consumer prices. Thus the consumer price falls.

[4] These tariffs – and value added taxes (VAT) – are not uniformly enforced (World Bank, 2003), in fact Bockel (2002) suggests that realistically only half of all import transactions are actually taxed.

Consumer prices for the three importable items (*mc*) – rice, fertilizer and non-agricultural products – are related to the border price by the commodity specific border-to-market marketing margin and by potential import subsidies (*isub*):

$$PC_{im,urbrich,1} = PM_{im} * (1 + IMARG_{im})(1 - isub_{im}) \qquad (42\text{-}44)$$

Prices that consumers face during the lean period ($t = 2$) for all nine commodities are marked up above the harvest ($t = 1$) prices by commodity-specific storage costs[5] (*STCOST*):

$$PC_{c,urbrich,2} = PC_{c,urbrich,1}(1 + STCOST_c) \qquad (45\text{-}53)$$

Since these seasonal storage costs are applicable only to rice, maize and roots and tubers, they are set to zero for the remaining six commodities – i.e. prices are invariant over seasons for these "annual" commodities.

Rural consumer prices differ from urban consumer prices by an internal marketing margin (*INTMARG*) that reflects transportation and marketing costs that can differ by commodity and season (18 equations).

$$PC_{c,rurrich,t} = PC_{c,urbrich,t} * (1 + INTMARG_{c,t}) \qquad (54\text{-}71)$$

This internal margin is negative for products that are primarily exported from rural to urban areas (rice, maize, roots and tubers, cash crops, other food), and is positive for those goods flowing from urban to rural areas (non food, fertilizers). The combination of seasonal storage costs and internal marketing margins that vary by season, permit us to calibrate the model consistently with the stylized fact that seasonal price variation is greater in more remote rural areas (Minten and Randrianarison, 2003). Further, by making a distinction between the urban-border (*IMARG*) and the urban-rural (*INTMARG*) margins, we more realistically capture the differing transaction costs and policies toward road maintenance. For example, while the road east from Antananarivo to the major port in Toamasina has been reasonably well maintained over the years, roads west from Antananarivo to rural areas are generally of inferior quality. Clearly in this instance, policies designed to reduce the urban-border marketing margin (*IMARG*) have not had a completely simultaneous effect on reducing the urban-rural margin (*INTMARG*).[6]

All of the consumer prices above have been defined for non-poor households. We assume that poor and non-poor households within any given milieu face the same prices. Thus there is one urban price for each commodity during each season (18 equations),

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[5] These storage costs are assumed to apply equally to imports and locally produced seasonal products to capture the seasonal variation in both domestic and international prices.
[6] The exception is, of course, for those rural area that are situated on the road between Antananarivo and Toamasina.

$$PC_{c,urbpoor,t} = PC_{c,urbrich,t} \qquad (72\text{-}89)$$

and one rural price (18 equations),

$$PC_{c,rurpoor,t} = PC_{c,rurrich,t} \,. \qquad (90\text{-}107)$$[7]

Finally, price indices for each household group are included to reflect changes in prices weighted by their shares of consumption:

$$PINDEX_h = \sum_i \sum_t \left(pcwt_{i,h,t} * \frac{PC_{i,h,t}}{PC0_{i,h,t}} \right) \qquad (108\text{-}111)$$

2.3.2 Supply Block

There are 75 equations in this block that describe production of agricultural crops, livestock, and nonfood products by each of the four household types (*h*). This specification allows for simulations such as improvements in agricultural productivity and increased input use to have differential effects on households.

Household supply of the five food crops (*f*) – fine grains, course grains, roots and tubers, cash crops, and other food products – is determined by (a) the total quantity of land available to each household, (b) the share of that land allocated to the specific crops, and (c) the associated yield for the crops. We begin with an initial total amount of land under cultivation ($area_0$). For the most part, land can be reallocated by each household group among the food crops in order to maximize profits. Thus the share of land owned by household group *h* allocated to the cultivation of food crop *f* ($SH_{h,f}$) is determined by the prices of all food crops (*ff*), giving us 20 equations (4 x 5):

$$\log(SH_{h,f}) = \alpha^s_{h,f} + \sum_{ff} \beta^s_{h,f,ff} \log(PP_{ff,h}) \qquad (112\text{-}131)$$

We do not restrict the sum of the shares to one (i.e. not $\sum_h \sum_f SH_{h,f} = 1$), thus land inputs are endogenously determined even though land is not explicitly traded. If the shares add up to more than one following a simulation, then extensification is practiced.[8] As is discussed later in Appendix I, the substitution and expansion elasticities are nonetheless

[7] In one of the simulations, however, we allow these prices to differ – a fertilizer subsidy targeted to the poor.

[8] We recognize, however, that given the existing degree of agricultural extensification in Madagascar, further expansions are largely limited fragile or denuded soil. Thus the model does not fully capture the effects of extensification. Further, as is discussed in Appendix I, reallocation of land that takes place through extensification is assumed to take place at the margin. In other words, farmers are not likely to reallocate more productive lowland rice plots to, say, maize. Rather, less productive upland plots are the more likely candidate.

quite small reflecting the difficulties inherent in switching crops and in bringing new productive land into production.[9]

The 20 equations for the yields of food crops *f* for household groups *h* ($YLD_{h,f}$) are also represented in log-linear form as a function of output prices and input (*in*) prices (proxying for conditional input demand):

$$\log(YLD_{h,f}) = \alpha^{y}_{h,f} + \beta^{y}_{h,f,f}\log(PP_{f,h}) + \sum_{in}\gamma^{y}_{h,f,in}\log(PC_{in,h,2}) \qquad (132\text{-}151)$$

where the coefficients represent price elasticities. Total household supply to the market is then determined as the product of the initial area of cultivated land, the share of land devoted to the crop, and the yield. Further, it is adjusted for losses and use of the output for seed (*loss*), and for any related conversion factors (e.g. paddy to rice) (*conv*):

$$HSCR_{h,f} = area_0 * SH_{h,f} * YLD_{h,f} * \overline{(1 - loss_f)} * \overline{conv_f}\ . \qquad (152\text{-}171)$$

Total supply of each of the five food crops is the sum of household supply:

$$SCR_f = \sum_h HSCR_{h,f} \qquad (172\text{-}176)$$

Household supply of livestock ($HSLV_h$) and non-agricultural production ($HSNF_h$) are represented as functions of own producer prices. And as with food crops, total market supply of livestock (*SLV*) and non-agricultural production (*SNF*) are equal to the sums of the varying household supplies:

$$\log(HSLV_h) = \alpha^{l}_{h} + \beta^{l}_{h,l,l}\log(PP_{l,h}) \qquad (177\text{-}180)$$

$$SLV = \sum_h SLV_h \qquad (181)$$

$$\log(HSNF_h) = \alpha^{nf}_{h} + \beta^{nf}_{h,nf,nf}\log(PP_{nf,h}) \qquad (182\text{-}185)$$

$$SNF = \sum_h HSNF_h \qquad (186)$$

2.3.3 Input Demand Block

Household group *h*'s demand for agricultural input *in* ($HDIN_{h,in}$) is a function of the price of the input and prices of the food crops for which the input is used. For the two inputs – fertilizer and traction – this results in 8 household demand equations:

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[9] This also follows from the observation that profit-maximizing conditions are not the sole criteria for production decisions. As noted in World Bank (2003), issues of food security as well as traditions often impact farmers' decisions affecting their abilities to diversify into other products.

$$\log(HDIN_{h,in}) = \alpha_h^f + \sum_f \beta_{h,f,in}^f \log(PP_{f,h}) + \gamma_{h,in}^f \log(PC_{in,h,2}) \qquad (187\text{-}194)$$

Total demand for the two inputs is simply the sum of the household demands:

$$DIN_{in} = \sum_h HDIN_h \qquad (195\text{-}196)$$

2.3.4 Consumption Block

Demand for each of the seven consumption items (*i*) – rice, maize, roots and tubers, cash crops, livestock, other food products, and non-food products – by the four household groups in each season (56 equations), $HC_{h,i,t}$, is modeled as an Almost Ideal Demand System (AIDS) (Deaton and Muelbauer, 1980):

$$\log(HC_{h,i,t}) = \alpha_{h,i,t}^h + \sum_j \beta_{h,i,j,t}^h \log(PC_{j,h,t}) + \gamma_{h,i,t}^h \log(YH_h) \qquad (197\text{-}252)$$

where YH_h is household income defined below. Note that these consumption levels only differ across seasons for rice, maize and roots and tubers – the "seasonal" commodities. Total demand for the seven consumption commodities is the sum of the household demands:

$$CONS_i = \sum_h \sum_t HC_{h,i,t} \qquad (253\text{-}259)$$

2.3.5 Income Block

Agricultural incomes in the four household groups ($YHAG_h$) are the sum of the values of crop and livestock production, less input costs:

$$YHAG_h = \sum_f (PP_{f,h} * SCR_{h,f}) + (PP_{l,h} * SLV_{h,f}) - \sum_{in} (PC_{in,h} * DIN_{h,in}) \qquad (260\text{-}263)$$

Total household incomes ($YHAG_h$) are the sum of agricultural incomes and exogenously determined non-agricultural income, with non-agricultural income adjusted by the price index:

$$YH_h = YHAG_h + \overline{YHNAG_h} * PINDEX \qquad (264\text{-}267)$$

2.3.6 Equilibrium Conditions

Equilibrium in the economy requires that each of the nine product markets clears. For each of the five food crops (*f*), this means that total quantity supplied (sum of domestic supply and net imports) is equal to the total quantity demanded (demand by households as well as animal feed):

$$SCR_f + M_f = CONS_f + \overline{FEED}_f \quad (268\text{-}272)$$

Note that net imports are fixed at zero for the three non-tradable food crops – course grains, roots and tubers, and other foods.

Total livestock (l) and non-agricultural products (nf) supplies are defined analogously to food crops (noting that livestock is a non-tradable), though domestic demand is limited to household demand:

$$SLV_l = CONS_l \quad (273)$$

$$SNF_{nf} + M_{nf} = CONS_{nf} \quad (274)$$

Supply of importable inputs – fertilizer – derives entirely from imports, while the supply of non-tradable inputs that are marketed[10] – traction – is exogenously determined by the current local supply.

$$M_{mn} = DIN_{mn} \quad (275)$$

$$\overline{SDIN_{dn}} = DIN_{dn} \quad (276)$$

Given that demand for draft power is not uniform throughout the year, instead occurring during peak periods characterized by supply bottlenecks, and that supply is slow to respond for various reasons including credit constraints, we opt to model the supply of traction as perfectly inelastic.[11]

In total, these 276 equations correspond to the 276 endogenous variables permitting the model to be solved. The original GAMS code using the NLP solver provided by Lundberg and Rich (2002), was adapted to solve this revised system of equations and to run the simulations described below. A summary of the revised GAMS code appears in Appendix II.

Finally, once the systems of equations were solved, we used changes in the average real income levels of each household group to simulate the effects of the policy experiments on urban, rural and national poverty. This was done by scaling the household consumption aggregate levels in the 2001 nationally representative household survey data up or down by the percent change in the real income levels for the corresponding household groups. Poverty measures were then applied to these new distributions using the original poverty line[12] to derive the simulated effects on poverty. These were then

[10] As differentiated from land and seed, that are not marketed but do enter the model as inputs.

[11] While stocks of draft animals can and do accumulate, they are also frequently hit by negative shocks such as disease and family deaths requiring animal sacrifices (Freudenberger, 1999, and World Bank, 2003) thus dampening supply responses.

[12] This is slightly different from Stifel and Thorbecke (2003) and Decaluwe et al. (1999), in which hypothesized nominal income distributions and poverty lines are scaled (in the former, shifted in the latter). Note that the household consumption aggregates are scaled by the change in real incomes, thus producing

compared to the baseline poverty levels that are consistent with the estimates of INSTAT (2002).

2.4 Strengths, Weaknesses and Future Extensions of the Model

Before describing the data and the calibration exercise, to better understand the model it is worthwhile to highlight its major strengths and weaknesses of the model, and to list several extensions that may be pursued in the future.

The primary strength of the model is that it explicitly takes into account the seasonal (lean vs. harvest) variation in prices of major agricultural products. Further, it provides a mechanism to examine the effects of different policies designed to reduce this seasonal price variability (i.e. reducing storage costs and seasonal urban-rural marketing margins). Another strength of the model is that production decisions are derived from yield function. This allows production decisions to be influenced by output and input relative price changes.

As with all multi-market and CGE models, a primary weaknesses of this model is that average incomes of the household groups are modeled assuming distributional neutrality. This is exacerbated, in part, by the fact that there are only four household groups defined for this model, and that the rural poor account for 60 percent of the population. Possible extensions to this model include (a) redefining the welfare groups to consider the poorest 50 percent of the population instead of the observed 70 percent poor, (b) including more narrowly defined household groups, and (c) developing a macro-micro simulation model that explicitly models the intra-group distributions using household survey data (Cogneau and Robilliard, 2000, and Pereira da Silva and Bourguignon, 2003).

A second possible extension would be one in which the rice market is modeled more explicitly along the lines of the risk/food security model described in World Bank (2003). Whereas the current model has a continuously differentiable rice supply curve, this extension could be represented by a kinked supply curve in which the elasticity of land allocation (out of rice into other crops) is close to zero for producer prices at or below the threshold level where "highly vulnerable micro producers" break even in rice production (approx. FMG 800), is relatively low for prices below a "food-security" point, and then is larger for all prices above this level. This extension would necessarily need to be combined with a redefinition of the household groups to include more remote areas in which producer prices fall to the thresholds described by the kinks.[13] The average rural rice price calibrated in the current model (see Table 5 in the next section) which does not account for intra-rural variation is well above the break-even price.

A final extension could be one in which the environmental effects of fertilizer application is modeled explicitly. This would include both the negative effects of the actual applications, but also the positive externalities associated with the decreased pressure on

an estimate of the new real incomes. Further note that scaling the consumption aggregates is intra-group inequality neutral.

[13] Or by dropping the simplifying assumption of perfect substitution between domestic and imported rice.

the land (e.g. fewer incentives to practice slash-and-burn – *tavy*[14] – cultivation techniques) that follows from higher levels of agricultural productivity.

3. Data & Calibration

Three types of data are needed to calibrate the model to a baseline solution that describes Madagascar in 2001:

1. Levels: Production, consumption, income and input levels must be defined for all commodities and household groups.

2. Prices: Initial consumer and producer prices are estimated for each commodity. They also define the marketing margins.

3. Behavioral Parameters: These are the demand and supply elasticities (β's and γ's in the equations above), some of which are estimated from survey data while others are best guesses in the absence of reliable data.

In calibrating the model, we benefited from previous multi-market models for Madagascar (Dostie, et al., 2000, and Lundberg and Rich, 2002). In particular, we update Lundberg and Rich's (2002) baseline solution[15] using the 2001 household survey (Enquete Prioritaire Aupres des Menages, EPM) and 2001 census of communes collected by Cornell University[16], as well as national accounts data and input from informed sources at the Ministry of Agriculture.[17] In what follows, we describe the baseline solution of the model and the methods and data used to derive it.

3.1 Levels

Using the consumption aggregate prepared by INSTAT and Oxford University (INSTAT, 2002) from the 2001 EPM multi-purpose survey of 5,080 households, we classified households into the four groups – Urban Non Poor, Urban Poor, Rural Non Poor, and Rural Poor – and estimated average income levels for these groups. The poverty line we use here is the one estimated by INSTAT (2002), in which 69.6 percent of the population was found to be poor.

As Table 1 indicates, while 77 percent of the population resides in rural areas, 86 percent of the poor are rural dwellers. Conversely, 44 percent of urban residents are poor, where households are considered to be poor if their per capita incomes (level of per capita household consumption) fall below FMG 928,000 per year.

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[14] World Bank (2002) cautions that while increasing productivity is a necessary condition to reduce slash-and-burn, it is not a sufficient condition given the influence of population pressures, lack of access to markets, conflict avoidance issues, cultural traditions and politics on deforestation.
[15] The Lundberg and Rich (2002) model was calibrated using the 1999 EPM.
[16] These data were collected as part of the USAID-funded *Ilo* project (http://mango.human.cornell.edu/ilo/).
[17] The initial version of this model was presented to officials of the Ministry of Agriculture on April 11, 2003. Feedback from this meeting strongly influenced the structure of the model, and further communications with participants assisted in determining appropriate elasticity estimates.

Table 1: Households

	Share of Population	Per Capita Income*	Agricultural Income as a Share of Total
Urban Non Poor	12.6	2259.2	0.10
Urban Poor	9.8	556.4	0.15
Rural Non Poor	17.7	1899.1	0.72
Rural Poor	59.8	455.7	0.80

* Average per capita household consumption aggregate
('000 FMG per annum)
Source: Baseline simulation

The average of the regionally deflated per capita household consumption aggregates for each household group is used to proxy for household income in the model. These per capita incomes range from FMG 2.3 million for the urban non poor, to FMG 456 thousand for the rural poor. As would be expected, the share of income derived from agriculture is much higher in rural areas than in urban areas, and for poorer households than for richer households.

Table 2: Household Production & Supply
'000 tons/year

	Rice, wheat	Maize, millet, sorghum	Roots & Tubers	Cash Crops	Other Foods
Production					
Urban Non Poor	125.9	11.2	97.8	6.8	5.4
Urban Poor	141.3	17.9	225.2	69.3	20.8
Rural Non Poor	636.1	86.4	840.5	80.5	29.0
Rural Poor	1616.6	202.0	2194.7	235.7	347.3
Total	2519.9	317.5	3358.1	392.3	402.4
Yield (tons/ha)	1.8	1.1	4.5	1.0	1.4
Land Area (1000 ha)	1400	289	746	387	287
Supply*					
Urban Non Poor	73.6	10.1	88.0	6.1	4.8
Urban Poor	82.7	16.1	202.6	62.4	18.7
Rural Non Poor	372.2	77.8	756.4	72.4	26.1
Rural Poor	946.0	181.8	1975.1	212.2	312.5
Total	1474.5	285.7	3022.1	353.1	362.1

* Supply is production less seed converted to consumable goods (e.g. paddy to rice), less feed for animals and losses.
Source: Baseline simulation

Turning to the sources of income for agricultural households, total production and supply by each household group are presented in Table 2. These quantities are based on estimates from survey and Ministry of Agriculture data.

Rice production is estimated to total 2.5 million tons per year. This corresponds to 1.4 million hectares of land[18] allocated to rice production, and an average yield of 1.8 tons per hectare[19]. After subtracting paddy used for seed (10 percent) and converting to rice, and then subtracting losses and animal feed, we find that total supply of rice is 1.5 million tons per year. The rural poor are the largest producers of rice, accounting for over 64 percent of total supply compared to their 60 percent share of the population, while the rural non poor provide only five percent of total supply even though they comprise over 12 percent of the population. The urban poor provide just under six percent of the rice supplied in the economy, less than their 10 percent share of the population. Finally, the rural nonpoor provide 25 percent of total rice supply, compared to their population share of 18 percent.

The second most important group of agricultural commodities in terms of the quantity of land allocated to it (746 thousand hectares) is roots and tubers. With yields of 4.5 tons per hectare, some 3.4 million tons are produced annually. As with rice, the bulk of roots and tubers are produced in rural areas (90 percent), and in particular by the poor (65 percent). Approximately nine percent of cultivated land is devoted to the production of maize, millet, sorghum and other course grains, while some 12 percent is allocated to cash crops. We note, however, that the latter is limited to regions that are particularly suitable for production of vanilla, cloves, coffee, sugar cane, tobacco, cotton and sisal – e.g. certain areas the North, Northeast and South.[20]

Table 3 shows the levels of commodity consumption and how they are distributed across household groups. Consumption is broken down into final consumption and intermediate consumption (i.e. agricultural inputs).[21] A total of 1.7 million tons of rice were estimated to be consumed in Madagascar in 2001. This is greater than the total domestic supply of rice by the quantity of rice imported – 212 thousand tons (or 13 percent of the milled equivalent of production). Of this amount, the rural poor consume 45 percent, while the rural non poor consume 39 percent. In rural areas, rice consumption accounts for over a third of the value of total consumption, whereas in urban areas it accounts for approximately a quarter.[22] Overall, the 2.7 million tons of roots and tubers consumed

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[18] Note that this represents cultivated area as opposed to physical area. In other words, if a 0.5 hectare plot of land is used twice in a year to cultivate rice, then it is counted as 1.0 hectares allocated to rice production.
[19] MADIO (2002), Minten et al. (1998), and Roubaud (1997) found yields that ranged from 1.5 to 2.0 tons per hectare.
[20] As such, the elasticity of substitution between annual crops and cash crops is very low. This is discussed further in Appendix I.
[21] These two types of consumption are included together to emphasize the fact that farming households are simultaneously consumers and producers.
[22] Because the rural poor are the major rice producers, they are also net sellers of rice as measured in terms of quantities (i.e. they sell 188.6 thousand tons per year on net). But because of the seasonal variation in

account for approximately a fifth of the value of total consumption. The rural poor consume some 60 percent of this total, while the rural non poor consume 25 percent.

Table 3: Household Consumption
'000 tons per year

	Rice	Maize, millet, sorghum	Roots & Tubers	Cash Crops	Live-stock	Other Foods	Fertilizer	Traction*
Urban Non Poor	194.0	21.1	153.1	0.7	16.3	117.7	0.6	2.2
Urban Poor	84.3	17.5	182.7	3.0	6.9	35.6	0.6	2.1
Rural Non Poor	651.2	97.4	728.1	14.6	20.1	94.1	2.2	9.3
Rural Poor	757.4	133.8	1622.5	1.3	25.0	94.7	2.2	44.4
Total	1686.9	269.9	2686.4	19.7	68.4	342.0	5.5	58.0

* Thousand days
Source: Baseline simulation

In Table 4, we illustrate the seasonal consumption patterns for rice, course grains and roots and tubers. Since the recent household survey data does not measure seasonal consumption patterns, we update Dostie et al.'s (2002) baseline simulation[23] to calibrate this portion of the model.

Table 4: Seasonal Consumption
'000 tons per six months

	Rice		Course Grains		Roots & Tubers	
	Harvest	Lean	Harvest	Lean	Harvest	Lean
Urban Non Poor	104.8	89.2	10.1	10.9	72.0	81.2
Urban Poor	45.5	38.8	8.4	9.1	85.9	96.8
Rural Non Poor	351.6	299.5	46.8	50.7	342.2	385.9
Rural Poor	409.0	348.4	64.2	69.6	762.6	859.9
Total	910.9	776.0	129.5	140.3	1262.6	1423.8

Consistent with Dostie et al., households substitute roots and tubers and course grains for rice during the lean season when prices for the latter rise both absolutely and relatively (see discussion below). Rice consumption drops by 15 percent from 911,000 tons in the six month period immediately following the harvest to 776,000 tons in the lean period, whereas consumption of roots and tubers increases during this same period by 14 percent from 1.3 million tons to 1.4 million tons.

consumer prices (see Table 5), they are net buyers of rice as measured in terms of values (i.e. they buy FMG 411.9 million per year on net). That the rural poor are net buyers in value terms will help us to understand the simulation results presented in the next section. Note that the model does not restrict the household groups to remain net buyers or sellers as production and consumption decisions are separable.

[23] Which itself is estimated from seasonal price variation, but for six time periods instead of two.

Returning to Table 3, the 20,000 tons of cash crops consumed each year, three-quarters of which is consumed by rural non-poor households, represents six percent of total supply. The remaining 333,000 tons is exported. Total livestock consumption is estimated at 68,000 tons per year. The latest nationally representative estimates of quantities produced that are available come from the 1993 EPM, and as such our estimates do not differ from Lundberg and Rich's own updated estimate. Nine kilograms of live weight meat is produced per person per year, which is equivalent to domestic demand. In other words, domestic supply is equal to domestic demand for this non-traded commodity.

Finally, demand for agricultural inputs appear in the last two columns of Table 3. Bockel (2002) finds that some 5,500 tons of fertilizer are imported each year constituting total supply. Based on use patterns estimated from the 2001 EPM, we determine that 80 percent of this is used in rural areas.[24] Given that use of tractors is extremely limited, traction refers generally to animal draft, the demand for which is some 58,000 days per year. This small amount, most of which is found in rural areas, reflects the degree to which manual labor – inelastically supplied in this model – is an important agricultural input. The alternative to the use of draft power to plow and stomp fields is human labor.

3.2 Prices

Baseline consumer and producer prices (Table 5) were estimated from the 2001 Cornell commune census for rice and from unit values from the 2001 EPM data for all other food crops. Seasonal margins are consistent with Minten and Randrianarison (2003) and Barrett (1996) for rice and with Dostie et al (2002) for course grains and roots and tubers. There are two particular points to make about consumer prices. The first is that for seasonal crops – rice, course grains, and roots and tubers – the seasonal margins are

Table 5: Consumer and Producer Prices
FMG per kg

	Consumer Prices				*Producer Prices*	
	Urban		Rural			
	Harvest	Lean	Harvest	Lean	Urban	Rural
Rice	2173	2499	1521	2573	1672	1170
Course Grains	1073	1180	815	1097	825	627
Roots & Tubers	999	1049	799	923	769	615
Cash Crops	3031	3031	2274	2274	2332	1749
Livestock	6498	6498	4548	4548	4998	3499
Other Foods	3770	3770	3016	3016	2900	2320
Non Food	1955	1955	2248	2248	1504	1729
Fertilizer	2500	2500	2875	2875	1923	2212
Traction*	500	500	575	575	384	442

** 100 FMG per day*
Source: Baseline simulation

[24] Stifel et al (2003) find that within rural areas fertilizer use declines dramatically with the degree of remoteness. Thus we caution that the benefits of fertilizer use in rural areas are not evenly distributed, and that simulations affecting the demand for fertilizer will most likely affect the least remote areas where fertilizer is primarily used.

larger in rural areas. For example, during the lean period rice prices in rural areas are 69 percent higher than during the harvest period, whereas the lean-period rice prices are only 15 percent higher than harvest rice prices in urban areas.[25] In fact, from the 2001 commune census data, we find the urban-rural marketing margin for rice switches between seasons, with urban prices higher during the harvest period and rural prices higher during the lean season (Minten and Randrianarison, 2003). This is consistent with what Barrett (1996) calls “inter-seasonal flow reversals” that follow from rice flowing from rural to urban areas in the post-harvest period where it is stored, and then flowing back to rural areas again when farming households exhaust their stocks and become food buyers. Note then that the larger inter-seasonal rice price variation in urban areas is a consequence of both the costs of storage and transportation costs.[26]

Second, prices of course grains and roots and tubers are higher during the lean period relative to the harvest, the margins are smaller relative to rice. For example in rural areas, prices for course grains are 35 percent higher in the lean period. Thus since the relative price of course grains to rice falls from 0.65 to 0.57 between seasons, it is not surprising that households substitute course grains for rice during the lean season (Table 4). The same phenomenon occurs with for cash crops.

Differences in average consumer prices for cash crops and other foods estimated using the EPM 2001 data were not statistically significant. As such, we assume that they do not vary by season, though they do differ across regions. Finally, producer prices differ from harvest period consumer prices by the marketing margin.

3.3 Elasticities

As described in the discussion of the model, crop production is a function of land allocated to products and to the respective yields. As such, there are no direct price elasticities of supply. Instead, there are price elasticities for the share of land allocated to crops, and price elasticities for per hectare yields of crops. These elasticities are a combination of direct estimates from the 2001 EPM data, as well as collaborative best guesses. Initial elasticity estimates and *guesstimates* were circulated among Ministry of Agriculture officials whose input helped formulate the set of elasticities used here.

Consumption and income elasticities are taken from Lundberg and Rich (2002), who use some Ravelosoa et al. (1999) estimates directly (e.g. rice, course grains, non-food), and aggregate others using volume-weighted averages (e.g. other food). All of the elasticities are described in further detail in Appendix I.

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[25] Using monthly retail-level data from 1983, Barrett (1996) finds a similar pattern of greater inter-season variability in average prices in rural areas, but also observes greater intra-season variability in prices in rural areas. Moreover, he finds an intra-seasonal reversal of the flow of rice trade.

[26] This generalization masks much of the heterogeneity in urban-rural trade flows. Nonetheless, it does capture the phenomenon that storage often takes place in less remote and urban areas (Minten and Randrianarison, 2003).

4. Policy Simulations & Results

Five types of policy simulations are analyzed using this model: (1) a reduction in the tariffs imposed on rice (fine grain) imports; (2) an improvement in the rural infrastructure manifesting itself in reduced transactions costs and marketing margins; (3) a reduction in storage costs, and a combination of reduced transportation and storage costs to reduce seasonal price variation; (4) the introduction of a subsidy on fertilizer imports; and (5) an increase in rice productivity following from improved extension services and/or high yielding varieties, and from more intensive use of exogenously determined inputs. For each of the simulations, we begin by highlighting the important outcomes and then discuss the mechanisms through which these outcomes occur.

4.1 Rice Trade Liberalization

Despite the fact that rice is the major staple crop produced throughout most of Madagascar,[27] the country is a net importer of rice. This has been the case since 1970 when production stagnated and demand increased sharply in the presence of rapid population growth. Following a rather liberal policy toward agricultural commerce in the 1980s, the government introduced a 30 percent import tax in 1991 in response to concerns over the effect of low prices on producers. The level of this tax changed frequently throughout the 1990s, and now the current effective tariff is relatively high at 35 percent – a 15 percent import tax and a 20 percent value added tax applied to imports.

Two policies are simulated here – a 20 percent reduction in the tariff on rice imports and a 20 percent increase in the tariff. For the former, this means that the effective tax on imports falls from 35 percent to 32 percent, while for the latter, the effective tax rises to 38 percent. We note, however, that since not all importers currently appear to pay the tariff, the simulations of the tariff changes may overestimate the effects of the policy changes.

The major outcomes of the simulated 20 percent reduction in rice import tariffs are (see Tables 6a and 6b):

a. Rice prices drop by 2.2 percent, pulling down the prices of all non-traded commodities by 0.8 percent (livestock) to 5.2 percent (course grains).

b. Real incomes rise in rural areas (0.2 percent for poor households, and 0.8 percent for non poor), remain unchanged for the urban rich, and fall by 0.4 percent for the urban poor. National poverty falls by 0.2 percent as the rural headcount ratio falls 0.2 percent.

c. Demand for rice and roots and tubers increase by 0.4 percent and 0.2 percent, respectively, while demand for all other consumption commodities decline. The net effect of the changes in consumption of food items is a 0.4 percent increase in calorie

[27] In parts of southern Toliara province, cassava is a primary staple crop (Paternostro et al., 2000, Dostie et al., 2002).

Table 6a: Effects of Changes in Rice Tariffs On Production and Consumption in Madagascar

Percentage Change

	Baseline	20% drop in tariff	20% rise in tariff
Production (Total Domestic Supply)			
Rice	**1,474.4**	-0.1	0.1
Course Grains	**285.7**	-0.4	0.4
Roots & Tubers	**3,022.2**	0.2	-0.2
Cash Crops	**353.1**	0.4	-0.4
Livestock	**68.4**	-0.2	0.2
Other Food	**362.1**	-0.1	0.1
Non-Food	**151.9**	0.0	0.0
Consumption			
Rice	**1,686.9**	0.4	-0.4
Course Grains	**269.9**	-0.4	0.4
Roots & Tubers	**2,686.4**	0.2	-0.2
Cash Crops	**19.7**	-0.5	0.5
Livestock	**68.4**	-0.2	0.2
Other Food	**342.0**	-0.1	0.1
Non-Food	**592.5**	-2.0	2.0
Input Demand			
Fertilizer	**5.5**	-1.4	1.4
Traction	**58.0**	0.0	0.0
Net Imports			
Rice	**212.6**	3.8	-3.8
Cash Crops	**-333.4**	0.4	-0.4
Non-Food	**440.6**	-2.7	2.7
Fertilizer	**5.5**	-1.4	1.4
Government Import Revenues			
Rice	**80.1**	-5.1	5.1
Non-Food	**204.4**	-2.7	2.7
Fertilizer	**0.8**	-1.4	1.4
Land Shares			
Rice	**0.5**	0.0	0.0
Course Grains	**0.1**	-0.2	0.2
Roots & Tubers	**0.2**	0.3	-0.2
Cash Crops	**0.1**	0.3	-0.3
Other Food	**0.1**	0.0	0.1
Total	**1.0**	0.1	-0.1

	Baseline	20% drop in tariff	20% rise in tariff
Household Demand			
Rice			
Harvest			
Urban Nonpoor	**104.8**	0.6	-0.6
Urban Poor	**45.5**	0.3	-0.3
Rural Nonpoor	**351.6**	0.5	-0.5
Rural Poor	**409.0**	0.2	-0.2
Lean			
Urban Nonpoor	**89.2**	0.6	-0.6
Urban Poor	**38.8**	0.3	-0.3
Rural Nonpoor	**299.5**	0.5	-0.5
Rural Poor	**348.4**	0.2	-0.2
Course Grains			
Harvest			
Urban Nonpoor	**10.1**	0.0	0.0
Urban Poor	**8.4**	-0.5	0.5
Rural Nonpoor	**46.8**	-0.3	0.3
Rural Poor	**64.2**	-0.6	0.6
Lean			
Urban Nonpoor	**10.9**	0.0	0.0
Urban Poor	**9.1**	-0.5	0.5
Rural Nonpoor	**50.7**	-0.3	0.3
Rural Poor	**69.6**	-0.6	0.6
Roots & Tubers			
Harvest			
Urban Nonpoor	**72.0**	0.6	-0.6
Urban Poor	**85.9**	0.3	-0.3
Rural Nonpoor	**342.2**	0.4	-0.4
Rural Poor	**762.6**	0.1	-0.1
Lean			
Urban Nonpoor	**81.2**	0.6	-0.6
Urban Poor	**96.8**	0.3	-0.3
Rural Nonpoor	**385.9**	0.4	-0.4
Rural Poor	**859.9**	0.1	-0.1

	Baseline	20% drop in tariff	20% rise in tariff
Household Demand (cont.)			
Cash Crops			
Urban Nonpoor	**0.7**	-0.4	0.4
Urban Poor	**3.0**	-0.7	0.7
Rural Nonpoor	**14.6**	-0.5	0.5
Rural Poor	**1.3**	-0.8	0.8
Livestock			
Urban Nonpoor	**16.3**	-0.1	0.1
Urban Poor	**6.9**	-0.5	0.5
Rural Nonpoor	**20.1**	0.1	-0.1
Rural Poor	**25.0**	-0.5	0.5
Other Foods			
Urban Nonpoor	**117.7**	0.0	0.0
Urban Poor	**35.6**	-0.4	0.4
Rural Nonpoor	**94.1**	0.0	0.0
Rural Poor	**94.7**	-0.3	0.3
Non-Food Products			
Urban Nonpoor	**216.3**	-1.3	1.3
Urban Poor	**72.3**	-2.1	2.1
Rural Nonpoor	**151.1**	-1.8	1.8
Rural Poor	**152.8**	-3.1	3.1
Fertilizer			
Urban Nonpoor	**0.6**	-1.4	1.4
Urban Poor	**0.6**	-1.4	1.4
Rural Nonpoor	**2.2**	-1.4	1.4
Rural Poor	**2.2**	-1.4	1.4
Traction			
Urban Nonpoor	**21.8**	0.0	0.0
Urban Poor	**21.2**	0.0	0.0
Rural Nonpoor	**93.2**	0.0	0.0
Rural Poor	**44.4**	0.0	0.0

Source: Simulation Results

Table 6b: Effects of Changes in Rice Tariffs On Prices and Incomes in Madagascar

Percentage Change

	Baseline	20% drop in tariff	20% rise in tariff
Urban Consumer Prices			
Harvest Period			
Rice	**2,173.0**	-2.2	2.2
Course Grains	**1,072.6**	-5.2	5.2
Roots & Tubers	**999.1**	-0.9	0.9
Lean Period			
Rice	**2,499.0**	-2.2	2.2
Course Grains	**1,179.8**	-5.2	5.2
Roots & Tubers	**1,049.1**	-0.9	0.9
Cash Crops	**3,031.4**	0.0	0.0
Livestock	**6,497.7**	-0.8	0.8
Other Food	**3,770.5**	-1.0	1.0
Non-Food	**1,954.8**	0.0	0.0
Fertilizer	**2,500.0**	0.0	0.0
Traction	**499.7**	-2.8	2.8
Urban Producer Prices			
Rice	**1,671.5**	-2.2	2.2
Course Grains	**825.1**	-5.2	5.2
Roots & Tubers	**768.6**	-0.9	0.9
Cash Crops	**2,331.9**	0.0	0.0
Livestock	**4,998.3**	-0.8	0.8
Other Food	**2,900.4**	-1.0	1.0
Non-Food	**1,503.7**	0.0	0.0

	Baseline	20% drop in tariff	20% rise in tariff
Rural Consumer Prices			
Harvest Period			
Rice	**1,521.1**	-2.2	2.2
Course Grains	**815.2**	-5.2	5.2
Roots & Tubers	**799.3**	-0.9	0.9
Lean Period			
Rice	**2,573.9**	-2.2	2.2
Course Grains	**1,097.2**	-5.2	5.2
Roots & Tubers	**923.2**	-0.9	0.9
Cash Crops	**2,273.6**	0.0	0.0
Livestock	**4,548.4**	-0.8	0.8
Other Food	**3,016.4**	-1.0	1.0
Non-Food	**2,248.0**	0.0	0.0
Fertilizer	**2,875.0**	0.0	0.0
Traction	**574.6**	-2.8	2.8
Rural Producer Prices			
Rice	**1,170.1**	-2.2	2.2
Course Grains	**627.0**	-5.2	5.2
Roots & Tubers	**614.8**	-0.9	0.9
Cash Crops	**1,748.9**	0.0	0.0
Livestock	**3,498.8**	-0.8	0.8
Other Food	**2,320.3**	-1.0	1.0
Non-Food	**1,729.2**	0.0	0.0

	Baseline	20% drop in tariff	20% rise in tariff
Incomes			
Nominal Income			
Urban Nonpoor	**2,259.4**	-1.1	1.1
Urban Poor	**556.5**	-1.6	1.6
Rural Nonpoor	**1,899.2**	-0.7	0.7
Rural Poor	**455.8**	-1.3	1.3
Real Income			
Urban Nonpoor	**100.0**	0.0	0.0
Urban Poor	**100.0**	-0.4	0.4
Rural Nonpoor	**100.0**	0.8	-0.8
Rural Poor	**100.0**	0.2	-0.2
Nominal Agricultural Income			
Urban Nonpoor	**226.0**	-1.3	1.3
Urban Poor	**83.4**	-3.8	3.8
Rural Nonpoor	**1,367.5**	-0.4	0.4
Rural Poor	**364.6**	-1.3	1.3
Real Agricultural Income			
Urban Nonpoor	**100.0**	-0.2	0.2
Urban Poor	**100.0**	-2.6	2.6
Rural Nonpoor	**100.0**	1.1	-1.1
Rural Poor	**100.0**	0.2	-0.2
Caloric Intake			
Urban Nonpoor	**2,121.0**	0.4	-0.4
Urban Poor	**996.1**	0.1	-0.1
Rural Nonpoor	**3,380.1**	0.4	-0.4
Rural Poor	**1,436.9**	0.0	0.0
Poverty (Headcount Ratio)			
Urban	**44.1**	0.0	0.0
Rural	**77.1**	-0.3	0.3
National	**69.6**	-0.2	0.2

Source: Simulation Results

consumption by the non poor, a 0.1 increase for the urban poor, and no change for the rural poor.

d. Rice imports rise by 3.8 as production falls (0.1 percent) and consumption rises (0.4 percent). But because the tariff rate is reduced, government import revenues from rice fall by 5 percent. As demand and consequently imports of non-food products and fertilizer fall, so do tariff revenues. Overall, government import revenues decline 3.4 percent.

e. Total land use increases by 0.1 percent as farmers shift out of course-grain production into roots and tubers and cash crops.

The immediate effect of the tariff reduction from 15 to 12 percent (total tax decline from 35 to 32 percent) is a 2.2 percent fall in rice prices across the board – both consumer and producer prices. This, however, translates to only a negligible fall in rice production because falling prices[28] of other staple crops make substitution to these crops less attractive. Indeed, prices of course grains fall by over 5 percent, resulting in a 0.4 percent fall in production in this sector.

With prices of traded goods fixed by world prices, the relative producer prices of cash crops to other crops rise by 2.3 percent, making this a relatively attractive crop. But since substitution possibilities from staple to cash crops are limited, especially in the one-year time frame of the model, the share of land allocated to cash crops only increases by 0.3 percent, and production increases by 0.4 percent.

These limited production substitution possibilities and declining producer prices translate into a fall in nominal agricultural incomes and total nominal incomes of over 1 percent (note that non-food producer prices do not change, and consequently production and any revenues from this sector are unchanged). These declining incomes also have effects on demand for consumer goods in addition to price changes.

Rice consumption increases by 0.4 percent following the fall in rice prices as the substitution effect outweighs the effect of falling nominal incomes. Non-poor households witness the largest gains with rice consumption rising by more than 0.5 percent, whereas rice consumption among the poor rises by no more than 0.3 percent. Consumption of roots and tubers also increases as the effect of declining prices and incomes have the same positive effect on demand for inferior goods. Again, consumption among the non-poor increases by a larger percentage than among the poor.

Since prices of traded goods such as cash crops and non-food products are unchanged, they become more expensive relative to non-traded goods, the prices of which all fall. The combination of lower nominal incomes and higher relative prices translates into

[28] For those who are critical of the realism of falling prices given downward rigidities of prices, it is best to think of these price changes as relative declines. This model abstracts from inflation, holding it constant at zero. By allowing for general price inflation, declining prices observed in the simulations can be conceptualized as rising at rates slower than the overall rise.

reduced demand for cash crops and non food. Consumption of livestock and other food also falls, largely driven by the declines in nominal incomes.

The decline in the prices of non-traded goods translates into 0.8 percent and a 0.2 percent rise in real incomes of the rural non poor and poor, respectively. As a result, rural poverty falls by 0.3 percent. However, calories consumed by the rural poor do not increase because the increase in calorie consumption from increased rice and cassava consumption is offset by the drop in consumption of course grains, cash crops, livestock and other foods. The substantially larger increase in rice consumption by the rural non poor means that caloric consumption for this group rises by 0.4 percent. Conversely, although the real incomes of the urban poor fall by 0.4 percent, their caloric intake rises marginally by 0.1 percent.

Given the marginal decline in rice production and the increase in consumption, rice imports rise by 3.8 percent. Tariff revenues from rice imports fall, however, as the increase in the volume is insufficient to cover the loss from the lower tariff. Overall, tariff revenues fall by 3.4 percent as imports of (i) fertilizer fall 1.4 percent because rice and course-grain production drops following the decline in producer prices and (ii) non-food fall because lower nominal incomes and higher relative prices diminish demand.

Finally, the simulated effects of a 20 percent rise in rice import tariffs are equal and opposite to those of a 20 percent decline.

4.2. Infrastructure Improvements

The next set of simulations examine the effects of improving the infrastructure and lowering transaction costs. The large farmgate-to-market, urban-to-rural and urban-to-border margins have negative impacts on regional and international trade. We simulate 20 percent reductions in each of these margins to determine the general effects of infrastructure improvements. Then we reduce urban-rural and urban-border margins each for both rice and fertilizer in to examine the effects of policies targeted at reducing transaction costs for these particular important commodities.

The major outcomes of the simulated 20 percent reduction in the farmgate-market price differentials (*MARG*) are (see Tables 7a and 7b):

a. Producer prices all rise by at least 4.8 percent, except for cash crops since the producer prices of export goods, determined by the world market, remain unchanged. Consumer prices of cash crops and roots and tubers fall by 4.6 percent and 0.8 percent, respectively, and rise for course grains, livestock and other foods by 1.7 percent, 0.2 percent and 0.5 percent respectively.

b. Both nominal and real incomes rise, with poor households benefiting from the greatest gains. Real incomes of the rural poor rise by 3.8 percent, while the urban poor witness 2.1 percent increases. This translates into a 2.2 percent fall in national poverty.

Table 7a: Effects of Changes in Transaction Costs On Production and Consumption in Madagascar
Percentage Change

	Baseline	20% drop farmgate-market margin	20% drop urban-rural margin	20% drop urban-border margin
Production (Total Domestic Supply)				
Rice	**1,474.4**	0.2	0.5	0.5
Course Grains	**285.7**	0.1	0.3	-0.4
Roots & Tubers	**3,022.2**	0.1	-0.1	0.3
Cash Crops	**353.1**	-0.6	-0.1	1.5
Livestock	**68.4**	1.5	1.1	0.3
Other Food	**362.1**	0.7	0.7	0.1
Non-Food	**151.9**	2.4	-0.1	-2.3
Consumption				
Rice	**1,686.9**	0.7	0.2	0.8
Course Grains	**269.9**	0.1	0.3	-0.5
Roots & Tubers	**2,686.4**	0.2	-0.1	0.4
Cash Crops	**19.7**	2.5	0.5	-1.1
Livestock	**68.4**	1.5	1.1	0.3
Other Food	**342.0**	0.8	0.7	0.1
Non-Food	**592.5**	3.7	9.4	5.0
Input Demand				
Fertilizer	**5.5**	3.0	7.3	1.7
Traction	**58.0**	0.0	0.0	0.0
Net Imports				
Rice	**212.6**	4.1	-1.9	3.2
Cash Crops	**-333.4**	-0.8	-0.1	1.7
Non-Food	**440.6**	4.2	12.6	7.6
Fertilizer	**5.5**	3.0	7.3	1.7
Government Import Revenues				
Rice	**80.1**	4.1	-1.9	3.2
Non-Food	**204.4**	4.2	12.6	7.6
Fertilizer	**0.8**	3.0	7.4	1.7
Land Shares				
Rice	**0.5**	0.0	0.0	-0.1
Course Grains	**0.1**	0.0	0.0	-0.6
Roots & Tubers	**0.2**	-0.2	-0.5	0.3
Cash Crops	**0.1**	-0.5	-0.5	0.7
Other Food	**0.1**	0.3	0.2	0.0
Total	**1.0**	-0.1	-0.2	0.1

	Baseline	20% drop farmgate-market margin	20% drop urban-rural margin	20% drop urban-border margin
Household Demand				
Rice				
Harvest				
Urban Nonpoor	**104.8**	0.0	0.2	0.1
Urban Poor	**45.5**	0.5	0.1	0.6
Rural Nonpoor	**351.6**	0.2	-2.5	0.7
Rural Poor	**409.0**	1.4	-0.2	1.1
Lean				
Urban Nonpoor	**89.2**	0.0	0.2	0.1
Urban Poor	**38.8**	0.5	0.1	0.6
Rural Nonpoor	**299.5**	0.2	0.8	0.7
Rural Poor	**348.4**	1.4	3.1	1.1
Course Grains				
Harvest				
Urban Nonpoor	**10.1**	-0.5	-1.3	-1.2
Urban Poor	**8.4**	-0.1	-1.3	-0.5
Rural Nonpoor	**46.8**	-0.4	2.4	-0.9
Rural Poor	**64.2**	0.6	4.9	-0.1
Lean				
Urban Nonpoor	**10.9**	-0.5	-1.3	-1.2
Urban Poor	**9.1**	-0.1	-1.3	-0.5
Rural Nonpoor	**50.7**	-0.4	-3.8	-0.9
Rural Poor	**69.6**	0.6	-1.4	-0.1
Roots & Tubers				
Harvest				
Urban Nonpoor	**72.0**	-0.2	0.1	-0.2
Urban Poor	**85.9**	-0.1	0.1	0.3
Rural Nonpoor	**342.2**	-0.2	-2.2	-0.1
Rural Poor	**762.6**	0.4	-0.5	0.6
Lean				
Urban Nonpoor	**81.2**	-0.2	0.1	-0.2
Urban Poor	**96.8**	-0.1	0.1	0.3
Rural Nonpoor	**385.9**	-0.2	-0.5	-0.1
Rural Poor	**859.9**	0.4	1.2	0.6

	Baseline	20% drop farmgate-market margin	20% drop urban-rural margin	20% drop urban-border margin
Household Demand (cont.)				
Cash Crops				
Urban Nonpoor	**0.7**	1.9	-0.2	-2.5
Urban Poor	**3.0**	2.7	-0.3	-2.2
Rural Nonpoor	**14.6**	2.4	0.5	-0.7
Rural Poor	**1.3**	4.1	2.3	-1.5
Livestock				
Urban Nonpoor	**16.3**	0.3	0.1	-0.5
Urban Poor	**6.9**	1.4	-0.1	-0.1
Rural Nonpoor	**20.1**	0.7	-0.2	0.9
Rural Poor	**25.0**	3.0	3.1	0.5
Other Foods				
Urban Nonpoor	**117.7**	0.0	-0.2	-0.4
Urban Poor	**35.6**	0.9	-0.3	0.0
Rural Nonpoor	**94.1**	0.4	0.3	0.7
Rural Poor	**94.7**	2.0	2.6	0.4
Non-Food Products				
Urban Nonpoor	**216.3**	0.8	0.0	2.1
Urban Poor	**72.3**	2.9	-0.3	2.8
Rural Nonpoor	**151.1**	2.6	13.7	8.7
Rural Poor	**152.8**	9.4	23.0	6.5
Fertilizer				
Urban Nonpoor	**0.6**	3.0	0.7	1.7
Urban Poor	**0.6**	3.0	0.7	1.7
Rural Nonpoor	**2.2**	3.0	9.0	1.7
Rural Poor	**2.2**	3.0	9.0	1.7
Traction				
Urban Nonpoor	**21.8**	0.0	-7.1	0.0
Urban Poor	**21.2**	0.0	-7.1	0.0
Rural Nonpoor	**93.2**	0.0	0.6	0.0
Rural Poor	**44.4**	0.0	0.6	0.0

Source: Simulation Results

Table 7b: Effects of Changes in Transaction Costs On Prices and Incomes in Madagascar
Percentage Change

	Baseline	20% drop farmgate-market margin	20% drop urban-rural margin	20% drop urban-border margin
Urban Consumer Prices				
Harvest Period				
Rice	**2,173.0**	0.0	0.0	-4.6
Course Grains	**1,072.6**	1.7	6.2	-8.6
Roots & Tubers	**999.1**	-0.8	0.5	-2.3
Lean Period				
Rice	**2,499.0**	0.0	0.0	-4.6
Course Grains	**1,179.8**	1.7	6.2	-8.6
Roots & Tubers	**1,049.1**	-0.8	0.5	-2.3
Cash Crops	**3,031.4**	-4.6	0.0	4.8
Livestock	**6,497.7**	0.2	-1.2	1.0
Other Food	**3,770.5**	0.5	0.2	-0.2
Non-Food	**1,954.8**	0.0	0.0	-4.6
Fertilizer	**2,500.0**	0.0	0.0	-4.6
Traction	**499.7**	6.1	17.5	-1.3
Urban Producer Prices				
Rice	**1,671.5**	4.8	0.0	-4.6
Course Grains	**825.1**	6.6	6.2	-8.6
Roots & Tubers	**768.6**	4.0	0.5	-2.3
Cash Crops	**2,331.9**	0.0	0.0	4.8
Livestock	**4,998.3**	5.1	-1.2	1.0
Other Food	**2,900.4**	5.3	0.2	-0.2
Non-Food	**1,503.7**	4.8	0.0	-4.6

	Baseline	20% drop farmgate-market margin	20% drop urban-rural margin	20% drop urban-border margin
Rural Consumer Prices				
Harvest Period				
Rice	**1,521.1**	0.0	8.6	-4.6
Course Grains	**815.2**	1.7	13.0	-8.6
Roots & Tubers	**799.3**	-0.8	5.5	-2.3
Lean Period				
Rice	**2,573.9**	0.0	-0.6	-4.6
Course Grains	**1,097.2**	1.7	7.8	-8.6
Roots & Tubers	**923.2**	-0.8	3.2	-2.3
Cash Crops	**2,273.6**	-4.6	6.7	4.8
Livestock	**4,548.4**	0.2	7.3	1.0
Other Food	**3,016.4**	0.5	5.2	-0.2
Non-Food	**2,248.0**	0.0	-2.6	-4.6
Fertilizer	**2,875.0**	0.0	-2.6	-4.6
Traction	**574.6**	6.1	14.4	-1.3
Rural Producer Prices				
Rice	**1,170.1**	4.8	8.6	-4.6
Course Grains	**627.0**	6.6	13.0	-8.6
Roots & Tubers	**614.8**	4.0	5.5	-2.3
Cash Crops	**1,748.9**	0.0	6.7	4.8
Livestock	**3,498.8**	5.1	7.3	1.0
Other Food	**2,320.3**	5.3	5.2	-0.2
Non-Food	**1,729.2**	4.8	-2.6	-4.6

	Baseline	20% drop farmgate-market margin	20% drop urban-rural margin	20% drop urban-border margin
Incomes				
Nominal Income				
Urban Nonpoor	**2,259.4**	0.5	0.0	-2.7
Urban Poor	**556.5**	2.0	-0.2	-2.4
Rural Nonpoor	**1,899.2**	0.9	2.5	-1.4
Rural Poor	**455.8**	3.7	6.4	-1.9
Real Income				
Urban Nonpoor	**100.0**	0.4	-0.1	0.1
Urban Poor	**100.0**	2.1	-0.5	0.4
Rural Nonpoor	**100.0**	1.0	-0.8	2.1
Rural Poor	**100.0**	3.8	2.7	1.5
Nominal Agricultural Income				
Urban Nonpoor	**226.0**	4.5	-1.2	-1.5
Urban Poor	**83.4**	13.8	-3.0	0.2
Rural Nonpoor	**1,367.5**	1.3	2.2	-0.7
Rural Poor	**364.6**	4.6	7.1	-1.6
Real Agricultural Income				
Urban Nonpoor	**100.0**	4.4	-1.3	1.3
Urban Poor	**100.0**	14.0	-3.2	3.1
Rural Nonpoor	**100.0**	1.4	-1.1	2.9
Rural Poor	**100.0**	4.8	3.4	1.8
Caloric Intake				
Urban Nonpoor	**2,121.0**	0.0	0.0	-0.2
Urban Poor	**996.1**	0.4	-0.1	0.3
Rural Nonpoor	**3,380.1**	0.1	-0.9	0.4
Rural Poor	**1,436.9**	1.0	1.1	0.8
Poverty (Headcount Ratio)				
Urban	**44.1**	-2.5	0.0	-0.4
Rural	**77.1**	-2.2	-1.7	-0.8
National	**69.6**	-2.2	-1.4	-0.8

Source: Simulation Results

c. Domestic consumption of all commodities rise, though most of this is driven by changes in demand of rural poor households. Rice consumption increases by 0.7 percent, cash crops by 2.5 percent and non food by 3.7 percent. Consumption of course grains rise marginally despite decreased demand by all household other than the rural poor. Caloric intake of the urban poor and rural households all increase, with the poor benefiting the most.

d. Domestic production of all commodities except cash crops rises by as much as 2.4 percent for non-food products and by as little as 0.1 percent for course grains and roots and tubers. Rice production, which grows by 0.2 percent, is insufficient to meet the 0.7 percent growth in domestic demand. Consequently, rice imports rise by 4.1 percent. Government import revenues increase by 4.2 percent as imports of non-food products and fertilizer also increase.

e. Total land use decreases as farmers shift land away from the production of roots and tuber and cash crops.

The immediate effect of the reduction in the farmgate-to-market margin is that all producer prices rise relative to consumer prices. This manifests itself in the absolute rise in the levels of all producer prices, except cash crops prices which are determined by the export market. Producer rice and non food-prices rise by 4.8 percent as consumer prices are set by the price of imports. Prices of course grains, livestock and other foods received by producers increase by more than 5 percent.

In reaction to these price changes, domestic production of all commodities except cash crops increase. Rice production increases by 0.2 percent, livestock by 1.5 percent and non-food production by 2.4 percent. Demand for agricultural inputs increase leading to a 3 percent rise in fertilizer imports. Land use, however, declines slightly as production of cash crops declines in response to the decline in producer prices for this crop *relative* to others. Less land is allocated to roots and tubers, though production of this crop increase as other inputs – fertilizer and labor[29] – increase.

The rise in producer prices and production levels translates into higher nominal and real incomes. Poor households benefit the most in terms of the magnitudes of these changes. Incomes of the urban poor rise by over 2 percent, while those of the rural poor increase by just under 4 percent. As such, urban poverty falls by 2.5 percent and rural poverty falls by 2.2 percent.

It is thus not surprising that as incomes rise, consumption of all items increases. In particular, demand for such luxuries (i.e. those with income elasticities greater than 1) as cash crops, livestock and non-food products rise the most – especially for the rural poor. For example, while total consumption of non-food products increases by 3.7 percent,

[29] Although labor is not modeled explicitly here, it is assumed to be supplied inelastically to some form of production. Thus, embedded in the yield response elasticities is a mechanism through which labor is allocated among production possibilities.

demand of the rural poor increases by 9.4 percent versus the 0.8 percent increase of the urban non poor.

Although course grains are inferior goods (i.e. negative income elasticities) for the non poor and roots and tubers are inferior goods for all but the rural poor, consumption of these products increases overall. This is the case despite the fact that prices of course grains increase as well. This increase in consumption is driven entirely by demand from the rural poor. As illustrated in Table 7a, demand for course grains and roots and tubers falls for urban households and rural non poor. But the increase in demand from rural poor households stemming from the income increases outweighs these declines.

On net, caloric intake of the poor rises by 1 percent, while the urban poor increase their consumption of calories by 0.4 percent. Because of relatively large substitutions of consumption by the non poor out of course grains and roots and tubers into other food items, calorie intake is not greatly affected. In fact, the simulation finds that the consumption of calories by the urban non poor does not change at all, while that of the rural non poor increases by only 0.1 percent.

The major outcomes of the simulated 20 percent reduction in the urban-rural price differentials (*INTMARG*) are (see Tables 7a and 7b):

a. Except for non-food items, rural producer prices levels rise by at least 5 percent (other food and roots and tubers) and by as much as 13 percent (course grains). In urban areas, producer prices of course grains, roots and tuber and other foods increase, and producer prices of livestock decrease.

b. Seasonal consumer price variation diminishes in rural areas, but not in urban areas. Rural rice prices fall in the lean period by 0.6 percent, and rise in the harvest period by 8.6 percent. Rural consumer prices for course grains, roots and tubers, cash crops, livestock and other food increase. Aside from the 6.2 percent increase for course grains and the 1.2 percent drop for livestock, consumer prices are relatively stable.

c. Nominal incomes of the urban non poor are not affected, while those of the urban poor fall by 0.2 percent. Nominal incomes of the rural non poor increase by 2.5 percent, while those of the rural poor rise by 6.4 percent. Rising prices, however, deflate these gains to such an extend that only the rural poor experience an increase in real income. Urban poverty is unchanged, while rural poverty falls by 1.7 percent.

d. Domestic consumption rises for all commodities except for roots and tubers. Again, most of this is driven by changes in demand of rural poor households. Rice consumption increases by 0.2 percent, livestock by 1.1 percent and non food by 9.4 percent. Consumption of course grains rises marginally despite decreased demand by all household other than the rural poor. Caloric intake of the urban poor and the rural non poor actually falls, while that of the urban non poor is unchanged and that of the rural poor increases by 1.1 percent.

e. Production of rice (0.5 percent), course grains (0.3 percent), livestock (1.1 percent) and other foods (0.7 percent) increase, while root and tuber, cash crop and non-food production fall marginally.

f. Total land use decreases by 0.2 percent as farmers shift land away from the production of roots and tuber and cash crops.

This simulation is inherently different from the previous one which addressed the farmgate-to-market margin affecting urban and rural prices symmetrically. In this case, where the urban-to-rural margin is reduced, prices change asymmetrically and consequently have different effects on urban and rural areas.

The immediate effect of infrastructure improvements that reduce urban-rural transaction costs on prices depends on the direction of trade, whether it be rural-urban or urban-rural. This is seen most clearly for rice where urban prices remain unchanged, and where harvest-period rural prices rise by 8.6 percent as the cost of transporting rice to urban areas falls (note: harvest-period urban consumption of rice rises while rural consumption falls). Conversely, when the direction of rice trade changes in the lean period, rural rice consumption prices fall by 0.6 percent, and consumption rises (by over 3 percent for the poor). For such commodities as course grains, roots and tubers, cash crops, livestock and other foods, which flow from rural areas to urban centers throughout the year, both rural producer and consumer prices rise. On the other hand, non food and fertilizer prices in rural areas fall as the cost of transporting them from urban areas falls.

In urban areas, as the prices of tradable goods remain unchanged, the prices (both consumer and producer) of course grains (6.2 percent), roots and tubers (0.5 percent) and other foods (0.2 percent) rise, and the prices of livestock fall by 1.2 percent.

In response to these price changes and to the fall in rural fertilizer prices, rice (0.5 percent), course-grain (0.3 percent), livestock (1.1 percent) and other-food (0.7 percent) production increase, while production of roots and tubers, cash crops and non food is curtailed by 0.1 percent. Note that the drop in non-food production occurs in rural areas where producer prices fall by 2.6 percent. In fact, non-food production rises in urban areas. Despite a rise in rural cash-crop prices, production falls as farmers respond to increasing returns to other crops and to the higher cost of draft power.

The net effect of increasing rice, course grain, livestock and other-food production, falling cash crop production, and the fall in producer prices for livestock on the nominal incomes of the urban non-poor is negative as agricultural incomes fall by 1.2 percent. This is entirely offset by an increase in income from higher urban non-food production. The negative impact of the fall in livestock prices and of the rise in traction prices outweigh the benefits of expanded output of non-food products for the urban poor, leaving them with nominal incomes 0.2 percent lower than the baseline. Rural households, on the other hand, experience rising nominal agricultural and total incomes following from higher producer prices and higher production levels.

The income gains in the rural sector are dampened by higher consumer prices to such an extent that the real incomes of the rural non poor fall by 0.8 percent. Since the overall rise in urban consumer prices is not as large as in rural areas, real incomes of the urban households fall but not by as much as they do for the rural non poor. The nominal income gains of the rural poor outweigh the price effects, as real incomes for this group rise by 2.7 percent.

Consumption of rice in urban areas increases despite lower nominal incomes, as urban households substitute rice for course grains and roots and tubers, the prices of which rise relative to those of rice. Rural rice consumption falls during the harvest period in response to rising prices, and rises in the lean period as households substitute intertemporally and across food crops. On net, rice consumption of non poor households in rural areas falls by 1 percent, and rises by 1.3 percent for poor households. Total rice consumption thus rises by 0.2 percent. Since the rice production response was larger, excess demand for rice falls. Consequently rice imports fall by 2 percent. Government import revenues, however, grow by 8.5 percent as demand for imported fertilizer increases by over 7 percent, and as demand for non-food products increases by over 9 percent.

The effects of targeted reductions of the urban-rural margins (i.e. streamlining distribution mechanisms) are more muted. Though are generally similar to the general reduction in urban-rural transaction costs, some differences are worth highlighting. Starting with rice (Tables 8a and 8b), we note that rural seasonal price variation does not diminish by as much because only rice is affected. As in the previous simulation, rural rice prices rise by 8.6 percent in the harvest period and fall by 0.6 percent in the lean period. Here, however, the price of course grains rises by 9 percent throughout the year, and the price of roots and tubers rises by 2.6 percent. As such, while the rural poor end up better off, with real incomes and caloric consumption increasing and poverty falling, the magnitudes of these changes are considerably smaller than for the general case – e.g. real income rises by 1.3 percent versus 3.1 percent, calorie consumption increases by 0.3 percent versus 1.1 percent, and poverty falls by 0.7 percent versus 1.4 percent.

In this case, all nominal incomes rise as producer prices of non-traded goods rise, and though rising consumer prices wipe out any purchasing power gains in urban areas, real incomes there do not actually fall. The rural non poor continue to suffer from real incomes falling by 0.9 percent.

Rice production increases by marginally more (0.7 percent), but consumption falls by 0.2 percent. As such, net rice imports fall by 6.3 percent instead of 1.9 percent. Overall government tariff revenues do increase, but by only 2.7 percent (versus 8.5 percent) because consumption of non-food items and fertilizer falls.

The reduction of urban-rural margins for fertilizer (Tables 9a and 9b) induces a 0.8 percent increase in rural rice production. But since consumer prices for rice and other traded consumer goods are unaffected, demand is unaffected and the increased

Table 8a: Effects of Changes in Rice Transaction Costs On Production and Consumption in Madagascar

Percentage Change

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Production (Total Domestic Supply)			
Rice	1,474.4	0.7	-0.3
Course Grains	285.7	0.4	-0.9
Roots & Tubers	3,022.2	-0.2	0.4
Cash Crops	353.1	-0.7	0.8
Livestock	68.4	0.7	-0.5
Other Food	362.1	0.3	-0.3
Non-Food	151.9	0.0	0.0
Consumption			
Rice	1,686.9	-0.2	0.8
Course Grains	269.9	0.4	-0.9
Roots & Tubers	2,686.4	-0.3	0.5
Cash Crops	19.7	1.2	-1.1
Livestock	68.4	0.7	-0.5
Other Food	342.0	0.3	-0.3
Non-Food	592.5	4.6	-4.1
Input Demand			
Fertilizer	5.5	3.4	-2.9
Traction	58.0	0.0	0.0
Net Imports			
Rice	212.6	-6.3	8.1
Cash Crops	-333.4	-0.8	0.9
Non-Food	440.6	6.2	-5.5
Fertilizer	5.5	3.4	-2.9
Government Import Revenues			
Rice	80.1	-6.3	8.1
Non-Food	204.4	6.2	-5.5
Fertilizer	0.8	3.4	-2.9
Land Shares			
Rice	0.5	0.1	0.0
Course Grains	0.1	0.3	-0.4
Roots & Tubers	0.2	-0.4	0.5
Cash Crops	0.1	-0.6	0.6
Other Food	0.1	0.1	-0.1
Total	1.0	-0.1	0.2

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Household Demand			
<u>*Rice*</u>			
Harvest			
Urban Nonpoor	104.8	0.3	1.4
Urban Poor	45.5	0.7	0.6
Rural Nonpoor	351.6	-2.5	1.1
Rural Poor	409.0	-1.3	0.4
Lean			
Urban Nonpoor	89.2	0.3	1.4
Urban Poor	38.8	0.7	0.6
Rural Nonpoor	299.5	0.9	1.1
Rural Poor	348.4	2.1	0.4
<u>*Course Grains*</u>			
Harvest			
Urban Nonpoor	10.1	-2.9	0.0
Urban Poor	8.4	-2.4	-1.0
Rural Nonpoor	46.8	4.1	-0.5
Rural Poor	64.2	5.3	-1.3
Lean			
Urban Nonpoor	10.9	-2.9	0.0
Urban Poor	9.1	-2.4	-1.0
Rural Nonpoor	50.7	-3.2	-0.5
Rural Poor	69.6	-2.1	-1.3
<u>*Roots & Tubers*</u>			
Harvest			
Urban Nonpoor	72.0	-0.3	1.2
Urban Poor	85.9	0.0	0.6
Rural Nonpoor	342.2	-1.6	0.8
Rural Poor	762.6	-0.9	0.3
Lean			
Urban Nonpoor	81.2	-0.3	1.2
Urban Poor	96.8	0.0	0.6
Rural Nonpoor	385.9	-0.1	0.8
Rural Poor	859.9	0.6	0.3

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Household Demand (cont.)			
Cash Crops			
Urban Nonpoor	0.7	0.2	-0.7
Urban Poor	3.0	0.6	-1.4
Rural Nonpoor	14.6	1.3	-1.0
Rural Poor	1.3	2.6	-1.6
Livestock			
Urban Nonpoor	16.3	-0.4	-0.2
Urban Poor	6.9	0.1	-1.1
Rural Nonpoor	20.1	0.1	0.1
Rural Poor	25.0	2.0	-1.0
Other Foods			
Urban Nonpoor	117.7	-0.4	-0.1
Urban Poor	35.6	0.1	-0.9
Rural Nonpoor	94.1	0.1	0.1
Rural Poor	94.7	1.5	-0.7
Non-Food Products			
Urban Nonpoor	216.3	1.3	-2.7
Urban Poor	72.3	2.4	-4.3
Rural Nonpoor	151.1	4.7	-3.7
Rural Poor	152.8	10.3	-6.4
Fertilizer			
Urban Nonpoor	0.6	1.4	-2.9
Urban Poor	0.6	1.4	-2.9
Rural Nonpoor	2.2	3.9	-2.9
Rural Poor	2.2	3.9	-2.9
Traction			
Urban Nonpoor	21.8	-2.3	0.0
Urban Poor	21.2	-2.3	0
Rural Nonpoor	93.2	0.2	0
Rural Poor	44.4	0.2	0.0

Source: Simulation Results

Table 8b: Effects of Changes in Rice Transaction Costs On Prices and Incomes in Madagascar

Percentage Change

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Urban Consumer Prices			
Harvest Period			
Rice	**2,173.0**	0.0	-4.6
Course Grains	**1,072.6**	9.0	-10.6
Roots & Tubers	**999.1**	2.6	-1.9
Lean Period			
Rice	**2,499.0**	0.0	-4.6
Course Grains	**1,179.8**	9.0	-10.6
Roots & Tubers	**1,049.1**	2.6	-1.9
Cash Crops	**3,031.4**	0.0	0.0
Livestock	**6,497.7**	2.3	-1.6
Other Food	**3,770.5**	2.4	-2.1
Non-Food	**1,954.8**	0.0	0.0
Fertilizer	**2,500.0**	0.0	0.0
Traction	**499.7**	7.5	-5.7
Urban Producer Prices			
Rice	**1,671.5**	0.0	-4.6
Course Grains	**825.1**	9.0	-10.6
Roots & Tubers	**768.6**	2.6	-1.9
Cash Crops	**2,331.9**	0.0	0.0
Livestock	**4,998.3**	2.3	-1.6
Other Food	**2,900.4**	2.4	-2.1
Non-Food	**1,503.7**	0.0	0.0

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Rural Consumer Prices			
Harvest Period			
Rice	**1,521.1**	8.6	-4.6
Course Grains	**815.2**	9.0	-10.6
Roots & Tubers	**799.3**	2.6	-1.9
Lean Period			
Rice	**2,573.9**	-0.6	-4.6
Course Grains	**1,097.2**	9.0	-10.6
Roots & Tubers	**923.2**	2.6	-1.9
Cash Crops	**2,273.6**	0.0	0.0
Livestock	**4,548.4**	2.3	-1.6
Other Food	**3,016.4**	2.4	-2.1
Non-Food	**2,248.0**	0.0	0.0
Fertilizer	**2,875.0**	0.0	0.0
Traction	**574.6**	7.5	-5.7
Rural Producer Prices			
Rice	**1,170.1**	8.6	-4.6
Course Grains	**627.0**	9.0	-10.6
Roots & Tubers	**614.8**	2.6	-1.9
Cash Crops	**1,748.9**	0.0	0.0
Livestock	**3,498.8**	2.3	-1.6
Other Food	**2,320.3**	2.4	-2.1
Non-Food	**1,729.2**	0.0	0.0

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Incomes			
Nominal Income			
Urban Nonpoor	**2,259.4**	1.2	-2.4
Urban Poor	**556.5**	1.8	-3.3
Rural Nonpoor	**1,899.2**	1.8	-1.5
Rural Poor	**455.8**	4.2	-2.8
Real Income			
Urban Nonpoor	**100.0**	0.0	-0.1
Urban Poor	**100.0**	0.3	-0.8
Rural Nonpoor	**100.0**	-0.9	1.7
Rural Poor	**100.0**	1.3	0.3
Nominal Agricultural Income			
Urban Nonpoor	**226.0**	1.1	-2.7
Urban Poor	**83.4**	3.8	-7.8
Rural Nonpoor	**1,367.5**	1.5	-0.9
Rural Poor	**364.6**	4.5	-2.7
Real Agricultural Income			
Urban Nonpoor	**100.0**	-0.1	-0.4
Urban Poor	**100.0**	2.2	-5.5
Rural Nonpoor	**100.0**	-1.2	2.4
Rural Poor	**100.0**	1.7	0.4
Caloric Intake			
Urban Nonpoor	**2,121.0**	-0.2	0.8
Urban Poor	**996.1**	0.1	0.1
Rural Nonpoor	**3,380.1**	-0.7	0.8
Rural Poor	**1,436.9**	0.3	0.1
Poverty (Headcount Ratio)			
Urban	**44.1**	-0.4	0.0
Rural	**77.1**	-0.8	-0.3
National	**69.6**	-0.7	-0.2

Source: Simulation Results

Table 9a: Effects of Changes in Fertilizer Transaction Costs On Production and Consumption in Madagascar
Percentage Change

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Production (Total Domestic Supply)			
Rice	**1,474.4**	0.7	1.4
Course Grains	**285.7**	0.2	0.5
Roots & Tubers	**3,022.2**	0.1	0.1
Cash Crops	**353.1**	0.2	0.4
Livestock	**68.4**	0.0	0.0
Other Food	**362.1**	0.0	0.1
Non-Food	**151.9**	0.0	0.0
Consumption			
Rice	**1,686.9**	0.0	-0.1
Course Grains	**269.9**	0.3	0.5
Roots & Tubers	**2,686.4**	0.1	0.1
Cash Crops	**19.7**	-0.1	-0.1
Livestock	**68.4**	0.0	0.0
Other Food	**342.0**	0.0	0.1
Non-Food	**592.5**	-0.2	-0.4
Input Demand			
Fertilizer	**5.5**	0.8	1.9
Traction	**58.0**	0.0	0.0
Net Imports			
Rice	**212.6**	-5.2	-10.5
Cash Crops	**-333.4**	0.2	0.4
Non-Food	**440.6**	-0.3	-0.5
Fertilizer	**5.5**	0.8	1.9
Government Import Revenues			
Rice	**80.1**	-5.2	-10.5
Non-Food	**204.4**	-0.3	-0.5
Fertilizer	**0.8**	0.8	1.9
Land Shares			
Rice	**0.5**	0.0	0.0
Course Grains	**0.1**	0.0	0.0
Roots & Tubers	**0.2**	0.0	0.0
Cash Crops	**0.1**	0.1	0.2
Other Food	**0.1**	0.0	0.0
Total	**1.0**	0.0	0.0

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Household Demand			
<u>*Rice*</u>			
Harvest			
Urban Nonpoor	**104.8**	0.0	0.0
Urban Poor	**45.5**	-0.1	-0.1
Rural Nonpoor	**351.6**	0.0	-0.1
Rural Poor	**409.0**	0.0	-0.1
Lean			
Urban Nonpoor	**89.2**	0.0	0.0
Urban Poor	**38.8**	-0.1	-0.1
Rural Nonpoor	**299.5**	0.0	-0.1
Rural Poor	**348.4**	0.0	-0.1
<u>*Course Grains*</u>			
Harvest			
Urban Nonpoor	**10.1**	0.3	0.6
Urban Poor	**8.4**	0.2	0.5
Rural Nonpoor	**46.8**	0.3	0.5
Rural Poor	**64.2**	0.3	0.5
Lean			
Urban Nonpoor	**10.9**	0.3	0.6
Urban Poor	**9.1**	0.2	0.5
Rural Nonpoor	**50.7**	0.3	0.5
Rural Poor	**69.6**	0.3	0.5
<u>*Roots & Tubers*</u>			
Harvest			
Urban Nonpoor	**72.0**	0.1	0.2
Urban Poor	**85.9**	0.1	0.1
Rural Nonpoor	**342.2**	0.1	0.2
Rural Poor	**762.6**	0.1	0.1
Lean			
Urban Nonpoor	**81.2**	0.1	0.2
Urban Poor	**96.8**	0.1	0.1
Rural Nonpoor	**385.9**	0.1	0.2
Rural Poor	**859.9**	0.1	0.1

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Household Demand (cont.)			
Cash Crops			
Urban Nonpoor	**0.7**	-0.1	-0.1
Urban Poor	**3.0**	-0.2	-0.2
Rural Nonpoor	**14.6**	0.0	-0.1
Rural Poor	**1.3**	0.0	-0.1
Livestock			
Urban Nonpoor	**16.3**	0.0	0.0
Urban Poor	**6.9**	-0.2	-0.2
Rural Nonpoor	**20.1**	0.0	0.0
Rural Poor	**25.0**	0.0	0.0
Other Foods			
Urban Nonpoor	**117.7**	0.0	0.1
Urban Poor	**35.6**	-0.1	0.0
Rural Nonpoor	**94.1**	0.1	0.1
Rural Poor	**94.7**	0.1	0.1
Non-Food Products			
Urban Nonpoor	**216.3**	-0.2	-0.3
Urban Poor	**72.3**	-0.5	-0.6
Rural Nonpoor	**151.1**	-0.2	-0.4
Rural Poor	**152.8**	-0.1	-0.3
Fertilizer			
Urban Nonpoor	**0.6**	-0.2	1.9
Urban Poor	**0.6**	-0.2	1.9
Rural Nonpoor	**2.2**	1.1	1.9
Rural Poor	**2.2**	1.1	1.9
Traction			
Urban Nonpoor	**21.8**	0.0	0.0
Urban Poor	**21.2**	0.0	0.0
Rural Nonpoor	**93.2**	0.0	0.0
Rural Poor	**44.4**	0.0	0.0

Source: Simulation Results

Table 9b: Effects of Changes in Fertilizer Transaction Costs On Prices and Incomes in Madagascar
Percentage Change

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Urban Consumer Prices			
Harvest Period			
Rice	**2,173.0**	0.0	0.0
Course Grains	**1,072.6**	-1.2	-2.4
Roots & Tubers	**999.1**	-0.8	-1.5
Lean Period			
Rice	**2,499.0**	0.0	0.0
Course Grains	**1,179.8**	-1.2	-2.4
Roots & Tubers	**1,049.1**	-0.8	-1.5
Cash Crops	**3,031.4**	0.0	0.0
Livestock	**6,497.7**	0.0	0.0
Other Food	**3,770.5**	-0.3	-0.5
Non-Food	**1,954.8**	0.0	0.0
Fertilizer	**2,500.0**	0.0	-4.6
Traction	**499.7**	-0.4	-0.9
Urban Producer Prices			
Rice	**1,671.5**	0.0	0.0
Course Grains	**825.1**	-1.2	-2.4
Roots & Tubers	**768.6**	-0.8	-1.5
Cash Crops	**2,331.9**	0.0	0.0
Livestock	**4,998.3**	0.0	0.0
Other Food	**2,900.4**	-0.3	-0.5
Non-Food	**1,503.7**	0.0	0.0

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Rural Consumer Prices			
Harvest Period			
Rice	**1,521.1**	0.0	0.0
Course Grains	**815.2**	-1.2	-2.4
Roots & Tubers	**799.3**	-0.8	-1.5
Lean Period			
Rice	**2,573.9**	0.0	0.0
Course Grains	**1,097.2**	-1.2	-2.4
Roots & Tubers	**923.2**	-0.8	-1.5
Cash Crops	**2,273.6**	0.0	0.0
Livestock	**4,548.4**	0.0	0.0
Other Food	**3,016.4**	-0.3	-0.5
Non-Food	**2,248.0**	0.0	0.0
Fertilizer	**2,875.0**	-2.6	-4.6
Traction	**574.6**	-0.4	-0.9
Rural Producer Prices			
Rice	**1,170.1**	0.0	0.0
Course Grains	**627.0**	-1.2	-2.4
Roots & Tubers	**614.8**	-0.8	-1.5
Cash Crops	**1,748.9**	0.0	0.0
Livestock	**3,498.8**	0.0	0.0
Other Food	**2,320.3**	-0.3	-0.5
Non-Food	**1,729.2**	0.0	0.0

	Baseline	20% drop urban-rural margin	20% drop urban-border margin
Incomes			
Nominal Income			
Urban Nonpoor	**2,259.4**	-0.2	-0.3
Urban Poor	**556.5**	-0.4	-0.4
Rural Nonpoor	**1,899.2**	-0.1	-0.2
Rural Poor	**455.8**	-0.1	-0.1
Real Income			
Urban Nonpoor	**100.0**	0.0	0.0
Urban Poor	**100.0**	-0.1	0.1
Rural Nonpoor	**100.0**	0.2	0.3
Rural Poor	**100.0**	0.3	0.5
Nominal Agricultural Income			
Urban Nonpoor	**226.0**	-0.2	0.1
Urban Poor	**83.4**	-1.0	0.2
Rural Nonpoor	**1,367.5**	0.0	-0.1
Rural Poor	**364.6**	0.0	0.0
Real Agricultural Income			
Urban Nonpoor	**100.0**	0.0	0.4
Urban Poor	**100.0**	-0.7	0.7
Rural Nonpoor	**100.0**	0.2	0.4
Rural Poor	**100.0**	0.4	0.7
Caloric Intake			
Urban Nonpoor	**2,121.0**	0.03	0.1
Urban Poor	**996.1**	-0.03	0.0
Rural Nonpoor	**3,380.1**	0.03	0.1
Rural Poor	**1,436.9**	0.03	0.1
Poverty (Headcount Ratio)			
Urban	**44.1**	0.0	-0.2
Rural	**77.1**	-0.3	-0.5
National	**69.6**	-0.2	-0.4

Source: Simulation Results

production simply replaces imports. Nominal incomes fall as the falling cost of agricultural production pulls the prices of non-traded goods down. The falling prices, however, translate into marginally rising rural incomes (rural incomes of the non poor do not fall in this simulation). The net effect is that rural poverty falls by 0.3 percent (versus 1.7 percent), and urban poverty is unaffected. Interestingly, calorie consumption is essentially unaffected.

The major outcomes of the simulated 20 percent reduction in the urban-border price differentials (*IMARG*) are (see Tables 7a and 7b):

a. Prices of imported commodities – rice, non food and fertilizer – fall by 4.6 percent, pulling the prices of staple foods and other foods down with them. Cash-crop prices rise by 4.8 percent with the fall in the cost of transporting commodities to the border for export. Livestock prices also rise, by 1 percent.

b. Real incomes of all households rise, with rural households benefiting the most – 2.1 percent for the non poor and 1.5 percent for the poor. Urban real incomes rise by less than 0.5 percent. Nominal incomes fall by 1.5 percent or more for all household groups. But the decline in most consumer prices, means that the purchasing power of all household groups rise, and poverty falls by 0.8 percent.

c. Rice consumption rises by 0.8 percent. In addition the increase in consumption of roots and tubers (0.4 percent), livestock (0.3 percent) and other food (0.1 percent) offsets the decrease in the consumption of course grains (0.5 percent) and cash crops (1.1 percent), so that calorie intake rises for all but the urban non poor. The rural poor benefit the most as calorie consumption rises by 0.8 percent on average.

d. Production of all agricultural commodities rises except for course grains. Non-food production also falls. The 0.5 percent increase in rice production is less than the increase in consumption, consequently the increase in excess demand results in a 3.2 percent increase in imports. Government revenues from rice imports thus rise by 3.2 percent, and total government import revenues rise by 6.3 percent as imports of non food and fertilizer increase by 7.6 percent and 1.7 percent, respectively.

e. Total land use increases by 0.1 percent as farmers allocate more land to cash crops and roots and tubers, and less to rice and course grains.

Inefficient distribution mechanisms and poor quality infrastructure that link ports with major market centers can be regarded as an equivalent to uniform barriers to international trade. Reducing in the urban-border price differential by means of infrastructure improvement will have a similar effect as a uniform reduction in import and export tariffs.[30] Thus, it is not surprising that the immediate effect of this simulation is to reduce the price of imported goods – rice, non food, and fertilizer – and to raise the price of

[30] Of course, this assumes that such tariffs exist. Even if they do not, excessively high urban-border transaction costs are essentially taxes on imports and exports.

exported goods – cash crops – in both urban and rural areas. Consequently consumption of imported goods rises, and of exported goods falls in response to these price changes.

Domestic supply responses to the producer price changes are not at straightforward, however, because optimally chosen production levels are a function of both output *and* input prices. Let us consider rice production to get a better sense of this. The 4.6 percent fall in the producer price leads to a fall in production, *ceteris paribus*. But since *ceteris* are not *paribus*, and the price of fertilizer inputs falls by 4.6 as well, rice production actually increases by 0.5 percent. This is the case even though the share of land allocated to rice production falls marginally.

The decline in input costs also stimulates production of roots and tubers and cash crops, though the latter is also affected by higher producer prices. With roots and tubers, lower producer and consumer prices follow from the increase in supply. Land allocated to the production of roots and tubers rises by 0.3 percent, while that allocated to cash crop increases 0.7 percent. Overall, land use increases only 0.1 percent as less land is devoted to rice and course grains – 0.1 percent and 0.6 percent, respectively.

The fall in producer prices for all commodities except for cash crops and livestock, lead to lower nominal incomes despite increased production in most sectors. Nominal incomes in urban areas fall by more than in rural areas – 2.5 percent versus less than 2 percent – because of the fall in prices of import-competing non-food products. But, given the fall in consumer prices of most commodities, real incomes all rise above the baseline level.

In terms of household consumption patterns, the combination of lower prices of other commodities and falling nominal incomes results in household substituting out of course grains (0.4 percent fall) into rice (0.5 percent increase) and roots and tubers (0.3 percent increase) – though rice consumption of the rural non poor actually falls by 1 percent. On net, calorie consumption in rural areas rises – by 0.4 percent for the non poor and by 0.8 percent for the poor. Caloric intake of the urban poor increases as well, by 0.3 percent. Because of increased consumption of non-food items at the expense of food items, it falls for the non poor by 0.2 percent.

Urban-border margin reductions targeted to rice (Tables 8a and 8b) and fertilizer (Tables 9a and 9b) again have muted total impacts on aggregate indicators such as poverty and caloric intake. National poverty falls by only 0.2 percent when domestic rice prices fall by 4.6 percent following a 20 percent reduction in the price of transporting imported rice to market centers. This is just a quarter of the change in poverty that follows a 20 percent reduction in the urban-border marketing margin. This follows from the fall in all other consumer prices not being large enough to counteract the drop in nominal incomes in urban areas, and to result in as large increases in real rural incomes. The real incomes of the urban non poor and the urban poor fall by 0.1 percent and 0.8 percent, respectively, while the gains to the rural poor are only 1.7 percent for the nonpoor and 0.3 percent for the poor.

The effect of targeted fertilizer margin reduction has effects that are equivalent to a subsidy. As such, we leave the discussion of these results to the presentation of the fertilizer subsidy simulations below.

The bottom line on these margin reduction simulations is that the rural poor are the primary beneficiaries in most of the scenarios discussed. The one obvious exception is the 20 percent reduction in the urban-border rice marketing margin in which the rural non poor capture most of the benefits in terms of real income and calorie gains (Table 8b). Surprisingly, the rural poor are the only households to benefit from reduced internal (i.e. urban-rural) transportation costs are the rural poor. This model suggests that the urban households and the rural non poor could be a source of resistance to such a policy. Though we will see below that, if combined with a policy to reduce inter-seasonal storage costs, these groups can also benefit.

4.3. Changes in Seasonal Price Variability

Two simulations are employed to address seasonal price stability. The first is a 20 percent reduction in the cost of inter-seasonal storage of food crops. The second is a 20 percent reduction in storage costs combined with a 20 percent reduction in the urban-rural margin. The former reduces the harvest-lean period price differential for food crops equally for all households, while the latter simulates a greater reduction in rural areas where seasonal price variation is documented to be higher. These simulations are much in the spirit of Barrett's (1996) discussion of how improving storage facilities can reduce the variance and skewness of rice prices that follow from inadequate facilities in rural areas and the need to transport rice to and from central storage areas.

The major outcomes of the simulated 20 percent drop in storage costs are (see Tables 10a and 10b):

a. Lean-period consumer rice prices fall by 6.5 percent, and lean-period prices of roots and tubers fall by 2 percent. Price of course grains fall by 6 percent in the harvest-period and by over 10 percent in the lean period.

b. Real incomes of all household groups rise, with the largest increase (2 percent) benefiting the rural poor. Nominal total incomes fall for all groups. But the decline in most consumer prices, means that the purchasing power of all household groups rises, and poverty falls by 1 percent.

c. A slight fall in harvest-period rice consumption is offset by an over two percent increase in lean-period rice consumption as household adjust their inter-temporal consumption patterns. Consequently, annual caloric intake rises for all household groups.

d. Since rice production increases only marginally, and since total rice consumption increases by just under 1 percent, rice imports rise by over 5 percent. Government revenues from rice imports also rise by just over 5 percent, but total import tariff revenues only increase by 0.5 percent as non-food imports fall 1.4 percent.

e. Total land use increases by 0.1 percent, as farmers shift out of course grain production into rice, roots and tubers, and cash crops.

The initial effect of the policy shock is that lean-period consumer prices of rice, course grains and roots and tubers fall relative to harvest period prices. Harvest-period rice prices – dictated by import prices – are unchanged, while lean-period prices fall by 6.5 percent and remain unaffected by supply and demand conditions.[31] Prices of course grains and roots and tubers, however, are affected by supply and demand conditions in addition to the reduction in storage costs. Consequently, we see a slight rise in the harvest period price of roots and tubers followed by a 2 percent fall in lean-period prices. Conversely, prices of course grains actually fall during the harvest period, dropping further by over 10 percent during the lean period.

Several factors result in these price patterns for roots and tubers and course grains. Mapping these out is also illustrative of how other outcomes are directly affected. In particular, following the chain of events that lead to a fall in nominal incomes enlightens the simulation.

Since rice producer prices are not affected by improved storage facilities[32], rice farmers do not have any direct incentive to increase production and incomes are not affected. Consequently, the increase in excess demand for rice is made up through increased imports. Nominal incomes are affected, however, by the decrease in demand for rice substitutes such as course grains. In fact, given the large cross-price elasticity of 1.64 (a one percent drop in the price of rice leads to a 1.64 percent drop in demand for course grains; see Table A4), demand for course grains drops by 0.7 percent. As course grains are supplied entirely by the domestic market, prices fall by 6 percent during the harvest period and by 10 percent during the lean period, and incomes fall as producer prices fall by 6 percent and production falls by 0.7 percent. Note that this substitution from course grains to rice follows even as course grain consumer prices fall because of the declining storage costs. The effect of improved storage facilities in this sector merely dampens the substitution effect.

Falling nominal incomes among farming households lead to drops in demand for other products such as cash crops (0.3 percent) and non-food items (1.1 percent). The former does not affect nominal incomes because the decline in domestic demand is soaked up by exports. However, falling demand for non-food items does affect the revenues of domestic producers, 97 percent of whom are urban dwellers. This is the major contributor to the 1 percent declines in nominal incomes of the urban non-poor and poor.

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[31] Admittedly, storage costs for imported rice are likely to be less than for domestically produced rice since the storage period is shorter (i.e. since the time of import which is not necessarily the same time as the harvest). As such, the fall in prices is likely to be somewhat overstated.
[32] The assumption being that markets are competitive and producers who undertake self-storage pass on the cost savings entirely to the consumers.

Table 10a: Effects of Reduction in Seasonal Price Variability On Production and Consumption in Madagascar
Percentage Change

	Baseline	50% drop in storage costs	20% drop urb-rur mrg & 50 drop strg. Cost
Production (Total Domestic Supply)			
Rice	**1,474.4**	0.2	0.7
Course Grains	**285.7**	-0.7	-0.3
Roots & Tubers	**3,022.2**	0.4	0.3
Cash Crops	**353.1**	0.3	0.2
Livestock	**68.4**	0.1	1.2
Other Food	**362.1**	0.0	0.6
Non-Food	**151.9**	0.0	-0.1
Consumption			
Rice	**1,686.9**	0.8	1.1
Course Grains	**269.9**	-0.7	-0.4
Roots & Tubers	**2,686.4**	0.5	0.4
Cash Crops	**19.7**	-0.3	0.2
Livestock	**68.4**	0.1	1.2
Other Food	**342.0**	0.0	0.7
Non-Food	**592.5**	-1.1	8.3
Input Demand			
Fertilizer	**5.5**	-0.6	6.7
Traction	**58.0**	0.0	0.0
Net Imports			
Rice	**212.6**	5.4	3.8
Cash Crops	**-333.4**	0.4	0.2
Non-Food	**440.6**	-1.4	11.2
Fertilizer	**5.5**	-0.6	6.7
Government Import Revenues			
Rice	**80.1**	5.4	3.8
Non-Food	**204.4**	-1.4	11.2
Fertilizer	**0.8**	-0.6	6.7
Land Shares			
Rice	**0.5**	0.1	0.0
Course Grains	**0.1**	-0.3	-0.4
Roots & Tubers	**0.2**	0.3	-0.2
Cash Crops	**0.1**	0.3	-0.2
Other Food	**0.1**	0.0	0.2
Total	**1.0**	0.1	-0.1

	Baseline	50% drop in storage costs	20% drop urb-rur mrg & 50 drop strg. Cost
Household Demand			
Rice			
Harvest			
Urban Nonpoor	**104.8**	-0.3	-0.1
Urban Poor	**45.5**	-0.5	-0.3
Rural Nonpoor	**351.6**	-0.4	-2.8
Rural Poor	**409.0**	-0.3	-0.5
Lean			
Urban Nonpoor	**89.2**	2.3	2.5
Urban Poor	**38.8**	2.1	2.2
Rural Nonpoor	**299.5**	2.2	3.0
Rural Poor	**348.4**	2.2	5.4
Course Grains			
Harvest			
Urban Nonpoor	**10.1**	1.9	0.5
Urban Poor	**8.4**	1.5	0.1
Rural Nonpoor	**46.8**	1.6	4.0
Rural Poor	**64.2**	1.6	6.5
Lean			
Urban Nonpoor	**10.9**	-2.6	-3.9
Urban Poor	**9.1**	-3.0	-4.3
Rural Nonpoor	**50.7**	-2.9	-6.6
Rural Poor	**69.6**	-2.9	-4.3
Roots & Tubers			
Harvest			
Urban Nonpoor	**72.0**	0.0	0.1
Urban Poor	**85.9**	-0.3	-0.2
Rural Nonpoor	**342.2**	-0.2	-2.4
Rural Poor	**762.6**	-0.3	-0.8
Lean			
Urban Nonpoor	**81.2**	1.3	1.4
Urban Poor	**96.8**	1.1	1.2
Rural Nonpoor	**385.9**	1.2	0.6
Rural Poor	**859.9**	1.0	2.2

	Baseline	50% drop in storage costs	20% drop urb-rur mrg & 50 drop strg. Cost
Household Demand (cont.)			
Cash Crops			
Urban Nonpoor	**0.7**	-0.3	-0.4
Urban Poor	**3.0**	-0.3	-0.6
Rural Nonpoor	**14.6**	-0.3	0.2
Rural Poor	**1.3**	0.0	2.3
Livestock			
Urban Nonpoor	**16.3**	-0.2	-0.1
Urban Poor	**6.9**	-0.2	-0.3
Rural Nonpoor	**20.1**	0.0	-0.1
Rural Poor	**25.0**	0.3	3.4
Other Foods			
Urban Nonpoor	**117.7**	-0.1	-0.3
Urban Poor	**35.6**	-0.2	-0.5
Rural Nonpoor	**94.1**	0.0	0.2
Rural Poor	**94.7**	0.2	2.8
Non-Food Products			
Urban Nonpoor	**216.3**	-1.2	-1.2
Urban Poor	**72.3**	-1.3	-1.6
Rural Nonpoor	**151.1**	-1.4	12.1
Rural Poor	**152.8**	-0.5	22.6
Fertilizer			
Urban Nonpoor	**0.6**	-0.6	0.1
Urban Poor	**0.6**	-0.6	0.1
Rural Nonpoor	**2.2**	-0.6	8.4
Rural Poor	**2.2**	-0.6	8.4
Traction			
Urban Nonpoor	**21.8**	0.0	-7.1
Urban Poor	**21.2**	0.0	-7.1
Rural Nonpoor	**93.2**	0.0	0.6
Rural Poor	**44.4**	0.0	0.6

Source: Simulation Results

Table 10b: Effects of Reduction in Seasonal Price Variability On Prices and Incomes in Madagascar

Percentage Change

	Baseline	50% drop in storage costs	20% drop urb-rur mrg & 50 drop strg. Cost
Urban Consumer Prices			
Harvest Period			
Rice	2,173.0	0.0	0.0
Course Grains	1,072.6	-5.9	0.1
Roots & Tubers	999.1	0.4	1.0
Lean Period			
Rice	2,499.0	-6.5	-6.5
Course Grains	1,179.8	-10.2	-4.4
Roots & Tubers	1,049.1	-2.0	-1.4
Cash Crops	3,031.4	0.0	0.0
Livestock	6,497.7	0.2	-0.9
Other Food	3,770.5	-0.3	-0.1
Non-Food	1,954.8	0.0	0.0
Fertilizer	2,500.0	0.0	0.0
Traction	499.7	-1.2	16.2
Urban Producer Prices			
Rice	1,671.5	0.0	0.0
Course Grains	825.1	-5.9	0.1
Roots & Tubers	768.6	0.4	1.0
Cash Crops	2,331.9	0.0	0.0
Livestock	4,998.3	0.2	-0.9
Other Food	2,900.4	-0.3	-0.1
Non-Food	1,503.7	0.0	0.0

	Baseline	50% drop in storage costs	20% drop urb-rur mrg & 50 drop strg. Cost
Rural Consumer Prices			
Harvest Period			
Rice	1,521.1	0.0	8.6
Course Grains	815.2	-5.9	6.4
Roots & Tubers	799.3	0.4	6.0
Lean Period			
Rice	2,573.9	-6.5	-7.1
Course Grains	1,097.2	-10.2	-3.0
Roots & Tubers	923.2	-2.0	1.3
Cash Crops	2,273.6	0.0	6.7
Livestock	4,548.4	0.2	7.6
Other Food	3,016.4	-0.3	4.9
Non-Food	2,248.0	0.0	-2.6
Fertilizer	2,875.0	0.0	-2.6
Traction	574.6	-1.2	13.1
Rural Producer Prices			
Rice	1,170.1	0.0	8.6
Course Grains	627.0	-5.9	6.4
Roots & Tubers	614.8	0.4	6.0
Cash Crops	1,748.9	0.0	6.7
Livestock	3,498.8	0.2	7.6
Other Food	2,320.3	-0.3	4.9
Non-Food	1,729.2	0.0	-2.6

	Baseline	50% drop in storage costs	20% drop urb-rur mrg & 50 drop strg. Cost
Incomes			
Nominal Income			
Urban Nonpoor	2,259.4	-1.0	-1.0
Urban Poor	556.5	-1.0	-1.2
Rural Nonpoor	1,899.2	-0.6	1.9
Rural Poor	455.8	-0.3	6.1
Real Income			
Urban Nonpoor	100.0	0.1	0.0
Urban Poor	100.0	0.3	-0.2
Rural Nonpoor	100.0	1.7	0.7
Rural Poor	100.0	1.9	4.6
Nominal Agricultural Income			
Urban Nonpoor	226.0	0.2	-1.0
Urban Poor	83.4	0.9	-2.0
Rural Nonpoor	1,367.5	0.1	2.3
Rural Poor	364.6	0.2	7.3
Real Agricultural Income			
Urban Nonpoor	100.0	1.3	0.1
Urban Poor	100.0	2.2	-1.0
Rural Nonpoor	100.0	2.4	1.1
Rural Poor	100.0	2.4	5.7
Caloric Intake			
Urban Nonpoor	2,121.0	0.4	0.4
Urban Poor	996.1	0.3	0.2
Rural Nonpoor	3,380.1	0.5	-0.4
Rural Poor	1,436.9	0.5	1.6
Poverty (Headcount Ratio)			
Urban	44.1	-0.4	0.0
Rural	77.1	-1.2	-2.7
National	69.6	-1.1	-2.3

Source: Simulation Results

While relative price changes explain the fall in consumption, and consequently production of course grains, direct price changes and falling nominal incomes explain the increase in consumption of roots and tubers. An inferior good for all household groups, (i.e. income elasticities are negative; see Table A5), demand for roots and tubers rises by 0.5 percent as nominal incomes fall by about 1 percent. At the same time, lean-season demand increases by approximately 1 percent for all households as prices fall by 2 percent. As is the case for rice, this increase in consumption is partially an inter-temporal substitution as households consume slightly less during the harvest period. On net, however, consumption of roots and tubers by all households increase.

Despite lower nominal incomes, all household groups are better off in terms of purchasing power. This follows from declining consumer prices for most products. The consequent increase in real incomes of over 1.5 percent in rural areas is manifested in a 0.5 percent increase in calorie consumption and a 1.2 percent drop in the share of rural households living in poverty. Real incomes in urban areas rise marginally, resulting in a 0.4 percent drop in poverty and a 0.3 percent increase in caloric intake.

Finally, in terms of agricultural production, the total land use increases by 0.1 percent as households shift out of maize production into rice, cassava and cash crops. This can be interpreted as either expansion into previously uncultivated land or plots laying fallow, or as more intensive use of land currently under cultivation.

The major outcomes of the simulated 50 percent drop in storage costs accompanied by a 20 percent decrease in the transaction costs of urban-rural trade, are (see Tables 10a and 10b):

a. Lean-period consumer rice prices fall by 6.5 percent in urban areas and by 7.1 percent in rural areas. Harvest-period rice prices rise by 8.6 percent in rural areas. Prices of roots and tubers rise in rural areas by approximately 4 percent, and fall during the lean season in urban areas. Rural prices of course grains increase by 6 percent in the harvest-period and fall by over 3 percent in the lean period.

b. Real incomes of all household groups rise, except for the urban poor, with the largest increase (4.6 percent) benefiting the rural poor. Nominal total incomes fall in urban areas. But the decline in most urban consumer prices, means that the purchasing power of non-poor households rises. Rural poverty falls by 2.7 percent, resulting in a 2.3 percent fall in national poverty.

c. Harvest-period rice consumption declines, but is offset by an over two percent increase in lean-period rice consumption as household adjust their inter-temporal consumption patterns. Consequently, annual caloric intake rises for all household groups, except for rural non-poor households.

d. Rice production increases by 0.7 percent, while total rice consumption increases by just over 1 percent. Rice imports thus rise by just under 4 percent. Government revenues from rice imports also rise by just under 4 percent, but total revenues increase by more than 9 percent as non-food and fertilizer imports increase.

e. Total land use decreases by 0.1 percent, as farmers shift out of course grains, roots and tubers, and cash crops.

The immediate difference between this simulation and the previous one is that seasonal variation in prices in rural areas decreases by even more than in urban areas. This is evident in rural areas where harvest-period prices for rice, maize and cassava all increase by over 6 percent, and where lean-period prices for rice and maize fall by 3 percent or more. In urban areas, harvest-period prices for these crops do not rise by more than 1 percent, and do not fall by more than 6.5 percent in the lean period.

Further, because of the reduction in transaction costs between rural and urban areas, rural producer prices for all food commodities rise by 5 percent or more. The same is not observed in urban areas as the wedge between urban and rural prices narrows. Consequently, nominal incomes rise in rural areas – 2 percent for the non-poor and 6 percent for the poor – and fall by about 1 percent in urban areas.

Harvest-period consumption of rice and roots and tubers falls, while lean-period consumption rises as households respond to the changes in the relative inter-temporal prices.[33] The magnitudes of these changes are largest in rural areas because (i) relative inter-temporal prices change more in rural areas, and (ii) incomes in rural areas rise. Despite similar patterns in the change of course-grain prices, consumption of this commodity increases in the harvest period and decreases in the lean period for all household groups. Given that prices of course grains fall by less than rice during the lean period (and rise by less during the harvest period in rural areas), all household groups substitute harvest-period consumption of course grains for rice, and lean-period rice consumption for course grains.

With the exception of course grains, where demand falls, production of all other food commodities increase in response to increases in demand. Livestock production increases by 1.2 percent driven entirely by the 3.4 percent increase in demand by the rural poor. Rice production grows by 0.7 percent, which in turn increases demand for imported fertilizer. Further, since total demand for rice outstrips the increase in domestic supply, imports of rice increase by just under 4 percent. The rising rural incomes and the 2.6 percent drop in prices, lead to an increase in rural demand for non-food products – 12 percent for the non poor and over 22 percent for the poor. Urban producers of non-food products, however, do not benefit from this increased demand as imports make up for the excess demand and producer prices remain unchanged. The slight drop in production on non-food items is attributable entirely to the fall in rural production in response to the 2.6 percent fall in rural producer prices.

[33] Note that consumption of roots and tubers by the urban non poor during the harvest period actually increases. This follows, despite prices rising 1 percent, because cassava is an inferior good and incomes of the urban rich fall – the income effect dominates the substitution effect.

Despite the decline in urban nominal incomes, urban consumer prices also fall enough that the real incomes of the rich are not changed, and the real incomes of the poor fall only modestly. As such, the incidence of urban poverty is not affected by policies to reduce seasonal price variation in this manner. The composition of the consumption bundles does change, however, as households substitute out of non-food items into food items, and caloric intake in urban areas increases by some 0.3 percent.

In rural areas, the opposite change in consumption patterns for the non poor takes place. As such, although nominal and real incomes for this group rise, caloric intake falls as non-food products are substituted for food products. Nonetheless, calorie consumed by the rural non rich remain well above levels below which individuals go hungry (2400 calories; see WHO 1983). The rural poor are the clear beneficiaries of such policies aimed at reducing rural price instability. Rising rural producer prices combined with higher production levels translate into nominal incomes increasing by 6 percent and real income rising some 4.6 percent. Rural poverty falls by 2.7 percent. Although an increased share of this income is spent on non-food items, food consumption increases as well leading to a 1.6 percent rise in calorie intake.

To wrap up, the primary difference in the outcomes between the policies to reduce seasonal price variation in a neutral manner and in a manner targeted to the rural areas, is that the rural poor – 59 percent of the population – are the primary beneficiaries of the latter. This is witnessed in terms of incomes, poverty and caloric intake. Declining urban nominal income in both cases, however, could result in resistance to such policies.

4.4. Changes in Fertilizer Policy

Fertilizer application is extremely low in Madagascar, with fewer that 12 percent of rural households using some form of chemical or organic fertilizer in 2001. Moreover, the percentage of households using fertilizers and the quantities used by them decreases considerably with distance from urban areas, with the non poor applying them with more intensity than the poor (Stifel et al, 2003). This could follow from delays in deliveries[34] or simply from high costs relative to returns (Bockel, 2002). Two simulations are employed here to assess the impact of increased fertilizer use. The first is a 20 percent fertilizer subsidy, and the second is a 20 percent subsidy on fertilizer for only the poor. The assumption underlying these simulations (and all others) is that fertilizer use and hence yields respond to changes in the price. Changes in use can be interpreted as either more households using fertilizer, or more fertilizer applied by those already using fertilizer, or both. We cannot distinguish among these possibilities here, though the larger (in absolute value terms) yield-fertilizer price elasticities for the poor represent lower use by the poor (see Table A2). Further, the price subsidies simulated here can be interpreted as improvements in the distribution of fertilizer in addition to reductions in the import price.

[34] We would like to thank Chris Barrett for pointing this out – the timing of the use of fertilizer is crucial, and if deliveries are delayed considerably because of difficult , costly and time-consuming travel conditions, benefits from application may erode and outweigh the cost of purchasing them.

The major outcomes of the simulated 20 percent fertilizer price subsidy are (see Tables 11a and 11b):

a. Consumer and producer prices of all non-traded food commodities (except livestock) fall. Course grain prices drop by 11 percent, roots and tubers by 7 percent, and other food by 2 percent. Livestock prices rise marginally. The prices of traded goods such as rice, cash crops and non food remain unchanged as they are determined in the world market.

b. Real incomes of all household groups rise, with the largest increase (2.5 percent) benefiting the rural poor. Nominal total incomes fall with the fall in producer prices. But the decline in most consumer prices, means that the purchasing power of all households rises. Rural and urban poverty fall by 1.6 percent and 0.5 percent, respectively, resulting in an overall 1.4 percent fall in national poverty.

c. Consumption of tradables fall as prices of these goods rise relative to non-traded goods. Rice consumption is 0.3 percent lower, cash crops 0.4 percent, and non food 1.5 percent. Substitution out of rice and cash crops into course grains (2.4 percent increase) and roots and tubers (0.7 percent increase) translates into calorie consumption rising some 0.3 percent.

d. Fertilizer demand increases some 9.5 percent as lower input costs lead to higher production levels for rice (7 percent), course grains (2.3 percent), roots and tubers (0.6 percent), cash crops (1.9 percent) and other food (0.4 percent).

e. Rice imports fall by 50 percent as the increase in production soaks up much of the domestic excess demand. The increase in government import tariff revenues from the 9.5 percent increase in fertilizer imports, however, is not enough to offset the losses from declining rice and non-food imports. Government tariff revenue falls by 15 percent.

f. Total land use increases by 0.2 percent, as farmers shift out of course grains and other foods into rice, roots and tubers and cash crops.

The immediate impact of the subsidy is to reduce production costs in the agricultural sector, and consequently to increase the quantities of agricultural commodities supplied at any given output price (a shift in the supply curves). Thus we see a 9.5 percent increase in demand for fertilizer as production of food crops increases. The effect of the increase in the supply of food is that food prices for non-traded goods are pushed down. Price levels of traded goods, however, remain unchanged since they are determined in the world market. But, the *relative* prices of traded goods do rise as the prices of non-traded goods fall, sparking a relatively large supply response for traded goods such as rice (7 percent increase) and cash crops (2 percent increase). Land under cultivation also increases by 0.2 percent as households increase their production of food crops.

Table 11a: Effects of Fertilizer Subsidy On Production and Consumption in Madagascar
Percentage Change

	Baseline	20% general subsidy	20% subsidy to poor
Production (Total Domestic Supply)			
Rice	**1,474.4**	6.9	5.3
Course Grains	**285.7**	2.3	1.8
Roots & Tubers	**3,022.2**	0.6	0.5
Cash Crops	**353.1**	1.9	1.4
Livestock	**68.4**	0.0	0.1
Other Food	**362.1**	0.4	0.4
Non-Food	**151.9**	0.0	0.0
Consumption			
Rice	**1,686.9**	-0.3	-0.2
Course Grains	**269.9**	2.4	1.9
Roots & Tubers	**2,686.4**	0.7	0.5
Cash Crops	**19.7**	-0.4	-0.5
Livestock	**68.4**	0.0	0.1
Other Food	**342.0**	0.4	0.4
Non-Food	**592.5**	-1.5	-0.9
Input Demand			
Fertilizer	**5.5**	9.5	4.3
Traction	**58.0**	0.0	0.0
Net Imports			
Rice	**212.6**	-50.3	-38.0
Cash Crops	**-333.4**	2.0	1.5
Non-Food	**440.6**	-2.1	-1.2
Fertilizer	**5.5**	9.5	4.3
Government Import Revenues			
Rice	**80.1**	-50.3	-38.0
Non-Food	**204.4**	-2.1	-1.2
Fertilizer	**0.8**	9.5	4.3
Land Shares			
Rice	**0.5**	0.2	0.2
Course Grains	**0.1**	-0.3	-0.2
Roots & Tubers	**0.2**	0.3	0.2
Cash Crops	**0.1**	0.6	0.5
Other Food	**0.1**	-0.1	0.0
Total	**1.0**	0.2	0.2

	Baseline	20% general subsidy	20% subsidy to poor
Household Demand			
Rice			
Harvest			
Urban Nonpoor	**104.8**	-0.2	-0.2
Urban Poor	**45.5**	-0.6	-0.3
Rural Nonpoor	**351.6**	-0.3	-0.3
Rural Poor	**409.0**	-0.4	0.0
Lean			
Urban Nonpoor	**89.2**	-0.2	-0.2
Urban Poor	**38.8**	-0.6	-0.3
Rural Nonpoor	**299.5**	-0.3	-0.3
Rural Poor	**348.4**	-0.4	0.0
Course Grains			
Harvest			
Urban Nonpoor	**10.1**	2.7	2.0
Urban Poor	**8.4**	2.2	1.7
Rural Nonpoor	**46.8**	2.5	1.8
Rural Poor	**64.2**	2.3	1.9
Lean			
Urban Nonpoor	**10.9**	2.7	2.0
Urban Poor	**9.1**	2.2	1.7
Rural Nonpoor	**50.7**	2.5	1.8
Rural Poor	**69.6**	2.3	1.9
Roots & Tubers			
Harvest			
Urban Nonpoor	**72.0**	0.9	0.7
Urban Poor	**85.9**	0.7	0.4
Rural Nonpoor	**342.2**	0.7	0.6
Rural Poor	**762.6**	0.6	0.5
Lean			
Urban Nonpoor	**81.2**	0.9	0.7
Urban Poor	**96.8**	0.7	0.4
Rural Nonpoor	**385.9**	0.7	0.6
Rural Poor	**859.9**	0.6	0.5

	Baseline	20% general subsidy	20% subsidy to poor
Household Demand (cont.)			
Cash Crops			
Urban Nonpoor	**0.7**	-0.3	-0.3
Urban Poor	**3.0**	-0.7	-0.3
Rural Nonpoor	**14.6**	-0.4	-0.6
Rural Poor	**1.3**	-0.1	0.4
Livestock			
Urban Nonpoor	**16.3**	-0.1	-0.3
Urban Poor	**6.9**	-0.7	-0.2
Rural Nonpoor	**20.1**	0.1	-0.4
Rural Poor	**25.0**	0.3	0.7
Other Foods			
Urban Nonpoor	**117.7**	0.4	0.3
Urban Poor	**35.6**	-0.1	0.2
Rural Nonpoor	**94.1**	0.5	0.2
Rural Poor	**94.7**	0.6	1.0
Non-Food Products			
Urban Nonpoor	**216.3**	-1.4	-1.2
Urban Poor	**72.3**	-2.4	-1.2
Rural Nonpoor	**151.1**	-1.8	-2.4
Rural Poor	**152.8**	-1.1	1.0
Fertilizer			
Urban Nonpoor	**0.6**	9.5	-1.5
Urban Poor	**0.6**	9.5	10.1
Rural Nonpoor	**2.2**	9.5	-1.5
Rural Poor	**2.2**	9.5	10.1
Traction			
Urban Nonpoor	**21.8**	0.0	0.0
Urban Poor	**21.2**	0.0	0.0
Rural Nonpoor	**93.2**	0.0	0.0
Rural Poor	**44.4**	0.0	0.0

Source: Simulation Results

Table 11b: Effects of Fertilizer Subsidy On Prices and Incomes in Madagascar
Percentage Change

	Baseline	20% general subsidy	20% subsidy to poor
Urban Consumer Prices			
Harvest Period			
Rice	**2,173.0**	0.0	0.0
Course Grains	**1,072.6**	-10.8	-8.2
Roots & Tubers	**999.1**	-6.9	-4.9
Lean Period			
Rice	**2,499.0**	0.0	0.0
Course Grains	**1,179.8**	-10.8	-8.2
Roots & Tubers	**1,049.1**	-6.9	-4.9
Cash Crops	**3,031.4**	0.0	0.0
Livestock	**6,497.7**	0.1	0.3
Other Food	**3,770.5**	-2.0	-1.6
Non-Food	**1,954.8**	0.0	0.0
Fertilizer	**2,500.0**	-20.0	-20.0*
Traction	**499.7**	-4.0	-3.0
Urban Producer Prices			
Rice	**1,671.5**	0.0	0.0
Course Grains	**825.1**	-10.8	-8.2
Roots & Tubers	**768.6**	-6.9	-4.9
Cash Crops	**2,331.9**	0.0	0.0
Livestock	**4,998.3**	0.1	0.3
Other Food	**2,900.4**	-2.0	-1.6
Non-Food	**1,503.7**	0.0	0.0

	Baseline	20% general subsidy	20% subsidy to poor
Rural Consumer Prices			
Harvest Period			
Rice	**1,521.1**	0.0	0.0
Course Grains	**815.2**	-10.8	-8.2
Roots & Tubers	**799.3**	-6.9	-4.9
Lean Period			
Rice	**2,573.9**	0.0	0.0
Course Grains	**1,097.2**	-10.8	-8.2
Roots & Tubers	**923.2**	-6.9	-4.9
Cash Crops	**2,273.6**	0.0	0.0
Livestock	**4,548.4**	0.1	0.3
Other Food	**3,016.4**	-2.0	-1.6
Non-Food	**2,248.0**	0.0	0.0
Fertilizer	**2,875.0**	-20.0	-20.0*
Traction	**574.6**	-4.0	-3.0
Rural Producer Prices			
Rice	**1,170.1**	0.0	0.0
Course Grains	**627.0**	-10.8	-8.2
Roots & Tubers	**614.8**	-6.9	-4.9
Cash Crops	**1,748.9**	0.0	0.0
Livestock	**3,498.8**	0.1	0.3
Other Food	**2,320.3**	-2.0	-1.6
Non-Food	**1,729.2**	0.0	0.0

	Baseline	20% general subsidy	20% subsidy to poor
Incomes			
Nominal Income			
Urban Nonpoor	**2,259.4**	-1.2	-1.0
Urban Poor	**556.5**	-1.8	-0.9
Rural Nonpoor	**1,899.2**	-0.7	-0.9
Rural Poor	**455.8**	-0.5	0.4
Real Income			
Urban Nonpoor	**100.0**	0.2	0.0
Urban Poor	**100.0**	0.5	0.8
Rural Nonpoor	**100.0**	1.3	0.6
Rural Poor	**100.0**	2.5	2.5
Nominal Agricultural Income			
Urban Nonpoor	**226.0**	0.6	-0.9
Urban Poor	**83.4**	1.4	3.9
Rural Nonpoor	**1,367.5**	-0.2	-0.7
Rural Poor	**364.6**	0.1	1.0
Real Agricultural Income			
Urban Nonpoor	**100.0**	1.9	0.1
Urban Poor	**100.0**	3.8	5.7
Rural Nonpoor	**100.0**	1.9	0.8
Rural Poor	**100.0**	3.2	3.2
Caloric Intake			
Urban Nonpoor	**2,121.0**	0.3	0.2
Urban Poor	**996.1**	0.1	0.2
Rural Nonpoor	**3,380.1**	0.3	0.1
Rural Poor	**1,436.9**	0.3	0.4
Poverty (Headcount Ratio)			
Urban	**44.1**	-0.5	-0.9
Rural	**77.1**	-1.6	-1.6
National	**69.6**	-1.4	-1.5

* Applies only to poor households.
Source: Simulation Results

Nominal incomes in both urban and rural areas fall, though by more in urban areas. Urban incomes drop by more than 1 percent, while those in rural areas fall by less that 0.7 percent. Declining consumer prices, however, mean that real incomes rise. The rural poor experience a 2.5 percent increase in purchasing power, while rural non poor real incomes rise 1.3 percent.

The increase in real incomes manifests itself in rising consumption, increasing caloric intake of all households (0.3 percent for all but the urban poor, for which the increase is 0.1 percent) and declining urban and rural poverty (0.5 percent and 1.6 percent, respectively). The rise in consumption is not distributed evenly across commodities as a result of relative-price changes. In fact, the consumption of rice, cash crops and non-foods actually falls as the relative prices of the commodities rise. Consumption of course grains, roots and tubers, and other food increases by 2.4 percent, 0.7 percent, and 0.4 percent respectively as households substitute into non-traded goods in response to the price changes.

Fertilizer imports rise by 9.5 percent following the introduction of a fertilizer subsidy, increasing government tariff revenues by a equal amount. However, import revenues fall as the increase in domestic supply of rice coupled with the slight drop in domestic demand results in a 50 percent fall in rice imports. Similarly, non-food imports fall by 2 percent. On net, tariff revenues fall by over 15 percent.

A policy of targeting poor households, providing the 20 percent fertilizer subsidy to only the poor, has similar results though the magnitudes differ. All prices of non-traded goods fall, production of all food items increase, and consumption of non-traded commodities increase but by smaller amounts. The primary difference between the targeted and the general subsidy in terms of the pattern of the outcomes is in terms of incomes. Because the costs of production primarily benefit only the poor[35], their real incomes rise by more with a targeted policy, whereas the real incomes of the nonpoor rise by less. A similar pattern is observed with caloric intake. Finally, national poverty falls slightly more, by 1.5 percent, due entirely to a greater reduction in urban poverty.

We should note that while a fertilizer subsidy is effective insofar as it alters the private costs of using it in agricultural production, it does not alter the social costs. In other words, the simulations described here do not account for the environmental risks associated with applying chemical fertilizers to fields or with more extensive/intensive use of land for productive purposes. We caution that the private benefits of fertilizer subsidies – higher production levels, real incomes and caloric intake, and lower prices and poverty – must be considered in light of the costs that include not only the cost of the subsidy, but also environmental costs. This is not to say that all of the external effects are negative. There are also positive externalities from the decreased pressure on land use (e.g. fewer incentives to practice slash-and-burn – *tavy* – cultivation techniques) that are associated with fertilizer-induced higher levels of agricultural productivity.

[35] Since the cost of traction falls, all households experience lower costs of production.

4.5. Changes in Agricultural Productivity

Finally, three simulations were used to examine the effects of increased rice productivity on welfare in Madagascar. The first two involve 10 percent exogenous increases in rice yields – the first is a general increase, and the second is an increase targeted to the poor. These productivity increases can be the result of the introducing high yielding rice varieties and/or improved access to agricultural extension services. The third experiment simulates the effects of loosening input supply bottlenecks and consequently increasing agricultural productivity. The constraint that is loosened is the supply of draft power. The effect of a 10 percent increase domestic supply of traction is simulated.

The major outcomes of the simulated 10 percent increase in rice yields are (see Tables 12a and 12b):

a. The consumer and producer prices of non-traded commodities, except course grains all rise. The price of roots and tubers rise by 1.1 percent, livestock by 3.0 percent, and other food by 2.6 percent. The prices of traded goods such as rice, cash crops and non food remain unchanged as they are determined in the world market.

b. Nominal and real incomes of all household groups rise, with the largest increases benefiting the poor – real incomes of the poor rise by 2 percent in urban areas, and by 3 percent in rural areas. Rural and urban poverty fall by 1.9 percent and 2.2 percent, respectively, resulting in a 1.9 percent fall in national poverty.

c. Consumption of all commodities, except course grains, rise with rising incomes. The largest increases in consumption are in traded commodities such as cash crops (1.1 percent) and non food (4.4 percent), as the prices of these goods fall relative to non-traded goods. Rice consumption rises only 0.8 percent, though rural households consume 1.5 percent more rice. Calorie consumption among the poor rises (1 percent for the rural poor, and 0.4 percent for the urban poor).

d. Rice production rises by 10 percent and livestock production increases by 1 percent. Other changes in production are marginal at most.

e. Rice imports fall by 62 percent as the increase in production soaks up much of the domestic excess demand. The fall in import tariff revenues from rice imports outweighs the 5.9 increase in revenues derived from the 4.4 percent increase in non-food consumption. As such, total tariff revenues fall by over 13 percent.

f. Total land use does not change significantly, though the composition does as households substitute out of course grains into other foods.

The immediate impact of the increase in rice yields is a 10 percent growth of rice production. Since rice prices remain unchanged at the adjusted world price, this increase in production – replacing 62 percent of rice imports – translates immediately into nominal income gains. Poor households witness the largest nominal income gains (4

Table 12a: Effects of Increased Rice Yields On Production and Consumption in Madagascar

Percentage Change

	Baseline	10% general increase	10% increase of poor	10% incr. in supply of traction
Production (Total Domestic Supply)				
Rice	**1,474.4**	9.9	6.9	2.1
Course Grains	**285.7**	-0.2	-0.1	0.7
Roots & Tubers	**3,022.2**	0.2	0.2	0.2
Cash Crops	**353.1**	0.0	-0.1	0.6
Livestock	**68.4**	0.9	0.7	0.1
Other Food	**362.1**	0.4	0.3	0.2
Non-Food	**151.9**	0.0	0.0	0.0
Consumption				
Rice	**1,686.9**	0.8	0.7	0.0
Course Grains	**269.9**	-0.2	-0.1	0.7
Roots & Tubers	**2,686.4**	0.2	0.2	0.3
Cash Crops	**19.7**	1.1	0.6	0.0
Livestock	**68.4**	0.9	0.7	0.1
Other Food	**342.0**	0.4	0.3	0.2
Non-Food	**592.5**	4.4	3.4	0.1
Input Demand				
Fertilizer	**5.5**	0.3	0.3	-0.6
Traction	**58.0**	0.0	0.0	10.0
Net Imports				
Rice	**212.6**	-62.1	-41.9	-14.5
Cash Crops	**-333.4**	-0.1	-0.1	0.7
Non-Food	**440.6**	5.9	4.6	0.2
Fertilizer	**5.5**	0.3	0.3	-0.6
Government Import Revenues				
Rice	**80.1**	-62.1	-41.9	-14.5
Non-Food	**204.4**	5.9	4.6	0.2
Fertilizer	**0.8**	0.3	0.3	-0.6
Land Shares				
Rice	**0.5**	0.0	0.0	0.1
Course Grains	**0.1**	-0.1	-0.1	-0.1
Roots & Tubers	**0.2**	0.0	0.0	0.1
Cash Crops	**0.1**	0.0	-0.1	0.2
Other Food	**0.1**	0.2	0.1	0.0
Total	**1.0**	0.0	0.0	0.1

	Baseline	10% general increase	10% increase of poor	10% incr. in supply of traction
Household Demand				
<u>*Rice*</u>				
Harvest				
Urban Nonpoor	**104.8**	0.1	0.1	-0.1
Urban Poor	**45.5**	0.7	0.7	-0.1
Rural Nonpoor	**351.6**	0.3	0.1	-0.1
Rural Poor	**409.0**	1.5	1.4	0.1
Lean				
Urban Nonpoor	**89.2**	0.1	0.1	-0.1
Urban Poor	**38.8**	0.7	0.7	-0.1
Rural Nonpoor	**299.5**	0.3	0.1	-0.1
Rural Poor	**348.4**	1.5	1.4	0.1
<u>*Course Grains*</u>				
Harvest				
Urban Nonpoor	**10.1**	-1.0	-0.8	0.7
Urban Poor	**8.4**	-0.3	-0.3	0.6
Rural Nonpoor	**46.8**	-0.7	-0.6	0.7
Rural Poor	**64.2**	0.3	0.4	0.8
Lean				
Urban Nonpoor	**10.9**	-1.0	-0.8	0.7
Urban Poor	**9.1**	-0.3	-0.3	0.6
Rural Nonpoor	**50.7**	-0.7	-0.6	0.7
Rural Poor	**69.6**	0.3	0.4	0.8
<u>*Roots & Tubers*</u>				
Harvest				
Urban Nonpoor	**72.0**	-0.4	-0.3	0.3
Urban Poor	**85.9**	0.0	-0.1	0.2
Rural Nonpoor	**342.2**	-0.2	-0.1	0.2
Rural Poor	**762.6**	0.4	0.4	0.3
Lean				
Urban Nonpoor	**81.2**	-0.4	-0.3	0.3
Urban Poor	**96.8**	0.0	-0.1	0.2
Rural Nonpoor	**385.9**	-0.2	-0.1	0.2
Rural Poor	**859.9**	0.4	0.4	0.3

	Baseline	10% general increase	10% increase of poor	10% incr. in supply of traction
Household Demand (cont.)				
Cash Crops				
Urban Nonpoor	**0.7**	0.5	0.3	0.0
Urban Poor	**3.0**	1.4	1.3	-0.1
Rural Nonpoor	**14.6**	0.9	0.2	0.0
Rural Poor	**1.3**	2.5	2.5	0.4
Livestock				
Urban Nonpoor	**16.3**	-0.1	-0.3	-0.1
Urban Poor	**6.9**	1.1	1.1	-0.2
Rural Nonpoor	**20.1**	0.0	-0.6	0.0
Rural Poor	**25.0**	2.2	2.3	0.5
Other Foods				
Urban Nonpoor	**117.7**	-0.2	-0.3	0.1
Urban Poor	**35.6**	0.8	0.8	0.0
Rural Nonpoor	**94.1**	-0.1	-0.5	0.1
Rural Poor	**94.7**	1.5	1.6	0.4
Non-Food Products				
Urban Nonpoor	**216.3**	1.7	1.0	-0.2
Urban Poor	**72.3**	3.9	3.7	-0.5
Rural Nonpoor	**151.1**	3.1	0.7	-0.2
Rural Poor	**152.8**	9.6	9.4	1.1
Fertilizer				
Urban Nonpoor	**0.6**	0.3	0.3	-0.6
Urban Poor	**0.6**	0.3	0.3	-0.6
Rural Nonpoor	**2.2**	0.3	0.3	-0.6
Rural Poor	**2.2**	0.3	0.3	-0.6
Traction				
Urban Nonpoor	**21.8**	0.0	0.0	10.0
Urban Poor	**21.2**	0.0	0.0	10.0
Rural Nonpoor	**93.2**	0.0	0.0	10.0
Rural Poor	**44.4**	0.0	0.0	10.0

Source: Simulation Results

Table 12b: Effects of Increased Rice Yields On Prices and Incomes in Madagascar
Percentage Change

	Baseline	10% general increase	10% increase of poor	10% incr. in supply of traction
Urban Consumer Prices				
Harvest Period				
Rice	2,173.0	0.0	0.0	0.0
Course Grains	1,072.6	-0.3	0.1	-3.6
Roots & Tubers	999.1	1.1	1.2	-2.2
Lean Period				
Rice	2,499.0	0.0	0.0	0.0
Course Grains	1,179.8	-0.3	0.1	-3.6
Roots & Tubers	1,049.1	1.1	1.2	-2.2
Cash Crops	3,031.4	0.0	0.0	0.0
Livestock	6,497.7	3.0	2.5	0.5
Other Food	3,770.5	2.6	2.0	-0.2
Non-Food	1,954.8	0.0	0.0	0.0
Fertilizer	2,500.0	0.0	0.0	0.0
Traction	499.7	0.7	0.7	-18.4
Urban Producer Prices				
Rice	1,671.5	0.0	0.0	0.0
Course Grains	825.1	-0.3	0.1	-3.6
Roots & Tubers	768.6	1.1	1.2	-2.2
Cash Crops	2,331.9	0.0	0.0	0.0
Livestock	4,998.3	3.0	2.5	0.5
Other Food	2,900.4	2.6	2.0	-0.2
Non-Food	1,503.7	0.0	0.0	0.0

	Baseline	10% general increase	10% increase of poor	10% incr. in supply of traction
Rural Consumer Prices				
Harvest Period				
Rice	1,521.1	0.0	0.0	0.0
Course Grains	815.2	-0.3	0.1	-3.6
Roots & Tubers	799.3	1.1	1.2	-2.2
Lean Period				
Rice	2,573.9	0.0	0.0	0.0
Course Grains	1,097.2	-0.3	0.1	-3.6
Roots & Tubers	923.2	1.1	1.2	-2.2
Cash Crops	2,273.6	0.0	0.0	0.0
Livestock	4,548.4	3.0	2.5	0.5
Other Food	3,016.4	2.6	2.0	-0.2
Non-Food	2,248.0	0.0	0.0	0.0
Fertilizer	2,875.0	0.0	0.0	0.0
Traction	574.6	0.7	0.7	-18.4
Rural Producer Prices				
Rice	1,170.1	0.0	0.0	0.0
Course Grains	627.0	-0.3	0.1	-3.6
Roots & Tubers	614.8	1.1	1.2	-2.2
Cash Crops	1,748.9	0.0	0.0	0.0
Livestock	3,498.8	3.0	2.5	0.5
Other Food	2,320.3	2.6	2.0	-0.2
Non-Food	1,729.2	0.0	0.0	0.0

	Baseline	10% general increase	10% increase of poor	10% incr. in supply of traction
Incomes				
Nominal Income				
Urban Nonpoor	2,259.4	1.4	0.9	-0.2
Urban Poor	556.5	2.8	2.7	-0.4
Rural Nonpoor	1,899.2	1.2	0.3	-0.1
Rural Poor	455.8	3.9	3.8	0.4
Real Income				
Urban Nonpoor	100.0	0.4	0.0	0.1
Urban Poor	100.0	1.9	1.8	0.3
Rural Nonpoor	100.0	0.6	-0.2	0.5
Rural Poor	100.0	3.1	3.1	1.4
Nominal Agricultural Income				
Urban Nonpoor	226.0	4.8	1.2	0.8
Urban Poor	83.4	13.5	13.1	1.2
Rural Nonpoor	1,367.5	1.4	0.2	0.1
Rural Poor	364.6	4.6	4.5	0.8
Real Agricultural Income				
Urban Nonpoor	100.0	3.8	0.3	1.1
Urban Poor	100.0	12.4	12.2	1.9
Rural Nonpoor	100.0	0.8	-0.3	0.8
Rural Poor	100.0	3.9	3.8	1.7
Caloric Intake				
Urban Nonpoor	2,121.0	-0.1	-0.2	0.1
Urban Poor	996.1	0.4	0.4	0.1
Rural Nonpoor	3,380.1	0.0	-0.1	0.1
Rural Poor	1,436.9	1.0	1.0	0.3
Poverty (Headcount Ratio)				
Urban	44.1	-2.2	-2.2	-0.4
Rural	77.1	-1.9	-1.9	-0.8
National	69.6	-1.9	-1.9	-0.8

Source: Simulation Results

percent in rural areas and 3 percent in urban areas). As such, the increase in nominal incomes among rice producing households is the major shock to the economy that results in moderately increased demand for most commodities.

Since prices of traded commodities are determined in the world market, not in the domestic market, they remain unchanged while increased demand for non-traded commodities push prices of these commodities up. This results in the relative prices of traded to non-traded goods falling, making traded good relatively more attractive than non-traded goods. Consequently, demand for traded goods increases more than for non-traded goods. For instance, rice consumption increases by 0.8 percent, cash crops by 1.1 percent, and non-food by 4.4 percent, while consumption of roots and tubers, livestock and other foods increase by less than 1 percent. These aggregated figures mask the differing changes in consumption by the household groups. The consumption patterns of the poor, and the rural poor in particular, drive these aggregate changes. For instance, rice consumption of the rural poor increases by 1.5 percent, while that of the non poor increases by less than 0.3 percent. Similarly, consumption of non food increases by 9.6 percent for the rural poor, and by less than 3 percent for the non poor.

The overall increase in consumption translates into higher calorie consumption levels among the poor (0.4 percent in urban areas and 1.0 percent in rural areas) and to a 2 percent decline in poverty.

As noted above, the effect of increasing rice yields is not to increase the domestic supply of rice, rather it is to increase the quantity of that supply which is produced domestically – i.e. the increase in rice production replaces imports, thus reducing the excess domestic demand for rice. As such, rice imports fall by 62 percent, while non-food imports rise by 6 percent. The net effect on government tariff revenues is that they fall by 13 percent.

The effect of interventions targeted to the poor that increase the productivity of only the poor have similar effects to untargeted interventions, though some of the magnitudes differ. Because poor households are also the primary beneficiaries of the untargeted program, the differences for the poor are not substantial. In fact, their nominal and real incomes and calorie consumption increase by virtually the same amount. Similarly, national poverty falls by 2 percent. The real incomes of the non poor, however, do not increase and indeed fall for the rural non poor as a consequence of higher prices of non-traded commodities. And since total rice production increases by 7 percent instead of 10 percent, rice imports fall by 42 percent instead of 62 percent.

The major outcomes of the simulated 10 percent increase in supply of draft power are (see Tables 12a and 12b):

a. Consumer and producer prices of all non-traded food commodities (except livestock) fall. Course grain prices drop by 3.6 percent, roots and tubers by 2.2 percent, and other food by an unsubstantial 0.2 percent. Livestock prices rise by 0.5. The prices of traded goods such as rice, cash crops and non food remain unchanged as they are determined in the world market.

b. Real incomes of all household groups rise, with the largest increase (1.4 percent) benefiting the rural poor. Nominal total incomes of all but the rural non poor fall with the fall in producer prices. But the decline in most consumer prices, means that the purchasing power of all households rises. Rural and urban poverty fall by 0.8 percent and 0.4 percent, respectively, resulting in a 0.8 percent fall in national poverty.

c. Consumption of traded food goods – rice and cash crops – are virtually unchanged. In both cases, increased consumption by the rural poor who have higher nominal incomes offsets the lower consumption levels of all other households whose nominal incomes fall. Substitution out of rice and cash crops for most households into course grains (0.7 percent increase) and roots and tubers (0.3 percent increase) translates into calorie consumption rising slightly by some 0.1 percent (0.3 percent for the rural poor).

d. Demand for draft power increases by the obvious 10 percent as the supply increase pushes traction prices down by 18 percent. The immediate rise in the relative price of fertilizer to traction reduces the demand for fertilizer by 0.6 percent. The lower input costs lead to higher production levels for rice (2 percent), course grains (0.7 percent), roots and tubers (0.2 percent), cash crops (0.6 percent) and other food (0.2 percent).

e. Rice imports fall by 14.5 percent as the increase in production soaks up much of the domestic excess demand. The increase in government revenues from the 0.2 percent increase in non food imports, however, is not nearly enough to offset the losses from declining rice and fertilizer imports. Government tariff revenue falls by 4 percent.

f. Total land use increases by 0.1 percent, as farmers shift land out of course grain production into rice, roots and tubers and cash crops.

The loosening of the traction supply bottlenecks by 10 percent has a similar initial impact to the 20 percent fertilizer subsidy. In this case, the price of traction falls by 18 percent and demand for traction rises by the obvious 10 percent, whereas with the fertilizer subsidy, the price of fertilizer falls by 20 percent and demand rises by 9.5 percent. The effect on production, however, is not as large which is not surprising given that the traction-price yield elasticities are all estimated to be smaller than those of fertilizer.

The mechanisms through which these effects take place are generally the same as with the fertilizer subsidy, and thus are not repeated here. The only real differences are the magnitudes of the effects and the degree to which farming households substitute agricultural inputs. On the one hand, in response to a 10 percent increase in the supply of draft power, farmers substitute cheaper traction for more expensive fertilizer. As such, use draft power increases by 10 percent while fertilizer use falls 0.6 percent. Note that the price of fertilizer is determined in the world market and does not change as a result of this shock. On the other hand, since the price of traction is flexible and the supply fixed, demand for draft power does not change with the introduction of a fertilizer subsidy, though the price does fall. No substitution of inputs takes place in the latter case, just more fertilizer is applied This also partly explains the greater magnitude of the effects of the fertilizer subsidy vis-à-vis the increase in supply of traction.

5. Concluding Remarks

In a predominantly agricultural economy such as Madagascar's, where 70 percent of the population is poor, improving livelihoods through policies that stimulate the agricultural sector is paramount to any poverty reduction strategy. To date, agricultural productivity remains low and stagnant, suggesting that there are means through which growth in the agricultural sector (and hence in the economy) can be kick-started. Of course, as a recent World Bank study notes, there is "no silver bullet" that will simultaneously solve all of Madagascar's problems (World Bank, 2003). Nonetheless, in an effort to better understand the set of instruments available to policy makers and what their effects might be, a multi-market model was developed to focuses on agriculture and the seasonal nature of the Malagasy economy. A series of policy experiments were then conducted – ranging from trade liberalization and fertilizer subsidies to increases in productivity and reduction of transaction costs – to assess the impact of these alternatives on the well-being of urban and rural, poor and non poor households in Madagascar.

In each of the simulations (summarized in Table 13) poverty falls, but by varying degrees. The policies with the largest impact on the level of poverty are those related to reducing the factors that drive wedges between consumer and producer prices: (a) a 20 percent reduction in the farmgate-to-market margin, and (b) a combination of a 20 percent reduction in the urban-rural price differential and a 50 percent drop in seasonal storage costs. While the former benefits the poor in both urban and rural areas, the latter benefits only those in rural areas as this policy experiment simulates a reduction in the current pattern of seasonal price variation that is observed to be greater in rural areas (Minten and Randrianarison, 2003). Both of these policies also have the largest impact on increasing calorie consumption among the poor, though some of this increase in food consumption depends on growing imports. It should be noted that increasing rice yields has a similar impact on nutrition without relying on imports. All three sets of policies do not result in increased land use.

Fertilizer price subsidies of 20 percent also have a reasonably large effect on poverty and the incomes of the poor. Although there is a reduction in tariff revenue for the government, the balance of payments position of the country does not deteriorate as the gain in foreign exchange from importing 50 percent less rice more than offsets the foreign exchange loss from importing fertilizer. According to these simulations, fertilizer subsidies induce the largest increase in land use. The model, however, is unable to predict if this occurs through extensification of land holdings or through more intensive use of current holdings (e.g. shorter fallow periods). Either way, there are environmental consequences from greater land use and from the use of chemical fertilizers, the risks of which should be further studied.

The policy with the smallest impact on poverty is the 20 percent reduction in tariffs imposed on rice imports. This follows because of the inherent dilemma of rice producers being both buyers and sellers of rice. A reduction in the price benefits the buyer and hurts the seller, when the two are wrapped up into one the outcome is not obvious *ex ante*.

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Appendix I: ***Elasticities***

The price elasticity of the share of land allocated to each crop is the $\beta^{s}_{h,f,ff}$ in the share equations (112-131),

$$\log(SH_{h,f}) = \alpha^{s}_{h,f} + \sum_{ff} \beta^{s}_{h,f,ff} \log(PP_{ff,h}),$$

and is interpreted as the percentage change in the share of land allocated to crop *f* resulting from a one percent change in the producer price of crop *ff*. These own- and cross-price elasticities are a combination of estimates from the 2001 EPM and Ministry of Agriculture estimates:

Table A1: Price Elasticities of Land Share

	Output Prices				
Share of land allocated to…	Rice	Course Grains	Roots & Tubers	Cash Crops	Other Foods
Rice	0.03	-0.01	-0.01	-0.01	-0.01
Course Grains	-0.01	0.06	-0.05	-0.05	-0.02
Roots & Tubers	-0.01	-0.05	0.05	-0.01	-0.01
Cash Crops	-0.01	-0.05	-0.01	0.05	-0.01
Other Foods	0	0	0	0	0.05

Source: EPM 2001 and Ministry of Agriculture

Two sets of elasticities are required for the yield equations (132-151),

$$\log(YLD_{h,f}) = \alpha^{y}_{h,f} + \beta^{y}_{h,f,f} \log(PP_{f,h}) + \sum_{in} \gamma^{y}_{h,f,in} \log(PC_{in,h,2}).$$

These are the own-price elasticity of yield, $\beta^{y}_{h,f,f}$, and the input-price elasticity of yield, $\gamma^{y}_{h,f,in}$. The former is interpreted as the percentage change in the yield of crop f resulting from a one percent change in the producer price of that crop. The latter is interpreted as the percentage change in the yield of crop f resulting from a one percent change in the consumer price of input *in*. Note that input prices in this model do not vary across seasons, and that these input-price elasticities differ across household groups.

Table A2: Yield Elasticities

		Fertilizer-Price Elasticity				*Traction-Price Elasticity*			
		Urban		Rural		Urban		Rural	
	Own-Price Elasticity	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor	Non-Poor	Poor
Rice	0.18	-0.20	-0.30	-0.20	-0.30	-0.10	-0.10	-0.10	-0.10
Course Grains	0.60	-0.10	-0.15	-0.10	-0.15	-0.05	-0.05	-0.05	-0.05
Roots & Tubers	0.12	-0.05	-0.05	-0.05	-0.05	-0.02	-0.02	-0.02	-0.02
Cash Crops	0.10	-0.05	-0.05	-0.05	-0.05	-0.02	-0.02	-0.02	-0.02
Other Foods	0.10	-0.03	-0.03	-0.03	-0.03	-0.01	-0.01	-0.01	-0.01

Source: EPM 2001 and Ministry of Agriculture

We note that these input elasticities are extremely difficult to estimate given (a) the scarcity of market transactions (i.e. use of own bullocks as draft power), and (b) that over 88 percent of rural households do not apply chemical fertilizers. As such, estimates from the EPM data were used as the basis for best guesses.

There are also two sets of elasticities associated with the input demand functions (187-194),

$$\log(HDIN_{h,in}) = \alpha_h^f + \sum_f \beta_{h,f,in}^f \log(PP_{f,h}) + \gamma_{h,in}^f \log(PC_{in,h,2}) .$$

The first is the output-price elasticity of demand, $\beta_{h,f,in}^f$, which is interpreted as the percentage change in the demand for input *in* for a one percent change in the producer price of crop *f*. The second is the own-price elasticity of demand, $\gamma_{h,in}^f$, which is interpreted as the percentage change in the demand for input *in* for a one percent change in the price of that input.

Table A3: Price Elasticities of Input Demand

	Fertilizer	Traction
Own-Price Elasticities		
Fertilizer	-0.8	
Traction		-0.4
Output-Price Elasticities		
Rice	0.3	0.3
Course Grains	0.1	0.1
Roots & Tubers	0.1	0.1
Cash Crops	0.4	0.4
Other Foods	0.1	0.1

Source: EPM 2001 and Ministry of Agriculture

Finally, the price elasticities, $\beta^{h}_{h,i,j,t}$, and the income elasticities of demand, $\gamma^{h}_{h,i,t}$, for the household demand equations (197-252),

$$\log(HC_{h,i,t}) = \alpha^{h}_{h,i,t} + \sum_{j} \beta^{h}_{h,i,j,t} \log(PC_{j,h,t}) + \gamma^{h}_{h,i,t} \log(YH_{h}),$$

are taken from Lundberg and Rich (2002) and Ravelosoa et al (1999).

Table A4: Price Elasticities of Household Demand for Commodities

	Rice	Course Grains	Roots & Tubers	Cash Crops	Live-stock	Other Food	Non Food
Rice	-0.77	0.07	-0.07	0.03	0.04	0.02	0.27
Course Grains	1.64	-0.53	0.19	-0.11	-0.50	-0.09	0.01
Roots & Tubers	-0.34	0.07	-0.30	0.11	0.08	0.03	0.87
Cash Crops	0.06	-0.07	0.06	-0.73	-0.04	-0.01	-0.57
Livestock	-0.13	-0.09	-0.05	-0.02	-0.65	-0.02	-0.48
Other Food	-0.05	-0.04	-0.03	0.02	-0.02	-0.63	-0.35
Non Food	-0.06	-0.02	-0.01	-0.04	-0.09	-0.04	-0.95

Source: Lundberg & Rich (2002) and Ravelosoa (1999)

Table A5: Income Elasticities of Demand for Commodities

	Urban		Rural	
	Non-Poor	Poor	Non-Poor	Poor
Rice	0.07	0.48	0.41	0.75
Course Grains	-0.45	0.27	-0.05	0.53
Roots & Tubers	-0.50	-0.01	-0.25	0.24
Cash Crops	0.81	1.01	1.60	1.33
Livestock	1.35	1.5	1.68	1.70
Other Food	0.91	1.14	1.24	1.23
Non Food	1.26	1.35	1.39	1.50

Source: Lundberg & Rich (2002) and Ravelosoa (1999)

Appendix II: ***GAMS Codes***

The following is the set of GAMS codes that summarize the model equations. The full set of codes is available from the authors (stifled@lafayette.edu).

```
$TITLE MADAGASCAR MULTI-MKT MODEL     MADMM.GMS

*----------------------------------------------------------------------*
*                MADAGASCAR MULTIMARKET MODEL                          *
* Model includes 7 commodities plus 2 inputs and 4 household groups    *
*                                                                      *
*----------------------------------------------------------------------*

*-------------------------------*
*-- Commodity set definitions --*
*-------------------------------*


*-------------------------------*
            SETS
*-------------------------------*

     T     seasons        / HARVEST, SOUDURE /

     C     commodities    / RICE              1 rice
                            CGRAIN            2 coarse grains eg maize sorghum millet
                            ROOTTUB           3 roots and tubers
                            CASHCRP           4 exportable cash crop
                            LIVESTK           5 livestock
                            OTHFOOD           6 other food
                            NONFOOD           7 nonfood products
                            FERT              8 fertilizer
                            TRACT             9 traction eg tractors zebu etc /

        I(C)   all commodities less inputs
                          / RICE,   CGRAIN,   ROOTTUB, CASHCRP,
                            LIVESTK, OTHFOOD, NONFOOD          /

        F(I)   food products less livestock
                          / RICE,   CGRAIN,   ROOTTUB, CASHCRP,
                                     OTHFOOD                   /

        L(I)   livestock  / LIVESTK /

        NF(I)  nonfood products
                          / NONFOOD /

        IN(C)  inputs                / FERT, TRACT /

        CS(F)   seasonal commodities
                          / RICE,   CGRAIN,   ROOTTUB /

        CY(C)   annual commodities
                          / CASHCRP, LIVESTK, OTHFOOD, NONFOOD, FERT, TRACT  /

        IA(I)  food products only
                          / RICE,   CGRAIN,   ROOTTUB, CASHCRP,
                            LIVESTK, OTHFOOD                   /

        IM(C)  importable products
                          / RICE, NONFOOD, FERT /

        IX(C)  exportable products
                          / CASHCRP /

        MN(IN) importable inputs     / FERT /
```

```
       DN(IN) non importable inputs / TRACT /

       H      households /   URBRICH
                             URBPOOR
                             RURRICH
                             RURPOOR  /

      UH(H)   urban hh   / URBRICH, URBPOOR  /
      RH(H)   rural hh   / RURRICH, RURPOOR /

 ALIAS (C,CC)
 ALIAS (I,J)
 ALIAS (IA,IJ)
 ALIAS (F,FF)
 ALIAS (NF,NNF)
 ALIAS (IN,IIN)
 ALIAS (L,LL)
 ALIAS (H,H2)
 ALIAS (UH,UUH)
 ALIAS (RH,RRH) ;


*--------------------------------*
       PARAMETERS
*--------------------------------*

* Supply Parameters

 SBETA(F,FF,H)     Price elasticity of land share
 SALPHA(H,F)       Intercept in share function

 YBETA(H,F)        Own-price elasticity of yield
 YGAMMA(F,IN,H)    Price elasticity wrt inputs
 YALPHA(H,F)       Intercept in yield function

 LBETA(H,L)        Own-price elasticity of livestock
 LALPHA(H,L)       Intercept in livestock supply equation

 NFBETA(H,NF)      Own-price elasticity of nonfood supply
 NFALPHA(H,NF)     Intercept in nonfood supply equation

 FBETA(IN,F,F,H)   Input demand elasticity
 FGAMMA(H,IN)      Own-price input demand elasticity
 FALPHA(H,IN)      Intercept in input demand equation

* Demand Parameters

 URBBETA(I,J,UH)  Price elasticity in urban demand equation
 URBGAMMA(UH,I)   Income elasticity in urban demand equation
 URBALPH(UH,I,T)  Intercept in urban demand equation

 RURBETA(I,J,RH)   Price elasticity in rural demand equation
 RURGAMMA(RH,I)    Income elasticity in rural demand equation
 RURALPH(RH,I,T)   Intercept in rural demand equation

* Miscellaneous

 ER0            Real exchange rate base                           (Fmg per $)
 PW0(C)         World price for imports                           ($ per ton)
 PWE0(C)        World price for exports
 PCWT(H,I,T)    Weights for consumer price index                    (unity)
 TM(C)          Import tariff                                       (Unity)
 TE(C)          Export tax
 STCOST(C)      Seasonal storage cost - percent of price            (Unity)
 LOSS(I)       Losses factor                                      (Unity)
 CONV(I)       Conversion factor from raw input to final product  ;
```

```
*---------------------------------*
          VARIABLES
*---------------------------------*

*-- Price block (116 endogenous variables) --*

   PP(H,C)     Producer price                          (Fmg per kg)
   PC(H,C,T)   Seasonal consumer price                 (Fmg per kg)

   IMARG(C)     Marketing margin on imports or exports    (percent)
   RMARG(C)     Marketing margin from or to ROW           (percent)
   MARG(C)      Domestic marketing margin                 (percent)
   INTMARG(C,T) Marketing margin from urban to rural      (percent)

   PM(C)      Import price                          (Fmg per kg)
   PX(C)      Export price                          (Fmg per kg)
   PW(C)      World price - fixed                   ($ per ton)
   PINDEX(H)  Consumer price index                  (unity)

   ISUB(C)    Import (export) subsidy rate          (percent)

*-- Supply block (75 endogenous variables: 117-191) --*

   SH(H,F)          Percentage share of area
   YLD(H,F)         Yield                                    ('000 tons per ha)
   HSCR(H,F)        Crop supply by hh                        ('000 tons)
   SCR(F)           Total supply                             ('000 tons)
   HSLV(H,L)        Livestock supply by hh                   ('000 tons)
   SLV(L)           Total livestock supply                   ('000 tons)
   HSNF(H,NF)       Nonfood supply by hh                     ('000 tons)
   SNF(NF)          Total nonfood supply                     ('000 tons)

*-- Input demand block (10 endogenous variables 192-201) --*

   HDIN(H,IN)      Input demand by hh                        ('000 tons)
   DIN(IN)         Total input demand                        ('000 tons)

*-- Consumption block (35 endogenous variables 202-264) --*

   CONS(I)        Total consumption                           ('000 tons)
   HC(H,I,T)      Seasonal household consumption              ('000 tons)
   CONANIM(C)     Feed demand                                 ('000 tons)

*-- Income block (8 endogenous variables 265-272) --*

   YH(H)          Household income                              (Bn Fmg)
   YHAG(H)        Household agricultural income                 (Bn Fmg)
   YHNAG(H)       Household non-agricultural income             (Bn Fmg)

*-- Trade - Market Clearing Block (4 endogenous variables 273-276) --*

   M(C)          Net Imports                                  ('000 tons)
   GOVIMP(C)     Gov't imports                                ('000 tons)
   SDIN(DN)      Supply of nontradable inputs


*-- Objective function --*

   OMEGA          Objective function
   ;
```

```
*----------------------------------*
          EQUATIONS
*----------------------------------*

*----------------------------------*
*--------- Equation Names ---------*
*----------------------------------*

*-- Price block (111 Equations) --*

   PPDEF(H,C)      Def of annual average seasonal producer price    (Fmg per kg)
   URPCMDEF(IM)    Def of cons price for importable urb rich        (Fmg per kg)
   URPCXDEF(IX)    Def of cons price for exportable urb rich        (Fmg per kg)
   URPCSDEF(C)     Def of seasonal cons price  for  urb rich        (Fmg per kg)
   RRPCDEF(C,T)    Def of cons prices for rural rich                (Fmg per kg)
   UPPCDEF(C,T)    Def of cons prices for urban poor                (Fmg per kg)
   RPPCDEF(C,T)    Def of cons prices for rural poor                (Fmg per kg)
   PMDEF(IM)       Definition of import price for importables       (Fmg per kg)
   PXDEF(IX)       Definition of export price                       (Fmg per kg)
   PINDXDEF(H)     Defin of consumer price index                    (unity)

*-- Supply block (75 Equations: 112-186) --*

   SHARE(H,F)      Share equation                                   (percentage)
   YIELD(H,F)      Yield equation                                   ('000 t per ha)
   HCSUPPLY(H,F)   Crop supply by hh                                ('000 tons)
   TCSUPPLY(F)     Total crop supply                                ('000 tons)

   HLSUPPLY(H,L)   Livestock supply by hh                           ('000 tons)
   TLSUPPLY(L)     Total livestock supply                           ('000 tons)

   HNFSUPPLY(H,NF) Nonfood supply by hh                             ('000 tons)
   TNFSUPPLY(NF)   Total nonfood supply                             ('000 tons)

*-- Input demand block (10 Equations: 187-196) --*

   HINDEM(H,IN)    Input demand by hh                              ('000 tons)
   TINDEM(IN)      Total input demand                              ('000 tons)

*-- Consumption block (63 Equations: 197-259) --*

   UHCONDEF(UH,I,T)  Urban household consumption eqn                  ('000 tons)
   RHCONDEF(RH,I,T)  Rural household consumption eqn                  ('000 tons)
   CONDEF(I)         Consumption equation                             ('000 tons)

*-- Income block (8 Equations: 260-267) --*

   YHAGDEF(H)     Ag income equation                               (Bn Fmg)
   YHDEF(H)       Household income equation                        (Bn Fmg)

*--  Equilibrium condition  (9 Equations: 268-276) --*

   FEQUIL(F)       Food      equilibrium equation 5
   LEQUIL(L)       Livestock equilibrium equation 1
   IEQUIL(MN)      Importable input equilibrium equation 1
   DEQUIL(DN)      Nontradable input equilibrium equation 1
   NEQUIL(NF)      Non food  equilibrium equation 1

*-- Objective function --*

   OBJ            Objective function

* TOTAL (276 plus the objective function)
   ;
```

```
*-----------------------------*
*--------- Equations ---------*
*-----------------------------*


*-- Price block (111 Equations) --*

 PPDEF(H,C)..
    PP(H,C)    =E= PC(H,C,"HARVEST") / ( (1 + MARG(C)) ) ;

 URPCMDEF(IM)..
     PC("URBRICH",IM,"HARVEST") =E=  PM(IM)*(1 + IMARG(IM)) * (1 - ISUB(IM)) ;

 URPCXDEF(IX)..
    PC("URBRICH",IX,"HARVEST") =E= (PX(IX)*(1 +  MARG(IX)))/(1 + IMARG(IX)) ;

 URPCSDEF(C)..
    PC("URBRICH",C,"SOUDURE")  =E= PC("URBRICH",C,"HARVEST")*(1 + STCOST(C)) ;

 RRPCDEF(C,T)..
    PC("RURRICH",C,T) =E= PC("URBRICH",C,T)*(1+INTMARG(C,T)) ;

 UPPCDEF(C,T)..
    PC("URBPOOR",C,T) =E= PC("URBRICH",C,T)  ;

 RPPCDEF(C,T)..
    PC("RURPOOR",C,T) =E= PC("RURRICH",C,T) ;

 PMDEF(IM)..
    PM(IM) =E= PW(IM)*ER0*(1+RMARG(IM))*(1 + TM(IM)) ;

 PXDEF(IX)..
    PX(IX) =E= PW(IX)*ER0/( (1+RMARG(IX))*(1+ TE(IX)) )  ;

 PINDXDEF(H)..
    PINDEX(H) =E= SUM(I,SUM(T,PCWT(H,I,T)*PC(H,I,T)/PC0(H,I,T)) ) ;


*-- Supply block (75 Equations: 112-186) --*

* Crop production

 SHARE(H,F)$SHARE0(H,F)..
        LOG(SH(H,F)) =E= SALPHA(H,F) + SUM(FF,SBETA(F,FF,H)*LOG(PP(H,FF))) ;

 YIELD(H,F)$YIELD0(H,F)..
        LOG(YLD(H,F)) =E= YALPHA(H,F) + YBETA(H,F)*LOG(PP(H,F))
                        + SUM(IIN,YGAMMA(F,IIN,H)*LOG(PC(H,IIN,"SOUDURE"))) ;

 HCSUPPLY(H,F)..
        HSCR(H,F) =E= AREA0*SH(H,F)*YLD(H,F)*(1-PERTE0(F))*CONV(F) ;

 TCSUPPLY(F)..
        SCR(F) =E= SUM(H,HSCR(H,F)) ;

* Livestock supply

 HLSUPPLY(H,L)$HSLV0(H,L)..
        LOG(HSLV(H,L)) =E= LALPHA(H,L) + LBETA(H,L)*LOG(PP(H,L)) ;

 TLSUPPLY(L)..
        SLV(L) =E= SUM(H,HSLV(H,L)) ;

* Nonfood supply (equation 15 and 16)

 HNFSUPPLY(H,NF)$HSNF0(H,NF)..
        LOG(HSNF(H,NF)) =E= NFALPHA(H,NF) + NFBETA(H,NF)*LOG(PP(H,NF)) ;

 TNFSUPPLY(NF)..
        SNF(NF) =E= SUM(H,HSNF(H,NF)) ;
```

```
*-- Input demand block (10 Equations: 187-196) --*

 HINDEM(H,IN)$HDIN0(H,IN)..
        LOG(HDIN(H,IN)) =E= FALPHA(H,IN) + SUM(F,FBETA(IN,F,F,H)*LOG(PP(H,F)))
                                           + FGAMMA(H,IN)*LOG(PC(H,IN,"SOUDURE")) ;

 TINDEM(IN)..
        DIN(IN) =E= SUM(H,HDIN(H,IN)) ;

*-- Consumption block (63 Equations: 197-259) --*

 UHCONDEF(UH,I,T)..
     LOG(HC(UH,I,T)) =E= URBALPH(UH,I,T)
                     + SUM(J,URBBETA(I,J,UH)*LOG(PC(UH,J,T)))
                     + URBGAMMA(UH,I)*LOG(YH(UH)) ;

 RHCONDEF(RH,I,T)..
      LOG(HC(RH,I,T)) =E= RURALPH(RH,I,T)
                      + SUM(J,RURBETA(I,J,RH)*LOG(PC(RH,J,T)))
                      + RURGAMMA(RH,I)*LOG(YH(RH)) ;

 CONDEF(I)..
      CONS(I) =E= SUM(H,SUM(T,HC(H,I,T))) ;

*-- Income block (8 Equations: 260-267) --*

 YHAGDEF(H)..
       YHAG(H) =E=  SUM(F, PP(H,F)           *HSCR(H,F) /1000 )
                  + SUM(L, PP(H,L)           *HSLV(H,L) /1000 )
                  - SUM(IN,PC(H,IN,"SOUDURE")*HDIN(H,IN)/1000) ;

 YHDEF(H)..
    YH(H) =E= YHAG(H) + YHNAG(H)*PINDEX(H) ;

*--  Equilibrium condition  (9 Equations: 268-272) --*

 FEQUIL(F)..
    SCR(F) + M(F) + GOVIMP(F) =E= CONS(F) + CONANIM(F) ;

 LEQUIL(L)..
    SLV(L) + M(L) + GOVIMP(L) =E= CONS(L) ;

 IEQUIL(MN)..
      M(MN) + GOVIMP(MN) =E= DIN(MN) ;

 DEQUIL(DN)..
   SDIN(DN) =E= DIN(DN) ;

 NEQUIL(NF)..
    SNF(NF) + M(NF) + GOVIMP(NF) =E= CONS(NF) ;


*-- Dummy Objective function (1 Equation) --*

 OBJ..             OMEGA =E= 10 ;

*-------------------------------*
* Model options & solve command *
*-------------------------------*

 OPTIONS ITERLIM=1000, LIMROW=1, LIMCOL=1 ;
 OPTIONS SOLPRINT=OFF ;

MODEL MADMM1 / ALL / ;

 SOLVE MADMM1 MINIMIZING OMEGA USING NLP;
```