Out-of-pocket health payments: a catalyst for agricultural productivity growth, but with potentially impoverishing effects

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Abstract

This paper analyses the relationship between health expenditures and productivity in Senegal by using a dynamic recursive Computable General Equilibrium (CGE) model that has been run from 2011 to 2020. This model links the growth rate of agricultural productivity to household investment in health goods taking into account catastrophic health payments considered as barriers to achieve maximal productivity gains. In fact, despite being a potential catalyst for productivity, out-of-pocket health expenditures can be a burden after a critical threshold has been crossed, and might potentially decrease household resources and place constraints on the productivity generating process.

Results show a positive impact on poverty reduction when the Government reduces the burden on households by financing catastrophic payment overshoots. Lower health costs also appear to improve households' well-being, especially in the case of agricultural households. These results suggest the need for policies which will reduce the health system's reliance on out-of-pocket payments and demonstrate that health programs should reach the most vulnerable households.

The effectiveness of poverty-oriented interventions can be increased by targeting households incurring catastrophic health expenditures.

Keywords: agricultural productivity, health, poverty, out-of-pocket health expenditures, Senegal

JEL classifications: Q12, I130, I320

1. Introduction

Agriculture is an important sector in Senegal and the main economic activity in rural areas (60% of the population) and comprises a large share of total employment (more than 45%). The sector faces several problems resulting from a productivity loss partly attributed to the poor rainy season. In many African countries, the poverty reduction objective is accompanied by a set of initiatives and reforms concerning fiscal management and budget allocation (CAADP, MTEF, Program-Budget etc.)[2] in order to deal with the institutional failure and the weakness of budgetary processes. The Senegalese Government has undertaken numerous reforms and activities in response to the global productivity decline in order to generate a higher economic growth rate. Despite it being widely recognized that agriculture can play a crucial role in poverty alleviation in African countries, Governments continue to invest less in this sector. Therefore, it is important to consider how to promote non-agricultural sectoral policies with strong spillover and externality effects on agriculture. Indeed, in a context of limited resources, a budget allocation process integrating direct as well as indirect effects across the economy can help increase policies' impact without necessarily relying on large financial resources. A better orientation and an efficient allocation of the resources can ensure linkage and consistency between social sector budget allocation and achievement of certain sets of agricultural development goals.

Human capital theory supports the view that people with greater health stock should have higher labor productivity thanks to the positive effects on physical and mental capacity, i.e. endurance and strength of workers. The loss of productivity can also be due to the change in time allocation by integrating time needed to care for sick family members (Asenso-Okyere et al., 2011).

Out-of-pocket health payments have an impact on household health, and in return, on welfare and productivity as earlier underlined in the Grossman theory of demand for health care. However, there is evidence that beyond a certain threshold these expenditures can become a burden when they account for a large share of household budget. In fact, out-of-pocket health

[2] CAADP : Comprehensive Africa Agriculture Development Programme
MTEF : Medium-Term Expenditure Framework

payments might increase agricultural productivity, but when catastrophic, they can lead to households' impoverishment by lowering their disposable income and by constraining them to sell their assets in order to afford medical goods and necessary services. In Senegal, household out-of-pocket payments represent the primary source through which health expenditures are made, namely 95% of private expenditures and 55% of the total expenditures. However, there is almost no insurance coverage in the informal sector and the coverage rate remains low in the formal sector, with only 10% of the workers concerned (World Bank, 2007). The reliance on out-of-pocket health payments in financing health care exposes households to financial risk when health expenditures account for a large share of their income.

We want to shed a new light on this potentially negative effect when analyzing productivity gains that result from investment in health. The purpose of this paper is to study the impact of household health expenditures on agricultural productivity by examining the way in which these expenditures can both produce productivity gains and push people into poverty as a result of diminishing disposable income and disruption of material living standards of a household. This study provides a valuable contribution by assessing the linkage between the health sector and the agricultural sector using a Computable General Equilibrium Model (CGE) for 2011 to 2020 and the most recent household survey data in Senegal (Poverty Monitoring Survey ESPS II). The contribution is empirical as well as methodological.

The paper is organized as follows. Firstly, we will revisit the linkage between health expenditure, health and productivity. Secondly, the poverty and catastrophic out-of-pocket health expenditure nexus will be studied. Thirdly, the linkage between health policies and agricultural productivity will be analyzed through a CGE framework, which incorporates the issue of dynamic adjustments and spillover effects.

2. Background

2.1. The health capital variable

A large body of literature has been developed on the macroeconomic and microeconomic relationship between health and productivity. Pitt and Rosenzweig (1986) developed a conceptual framework that evaluates the linkage between health and productivity and explains the mechanisms by which health affects utility and production. The authors defined utility as a function of the amount of produced food commodity, market-purchased food commodity, leisure and health state. The latter is modeled through a production function linking changes in health inputs and health status. In their model, the agricultural commodity is produced according to a conventional production technology; with the additional consideration of the ability of the farmer's health status to affect the production level. Therefore, an increase in the farmer's health status will serve to produce more healthy time. This means that additional healthy days are available for leisure or for farm labor. Numerous studies have examined empirically the relationship between health variables and productivity at micro level. Using a stochastic agricultural production, Croppenstedt and Muller (2000) found that nutrition, distance to the source of water, and morbidity affect agricultural productivity in Ethiopia. Badiane and Ulimwengu (2009) also used the stochastic frontier regression techniques and found a positive and significant relationship between health and agricultural technical efficiency in Uganda. Likewise, using cross-section data on hoe-cultivating farm households in Sierra Leone, Strauss (1986) established a link between nutritional status and labor productivity.

2.2. Health investment as an economic investment

Demand for health and health investment has led to a rich and controversial body of literature. Grossman (1972) provided a theoretical framework consistent with the utility maximization to reflect the interdependence between health and expenditure patterns. Other authors also empirically explored the Grossman model (Zweifel and Breyer, 1997; Cochrane et al., 1978; Stratmann, 1999). Zweifel and Breyer (1997) found no evidence of a positive relationship between health and demand for medical care, whereas Grossman's model appears to predict a positive relationship. Cochrane et al. (1978) found that indicators of medical care usage are positively related to morbidity. However, these empirical studies might have an important limitation as they treated health as an exogenous variable. Stratman (1999) showed that when controlling for endogeneity of health variables, medical services tend to decrease work loss days, in line with the predictions of the Grossman model.

In a recent study, Allen et al. (2014) examined the impact of health expenditures on agricultural labor productivity in order to inform the necessary policy decisions regarding the orientation of scarce public resources towards most effective uses in the context of Tanzania. They found that marginal productivity of labor as well as capital and fertilizers respond significantly to health expenditures. Fan and Zhang (2008) found that Government's spending on agricultural research and extension improved agricultural productivity in Uganda, but no large impact was found for health. Benin et al. (2009) found that the provision of public goods and services in the agricultural, education, health and rural road sectors had a substantial impact on agricultural productivity in Ghana.

A few applied studies analyzed the effects of health on non-health sectors, especially in agriculture using a general equilibrium framework. Savard and Adjivi (1997) developed a model in which health is incorporated in the form of improved labor productivity to take into account external effects. Some authors have developed models with a broad focus on the macroeconomic impact of diseases; for example, the HIV/AIDS[3] model that assesses the economic impact of HIV and AIDS (Kambou et al., 1992; Arndt, 2003; Bell et al., 2003). Inclusion of the dynamic aspect is likely to improve understanding of the relation between health and economic outcomes, including income and labor productivity (McNamara et al., 2012).

It is widely recognized that health expenditures can boost productivity, but as stated earlier, these payments are a financial burden leading to impoverishment or limited efficiency when they become catastrophic, as households must reduce their expenditure on other necessities, and on agricultural inputs in the case of farmers. Our contribution is as follows. Unlike the previous studies, our analyses integrate the burden of catastrophic out-of-pocket health expenditures that might limit the extent of the impact of such expenditures on productivity after crossing a critical threshold. Another source of concern that we integrate is the dynamic and the spillover effects. Our approach also considers both the retroactive effects and the non-automatic adjustment of productivity with respect to health investment. Health spending will be linked to the household production function to get the elasticity of productivity with respect to medical expenditures, which will be included in the CGE model. The estimated model accounts for the endogeneity of the health variables. We believe that our research is also insightful from a policy perspective as it provides policy recommendations regarding the protection against catastrophic expenditures and examines the interactions between the agriculture and health sectors.

[3] HIV (Human Immunodeficiency Virus); AIDS (Acquired Immune Deficiency Syndrome)

3. The modeling framework

The theoretical framework presents the core CGE model and the microsimulations that we use to derive both the poverty measures and the catastrophic headcount ratios.

3.1. The CGE model

For our analysis, we use the model presented in Thurlow (2004) that is a dynamic extension of the standard model developed by the International Food Policy Research Institute (IFPRI) and documented in Lofgren (2002). The model is calibrated using the 2011 agricultural Social Accounting Matrix (SAM).

Table A1 and Table A2 in the appendix provide a description of the model, and further explanation can be found in the above-mentioned documents which include the mathematical model statement with an equation-by-equation description, the features, and the data required. Recursive CGE computes static equilibria at each point in time, that are then linked in a long run recursive-path by specifying growth dynamics between time-steps (De Cian, 2006). Based on this model, we incorporate interactions between health inputs purchased by households and agricultural productivity, while recognizing that the effects of health goods consumption on productivity might be lower when they constitute a large share of household income.

The CGE has eleven agricultural commodities as defined in the SAM. The aggregated agricultural sector is completed by the Livestock, Forestry and Fisheries accounts. Detailed information about the non-agricultural sectors (industry and services) is also provided and the model aims to capture the linkage between all these sectors. The model is written as a set of simultaneous equations, including several nonlinear equations, defining the behavior of the different agents, as specified in the appendix. The sectoral disaggregation of the accounts includes the following features: decomposition of the agricultural account into eleven crops plus livestock, fishing and forestry, and decomposition into fourteen regions on the crop production side. This allows for an efficient modeling of the agricultural sector in Senegal by measuring in the best possible way sub-national heterogeneity in cropping patterns and resource endowments. Households are disaggregated into eight categories: rural and poor agricultural, rural and non-poor agricultural, rural and poor non-agricultural, rural and non-poor non-agricultural, urban and poor agricultural, urban and non-poor agricultural, urban and poor non-agricultural, and urban and non-poor non-agricultural households. The main feature that we include in our CGE model is the linkage between health expenditures and agricultural productivity that will be explained later.

Household consumption, including medical expenditures, is measured in local currency over the 12 months (or 30 days for food and some non-food consumption) preceding each interview. This is used to compute income estimation. Health consumption spending includes all food and non-food expenditures made by households to purchase goods and services in order to meet their health needs. The health sector is highlighted in the SAM, which uses the structure of household health consumption from the survey and macro statistics from the national statistical office. The SAM is balanced using the cross-entropy method (Robillard and Robinson, 1999).

The model assumes that each producer a maximizes its profits by choosing the quantities, so that the marginal revenue products of the different factors are equal to their rents (equation 5). The structure of the production technology has at the top level a constant elasticity of substitution (CES) function of the quantities of value-added QVA and aggregate intermediate input $QINTA$. The former itself is a CES function of factors QF_f whereas the latter is a Leontief of disaggregated intermediate inputs $QINT$ as specified below (refer to Table A1 in the appendix for the full list of notations).

$$QA_a = \alpha_a^a \cdot \left(\sum_{f \in F} \delta_a^a \cdot \left(QVA_a \right)^{-\rho_a^{va}} + (1 - \delta_a^a) \cdot \left(QINTA_a \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \quad (2)$$

$$\frac{QVA_a}{QINTA_a} = \left(\frac{PINTA_a}{PVA_a} \cdot \frac{\delta_c^a}{1 - \delta_c^a} \right)^{\frac{1}{\rho_a^a + 1}} \quad (3)$$

$$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot \left(QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \quad (4)$$

$$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot \left(1-tva_a\right) \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot \left(QF_{f\,a}\right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot \left(QF_{f\,a}\right)^{-\rho_a^{va}-1} \quad (5)$$

$$QINT_{c\,a} = ica_{c\,a} \cdot QINTA_a \quad (6)$$

We assume that the growth rate of productivity depends on household health investment, which corresponds to the health goods purchased by households from the health sector. Health is considered as an investment good, meaning that its consumption is expected to provide productivity gains. Considering this, the total factor productivity α_a^{va} can be specified as endogenous and written as follows:

$$\alpha_a^{va}(t+1) = \alpha_a^{va}(t)\,(1 + \Phi(H)) \quad (7)$$

Where H is a health related variable in relation to household health investment and Φ translates the incidence of our health related variables on agricultural productivity.

We can write:

$$\alpha_a^{va}(t+1) = \alpha_a^{va}(t)\,(1 + \vartheta \sum_h^H (\frac{\Delta(P_{health}(h,t_0)Q_{health}(h,t-1))}{P_{health}(h,t_0)Q_{health}(h,t-1)}) \quad (8)$$

With h the index for household groups within the model, $P_{health}(h,t_0)$ and $Q_{health}(h,t)$ respectively the price and the quantity of health goods consumed by household *h* at period *t*. The responsiveness of agricultural productivity to household consumption level of health inputs is captured through the elasticity parameter ϑ, which is estimated using household level data. Each household maximizes a Stone Geary utility function subject to a consumption expenditure constraint. The demand side of the health good consumption is as follows.

$$P_{health}(h,t) \cdot Q_{health}(h,t) = \mu(h,t) + P_{health}(h,t) \cdot \gamma_{health}^{m}(h) + \beta_{health}^{m}(h) \cdot \left(EH(h,t) - \sum_{c' \in C} P_{c'} \cdot \gamma_{c'}^{m}(h) \right)$$

Where $\gamma_{health}^{m}(h)$ represents the minimum consumption level of household *h*, $\beta_{health}^{m}(h)$ is the budget share of health goods in the household consumption basket and $EH(h,t)$ is the actual consumption spending for household h. Besides, we include an exogenous shock $\mu(h,t)$ that represents the health environment and endowment (motivation of health center staffs, household's health endowment, geographic accessibility of health centers etc.). It is calibrated using the distribution of residuals derived from health expenditure equation estimated by using the survey data (see the section "CGE simulation results and the macroeconomic implications" and the note below Table A3 for the distribution). Changing the magnitude of this environmental factor could allow for an exogenous increase of households' health expenses up to the threshold level or a reduction below. This might be interesting in the case where one would like to simulate policies that exogenously compel households to more or less direct their expenditures towards health goods and services, or in the case where unexpected shock-related expenditures are simulated. However, our policy simulation setup does not concentrate on these questions. The postulate of utility maximization mainly drives the health care demand behavior, as widely accepted in the literature. In fact, it is more realistic to let the households decide on how much to spend on the different available goods based on available income, well-being and the general equilibrium price substitution effects. The managerial components of policies are not examined in this paper.

3.2. The microsimulation module

To assess the impact on poverty, we use a microsimulation model which takes into account the poverty distribution in the country. The poverty microsimulation module is calibrated to the survey ESPS II. Endogenous changes in consumption resulting from the CGE model are passed down to the household by linking each of the household in the microsimulation model to the corresponding household in the CGE. The method is a non-parametric microsimulation where the calculated poverty indexes are the FGT (Foster-Greer-Thorbecke) family of poverty measures that propose summary indicators of the extent of poverty.

$$FGT = \frac{1}{N}\sum_{i=1}\left(\frac{z-y_i}{z}\right)^{\alpha} .\ I(y_i \leq z)$$

For $\alpha = 0$ the FGT index collapses to the headcount ratio P_0 , which is the most widely used poverty measure that quantifies the proportion of the population that is poor, but does not show how poor the poor are. The case where $\alpha = 1$ gives the poverty gap index (P_1) that measures the extent to which individuals fall below the poverty line as a proportion of the poverty line. The sum of these poverty gaps gives the minimum cost of eliminating poverty with a perfect targeting of transfers. The case where $\alpha = 2$ gives an indication on the severity by squaring the normalized gap (P_2) and thus weights the gap by the gap.

The cost of basic need method approach is used to define the poverty line. This method first estimates the cost of acquiring enough food for adequate nutrition, namely 2,400 calories per adult per day, and then adds the cost of other essentials. We also define a new poverty measure to integrate the impoverishment effect corresponding to the extent to which households are pushed into poverty by making out-of-pocket health expenditures.

The last part of the section describing the CGE model shows the linkage between productivity and health expenditures. However, given the fact that we want to capture more accurately the effect of household health payments, we allow this relation (equation 8) to depend also on the magnitude of catastrophic out-of-pocket health payments through the inclusion of the household group's related headcount ratio that we define as follows:

$$\boldsymbol{H}_c^h = \frac{1}{H^h} \sum_{i=1}^{H^h} Ind \left(\frac{T_i^h}{Y_i^h} - \xi_c\right) \quad (9)$$

Where $Ind\ (.)$ equals 1 if $\frac{T_i^h}{Y_i^h} > \xi_c$ and 0 otherwise, ξ_c represents the threshold above which the ratio of health expenditures to income ($\frac{T_i^h}{Y_i^h}$) is considered as catastrophic, H^h the sample size of the aggregated household group h , Y_i^h is the income, with *i* subscript for household within the aggregate group h.

Out-of-pocket payments are considered catastrophic and make households impoverish if they exceed 40% of annual household non-food expenditures (Kawabata, Xu and Carrin, 2002; Xu et al., 2003; Karami et al., 2009) or 10% of the ratio between health expenditures and consumption expenditures (Pradhan and Prescott, 2002; Wagstaff and Van Doorlaer, 2003; Russell, 2004). In our case, catastrophic payments are defined with regard to the household's total expenditures.

$\boldsymbol{H}_c^h$ gives an estimate of the proportion of households who experienced health payments above the threshold ξ_c within each household group in the SAM. It is endogenous and calculated each year after passing down changes of health expenditures and income of household groups in the

CGE model to their corresponding households in the health side of the microsimulation module, similar to the calculation of poverty measures.

$\boldsymbol{H}_c^h$ is related to the severity of morbidity level within the different household groups and translates the effectiveness of health inputs in generating technical progress. If all households within a given household group h spend on health goods without catastrophe, then there is a perfect transmission of investment in health inputs to productivity accordingly with elasticity ϑ.

Considering this, equation (8) can be rewritten in the following manner:

$$\alpha_a^{va}(\mathrm{t}+1) = \alpha_a^{va}(\mathrm{t})\left(1 + \vartheta \sum_h^H \frac{\Delta\left(P_{health}(h,t_0)Q_{health}(h,t)\right)}{P_{health}(h,t_0)Q_{health}(h,t-1)} \left(\boldsymbol{H}_c^h(t)\right)^{(1-1_{[\Delta(PQ)>0]})}\left(1-\boldsymbol{H}_c^h(t)\right)^{1_{[\Delta(PQ)>0]}}\right) \quad (10)$$

The model is intended to take into account the potential non-automatic adjustment of productivity with respect to health investments. Moreover, the general equilibrium framework allows integrating the bi-directional linkage between productivity and health expenditures. Health expenditures enhance productivity, which ultimately increases household income and therefore the capacity to invest in goods and services that can maintain or potentially improve health and provide energy for the farmers.

The logic behind the last equation is that if health expenditures increase (i.e. ΔPQ>0) for a household group in the model compared to the previous periods, the positive impact on productivity depends not only on the estimated parameter ϑ, but also on the share of households who had not incurred catastrophic health expenditures ($\mathbf{1}-\boldsymbol{H}_c^h(t)$). This amount is provided by the health module of the household survey and updated with the microsimulation module. Therefore, a lower $\boldsymbol{H}_c^h(t)$ tends to generate more easily technical progress. Similarly, if ΔPQ<0, the extent through which productivity is reduced depends this time on the share of households that faces catastrophic expenditures. If ΔPQ=0 for all individuals, then productivity remains at the same level. Indicator functions are used for a mathematical and straightforward formulation.

The proposed framework integrates the externality effects between sectors and therefore determines the economy wide impacts of the structure and the changes in household out-of-pocket health payments. One strength of our paper is that productivity shift is endogenized and no technological progress is assumed *ad hoc*, as it is commonly done in the CGE literature.

4. Policy simulations and discussion

4.1. Simulation designs

When designing policies that integrate health into agriculture, it is essential to consider some negative effects that might exist when household out-of-pocket expenditures exceed a critical threshold in terms of share of total income. As explained earlier, our study attempts to provide evidence on this issue. It shows the advantage of providing financial protection by examining the long run effects of potential policies lowering the burden of catastrophic health payments on individuals.

Our first type of simulations aims to assess the impacts on individuals if the Government takes the burden off households and offers them protection from drug expenditures that might otherwise threaten their financial security. The comparison between potential Government strategies to finance these expenditures will also be analyzed as different funding options might lead to different impacts on the economy and on households' well-being. In the first simulations, the excess is entirely supported by the Government mainly through the reduction of savings or through increases of taxes on domestic institutions or on commodity taxes, whether uniformly or not.

This can be simulated by transferring the overall payment overshoot $\sum_{i=1}^{H^h} O_i . Y_i = \sum_{i=1}^{H^h} T_i^h - \xi_c Y_i^h$ to each household group in each period. These amounts are derived from the linked micro module. Catastrophic payment overshoot captures the intensity of the occurrence of catastrophic expenditures. The Government should help households facing catastrophic health expenditures and reduce the impoverishing effects of out-of-pocket health expenditures. Adoption of mutual health insurance can also be a more efficient funding mechanism regarding sustainability. Insurance coverage is practically absent among workers in the informal sector and very low in the formal sector; only 20% of the population is covered by health insurance. A *sesame plan* (free care for the elderly) was introduced in 2006, but as many other initiatives offering financial protection methods and health services, such programs are jeopardized by political instability.

The impact of a 50% coverage of catastrophic out-of-pocket health payments representing an alternative to full coverage is also presented in the appendix. In this cost-sharing option, households bear only half of the cost up to the critical threshold.

The second type of analysis is to assess the impacts of the reduction of health good prices on the economy and on households. In fact, lowering the cost of medical goods could also reduce the financial burden on households, especially for those with low incomes. This price reduction could come from productivity gains in the domestic health producing sector, government subsidies or decrease of import prices following a reduction of the import tariff rate. We will only focus on the last two channels. Most of the drugs used in Senegal (85-90%) are imported with relatively high trade margins, which contributes to the inaccessibility of many medications (Ministry of Health, 2005). Drugs imported from outside the WAEMU and ECOWAS[4] are subject to a tax rate of 2.5%. We will simulate the impact of an annual 3% duty rate τ decrease over the simulation period. This duty escalator, meaning a progressive liberalization, is likely to mitigate the shock on domestic prices of health goods and give incentive each year to households for an incremental investment in health. In this simulation the associated direct cost per year can be represented by the opportunity cost of lowering the import tariffs for health goods that is $pwm\,QM\,EXR\,tm0\,(1-\ (1-\tau)^{n})$, where pwm is the import price, QM the quantity of imported health good, $tm0$ the initial import tariff, n related to the geometric sequence and EXR the exchange rate. We will also simulate the impact of 3% annual increases of activity subsidy ρ on the health sector and see the impact on poverty in the dynamic perspective. The size of the simulations is not critical here, as simulating different levels might generate the same types of mechanisms in the economy. This second type of simulation can highlight alternative policies that do not rely on income tax funding. To compare simulations of different nature, poverty reduction per average unit of government revenue loss will be calculated. Table 1 describes the different policy simulations.

[4] WAEMU : West African Economic and Monetary Union
ECOWAS : Economic Community of West African States

Table 1: Simulation designs

Simulations' names	**Simulations' description**
$\boldsymbol{S_1}$ **and** $\boldsymbol{S'_1}$	Full ($\boldsymbol{S_1}$) and partial ($\boldsymbol{S'_1}$) coverage of the catastrophic out-of-pocket health payments financed by saving
$\boldsymbol{S_2}$ **and** $\boldsymbol{S'_2}$	Full and partial coverage of the catastrophic out-of-pocket health payments financed by uniform direct tax rate for institutions, e.g. the percentage adjustment is the same for all
$\boldsymbol{S_3}$ **and** $\boldsymbol{S'_3}$	Full and partial coverage of the catastrophic out-of-pocket health payments financed by non-uniform direct tax rate
$\boldsymbol{S_4}$ **and** $\boldsymbol{S'_4}$	Full and partial coverage of the catastrophic out-of-pocket health payments financed by uniform sales tax
$\boldsymbol{S_5}$ **and** $\boldsymbol{S'_5}$	Full and partial coverage of the catastrophic out-of-pocket health payments financed by scaled sales tax
$\boldsymbol{S''_1}$	Duty escalator (3%) for health goods, base value 2.5%
$\boldsymbol{S''_2}$	3% annual increases of activity subsidy to health sector, base value 10%

Source: The authors

The following subsection shows the magnitude of catastrophic health expenditures in Senegal and across our aggregated household groups.

4.2. The distribution of catastrophic out-of-pocket health expenditures

Before a discussion of the simulation results, we want to highlight the magnitude and the distribution of out-of-pocket health expenditures across the household groups h. We will also show whether these expenditures exacerbate the poverty of households. This is likely to lower their potential effect on productivity.

We use the mean positive gap to assess the magnitude of the catastrophe of household out-of-pocket health expenditures and see how excessive they are. In contrast to the headcount ratio, it gives an indication of how much consumers' payments exceed the threshold. It is computed using the following formula:

$$\boldsymbol{H}_c^g = \overline{\boldsymbol{O}_\iota} / \boldsymbol{H}_c = \sum_i^H \left(\frac{T_i}{Y_i} - \xi_c\right) Ind\left(\frac{T_i}{Y_i} - \xi_c\right) \Big/ \sum_{h=1}^H Ind\left(\frac{T_i}{Y_i} - \xi_c\right) \qquad (24)$$

where $\overline{\boldsymbol{O}_\iota}$ represents the average of overshoot $O_i = \frac{T_i}{Y_i} - \xi_c$. It expresses the intensity of the occurrence of catastrophic out-of-pocket expenditures.

To measure the inequality in health expenditures, concentration indices[5] $\boldsymbol{C}^{\boldsymbol{H}_c}$ and $\boldsymbol{C}^{\overline{\boldsymbol{O}_\iota}}$ are used to compute weighted headcount $\boldsymbol{H}_c^{\boldsymbol{w}} = H_c\,(1 - \boldsymbol{C}^{\boldsymbol{H}_c})$ and weighted overshoot $\overline{\boldsymbol{O}_\iota}^{\boldsymbol{w}} = \bar{O}_\iota\,(1 - \boldsymbol{C}^{\overline{\boldsymbol{O}_\iota}})$. This allows us to see whether the households who experienced catastrophic health expenditure were unequally distributed across the population, between the richest and the poorest households.

The calculations of the indices indicate that household out-of-pocket health expenditures have an impact on poverty when they are catastrophic. These measures elucidate the impoverishment effect which corresponds to the extent to which households are pushed into poverty and likely become unable to achieve their maximum potential productivity by making catastrophic out-of-pocket health expenditures.

Let Z_{pov} (pre) be the pre-payment poverty line and x_i the pre-payment income per adult equivalent of household *i*. We use the Foster–Greer–Thorbecke (FGT) class of poverty indices that can be defined as follows.

The pre-payment poverty headcount is: $\boldsymbol{P}^{\mathbf{0}}(pre) = \frac{1}{H} \sum_{i=1}^H Ind(\, x_i\text{-}\ Z_{pov}$ (pre))

The pre-payment poverty gap is: $\boldsymbol{P}^{\mathbf{1}}(pre) = \frac{1}{H} \sum_{i=1}^H(\, x_i\text{-}\ Z_{pov}$ (pre))

[5] C = $\frac{2}{H\mu} \sum_{i=1}^H h_i\, r_i - 1 - \frac{1}{H}$ where h_i is the health variable, μ its mean, and r_i the fractional rank of household i in the living standards distribution where income per adult equivalent is the measure of living standards. For more details see Kakwani, Wagstaff, and van Doorslaer, 1997; O' Donnell et al., 2008.

The normalized pre-payment poverty gap controls for differences in poverty lines between strata and is expressed as: $\boldsymbol{NP^1}(pre) = \frac{P^1(pre)}{Z_{pov}\ \text{(pre)}}$

We compare the pre- and post-payment measures, in order to measure the poverty effects of out-of-pocket health payments, as follows:

$\Delta\boldsymbol{P^0}$ = $P^0(post) - P^0(pre)$

$\Delta\boldsymbol{P^1}$ = $P^1(post) - P^1(pre)$

$\Delta\boldsymbol{NP^1}$ = $NP^1(post) - NP^1(pre)$

In the post-payment measures, the income per adult equivalent x_i is recomputed by subtracting household out-of-pocket health payments, and the poverty line Z_{pov} (pre) is adjusted by deducting an amount of the poverty line derived from health spending among the group that provides the reference for the non-food based poverty line.

Table 2 considers a range of values for the thresholds, although the CGE simulations are based on the 10% threshold. This could indicate the extent to which people are pushed into poverty. In addition, the 10% threshold is the most common - but maybe arbitrary - threshold in the literature. The higher thresholds (20% and 25%) represent an extremely severe definition of the catastrophe owing to higher out-of-pocket costs. In general, the results in Table 2 show negative concentration indices, and higher values for the weighted gap from critical thresholds and the weighted headcount compared to the unweight measures. This indicates a greater tendency for the poor to incur financial catastrophe.

Table 2: Distribution-sensitive catastrophic health expenditures (at national level)

Indices	Threshold budget share $\boldsymbol{\xi_c}$				
	5%	10%	15%	20%	25%
$\boldsymbol{H_c}$	16.18%	6.26%	2.33%	1.38%	0.87%
	(0.009)	(0.006)	(0.003)	(0.003)	(0.002)
Concentration index $\boldsymbol{C^{H_c}}$	-0.051	-0.081	-0.087	-0.076	-0.27
	(0.019)	(0.031)	(0.047)	(0.066)	(0.077)
Ranked weighted $\boldsymbol{H_c^w}$	17.01%	6.77%	2.53%	1.48%	1.10%

$\overline{O_\iota}$	1.00% (0.001)	0.49% (0.0008)	0.28% (0.0007)	0.19% (0.0006)	0.14% (0.0005)
Concentration Index $C^{\overline{O_\iota}}$	-0.152 (0.044)	-0.217 (0.068)	-0.285 (0.088)	-0.357 (0.104)	-0.411 (0.117)
Ranked weighted $\overline{O_\iota}^w$	1.15%	0.60%	0.36%	0.26%	0.20%

Source: Séne and Cissé, 2015

Note: standard errors in parentheses. Standard errors of the concentration indices are estimated using the Kakwani, Wagstaff and Doorslaer (1997) estimator.

The prevalence of catastrophic out-of-pocket health expenditures is estimated at 6.26%. The size of the excess of catastrophic out-of-pocket health spending stands around 8% of the household income, as shown by the mean of positive gap in Table 3.

At the 10% threshold[6], we found evidence that catastrophic out-of-pocket health payments exacerbate poverty. Estimations reveal that the conventional poverty headcount ratio increases by 1.44 percentage point when controlling for catastrophic out-of-pocket health expenditure. The average deficit to reach the poverty line also increases due to the burden of excessive health payments. When extrapolating at national level, we found that many persons (195, 716) that encountered catastrophic health expenditures were pushed into poverty due to the burden of excessive health expenditures (for more details on the out-of-pocket health expenditures see Séne and Cissé, 2015). The headcount ratio $\boldsymbol{H_c}$ varies across household groups, reaching a maximum value for urban agricultural household group (10.30%). Therefore, the impact of out-of-pocket health expenditures on productivity might be heterogeneous across the aggregated household groups within the CGE model.

Catastrophic out-of-pocket health payments might reduce the full impact of health investment on productivity, while at the same time they negatively affect the capacity of farm laborers to afford food and nutrients that they need for the maintenance of good health and energy. The high share of out-of-pocket household payments can also lead to negative effects on the efficient use of

[6] We used the 10% threshold for total household income. This experiment parameter is the most common threshold in the literature (Pradhan and Prescott, 2002; Wagstaff and Van Doolaer, 2003 and Russell, 2004), with the rationale that this represents an approximate threshold at which the household is forced to sacrifice other basic needs, sell productive assets, incur debt, or become impoverished (Russell, 2004).

fertilizer and other traditional agricultural inputs, in a context where households' purchasing power decreases as a result of lower disposable incomes. Households who incur catastrophic expenditures can be forced to cut down on subsistence needs and sell productive goods in response to the financial shock. In addition, catastrophic out-of-pocket health payments might reflect very severe shock on the household health status. These issues are incorporated in the model following the specification in equation (10) that stipulates that aggregated household groups with fewer occurrences of catastrophic payments are more likely to achieve their maximum potential productivity gains resulting from the consumption of health goods.

Table 3: Poverty and catastrophic out-of-pocket health expenditures

	CGE household groups								
	Rural agricultural poor	Rural agricultural rich	Rural non-agricultural poor	Rural non-agricultural rich	Urban agricultural poor	Urban agricultural rich	Urban non-agricultural poor	Urban non-agricultural rich	Senegal
$\boldsymbol{H_c}$	4.37	5.07	6.32	8.24	10.30	3.59	4.72	7.16	6.26
$\boldsymbol{H_c^g}$	5.91	5.64	7.72	9.19	5.46	3.93	9.82	7.57	7.82

	Rural agricultural	Rural non-agricultural	Urban agricultural	Urban non-agricultural	Senegal
$\boldsymbol{P^0(pre)}$	61.09	54.5	42.96	32.69	46.71
$\boldsymbol{P^0(post)}$	62.24	55.67	42.97	34.55	48.14
$\Delta \boldsymbol{P^0}$	1.15	1.17	0.01	1.86	1.43
$\boldsymbol{NP^1(pre)}$	18.80	18.52	13.03	9.02	14.53
$\boldsymbol{NP^1(post)}$	19.55	19.62	13.8	9.65	15.35
$\Delta \boldsymbol{NP^1}$	0.75	1.1	0.77	0.63	0.82
$\boldsymbol{NP^2(pre)}$	8.19	8.98	5.62	3.80	6.59
$\boldsymbol{NP^2(post)}$	8.64	9.99	6.06	4.09	7.16
$\Delta \boldsymbol{NP^2}$	0.45	1.01	0.44	0.29	0.57

Note: The above measures are for the 10% threshold. NP^2 is the severity index.

Source: the authors

4.3. CGE simulation results and the macroeconomic implications

The estimation of parameter ϑ is presented in Table A3 in the appendix. We performed a two-stage least square (2SLS) and a multilevel mixed-effects linear (MMEL) regression, allowing random intercept combined with a two-stage residual inclusion (2SRI)[7] to correct for endogeneity. Both estimations provide approximately the same value for ϑ. The instruments of medical spending are good predictors and the Kleibergen-Paap rank Wald F-statistic[8] as well as the Hansen J test reveal the appropriateness of the instruments.

Table 4 shows the macroeconomic impacts of the different simulations. In the base-run simulation, we assume that the gross domestic product (GDP) grows at around a quite realistic rate of 3.7% on the period considered here (2011-2020), which is the average growth rate for the period 2005-2011. The agricultural GDP has been characterized by erratic growth levels during this period, reaching the highest point of 18.5% in 2008 and the lowest (-13.1%) in 2011. The baseline scenario (Business As Usual, BAU) assumes that the annual agricultural GDP growth rate for 2011-2020 is 3.5%. However, albeit this growth rate reflects the recent performance in the overall agricultural sector and assumes that Senegal continues along current economic trends, it does not focus on the details for each specific crop. This simulation represents the counterfactual for our analysis. The baseline also assumes the continuation of demographic trends. Urban populations are supposed to grow at 2.5%, while rural populations grow at 2.1%. The annual growth rate of government consumption is fixed at 3.9, as well as the growth rate of foreign savings, to reflect the past trend in these key variables. Economic growth also results from increases in factors. We assume a homogenous land expansion within the different agricultural crop production systems of 1.9%. Capital accumulation grows endogenously as a result of the dynamic interaction between investment and saving across the periods.

[7] For more details see Garen, 1984; Vella, 1993; Terza et al., 2008; Wooldridge, 2010
[8] See Stock and Yogo, 2005; Baum et al., 2003; Kleibergen and Paap, 2006

All the simulations are based on the endogenous technical progress growth that is generated by the consumption of health goods, and take into account the effect of catastrophic out-of-pocket health expenditures in the transmission mechanisms.

Results reveal an increase of the agricultural GDP compared to the baseline simulation as a result of productivity gains in the agricultural sector. The decrease of health goods consumer prices in turn increases the total private consumption in $S"_1$ (tariff reduction simulation) and $S"_2$ (subsidy simulation). The quantity of imported goods increases following the tariff reduction in $S"_1$. Simulations of the full coverage of the catastrophic out-of-pocket health payments (S_i simulations) that have the same direct cost and generate approximate government revenue loss show that the agricultural growth does not change much in general with the funding options. However, we can observe slightly more impact when the funding option relies on uniform direct tax rate for institutions (S_2) with 3.73% average growth rate over the simulation period.

Table 4: Macroeconomic impacts

	$\boldsymbol{Imports}$	$\boldsymbol{GDP\ Agr.}$	$\boldsymbol{Priv.cons}$
Simulations			
$\boldsymbol{Initial}$	-2,958.48	946.35	5,733.16
$\boldsymbol{BAU}$	3.70	3.54	3.33
$\boldsymbol{S_1}$	3.52	3.68	3.55
$\boldsymbol{S_2}$	3.45	3.73	3.63
$\boldsymbol{S_3}$	3.45	3.71	3.63
$\boldsymbol{S_4}$	3.52	3.72	3.62
$\boldsymbol{S_5}$	3.53	3.70	3.63
$\boldsymbol{S"_1}$	3.98	3.53	3.51
$\boldsymbol{S"_2}$	3.68	3.59	3.36

Source: The authors

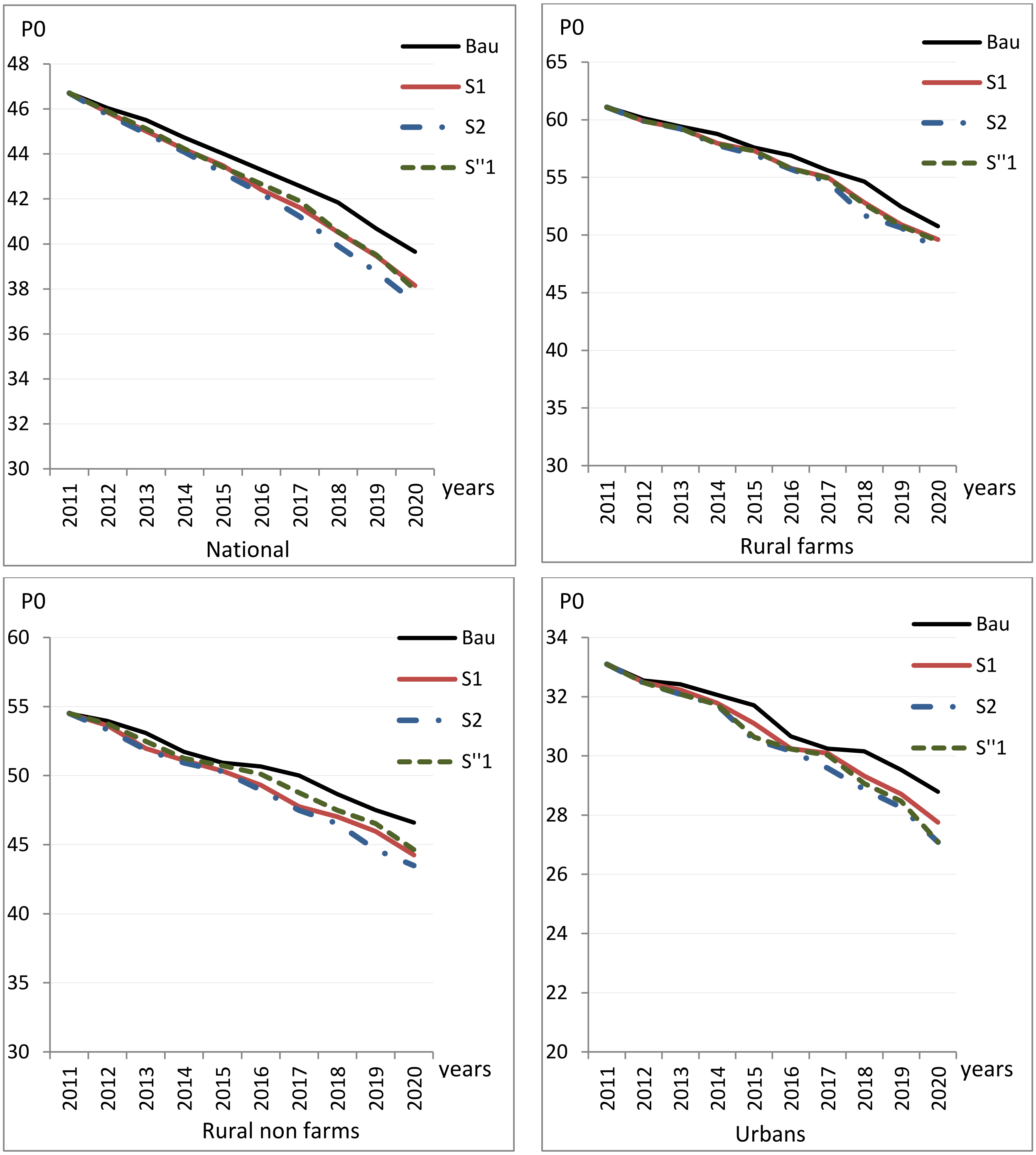
Figure 1 and Table A4 in the appendix summarize the key results in terms of poverty reduction. The poverty evolutions in Figure 1 are drawn only for the selected simulations BAU, S_1, S_2 and $S"_1$ for a good visualization[9]. For the remaining simulations, the detailed results are presented at national level in the appendix. Figures show that poverty decreases as factors' returns, especially in the agricultural sector, are affected.

Scenario S_2 shows the large impact on poverty reduction at national level (2.26 percentage points) among the full expenditure coverage scenarios. In this scenario the Government takes the burden off households by removing the financial shock of out-of-pocket health expenditures, using uniform direct tax rate for institutions as a funding option. This demonstrates the implications of catastrophic health expenditures on households' welfare. It is therefore important for policy-makers to try to mitigate the effect of catastrophic health payment by establishing assistance programs for the most affected households.

The scenarios lowering import tariffs and increasing subsidies to the health sector also have poverty reducing effects, albeit marginal for the subsidy scenario with simulated shocks. These results confirm the importance of health in the economy. Regarding this direction, larger shocks would affect more prices and would have more visible impacts. On average, rural areas observe more reduction in poverty than urban areas in almost all the simulations. For example, the poverty rate in the whole rural area decreased by 2.69 percentage points in S_2 compared to the counterfactual scenario, while there was a reduction of 1.7 percentage point in urban areas. These simulations have the effect of increasing health good consumption compared to the baseline growth rate, especially for the subsidy simulation, as indicated in Table A5 in the appendix. In general, the growth rate of health group consumption is higher for urban non-agricultural and rich households with 4% for $S"_2$, and around 3.7% for S_1.

[9] In fact, some simulations might overlap because they present a very similar poverty path, albeit with marginal differences. Figure 1 only shows evidence that policy options concerning catastrophic health payments have a potential for poverty reduction and does not intend to compare simulations of different types.

Figure 1: Poverty evolution per household type for selected simulations



Source: The authors

The comparison of full coverage simulations with the partial coverage simulation and the tariff and subsidy simulations, makes it necessary to take into account the endogenous government revenue loss with regards to the current path of the economy, beyond the estimated direct cost in Table 5. Therefore, we calculate the response of poverty reduction in unit of government revenue loss (ξ) for simulations S_2 , S'_2 (that show, respectively, larger impacts among the full coverage and partial coverage simulations), for import tariff and subsidy simulations. These effects ξ are derived as absolute poverty reduction per unit of average government revenue loss over the simulation period for each scenario.

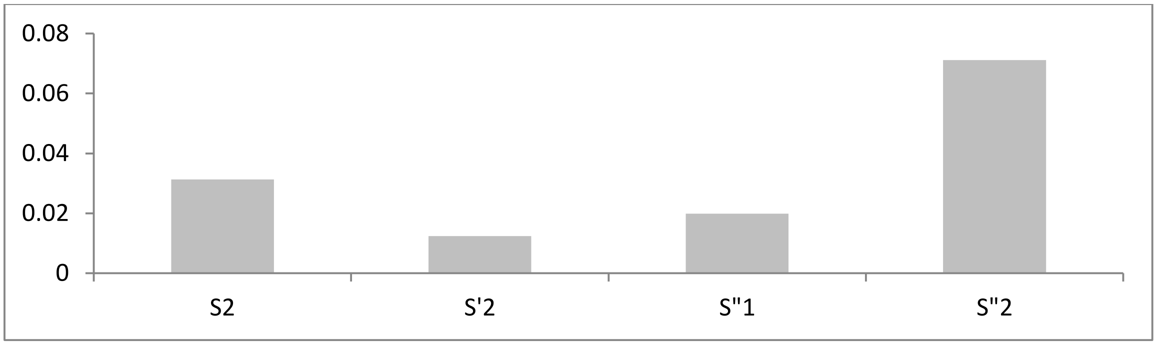
Table 5: Poverty reduction and policy costs with respect to national poverty

Simulations	Poverty reduction $P_{0_{initial}}$- $P_{0_{2020}}$	Estimated direct cost in year *t*	Estimated direct cost average over the simulation period (billion CFA)	Average government revenue loss, endogenous (billion CFA)
S_2	9.31	$\sum_{i=1}^{H^h} O_i . Y_i = \sum_{i=1}^{H^h} T_i^h - \xi_c Y_i^h$	20.6	29.7
S'_2	9.47	$\sum_{i=1}^{H^h} \frac{1}{2} O_i . Y_i = \sum_{i=1}^{H^h} \frac{1}{2} (T_i^h - \xi_c Y_i^h)$	10.3	76.5
$S"_1$	8.75	$\text{pwm(t) QM(t) EXR(t) tm0} (1 - (1 - \tau)^n)$	0.018	44.1
$S"_2$	7.12	$- PA_{health} (t) QA_{health} (t) ta_{health} (1 - (1 + \rho)^n)$	1.66	10.0

Source: The authors
Note: On May 23, 2014, 479.576 CFA Franc (African Financial Community) = US $1 (OANDA, 2014). This is the currency used in West Africa.

As shown in Figure 2, subsidizing the health sector and full coverage of catastrophic out-of-pocket health expenditures financed by a uniform tax on institutions are found to yield greater efficiency gains in the long run, than the other simulations.

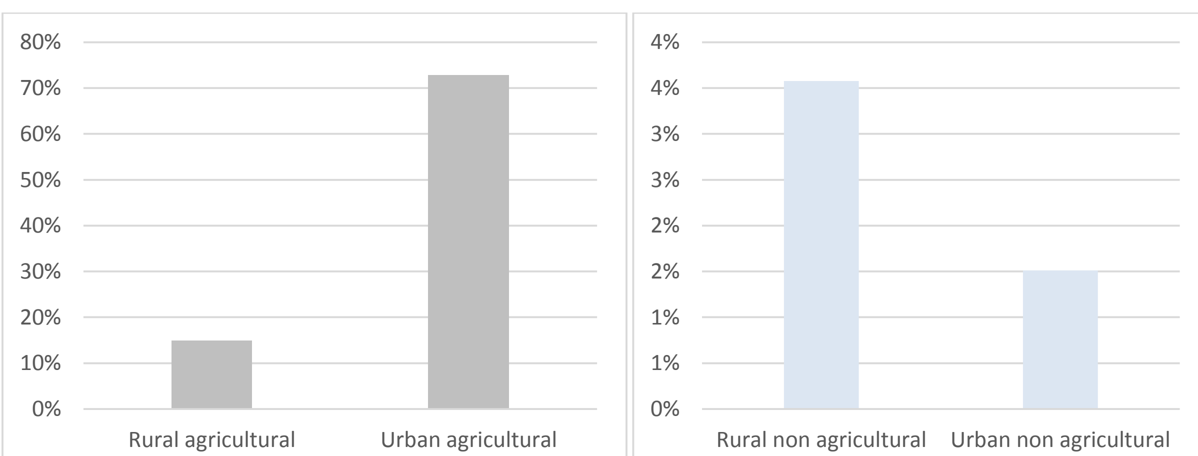
Figure 2: Poverty reduction ($P_{0_{initial}}$- $P_{0_{2020}}$) per unit of government revenue loss for specific simulations



Source: The authors

In addition, we analyze the public transfers' effectiveness of the full coverage scenario (financed by uniform direct taxes) between household groups h by scaling their relative poverty change to the specific amount of money they received as follows: $(P_{0_{initial}}{}^{h} - P_{0_{2020}}{}^{h})/P_{0_{initial}}{}^{h}$. Figure 3 shows the variation of the poverty reduction per unit of money received, for each household group. Our results indicate higher effectiveness for agricultural households, especially those in urban areas who are the most frequently affected by catastrophic health payments.

Figure 3: Relative variation of poverty per billion transferred (average over the simulation period) for specific household groups



Source: The authors

5. Conclusion

This paper has outlined the issue of integrating the relationship between health expenditures and productivity in a dynamic CGE model. It also focused on the impact of catastrophic out-of-pocket health payments on the economy, taking the specific case of Senegal during 2011-2020. According to the analysis of out-of-pocket health payments, there is evidence that many households are pushed into poverty by unforeseeable catastrophic expenditures. The idea that health good consumption has a positive impact on productivity is widely recognized in the existing literature, especially in microeconomics. This paper, based on the elasticity derived at household level, carries out the macroeconomic impact of the removal of catastrophic payment overshoot and also examines the ways in which policies affect prices and the way in which health good consumption affects welfare. The model is a recursive dynamic CGE with the agricultural technical progress modeled as endogenous and depending on the change of health consumption over time. Results reveal that price reduction policies promoting health good consumption have a positive impact on the agricultural sector and spillover effects on the rest of the economy. The study also indicates that poverty reducing effects and productivity gains are reached when simulating financial protection against the huge financial cost of illness.

Simulations show that an introduction of catastrophic coverage programs will reduce impoverishing effects on households who experienced financial hardship owing to high health expenditures. There is a potential to reduce poverty and enhance economic growth by assisting households. These results highlight the need to have an efficient health care system that relies less on household financial contributions to yield higher impact on productivity and to diminish the impoverishing effects on the population. The reduction of import tariffs and subsidies to the health sector emphasizes the negative impact of the presence of financial barriers to health care access.

Poor and more vulnerable persons such as urban agricultural households, who are the most affected by catastrophic out-of-pocket health expenditures, have to be considered when designing health policy. As it has been seen in this study, health policies have potential spillover effects for the agricultural sector and for poverty reduction. Subsidizing the health sector and financing full coverage of catastrophic out-of-pocket health expenditures through uniform taxes on institutions are more effective approaches. This study provides an incentive for the establishment of a catastrophic drug assistance policy that remains unimplemented to this day in Senegal.

References

Allen, S., Badiane, O., Sene, L., and Ulimwengu, J. (2014), Government Expenditures, Health Outcomes and Marginal Productivity of Agricultural Inputs: The Case of Tanzania. Journal of Agricultural Economics 65: 637–662.

Antle, J. M., and Pingali P. L. (1994). Pesticides, productivity, and farmer health: A Philippine case study. American Journal of Agricultural Economics 76:418–430.

Arndt, C. (2003). HIV/AIDS, Human Capital, and Economic Growth Prospects for Mozambique. Africa Region Working Paper Series No. 48. Washington DC: World Bank. Region Working Paper Series No. 48. Washington DC: World Bank.

Asenso-Okyere, K., Chiang C., Thangata P., and Andam K. S. (2011). Interactions between Health and Farm-Labor Productivity. Washington, DC: IFPRI.

Badiane, O. and Ulimwengu, J. (2009). The Growth-Poverty Convergence Agenda: optimizing social expenditures to maximize their impact on agricultural labor productivity, growth, poverty reduction in Africa. Discussion paper. Washington, D.C.: International Food Policy Research Institute.

Baum, C. F., Schaffer, M. E., and Stillman, S. (2003). Instrumental Variables and GMM: Estimation and Testing. The Stata Journal 3 (1), 1-31.

Bell C, Devarajan S and Gersbach H. (2003). The long-run economic costs of AIDS: Theory and an application to South Africa. Policy Research Working Paper No. 3152. World Bank: Washington, DC.

Benin, S., Mogues, T., Cudjoe, G., and Randriamamonjy, J. (2009). Public expenditures and agricultural productivity growth in Ghana. Beijing: International Association of Agricultural Economists Conference.

Cochrane, A., St Leger, A., and Moore, F. (1978). Health service input and mortality output in developed countries." Journal of Epidemiology and Community Health 32:200-205.

Croppenstedt, A., and Muller, C. (2000). The impact of farmers' health and nutritional status on their productivity and efficiency: Evidence from Ethiopia. Economic Development and Cultural Change 48 (3): 475–502.

De Cian, E. 2006. International Technology Spillovers in Climate-Economy Models: Two Possible Approaches. Fondazione Eni Enrico Mattei, 2006.141.

Fan, S., and Zhang, X. (2008). Public Expenditure, Growth and Poverty Reduction in Rural Uganda. African Development Review, 20: 466–496. doi: 10.1111/j.1467-8268.2008.00194.x.

Garen, J. (1984) .The Returns to Schooling: A Selectivity Bias Approach with a Continuous Choice Variable, Econometrica, Vol 52, pp. 1199–1218.

Grossman M. (1972a). The demand for health: A theoretical and empirical investigation. NBER Occasional Paper 119. National Bureau of Economic Research: New York.

Grossman, M. (1972b). On the Concept of Health Capital and the Demand for Health. Journal of Political Economy 80 (2): 223–255.

Kakwani, C., Wagstaff, A., Van Doorslaer, E. (1997). Socioeconomic inequalities in health: measurement, computation and statistical inference. J Econ, 77:87-104

Kambou, G., Devarajan, S., and Over, M. (1992). The Economic Impact of AIDS in an African Country: Simulations with a General Equilibrium Model of Cameroon. Journal of African Economies 1(1): 109-130.

Karami, M., Najafi, F., and Karami, M. B. (2009). Catastrophic health expenditure in Kermanshah, West of Iran: magnitude and distribution. J Res Health Science. 9(2): 36-40.

Kawabata, K., Xu, K. and Carrin. (2002). Preventing impoverishment through protection against catastrophic health expenditure. Bull. World Health Organization. 80(8): 612 15.

Kleibergen, F., and Paap, R. (2006). Generalized Reduced Rank Tests Using the Singular Value Decomposition, Journal of Econometrics 127, 97–126.

Löfgren, H., Harris, R., and Robinson, S. (2002). "A Standard Computable General Equilibrium (CGE) Model in GAMS." IFPRI Trade and Macroeconomics Discussion Paper 75. Washington, DC: International Food Policy Research Institute.

McNamara, P. E., Ulimwengu, J. M., and Leonard, K. L. (2012). Do health investments improve agricultural productivity? Lessons from agricultural household and health research. Edited by Shenggen Fan and Rajul Pandya-Lorch, 113.

OANDA. Currency Converter. (2014). Last accessed May 23, 2014, from http://www.oanda.com.

O'Donnell, O., van Doorslaer E., Wagstaff, A., and Lindelow, M. (2008). Analyzing Health Equity Using Household Survey Data. A Guide to Techniques and Their Implementation. Washington, DC: The World Bank.

Pitt, M., and Rosenzweig, M. (1986). Agricultural prices, food consumption, and the health and productivity of Indonesian farmers. In Singh, J., Squire, L. and J. Strauss (Eds.) Agricultural household models. Johns Hopkins University Press, Baltimore, MD.

Pradhan, M., and Prescott, N. (2002). Social risk management options for medical care in Indonesia. Health Econ, 11:431–446.

Robillard, A. S., and Robinson, S. (1999). Reconciling household surveys and National Accounts Data Using a Cross Entropy Estimation Method, IFPRI. Discussion paper N° 50.

Russell, S. (2004). The Economic Burden of Illness for Households in Developing Countries: A Review of Studies Focusing on Malaria, Tuberculosis, and Human Immunodeficiency Virus/Acquired Immunodeficiency Syndrome. American Journal of Tropical Medicine and Hygiene 71(Supp. 2): 147–55.

Séne, L.M., and Cissé, M. (2015). Catastrophic out-of-pocket payments for health and poverty nexus: evidence from Senegal. International Journal of Health Economics and Management. 10.1007/s10754-015-9170-4.

Singh, I., Squire, L., and Strauss, J. (1986). Agricultural Household Models: Extensions, Applications and Policy. Baltimore: Johns Hopkins University Press.

Stock, J. H., and Yogo, M., (2005). Testing for weak instruments in linear IV regression. In D. W. Andrews, K., and Stock J.H. (Eds.), Identification and inference for econometric models: essays in honor of Thomas Rothenberg (pp. 80-108). Cambridge: Cambridge University.

Stratman, J. (1999). What Do Medical Services Buy? Effects of Doctor Visits on Work Day Loss. Eastern Economic Journal. Vol. 25(1) pp. 1-16

Terza, J., Basu, A., and Rathouz, P. (2008). Two-stage residual inclusion estimation: addressing endogeneity in health econometric modeling. Journal of Health Economics, 27:531-543.

Thurlow, J. (2004). A Dynamic Computable General Equilibrium (CGE) Model for South Africa: Extending the Static IFPRI model. TIPS Working Paper Series, WP-2004.

Vella, F. (1993). A simple estimator for models with censored endogenous regressors, International Economic Review, Vol. 34, pp. 441–457.

Wagstaff A., and van Doorslaer E. (2003). Catastrophe and impoverishment in paying for health care: with applications to Vietnam 1993– 1998. Health Econ 2003, 12:921– 934.

Xu, K., Evans, D.B., Kawabata, K., Zeramdini, R., Klavus, J., and Murray C.J. (2003). Household catastrophic health expenditure: a multicounty analysis. Lancet 2003, 362: 111– 117.

Zweifel, P., and Breyer, F. (1997). Health Economics, Oxford University Press, New York.

Wooldridge, J. M. Econometric Analysis of Cross Section and Panel Data (Cambridge: MIT Press, 2010).

Appendix

Table A1: Model sets, parameters, and variables

Symbol	Explanation	Symbol	Explanation
Sets			
$a \in A$	Activities	$c \in CMR(\subset C)$	Regionally imported commodities
$a \in ALEO(\subset A)$	Activities with a Leontief function at the top of the technology nest	$c \in CMNR(\subset C)$	Non-regionally imported commodities
$c \in C$	Commodities	$c \in CT(\subset C)$	Transaction service commodities
$c \in CD(\subset C)$	Commodities with domestic sales of domestic output	$c \in CX(\subset C)$	Commodities with domestic production
$c \in CDN(\subset C)$	Commodities not in *CD*	$f \in F$	Factors
$c \in CE(\subset C)$	Exported commodities	$i \in INS$	Institutions (domestic and rest of world)
$c \in CEN(\subset C)$	Commodities not in *CE*	$i \in INSD(\subset INS)$	Domestic institutions
$c \in CM(\subset C)$	Aggregate imported commodities	$i \in INSDNG(\subset INSD)$	Domestic non-government institutions
$c \in CMN(\subset C)$	Commodities not in *CM*	$h \in H(\subset INSDNG)$	Households
Parameters			
$cwts_c$	Weight of commodity *c* in the CPI	pwm_c	Import price (foreign currency)
$dwts_c$	Weight of commodity *c* in the producer price index	$pwmr_{cr}$	Import price by region (foreign currency)
ica_{ca}	Quantity of c as intermediate input per unit of activity *a*	$qdst_c$	Quantity of stock change
$icd_{cc'}$	Quantity of commodity *c* as trade input per unit of *c*' produced and sold domestically	$\overline{qg}_c$	Base-year quantity of government demand
$ice_{cc'}$	Quantity of commodity *c* as trade input per exported unit of *c*'	$\overline{qinv}_c$	Base-year quantity of private investment demand
$icer_{cc'r}$	Quantity of commodity *c* as trade input per exported unit of *c*' from region *r*	$shif_{if}$	Share for domestic institution *i* in income of factor *f*
$icm_{cc'}$	Quantity of commodity *c* as trade input per imported unit of *c*'	$shii_{ii'}$	Share of net income of *i*' to *i* (*i*' ∈ INSDNG'; *i* ∈ INSDNG)
$icmr_{cc'r}$	Quantity of commodity *c* as trade input per imported unit of *c*' from region *r*	ta_a	Tax rate for activity *a*
$inta_a$	Quantity of aggregate intermediate input per activity unit	$\overline{tins}_i$	Exogenous direct tax rate for domestic institution *i*
iva_a	Quantity of aggregate intermediate input per activity unit	$tins01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates
$\overline{mps}_i$	Base savings rate for domestic institution *i*	tm_c	Import tariff rate
$mps01_i$	0-1 parameter with 1 for institutions with potentially flexed direct tax rates	tmr_{cr}	Regional import tariff
pwe_c	Export price (foreign currency)	tq_c	Rate of sales tax
$pwer_{cr}$	Export price by region (foreign currency)	$trnsfr_{i\,f}$	Transfer from factor *f* to institution *i*
Greek symbols			
α_a^a	Efficiency parameter in the CES activity function	δ_c^t	CET function share parameter
α_a^{va}	Efficiency parameter in the CES value-added function	δ_{fa}^{va}	CES value-added function share parameter for factor *f* in activity *a*
α_c^{ac}	Shift parameter for domestic commodity aggregation function	γ_{ch}^m	Subsistence consumption of marketed commodity *c* for household *h*
α_c^q	Armington function shift parameter	θ_{ac}	Yield of output c per unit of activity *a*

α_c^t	CET function shift parameter	ρ_a^a	CES production function exponent
α_c^m	Shift parameter in the CES regional import function	ρ_a^{va}	CES value-added function exponent
α_c^e	Shift parameter in the CES regional export function	ρ_c^{ac}	Domestic commodity aggregation function exponent
β^a	Capital sectoral mobility factor	ρ_c^q	Armington function exponent
β_{ch}^m	Marginal share of consumption spending on marketed commodity c for household h	ρ_c^t	CET function exponent
δ_a^a	CES activity function share parameter	ρ_c^m	Regional imports aggregation function exponent
δ_{ac}^{ac}	Share parameter for domestic commodity aggregation function	ρ_c^e	Regional exports aggregation function exponent
δ_c^q	Armington function share parameter	η_{fat}^a	Sector share of new capital
υ_f	Capital depreciation rate		
Exogenous variables			
$\overline{CPI}$	Consumer price index	$\overline{MPSADJ}$	Savings rate scaling factor (= 0 for base)
$\overline{DTINS}$	Change in domestic institution tax share (= 0 for base; exogenous variable)	$\overline{QFS}_f$	Quantity supplied of factor
$\overline{FSAV}$	Foreign savings (FCU)	$\overline{TINSADJ}$	Direct tax scaling factor (= 0 for base; exogenous variable)
$\overline{GADJ}$	Government consumption adjustment factor	$\overline{WFDIST}_{fa}$	Wage distortion factor for factor *f* in activity *a*
$\overline{IADJ}$	Investment adjustment factor		
Endogenous variables			
AWF_{ft}^a	Average capital rental rate in time period *t*	QF_{fa}	Quantity demanded of factor *f* from activity *a*
$DMPS$	Change in domestic institution savings rates (= 0 for base; exogenous variable)	QG_c	Government consumption demand for commodity
DPI	Producer price index for domestically marketed output	QH_{ch}	Quantity consumed of commodity *c* by household *h*
EG	Government expenditures	QHA_{ach}	Quantity of household home consumption of commodity *c* from activity *a* for household *h*
EH_h	Consumption spending for household	$QINTA_a$	Quantity of aggregate intermediate input
EXR	Exchange rate (LCU per unit of FCU)	$QINT_{ca}$	Quantity of commodity *c* as intermediate input to activity *a*
$GOVSHR$	Government consumption share in nominal absorption	$QINV_c$	Quantity of investment demand for commodity
$GSAV$	Government savings	QM_c	Quantity of imports of commodity *c*
$INVSHR$	Investment share in nominal absorption	QMR_{cr}	Quantity of imports of commodity *c* by region *r*
MPS_i	Marginal propensity to save for domestic non-government institution (exogenous variable)	QER_{cr}	Quantity of exports of commodity *c* to region *r*
PA_a	Activity price (unit gross revenue)	QQ_c	Quantity of goods supplied to domestic market (composite supply)
PDD_c	Demand price for commodity produced and sold domestically	QT_c	Quantity of commodity demanded as trade input
PDS_c	Supply price for commodity produced and sold domestically	QVA_a	Quantity of (aggregate) value-added
PE_c	Export price (domestic currency)	QX_c	Aggregated quantity of domestic output of commodity
PER_{cr}	Export price by region (domestic currency)	$QXAC_{ac}$	Quantity of output of commodity *c* from activity *a*

$PINTA_a$	Aggregate intermediate input price for activity *a*	RWF_f	Real average factor price
PK_{ft}	Unit price of capital in time period *t*	$TABS$	Total nominal absorption
PM_c	Import price (domestic currency)	$TINS_i$	Direct tax rate for institution *i* ($i \in$ INSDNG)
PMR_{cr}	Import price by region (domestic currency)	$TRII_{ii'}$	Transfers from institution *i*' to *i* (both in the set INSDNG)
PQ_c	Composite commodity price	WF_f	Average price of factor
PVA_a	Value-added price (factor income per unit of activity)	YF_f	Income of factor *f*
PX_c	Aggregate producer price for commodity	YG	Government revenue
$PXAC_{ac}$	Producer price of commodity *c* for activity *a*	YI_i	Income of domestic non-government institution
QA_a	Quantity (level) of activity	YIF_{if}	Income to domestic institution *i* from factor *f*
QD_c	Quantity sold domestically of domestic output	ΔK^a_{fat}	Quantity of new capital by activity *a* for time period *t*
QE_c	Quantity of exports		

Source: Adapted from Lofgren *et al* (2002) and Thurlow (2004)

Table A2: Model equations

Production and price equations

$$QINT_{ca} = ica_{ca} \cdot QINTA_a \quad (1)$$

$$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca} \quad (2)$$

$$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \quad (3)$$

$$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{fa}^{va} \cdot \left(\alpha_{fa}^{vaf} \cdot QF_{fa} \right)^{-\rho_a^{va} - 1} \quad (4)$$

$$QA_a = \alpha_a^a \cdot \left(\sum_{f \in F} \delta_a^a \cdot \left(QVA_a \right)^{-\rho_a^{va}} + (1 - \delta_a^a) \cdot \left(QINTA_a \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}} \quad (5)$$

$$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a \quad (6)$$

$$QXAC_{ac} = \theta_{ac} \cdot QA_a \quad (7)$$

$$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac} \quad (8)$$

$$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}{}^{-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}} \tag{9}$$

$$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}-1} \tag{10}$$

$$PER_{c\,r} = pwer_{c\,r} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icer_{c'c\,r} \tag{11}$$

$$QE_c = \alpha_c^e \cdot \left(\sum_{r \in R} \delta_{c\,r}^e \cdot \left(QER_{c\,r} \right)^{-\rho_c^e} \right)^{-\frac{1}{\rho_c^e}} \tag{12}$$

$$\frac{PER_{c\,r}}{PE_c} = QER_{c\,r} \cdot \left(\sum_{r' \in R} \delta_{c\,r'}^e \cdot \left(QER_{c\,r'} \right)^{-\rho_c^e} \right)^{-1} \cdot \delta_{c\,r}^e \cdot \left(QER_{c\,r} \right)^{-\rho_c^e-1} \tag{13}$$

$$PE_c = pwe_c \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c} \tag{14}$$

$$QX_c = \alpha_c^t \cdot \left(\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}} \tag{15}$$

$$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}} \tag{16}$$

$$QX_c = QD_c + QE_c \tag{17}$$

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c \tag{18}$$

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c} \tag{19}$$

$$PMR_{c\,r} = pwmr_{c\,r} \cdot \left(1 + tmr_{c\,r} \right) \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icmr_{c'c\,r} \tag{20}$$

$$QM_c = \alpha_c^m \cdot \left(\sum_{r \in R} \delta_{c\,r}^m \cdot \left(QMR_{c\,r} \right)^{-\rho_c^m} \right)^{-\frac{1}{\rho_c^m}} \tag{21}$$

$$\frac{PMR_{c\,r}}{PM_c} = QMR_{c\,r} \cdot \left(\sum_{r' \in R'} \delta_{c\,r'}^m \cdot \left(QMR_{c\,r'} \right)^{-\rho_c^m} \right)^{-1} \cdot \delta_{c\,r}^m \cdot \left(QMR_{c\,r} \right)^{-\rho_c^m-1} \tag{22}$$

$$PM_c = pwm_c \cdot (1 + tm_c) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'\,c} \tag{23}$$

$$QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + (1 - \delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}} \tag{24}$$

$$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q} \right)^{\frac{1}{1+\rho_c^q}} \tag{25}$$

$$QQ_c = QD_c + QM_c \tag{26}$$

$$PQ_c \cdot (1 - tq_c) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c \tag{27}$$

$$QT_c = \sum_{c' \in C'} \left(icm_{c\,c'} \cdot QM_{c'} + icmr_{c\,c'} \cdot QMR_{c'} + ice_{c\,c'} \cdot QE_{c'} + icer_{c\,c'} \cdot QER_{c'} + icd_{c\,c'} \cdot QD_{c'} \right) \quad (28)$$

$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c \quad (29)$$

$$DPI = \sum_{c \in C} PDS_c \cdot dwts_c \quad (30)$$

Institutional incomes and domestic demand equations

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{f\,a} \cdot QF_{f\,a} \quad (31)$$

$$YIF_{i\,f} = shif_{i\,f} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right] \quad (32)$$

$$YI_i = \sum_{f \in F} YIF_{i\,f} + \sum_{i' \in INSDNG'} TRII_{i\,i'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR \quad (33)$$

$$TRII_{i\,i'} = shii_{i\,i'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'} \quad (34)$$

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{i\,h} \right) \cdot (1 - MPS_h) \cdot (1 - \overline{tins}_h) \cdot YI_h \quad (35)$$

$$PQ_c \cdot QH_{c\,h} = PQ_c \cdot \gamma^m_{ch} + \beta^m_{ch} \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma^m_{c'h} \right) \quad (36)$$

(See above for health)

$$QINV_c = IADJ \cdot \overline{qinv}_c \quad (37)$$

$$QG_c = \overline{GADJ} \cdot \overline{qg}_c \quad (38)$$

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI} \quad (39)$$

$$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{r \in R} \sum_{c \in CMR} tmr_{cr} \cdot pwmr_{cr} \cdot QMR_{cr} \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR \quad (40)$$

System constraints and macroeconomic closures

$$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c \quad (41)$$

$$\sum_{a \in A} QF_{f\,a} = QFS_f \quad (42)$$

$$QFS_f / QFS^0_f = \left(RWF_f / RWF^0_f \right)^{etals_f} \quad (43)$$

$$RWF_f = \left(\frac{YF_f}{QFS_f} \right) \Big/ \left(\frac{CPI}{CPI^0} \right) \quad (44)$$

$$YG = EG + GSAV \quad (45)$$

$$\sum_{c \in CMNR} pwm_c \cdot QM_c + \sum_{r \in R} \sum_{c \in CMR} pwmr_{cr} \cdot QMR_{cr} \cdot \sum_{f \in F} trnsfr_{row\ f}$$
$$= \sum_{c \in CENR} pwe_c \cdot QE_c + \sum_{r \in R} \sum_{c \in CER} pwer_{cr} \cdot QER_{cr} + \sum_{i \in INSD} trnsfr_{i\ row} + FSAV \qquad (46)$$

$$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c \qquad (47)$$

$$MPS_i = \overline{mps}_i \cdot \left(1 + MPSADJ\right) \qquad (48)$$

Capital accumulation and allocation equations

$$AWF_{f\,t}^{a} = \sum_{a} \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right] \qquad (49)$$

$$\eta_{f\,a\,t}^{a} = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^{a} \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF_{f\,t}^{a}} - 1 \right) + 1 \right) \qquad (50)$$

$$\Delta K_{f\,a\,t}^{a} = \eta_{f\,a\,t}^{a} \cdot \left(\frac{\sum_{c} PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right) \qquad (51)$$

$$PK_{f\,t} = \sum_{c} PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}} \qquad (52)$$

$$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K_{f\,a\,t}^{a}}{QF_{f\,a\,t}} - \upsilon_f \right) \qquad (53)$$

$$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_{a} \Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f \right) \qquad (54)$$

Productivity growth

$$\alpha_a^{va}(\mathrm{t}+1) = \alpha_a^{va}(\mathrm{t}) \Bigg(1 + \vartheta \sum_{h}^{H} \frac{\Delta\left(P_{health}(h,t) Q_{health}(h,t)\right)}{P_{health}(h,t) Q_{health}(h,t-1)} \left(\boldsymbol{H}_c^h(t)\right)^{(1-1_{[\Delta(PQ)>0]})} \left(1 - \boldsymbol{H}_c^h(t)\right)^{1_{[\Delta(PQ)>0]}} \Bigg) \qquad (55)$$

Source: Adapted from Lofgren *et al* (2002) and Thurlow (2004)

Table A3: Estimation of the elasticity parameter ϑ

Variables	MMEL-2SRI	2SLS
Land	0.418***	0.380***
	(0.071)	(0.054)
Fertilizer	0.0297**	0.0445***
	(0.0124)	(0.0077)
Capital	0.0343***	0.0276***
	(0.008)	(0.009)
Labor	0.0208*	0.0159*
	(0.0108)	(0.008)
Health spending (Hs) : **ϑ**	0.111***	0.117***
	(0.0318)	(0.034)
H residual	-0.0128	
	(0.010)	
Constant : **ς**	0.495**	0.484**
	(0.215)	(0.223)
Observations	1,499	1,499
Log-pseudo likelihood	-2567.88	
$\sigma(\boldsymbol{u_0})$	0.313	
	(0.093)	
Hansen J-statistic (P-value)		0.149
Kleibergen-Paap Wald rank F statistic		16.08
Kleibergen-Paap rank LM statistic (P-value)		0.00

Source: The authors

Notes:

The dependent variable is the output.

Robust-clustered standard errors in parentheses *** p<0.01, ** p<0.05, * p<0.1.

MMEL: Multilevel mixed-effects linear regression.

The first step results are available but not reported. The instruments for health expenditures are: age of household head, education of household head, private health center frequentation, house ownership, radio, improved toilet, type of activity, wall material, use of mosquitoes and vaccine.

"H residual" represents the residual from this regression.

$y = A\prod_{i=1}^{n} x_i^{\beta_i}$ With $\log A = \alpha_0 + \vartheta\, Hs\ + \mu_0$, y is the output, x_i the traditional inputs and Hs health spending. All variables are in logarithm.

The exogenous shock $\mu(h, t_0)$ is calibrated using the sum of the residuals "H residual" across the household groups. It is expressed in the SAM unit and is distributed as follows: rural agricultural poor (3.67), rural agricultural rich (5.20), rural non-agricultural poor (3.51), rural non-agricultural rich (8.87), urban agricultural poor (0.18), urban agricultural rich (0.87), urban non-agricultural poor (3.50), urban non-agricultural rich (14.62).

Table A4: Poverty (P^0) evolution for all the simulations

	BAU	S_1	S_2	S_3	S_4	S_5	S'_1	S'_2	S'_3	S'_4	**5**	$S"_1$	S
2011	46.71	46.71	46.71	46.71	46.71	46.71	46.71	46.71	46.71	46.71	46.71	46.71	46
2020	39.65	38.15	37.39	37.76	37.40	37.47	39.13	37.24	38.52	37.35	39.13	37.96	39

Source: The authors

Table A5: Health good consumption growth rate per household group and for selected simulations

	Initial value	***BAU***	S_1	S_2	S_3	S_4	S_5	S'_1	$S"_1$	$S"_2$
Rural agricultural poor	5.20	3.02	3.11	3.18	3.12	3.16	3.13	3.06	3.05	3.72
Rural agricultural rich	4.21	2.96	3.08	3.14	3.09	3.12	3.10	3.02	3.00	3.66
Rural non-agricultural poor	5.64	2.89	3.10	3.15	3.11	3.14	3.13	2.99	2.94	3.58
Rural non-agricultural rich	14.01	2.96	3.23	3.28	3.24	3.27	3.26	3.10	3.01	3.67
Urban agricultural poor	0.84	1.53	1.92	2.02	1.93	1.96	1.94	1.72	1.59	2.01
Urban agricultural rich	1.45	3.28	3.29	3.36	3.29	3.35	3.35	3.28	3.41	3.87
Urban non-agricultural poor	9.40	3.34	3.50	3.59	3.53	3.58	3.58	3.42	3.49	3.94
Urban non-agricultural rich	59.18	3.40	3.63	3.71	3.77	3.70	3.70	3.52	3.53	4.00

Source: The authors