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Essays on Modeling and Evaluation of Pro-Poor-Growth Strategies in Africa

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List of abbreviations and acronyms

ANSD: Agence National de la Statistique et de la Démographie

APE: Agricultural Pubic Expenditure

CAADP: Comprehensive African Agricultural Development Program

CAPSU: Independent Fund for Universal Social Protection

CES: Constant Elasticity of Substitution

CFA: African Financial Community

CGE: Computable General Equilibrium

DAPSA: Direction de l'Analyse, de la Prévision et des Statistiques Agricoles

DPEE: Direction de la Prévision et des Etudes Economiques

ECOWAS: Economic Community of West African States

ESPS: Enquête de Suivi de la Pauvreté. Poverty Monitoring Survey

FGT: Foster-Greer-Thorbecke

FIML: Full Information Maximum Likelihood

FM: Farm Management

FOC: First Order Conditions

GDP: Gross Domestic Product

GIP SPSI: Groupement d'Intérêt Public Santé et Protection Sociale International

GMLM: Generalized Mixed Linear Model

HDI: Human Development Index

HDP: Highest Posterior Density

HR: Human Resource

IFPRI: International Food Policy Research Institute

LGA: Local Government Authorities

MA: Market Access

MDG: Millennium Development Goals

MFR: Managing for Results

MHO: Mutual Health organizations

MMEL: Multilevel Mixed-Effects Linear

MOHSW: Ministry of Health and Social Welfare

MTEF: Medium-Term Expenditure Framework

NOAA: National Oceanic and Atmospheric Administration

NR: Natural Resource

OLS: Ordinary Least Squares

PFMS: Public Finance Management System

PGE: Growth Poverty Elasticity

PGM: Growth Poverty Multiplier

PIF: Policy Impact Function

PNAE: Public Non-Agricultural Expenditure

PNIA: Programme National d'Investissement Agricole

PPG: Pro Poor Growth

PRSD: Poverty Reduction Strategy Documents

RD: Research and Development

RE: Random Effect

REPOA: Research on Poverty Alleviation

SAM: Social Accounting Matrix

SEM: Structural Equation Model

SFA: Stochastic Frontier Analysis

SIGFIP: Système Intégré de Gestion des Finances Publiques

SMTEF: Sectoral Medium-term Expenditure Framework

SPM: Supplemental Poverty Measure

SSA: Sub-Saharan African

SUR: Seemingly Unrelated Equations

TFP: Total Factor Productivity

TOFE: Table of Government Financial Operation

TP: Technical Progress

TSH: Tanzanian shillings

UBOS: Uganda Bureau of Statistics

UNDP: United Nations Development Programme

2SPS: Two-Stage Prediction Substitution

2SRI: Two-Stage Residual Inclusion

Chapter I

Introduction and Summary

I.1. Introduction

Africa has the highest rate of poverty in the World, and despite tremendous progress, many countries will not meet the Millennium Development Goals (MDG) owing to many factors such as the instability and the non-inclusiveness of the slight growth observed in the 2000's[1]. Given the relation between poverty and growth, especially in the agricultural sector, there are timely research questions on these central issues and a necessity to find out the most efficient development strategies. More specifically, there is a real need to carry out comprehensive analyses of the impacts of governmental policies on growth and ultimately on poverty. It has been widely recognized that there is complementarity between growth objectives and poverty reduction strategies. However, setting-up efficient policies requires identifying the adequate growth profile, as the size of poverty reduction pay-off following an average income increase might depend on the sector that leads growth and on the extent in which it is related to poor individuals. Efficient policies also require focusing on optimal sectoral policy instruments within the ongoing development agenda. The identification of key sectors with regards to a range of policy goals, including poverty reduction and growth in per capita income, and key sectoral policy programs, can provide guidance to the authorities regarding the orientation of scarce financial resources. Many authors have investigated the growth-poverty nexus (Diao et al 2005, Christiaensen et al. 2006, Dorosh and Thrulow, 2014), but have not explicitly investigated the prior relation (the policy-growth linkage) that should determine the amount of public spending leading to a specific level of growth. Some other authors (Fan and Zhang, 2008; Fan and Rosegrant, 2008; Benin et al., 2009 etc.) have provided evidence that public agricultural expenditures are efficient to promote agricultural growth, but using more simplistic tool that the ones proposed in this dissertation. For a more complete impact assessment, there is a need to develop an analytical framework that can clearly provide guidance to reach growth and poverty reduction targets by dealing with the complexity of the relationships between disaggregated agricultural and non-agricultural public spending and the productivity of the different sectors, especially in the agricultural sector. The latter has been given priority in the development agenda with the Comprehensive African Agricultural Development Program (CAADP), an African leaders' collective vision, set in order to promote agricultural-led growth. In fact, the member states of the African Union committed to achieve at least 6% growth in the agricultural sector and to devote 10% of their national budgets

[1] In the 2000's six of the world's ten rapidly growing countries were in Africa (ADB, 2012).

to agriculture development. Within sectors there is a need to identify intervention options that are likely to generate more technical progress and higher poverty reduction. The ongoing agricultural policy framework, namely CAADP, is a good illustration and needs to be technically supported for a successful implementation of its agenda.

In a world of limited resources, there might be a trade-off between investing in economic policy programs that promote growth in the productive sectors and providing public goods, especially in social services. Thus, there is a trade-off between promoting future growth and the provision of public goods today. The latter results from the fact that promoting future growth demands for public investments. These investments are done via different economic policy programs, which reduce the total budgetary resources available for public good services. However, more recent research points to a potential positive trade-off effect between public good services and future growth. In this regard, this dissertation provides empirical evidence on how the government might meet the social services needs while, at the same time, getting significant growth externalities from the resulting investments in social services, particularly in health.

This cumulative dissertation encompasses 5 contributions that deliver novel insights on these development issues and can be understood independently.

Chapter II and IV focus on the analysis of potential impacts of public health expenditures on productivity and hence future growth. In particular, chapter II provides an empirical analysis of the impact of public health expenditures on farmer’s productivity using the Tanzania case study. In fact, in a context of tight budget constraint prevailing among the government agencies, reinforcing the synergies between the different sectors can help to maximize growth and poverty reduction. This paper combines a traditional agricultural household model with a health production function and shows evidence that health affects productivity. Heterogeneous impacts are found across disease types, productivity of agricultural inputs, categories of expenditures and Tanzanian districts.

Likewise, I investigate the potential impact of out-of-pocket health expenditures on agricultural productivity and poverty in Chapter III and IV, respectively. Beyond public spending, private expenditures, especially out-of-pocket health expenditures, also have an impact on productivity, although having an impoverishing effect on households and constraining the productivity generating process when they became catastrophic because crossing a critical share of household total income. The issue on the impoverishment of out-of-pocket health expenditures is largely discussed in chapter III, which additionally used a conditional mixed process to estimate their determinants

Chapter V provides the second major contribution to this dissertation by analyzing the policy-growth linkages in addition to the growth-poverty linkages. This chapter deals with the essential identification pre-requisite by considering the cost issue of generating growth through technical progress; an issue that is often overlooked when determining the key sectors and key policy programs. Many studies have analyzed pro-poor-growth through the comparison of growth-poverty linkages across the economic sectors without assessing the cost of generating poverty reduction (Diao et al., 2005; Dorosh and Thurlow, 2014). In an innovative way, this paper combines empirical and expert data in order to estimate a Policy Impact Function (PIF) that ensures the linkages between sector specific technical progress and public spending in both agricultural and non-agricultural sectors. As pointed out by Headey et al. (2009), previous authors warranted the need to use country specific survey data instead of cross-country regressions that may yield too much broad insight and do not integrate idiosyncratic factors. (See Palaniswamy and Birner 2006; Bezemer and Headey 2008). A specification under a two-stage approach is adopted for the estimation of the PIF. At the lowest stage, policy programs are combined and lead to an effective budget; while at the upper stage, a sigmoid function shows how the resulting effective budget generates technical progress in each single sector. In turn, technical progress impacts on various political outcomes like population welfare. The PIF is intended to analyze a full range of agricultural policies while keeping economic non-agricultural policies at the aggregated level. It allows the estimation of the optimal allocation for an efficient implementation of the CAADP in the aim of generating the highest productivity improvement. We also show that considering the cost issue might lead to rankings of the sectors different from those resulting from the most commonly used approaches based on indexes of the responsiveness of poverty to exogenous sectoral growth. In addition, this contribution can be directly linked with the political economy models explaining the role of political incentives and policy beliefs of a government investing in agriculture and non-agricultural sectors.

Beyond all the identification of economic and political solutions, the implementation of the budget allocation between the different sectors and the different policy programs is a crucial point in achieving targeted growth and poverty reduction. Chapter VI analyzes the impact of a Medium-Term Expenditure Framework (MTEF) – a multi-year budget programming tool for a good implementation of the budget across sectors and policy programs - in Africa, with a special focus in Senegal. In particular, the chapter assesses the effectiveness of the MTEFs in allocating resources to priority sectors in the budget process and in improving budget discipline. The analyses show despite having the potential to make public expenditures more efficient and effective the adoption of the MTEFs still remains incomplete.

At a methodological level this dissertation approaches policy-growth linkages by conducting theoretically and empirically well-grounded analyses in order to better understand the African economies and policies, particularly in the agricultural sector, as more than 70 percent of the region's poor live in rural areas and are engaged in farming activities (IFAD, 2012). The presented chapters are evidence based and tackle policy-growth-poverty linkage and allocation of public spending in Africa through varying quantitative approaches. In fact, conducting the research with applied and quantitative methods allows dealing with the complexity of the investigated factors and the relationships and, at the same time, provides statistical methods to evaluate the validity and the credibility level of the different findings. Econometric approaches are used throughout the contributions. Besides, Chapters IV and V integrate simulations and are based on linked micro-macro approaches. In these chapters macroeconomics and microeconomics modeling are combined in order to better understand the growth and poverty effects of specific agricultural and non-agricultural policy interventions. As pointed out by Bourguignon et al. (2008), linked micro-macro modeling can help deal with the limitations of single and pure micro model (or macro model) that, when taken solely, only provides partial responses of policies at macro (or micro) level. The integrated micro-macro approaches are based on a quasi-dynamic and micro-simulated Computable General Equilibrium (CGE) model that I constructed for the application to Senegal and calibrated using an agricultural and regional focused Social Accounting Matrix that has also been built within this dissertation.

A Bayesian Alternative to the Entropy method (Heckelei et al. 2008) is used to econometrically estimate the PIF specified in Chapter V due to the indeterminacy of the resulting equation systems. This method uses expert data to get prior information on the levels and the ranges of the different parameters. Based on the pioneering work of Mundlak et al. (1989, 1997, 2008), Grossman (1972), Pitt and Rosenzweig (1986) and Fulginiti and Perrin (1993) chapters II and IV used conventional econometric methods to assess the impact of health spending on agricultural productivity and poverty. Control function approach through a two-stage residual inclusion - 2SRI (Garen, 1984;

Vella, 1993; Terza et al., 2008; Wooldridge, 2010) and general covariance structure model often called Structural Equation Modelling – SEM (Fox, 2002) are applied to control for endogeneity of health related variables, which has been identified as being a major cause of the controversy of the previous researches exploring health and productivity nexus. Besides, Chapter IV considers the non-automatic adjustment of health investment and productivity by using a CGE modeling that integrates the spillover effects in the economy, especially accounting for the bi-directional linkage between health and productivity. Both chapter II and IV emphasize the need for greater and efficient investment in the non-agricultural health sector in order to both meet the social demand and generate productivity growth under the extremely tight budgetary conditions and given the trade-off between growth and social services.

The Table I.1 provides an overview of the dissertation by classifying the chapters according to their contents and their methodology.

Table I.1: Overview of the contributions

			Chapter II	Chapter III	Chapter IV	Chapter V	Chapter VI
	Theory			✓	✓	✓	
	Empirical	Econometrics	✓	✓	✓	✓	
		Non-Parametric tests					✓
		Simulations			✓	✓	
	Economic Policies				✓	✓	✓
	Social Services Health		✓	✓	✓		
	Budget Allocation		✓			✓	✓
	Micro level data		✓	✓	✓		
	Macro level data				✓	✓	✓
	Integrated Micro Macro				✓	✓	

Note

Chapter II: Government Expenditures, Health Outcomes, and Marginal Productivity of Agricultural Inputs: The Case of Tanzania

Chapter III: Catastrophic out-of-pocket payments for health and poverty nexus: evidence from Senegal

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

Chapter V: Identifying key sectors and key policies of a Pro Poor Growth strategy: A new approach

Chapter VI: Harmonized Budget Programming Reforms in Africa: Senegal's experience with MTEF

The different contributions are summarized in the following chapter.

I.2. Summary

Government Expenditures, Health Outcomes, and Marginal Productivity of Agricultural Inputs: The Case of Tanzania

In Sub-African countries as it should be in many other developing economies, increasing the total agricultural government spending might not be easy due to the resource limitation and one alternative option for agricultural growth can be the promotion of indirect effects from non-agricultural expenditures and the change of their mix such in an optimal way. This paper analyzes the impact of health on agricultural productivity by allowing heterogeneity in the agricultural function with the functional parameters affected by the technology changing nature of morbidity. Using data from the 2008 Household Budget Survey and the 2007/08 Agricultural Census in Tanzania, we estimate the impact of household health status on productivity and the impact of disaggregated effect of public health spending on health outcomes. The link between health, spending, and productivity has been explored by numbers of author without a strong evidence and consensus on the nature of the linkages. This paper controls for the measurement errors, household heterogeneity, and endogeneity in order to bring an appropriate answer to the question. The results highlight the fundamental importance of health good of farmers to boost agricultural productivity. Efforts should be undertaken in this direction to avoid the loss of productivity that can result from illness.

Catastrophic out-of-pocket payments for health and poverty nexus: evidence from Senegal

Out-of-pocket payments are a major source of funding for household healthcare in Senegal. These payments are financial burdens leading to impoverishment when they become catastrophic, as households must reduce their expenditures on other necessities.

The objective of this paper is to explain the possible factors that determine the severity of catastrophic health expenditures by using a conditional mixed-process estimator procedure applied to the 2011 poverty monitoring survey. Besides, the impoverishing effects of such expenditures are investigated through the computation of an SPM-like estimate (Supplemental Poverty

Measure) that measures more accurately household resources. The paper also provides knowledge about both the occurrence and the intensity of catastrophic out-of-pocket health expenditures.
The results show that many individuals are pushed into poverty due to the burden of catastrophic payments. The level of overall health spending, the progressivity of household health expenditures, the expensiveness of health services and the characteristics of health facilities are among the causes of catastrophic health payment. These findings provide insight for efficient Government action to fight poverty by tackling the impoverishing effects of catastrophic health expenditures.

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

In a context of limited resources, a budget allocation process integrating direct as well as indirect effects across the economy can help to increase the impact of policies. Out-of-pocket health payments have an impact on household health and in return for welfare and productivity as underlined in the Grossman theory of demand for health care. However, there is evidence that at a certain threshold, these expenditures can become a burden because they account for a large share of household budget. In fact, out-of-pocket health payments might increase agricultural productivity, but when catastrophic, they can make households impoverished by lowering their disposable income and by constraining them to sell their productive assets to afford medical goods and necessary services. Unlike the previous studies, this paper investigates the impact of household health payment on agricultural productivity by considering some impoverishing effects that beyond productivity gains can also push people into poverty. It provides a valuable contribution by assessing the linkage between the health sector and the agricultural sector using the most recent household survey data in Senegal and a dynamic recursive Computable General Equilibrium (CGE) model that has been run from 2011 to 2020.
Health is considered as an investment good, meaning that its consumption is expected to provide productivity gains. 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, but also depends on the magnitude of catastrophic out-of-pocket health payments.

Results show a positive impact on poverty reduction when the Government finance catastrophic payment overshoots. Lower health costs also appear to improve households' well-being, especially in the case of agricultural households. Simulations show that an introduction of catastrophic coverage programs will reduce impoverishing effects of the households that experienced financial hardship owing to the high health expenditures.

Identifying key sectors and key policies of a Pro Poor Growth strategy: A new approach

This paper develops a framework that assesses poverty-growth linkages, e.g. economic potential to reduce poverty via growth and growth-policy linkages, e.g. the costs to promote growth in a specific sector, in order to better understand and evaluate Pro-Poor Growth strategies. It combines empirical data on sectoral input and output, and country expert data collected in personal interviews with an innovative methodology to estimate a Policy Impact Function (PIF). The latter links spending on agricultural and non-agricultural policy instruments to technical progress in each economic sector.

There is a crucial need to better understand African economies and the existing potentials for poverty reduction. This should start with the identification of key sectors and key policy programs for an efficient use of the resources. Recently, some authors pursued exploring toward this direction by assessing and comparing the CGE multiplier impacts of each specific sector-led growth on poverty reduction (Diao et al., 2005; Christiaensen et al. 2006; Dorosh and Thurlow, 2014). Still, there has not been sufficient and complete work in the sense of investigating the growth-linkage for the different economic sectors in a broad range of policy concerns and considering the cost issue of generating sectional growth.

The use of CGE multipliers might lead to contradictory conclusions and distorted picture in comparison to the CGE elasticities that account for sector size among the criteria determining the fact of being a key sector, in addition to the interdependence of the sectors to the rest of the economy[2]. However, both multiplier and elasticity concepts are partial as they don't consider that

[2] The CGE multiplier normalizes by the size of the sector being shocked and therefore looks at the impacts of additional unit of the output while CGE elasticity analyzes the impacts of the shift of sector output by 1% (e.g. realized from investment to raise technical progress).

growth through technical progress is costly and does not require the same public resources in the different sectors. Therefore, through the PIF framework, the paper brings an approach integrating the final and crucial question for the identification of key sectors that is: how costly is it for a government to promote technical progress in each single sector? Key sectors are finally those with relatively high growth-poverty linkages induced by the unit of public budget expenditure used to promote technical progress. Besides, the proposed Policy Impact Function (PIF) allows the derivation of the optimal agricultural policy programs within the CAADP framework. Finally, this framework can be linked to the political economy to see whether the observed political performance gap is explained by the knowledge gap, e.g. lack of evidence that identifies the optimal policies or whether it is due to the lack of incentive to apply the optimal policies that are already identified.

Harmonized Budget Programming Reforms in Africa: Senegal's experience with MTEF

Strategic budget management has been shown as being an important contributor to poverty reduction. The emergence of the results oriented management paradigm in the 1990s led to the adoption of the Medium-Term Expenditure Framework (MTEF) as a program and budgeting tool in several African countries. The MTEF is designed as a multi-year budgetary programming tool for improving budget discipline, predictability, and enhancing the link between the budget formulation process and development strategies. In June 2009, the countries in WAEMU adopted an additional legal stage in order to place the tool at the core of the budgetary process. The implementation of the harmonized public finance framework guidelines for WAEMU[3] member states contributes to the achievement of the convergence criteria and provides guidance on macroeconomic management by ensuring efficient financial and economic policies. These guidelines help increase integration of economic policies and accelerate the spread of good practices in budget management. Adoption of the MTEF approach by Senegal and several African countries stems from a desire to improve budget performance. We used non-parametric statistics due to the unknown distribution of the series and the limited number of observations to conduct a midterm review of the MTEFs. The impact of MTEFs on budget management and efficiency in Senegal is assessed by comparing the approved and executed amounts in matching fiscal years,

[3] West African Economic and Monetary Union

their budget variations, and their sector allocations. The data cover the period of 2000–2009 and are mainly sourced from the Senegalese government's Integrated Public Finance Management System database. To determine budget predictability, Spearman and Kendall tests are conducted on the MTEFs, budget projections, and on budget implementation under schedule. The results indicate that budget predictability in ministries with or without the MTEFs did not improve. However, an increase in some priority areas such as education, environment, and transport is noted. This contribution concludes that MTEFs neither improve budget discipline, assessed with fiscal balances, nor encourage resource allocation to priority areas. Notwithstanding, the MTEF implementation in Senegal has yielded improved budget programming and consistence in projections. It appears that even if there has been no redistribution in favor of some priority sectors, there has been a gradual increase in their allocations since the inception.

In a nutshell, the MTEF is a useful resource with untapped potential; this reality will remain stagnant as long as reforms in Africa remain incomplete. The main challenge for government authorities is to complete the implementation process with the establishment of a comprehensive MTEF in order to ensure that all the ministries adhere to planned allocations.

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Chapter II

Government Expenditures, Health Outcomes, and Marginal Productivity of Agricultural Inputs: The Case of Tanzania

Authors

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Abstract

This paper examines the impact of health expenditures on agricultural labour productivity, to inform the necessary policy decisions about targeting scarce public resources towards their most effective uses. We link health sector expenditures in rural Tanzania to health outcomes and agricultural labour productivity using data from the 2008 Household Budget Survey (10,975 households) and the 2007/08 Agricultural Census (52,594 households) across 113 districts in Tanzania. The results indicate that the marginal productivity of labour as well as land and fertilizers respond significantly to health expenditures. However, the magnitude of the response varies across types of disease, categories of expenditures, and agricultural inputs. These findings suggest both the need and scope for targeting public expenditures in the health sector to achieve better agricultural growth outcomes.

Key words: Tanzania, health, marginal productivity, social expenditures, state variable
JEL Classifications: Q11, C33

II.1. Introduction

Achieving the Millennium Development Goal of halving poverty would still leave the average poverty rate for many African countries at 30 percent. For the foreseeable future, these countries face a double challenge of finding sufficient resources to invest in growth and meeting the cost of social services for a large number of poor and vulnerable people. In the face of the budget constraints faced by most of these countries, the pace of future economic growth will depend on the ability of governments to find ways to maximize the impact of their large and increasing expenditures in social sectors on agricultural labour productivity. One way to do that is to first recognize that the mix of social expenditures is not growth-neutral and then, to try and target such expenditures to areas where they have the biggest and most immediate impact on productivity.

Over the past decade, African countries have made efforts to increase public expenditures in agriculture to support more rapid economic growth. Results from recent studies on long term growth and poverty trends among African countries suggest that most of these countries would have to raise public sector expenditures in agriculture by double-digit rates of growth on an annual basis in order to significantly reduce poverty during the current decade (Badiane and Ulimwengu, 2009). Such a rapid expansion of public investment in agriculture is beyond the means of many of these countries and even with that level of investment, average poverty rates would still remain high at around 30 percent.

High rates of poverty coupled with increasingly open political systems will lead to increasing pressure on governments to raise future spending on social services in an effort to address the burden of widespread poverty. In fact, public expenditures in each of the social sectors (health, education, and social protection) not only already exceed expenditures in agriculture but have also risen much faster over the last three decades. Given the tight budget constraints faced by African countries, future success in accelerating agricultural growth and reducing poverty will depend on the ability to maximize the impact of resources spent in the social sectors on labour productivity among farm households. This is only possible if countries shift from treating social services as entitlements with possible long-term effects on growth to treating them as public investments that can yield significant short-term impacts in a variety of sectors, including agriculture. This in turn requires the recognition that the mix of public expenditures on a given social service is not growth neutral and that different categories of expenditures may affect labour productivity differently (Badiane and Ulimwengu, 2013).

In this paper, we examine the relationship between health expenditures, health outcomes, and agricultural labour productivity among rural households in Tanzania. Administratively, Tanzania is sub-divided into 21 administrative regions and 133 councils (both district and municipal) with 10,342 villages (MOHSW, 2009). Local Government Authorities (LGAs) at the district level are responsible for delivering public health services, primary education, agricultural extension, water supply systems, and local road maintenance (United Republic of Tanzania, 2006). As in many sub-Saharan African countries, the majority of the poor population in Tanzania is located in rural areas and depends upon agriculture for their livelihood. In Tanzania, around 80 percent of people are employed in agriculture[4] and economic growth has not translated into a steep decline in poverty (Pauw & Thurlow, 2010). The government has striven to address poverty through investments in various social services including public health and education, agricultural extension, and infrastructure, and it appears some changes have taken place. For example, the Primary Health Care Service Development Programme increased primary health service provisions through staff and supply increases and upgraded facilities (MOHSW, 2009).

The Centre for Research on Poverty Alleviation (REPOA), a Tanzanian non-governmental organization, noted that from 1978 to 2005, infant mortality was halved, with similar reductions in under-five mortality, partially as a result of prevention and treatment of malaria, increased Vitamin A supplementation, immunization, and better nutrition (REPOA, 2006). For future health and development strategies, it is important to know the extent to which broader improvements in health outcomes are associated with higher levels of productivity among poor rural households and what role different categories of public expenditures on health have played.

In an extensive review, Paternostro et al. (2007) note that despite the analyses of the linkages between expenditures and growth or poverty, a lack of empirical validation (due to both the time lags associated with the impacts and the data constraints) limits the ability to identify poverty-focused public policies. Estimating these relationships is also complicated by endogeneity (Headey et al., 2010). This often leads to inconclusive results that are difficult to use for formulating policy and funding actions. For example, previous studies note that while better health capital indicators

[4] United Republic of Tanzania Website: http://www.tanzania.go.tz/agriculture.html; accessed October 9, 2013.

can increase growth rates in Africa by 22 to 30 percent, results have been mixed when looking at health care expenditures and outcomes (Anyanwu & Erhijakpor, 2007).

We analyze the impact of public health expenditures on health outcomes among farm households, and in turn how changes in health outcomes affect agricultural productivity. We use household-level data on agricultural production and health outcomes as well as public expenditure data at the district level. We use a novel approach that tackles both heterogeneity in production technologies and endogeneity of the marginal productivities of inputs. The paper also addresses the challenge of measuring overall household health status as well as the heterogeneity in the link between health and agricultural factor productivity. The remainder of the paper is organized as follows. Section II.2 describes the model that is used to assess the impact of health expenditures on household level health status and productivity. It is followed in Section II.3 by a description of the dataset. Section II.4 discusses the findings showing how different categories of district level health expenditures impact health outcomes among farm households and how that in turn affects the marginal productivity of labour and other inputs in the same households. Section II.5 concludes with policy implications and suggestions for the future research agenda.

II.2. Modeling Social Expenditures and Agricultural Productivity in Tanzania

Empirical studies provide evidence of how health constraints can impede agricultural productivity, both in the short and long term. In addition to directly impacting the quantity of labour available for agriculture, illness also lowers the quality and productivity of labour. Health issues and constraints, particularly malaria, have been found to have a negative and significant impact on Total Factor Productivity (TFP) in Africa (Cole & Neumayer, 2006; Strauss & Thomas, 1998). Health constraints have also been shown to lead to a shift in cropping patterns (Asenso-Okyere et al., 2009) and can influence adoption decisions for new agricultural technology (Ersado et al., 2004).

While public expenditures represent the primary vehicle through which public policy impacts health outcomes, there are few studies that capture linkages between expenditures, health outcomes, and productivity. Where they exist, such studies evaluate expenses and health outcomes at the macroeconomic level (see Anganwu & Erhijakpor, 2007 and Benin et al., 2009 for detailed reviews). Examples include the study by Baldacci et al. (2004), which shows that an increase in health spending of 1 percent of GDP translates into an increase of 0.6 percentage points in under-five child survival, especially in low-income countries. Others have analyzed the impact of public expenditures on mortality or morbidity or, at the aggregate level, on rural poverty through effects on total factor productivity and incomes (Fan, Hazell, and Haque, 2000; Fan, Hazell, and Thorat, 2000; and Fan and Zhang, 2008). A few studies have explicitly modeled either the relationship between health and agricultural productivity by incorporating a health variable into the production function (Pitt & Rosenzweig, 1986), or the link between public expenditures and productivity (Benin et al., 2009).

The relationship between agricultural efficiency and health has also been investigated in the literature using stochastic frontier analysis (SFA) (Ulimwengu, 2009; Phillips & Marble, 1986). While estimating efficiency in production can provide additional information about the production constraints, there are some weaknesses associated with these approaches. The models require specification of a functional form that can be too restrictive to mirror the actual conditions. Without this implied structure, they can be very sensitive to measurement error (Saradifis, 2002). This type of efficiency analysis can also ignore important farm-level differences between technology and production possibilities by assuming a homogeneous production frontier for all households (Mundlak, 1988). Others have augmented the human capital portion of the production function and/or allowed changes to labour efficiency (Teal, 2011), used social indicators as determinants of an unobservable latent variable (Baldacci et al., 2003), or estimated government expenditures as direct determinants of agricultural growth and poverty (Fan et al., 2002).

Expanding empirically on these previous estimation methods, we develop and implement a model to link directly different categories of public expenditures on health services to household health outcomes, and estimate the resulting impact on the marginal productivity of labour and other agricultural inputs. The approach is novel in that it accounts for both heterogeneity in production technologies and endogeneity of the marginal productivities of inputs. It is based on the assumption that government expenditures on social services such as health affect agricultural production directly but also indirectly through decisions regarding the use of inputs and adoption of technology. To try to capture both, we first adopt the framework developed by Mundlak et al. (1997) used to model farmers' decision processes. Mundlak et al. (2008) argue that the wide variation in the estimation results of agricultural production functions may be partially due to the exclusion of factors representing the political, economic, or physical environment ("states"), which have both direct and indirect effects on farm production and decisions.

We also account for the challenge in measuring overall household health status as a latent variable, which cannot be observed directly. We use observable proxies for health (the number of household members without the common illnesses of malaria, diarrhea, fever, and long-term illness in the past month) to capture overall household health status, which is not directly observable. To account for possible measurement error, a confirmatory factor analysis is used to estimate the relationship between the set of observed health indicators (the proxies) and the latent health variable using the structural equation model (SEM) approach.

We use the generalized mixed linear model (GMLM) to implement empirically the state variable approach. The GMLM estimation procedure allows for technological heterogeneity and endogenous marginal productivity of agricultural inputs. Technological heterogeneity within a country is particularly important for countries that have transferred management of public expenditures to lower levels of government (Gupta et al., 2002), as in Tanzania. To address issues related to potentially endogenous inputs (including health), a two-stage residual inclusion (2SRI) approach is used, following Wooldridge (2010) and Terza et al. (2008), as discussed in more detail later in the paper.

To implement the state variable approach, input elasticities can either be calculated from observed factor shares (assuming allocative and technical efficiency) or from fitting a production function that is simultaneously determined by both observed inputs and state variables (Fulginiti & Perrin, 1993). As the assumption of efficiency is likely too restrictive for rural households in Tanzania, we take the second approach, discussed in more detail below.

To efficiently estimate the health production function, following Baldacci et al. (2003), we model health status using a latent variable approach in the form of a general covariance structure model or SEM:

$$H = \varphi M + \zeta \qquad (1a)$$

$$D = \vartheta H + \varepsilon \qquad (1b)$$

where φ are parameters linking the latent health status variable (H) to the exogenous variables (M), including categories of district level government expenditure on health services, with ζ specified as random disturbances. The observed heath proxy variables (D) are linked to the latent health variable through the matrix of parameters ϑ as specified in equation (1b).

Following Mundlak et al. (1997), we assume that each farm chooses a production technology $Y_j(X)$ with production techniques (*j*), where (*X)* is a vector of constrained (*k*) and unconstrained (*v*) inputs so that $Y_j(X) \ni v, k$. Depending on the choice of *(j)*, each farm selects the profit-maximising optimal level of inputs (*X)* for each technique (*j)*. Assuming that the production function is conditional on the state variables, in our case the health status variable *(H)*, implies that changes in *(H)* will lead to changes in the optimal level of inputs (*x*)* as well as the chosen technology *Y (x*,H)*. It then follows that the slope (β) and intercept *(Γ)* are both determined by *(H)*, as shown in Equation 2, where the dependent variable *(Y)* represents agricultural production and ε the stochastic component (Mundlak et al. 1997).

$$ln\, Y = \Gamma\,(H) + \beta(H, x) + \varepsilon \qquad (2)$$

Assuming heterogeneity in production technologies across locations, our empirical model takes the form described below, in which *h* and *d* represent the household identifier and district location, respectively, and l the different inputs that are used. In order to capture the impact of the natural environment on household production, we have added precipitation (p_d) to the list of exogenous variables. The parameter γ_{1l} reflects the impact of state variables, in this case the health status of households in a given district, on the marginal productivity of individual inputs.

$$Y_h = \beta_0 + \textstyle\sum_l \beta_{hl} x_{hl} + b\widehat{H}_d + \beta_d p_d + \delta_d p_d^2 + \varepsilon_h \qquad (3)$$

$$\beta_{hl} = \gamma_{0l} + \gamma_{1l}\widehat{H}_d + u_{hl} \qquad (4)$$

The health data used to estimate equations (1a) and (1b) are from the 2008 Household Budget Survey and the production data used to estimate equations (3) and (4) are from the 2007/08 Agricultural Census. Because the two data sets, although from the same districts, are not based on identical household samples, district-level expected values of health outcomes ($\widehat{H}_d$), calculated as the average factor scores[5] of household members living in the district, obtained from (1a) and (1b) above, are used as the state variables in equation (4) to estimate the marginal productivity (β_{hl}) of each input (x_{hl}).

[5] This calculation method is an analogous to regression scoring where the means of the latent variables are conditional on the observed variables.

II.3. Data and Summary Statistics

The agricultural production data we use is from the 2007/08 Agricultural Census, a nationally representative survey covering 52,594 households in Tanzania for the agricultural year that ran from October 1, 2007 to September 30, 2008 (National Bureau of Statistics, 2010). Given the variety of crops produced on a single plot in Tanzania, we estimate the value of production as shown in Equation *(5):*

$$Y_h = \sum_{c=1}^{n} (y_{hc} \cdot P_c \cdot a_{hc}) \qquad (5)$$

Here, (Y_h) is the value of aggregate production for each household *(h)*, where y_{hc} is the quantity of production of crop c, P_c is its price, and a_{hc} is the share of land allocated to that crop.[6] We account for differences in land use and price heterogeneity by computing the value of aggregate production as the weighted sum of the value of all crops produced by the household, using the share of acreage for each crop as weights.[7]

We treat aggregate agricultural output as defined here as a function of weather or the natural environment (represented by the level of precipitation), labour (measured by the number of adult household members that are involved in agriculture as their main activity), the number of traction animals, the amount spent on inorganic fertilizer, and the acres of land planted. In order to address endogeneity issues, labour and fertilizer are instrumented as discussed in detail in the next section. We use satellite-collected daily precipitation data (in millimeters per day) from the Climate Prediction Center of the US National Weather Service (NOAA, 2010) that have been averaged over the district observation points for the agricultural year. We only have data on quantity of organic fertilizer used for 25 percent of households, so we use the amount spent on inorganic fertilizer.

In addition to the agricultural variables, data on health and household location are taken from the 2008 Household Budget Survey (National Bureau of Statistics, 2011). For the latent-variable approach, the numbers of household members not affected by malaria, diarrhea, fever or long-term

[6] Prices were not available for Tanzania for the range of crops produced. To be able to aggregate across all crops, we created the value of production for crops without Tanzania price data using an average of the prices from surrounding countries that produced these crops (Burundi, Cameroon, Eritrea, Kenya, Rwanda, and Tunisia) (FAO, 2012).

[7] The weights are crop prices but these prices are not location-specific; to account for heterogeneity among prices, we multiply the price for each crop with the area share of the respective crop and use the resulting adjusted price as weight in calculating aggregate production for each household.

illness over the past month were used as health indicators. These illnesses are the most documented illnesses in this dataset as well as in previous studies for Tanzania (Koestle, 2002). Summary statistics for these household-level variables are presented in Table II.A.1 in the Appendix.

Data on district expenditures for a range of categories are compiled and available online from the National Bureau of Statistics (Local Government Finance Working Group, 2011). For health expenditures, we use only those categories which are likely to be directly related to service delivery (personal salaries for employees and development grants that are funded).[8] As districts vary greatly in size, we calculate the district-level average expenditures per capita for 2005 and 2006, using population data from the Population Census for 2002/03, the most recent compiled source of population data for Tanzania (National Bureau of Statistics, 2006). Table II.1 presents the amount of spending in Tanzanian shillings (TSH) per capita.[9]

Table II.1: District Expenditure Data

District Expenditures (TSH) per Capita (Mean 2005 & 2006)		
Expenditure Category	**Mean**	**Standard Deviation**
Health Personal Salaries	7,107	14,550
Health Development Grants	2,576	7,556
Health Total Spending	13,433	30,524

Source: Local Government Finance Working Group (2011)

II.4. Results

We first present the findings regarding household health status outcomes, followed by a discussion of the results from the estimation of the production function and its determinants, including health outcomes. We finish with a discussion of the linkages between health expenditures, health status, and the marginal productivity of labour, land, and fertilizer.

[8] In Tanzania, past research has estimated that 88 percent of charges in health that are not directly for development or salaries (termed 'other charges') are diverted away from the intended purposes (Sundet, 2004).

[9] On March 28, 2013, TSH 1,577.42 = $1 (OANDA, 2013). In the estimations, millions of TSH per capita are used for scaling purposes and interpretation.

II.4.A. Impact of Health Expenditures on Health Status Outcomes

As mentioned above, we use all proxy indicators concurrently to estimate households' health status. To account for possible measurement error, a confirmatory factor analysis is used to estimate the relationship between the set of observed health indicators (the proxies) and the latent health variable, which is presented in the lower half of Table II.2 using the structural equation model (SEM) approach. The top half of Table II.2 links the exogenous variables, including categories of district level government expenditure on health services and household characteristics to the latent health variable.

In addition, because we need to set at least one loading parameter to one (1) (the one chosen to define "health status"), we fix each of them alternatively, as shown in the lower half of Table II.2. This constraint is necessary to scale the latent variable, making it equal to each disease indicator in the absence of measurement error. We also allow controls for other factors that may influence health outcomes, including access to a health center, education, and household infrastructure characteristics (floor material, toilet, garbage disposal, and water access). Given the fact that some of these variables may be correlated, we tested for multicollinearity but found no evidence of it.[10] The results presented in Table II.2 indicate that all health variables have a significant effect on overall household heath status, thus justifying our use of several health indicators instead of a single symptom or disease. On the expenditure side, the results suggest that only salary expenditures have a significant impact on health outcomes. The perhaps surprising insignificance of development spending may reflect the currently low expenditure levels, which may not have reached a critical level in order to have a significant impact on health status. Our results for salaries suggest a quadratic relationship between health status and expenditures (the existence of a minimum amount from which health expenses start improving farmers' health).[11] That threshold is TSH 57,351 per capita (approximately US$36[12] per capita per year) for long-term health, and is similar for the other diseases: TSH 57,323 for malaria, TSH 57,308 for diarrhea, and TSH 57,317

[10] We do this using the Klein Variance Inflation Factors criterion and eigenvalues of the correlation matrix. The condition number (the square root of the ratio of the largest to the smallest eigenvalue) of 6.4 is far below the threshold values of 15, when concerns about multicollinearity arise, and 30, where multicollinearity concerns become serious (see Chatterjee, Hadi, and Price, 2000). Also, the largest value of the variance inflation factors is less than 10, with a mean value of 1.2. There is thus no evidence of multicollinearity.

[11] The maximum/minimum is the value of x that solves $\frac{dy}{dx} = 0$.
In this specification (y=a+bx+cx*x), the solution is given by $x = -\frac{b}{2c}$.

[12] All dollar amounts are in US dollars.

for fever. Because each of the diseases contributes differently to overall household health status and salary expenditures are not disaggregated by disease, we had to compute a composite minimum health salary expenditure threshold, using the rescaled values of the coefficients for the four disease indicators in Table II.2 as weights. The results yield a threshold amount of TSH 57,325 per capita, which is exceeded by observed salary expenditures only in two urban districts, Musoma and Iringa, accounting for about 10% of all households. However, more than a quarter of all households are located in districts that have per capita salary expenditures that are only 4% below the threshold. This suggests that there are still important funding gaps that need to be filled if the country is to reach the point where health expenditures start yielding significant impacts on farmers' health status.

The results in the top half of the table also highlight the importance of many other factors in determining the health status of rural households. These include the positive relationship between the accessibility of health centers and health outcomes, as shown in the literature (Schoeps et al., 2011; Lavy et al., 1996). Similarly, the results also show that improvement of housing conditions such as purchasing mosquito nets and sanitation measures in the home (proper disposal of garbage) tend to improve health status. Education (household members who have completed secondary school) is also shown to have a positive impact on health, as pointed out in the literature (Berger and Leigh, 1989; Grossman, 1975; Schultz, 1990). We now turn to the estimation of the production function linking health status to productivity, the next step in assessing the role played by health expenditures in determinant productivity levels among farm households.

Table II.2: Health Expenditures and Health Outcome

Variables	No Long-Term Illness	No Malaria	No Diarrhea	No fever
Health Development/capita	3.619	2.803	3.826	2.369
	(5.76)	(4.46)	(6.08)	(3.77)
Health Development/capita^2	-83.380	-64.580	-88.140	-54.570
	(104.60)	(81.02)	(110.60)	(68.47)
Health Salaries/capita	-12.17***	-9.43***	-12.86***	-7.97***
	(3.65)	(2.83)	(3.85)	(2.39)
Health Salaries/capita^2	106.1**	82.21**	112.2**	69.47**
	(51.23)	(39.68)	(54.16)	(33.54)
Rural	0.138***	0.107***	0.145***	0.090***
	(0.03)	(0.02)	(0.03)	(0.02)
Time to nearest Dispensary/ Health Center/Hospital	-0.017**	-0.013**	-0.018**	-0.011**
	(0.01)	(0.01)	(0.01)	(0.01)
Dispose of garbage (dummy for use of rubbish bin)	0.055*	0.042*	0.058*	0.036*
	(0.03)	(0.02)	(0.03)	(0.02)
Education	0.054**	0.042**	0.057**	0.035**
	(0.02)	(0.02)	(0.02)	(0.02)
Floor material (dummy for earth)	0.024	0.018	0.025	0.015
	(0.03)	(0.02)	(0.03)	(0.02)
Housing improved (mosquito net, proper floor, etc.)	0.293***	0.227***	0.310***	0.192***
	(0.02)	(0.02)	(0.03)	(0.02)
No toilet	-0.024	-0.018	-0.025	-0.016
	(0.05)	(0.04)	(0.05)	(0.03)
Time to water for consumption	-0.010	-0.008	-0.011	-0.007
	(0.01)	(0.01)	(0.01)	(0.01)

Table II.2 continued

Variables	No Long-Term Illness	No Malaria	No Diarrhea	No Fever
Measurement Model /Health Status Indicators				
Members without long-term health problems	1	1.291***	0.946***	1.528***
	0	(0.009)	(0.003)	(0.013)
Members without malaria	0.775***	1	0.733***	1.183***
	(0.006)	0	(0.005)	(0.012)
Members without fever	0.654***	0.845***	0.619***	1
	(0.006)	(0.009)	(0.005)	0
Members without diarrhea	1.057***	1.365***	1	1.615***
	(0.004)	(0.009)	0	(0.013)
Variances				
Health status	0.962***	0.577***	1.075***	0.412***
	(0.015)	(0.011)	(0.016)	(0.009)
No long-term health problems	0.0947***	0.0947***	0.0947***	0.0947***
	(0.002)	(0.002)	(0.002)	(0.002)
No fever	0.282***	0.282***	0.282***	0.282***
	(0.004)	(0.004)	(0.004)	(0.004)
No malaria	0.260***	0.260***	0.260***	0.260***
	(0.004)	(0.004)	(0.004)	(0.004)
No diarrhea	0.003	0.003	0.003	0.003
	(0.002)	(0.002)	(0.002)	(0.002)
chi^2	1778	1778	1778	1778
Log Likelihood	121082	121082	121082	121082
N	9820	9820	9820	9820

*Standard errors in parentheses *p<0.10, **p<0.05, ***p<0.01*

II.4.B. Determinants of Agricultural Production not related to Health

We estimate the production function first without state (health) variables, allowing us to compare Ordinary Least Squares (OLS) estimates with the random effects (RE) estimates. The OLS estimation is done with and without precipitation. To correct endogeneity problems in inputs, the likely endogenous inputs (labour and fertilizer) are instrumented. We use both two-stage prediction substitution (2SPS) as well as two-stage residual inclusion (2SRI) approaches when estimating the production function. The two-stage instrumental variable method of replacing the endogenous variables with their predicted values obtained from a first and separate regression (2SPS) can lead to incorrect standard errors and in case of nonlinearity, cause inconsistent estimations. The (2SRI) approach includes the first-stage residuals in the second stage to help control for this (for more details see Terza, Basu, and Rathouz, 2008; Vella, 1993; Garen, 1984 and Wooldridge, 2010). We first estimate versions of the model without state (health) variables and without interaction terms, as shown in Table II.3.[13] We then estimate versions that are nonlinear in the endogenous variables (regressions in Table II.4), applying the (2SRI) approach.

In all versions of the model, labour is instrumented as men 15-55 years old and male household head. Fertilizer is instrumented as: distance to the source of fertilizer; the village price index for fertilizer (computed as the mean of the prices faced by individuals in the village); literacy of the household head. These instruments are good predictors of the endogenous variables in the first-stage equations (R-squares around 0.25 and 0.36 respectively for labour and fertilizer, with all the coefficients significant). We applied several diagnostic tests which confirm the appropriateness of instrumental variables, as reported at the bottom of Table II.A2.[14] The Kleibergen-Paap rank Wald F statistic eliminates concerns that instruments used are only weakly correlated with the endogenous variables and the Hansen J eliminates concerns that instruments are correlated with the error term in the equation of interest, which would yield estimates that are biased in the same direction as OLS and possibly not consistent.

The same instrumental variable approach is also used to correct for the possible endogeneity of health variables (as geographical allocation of health expenditures may be associated with health outcomes). In this case, the corresponding residuals from the structural health equation in the SEM are included in the production function along with the district-level expected values of health using factor scores from the SEM. The results of the first-stage regressions and the relevant tests are presented Table II.A2 in the Appendix. Results of the estimations of the production function are reported in Table II.3 with additional results in Table II.A3 and II.A4 where all inputs and outputs

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[13] In these linear cases, like 2SPS, 2SRI is identical to the popular two-stage least squares (2SLS) (or linear instrumental variables (IV)) method and is, therefore, consistent (Terza, Basu, and Rathouz, 2008).

[14] The Hansen J test of over-identification provides information on the relevance of the instrument and it fails to find evidence of violation of the exclusion restriction with p-value well above 0.1. The Kleibergen-Paap (2006) F statistic performs a weak identification test (in contrast to the Kleibergen-Paap rk LM statistic, which performs an under-id test) and is appropriate in the case of heteroscedasticity-robust standard errors in regression (See Stock and Yogo, 2005 and Baum, Schaer and Stillman, 2003 for details).

are logged values and estimates can be interpreted as elasticities. The results show that all input elasticities are significant and positive. Compared to other inputs, the elasticity of production with respect to land is the highest (0.660). The value of the land elasticity is consistent with the proposition that agricultural growth in sub-Saharan Africa is driven primarily by land expansion (Dethier and Effenberger, 2011). The elasticities with respect to labour and other inputs are also significant and positive across all models.

Precipitation appears to have a nonlinear relationship with production (too much precipitation in one area during a season can be detrimental to crop production). The results suggest a tipping point of 851 millimeters of precipitation[15] using the preferred RE model (Table II.3) beyond which additional precipitation begins to have negative effects on agricultural production. This tipping point is based on aggregate output and thus does not take into account crop specific responses to rainfall, nor does it address issues related to rainfall variability. Two thirds of all households in the districts covered by the study fall between the minimum level of precipitation of 451.2 mm and the tipping point. This nonlinear and significant relationship between climatic variables and agricultural productivity has been documented elsewhere in the literature (Maddison et al., 2006; Gommes, 1999). The results here highlight the necessity of controlling for agro-climatic conditions as well as other sources of heterogeneity when estimating input elasticities. In the next section, we expand estimates of the production function to include health indicators as state variables, in line with equations *(3)* and *(4).*

[15] The tipping point is the value of rainfall for which agricultural production reaches its maximum level. It is the value of x that solves $\frac{dy}{dx} = 0$. In our specification (lny=a+blnx+clnx*lnx), the solution is given by $x = e^{\frac{-b}{2c}}$.

Table II.3: Production Estimation

VARIABLES	2SLS [2SPS]	RE Model with Precipitation [2SRI]
Land	0.62***	0.66***
	(0.06)	(0.03)
Labour	0.28***	0.15**
	(0.07)	(0.06)
Fertilizer	0.04***	0.05***
	(0.01)	(0.01)
Animals	0.17***	0.26***
	(0.03)	(0.03)
Precipitation		31.34***
		(1.57)
Precipitation²		-2.32***
		(0.12)
Labour residual		-0.03*
		(0.02)
Fertilizer residual		-0.05***
		(0.02)
Constant	11.80***	-93.96***
	(0.06)	(5.29)
District FE/RE	YES	
Observations	47582	41,968
Number of groups		107
Adj R²	0.360	
Chi² Wald		1305
Log Likelihood		-79666

*Note: Robust and clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*
[2SPS]: labour and fertilizer instrumented (specification in Table II.A2 in appendix 1); standard errors adjusted;
[2SRI]: two-stage residual inclusion

II.4.C. Health Status and Agricultural Productivity

Following Equations *(3)* and *(4)*, the agricultural production function at the household level was estimated using a generalized mixed linear model, with the results presented in Table II.4. The estimation incorporates the expected values of health measures estimated from equations *(1a)* and *(1b)*, together with the intercepts and indirect effects for health. To allow for comparison, the results without state variables (the RE model from Table II.3) are also presented in the first column of Table II.4 (No State). As noted above, a two-stage residual inclusion (2SRI) approach is applied, but the interaction terms between residuals and the inputs were not significant and did not improve the quality of the model, so they were not included.

The results in Table II.4 confirm the impact of health outcomes on the magnitude and significance of input elasticities, both separately and when interacted with state variables. It appears that all health indicators have direct and indirect effects on productivity. These results are significant even after controlling for variation in precipitation. In addition, there are significant differences among most inputs when it comes to the influence of particular diseases.

Table II.4: Production Function Estimation with and without State Variables

VARIABLES	**No State**	**No Long-Term Health**	**No Malaria**	**No Diarrhea**
Land	0.66***	0.65***	0.64***	0.65***
	(0.03)	(0.04)	(0.04)	(0.04)
Labour [i]	0.15**	0.20***	0.20***	0.20***
	(0.06)	(0.06)	(0.06)	(0.06)
Fertilizer [i]	0.05***	0.06***	0.06***	0.06***
	(0.01)	(0.01)	(0.01)	(0.01)
Animals	0.26***	0.26***	0.26***	0.26***
	(0.03)	(0.03)	(0.03)	(0.03)
Precipitation	31.34***	34.61***	35.74***	34.33***
	(1.57)	(1.67)	(1.67)	(1.67)
Precipitation²	-2.32***	-2.55***	-2.63***	-2.52***
	(0.12)	(0.12)	(0.12)	(0.12)
Health Intercept		2.50***	3.62***	2.28***
		(0.15)	(0.21)	(0.14)
Land*Health		0.05	0.06	0.04
		(0.12)	(0.15)	(0.11)
Labour [i] *Health		-0.03	-0.06	-0.03
		(0.17)	(0.21)	(0.16)
Fertilizer [i] *Health		-0.04***	-0.05***	-0.04***
		(0.01)	(0.02)	(0.01)
Animals*Health		0.04	0.05	0.03
		(0.09)	(0.12)	(0.08)
Health residual		-2.42***	-2.70***	-2.35***
		(0.16)	(0.17)	(0.15)
Labour residual	-0.03*	-0.05**	-0.05***	-0.05**
	(0.02)	(0.02)	(0.02)	(0.02)
Fertilizer residual	-0.05***	-0.06***	-0.06***	-0.06***

	(0.02)	(0.02)	(0.02)	(0.02)
Constant	-93.96***	-106.0***	-109.9***	-105.0***
	(5.29)	(5.64)	(5.65)	(5.64)
Observations	41,968	38,799	38,799	38,799
Number of groups	107			
Wald Chi²	1317	1511	1522	1507
Log Likelihood	-93240	-73943	-73929	-73946

*Note: Robust and clustered standard errors in parentheses *** $p<0.01$, ** $p<0.05$, * $p<0.1$*
[i] *:instrumented using the specification shown in the appendix*
Fever is excluded because it appeared to be strongly correlated with all other health variables

To further understand the results in Table II.4, we employ a series of metrics developed by Fulginiti and Perrin (1993). The first metric, presented in Table II.5, is the average production elasticity with respect to inputs from Equation *(3)*. The production function elasticities add up to around 1.15 in the version of the model without state variables and 1.18 based on the different models with state variables (Table II.5), suggesting the possibility of increasing returns to scale.[16] Sarris et al. (2006), for instance, found some evidence of increasing returns to scale using survey data from Ruvuma and Kilimanjaro, two cash crop growing regions of Tanzania. Their findings suggest marginal products that are higher than factor cost for capital and intermediate inputs. They found the same for land in Kilimanjaro[17] but not in Ruvuma. In contrast, they found the marginal products of labour used on farms to be much lower than prevailing market wages.

We see that all elasticities shift when we account for health status. In general, better health (especially no malaria) has a positive impact on labour productivity as well as on fertilizer and animal productivity. The labour elasticity, estimated at 0.18 with no state variables included, rises to 0.22 with inclusion of the long-term health indicator, 0.22 with the no-malaria indicator, and 0.21 with the no-diarrhea indicator. The results, however, suggest a negative impact of good health on land productivity, which is not what one would expect *a priori*. To exclude the possibility that the negative impact may result from interaction between variables, we estimated the production function using a translog function that controls for interaction effects between inputs. We still find a negative impact of good health on the marginal productivity of land, as shown in Table II.A3 in the annex.

[16] The hypothesis of constant returns to scale was tested and rejected, but not strongly (the probability value of 0.082 is not considered low enough to justify absolute rejection), suggesting a certain ambiguity with respect to returns to scale.
[17] In this region, productive and cash crop land is in short supply.

One possible explanation may be that households with poorer health status are obliged to reduce the scale of activities, which may lead to the prioritization of higher productivity plots, while healthier households would be tempted to expand land use beyond the limit of what they can manage efficiently or into less fertile areas. In other words, this result may be a reflection of diminishing returns to land. Another possible but less likely explanation is that households with better health status would tend to diversify more and thus farm less intensively at the margin, leading to lower productivity. However, if correct, this hypothesis implies that good health is a major determinant of income diversification.

Table II.5: Marginal Productivity of Inputs

Model	Land	Labour	Fertilizer	Animal
No State	0.665	0.178	0.050	0.254
No Long Term Health Problems	0.649	0.216	0.054	0.257
No Malaria	0.647	0.218	0.056	0.256
No Diarrhea	0.651	0.214	0.054	0.259
Test for return to scale: Model with no state variable from Table II.3				
H0: Land+Labour+Fertilizer+Animal = 1	*Land+Labour+Fertilizer+Animal -1*		Std. Err.	P-value
Chi2 = 3.03	0.113		0.065	0.082

Source: Author's calculations;
Note: Square roots of variances for all elasticities presented are less than 0.005

Overall the results show that there is bias in the estimation of production elasticities if no account is taken for state variables such as household health outcomes and factors that affect them, such as public expenditures, as well as other household and location characteristics. A more complete picture of the impact of health status on production is provided by the elasticity of production with respect to the individual health variables. Following Fulginiti and Perrin (1993), based on equations *(3)* and *(4)*, with both (*Y*) and (*H*) in log form, and where (H) represents health status variables, the elasticity is:

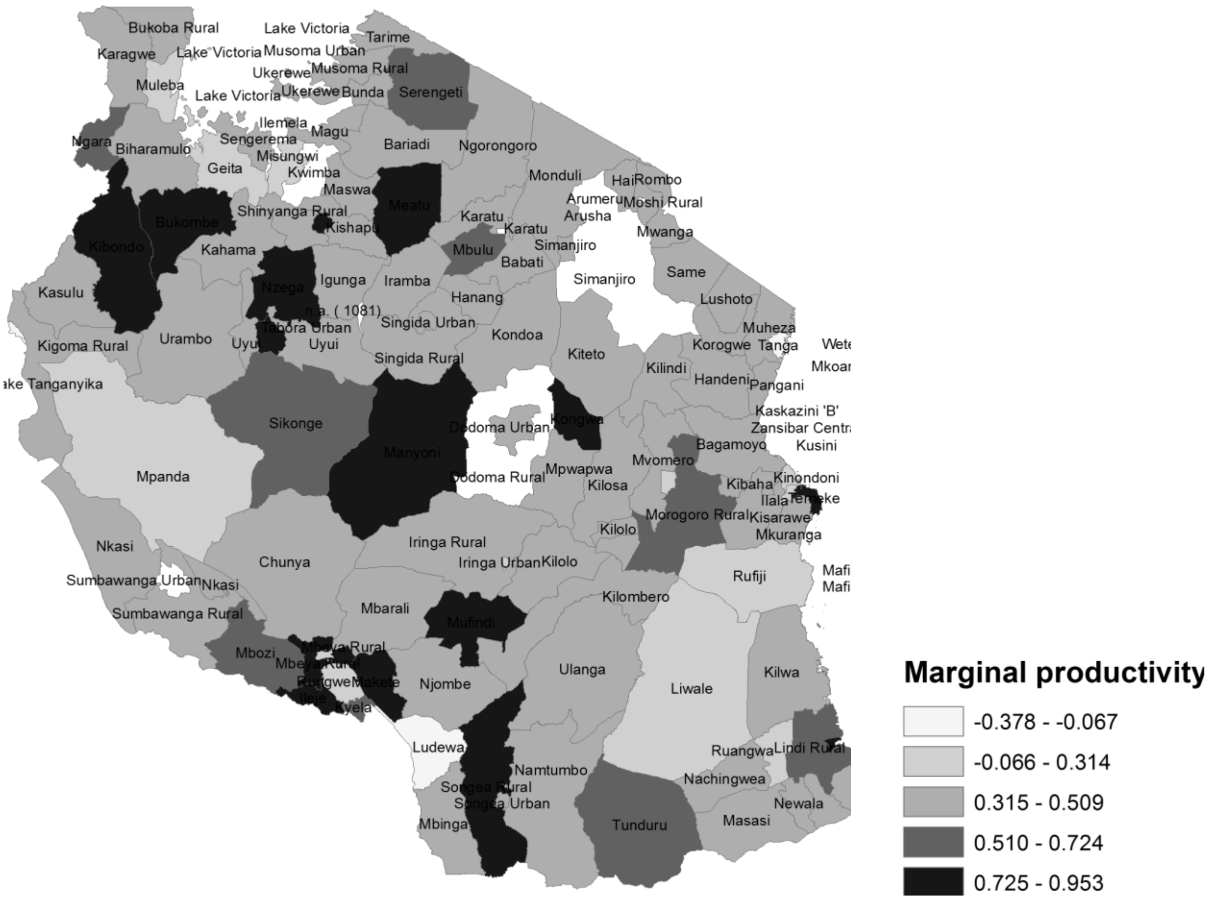
$$\frac{\partial Y}{\partial H} = \sum_l \gamma_{1l} x_l + b \qquad (6)$$

The production elasticities (calculated at the mean point) are 2.4 for long-term disease, 2.2 for diarrhea, and 3.5 for malaria. The elasticity estimates are all positive (overall production increases with improvement in health status) and the effect is highest for malaria. The values of the estimates suggest that agricultural production among the households covered by the study increases by 3.5%

for every 1% increase in the number of household members not affected by malaria. A 1% increase in the number of household members not suffering from long-term illness raises production by 2.4%.

These findings suggest both the need and scope for careful targeting of public health expenditures, in particular, and the implementation of health programmes in general, to improve their impact on agricultural productivity. However, there is substantial variation in the productivity impact of health status variables across districts, shown in Figure II.1. The same pattern of district heterogeneity is observed in the elasticities of the marginal productivity of land and fertilizer with respect to health (see Figures II.A1 and II.A2 in the Appendix). It appears from the maps that the impact of health on the marginal productivity of land and fertilizer tends to be highest in the Eastern and Southeastern as well as Western and Northwestern regions, whereas the impact on labour productivity seems to be highest in the Central and Southwestern regions. The reasons for the variations could be linked to variability in knowledge of, or access to, technologies, which in turn could be the effect of institutional, infrastructural, and/or agro-ecological differences across Tanzania. Availability of data does not allow us to investigate the real reasons behind the technological diversity across regions here. But these findings highlight the shortcomings of the homogeneous technology assumption and, at least in the case of Tanzania, of policy recommendations based on national averages.

Figure II.1: Elasticity of Marginal Productivity of Labour with Respect to Long-Term Illness



Source: Authors' calculation

II.V. Conclusion

Combining the most recent nationally representative data on agricultural production and household characteristics available for Tanzania, we evaluate the impact of changes in specific categories of health expenditures at the district level on health status among farm households and the resulting effect on the marginal productivity of labour and other agricultural inputs among the same households. Overall, our findings suggest that the farm productivity responses to changes in the use of agricultural inputs are in part determined by the health status of farm households, and that such status is impacted differently by different categories of government expenditures on health services. In particular, the results suggest that salary expenditures (possibly through more personnel or better incentives) have a greater impact on health outcomes among rural households than expenditures on health development grants, at least to date.

The findings show variation in effects for different health variables and expenditure categories, and across particular agricultural inputs. Overall, production elasticities respond more positively to the absence of malaria than long-term disease or diarrhea. These differences suggest that targeting malaria control may be more effective than focusing on overall morbidity or health status. In addition, looking at particular inputs and health indicators, it appears that the marginal productivity of labour is most affected by malaria incidence. In other locations, the significance of particular diseases may be different, implying that more investigation and analysis is necessary to target interventions and government spending appropriately. This is extremely important for countries needing to accelerate agricultural growth in the context of tight budget constraints and large-scale poverty. It is often the case that in these countries, government expenditures in the social sectors are considered lost to agriculture and budget allocation is perceived as a zero-sum game.

Our findings indicate that, on the contrary, agriculture can benefit considerably from resources invested in the health sector. For that to happen, however, more attention needs to be paid during budget negotiations to the quality of health sector investments and their synergy with productivity goals in the agricultural sector, rather than the absolute level and share of the health sector budget. Such an approach would allow countries to exploit the significant potential suggested by our findings in leveraging investments in the health sector to effect greater impact on productivity growth among vulnerable farm households and thereby reduce poverty and improve food security, not just in the rural areas. The large number of poor consumers that spend a large fraction of their incomes on food would also benefit from a rise in agricultural productivity through lower levels of, or slower increases in, local food prices.

Finally, the geographical distribution of input elasticities with respect to health variables, even after controlling for variation in precipitation, seems to confirm technology heterogeneity across districts. As noted, this might reflect institutional, infrastructural, and/or agro-ecological differences not related to rainfall variations across Tanzania. It may also reflect differences in how the Tanzanian central and local governments have prioritized their infrastructure expenditures across districts to develop economically competitive regions. Given this, there may be estimation bias when marginal productivities of inputs are assumed to be constant across locations or farming households. Technology heterogeneity also means that technology policies and programmes based on national averages are likely to fail.

To generate more comprehensive policy-making guidance, the analysis presented in the current paper could be expanded to include other types of diseases as well as more categories of expenditures in the health sector (in particular by households themselves), but also expenditures and outcomes in other social sectors such as education and social protection.

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Appendix

Table II.A1: Summary Statistics

Production	obs	mean	std dev	min	max
production (area-weighted tsh)	51534	883,586	1,919,735	0	141,000,000
labour	52594	2.05	1.44	0	22
land (acres)	51534	3.9	5.1	0	160
fert (tsh)	51534	18,527	76,550	0	1,767,000
animals	52594	1	2.58	0	100
Annual precipitation (mm)	42363	844	250	452	2115
Instruments for labour and fertilizer					
Men between 15-55 years old	52594	2.54	1.60	0	31
Distance to source of fertilizer (km)	52594	8.34	1.44	<1	9
Sex of the head	52594	0.79	0.41	0	1
Village fertilizer price index	52594	762	2400	-	34000
Literacy of the head	52594	0.65	0.48	0	1
Latent variables indicators (households)					
No malaria	10972	0.48	0.85	0	11
No fever	10972	0.53	0.93	0	11
No diarrhea	10972	0.72	1.07	0	13
No long term health problems	10972	0.69	1.06	0	14
Health equation variables					
Time to the nearest Dispensary/Health center/Hospital (minute)	9819	9.42	10.42	-	98
Rural		0.31	0.46	0	1
Dispose of garbage (use of rubbish bin)	9819	0.16	0.36	0	1
Floor material (earth)	9819	0.41	0.49	0	1
Improvement of housing condition (mosquito, proper floor etc.)	9819	0.22	0.41	0	1
No toilet	9819	0.04	0.20	0	1
Time to water for consumption	9819	1.94	1.20	0	4.07
Education (# members who have completed secondary school)	9819	0.14	0.44	0	5

Source: Authors' calculation from NBS 2010 and 2011

Table II.A2: Instruments for Labour and Fertilizer

VARIABLES	Joint test	Labour	Fertilizer
Men between 15-55 years old		0.51***	
		(0.00)	
Distance to the source of fertilizer			-1.80***
			(0.01)
Village price index for fertilizer (/100)			-0.00***
			(0.00)
Sex of the head		0.18***	
		(0.00)	
Literacy of the head			0.42**
			(0.13)
Constant		-0.11***	17.43***
		(0.01)	(0.09)
Observations		52,594	51,534
R-squared		0.25	0.36
Diagnostic statistics [18]			
Hansen J-statistic (p-value)	0.84	0.10	0.91
Kleibergen- Paap Wald rk F statistic	139.84	184.66	335.05
Kleibergen-Paap rk LM statistic (p-value)	0.00	0.00	0.02
Endogeneity test (p-value) (H0: variable is exogenous)	0.03	0.64	0.01

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

[18] The robustness of the results is also tested by treating each of the variables alternatively as endogenous to test.

Table II.A3: Production Estimation with and without State Variables – Translog

Variables	No State Variable	No Long-Term Health
Land	0.91***	0.91***
	(0.03)	(0.03)
Labour	0.49***	0.52***
	(0.07)	(0.07)
Fertilizer	-0.12***	-0.12***
	(0.01)	(0.01)
Animals	0.45***	0.507***
	(0.05)	(0.051)
Precipitation	16.38***	19.19***
	(1.55)	(1.66)
Precipitation²	-1.23***	-1.42***
	(0.12)	(0.12)
Labour residual	-0.10***	-0.11***
	(0.02)	(0.02)
Fertilizer residual	-0.00	-0.01
	(0.02)	(0.02)
Health		1.46***
		(0.16)
Health residual		-1.43***
		(0.16)
Land* Land	-0.17***	-0.17***
	(0.00)	(0.00)
Labour* Labour	-0.19***	-0.19***
	(0.03)	(0.03)
Fertilizer* Fertilizer	0.02***	0.02***
	(0.00)	(0.00)
Animals* Animals	-0.06***	-0.06***
	(0.02)	(0.02)
Land* Labour	0.11***	0.11***
	(0.02)	(0.017)
Land* Fertilizer	-0.01***	-0.01***
	(0.00)	(0.00)
Land* Animals	0.08***	0.06***
	(0.02)	(0.02)
Labour* Fertilizer	-0.02***	-0.02***
	(0.00)	(0.00)
Labour* Animals	-0.11***	-0.13***
	(0.03)	(0.03)
Fertilizer* Animals	-0.02***	-0.02***
	(0.00)	(0.00)

Variables	No State Variable	No Long-Term Health
Health* Land		0.11
		(0.11)
Health* Labour		0.01
		(0.20)
Health* Fertilizer		0.00
		(0.04)
Health* Animals		0.05
		(0.16)
Health* Land* Land		-0.05***
		(0.01)
Health* Labour* Labour		-0.07
		(0.09)
Health* Fertilizer* Fertilizer		-0.01
		(0.00)
Health* Animals* Animals		-0.05
		(0.07)
Health* Land* Labour		-0.02
		(0.05)
Health* Land* Fertilizer		0.02**
		(0.01)
Health* Land* Animals		0.00
		(0.05
Health* Labour* Fertilizer		0.01
		(0.01)
Health* Labour* Animals		0.16*
		(0.09)
Health* Fertilizer* Animals		0.00
		(0.01)
Constant	-43.21***	-53.55***
	(5.22)	(5.61)
Observations	41,968	
Number of groups	107	
Wald Chi²	4731	4605
Log Likelihood	-78317	(72814)

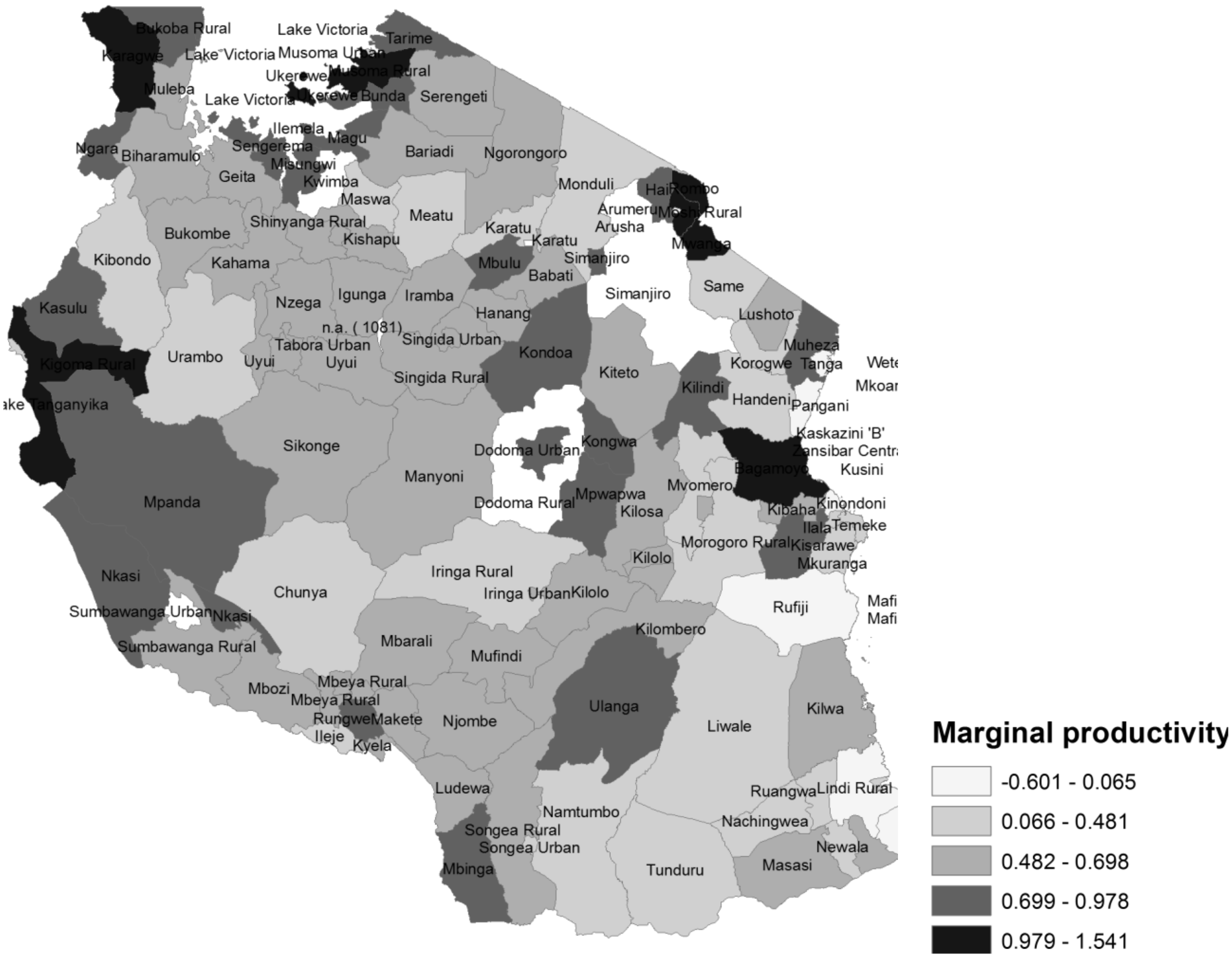
Note: We find that the impact on land is negative whether we used a Translog functional form for the production function or a Cobb-Douglas functional form. Elasticity of land in the model without health is 0.546, while it decreases in the model with health (0.536).
*Note: Robust and clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; Many standard errors are reported using only two digits for simplicity of presentation but are not equal to 0.*

Table II.A4: Additional Production Model Specifications

VARIABLES	**RE Model 2SPS**	**OLS 2SRI**
Land	0.52***	0.61***
	(0.02)	(0.06)
Labor	0.35***	0.26***
	(0.03)	(0.07)
Fertilizer	0.05***	0.04***
	(0.01)	(0.01)
Animals	0.24***	0.17***
	(0.02)	(0.03)
Precipitation		
Precipitation²		
Labor residual		-0.12***
		(0.03)
Fertilizer residual		-0.08***
		(0.03)
Constant	11.77***	11.82***
	(0.06)	(0.06)
District FE/RE	YES	YES
Observations	47582	47582
Number of groups		
Adj R²		0.36
Chi² Wald	1464.57	
Log Likelihood	-65904.18	

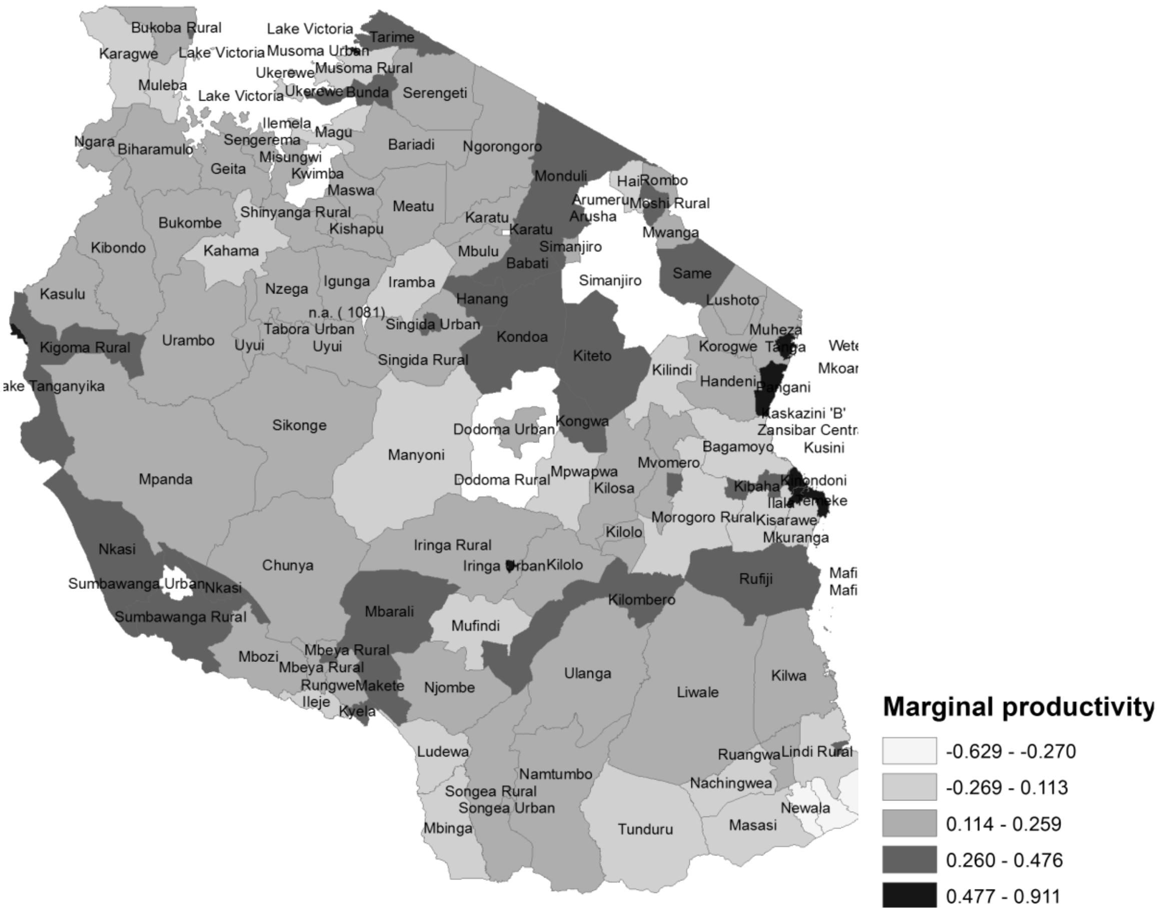
*Note: Robust and clustered standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1*
2SPS: labour and fertilizer instrumented using the specification in the appendix; standard errors adjusted
2SRI: two-stage residual inclusion

Figure II.A1—Elasticity of Marginal Productivity of Land with Respect to Long-Term Illness



Source: Authors'calculation

Figure II.A2—Elasticity of Marginal Productivity of Fertilizer with Respect to Long-Term Illness



Source: Authors'calculation

Chapter III

Catastrophic out-of-pocket payments for health and poverty nexus: Evidence from Senegal

Authors

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Abstract

Out-of-pocket payments are the primary source through which health expenditure is met in Senegal. However, these payments are financial burdens that lead to impoverishment when they become catastrophic. The purpose of this study is to cast light on the determinants of catastrophic household out-of-pocket health expenditures and to assess their implications on poverty.

The 2011 poverty monitoring survey is used in this study. This survey aims to draw poverty profiles and to highlight the socio-economic characteristics of different social groups.

In line with the concerns raised by the new Supplemental Poverty Measure (SPM), poverty statistics are adjusted to take into account household health expenditures and to estimate their impoverishing effects. To identify the determinants of the magnitude of catastrophic health expenditure, we implement a seemingly unrelated equations system of Tobit regressions to take into account censoring through a conditional mixed-process estimator procedure.

We identify major causes of catastrophic expenditures, such as the level of overall health spending, the expensiveness of health goods and services, the characteristics of health facilities, the health stock shocks, the lack of insurance, etc. Results show evidence that catastrophic health expenditures jeopardize household welfare for some people that fall into poverty as a result of negative effects on disposable income and disruption of the material living standards of households.

Our findings warrant further policy improvements to minimize the financial risks of out-of-pocket health expenditures and increase the efficiency of health care system for more effective poverty reduction strategies.

Keywords: Out-of-pocket expenditure, health care, health, Poverty.

JEL Classification: I11, I140, I320.

III.1. Introduction

Household out-of-pocket payments represent 95% of private expenditures and 55% of total health expenditures in Senegal. As in many developing countries, out-of-pocket payments are the primary source through which health expenditure is made, but there is no broader health financing system that offers financial risk protection.

The aim of this paper is to evaluate the impact of household out-of-pocket health spending using the most recent household poverty monitoring survey in Senegal. The objective is to determine the distribution and the magnitude of out-of-pocket health spending and also to assess if these expenditures are determinant in pushing people into poverty.

We want to shed new light on the distribution of poverty in Senegal using more complete and adequate measures that take into account the effect of certain categories of spending, such as household out-of-pocket health payments. The same idea might be applicable to payroll taxes or any other expenditure that risks impoverishing households.

It is easily observable that these kinds of spending can be an investment in the long run but can also be burdens that may affect household welfare and economic status in the short run by messing up their spending structure and planning, which often leads to a reduction of the consumption of some goods in favor of medicines or an increase of household debt balance. In fact, borrowing money is a common method of dealing with health care costs among the poor in a country where health insurance is not wide-spread, especially in rural areas.

The key figures related to the financing of the health system show that health expenditures represent only 8.3% of the state budget on average in the period 2000-2005. This is far from the Abuja Declaration goal of allocating 15 % of annual budgets to the health sector[19]. Also, the public funds are not mobilized effectively and not prioritized to reduce existing strong disparities across regions regarding budget allocation and health status.

Meeting the World Health Organization's standards for universal health care requires building an efficient and well-run health system (World Health Organization, 2014). Hence, there is a need to better understand financing sources of health services including households' participation, their

[19] In April 2001, heads of state of African Union countries met and pledged to set a target of allocating at least 15% of their annual budget to improve the health sector (United Nations, 2001).

implications in terms of poverty, and the characteristics that make people more vulnerable to catastrophic expenditures.

The impact of household out-of-pocket health spending on disposable income is sometimes severe and this can be a reason why households fall into poverty over time. Subtracting these types of spending can help estimate the current household status and see how a shock on health status can affect household social and economic situations as proceeding this way offers a more accurate assessment of household resources.

The distribution of poverty prevalence will be evaluated, in order to evaluate whether there is any bias when not considering household out-of-pocket health spending.

Senegal's economy has returned to growth during recent years. Gross domestic product (GDP) on average grew by around 5% since 1995. However, the recorded economic performance has not contributed as much as we hoped to improve the living conditions of populations and to cause a substantial reduction of poverty. Indeed, with a Human Development Index (HDI) of 0.459 in 2011, Senegal remains among the least developed countries despite the increase of Government willingness to fight poverty and food insecurity through several development programs implemented since the late 1900s, in addition to the Millennium Development Goals (MDGs), which call for a reduction of the proportion of people with less than US$1 per day.

The official national poverty rate was estimated at 46.7% in 2011 according to the traditional measurement approach, with a small improvement in 2012, 5 out of 11 men (45.39%) living below the poverty line. However, as stated above, the official measure fails to isolate the burden effect of some range of expenses and might not provide an appropriate estimate of poverty. Indeed, the classical poverty measures will be compared to the alternative approach including the feature on health expenditures to see whether it presents a different picture or not.

The health sector is among the Senegal Government's priority sectors, as stated in its Poverty Reduction Strategy Papers. Significant efforts have been made but many actions and strategies are yet to be taken. The health system is characterized by a deficiency of personnel, insufficient infrastructures to cover the needs of the entire population, unequal distribution of workers and a lack of personnel motivation to work throughout the country, particularly in poor and remote areas.

The literature on health expenses and economic status has grown over the past decade. Several studies in different countries have shown that many households have been impoverished by the catastrophic out-of-pocket health spending: India (Flores et al., 2008; Garg and Karan , 2009; Pal, 2012; Gupta and Joe, 2013), United States (Bennett KJ, Dismuke CE, 2010), Turkey (Yardim et al., 2010), China (Yi et al., 2009), Colombia (Amaya Lara and Ruiz Gómez, 2011), Zambia (Hjortsberg, 2003), Kenya (Chuma and Maina, 2012), Tanzania (Brinda et al., 2014). In a worldwide study, Xu et al. (2003) explored the determinants of catastrophic health expenditures in 59 countries and found that the share of government spending in total health spending was the primary explanation for the prevalence of catastrophic health expenditures.

In a more recent work in India, Gupta and Joe (2013) suggested a multidimensional approach to see the incidence of catastrophic expenditure by integrating health expenditure with other social and economic parameters of deprivation.

To our knowledge, no study in Senegal focuses on the distribution and determinants of catastrophic out-of pocket health expenditures or analyses their linkage to poverty.

This study attempts to make a valuable contribution to this topic. The analysis aims not only to assess the impact of out-of-pocket health expenditure on poverty, but also to see the factors affecting the magnitude of the catastrophe, using an appropriate econometric method. Our approach integrates a measure based on the novel SPM (Supplemental Poverty Measure)[20] that renewed interest on poverty measures into the country framework by using the most recent household survey in Senegal.

The paper is organized as follows. The distribution of out-of-pocket health spending, some key figures on health, and the theoretical framework, will be presented firstly. Secondly, we will focus on the impacts of catastrophic household out-of-pocket health expenditures on poverty measurement, and we will finish with discussions on results and policy implications.

[20]SPM incorporates additional items such as tax payments and work expenses in its family resource estimates. Short, Kathleen , 2013

III.2. Catastrophic health expenditures and poverty measurement issue

Our poverty measure subtracts out-of-pocket medical expenses before calculating the overall resources available for households. As stated earlier, our statistics are based on an SPM-like estimate that has recently been implemented by the Census Bureau in its objectives and attempts to calculate a more comprehensive measure of resources. The out-of-pocket health expenditures should be subtracted from total spending when measuring poverty in order to avoid underestimation of poverty rates.

Out-of-pocket payment is considered as catastrophic and can impoverish households if exceeding 40% of annual household non-food expenditure (Kawabata, Xu and Carrin, 2002; Xu and al., 2003; Karami et al., 2009). Another approach consists in using 10% as a critical threshold for the ratio between health expenditure and consumption expenditure (Pradhan and Prescott, 2002; Wagstaff and Van Doorlaer, 2003; Russell, 2004).

Although some studies have analyzed the use of health care in Senegal and the determinants of health-seeking behavior (Fassin et al., 1988; Jütting, 2004, Lépine and Le Nestour, 2012), this study is an important contribution as it is the first analysis of household catastrophic out-of- pocket health expenditures and their impact on poverty. Health expenditures were found to be among the factors that drive households into poverty (Krishna 2006).

Beyond absenteeism from work that causes illness, out-of-pocket health expenditures can have serious effects on household incomes and on their patrimony as households are sometimes compelled to sell some of theirs goods to afford medical goods and necessary services in order to cure their sick members.

This study does not attempt to analyze the effect of illness on productivity and household welfare and neither does it aim to capture potential returns of health spending in the future, but it focuses on how some categories of health expenditure can affect the current households' poverty status by diminishing their disposable incomes and therefore their capacity to purchase other essential goods. In this paper, out-of-pocket health expenditures correspond to consultation, medication, traditional medicine, medical examinations, hospitalization, transportation, laboratory tests / radiography, etc.

We do not say that out-of-pocket health spending does not have any impact on welfare. This would be in contradiction to the Grossman theory of demand for health care as it can increase household health stock and boost productivity mainly in future time periods. It has been proven that the marginal productivity of labour as well as land and fertilizers respond significantly to health (Allen et al., 2014).

However, it should be recognized that for some categories of individuals, especially among the poor, at a certain critical threshold, these expenditures can became burdens and account for a very large portion of total income. Annual health expenditure is estimated to reach 2,461 CFA[21] per capita with an important heterogeneity across location (1,764 CFA in rural areas; 3,857 CFA in the capital city Dakar and 2,766 CFA in other urban areas).

Table III.1 depicts the distribution of frequentation of health services across strata. In relation to the administrative structure of the country, the organizational structure of the health care system in Senegal is pyramidal and divided into three main levels: regional hospitals, district level health centers, and health posts. On the lowest level there are numerous *health rooms* that represent health points. The private sector and traditional medicine complete the system.

Health posts are the most popular health facilities in all areas, especially in rural areas (54.2%). Hospitals follow, and are reported by 24.9% of the visitors at national level. Traditional practitioners are the least visited with less than 1% of individuals.

Figure III.A1 in the Appendix illustrates through a map how the average propensity for consumption of health goods at household level varies across regions. It shows some spatial heterogeneity in health good consumption behavior. The Conflict-affected regions of Zinguinchor and Kedougou [22] have the highest average out-of-pocket expenditure share (6% and 5% respectively). In addition to expensive healthcare services and poor quality of care, this trend might be explained by the fact that much of the population in these regions remains isolated due to infrastructure conditions and remoteness, which may increase indirectly health related expenditures such as transportation when seeking for health care.

[21] On May 23, 2014, 479.576 CFA Franc (African Financial Community) = US $1 (OANDA, 2014). This is the currency used in West Africa.

[22] The remote areas of these southern regions might be affected by the geographical imbalance of health workers and insufficient health facilities with the Casamance crisis (Separatist rebels of MFDC have been fighting for independence for the province of Casamance since 1982, despite peace agreements signed in 2004).

Table III.1: Distribution of the visits of health facilities across locations

Areas		Dakar	Other urban Areas	Rural Areas	Senegal
Type of service					
	Hospital	26.6	40.8	18.6	24.9
	Clinic	10.4	7.1	2.7	5.4
	Health center	19.1	14.4	8.6	12.2
	Health post	31.6	26.9	54.2	43.5
	Health room	0.8	0.5	9.4	5.6
	Marabout	1.2	1.6	2.9	2.2
	Traditional Practitioner	0.7	0.5	1	0.8
	Other	9.8	8.2	2.7	5.4
	Total	100	100	100	100

Source: Enquête de suivi de la pauvreté (ESPS), 2011

Note: Health centers have generally one to two medical doctors and 15-20 people as part of the health staff. Health posts have four or five health workers and no medical doctor. Health rooms have one or two health agents and a midwife (Heyen-Perschon, 2005).

Table III.2 indicates the occurrence of the different types of illnesses/symptoms that individuals have experienced during the four weeks preceding the survey.

Malaria and Fever are the most common health problems and are reported in more than 25% of the cases. Nearly half of the respondents (45.9%) reported to have either malaria or fever and both may have occurred together. Besides malaria and fever, significant proportions of patients reported back or limb pain (21.8%), flu/cough/cold (17.4%) and stomachache (13.7%). The remaining health problems that are not presented have smaller proportions.

Malaria has been a longstanding public health problem throughout Senegal. In fact, Senegal is one of the countries in Africa where malaria is endemic and represents the leading cause of morbidity and hospital mortality. Senegal accounts for an estimated 1% of all cases in the African Region of World Health Organization (World Health Organization, 2008). Despite large efforts most children die from malaria at home without receiving adequate treatment and protection. In 2008, only 31% of children under the age of 5 slept under a treated mosquito net (UNICEF, 2009).

Table III.2: Prevalence of illness

Diseases	Proportion
Ear / nose / throat Problems	2.6
Injury / Fracture / Sprain	3.2
Diarrhea	4.0
Dental problem	4.9
Skin problem	4.9
Voltage \ Diabetes	6.1
Eye problem	6.6
Stomachache	13.7
Flu / cough / cold	17.4
Back pain / limbs	21.8
Fever	25.2
Malaria	25.4

Source: Enquête de suivi de la pauvreté (ESPS), 2011

III.3. Methods

III.3.1. Sampling and data collection and poverty measure

The 2011 poverty monitoring survey is used in this study. This survey aims to draw the poverty profile and to highlight the socio-economic characteristics of the different social groups.

It is a random sample survey at national level that uses a two-stage cluster sampling method with stratification in the first stage. Statistical units of the first stage are districts. Secondary units are constituted by households drawn from the district in the first stage. The overall survey sample covers 17,891 households with 5,953 households constituting the sub-sample from which the questionnaire on expenditures was administrated. Our study is based on this sub-sample.

The poverty monitoring survey of 2011 is the second of its kind, after that of 2005-06. The collected information includes health, household spending, education, access to basic community services, etc.

The household consumption measured in local currency over the 12 months (or 30 days for food and some non-food consumption) preceding each interview is used to compute income estimation. Consumption spending includes all food and non-food expenditures made by households to purchase goods and services for meeting their needs.

The poverty line used in the poverty measure is based on the cost of basic needs method. This method consists in determining a food poverty line that is designed in a manner in which each individual is able to buy food that can provide him (or her) a sufficient number of calories to live healthily. A basket of the 26 most consumed goods covering more than 80% of household consumption has been chosen in the construction.

The same basket is used across strata but its value changes over time and space using specific price for each class. The total poverty line corresponds to the estimated food poverty line plus an amount to cover non-food expenditures. The non-food poverty line is calculated for each stratum as the average of non-food expenditure per adult-equivalent from all households who are around +/- 5% of the food poverty threshold.

III.3.2. Catastrophic out-of-pocket health expenditure through a Mixed Process Estimator

The determinants of catastrophic out-of-pocket health expenditure are analyzed upstream of the analysis of their impoverishing effect. Section III.3.3 presents the theoretical relationship between health shock, health expenditures, and welfare.

Taking into account the fact that we cannot observe health spending for some individuals because they are not ill, we used a system of Tobit regressions that involved censoring through a conditional mixed process estimator procedure developed by Roodman (2007). The procedure estimates multi-equations where the dependent variable of each equation may have a different format. The model is recursive with three structural equations and the estimation is a full information maximum likelihood (FIML).

The methodological approach is justified by our attempt to sort out the issues and concepts related to the econometric analysis of data such as health expenditure that contains a large number of zero expenditure observations, which can lead to a number of estimations bias when using inappropriate estimators.

A SUR (Seemingly Unrelated Equations) system of two Tobit models for household out-of-pocket health expenditure and the catastrophic health expenditure gap combined with a linear equation explaining household health status (measured as an ill-health score by counting the reported diseases within the household) is implemented. This accounts for correlations among unobservable factors affecting our endogenous dependent variables in addition to dealing with censoring issues. The empirical model can be written as follows:

$$
\begin{gathered}
H_i^* = \alpha I_i^* + \mathrm{X}_i \beta + \varepsilon_{Hi} \\
H_i = H_i^* \text{ if } \{ H_i^* > 0 \; and \; 0 \; if \; H_i^* \le 0\} \\
I_i^* = \delta S_i + \mathrm{M}_i \beta + \varepsilon_{Ii} \qquad (1) \\
I_i = I_i^* \text{ if } \{ I_i^* > 0 \; and \; 0 \; if \; I_i^* \le 0\} \\
S_i = f(E_i) + \varepsilon_{Si}
\end{gathered}
$$

Where H_i^* represents a censored variable measuring the distance from the catastrophic expenditure threshold[23] for the household *i*, observed only for a household whose health expenditure is above the threshold. The endogenous I_i^* corresponds to the total out-of-pocket household health expenditures. S reflects the above mentioned measure of health status, inversely related to the aggregate household health stock. X_i, M_i and E_i are sets of exogenous household socio-economic, environmental and control variables, such as location and household size, that enter into consideration in the specification of the endogenous variables. ε_{Hi} ε_{Ii} and ε_{Si} are random disturbances of the equations. The empirical model is jointly estimated.

As stated earlier, this study makes a considerable contribution to the existing literature on the determinants of catastrophic out-of-pocket health spending. It uses the same framework to estimate health production function and out-of-pocket health expenditures and allows correlation between dependent variables to take into account endogeneity. Many studies on health expenditure do not deal with endogeneity (Hjortsberg, 2003; Su et al., 2006), which needs to be controlled in the modelling of healthcare expenditure to avoid bias in estimates.

[23] 10% of 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).

A binary dependent variable that equals one when a household encounters catastrophic health expenditure and zero otherwise is commonly used to analyze the catastrophic health spending. However, this does not take into account the magnitude of the catastrophic out-of-pocket spending, contrary to the model we propose that uses the overshoot $O_i = \frac{T_i}{Y_i} - \xi_c$ as H_i , our main dependent variable, and then captures the intensity of the occurrence of catastrophic expenditures. The parameter ξ_c represents the threshold budget share above which the ratio $\frac{T_i}{Y_i}$ corresponding to health expenditures is to be considered catastrophic.

We conducted a preliminary data analysis to explore the correlates of both catastrophic out-of-pocket health expenditures and out-of-pocket health expenditures using simple bivariate statistics (see Brinda et al. 2014 for example). In addition, we used knowledge gained in the literature to specify the model. Variables such as type of health facilities visited, characteristics of the offered services and health insurance subscription are added in the explanation of catastrophic health spending. The household health status proxied by the occurrence of illness as well as the severity of diseases proxied by duration is expected to be a strong determinant of the amount of health spending and therefore their catastrophe.

Housing infrastructure and socio-economic household characteristics (rural/urban residence, education, age of household head, sex of household head, size, toilet facilities, household age structure, e.g. number of old people in the household (>50) and number of children under 5 years, mosquito nets use, etc.) might affect catastrophic out-of-pocket health spending through their effect on household health status. Descriptive statistics and description of the variables are presented in Table III.A1 in the appendix.

III.3.3. Out-of-pocket household health expenditure and welfare *nexus*

To better illustrate the relationship between household welfare, health spending and health shock, and to provide more rationale to our study, we consider the following Koç (2004) and Abul Naga and Lamiraud (2008; 2011) framework in which a household maximizes utility by choice of consumption good and health inputs. The effect of health shocks on demand for health inputs and welfare is examined, holding the household income constant. This conceptual framework shows why budget share for health inputs rises in response to a health deterioration arising from an exogenous health shock and therefore indicates the nature of the association between households' poverty and their health out-of-pocket expenditures.

Let I denote health inputs and s denote an exogenous health endowment. The household maximizes its utility u $[{(y - p_I I)}/{p_C}$, H (I, s)] through the choice of I. ${(y - p_I I)}/{p_C}$ is the remaining disposable income for spending on other non-medical goods C.

The first order necessary condition for an optimum choice of I, $Foc\ (I, y, p_I\ , s)$ = ${\partial u}/{\partial I}$ entails a level I_{opt} such that $Foc\ (I_{opt}, y, p_I\, , s)$= 0.

$$Foc\ (I, y, p_I\ , s) = -\frac{p_I}{p_c} u_1 + u_2\ H_1 = 0 \qquad (2)$$

where u_i and H_i correspond to first derivatives of the utility and the health production function with respect to their ith arguments.

Until now we have had the marginal effect of I on household utility. But let's continue derivation to get the marginal effect of exogenous household shock.

With a second differentiation we have

$${\partial Foc}/{\partial I} = (\frac{p_I}{p_c})^2\ u_{11} - 2\,\frac{p_I}{p_c} u_{12}\ \ H_1 + u_{22}\ H_1{}^2 + u_2\ \ H_{11} \qquad (3)$$

With u_1, u_2 >0, u_{11}, u_{22} ≤ 0 and $u_{12} \geq 0$ for all C, I > 0 and H_1, H_2 > 0 and $H_{11} \leq 0$ for all I > 0 representing the positive and decreasing assumptions about the marginal utility of income and health. Given these assumptions we have ${\partial Foc}/{\partial I} < 0$.

Let $v(y, p_c\, , p_I\, , s\ )$ denote the household's indirect utility function. The effect of health shock on household welfare is given by

$${\partial v}/{\partial s} = (-\frac{p_I}{p_c}\ u_1 +\ u_2\ H_1\ )\ {\partial I}/{\partial s}\ |\ I_{opt} +\ u_2\ H_2\ |\ I_{opt} \qquad (4)$$

The right side of (4) is zero from the envelope theorem. Accordingly, $u_2\ H_2\ |\ I_{opt} > 0$ entails that welfare increases with health, meaning that a health shock results in a welfare deterioration holding true the previous assumptions on marginal utility.

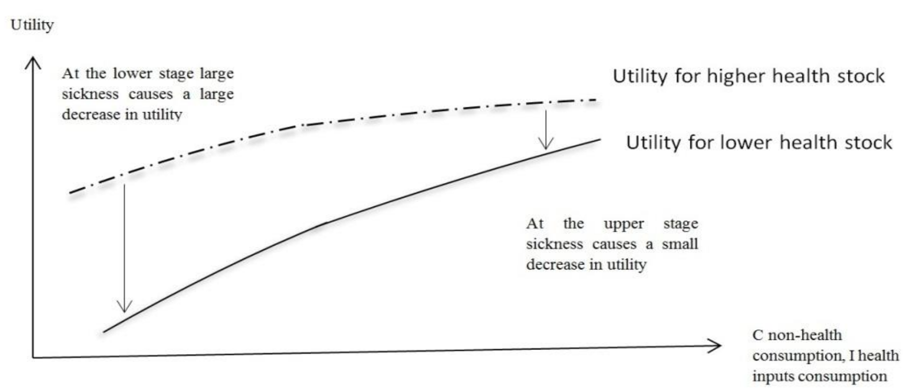
The implicit function assures that ${\partial I}/{\partial s} = -\frac{{\partial Foc}/{\partial s}}{{\partial Foc}/{\partial I}}$

So that ${\partial I}/{\partial s}$ will take the sign of ${\partial Foc}/{\partial s}$ that equals to

$$\partial \text{Foc}/\partial \text{s} = -\frac{p_I}{p_c} u_{12} \; H_2 + u_{22} H_1 \; H_2 + u_2 H_{12} \quad (5)$$

The demand for health inputs, and accordingly the budget share, rises as consequence of health shock ($\partial \text{I}/\partial \text{s}$ < 0) when the derivative in (5) is negative. While under the above assumptions the first and second right side terms of (5) are negative, the overall effect is ambiguous when $H_{12} > 0$. Through the additional restriction $H_{12} \leq 0$ would entail that I rises as a consequences of a health shock. This means that the marginal product of health inputs is lower for individuals with higher health stocks, as represented in Figure III.1, or independent to s when $H_{12} = 0$.
However, despite the potential importance of this specific point on marginal product, there has been relatively little empirical work done on how the marginal utility of consumption varies with health status. We leave for the future our contribution to this considerable empirical challenge in constructing credible estimates and in examining conditions under which the relation between marginal utility and health status is really valid and applicable.
The budget share for health inputs always rises in response to a deterioration of the well-being arising from an exogenous health shock (Koç, 2004; Abul Naga and Lamiraud, 2008).

Figure III.1: Health stock and marginal utility



Source: Authors

Let us consider g(y, Z) as the household poverty overshoot that equals Z_{pov} – y, with Z_{pov} the poverty line and y the income.
In line with the Pareto principle (Atkinson, 1987), g(y , Z_{pov}) is monotonically decreasing with the income or any measure of living standards y for all y ≤ Z_{pov} and g(y, Z_{pov}) equals to zero if

y ≥ Z_{pov} . Given this property, g is invertible and it exists Θ such as y = Θ(g, Z_{pov}). From the model and from equation (1) we can express the out-of-pocket health expenditures in this manner:

$$T = Ӽ\left(\Theta\left(g, Z_{pov}\right), S, I, M, E\right) + \mu$$

Where S represents household health status, M and E represent households' socio-economic and environmental characteristics, I the level of out-of-pocket household health expenditure and μ the residual term.

$\partial T/\partial g$ depicts the relation between catastrophic out-of-pocket household expenditures(above the catastrophic threshold) and poverty overshoot informs on the linkages between these catastrophic expenditures and aggregate poverty level. It indicates the intermediary variables through which the relation exists.

$$\partial T/\partial g = x_1\, \partial\Theta/\partial g + x_2\, \partial S/\partial g + x_3\, \partial I/\partial g + x_4\, \partial M/\partial g + x_5\, \partial E/\partial g + \partial\mu/\partial g$$

With x_j the derivate of Ӽ with regards to its j-th parameter. Many terms in the right-side equation are most plausibly positive or equal to zero, provided the variables are measured in terms of non-deprivation. The term $\partial\Theta/\partial g$ is negative as Θ(g, Z_{pov}) is decreasing in g. However, the sign of x_1 cannot be determined easily as depending on the relation between Ӽ and income.

The above framework based on Koç (2004), and Abul Naga and Lamiraud (2008, 2011) shows theoretically through the linkages between health shock, health expenditures, and welfare that we might miss an important part, perhaps one central point, of the true story when ignoring out-of-pocket health expenditure in poverty analysis. We will investigate empirically the existence of association between household out-of-pocket health expenditures and poverty using the following methods.

In line with the concerns raised by the new SPM tool and following Wagstaff and Doorslaer (2003) poverty measures are adjusted to take into account household health expenditures.

Let us define the catastrophic headcount ratio as specified in equation (6).

$$\boldsymbol{H}_c = \frac{1}{H}\sum_{i=1}^{H} Ind\left(\frac{T_i}{Y_i} - \xi_c\right) \qquad (6)$$

Where $Ind(.)$ equals to 1 if $\frac{T_i}{Y_i} > \xi_c$ and 0 otherwise, ξ_c represents the threshold above which the ratio $\frac{T_i}{Y_i}$ corresponding to health expenditures is to be considered catastrophic, H the sample size,

Y_i income and *i* subscript for household. However, this measure fails to capture the extent to which households exceed the threshold budget share ξ_c. The catastrophic payment gap is used to overcome this shortfall in analogy to poverty literature.

$\boldsymbol{H_c}$ gives an estimate of the proportion of households with health payments above the threshold but does not capture the amount by which these payments exceed ξ_c.

Therefore, the mean positive gap is defined and indicates how much on average household out-of-pocket health expenditures are catastrophic.

$$\boldsymbol{H_c^g} = \overline{\boldsymbol{O_\iota}} / \boldsymbol{H_c} = \sum_i^H \left(\frac{T_i}{Y_i} - \xi_c\right) Ind\left(\frac{T_i}{Y_i} - \xi_c\right) \Big/ \sum_{h=1}^H Ind\left(\frac{T_i}{Y_i} - \xi_c\right) \qquad (7)$$

Where $\overline{\boldsymbol{O_\iota}}$ represents the average of overshoot $O_i = \frac{T_i}{Y_i} - \xi_c$ if catastrophic and captures the intensity of the occurrence of catastrophic expenditures.

To account for the distribution of catastrophic expenditures in relation to income and between the richest and the poorest households, concentration indices[24] $\boldsymbol{C^{H_c}}$ and $\boldsymbol{C^{\overline{O_\iota}}}$ are used to compute weighted headcount $\boldsymbol{H_c^w} = H_c\ (1 - \boldsymbol{C^{H_c}})$ and weighted overshoot $\overline{\boldsymbol{O_\iota}}^{\boldsymbol{w}} = \bar{O_\iota}\ (1 - \boldsymbol{C^{\overline{O_\iota}}})$.

The concentration indices range from -1 to +1. A positive value indicates that the richer households are more likely to exceed the threshold while a negative value reveals a greater tendency for poor households to exceed the critical threshold.

The measures used to examine the impact of out-of-pocket payments on poverty measures are defined below. The idea is to measure the impoverishment effect corresponding to the extent to which households are pushed into poverty by 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*. The following FGT poverty measures can be defined

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

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[24] 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 pre-payment poverty gap: $\boldsymbol{P^1}(pre) = \frac{1}{H}\sum_{i=1}^{H}(x_i - Z_{pov}\text{ (pre)})$

The normalized pre-payment poverty gap that eliminates the effect of poverty line in comparisons is: $\boldsymbol{NP^1}(pre) = \frac{P^1(pre)}{Z_{pov}\text{ (pre)}}$

Differentiating these measures with regards to pre and post payment measures gives the effects of out-of-pocket health payments on poverty.

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

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

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

In the post-payment measures x_i is recalculated by subtracting household out-of pocket health expenditures and the poverty line Z_{pov} (pre) adjusted by deducting an amount from the poverty line derived from health spending among the group that provides the reference for the non-food based poverty line. Otherwise, the use of the food poverty line is applicable whether income x_i is pre-payment or post-payment, albeit restrictive.

III.4. Results and Discussion

III.4.1. Determinants of household out-of-pocket expenditure on health

Understanding the determinants of catastrophic household health expenditures is important as being a basis for developing effective health policies. The assessment of these determinants is done by using the model presented in equation (1).

Results are indicated in Table III.3 and reveal that households with more elderly people and children have more health problems (S) and hence might encounter catastrophic expenditures. Indeed, having children under-five years of age and elderly people appears to reduce the household-level health status, as these populations are more vulnerable to most types of diseases. More attention should also be paid to these groups of the population that are generally not financially autonomous and specific policies should follow. The use of mosquito nets has a positive effect on health outcomes in the household because they remain effective against malaria and positively affect the occurrence and intensity of catastrophic health expenditures. The health production function shows that having improved toilet facilities also affects positively household health stock. Households with a man as head registered fewer cases of illness.

Results also show that the occurrence of diseases within household, coupled with their severities increase the demand for medical care (I), which in turn increases the magnitude of catastrophic health expenditure. Households therefore tend to face higher risk of incurring catastrophic health expenditures.

This linkage is not as obvious as it seems because there are individuals who are sick but do not seek healthcare or spend money on healthcare, and there are also individuals who spend on medical care without being sick or who are less severely affected. The less healthy people may use more resources to recover their health, but on another hand, some healthier people may spend on medical care to maintain their health.

Catastrophic out-of-pocket health expenditure (H) happens when prices of medical goods increase compared to their level in the previous year. Indeed, we found that households that have more frequently experienced increase of prices of medical goods/services are those that tend to have deeper catastrophic out-of-pocket expenditures. This is captured with the variable *# Prices [$P_t > P_{t-1}$]*, indicating the extent to which household members have observed an increase of medical goods/services prices or tariffs. However, we have to admit that we might have an asymmetric or biased perception in the reported price increases, as these are household specific.

Table III.3: Determinants of catastrophic out-of pocket health expenditure

Variables	Catastrophic out-of-pocket health expenditure (H)	Variables	Out-of-pocket health expenditures level (I)	Variables	Household heath status/ ill-health score (S)
Radio (yes=1)	-0.0721**	Radio	54,238***	House ownship (yes=1)	-0.0269
	(0.0315)		(15,598)		(0.0619)
I	0.000***	S	6,020*	Size	0.192***
	(0.000)		(3,534)		(0.0131)
# Prices [P_t>P_{t-1}]	0.119***	Severity (# days)	1,036***	# Mosquito nets	-0.0306***
	(0.0335)		(310.1)		(0.0109)
High cost	0.0145**	S*Severity	-124.2**	# Vaccine	0.0232
	(0.00690)		(52.60)		(0.0343)
Waiting	-0.0157*	Care seeking	12,060***	Sex household head (Male=1)	-0.135**
	(0.0095)		(4,303)		(0.0566)
Perceived inefficiency of treatments	-0.0143	Private health service	3,879	Age household head	-0.00321
	(0.0158)		(8,363)		(0.00256)
Hospital (yes=1)	0.00600	House ownship (yes=1)	13,412	Education household head	-0.000
	(0.00975)		(10,392)		(0.0239)
Health center	-0.0573***	Other urban (out of Dakar)	-69,089***	Rural vs Urban (Rural=1)	0.163**
	(0.0139)		(20,616)		(0.0686)
Health Post	-0.0224***	Rural vs Urban (Rural=1)	-73,302***	Improved toilet (yes=1)	-0.304***
	(0.0087)		(23,688)		(0.0670)
Health room	0.00584	Farmer (yes=1)	-2,232	Waste disposal (yes=1)	0.0512
	(0.0123)		(7,973)		(0.0791)
Marabout	0.00714			Mud/Sand (yes=1)	-0.256***
	(0.0327)				(0.0662)
Private Doctor	-0.0265			Subdivided area (yes=1)	-0.0712
	(0.0392)				(0.0668)
Accident shock (yes=1)	0.0431***			Child	0.104***
	(0.0158)				(0.0369)
				Aged	0.0960**
# Insurance or/and MHO	-0.0128*				(0.0477)
	(0.00758)				
Rural vs Urban (Rural=1)	0.0424***				
	(0.00708)				
Constant	-0.328***	Constant	58,335*	Constant	0.568***
	(0.0142)		(32,513)		(0.192)
lnsig_H	lnsig_I	lnsig_S	atanhrho_HI	atanhrho_HS	atanhrho_IS
-2.115***	11.87***	0.691***	-0.577***	-0.134***	-0.105***
(0)	(0.196)	(0.0167)	(0.112)	(0.0462)	(0.0235)
Log pseudo likelihood	-24698.036				
Observations	5,953				

Note: Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0. lnsig_ and atanhrho_: refer to unbounded scale logarithm and arc-hyperbolic tangents transformation of the standard deviation parameter of each error term and the correlation for each pair from the three equations (reflecting endogeneity).
Source: authors

Results also indicate some significant impacts associated with the type of health service providers when determining the intensity of the catastrophe. While *Health centers* and *Health posts* have a reducing effect on catastrophic health, we find no significant effect for the other structures. This might reflect some differences in the efficiency of the different types of services or in the provision of treatments that are relatively more expensive across health service types.

The occurrence of other kinds of adverse events, such as accidents, is likely to be associated with a high risk of catastrophic health expenditures.

The long waiting periods that confront patients entering healthcare facilities (variable *Waiting*) reduce catastrophic out-of-pocket health expenditure, perhaps in contradiction to what we should expect, as it could induce other costs by constraining the household to come another day for care or examination likely generating additional transport costs. However, this result could be explained by demand factors such as preference of patients regarding efficiency of the provided services or the possibility to get relatively cheaper products.

Results show also that households located in rural areas have significantly more severe catastrophic expenditures compared to those living in urban areas despite having significantly lower health expenditures. Households with more health insurance enrollees or/and with more individuals engaged in Mutual Health organizations[25] (MHO) have lower catastrophic health expenditures. This is in line with the statement of Waters et al. (2004) according to which one rationale for health insurance coverage is to provide financial protection against catastrophic health expenditures.

[25] MHOs are voluntary organizations that provide health insurance services to their members. There are currently over 130 MHOs functioning in Senegal (Diop, F. and Ba, A., 2010).

III.4.2. Poverty and household out-of-pocket expenditure on health

As explained earlier, we estimate how much the household health expenditures are catastrophic, their distribution with regards to the thresholds and across poor and non-poor, as well as the proportion of households below the poverty line before and after adjusting for health expenditures. Discussed results concentrate on the 10 % threshold but we also define measures with respect to various thresholds. As previously stated, this value is the most commonly used, although it may be arbitrary. Therefore, we think that considering a range of value for the threshold might provide a helpful indication regarding how many households would be affected, in addition to the popular approach. The 20% and 25% thresholds correspond to an extremely severe definition of the catastrophe.

Table III.5 shows that 6.26% of households incurred health expenditure above the critical threshold of 10% of the total income with some disparities across areas. This ratio is higher in Dakar with 7.72%. The mean of positive gap is estimated to be about 7.82 %, meaning that the amplitude of the excess of catastrophic out-of-pocket health spending is around 8% of the household income, with a more severe effect out of the capital.

The results in Table III.4 reveal that the weighted headcount and the weighted gap from critical thresholds are in general higher than the un-weighted measures, showing that the poor tend to exceed the threshold. This is in line with the negative values of the concentration indices.

Table III.4: Distribution-Sensitive catastrophic health expenditure measures at national level

Measures	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%
$\boldsymbol{\overline{O_\iota}}$	1.00%	0.49%	0.28%	0.19%	0.14%
	(0.001)	(0.0008)	(0.0007)	(0.0006)	(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%

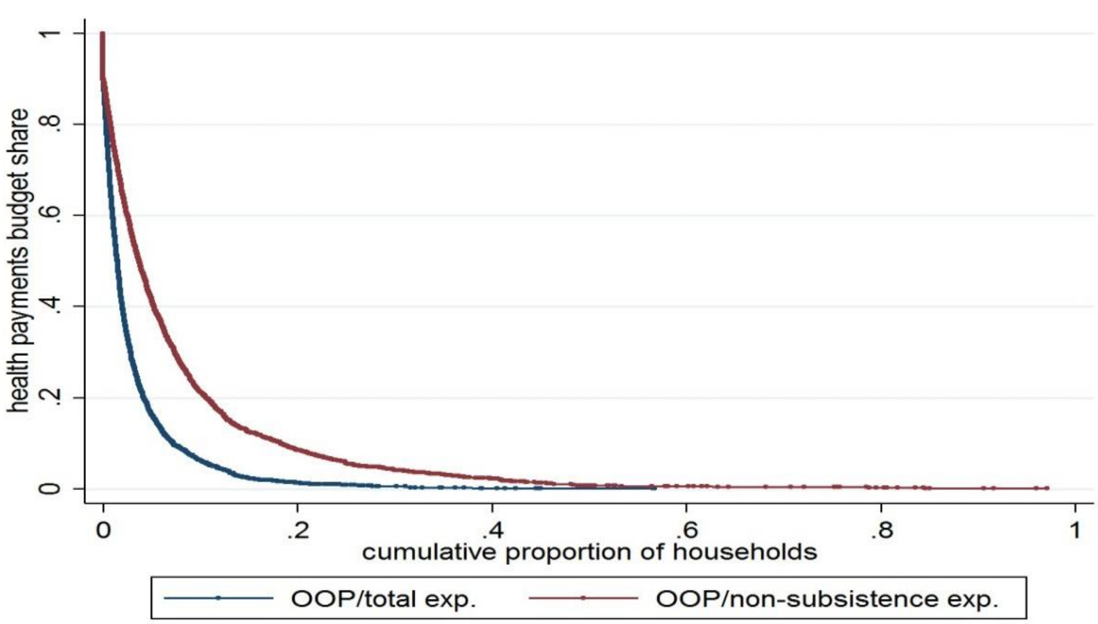
Source: Authors

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

Figure III.2 shows for comparison the distributions of out-of-pocket household expenditures in two approaches: when catastrophic payments are defined regarding total household income, as in our case, and when catastrophic payments are defined with respect to health payment relative to non-food expenditure (Xu et al., 2003; Kawabata, Xu and Carrin, 2002). The shares of health payments in total budget and in non-subsistence budget are plotted against the cumulative percentage of households ranked by decreasing budget share.

The different health budget share curves show that at a given threshold, the headcount ratio is higher in the non-subsistence expenditure based approach. This confirms the existence of catastrophic health expenditures regardless of the method used.

Figure III.2: Health expenditure as share of household total income and non-subsistence expenditure



Sources: authors

Calculations of various measures show that the incidence and the intensity of poverty are impacted by out-of-pocket health expenditures. The pre–payment poverty ratio is 46.7% and is higher in rural areas (57.13).

Table III.5: Poverty and out-of-pocket health spending

Measures	Zones			
	Dakar	Other urban areas	Rural Areas	Senegal
$\boldsymbol{H_c}$	7.72 (0.018)	4.79 (0.008)	6.18 (0.007)	6.26 (0.006)
$\boldsymbol{H_c^g}$	7.20 (0.021)	9.44 (0.020)	7.68 (0.017)	7.82 (0.011)
$\boldsymbol{P^0(pre)}$	26.09 (0.028)	41.15 (0.017)	57.13 (0.014)	46.70 (0.011)
$\boldsymbol{P^0(post)}$	27.53 (0.029)	43.39 (0.018)	58.28 (0.014)	48.14 (0.011)
$\Delta\boldsymbol{P^0}$	1.44 (0.010)	2.20 (0.007)	1.16 (0.003)	1.44 (0.003)
$\boldsymbol{NP^1(pre)}$	5.77 (0.007)	13.08 (0.007)	18.63 (0.006)	14.53 (0.004)
$\boldsymbol{NP^1(post)}$	6.47 (0.008)	13.67 (0.007)	19.59 (0.006)	15.35 (0.004)
$\Delta\boldsymbol{NP^1}$	0.70 (0.002)	0.59 (0.000)	0.96 (0.001)	0.82 (0.001)
$\boldsymbol{NP^2(pre)}$	2.14 (0.003)	5.87 (0.004)	8.67 (0.006)	6.59 (0.002)
$\boldsymbol{NP^2(post)}$	2.38 (0.004)	6.23 (0.004)	9.45 (0.005)	7.16 (0.003)
$\Delta\boldsymbol{NP^2}$	0.25 (0.000)	0.36 (0.000)	0.78 (0.002)	0.57 (0.001)

Note: The measures are for the 10% threshold. NP^2 is the severity index. Standard errors of the statistics in parentheses.

Source: authors

At the threshold of 10%, the poverty headcount ratio increases by 1.44 percentage points when accounting for out-of-pocket health expenditure, as well as the average deficit to reach the poverty line (See Table III.5). At this point, there are more than 195,716 persons that are pushed below the poverty line due to catastrophic out-of-pocket health spending when extrapolating these data to the national level. Robustness of results regarding the existence of the impoverishing effect are ensured by the non-subsistence expenditure based approach that identifies more severe impact as illustrated in Figure III.2. These results show some evidence that households are impoverished by catastrophic out-of-pocket health expenditures, albeit relatively not too heavily in average.

In comparison, out-of-pocket health expenditures are more frequent in a country like Kenya, where 16% of households incurred catastrophic health expenditures, and less in a country like Burkina Faso, where it was estimated that less than 2% of the households incurred these extreme expenditures. Regarding poverty, countries like Laos in 2008 and Philippines in 2009 have estimated impoverishment effects quite similar to those in Senegal, with respective estimates of 1.1% and 1% (World Health Organization, 2011a, 2011b).

Catastrophic health payments are additional factors pushing some households into poverty in Senegal. Therefore, there is a need for Government to provide better social protection and an efficient health financing system that can make them less vulnerable to financial catastrophes.

III.5. Conclusion

Out-of-pocket payments are the primary source through which health expenditure is met in Senegal, as in many other developing countries. These payments are financial burdens leading to impoverishment when they become catastrophic, as households must reduce their expenditures on other necessities. The purpose of this study was to cast a new light on the determinants of catastrophic household out-of-pocket health spending and its implications on poverty.

The econometric analysis shows factors that explain catastrophic household out-of-pocket health expenditures such as high costs, annual increase of the prices of health goods/services, disease occurrence within the household, level of health spending, health insurance, etc.

Analyses indicate that many individuals are pushed into poverty due to the burden of this type of payments. These findings provide insight for efficient Government action to fight poverty by tackling the impoverishment effects of catastrophic health expenditures. Financial mechanisms offering protection against the burden of catastrophic health expenditures should be provided to achieve greater poverty reduction. Reducing the occurrence of illness through good sanitation, a healthier environment, and policies that ameliorate quality of health care in terms of treatment efficiency, reliance on out-of-pocket payments, and cost reduction would be beneficial to households.

Individuals experiencing catastrophic health payments are associated with the lack of health insurance contracts. A crucial point is to increase the current low number of individuals covered under health insurance or enrolled in Mutual Health Organizations. 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. The Government should expand its policy of mutual health insurance to cover more rural populations across the country and the informal sector. Mutual Health Organizations can easily reach the informal sector workers that do not have access to formal coverage. Beyond finding a more efficient funding mechanism, the political difficulty of implementing policies will be effective targeting of beneficiaries. However, it is sure that a mass extension of health coverage may lower catastrophic health expenditures.

Households facing high costs of medical goods observe more severe catastrophic health expenditures. Therefore, more subsidy policies in health establishment may be necessary and would at least offer some financial protection to households and reduce the impoverishing effects of out-of-pocket health expenditures.

The elderly should receive more attention through the reinforcement of existing policies such as the *Sesame Plan* (free care for elderly) introduced in 2006 by the Senegalese Government. The plan aimed to reduce social vulnerability among the elderly. However, the implementation of this program has not been achieved, and is jeopardized by political instability. There is a strong need to develop appropriate measures to ensure the follow-up of these kinds of policies and to improve sustainability of existing social financing mechanisms.

The new broad project of social protection CAPSU[26] that includes the *Sesame Plan* and consolidates all the subvention and exemption initiatives should learn from the previously applied reforms and programs to target more vulnerable groups like the elderly and children. The results show disparities across locations with regards to the magnitude of catastrophic expenditures and poverty distribution. This indicates the importance of a broader health care policy for the entire population and highlights the need for decentralization of financial protection methods and health services. Investments should be concentrated on individuals in rural areas and also in cities other than Dakar, as these living areas have increasing effects on catastrophic health expenditures and

[26] Independent Fund for Universal Social Protection

fewer facilities. Indeed, it is estimated that around 70% of doctors and 80% of pharmacists and dentists are in Dakar, the capital city, whereas only about 20% of the Senegalese population live in the capital. In addition, data exploration reveals that the most common reported illness suffered amongst households incurring catastrophic out-of-pocket health expenditures is Malaria or fever (around 49% of the reported cases, both may occur simultaneously). Besides, digestive diseases including diarrhea (21%) are often reported by individuals in households that face catastrophic health payments. Interventions that try to provide appropriate treatment and lower fees for these diseases could significantly decrease the economic burden on households.

National poverty estimates should be assessed by taking into account household out-of-pocket expenditures on health, and government policies on poverty reduction have to integrate healthcare programs in order to avoid potential impoverishing effects.

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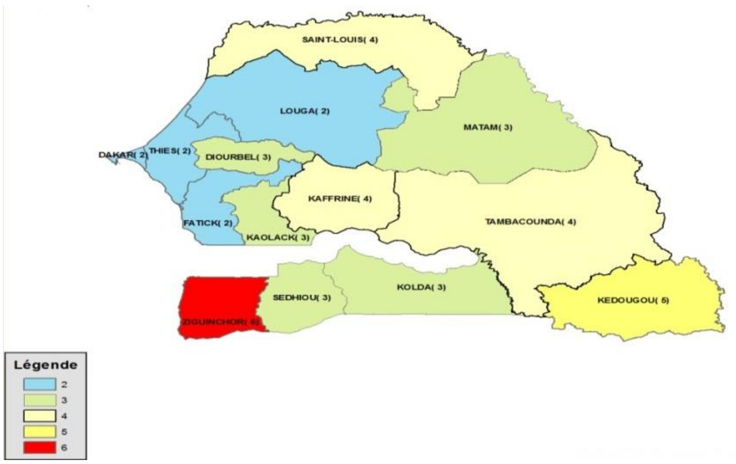
Appendix

Figure III.A1: Map of Out-of-pocket health spending as share of total expenditure across regions (%)



Source: Authors

Table III.A1: Descriptive statistics of variables

Variables	Description	Obs	Mean	Std. Dev.	Min	Max
Overshoot, H	Intensity of the catastrophic out-of-pocket spending e.g. distance from threshold budget share	5953	0.01	0.06	0	2.41
Radio	Radio : 1 if owned	5953	0.07	0.26	0	1
Insurance or/and MHO	Insurance or/and MHO (members covered)	5953	0.21	1.04	0	22
Rural vs Urban(Rural=1)	1 if lives in rural area	5953	0.49	0.50	0	1
#[Pt > P t-1]	Occurrence of increase of medical goods/services prices experienced (number of times)	5953	0.14	0.15	0	0.9
High cost	Times cost perceived high by members (score e.g. number of times)	5953	0.14	0.57	0	16
Waiting	Waiting times judged long by members	5953	0.15	0.55	0	16
Inefficiency	Inefficient treatment of members (score from individuals perception)	5953	0.03	0.31	0	15
Hospital	Hospital visited by household members (1 if yes)	5953	0.24	0.43	0	1
Health center	Health center visited by household members (1 if yes)	5953	0.14	0.34	0	1
Health Post	Health post visited by household members (1 if yes)	5953	0.29	0.46	0	1
Health room	Health room visited by household members (1 if yes)	5953	0.04	0.20	0	1
Marabout	Marabout visited by household members (1 if yes)	5953	0.03	0.16	0	1

Private Doctor	Private doctor visited by households members (1 if yes)	5953	0.02	0.12	0	1
Accident shock (1/0)	Other kind of adverse events (accident shock) occurrence (1 if yes)	5953	0.03	0.17	0	2
Total expenditure, I	Household aggregate out-of-pocket health expenditure level (CFA)	5953	62009	151044	0	5025250
Health status, S	Correspond to inverse household health stock e.g. ill-health score from the overall disease occurrence	5953	2.07	2.32	0	22
Severity (# days)	Severity proxied by duration of illness (days)	5953	11.23	17.51	0	242
Care seeking	Looking for treatment or not (1 if yes)	5953	1.47	1.85	0	26
Private health service	Number of visits to private health services	5953	0.12	0.46	0	9
House owner (1/0)	1 if house owner	5953	0.80	0.40	0	1
Farmer (1/0)	1 if farmer household	5953	0.22	0.42	0	1
Size	Size of the household, control variable	5953	9.24	5.84	1	69
Mosquito net	Mosquito nets use (persons covered)	5953	7.06	6.00	0	68
Vaccine	Vaccine occurrence in the household	5953	1.39	1.77	0	15
Sex of household head (Male=1)	1 if household head is male	5953	0.75	0.43	0	1
Age of household head	Age of the household head	5953	51.51	14.42	17	98
Education of household head	Education of the household head, level	5948	1.58	1.04	1	5
Improved toilet (yes=1)	1 if improved toilet	5953	0.65	0.48	0	1
Waste disposal (=1)	1 if waste disposal available	5953	0.13	0.33	0	1
Mud/Sand (1/0)	1 if mud/sand floor	5953	0.39	0.49	0	1
Subdivided area	1 if living in an area subdivided	5953	0.56	0.50	0	1
Child	Numbers of children in the household (less than 5)	5953	1.76	1.85	0	21
Aged	Number of old persons (>50)	5953	1.11	0.96	0	6

Source: Authors

Chapter IV

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

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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

IV.1. Introduction

Agriculture is an important sector in Senegal and the main economic activity in rural areas (60% of the population, World Bank, 2011) and comprises a large share of total employment (more than 45%, ESPS, 2011). The sector is affected by a continuing decline in exports and foods supply as a result of productivity loss partly attributed to the poor rainy season and factors related to mismanagement and political considerations. 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.)[27] 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 payments might increase agricultural productivity, but when catastrophic, they can lead to households'

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

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 (GIP SPSI, 2006). However, there is almost no insurance coverage in the informal sector and the coverage rate remains low in the formal sector, which constitutes only 10 percent of the workers (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 rest of the paper is organized as follows. In Section IV.2 we provide some background knowledge by revisiting the linkage between health expenditures, health, and productivity. Section IV.3 then introduces the methodology used in this paper. Section IV.4.1 presents the simulation design developed in our research. Section IV.4.2 analyzes the distribution of catastrophic out-of-pocket health expenditures and their relationship with poverty. Finally, in Section IV.4.3 the linkage between health policies and agricultural productivity is analyzed through a CGE framework, which incorporates the issue of dynamic adjustments and spillover effects. Section IV.5 concludes.

IV.2. Background

IV.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.

IV.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[28] 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 relevant 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.

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

IV.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.

IV.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 IV.A1 and Table IV.A2 in the appendix provide a description of the model, and further explanation can be found in the above-mentioned papers 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 the consumption of health goods 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 includes Livestock, Forestry, and Fisheries accounts. Detailed information about the non-agricultural sectors (industry and services) is also provided. The model aims to capture the linkage between all these various 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 of the production into fourteen regions. This allows for an efficient modeling of the agricultural sector in Senegal by taking into account as much as possible the 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.

The 2011 poverty monitoring survey (ESPS II) is used to model the demand side of the CGE. It covers 17,891 households with 5,953 households constituting the sub-sample from which the questionnaire on expenditures was administrated. It is a random sample survey at national level and based on two-stage cluster sampling method. This survey aims to highlight the socio-economic characteristics of the different social groups (ESPS, 2011).

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 household interview. The expenditure data is used to compute household income estimation. Health consumption expenditures include 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 same structure of household health consumption as in the Poverty Monitoring Survey ESPS II, plus macro statistics from the National Agency for Demography and Statistics (ANSD). The SAM is balanced using the cross-entropy method as described in 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 4). 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 IV.A1 in the appendix for the full list of notations).

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

$$\frac{QVA_a}{QINTA_a} = \left(\frac{PINTA_a}{PVA_a} \cdot \frac{\delta_c^a}{1 - \delta_c^a} \right)^{\frac{1}{\rho_a^a + 1}} \quad (2)$$

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

$$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta^{va}_{f\,a} \cdot (QF_{f\,a})^{-\rho^{va}_a} \right)^{-1} \cdot \delta^{va}_{f\,a} \cdot (QF_{f\,a})^{-\rho^{va}_a - 1} \qquad (4)$$

$$QINT_{c\,a} = ica_{ca} \cdot QINTA_a \qquad (5)$$

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:

$$\alpha_a^{va}\,(t+1) = \alpha_a^{va}\,(t)\,(1 + \Phi(\Psi)) \qquad (6)$$

Where Ψ 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:

$$\alpha_a^{va}\,(t+1) = \alpha_a^{va}\,(t)\,(1 + \vartheta\ \sum_{h=1}^{G} (\frac{\Delta(P_{health}\,(h,t_0)Q_{health}(h,t-1))}{P_{health}\,(h,t_0)Q_{health}\,(h,t-1)}) \qquad (7)$$

With h the index for household groups within the model, G the number of household groups in 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.

$$P_{health}\,(h,t).\ Q_{health}(h,t) = \mu(h,t) + P_{health}\,(h,t).\,\gamma^{m}_{health}(h) + \beta^{m}_{Q_{health}}(h).\ \left(EH(h,t) - \sum_{c' \in C} P_{c'}\ .\ \gamma^{m}_{c'}\ (h)\right) \qquad (8)$$

Where $\gamma^{m}_{health}(h)$ represents the minimum consumption level of household h, $\beta^{m}_{health}(h)$ 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 section IV.4.3 and the note below Table IV.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. Here, health care demand behavior is determined mainly by the postulate of utility maximization, 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.

IV.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. Just as the CGE model, the poverty microsimulation module is also calibrated to the 2011 Senegalese household poverty monitoring 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.

$$FGT = \frac{1}{M}\sum_{m=1}^{M}\left(\frac{z-y_m}{z}\right)^{\alpha}.\ I(y_m \leq z) \quad (9)$$

where z is the poverty line, M is the number of households in the survey, y_m is the income of household m and $I(y_m \leq z)$ is an indicator function which is equal to one when $y_m \leq z$ and zero otherwise. 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 7) 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:

$$\boldsymbol{H}_c^h = \frac{1}{M^h} \sum_{m=1}^{M^h} Ind\,(\frac{T_m^h}{Y_m^h} - \xi_c) \tag{10}$$

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

Out-of-pocket payments are considered catastrophic and poverty increasing if they exceed 40% of annual non-food expenditures by households (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 total household 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 transmitting changes in health expenditures and income from household groups in the CGE model to the corresponding households in 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 catastrophic outcomes as defined here, then there is a perfect transmission of investment in health inputs to productivity in line with the elasticity ϑ.

Considering this, equation (7) can be rewritten in the following manner:

$$\alpha_a^{va}(\mathrm{t}+1) = \alpha_a^{va}(\mathrm{t})\left(1 + \vartheta \sum_{h=1}^{G} \frac{\Delta\left(P_{health}(h,t_0) Q_{health}(h,t)\right)}{P_{health}(h,t_0) Q_{health}(h,t-1)} \left(\boldsymbol{H}_c^h(t)\right)^{\left(1-1_{[\Delta(PQ)>0]}\right)} \left(1 - \boldsymbol{H}_c^h(t)\right)^{1_{[\Delta(PQ)>0]}}\right) \quad (11)$$

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 equation (11) 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 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.

Catastrophic out-of-pocket health payments might reduce the full impact of health investment on productivity, while at the same time 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 fertilizer and other traditional agricultural inputs, in a context where household 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 (11) 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.

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 shift in productivity is endogenized and no technological progress is assumed *ad hoc*, as it is commonly done in the CGE literature.

IV.4. Policy simulations and discussion

IV.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 policies that mitigate the consequences of catastrophic health payments on individuals. The simulations are run over a ten year period from 2011 to 2020.

Under the first policy that is simulated, the government would pay for the cost of drugs beyond amounts that might otherwise threaten the financial security of a given household. In this case, we also simulate alternative options for the government to pay for the policy and the resulting impact on the economy and household well-being. In the first option, the excess or catastrophic share of expenditures is entirely supported by the government and financed through reduced public savings or through increased taxes on domestic institutions or on commodities, whether uniformly or not. This is simulated by transferring amounts equivalent to full payment overshoot $\sum_{m=1}^{M^h} O_m . Y_m = \sum_{m=1}^{M^h} T_m^h - \xi_c \, Y_m^h$ to each household group in each period in order to eliminate the impoverishing effects of out-of-pocket health expenditures. The size of the catastrophic payment overshoot captures the intensity of the occurrence of catastrophic expenditures. In order to reduce the fiscal burden of the policy and ensure its sustainability, an option with transfers equivalent to 50% of catastrophic out-of-pocket health payments is also presented in the appendix. In this cost-sharing option, households bear half of the cost up to the critical threshold.

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[29]; only 20% of the population is covered by health insurance (Pereznieto, 2009).

The second policy option is to reduce the price of health good for households. This price reduction could come from productivity gains in the domestic health producing sector, government subsidies or reduction of the import tariffs on imported health goods. We consider only the last two channels. Most of the drugs used in Senegal (85-90%) are imported with relatively high margins, which contributes to their relative inaccessibility (Ministry of Health, 2005). Drugs imported from outside the WAEMU and ECOWAS[30] are subject to a tax rate of 2.5%. We simulate the impact of an annual 3% decrease in the duty rate τ over the simulation period. This duty escalator, meaning a progressive liberalization, is likely to mitigate the burden of health good expenditures and give incentive to households to invest more in health. Under this scenario, the associated direct cost per year is given by the lost revenue resulting from the lowering 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 the number of years between the base year 2011 and the current simulation period t in the dynamic model, and EXR the exchange rate. We also simulate an alternative option of a 3% annual increases of subsidy ρ to the domestic health sector. The size of the simulations is not critical here, as simulating different levels might generate the same types of mechanisms in the economy. The different scenarios are ranked using as criterion the degree of poverty reduction achieved per unit of lost government revenue. Table IV.1 describes the different policy simulations.

Table IV.1: Simulation designs

Simulations' names	**Simulations' description**
$\boldsymbol{S_1}$ **and** $\boldsymbol{S'_1}$	Full (S_1) and partial (S'_1) coverage of the catastrophic out-of-pocket health payments financed by saving
$\boldsymbol{S_2}$ **and** $\boldsymbol{S'_2}$	Full (S_2) and partial (S'_2) 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 institutions

[29] 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.
[30] WAEMU : West African Economic and Monetary Union
ECOWAS : Economic Community of West African States

S_3 and S'_3	Full (S_3) and partial (S'_3) coverage of the catastrophic out-of-pocket health payments financed by non-uniform direct tax rate
S_4 and S'_4	Full (S_4) and partial (S'_4) coverage of the catastrophic out-of-pocket health payments financed by uniform sales tax
S_5 and S'_5	Full (S_5) and partial (S'_5) coverage of the catastrophic out-of-pocket health payments financed by scaled sales tax
S''_1	3% annual decrease of tariffs on health goods, base value 2.5%
S''_2	3% annual increases of activity subsidy to health sector, base value 10%

Source: The author

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

Before discussing the simulation results, we want to highlight the magnitude and the distribution of out-of-pocket health expenditures across household groups . We also discuss the extent to which these expenditures are likely to have poverty exacerbating effects and productivity lowering effects among households. Some metrics already defined in Séne and Cissé (2015) are presented.

We use the mean positive gap to assess the magnitude of the catastrophic impact of household out-of-pocket health expenditures that is to see how excessive they are. In contrast to the headcount ratio, it gives an indication of how much consumer payments exceed the threshold amount. At the national level it is computed using the following formula:

$$\boldsymbol{H}_c^g = \overline{\boldsymbol{O}_\iota} \Big/ \boldsymbol{H}_c = \sum_m^M \left(\frac{T_m}{Y_m} - \xi_c\right) Ind \left(\frac{T_m}{Y_m} - \xi_c\right) \Big/ \sum_{m=1}^M Ind \left(\frac{T_m}{Y_m} - \xi_c\right) \quad (12)$$

where $\overline{\boldsymbol{O}_\iota}$ represents the average of overshoot payment $O_m = \frac{T_m}{Y_m} - \xi_c$. The expression measures the intensity of the occurrence of catastrophic out-of-pocket expenditures.

To measure the inequality in health expenditures, concentration indices[31] $\boldsymbol{C}^{\boldsymbol{H}_c}$ 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 $\overline{\boldsymbol{O}_\iota}^{\boldsymbol{w}} = \bar{O}_\iota\,(1 - \boldsymbol{C}^{\overline{\boldsymbol{O}_\iota}})$.

[31] $C = \frac{2}{M\mu} \sum_{m=1}^M h_m r_m - 1 - \frac{1}{M}$ where h_m is the health variable, μ its mean, and r_m the fractional rank of household m 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.

This allows us to see whether the households who experienced catastrophic health expenditures were unequally distributed across the population, between the richest and the poorest households. The calculations of the indices help illustrate the impact of household out-of-pocket health expenditures on poverty when they reach catastrophic levels. These measures elucidate the impoverishment effect which corresponds to the extent to which households are pushed into poverty and likely to become unable to achieve their maximum level of potential productivity due to catastrophic out-of-pocket health expenditures.

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

The pre-payment poverty headcount is: $\boldsymbol{P^0}(pre) = \frac{1}{H}\sum_{m=1}^{M} Ind(x_m \text{-} Z_{pov}\text{ (pre)})$ (13)

The pre-payment poverty gap is: $\boldsymbol{P^1}(pre) = \frac{1}{H}\sum_{m=1}^{M}(x_m \text{-} Z_{pov}\text{ (pre)})$ (14)

The normalized pre-payment poverty gap controls for differences in poverty lines between strata and is expressed as: $\boldsymbol{NP^1}(pre) = \frac{P^1(pre)}{Z_{pov}\text{ (pre)}}$ (15)

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

$\Delta\boldsymbol{P^0} = P^0(post) - P^0(pre)$ (16)

$\Delta\boldsymbol{P^1} = P^1(post) - P^1(pre)$ (17)

$\Delta\boldsymbol{NP^1} = NP^1(post) - NP^1(pre)$ (18)

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. The results are discussed further below (and will be presented in Table IV.3).

Although the CGE simulations are based on a threshold value of 10%, Table IV.2 considers a range of threshold values and illustrates the extent to which catastrophic payments can push people into poverty[32]. The higher thresholds (20% and 25%) represent an extremely severe definition of

[32] The 10% threshold is the most common - albeit arbitrary - threshold in the literature (Pradhan and Prescott, 2002; Wagstaff and Van Doolaer, 2003 and Russell, 2004), The rationale is that this represents an approximate

the catastrophe owing to higher out-of-pocket costs. In general, the results in Table IV.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 IV.2: Distribution-sensitive catastrophic health expenditures (at national level)

Indices	Threshold budget share ξ_c				
	5%	10%	15%	20%	25%
H_c	16.18%	6.26%	2.33%	1.38%	0.87%
	(0.009)	(0.006)	(0.003)	(0.003)	(0.002)
Concentration index 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 H_c^w	17.01%	6.77%	2.53%	1.48%	1.10%
$\overline{O_\iota}$	1.00%	0.49%	0.28%	0.19%	0.14%
	(0.001)	(0.0008)	(0.0007)	(0.0006)	(0.0005)
Concentration Index $C^{\overline{O_\iota}}$	-0.152	-0.217	-0.285	-0.357	-0.411
	(0.044)	(0.068)	(0.088)	(0.104)	(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 indexes are significant. The weighted measures also.

At the 10% threshold, 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 at 7.82% of the household income at the national level, as shown by the mean of positive gap in the last column of Table IV.3.

Results show that catastrophic out-of-pocket health payments exacerbate poverty. Estimations reveal that the conventional poverty headcount ratio for Senegal increases by 1.43 percentage point when controlling for catastrophic out-of-pocket health expenditure ($\Delta \boldsymbol{P^0}$). The average deficit to reach the poverty line also increases due to the burden of excessive health payments ($\Delta \boldsymbol{NP^1}$).

threshold at which the household is forced to sacrifice other basic needs, sell productive assets, incur debt, or become impoverished (Russell, 2004).

When extrapolating at national level, we found that a large number of people (195, 716)[33] 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.

Table IV.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
$\boldsymbol{P^0}(\boldsymbol{pre})$	61.09	54.5	42.96	32.69	46.71
$\boldsymbol{P^0}(\boldsymbol{post})$	62.24	55.67	42.97	34.55	48.14
$\Delta\boldsymbol{P^0}$	1.15	1.17	0.01	1.86	1.43
$\boldsymbol{NP^1}(\boldsymbol{pre})$	18.80	18.52	13.03	9.02	14.53
$\boldsymbol{NP^1}(\boldsymbol{post})$	19.55	19.62	13.8	9.65	15.35
$\Delta\boldsymbol{NP^1}$	0.75	1.1	0.77	0.63	0.82
$\boldsymbol{NP^2}(\boldsymbol{pre})$	8.19	8.98	5.62	3.80	6.59
$\boldsymbol{NP^2}(\boldsymbol{post})$	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 author

[33] Namely the increase in the poverty headcount ratio (1.43%) times population size estimated at 13 591 436 millions (ESPS, 2011).

IV.4.3. CGE simulation results and the macroeconomic implications

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.

The elasticity of productivity with respect to health goods consumption, ϑ, is presented in Table IV.A3 in the appendix. It is estimated through 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)[34] 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[35] as well as the Hansen J test reveals the appropriateness of the instruments.

Table IV.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% for the period considered here (2011-2020), which is the observed 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%, which reflects the recent performance in the overall agricultural sector. The baseline also assumes the continuation of demographic trends. Urban population is supposed to grow at 2.5%, while rural population grows 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. The various results show an increase in agricultural GDP compared to the baseline scenario as a response to productivity gains in the agricultural sector resulting from alternative policy options to reduce the burden of catastrophic out-of-pocket health expenditures. Under scenarios S''_1 (tariff reduction) and S''_2 (increase in subsidy), the decrease in the price of health goods consumed by households raises total private consumption in the economy.

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

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_s simulations, s=1,…,5) have the same direct cost that equals the overall transfer payments households receive from the government. These simulations 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 IV.4: Macroeconomic impacts

	Imports	***Agricultural GDP***	***Private consumption***
Simulations			
Initial	-2,958.48	946.35	5,733.16
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 author

Figure IV.1 and Table IV.A4 in the appendix summarize the key results in terms of poverty reduction. The poverty evolutions in Figure IV.1 are drawn only for the selected simulations BAU, S_1, S_2 and $S"_1$ for a good visualization[36]. For the remaining simulations, the detailed results are presented at national level in the appendix.

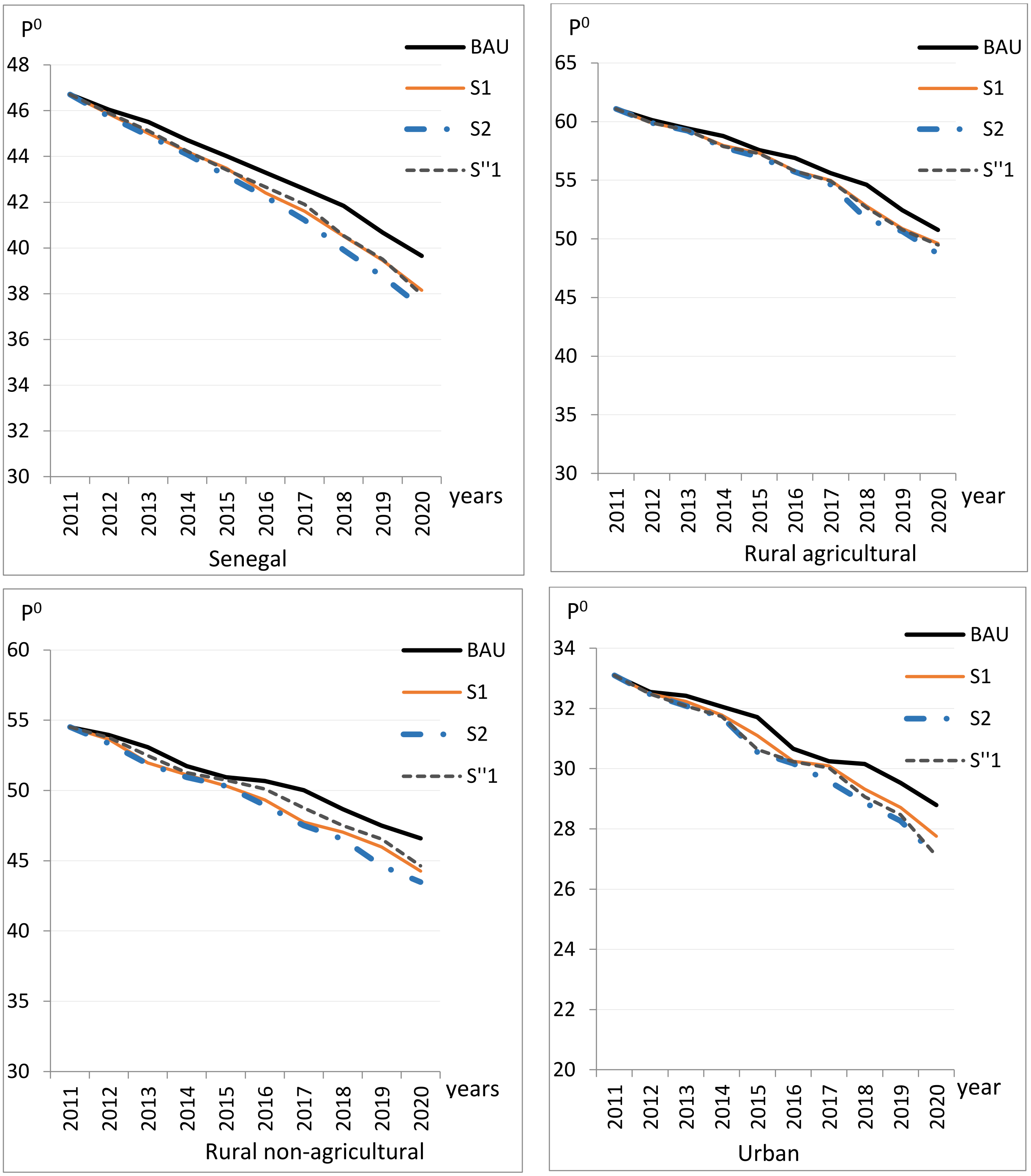
[36] In fact, some simulations might overlap because they present a very similar poverty path, albeit with marginal differences. Figure V.1 only shows evidence that policy options concerning catastrophic health payments have a potential for poverty reduction and does not intend to compare simulations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

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 illustrates the potentially significant implications of catastrophic health expenditures on households' welfare.

The scenarios lowering import tariffs and increasing subsidies to the health sector also have poverty reducing effects, albeit marginal for the subsidy scenario. Regarding this direction, larger shocks would affect more prices and would have greater impacts. All simulations have the effect of increasing the consumption of health goods compared to the baseline, especially for the subsidy simulation, as indicated in Table IV.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.

On average, rural areas experience a larger reduction in poverty than urban areas in almost all the simulations. For example, the poverty rate in the whole rural area decreases by 2.69 percentage points in S_2 compared to the counterfactual scenario, while there is a reduction of 1.7 percentage points in urban areas.

Figure IV.1: Poverty evolution per household type for selected simulations



Source: The author

The comparison of full coverage simulations with the partial coverage simulation and the tariff and subsidy simulations, requires taking into account the endogenous government revenue losses beyond the estimated direct cost in Table IV.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 are expressed as absolute poverty reduction per unit of average government revenue loss over the simulation period for each scenario.

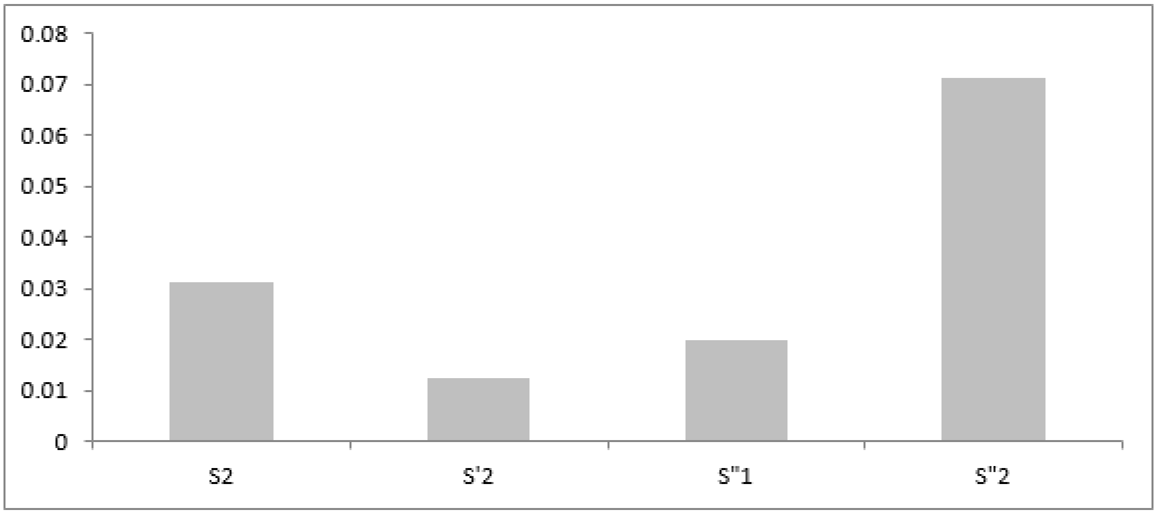
Table IV.5: Poverty reduction and policy costs with respect to national poverty

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	$\sum_{m=1}^{M^h} O_m . Y_m = \sum_{m=1}^{M^h} T_m^h - \xi_c \, Y_m^h$	20.6	29.7
S'_2	9.47	$\sum_{m=1}^{M^h} \frac{1}{2} O_m . Y_m = \sum_{m=1}^{M^h} \frac{1}{2} (T_m^h - \xi_c \, Y_m^h)$	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

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

As shown in Figure IV.2, subsidizing the health sector ($S"_2$) and full coverage of catastrophic out-of-pocket health expenditures financed by a uniform tax on institutions (S_2) are found to yield greater efficiency gains in the long run, than the other simulations.

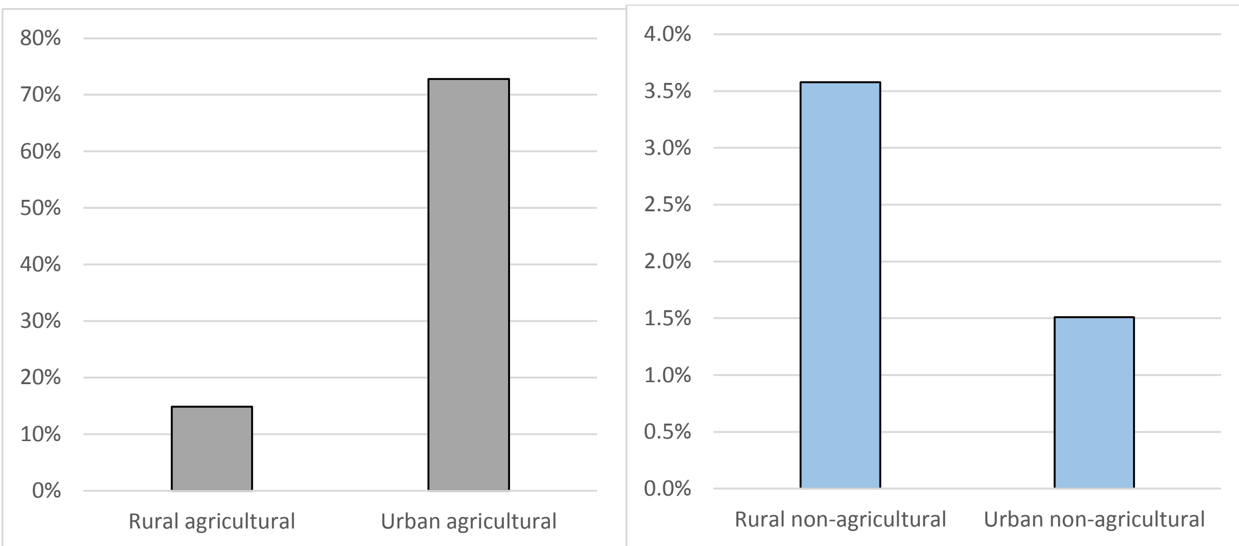
Figure IV.2: Poverty reduction per unit of government revenue loss for specific simulations



Source: The author

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 $({P_0}_{initial}{}^{h} - {P_0}_{2020}{}^{h})/{P_0}_{initial}{}^{h}$ to the specific amount of money they received. Figure IV.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 IV.3: Relative variation of poverty per billion transferred (average over the simulation period) for specific household groups



Source: The author

IV.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 over the period 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 simulates the macroeconomic impact of alternative government policies to protect households from the effects of catastrophic payment overshoot.

It also examines the ways in which policies affect health good prices, their consumption, productivity, and ultimately the level of poverty. 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 policies reducing the cost and promoting consumption of health goods have a significant and positive impact on the agricultural sector growth and important spillover effects on the rest of the economy. The simulations also show considerable productivity gains and poverty reducing effects resulting from policies protecting vulnerable households against large unpredictable financial costs of illness.

The various scenarios show that programs protecting against catastrophic out-of-pocket health expenses are workable options to reduce the long term impoverishing effects on vulnerable households. The potential returns in terms of reducing poverty and enhancing long term economic growth far outweigh related potential fiscal costs. The results highlight the need to have an efficient health care system that does not put the entire financial burden of health services on households, in particular in the case of major illnesses. The gains in terms of long term growth and progress in poverty reduction can be substantial. Subsidizing the provision of health goods and providing full coverage of catastrophic out-of-pocket health expenditures through uniform taxes on institutions can be cost effective policy options. The main target of such policies should be poor and more vulnerable groups, such as rural and urban agricultural households, who are the most affected by catastrophic out-of-pocket health expenditures.

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Appendix

Table IV.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^{t}_{c}	CET function share parameter
α^{va}_{a}	Efficiency parameter in the CES value-added function	δ^{va}_{fa}	CES value-added function share parameter for factor *f* in activity *a*

γ^{m}_{ch}

α_c^{ac}	Shift parameter for domestic commodity aggregation function		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* ∈ 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 IV.A2: Model equations

Production and price equations	
$QINT_{c\,a} = ica_{ca} \cdot QINTA_a$	(A1)
$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca}$	(A2)
$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(A3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot (1 - tva_a) \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot \left(\alpha_{f\,a}^{vaf} \cdot QF_{f\,a} \right)^{-\rho_a^{va}-1}$	(A4)
$QA_a = \alpha_a^{a} \cdot \left(\sum_{f \in F} \delta_a^{a} \cdot \left(QVA_a \right)^{-\rho_a^{va}} + (1 - \delta_a^{a}) \cdot \left(QINTA_a \right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(A5)
$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$	(A6)
$QXAC_{a\,c} = \theta_{a\,c} \cdot QA_a$	(A7)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(A8)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{\ -\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(A9)
$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}-1}$	(A10)
$PER_{c\,r} = pwer_{c\,r} \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icer_{c'c\,r}$	(A11)
$QE_c = \alpha_c^{e} \cdot \left(\sum_{r \in R} \delta_{c\,r}^{e} \cdot \left(QER_{c\,r} \right)^{-\rho_c^{e}} \right)^{-\frac{1}{\rho_c^{e}}}$	(A12)
$\frac{PER_{c\,r}}{PE_c} = QER_{c\,r} \cdot \left(\sum_{r' \in R} \delta_{c\,r'}^{e} \cdot \left(QER_{c\,r'} \right)^{-\rho_c^{e}} \right)^{-1} \cdot \delta_{c\,r}^{e} \cdot \left(QER_{c\,r} \right)^{-\rho_c^{e}-1}$	(A13)
$PE_c = pwe_c \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$	(A14)
$QX_c = \alpha_c^{t} \cdot \left(\delta_c^{t} \cdot QE_c^{\rho_c^{t}} + (1 - \delta_c^{t}) \cdot QD_c^{\rho_c^{t}} \right)^{\frac{1}{\rho_c^{t}}}$	(A15)
$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^{t}}{\delta_c^{t}} \right)^{\frac{1}{\rho_c^{t}-1}}$	(A16)
$QX_c = QD_c + QE_c$	(A17)

$$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c \tag{A18}$$

$$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c} \tag{A19}$$

$$PMR_{c\,r} = pwmr_{c\,r} \cdot \left(1 + tmr_{c\,r}\right) \cdot EXR - \sum_{c' \in CT} PQ_c \cdot icmr_{c'c\,r} \tag{A20}$$

$$QM_c = \alpha_c^m \cdot \left(\sum_{r \in R} \delta_{c\,r}^m \cdot \left(QMR_{c\,r}\right)^{-\rho_c^m} \right)^{-\frac{1}{\rho_c^m}} \tag{A21}$$

$$\frac{PMR_{c\,r}}{PM_c} = QMR_{c\,r} \cdot \left(\sum_{r' \in R'} \delta_{c\,r'}^m \cdot \left(QMR_{c\,r'}\right)^{-\rho_c^m} \right)^{-1} \cdot \delta_{c\,r}^m \cdot \left(QMR_{c\,r}\right)^{-\rho_c^m - 1} \tag{A22}$$

$$PM_c = pwm_c \cdot \left(1 + tm_c \right) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'\,c} \tag{A23}$$

$$QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + (1 - \delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}} \tag{A24}$$

$$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} \cdot \frac{\delta_c^q}{1 - \delta_c^q} \right)^{\frac{1}{1+\rho_c^q}} \tag{A25}$$

$$QQ_c = QD_c + QM_c \tag{A26}$$

$$PQ_c \cdot \left(1 - tq_c \right) \cdot QQ_c = PDD_c \cdot QD_c + PM_c \cdot QM_c \tag{A27}$$

$$QT_c = \sum_{c' \in C'} \left(icm_{c\,c'} \cdot QM_{c'} + icmr_{c\,c'} \cdot QMR_{c'} + ice_{c\,c'} \cdot QE_{c'} + icer_{c\,c'} \cdot QER_{c'} + icd_{c\,c'} \cdot QD_{c'} \right) \tag{A28}$$

$$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c \tag{A29}$$

$$DPI = \sum_{c \in C} PDS_c \cdot dwts_c \tag{A30}$$

Institutional incomes and domestic demand equations

$$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{f\,a} \cdot QF_{f\,a} \tag{A31}$$

$$YIF_{i\,f} = shif_{i\,f} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right] \tag{A32}$$

$$YI_i = \sum_{f \in F} YIF_{i\,f} + \sum_{i' \in INSDNG'} TRII_{i\,i'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR \tag{A33}$$

$$TRII_{i\,i'} = shii_{i\,i'} \cdot (1 - MPS_{i'}) \cdot (1 - \overline{tins}_{i'}) \cdot YI_{i'} \tag{A34}$$

$$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{i\,h} \right) \cdot \left(1 - MPS_h\right) \cdot (1 - \overline{tins}_h) \cdot YI_h \tag{A35}$$

$$PQ_c \cdot QH_{c\,h} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right) \tag{A36}$$

(See section IV.3.1 for health)

$$QINV_c = IADJ \cdot \overline{qinv}_c \tag{A37}$$

$$QG_c = \overline{GADJ} \cdot \overline{qg}_c \tag{A38}$$

$$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI} \tag{A39}$$

$$\begin{aligned} YG = & \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CMNR} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \\ & \sum_{r \in R} \sum_{c \in CMR} tmr_{cr} \cdot pwmr_{cr} \cdot QMR_{cr} \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR \end{aligned} \tag{A40}$$

System constraints and macroeconomic closures

$$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c \tag{A41}$$

$$\sum_{a \in A} QF_{f\,a} = QFS_f \tag{A42}$$

$$QFS_f \Big/ QFS_f^0 = \left(RWF_f \Big/ RWF_f^0 \right)^{etals_f} \tag{A43}$$

$$RWF_f = \left(\frac{YF_f}{QFS_f} \right) \Big/ \left(\frac{CPI}{CPI^0} \right) \tag{A44}$$

$$YG = EG + GSAV \tag{A45}$$

$$\begin{aligned} & \sum_{c \in CMNR} pwm_c \cdot QM_c + \sum_{r \in R} \sum_{c \in CMR} pwmr_{cr} \cdot QMR_{cr} \cdot \sum_{f \in F} trnsfr_{row\,f} \\ = & \sum_{c \in CENR} pwe_c \cdot QE_c + \sum_{r \in R} \sum_{c \in CER} pwer_{cr} \cdot QER_{cr} + \sum_{i \in INSD} trnsfr_{i\,row} + FSAV \end{aligned} \tag{A46}$$

$$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c \tag{A47}$$

$$MPS_i = \overline{mps}_i \cdot \left(1 + MPSADJ\right) \tag{A48}$$

Capital accumulation and allocation equations

$$AWF_{f\,t}^a = \sum_a \left[\left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot WF_{f\,t} \cdot WFDIST_{f\,a\,t} \right] \tag{A49}$$

$$\eta_{f\,a\,t}^a = \left(\frac{QF_{f\,a\,t}}{\sum_{a'} QF_{f\,a'\,t}} \right) \cdot \left(\beta^a \cdot \left(\frac{WF_{f,t} \cdot WFDIST_{f\,a\,t}}{AWF_{f\,t}^a} - 1 \right) + 1 \right) \tag{A50}$$

$$\Delta K_{f\,a\,t}^a = \eta_{f\,a\,t}^a \cdot \left(\frac{\sum_c PQ_{c\,t} \cdot QINV_{c\,t}}{PK_{f\,t}} \right) \tag{A51}$$

$$PK_{f\,t} = \sum_c PQ_{c\,t} \cdot \frac{QINV_{c\,t}}{\sum_{c'} QINV_{c'\,t}} \tag{A52}$$

$$QF_{f\,a\,t+1} = QF_{f\,a\,t} \cdot \left(1 + \frac{\Delta K^{a}_{f\,a\,t}}{QF_{f\,a\,t}} - \upsilon_f\right) \tag{A53}$$

$$QFS_{f\,t+1} = QFS_{f\,t} \cdot \left(1 + \frac{\sum_{a} \Delta K_{f\,a\,t}}{QFS_{f\,t}} - \upsilon_f\right) \tag{A54}$$

Productivity growth

$$\alpha_a^{va}(\mathrm{t}+1) = \alpha_a^{va}(\mathrm{t})\left(1 + \vartheta \sum_{h=1}^{G} \frac{\Delta\left(P_{health}(h,t)Q_{health}(h,t)\right)}{P_{health}(h,t)Q_{health}(h,t-1)} \left(\boldsymbol{H}_c^h(t)\right)^{(1-1_{[\Delta(PQ)>0]})}\left(1-\boldsymbol{H}_c^h(t)\right)^{1_{[\Delta(PQ)>0]}}\right) \tag{A55}$$

Note:

CET: Constant Elasticity of Transformation

CES: Constant Elasticity of Substitution

CPI: Consumer Price Index

FCU: Foreign Currency Unit

LCU: Local Currency Unit

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

Table IV.A3: Estimation of the elasticity of productivity with respect to health expenditures 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 (**Ψ**) : **ϑ**	0.111***	0.117***
	(0.0318)	(0.034)
Ψ 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

Notes:

The dependent variable is the output. The variables are in logarithm.

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

MMEL: Multilevel mixed-effects linear regression.

2SRI: Two-Stage Residual Inclusion.

2SLS: Two-Stage Least Square.

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.

"Ψ residual" represents the residual from this regression.

The regressions presented in Table IV.A3 are the logarithm transformations of the following production function:

$y = A \prod_{i=1}^{n} x_i^{\beta_i}$ With $\log A = \alpha_0 + \vartheta\, \Psi + \mu_0$, y is the output, x_i the traditional inputs and Ψ the health spending.

The exogenous shock $\mu(h, t_0)$ is calibrated using the sum of the residuals "Ψ 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).

Source: The author

Table IV.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''_2
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	46.71
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	39.58

Source: The author

Table IV.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 author

Chapter V

Identifying key sectors and key policies of a Pro Poor Growth strategy: A new approach

Authors

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V.1. Introduction

Africa is one of the most growing regions in the world, and in the 2000s six African countries were among the world ten fastest growing countries (AFD, 2012). However, despite this performance over the last decades, it is widely recognized that poverty is still persistent. Therefore, getting empirical evidence on growth-poverty linkages and analyzing the policy options could help the governments strengthen their ongoing poverty reduction agenda. There is timely research question to assess poverty-growth linkages in order to better understand and evaluate Pro Poor Growth (PPG) strategies. Devising Pro Poor Growth strategies demand the knowledge of both growth-poverty and policy-growth linkages. Hence, at a conventional level, we need to assess the patterns through which growth translates into poverty as well as the way policies generate growth.

Many studies have analyzed PPG through the comparison of growth-poverty linkages across the economic sectors (Diao et al., 2005; Christiaensen et al. 2006; Dorosh and Thurlow, 2014). However, most of the existing approaches have shortcomings in identifying key sectors as they only focus on the growth-poverty linkage by assuming exogenous growth and therefore ignoring the policy-growth side. Analogously, the existing studies that investigate key policies only assess the policy-growth linkages (Fan and Zhang, 2004; Benin et. al, 2009). Only very few studies assess the policy-poverty linkage in a reduced form, but without explicitly separating policy-growth and growth-poverty linkages and without focusing on a specific range of policy programs (Fan et al. 2000, Fan and Rosegrant, 2008).

Thus, deriving key sectors without integrating comprehensively the growth-poverty and the policy-growth linkages leads to partial and biased results. The cost issues to generate growth, and in turn poverty reduction have to be investigated.

The derivation of the policy-growth relationship can be found in Benin et al (2009). They estimated the effects of different types of public spending on agriculture, education, health and rural roads on agricultural productivity through a simultaneous equations modeling approach, using public expenditure data at district and regional level and household-level agriculture production data in Ghana. One of their results was that an increase in the public spending in the agricultural sector by 1% is associated with a 0.15 % increase in agricultural productivity, with a higher effect with development expenditures. Likewise, Dial et al. (2010) undertake CGE simulation to analyze agricultural growth and investment options for poverty reduction in Nigeria. They estimate the growth elasticity of public investments at 0.24 percent per year using historical data for spending and agricultural total factor productivity (TPF) growth and by assuming that there is a Cobb-Douglas type relationship between TPF and public investment. However, they do not analyze the impact of specific and disaggregated agriculture related policies.

Fan and Zhang (2004) focus on the impact of specific spending such as Research and Development (R&D), and Infrastructure on rural non-farm productivity and agricultural productivity in China. Similarly, Fan and Rosegrant (2008), based on the IFPRI's IMPACT model and poverty-growth elasticities estimated the average technical progress induced by the total budget expenditure for agricultural and non-agricultural policy programs. They considered the public investment drivers affecting agricultural growth, such as agricultural research, irrigation, and rural roads. However, these analyses did not estimate technical progress in specific subsectors, and did not explicitly integrate the composition of budget spending for different policy programs and the different policy options to mobilize resources.

The literature on the identification of key sectors shows different methodologies, stimulating too many discussions and wide debates about the most convenient approach to use. A large part of them seeks to rank sectors by distinguishing the activities that have important interdependence (backward and forward linkages)[37] with the rest of the economy using Social Accounting Matrix (SAM) framework or micro economic data (Rasmussen, 1956; Hirschman 1958; Haggblade, Hazel, and Brown 1989; Lenzen, 2003; Cai and Leung, 2004, Temurshoev and Oosterhaven, 2013). Another trend uses a General Equilibrium Approach (CGE) to integrate price and re-allocation effects in their linkage analyses (Byerlee, 1973; Bautista and Thomas, 1998). Likewise, using a Computable General Equilibrium (CGE) approach, more recent studies have compared economic sectors by examining the supply side multipliers that give the effects of sector-led productivity growth, especially in agriculture, on the economy and on household welfare (Diao et al 2005, Christiaensen et al. 2006, Dorosh and Thrulow, 2014).

This paper will also compare the Growth Poverty Multiplier (GPM) commonly used in the above mentioned papers and that incorporates a sector's economic linkages to poor households with a new concept of Poverty Growth Elasticity (PGE) we introduce. With this metric, the sector size criterion is additionally taken into account when identifying the key sectors. As pointed out by

[37] *Backward* linkages relate to the dependence of a given economic sector on inputs produced from other sectors. *Forward* linkages refer to the situation where the growth of a given sector leads to growth of the other sectors that use its output as input.

Diao et al. (2010) the size of the subsectors in the economy is among the factor to consider in designing an agricultural strategy and prioritizing growth. These two concepts (GPM and PGE) might lead to controversial results depending on how one weighs the initial contribution of the sectors to the economy (in terms of sector size) and their interdependencies with the rest of the economy among the criteria that determine key sectoral status. Fortunately, the controversial debate that might resurge from the calculations of the PGE and GPM concepts is not necessary as both of these concepts fail to inform about the required costs to achieve poverty reduction. The costs associated with the various investment options are far more critical to consider in weighing the various investment options needed to induce economic growth in the different economic sectors.

In this framework, we follow the literature and combine econometric approaches estimating policy-growth relation with modeling approaches of growth-poverty relation. Our Policy Impact Function (PIF) models the policy-growth linkage and brings valuable contribution to the literature in various ways. It allows the consideration of the cost issues for a straightforward identification of the key sectors by explicitly taking into account both their growth-poverty reduction potential and their responsiveness to government spending.

Besides, the estimation of the PIF includes all relevant agricultural policy instruments and non-agricultural spending in a set a sector specific nested two stage function. In fact, we not only disaggregate public spending in economic activities between Public Agricultural Expenditures (PAE) and Public Non-agricultural Expenditures (PNE), but also explicitly integrate different policy programs such as water and land management, farm management policies for food crops, animals or export crops, investments in road and storage related infrastructure, Research and Development and Extension services. Our PIF simultaneously assesses the impact of the different policy programs and therefore allows the integration of the complementary effects between those programs.

The policy-growth relationships expressed through the policy impact function are sector and subsector specific because optimal budget allocation into agricultural and non-agricultural policy programs might vary across the different economic sectors and the same budget allocation might translate into different effective budgets inducing different technical progress in different sectors. Besides, our approach allows for diminishing and increasing returns of investments while existing approaches assume constant return that could be unrealistic in the real world.

Based on our approach, we can identify the key sectors and key policies. Furthermore, we can use the policy impact function to derive optimal allocations to realize maximal achievements for given policy goals. The issue of optimal allocations has been often overlooked in most of the previous studies. Beyond identifying key sectors, the distribution of spending across subsector and sector specific policy programs can also influence the effectiveness of budget allocation and boost productivity, which, in turn, might generate significant results in terms of policy outcomes, especially poverty alleviation. This intra-sectoral allocation of public spending still remains an underexplored area of research. Improvement of budget allocation and better management practices are one of the pre-requisites to guarantee the success of development policies. An Effective budget allocation and an orientation of the budget toward the key sectors and key policy programs might be an appropriate tool for reducing poverty. For instance, in Africa, despite the fact that agriculture has a large share in employment, governments allocate little money to this sector, which should be intuitively a key component of development strategies given its linkage to poor households. In fact, the vast majority of African countries have generally failed to achieve the 10% budget allocation to agriculture as promoted by the Comprehensive African Agricultural Development Program (CAADP)[38].

Contrary to most of the previous studies that investigate the policy-growth linkage, our approach is applicable at country level and takes into account country specifities. The use of cross-country analyses might affect the estimations as pointed out in (Heady at al., 2009). In fact, because of the problem to get adequate time-series data to estimate country specific Policy Impact Function (PIF), they recommended to use additional information from expert data. Previous authors also warranted the need to use country specific survey data instead of cross-country regressions that might yield too much broad insights and do not integrate idiosyncratic factors. (See Palaniswamy and Birner 2006; Bezemer and Headey 2008).

Our approach to estimate the PIF combines in an innovative way empirical data on sectoral input and output, and country expert data collected in personal interviews. To do this, we apply a Bayesian alternative to Generalized Maximum Entropy and Generalized Cross Entropy (Heckelei et al., 2008) in order to estimate the PIF and link spending on both non-agricultural and agricultural

[38] An African leaders' collective vision, is set in order to promote agricultural-led growth. The member states of the African Union committed to achieve at least 6% growth in the Agriculture sector and to devote 10% of their national budgets to agriculture development.

policy programs within the CAADP to a set of political outcomes, including welfare of the population. The expert data are used to get prior information on the levels and the ranges of the parameters of the PIF.

Furthermore, we derive an integrated approach of policy-growth and growth-policy linkages by integrating the PIF into a Quasi-Dynamic Computable General Equilibrium (DCGE).

Finally, our approach can be directly linked with the political economy models explaining the role of political incentives and policy beliefs (knowledge) of government investing in agriculture and non-agriculture sectors.

The rest of the paper is organized as follows. Section V.2 introduces the theoretical framework of this paper. Section V.3 presents the methodological framework that basically relies on the integrated PIF-CGE approach. In Section V.4, we present the estimation strategy and the econometric models with an application to Senegal. Section V.5 discusses the results.

V.2. Defining the key sectors and key policies: a theoretical framework

The logic of our Policy Impact Function is underlined in Figure V.1. The latter illustrates the way different options of policy interventions like those within the CAADP translate in terms of achievement of different policy outcomes like poverty reduction (Z_2), farm income (Z_1), provision of public goods (Z_3), urban consumer income (Z_5), welfare of the export sector (Z_4), welfare of the indusry sector (Z_6) and sustainability (Z_7).

These policy programs intervene in both the agricultural and the non-agricultural sector. They can be categorized into policy programs promoting technical progress, such as intervention related to natural resource (land and water policies), human resource (extension services and Research and Development) and farm management (improved access to fertilizer, pesticides, and higher quality seeds), and policy related to market access such as investment in roads and storage infrastructure. Policy programs might impact differently growth in the different sectors, which, in turn, might induce different levels of poverty reduction or achievements in other policy outcomes.

Let us denote by Z_k the achieved political outcome (For example the poverty reduction level Z_2) and w_s the growth rate of a sector s. Be is the amount of budget expenditure used to promote growth. We can formalize the poverty-growth linkage and the policy-growth linkage in the following manner.

Z_k = CGE(w_s) (1) and w_s= PIF(Be) (2)

Based on this framework, a key sector is a sector for which additional budget investment induces high poverty reduction. This implies that key sectors are characterized by the following properties: high growth-policies linkages and efficient policy-growth relations. Formally, we define key sectors as sectors for which additional budget investment is the most effective regarding poverty reduction. Thus, formally it follows:

$$\frac{\partial Z_k}{\partial Be} = \frac{\partial CGE}{\partial w_s} \cdot \frac{\partial PIF}{\partial Be} \qquad (3)$$

The resulting metric $(\frac{\partial Z_k}{\partial Be}, k = 2)$ is called PPG-elasticity. Obviously, the PPG elasticity is separated into independent partial derivatives. The first term is the marginal growth impact corresponding to Growth Poverty Elasticity (GPE), and the second term is the marginal productivity denoted by MBP.

According to our framework, assessing the key sectors using only CGE elasticities (Diao et al., 2005; Christiaensen et al. 2006; Dorosh and Thurlow, 2014) is incomplete and may lead to biased results because it fails to integrate the policy-growth linkages. For example, let us consider a sector like telecommunication in Senegal, which has a high technical progress (t.p.) and which is also related to the poor, e.g. has high CGE-elasticities.[39] But, assume like it is in fact the case for Senegal that this sector has already reached his t.p. potentials, e.g. cannot, or only slightly be improved via policy programs. This implies that state budget investments in promoting t.p. in this sector have a very low productivity. Given all this, our comprehensive analysis will not identify this sector as being a key while traditional approaches will wrongfully do.

The above framework and the provided illustration demonstrate the shortcomings of existing approaches and the usefulness of our new approach.

Similarly, key policies for poverty reduction are policies that are efficient in reducing poverty. More precisely, they are policies that are efficient in producing technical progress in sectors that lead to a high poverty reduction. Formally, we have

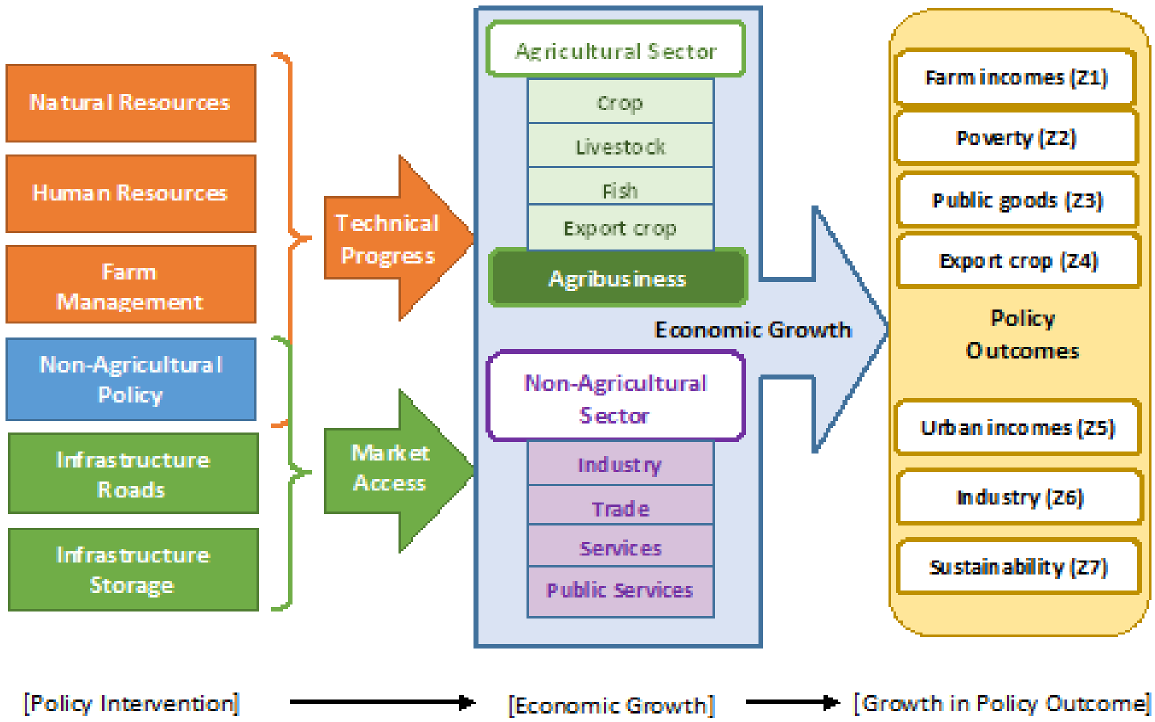
$$\text{PPG}(\gamma_p) = \sum_s \frac{\partial CGE}{\partial w_s} \cdot \frac{\partial PIF}{\partial \gamma_p} \qquad (4)$$

Following our framework, finding the most effective Pro Poor Growth strategies requires firstly the identification of key economic sectors that when leading growth have the highest impacts on

[39] Growth in the Telecommunication sector induces favorable consumer price change for all the households. This is in relation with the fact that Telecommunications is the only sector among private services for whom products have relatively an important budget share in the consumption structure of all the households, even those in rural areas.

the income of the poor households. Secondly, it requires to identify the key policy programs that are likely to induce economic growth at a minimal cost by investing a minimal amount of budget.

Figure V.1: Intervention logic of the policy programs



Source: Authors

V.3. Methodological approach: an integrated PIF-CGE approach

V.3.A. The concepts of CGE-elasticity

The Poverty Growth Elasticity (PGE) is defined and calculated to assess the impact of total factor productivity growth in the different economic sectors on the policy concerns, Z_k ; $k = 1,2, \ldots, 7$, reminded below. This metric is the linear growth rate for the seven policy concerns induced by an increase of the technical progress in each single sector s from 1% in the base run scenario to 10 % in the different simulations (*sim).*

$$\Delta_{tp_s} = \Delta_{tp_s}^{sim} - \Delta_{tp_s}^{Base} = 10\% - 1\% \qquad (5)$$

$$\xi_{z_k s}^{CGE} = (\frac{Z_{kt}^{sim} - Z_{kt}^{base}}{Z_{k0}^{base}}) \frac{1}{t\, \Delta_{tp_s}} \qquad (6)$$

Z_1= Real net-income of small-scale farmer households

Z_2= Normalized poverty measure overshoot from the poverty line

Micro simulation modules can be used to assess impacts on poverty. In our application on Senegal data, the micro simulation module is calibrated to Poverty Monitoring Surveys. Endogenous changes in consumption resulting from the CGE model are passed down to the household by mapping each of the household in the micro simulation model to the corresponding household in the CGE[40]. We used a non-parametric micro simulation where the calculated poverty indexes are the Foster-Greer-Thorbecke (FGT) family of poverty measures.

$$FGT = \frac{1}{N} \sum_{i=1} \left(\frac{z-y_i}{z}\right)^{\alpha} .\ I(y_i \leq z) \qquad (7)$$

For $\alpha = 0$ the FGT index collapses to the headcount ratio P_0 and $\alpha = 1$ gives the poverty gap index (P_1) that measures the extent to which individuals are poor.

The poverty reduction concern Z_2 is measured as $100\ (1 - P_1)$.

Z_3= Public goods, e.g. total state revenue subtracted by CAADP budget and transfers

Z_4= Sum of total GDP generated in the export sector

Z_5= Real net-income of urban consumer households

Z_6= Sum of total GDP generated in industry sector

Z_7= Negative of the sum of total purchased input payments per hectare of agricultural land

The PGE concept informs on how an increase of a sector's output by 1 percent (e.g. from investment to raise productivity) impacts on poverty reduction while the CGE-multiplier relies on an absolute unit increase. The corresponding Growth Poverty Multiplier (GPM) controls for the size of the sector being shocked and by normalizing the PGE by an index of sector size.

V.3.B. The two-stage Policy Impact Function

The Policy Impact Function is a political technology $PIF^s(Z, \gamma)$ that translates policy programs γ into policy outcomes (the concerns Z_k).

[40] See (Colombo, 2010) for explanation of survey data and CGE model linkages.

In fact, in order to capture the importance of different policy programs $\gamma \in$ P (set of policies) on technical progress realized in a specific sector s, a two-stage policy impact functions PIF^{s} (γ) are defined for each sector s as follows:

$$tp_s = \overline{tp}_s \frac{exp(ex.a_s Bud_s^{eff} - ex.b_s)}{1 + exp(ex.a_s Bud_s^{eff} - ex.b_s)} \quad (8)$$

$$Bud_s^{eff} = \omega_s \left[\sum_p \mu_{sp} \ (\gamma_p)^{-\rho^{IF}}\right]^{-1/\rho^{IF}} \quad (9)$$

Equation (9) transforms budget allocation into effective budget allocation following a Constant Elasticity of Substitution (CES) specification. In equation (8) effective budget is transformed into technical progress using a logistic function where $\overline{tp}_s$ represents the maximal technical progress that can be achieved via governmental policies. The marginal impacts of additional effective budget spending are diminishing and approximate zero for a sufficient large effective budget.

The shifter parameter ω_s is accordingly normalized such as with an optimal budget allocation; the effective budget equals the total budget (Be), $Bud_s^{eff}(\gamma) = Be(\gamma) = \sum_p \gamma_p$, and is lower for any non-optimal budget allocation.

Assuming growth through technical progress, the overall poverty-growth linkage can be linearly approximated as follows.

Where $w_{z_k} = \sum_s \xi_{z_k s}^{CGE} \ (tp_s - tp_s^0) + w_{z_k}^0$ (10)

Where $\xi_{z_k s}^{CGE}$ represents the Poverty Growth Elasticities (PGEs) and w_{z_k} is the induced growth rate of the different policy concerns, including poverty reduction for $k = 2$.

$w_{z_k}^0$ is the growth rate of the policy concerns Z_k at the baseline scenario, e.g. simulation of the current path of the economy and tp_s^0 is technical progress at the base. In our case study $\xi_{z_k s}^{CGE}$ and w_z^0 are computed using simulations from the dynamic extension of the standard model developed by the International Food Policy Research Institute (IFPRI) (see Lofgren 2002 and Thurlow, 2004). The CGE model is calibrated by using the 2011 agricultural and regional Social Accounting Matrix (SAM) that we have built for Senegal.

tp_s is the technical progress in the sector s generated as expressed in equation (8).

Futhermore, we can analyze the effectiveness of the different CAADP policy programs by deriving the marginal impacts on poverty reduction (Z_2) for each policy program to understand how policies translate into outcomes. This corresponds to the marginal decrease in poverty that would be achieved if the budget expenditure within a specific policy program is increased by one unit. They are derived as follows.

$$\text{PPG}(\gamma_p) = \sum_s \xi_{Z_2\,s}^{CGE} \frac{\partial tp_s}{\partial \gamma_p} \qquad (11)$$

With

$$\frac{\partial tp_s}{\partial \gamma_p} = \overline{tp}_s\ ex.a_s \frac{\exp(ex.a_s Bud_s^{eff} - ex.b_s)}{(1+\exp(ex.a_s Bud_s^{eff} - ex.b_s))^2} \frac{\partial Bud_s^{eff}}{\partial \gamma_p} = ex.a_s\ tp_s \left(1 - {tp_s}/{\overline{tp}_s}\right) \frac{\partial Bud_s^{eff}}{\partial \gamma_p} \qquad (12)$$

Thus the marginal impact of γ_p is

$$\frac{\partial tp_s}{\partial \gamma_p} = ex.a_s\ tp_s \left(1 - {tp_s}/{\overline{tp}_s}\right) \mu_{sp} \left[\frac{Bud_s^{eff}}{\gamma_p}\right]^{1+\rho^{IF}} \omega_s^{-\rho^{IF}} \qquad (13)$$

Thus, with our modelling framework, it is also possible to estimate the key policies that achieve the highest technical progress in sectors where growth generates the highest outcomes, focusing especially on poverty reduction. This derivation of key policies can provide guidance to decision makers for evidence-based decisions in order to efficiently define policies. Politicians generally fail to fully understand the relationship between political instruments and desired policy outcomes.

V.4. Empirical application for Senegal

V.4.A. Estimation strategy and econometric models

i. Estimation of Technical progress

Technical progress in all its aspects is hard to measure precisely, but its essential quantitative characteristic is to shift the production function enabling greater output to be produced with the same volume of inputs, or the same output with lesser inputs (Kennedy and Thirlwal, 1972). Prior to the estimation of the policy impact function, we applied the standard neo-classical growth accounting exercise to break down the output growth in production factor growth and growth of Total Factor Productivity (TFP) that corresponds to the rate of technical progress in the different mesosectors (Solow, 1956; Solow, 1957). Assuming the special case of a neutral technical change, e.g. marginal rates of substitution untouched, the following production function is assumed for each of the sectors.

$Y_t = A_t \text{ f } (N_t, K_t, L_t)$, where A_t represents the Total Factor Productivity (TFP), N_t the labor force, K_t the capital stock and L_t the quantity of land only specified for the agricultural sectors. Furthermore, considering the Cobb-Douglas functional form $\text{f } (N_t, K_t, L_t) = {N_t}^{\alpha} {K_t}^{\beta} {L_t}^{\delta}$ and differentiating totally the log-transformation with respect to time gives the following expression.

$$\frac{\dot{Y}}{Y} = \frac{\dot{A}}{A} + \alpha \frac{\dot{N}}{N} + \beta \frac{\dot{K}}{K} + \delta \frac{\dot{L}}{L}, \alpha + \beta + \delta = 1 \qquad (14)$$

The Total Factor Productivity growth $\frac{\dot{A}}{A}$ can be estimated using the equation (14) as the difference between output growth and a weighted sum of factor growths with weights equal to the factor shares.

The Solow residual $\frac{\dot{A}}{A}$ might not measure only technical change, especially if the neoclassical assumptions do not hold. But despite potential shortcomings, it has been proven that the TFP growth computed from the above framework is highly correlated to the most sophisticated indexes that control measurement errors and market imperfections (Basu and Fernald, 1997). Furthermore, the trend of TFP growth is estimated by applying the Hodrick-Prescott (HP) filter to the raw TPF series in order to control cyclical fluctuations. In fact, Total Factor Productivity Growth highly moves pro-cyclically e.g. tends to move in the same direction as the output. This filter has been used in many studies (Blackburn and Ravn, 1992, Kydland and Prescott, 1990; Baxter and King, 1999; Ravn and Uhlig, 2002), despite being subject to some criticisms (Söderlind, 1994; Cogley and Nason, 1995). The Hodrick-Prescott framework will decompose the TFP growth $T_t = \frac{\dot{A}}{A}$ in the sum of a trend component g_t and a cyclical component c_t.

The filter is defined as the solution to the following optimization problem.

$$\min_{g_t} \sum_{t=1}^{T} {c_t}^2 + \lambda ((g_{t+1} - g_t) - (g_t - g_{t-1}))^2 \qquad (15)$$

λ is the smoothing parameter that the researchers typically set to 1600 when using quarterly data, but different values have been applied for other frequencies. For our annual data we follow Cooley and Ohanian (1991), and Correia, Neves and Rebelo (1992) by setting a value of 400; Backus and Kehoe (1992) set the parameter to 100, Baxter and King (1999) used a value of 10 while Ravn and Uhlig (2002) suggest setting it to 6.5 The larger is the value; the smoother is the estimated trend, the solution being the least squares fit of a linear trend model for λ approaching infinity (Hodrick-Prescott, 1997). Derivation of the solution to the optimization problem is provided in the appendix

V. A.1 and detailed information on the background of the Hodrick-Prescott (HP) filter can be found in Hodrick-Prescott (1997) and King and Rebelo (1989).

ii. PIF's Estimation

While standard econometric methods will not be appropriate in our case given the large number of parameters, the estimation is possible by applying the Bayesian alternative to the generalized cross entropy (Hecklei, Mittelhammer and Janson, 2008).

We estimate the PIF using empirical budget data on Public Agricultural Expenditures (PAE) and Public Non-agricultural Expenditures (PNE). Prior information from political expert survey data will help to get prior information on the level of the PIF-parameters. We also use these collected data on experts' view in order to define boundaries for the parameters assuming a 95% confidence intervals.

The Bayesian alternative to entropy methods is described below.

As a reminder, a classical entropy method can be formulated as follows:

$\hat{\varphi}$ = argmax v(φ) s.t . g(φ) $= 0$ (16)

Where v(φ) is the entropy metric and g(φ) $= 0$ corresponds to M equations of K unknown parameters φ $(K > M)$ defining admissible values of the parameter of interest φ.

Heckelei et al. approach's is an alternative to entropy methods for deriving solutions to an undetermined system of equations, by taking the additional prior information and setting a useful and defensible choice of the extremum metric $v(\varphi)$.

$v(\varphi) = P(\varphi) = \prod_{k=1}^{K} p_i(\varphi_i)$ (17)

In their approach, the combination of the prior and the dichotomous likelihood I_ψ (narrowing the feasible space of solutions) gives the posterior density.

$h(\varphi) \propto P(\varphi)\, I_\psi$ (18)

The maximization of $h(\varphi)$ gives the highest posterior density (HPD) estimates of φ.

Following this, our optimization problem for our parameters can be specified as follows:

$\max_{\chi,\epsilon} V(\chi)\prod_{i,p} p_e\,(\epsilon_{ip})$ s.t. PIF(χ) $+ \varepsilon = 0$ (19)

where χ represents the vector of parameters of the PIF, V(χ) the associated prior distribution and $p_e\,(\epsilon_{ip})$ distribution of the error terms. We assume that individual parameters are normally distributed V(χ) ~ N (χ_0, Σ).

The HDP is then given by:

$$\min_{\substack{s.t.\\ \text{PIF}(\chi)+\varepsilon=0 \\ res(\chi)=0}} \quad (\text{Vec}(\chi) - Vec(\chi_0))' \, \Sigma^{-1} (\text{Vec}(\chi) - Vec(\chi_0)) \qquad (20)$$

$res(\chi)$ represents additional restrictions on the parameters and integrates the policy beliefs of politicians and stakeholders translating specific ideas on how policies generate technical progress.

V.4.B. Empirical data

The PIF is estimated using budget data, expert survey data and estimated empirical data on technical progress (plotted in Figure V.A.1 for some selected sectors).

- Production data

Sector input (labor and capital) and output data used to estimate t.p. in the different sectors are mainly from the National Agency of Statistics (ANSD) while land data are from the DAPSA. These data generally cover the period 1980-2009.

- Expert data

Expert surveys were conducted on policy goals and preferred policy positions of policy makers and stakeholders. From the data, we derive the relative interests (X_k) of political actors and organizations on the different policy goals, the desired target for achieving the goals (Z_k) and preferred policy positions that correspond to their own appropriate allocations to different policy programs (γ_p) and sub-programs under the CAADP agenda. In Senegal, the different policy programs formulated under CAADP are: water (γ_1) and land (γ_2) management, farm management policies for food crops (γ_3), animals (γ_4) and export crops (γ_5), investments in road (γ_6) and storage related infrastructure (γ_7), Research and development (γ_8) and Extension services (γ_9), and investments in the non-agricultural sector (γ_{10}). These policy programs are used in our empirical application.

The interviews were conducted among the stakeholder groups and policy makers. For each specific policy area, the respondents are considered as experts for the organization representing that area. Targeted organizations were carefully selected using a list of potentially relevant organizations compiled based on desk research and expert interviews. Based on this initial list and by using a snowball sampling method, personal interviews were conducted with the representatives of the preselected organizations. Interviewers were asked to identify all the influential organizations on the provided list or suggest the new ones. The suggested organizations that were not initially included to the list were added on the list when they are nominated more than three times. In total, we have 15 governmental organizations and 31 non-governmental organizations. These non-governmental organizations includes 7 donors, 10 research organizations, 4 civil society groups and 8 socioeconomic interest groups (2 farmer and 6 agribusiness interest groups).

- Social Accounting Matrix

The constructed Senegalese 2011 agricultural SAM is mainly based on the 2011 Supply-Use table and trade data provided by the National Agency of Statistics. The breakdown of the agricultural sector is done using information from the most recent household poverty monitoring survey (ESPS) and agricultural surveys conducted by the DAPSA[41] and the Senegalese Institute for Agricultural Research (ISRA). Other data comes mainly from the balance of payments which records the transactions among the residents and the rest of the world and the Table of Government Financial Operation (TOFE) from DPEE[42] which tracks tax and non-tax revenue of the government, as well as budget expenditures including transfers. The SAM has been built in a perspective to construct and calibrate a dynamic CGE model used to derive the multipliers, as stated above. A social accounting matrix is a comprehensive, economy wide data framework that provides a coherent presentation of the production activities, incomes, investments and the other transaction flows among the economic agents (sectors, government, household and the rest of the world). The CGE model used in our integrated PIF-CGE approach is calibrated with the SAM and includes 43 sectors with the crop production sectors desegregated by regions.

- Micro-simulation data

The Senegalese 2011 household poverty monitoring survey is used for poverty assessment in the microsimulation model. It is a random sample survey at the national level that uses a two-stage cluster sampling method with stratification in the first stage (the statistical units of the first stage are districts while the secondary units are households drawn from the district in the first stage. The overall survey sample covers 17,891 households with 5953 households receiving the questionnaire on expenditures.

[41] *Direction* de l'Analyse, de la Prévision et des Statistiques Agricoles

[42] Direction de la prévision et des études économiques

- Budget data

Data on budget are from the Statistics of Public Expenditure for Economic Development (SPEED) compiled by IFPRI. For Senegal the budget data used in the estimations cover the period 1980-2009 (See Figure V.A.7 in the appendix).

V.5. Results

V.5.A. Estimation results

Table V.1 presents the prior parameters and estimated parameters of the policy impact function. A PIF is estimated for the different sectors of the Senegalese economy. For food crop and export crop sectors, the same t.p. is estimated for all the corresponding subsectors. Please not the given the large number of sectors and results only aggregated values of the parameters over the megasectors are presented.

Table V.1: Estimated parameters of the PIF (aggregation over the megasectors)

						μ_{sp}						ω_s	ρ^{IF}	$ex.a_s$	$ex.b_s$	$\overline{\overline{tp}}_s$
MESOSECTORS	Parameters	water	land	pr-crop	pr-animal	pr-export	Inf-road	inf-storage	Research_Dev	Extension	Non-agr	normalisation	rho			
		(γ_1)	(γ_2)	(γ_3)	(γ_4)	(γ_5)	(γ_6)	(γ_7)	(γ_8)	(γ_9)	(γ_{10})					
FOOD CROPS	Est.	0.112	0.131	0.211	0.000	0.000	0.217	0.041	0.069	0.106	0.113	2.987	-0.500	0.072	-4.564	11.023
	Prior	0.094	0.107	0.138	0.000	0.000	0.249	0.050	0.089	0.131	0.139	6.440	-0.500	0.026	-4.265	8.330
EXPORT CROPS	Est.	0.088	0.088	0.104	0.000	0.096	0.268	0.060	0.124	0.068	0.104	1.124	-0.500	0.009	-0.665	4.319
	Prior	0.075	0.064	0.000	0.000	0.138	0.249	0.100	0.178	0.079	0.111	6.330	-0.500	0.010	-0.969	10.000
LIVESTOCK	Est.	0.368	0.048	0.000	0.208	0.000	0.016	0.096	0.024	0.136	0.104	0.412	-0.500	0.006	-0.379	0.629
	Prior	0.247	0.052	0.000	0.202	0.000	0.018	0.121	0.040	0.177	0.144	5.477	-0.500	0.024	-3.628	4.855
FISH	Est.	0.000	0.000	0.000	0.176	0.000	0.112	0.320	0.168	0.168	0.056	0.135	-0.500	0.006	-0.307	0.066
	Prior	0.000	0.000	0.000	0.170	0.000	0.109	0.301	0.159	0.159	0.096	4.854	-0.500	0.045	-2.765	0.719
AGRIBUSINESS	Est.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.125	-0.500	0.014	-1.223	1.431
	Prior	0.000	0.000	0.000	0.000	0.000	0.160	0.286	0.068	0.416	0.070	4.279	-0.500	0.018	-5.516	3.262
INDUSTRY	Est.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	2.729	-0.500	0.014	-2.499	6.069
	Prior	0.000	0.000	0.000	0.000	0.000	0.051	0.297	0.049	0.359	0.243	3.902	-0.500	0.009	-4.570	5.173
SERVICES	Est.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	1.804	-0.500	0.016	-4.405	3.415
	Prior	0.000	0.000	0.000	0.000	0.000	0.051	0.671	0.011	0.038	0.228	2.888	-0.500	0.014	-5.307	5.199
PUBLIC SERV.	Est.	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.000	0.878	-0.500	0.020	-4.773	0.477
	Prior	0.000	0.000	0.000	0.000	0.000	0.051	0.488	0.011	0.038	0.411	2.197	-0.500	0.040	-10.694	1.465

Source: Authors

V.5.B. Key sectors

i. Poverty Growth Elasticities (PGE) and Growth Poverty Multipliers (GPM)

As said earlier, some recent works have used the CGE framework in order to run simulations that compare the poverty-growth linkage across sectors. We follow the trend of the literature, but turn our attention to the fact that these methods are limited because they might lead to controversy without integrating the cost issues.

The results show that PGE's vary significantly across subsectors. As can be seen in Figure V.3, within agriculture, relatively high PGEs are observed for millet and peanut, the main export crop, while for fruits and roots we have low PGEs. Analogously, in agribusiness a high PGE of 0.019 is found only for food processing, while PGEs are extremely low for all other agribusiness sectors (Figure V.2).

Figure V.2 shows that the highest PGE's are found for the market service sectors, namely trading (0.058), followed by telecommunication (0.042). This implies that technical progress realized in these sectors reduces poverty more than in the livestock or the food processing sector. Technical progress in the Trade sector reduces transaction costs and leads to an improved market access.

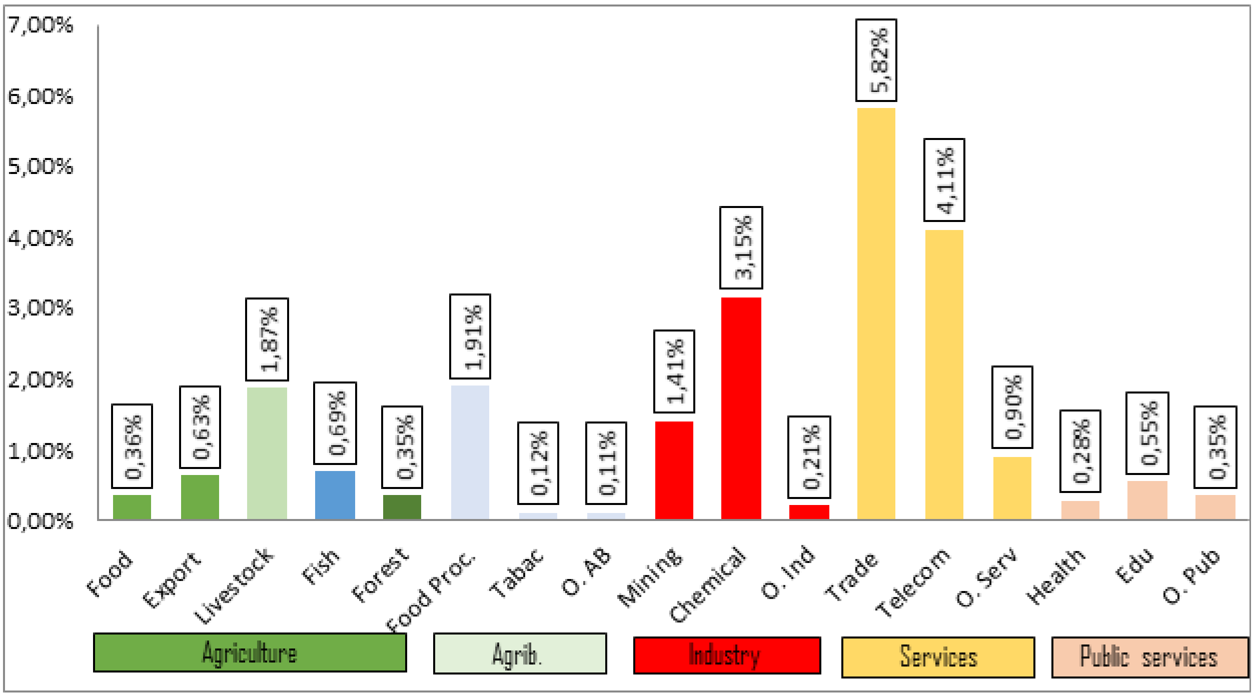
Within industrial sectors, a comparatively high PGE is observed only for chemical manufacturing with a value of 0.031, followed by mining with a PGE of 0.014, while for all other industries as well as for all public service sectors we found rather low PGEs (below 0.006).

The observed growth implies changes in price and income that occur together. The effect on household real income depends on the magnitude of changes in prices and nominal income. Therefore, both price and income need to be analyzed to interpret the variations of household real income.

To better understand these changes, there is a need to conduct the analysis at a detailed level as the effect might vary depending on the household characteristics. In fact, productivity shock in one sector might have differentiated effects across household groups and the same household might be affected differently by a given growth profile.

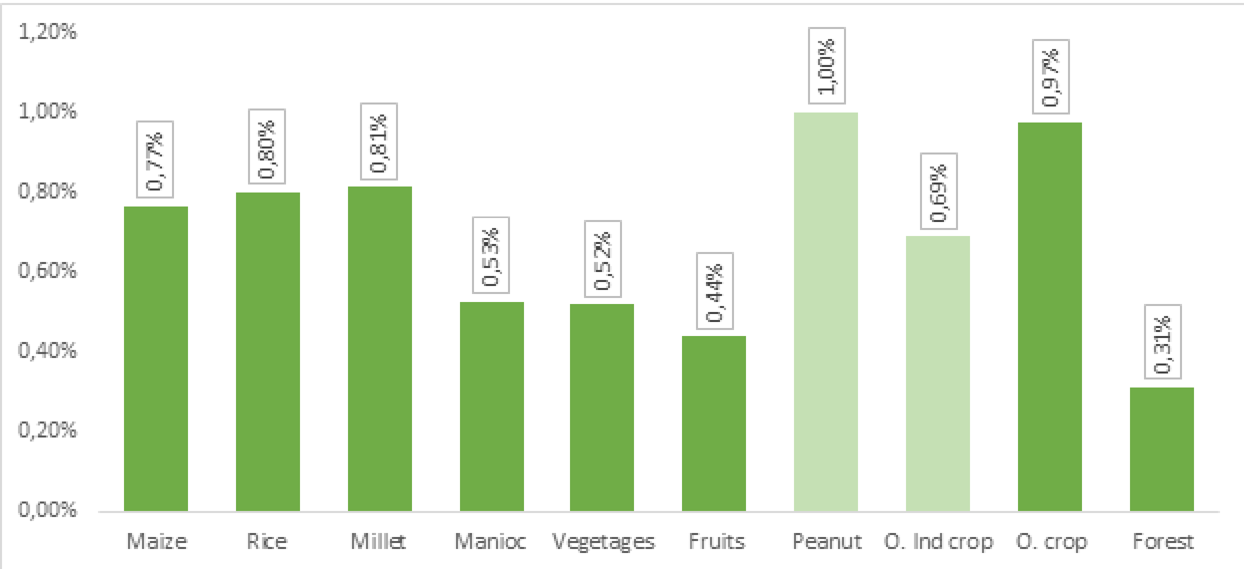
As can be seen from Figure V.A.2 in the appendix, results indicate that the largest part of welfare variation comes from the income effect for both rural and urban households (see the appendix for the welfare decomposition). Therefore, the income variation is informative enough to assess the impact on household welfare as it is the important determinant of the impacts of the different growth profiles.

Figure V.2: PGE by sectors



Source: Authors

Figure V.3: PGE by agricultural subsectors



Source: Authors

Following growth led by technical progress in each single sector s, the importance of the income effect in the multiplier for a given household type will depend on the propensity of the sector to use a given factor f and on the share of this factor income distributed to the household.

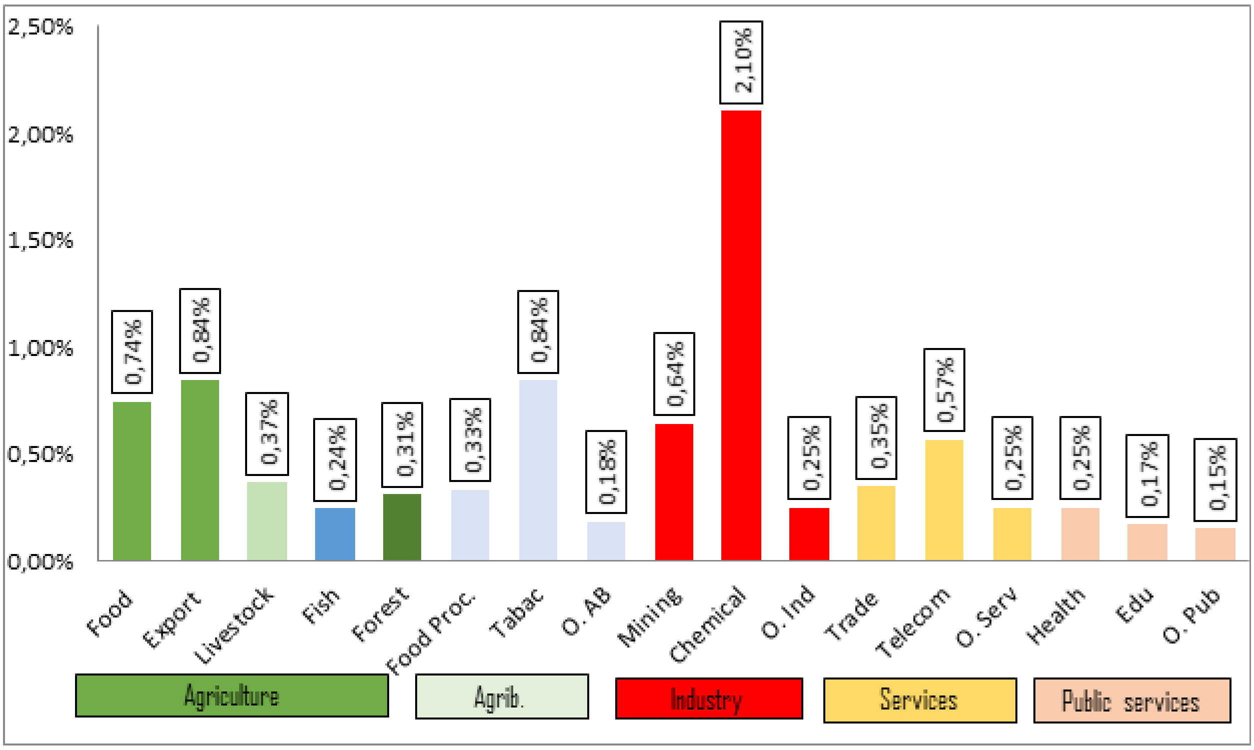
The importance of the price effect for households depends on the weight of goods produced by the driving sector in the composition of the households' consumption basket.

While PGE's of non-agricultural sectors are clearly dominated by income effects, significant price effects can also be observed for agriculture. However, the higher income effect of non-agricultural sectors, even for rural poor households, appears surprising at a first glance. Especially, earlier studies highlight the fact that the majority of poor households are constituted by rural farm households which earn their main income from agriculture. Accordingly, economic growth in agriculture has a higher impact on the income of the poor when compared to non-agriculture (see for example Chistiaensen and Demery, 2007; World Bank 2007; Diao et al. 2012 or Dorosh and Thurlow 2014). However, these studies analyze the growth-poverty linkage applying a multiplier concept. Compared to our PGE analysis, Growth-Poverty-Multipliers (GPM) analyze the impact of a "normalized" economic growth shock induced in a specific sector on the reduction of poverty, as previously mentioned.

Accordingly, identified key sectors of PPG (pro poor growth) may significantly differ depending on the concept applied. For example, Figures V.4 and V.5 present Growth-Poverty impacts of sectors measured by their corresponding GPM derived from calculated PGE's via dividing by an index of sectoral shares in GDP. As can be seen from these figures, agricultural sectors tend to have in average a higher impact on poverty reduction applying a multiplier (GPM) concept, while non-agricultural sectors are relatively more pro-poor compared to agricultural sectors applying an elasticity (PGE) concept, i.e. taking the sector size explicitly into account.

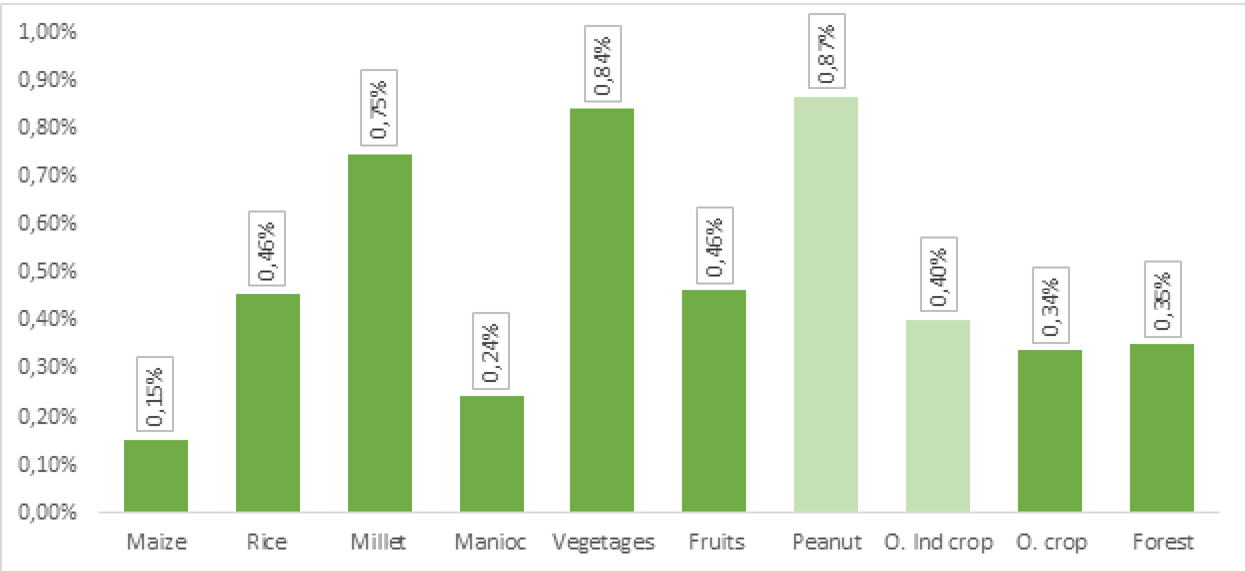
In particular, telecommunication and trading have significantly higher PGE-values while corresponding GPM-values are higher for agriculture. Moreover, within agriculture, livestock appears more pro poor when compared to both stable and export crops based on PGE-values, respectively, while GPM-values are significantly higher for food and export crops compared to livestock.

Figure V.4: GPM by sectors



Source: Authors

Figure V.5: GPM by agricultural subsectors



Source: Authors

Please note that for Senegal as in most African countries, agriculture has a much higher direct link to rural and urban poor households via factor markets, since both poor household types are mainly employed in the farm sector, as well as via commodities markets since poor households spend the largest share of their income on food. Moreover, following Thorbecke and Jung (1994) decomposing the income effect further into direct and indirect factor market effects as well as indirect loop effects reveals that, at least for the Senegalese economy, for all sectors main growth effects on income of the poor operate via factor markets. Accordingly, given the significant dependence of poor households on agriculture, agriculture appears as a natural key sector. Nevertheless, applying the PGE that considers the economic size of a sector still has a larger impacts for non-agriculture, especially trade for which t.p. reduces transaction costs, telecommunication, and chemistry. Quite straightforward explanations could be obtained by looking at their weight in the economy. Trade and telecommunication account respectively, for 16.7 and 7.3 percent of the Senegalese GDP (see Table V.A.1 in the appendix). In particular, regressing sectoral PGE's on GDP-shares reveals that a large part of the variance in PGE can be explained by sector size only (See V.A.3 in the appendix). Beyond the value addition share, the magnitude of PGE depends also on many other factors, albeit correlated with the sector size. Figure V.A.3 in the appendix plots the correlations between the PGE and the export orientation of sectors, the inter-sectoral linkages, namely backward and forward linkages, the import propensity, employment share and value added share. We found evidence of correlation between welfare concerns and the value added share, the employment share, the export share, the forward linkages. There are additional channels that might enter into consideration such as the initial productivity level of sectors, wages through the stimulation of the demand, sectors related sale and activity tax payments, sector's contribution to the overall saving etc.

ii. Pro Poor Growth Elasticities (PPG)

One strength of the analyses is that productivity shift will be endogenized and no technological progress is assumed to fall from the sky, as commonly done in the existing literature. As mentioned, unlike the widespread method of considering the exogenous technological technical progress, the PIF will show the way in which government spending on policy programs will generate technological progress, which in turn will determine the different policy concerns, including income growth and poverty reduction, based on the multiplier $\xi_{z_k s}^{CGE}$. The key policy question is not only to identify the sectors with the highest responsiveness of poverty to growth, but also to see to what extent it is easy to stimulate growth in the different sectors through public investments.

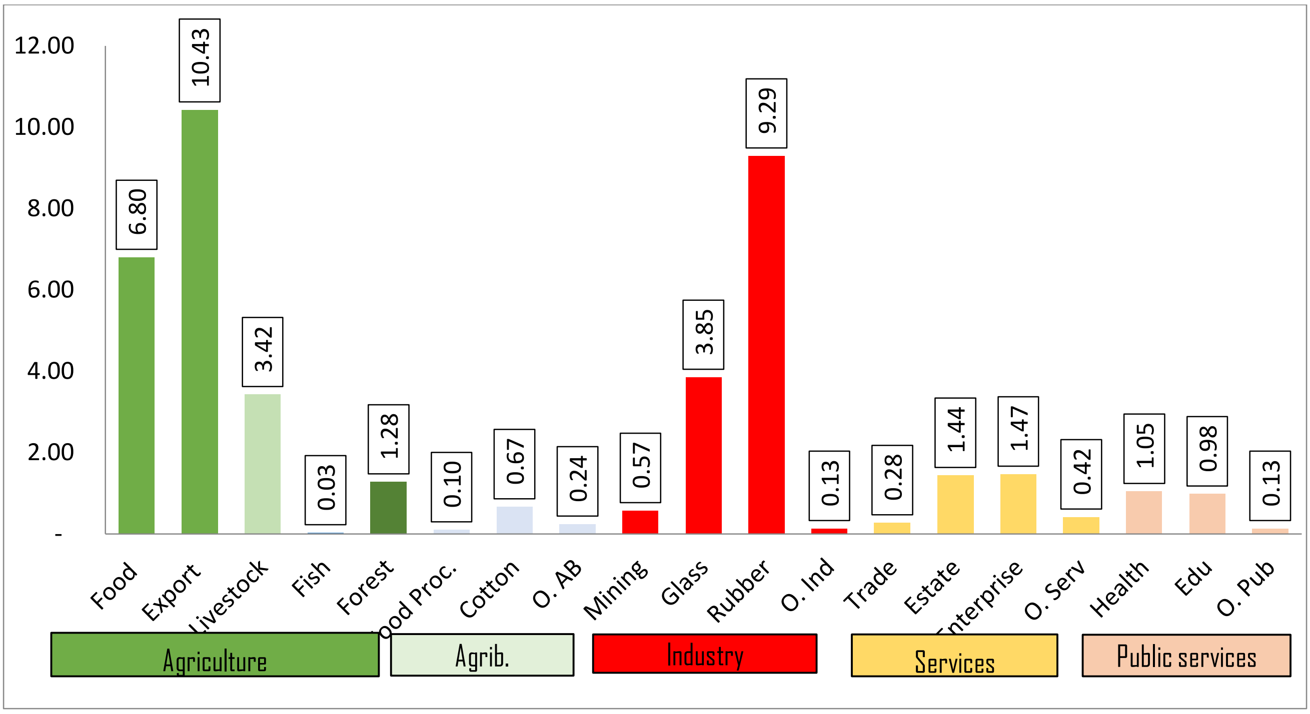
Therefore, taking into account that t.p. does not fall from heaven, from a viewpoint of a government, the final question in identifying key sectors is: how costly is it for a government to promote /achieve t.p. in different sectors? Hence, overall key sectors are characterized by a relatively high growth-poverty linkages induced per public budget expenditures used to promote t.p. in this sector. Our analysis is in line with Diao et al. (2012). They pointed out that if policymakers are to conclude whether agriculture or non-agriculture is a more effective policy option for achieving poverty reduction, comparable cost assessments for both sectors are needed. Of course, this is even more important if specific agricultural and non-agricultural sectors should be identified as key sectors.

In this regard, our estimated two-stage policy impact function (PIF) links budget allocated to specific agricultural and non-agricultural policy programs to sectoral technical progress. It is possible, in the light of these estimates to evaluate the marginal costs of promoting t.p. in specific agricultural and non-agricultural sectors.

An overview of Marginal Budget Productivity ($MBP = {}^{\partial tp_s}/_{\partial Be}$) in promoting t.p. in different sectors in Senegal is provided in Figure V.6. The marginal cost equals the multiplicative inverse of marginal budget productivity, where for convenient scaling we present marginal budget productivities instead of marginal costs. To see this more clearly, the marginal productivity of 10.43 for export crops corresponds to the marginal cost of roughly 1/10.43 = 0.1, i.e. a share 0.1 of the total budget spent under the status-quo policy in 2010 on economic policy programs has to be invested to achieve an increase in t.p. by 1 percent point. The marginal budget productivities for the status-quo policy in 2010 reveal that policy programs have been most effective in promoting t.p. in the agricultural sector.

Within Agriculture, Export crops appear to be most productive, followed by food crops and livestock, while for non-agricultural sectors marginal budget productivity is comparatively low. Only for rubber and glass industry significant productivity levels can be observed, while for all other industries and services budget productivities are extremely low implying that cost to promote t.p. in these sectors is much higher when compared to agriculture, especially for the trading sector and telecommunication sector.

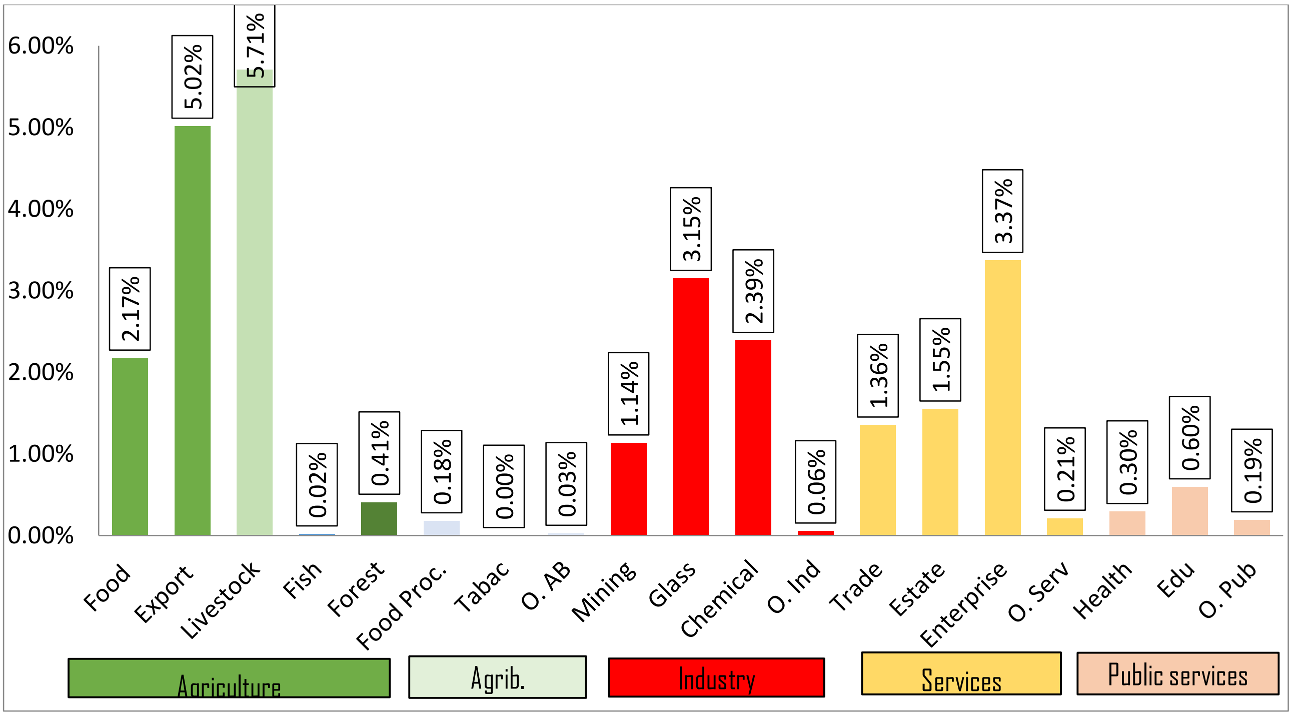
Figure V.6: Marginal budget productivity by sectors



Source: Authors

On the basis of the estimation of the PIF using empirical data, it appears that although technical progress in non-agricultural sectors has higher impacts on poverty than technical progress in agricultural sectors, promoting growth in agriculture is less costly. The findings do not mean that the agricultural sector should be the only priority in Senegal and no attention should be paid to non-agricultural sectors as these have a meaningful impact on poverty reduction, although they are more resource demanding. Overall, from the view point of a rational government facing serious budget constraints promoting t.p. in sectors with high potentials for Pro Poor Growth (PPG), like telecommunication, appears attractive. Vice-versa, promoting tp. in the food and export crop sector, which have only moderate poverty reduction potential based on PGE-elasticities appears quite promising given the relatively low cost (or vice versa high marginal budget productivity) for promoting t.p. in these sectors. Hence, to come up with a final answer on which sectors are the key sectors for poverty reduction we define an additional metrics named PPG-elasticities that is the product of the PGE-elasticities and the marginal budget productivity (MBP). This metric integrates both the poverty-growth linkage and the growth-spending linkage and therefore corresponds to poverty reduction that can be achieved by spending an additional budget unit on promoting tp. in a given sector. Figure V.7 presents the PPG-elasticities and shows that, by far, the highest potentials to reduce poverty via economic growth can be found for livestock and export crops. However, non-agricultural sectors, especially the market service sector and glass industry, have also potentials for pro poor growth. The PGE and GPM concepts are only weakly correlated to the PPG metric as shown in the Figures V.A.5 and V.A.6 in the appendix.

Figure V.7: PPG-elasticities by sectors



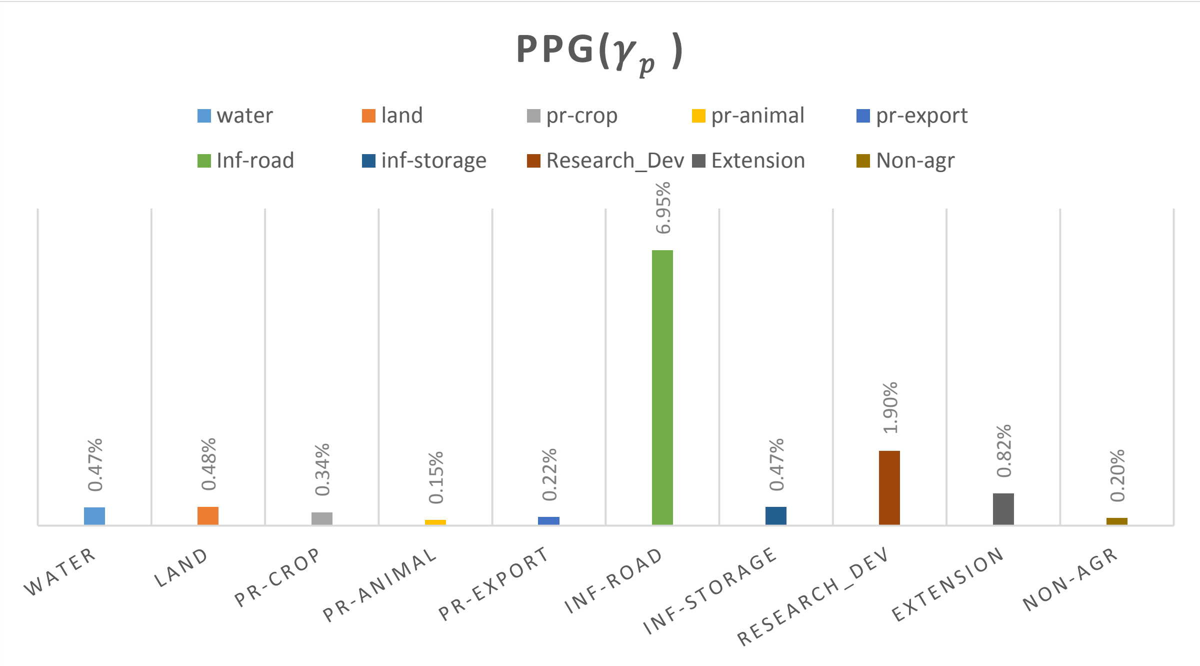
Source: Authors

V.5.C. Key policies PPG (γ)

An important contribution is the identification of the key policy programs under the CAADP framework. These key policy programs are those which maximize technical progress in the key sectors based on the PPG elasticities. In doing so, our approach beyond identifying key sectors seeks to go further by outlining the strategic policy programs that promote poverty reduction. Increasing overall public spending or agricultural spending might not be easily feasible in a world of constrained resources. However, one alternative attempt to foster technical progress and growth can be the change or the reallocation of the composition of these spending while keeping the total spending unchanged if possible. Intra-Sectoral allocation of public spending remains largely an unexplored area of research. Closing this research gap could help relieve the persistent productivity problem in many African countries. For each of the sectors of the Senegalese economy involved in the analysis, a PIF is estimated.

According to equation (11), we calculate the marginal effectiveness PPG(γ_p) of specific CAADP programs in reducing poverty as shown in Figure V.8. The PPG(γ_p) corresponds to the marginal decrease in poverty that would be achieved if the budget expenditure within a specific policy program is increased by one unit. The CAADP pillars can be subdivided into programs aiming to improve natural resource management (NR), farm management (FM), human resource management (HR) and market access (MA).

Figure V.8: Marginal effectiveness of CAADP policy programs in reducing poverty



The results show that in Senegal the most productive policy programs in terms of poverty reduction at the national level are investments in road infrastructures by far, research and development, and agricultural extension services. This is in line with previous findings of Fan and Zhang (2008) who showed that investment into agriculture Research and Development and extension services offers one of the best avenues for enhancing economic growth in the agricultural sector and reducing poverty. Furthermore, Fan and Zhang also showed that investment in rural road infrastructure has a high return and can have a large effect on agricultural productivity and poverty reduction.

Based also on the estimation of the PIF and under the CAADP, Table V.2 provides for each agricultural sector the optimal distribution of the budget among the different pillars. Heterogeneity is found in the optimal allocation across the different agricultural sectors. In fact, Table V.2 reveals that promoting t.p. in different agricultural sectors depends on these different programs, to varying degrees, e.g. livestock depends especially on the improvement of water management (NR-land), while food crops depend more on improved farm management and market access (both foster fertilizer and pesticide use). Export crops depend especially on improved infrastructure (MA-storage and MA-road) and also on improved research and development (HR-R&D). The results show only little spillover effects for non-agricultural programs with optimal budget share below 9% for all sectors. There are negligible spillover effects of agricultural programs on non-agricultural t.p. Concretely, this is translated with an optimal budget share that equals trivially 1 for non-agricultural policy for all non-agricultural sectors (not reported in Table V.2).

Table V.2: Optimal CAADP budget shares for sectors

	food crop	*export crop*	*livestock*	*fish*	*forest*
NR-water	8.2%	5.4%	55.8%	0.0%	9.4%
NR-land	11.3%	3.5%	1.0%	0.0%	12.5%
FM-crop	29.5%	0.0%	0.0%	0.0%	20.5%
FM-animal	0.0%	0.0%	21.4%	15.0%	0.0%
FM-export	0.0%	22.6%	0.0%	0.0%	0.0%
MA-road	31.4%	38.2%	0.1%	6.5%	37.0%
MA-storage	1.1%	4.7%	6.0%	50.7%	1.4%
HR-R&D	2.9%	18.1%	0.3%	13.1%	4.1%
HR-Extension	7.0%	1.4%	9.4%	13.1%	9.3%
Non-agr	8.6%	6.1%	6.1%	1.7%	5.9%

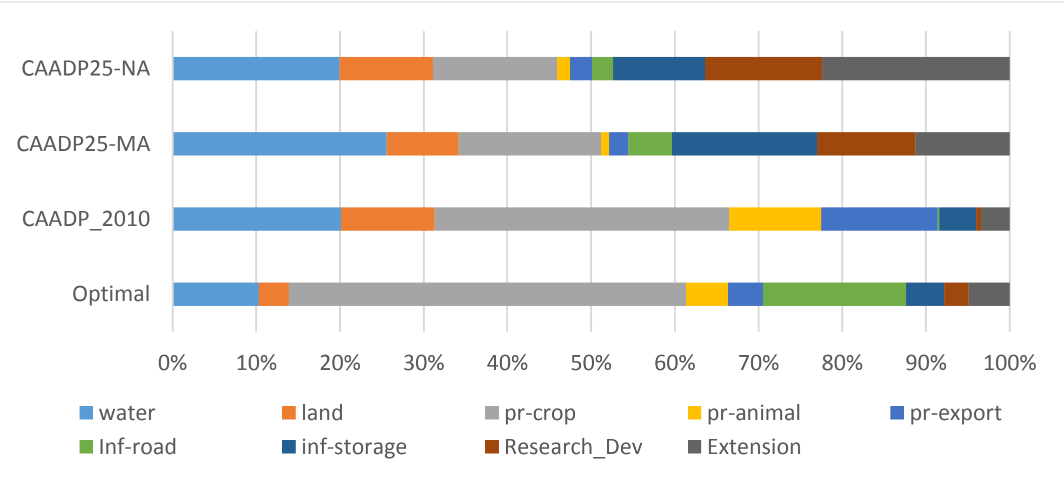
Source: Authors

An interesting quantitative assessment of the CAADP 2010 investment plan could be its comparison with the optimal budget allocation and estimated required resources that we derived from the model. Figure V.9 presents this comparison that can be a significant contribution in making CAADP successful.

In Senegal, under the optimal PPG-strategy the share of Agricultural Pubic Expenditure (APE) rises from the value of 10.8% targeted in the CAADP investment plan to 14.5%. This coincides with an allocation of 15.5% of total budget to non-agricultural policy programs (PNAE), while in 2010 around 20% of the total budget was devoted to PNAE.

As can be seen from Figure V.9 compared to CAADP-2010, optimal CAADP expenditure focuses on market access, especially investment in road infrastructure. Investments in improved market access increase from a share below 1.5% in CAADP-2010 to a share of over 10% under an optimal PPG-strategy. Moreover, investments promoting agricultural R&D and extension services would be significantly higher under an optimal PPG-strategy when compared to CAADP-2010 with an optimal share of almost 4% and a share of less than 1.5% under CAADP-2010. In absolute terms investment in R&D would increase more than 7 times, while expenditure for agricultural extension services would double. Furthermore, based on our own expert survey data, we derived different policy strategies for CAADP-2025. The interviewed organizations were classified by using cluster analysis based on their relative political interest of the policy outcomes (X_k), their preferred policy outcomes (Z_k), and their policy position (γ_p). An important cluster of organizations (labeled CAADP25-MA in Figure V.9) prefers a stronger focus on agriculture with a CAADP budget share of over 14%, and within CAADP a stronger focus on market access, while a second cluster (CAADP25-NA) prefers constant CAADP budget shares of 10%, i.e. focusing spending on non-agriculture policies.

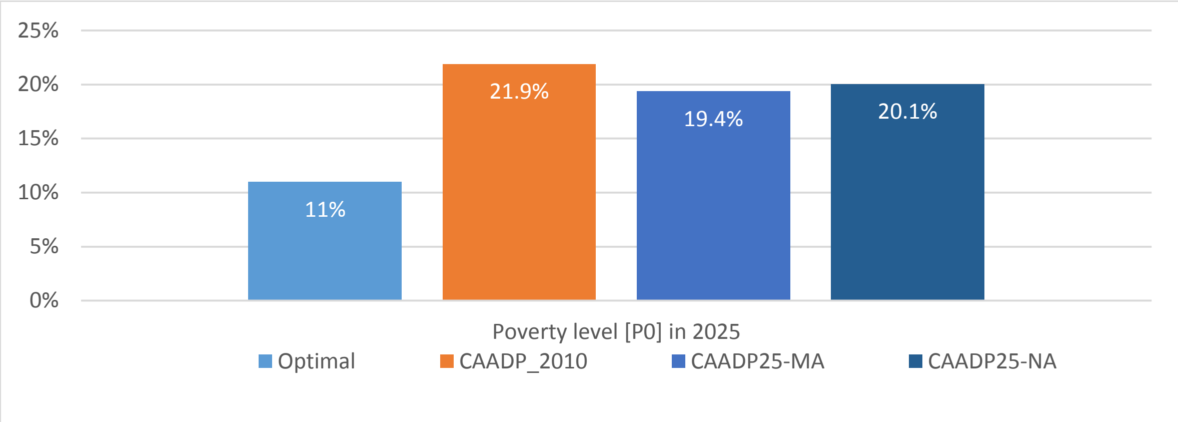
Figure V.9: Optimal CAADP budget shares for PPG



Source: Authors

The simulations show that under this optimal budget allocation, the actual poverty rate of 45% would stand at 11% by 2025. The implementation of the CAADP-2025, as reported by the government and stakeholder organizations would also have significant impact on poverty that is expected to fall at around 20% (Figure V.10).

Figure V.10: Achieved poverty reduction induced by alternative CAADP strategies



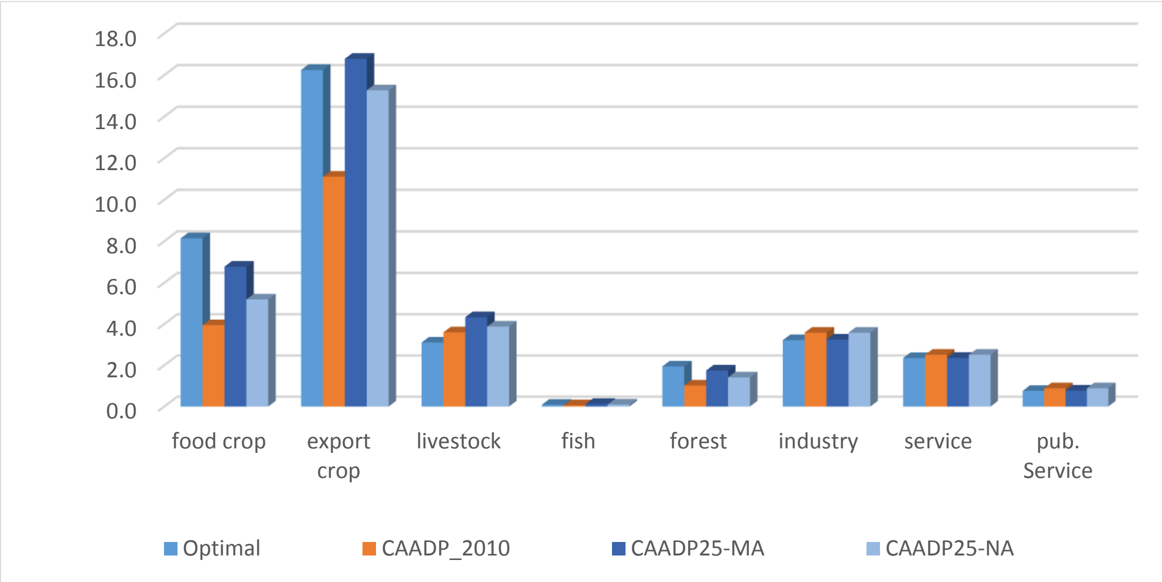
Source: Authors

Moreover, we found no conflict between poverty reduction and the other policy outcomes Z_k. Figure V.A.4 in the appendix shows that in Senegal, the same sectors promoting poverty reduction also promote both growth of farm incomes and urban households. Non-agricultural sectors, like glass and chemistry industry, increase urban household income, but have limited impact on farm incomes and poverty reduction. The key sectors of high PPG are also in line with key sectors promoting state budget revenues, i.e. provision of public good services. However, the sectors that promote industrial growth have in general the lowest impact on poverty reduction.

The achieved technical progress induced in the selected sectors is presented in the Figure V.11 under different budget allocations (the optimal budget allocation, CAADP-2010, CAADP-25 budget allocation for the identified policy clusters of stakeholder and governmental organizations CAADP25_MA, CAADP25_NA). The estimated PIF gives expected t.p. at sectoral level, and includes both true technical progress and increased technical efficiency at the micro level.

The reallocation of the budget from from non-agriculture to agriculture would especially increase average t.p. in the agricultural sector from roughly 4% to 8%, while t.p. in the non-agricultural sectors would in average only slightly decrease, from 3.6% to 3.2% for industry and 2.5% to 2.4% for the service sector.

Figure V.11: Achieved t.p. by sectors induced by alternative CAADP-strategies



Source: Authors

V. 6. Conclusion

In this paper, we develop an innovative Policy Impact Function (PIF) in order to analyze the links between policies and development outcomes. The PIF shows how government investments in agricultural and non-agricultural economic policy programs generate growth in the different sectors and, in turn, poverty reduction. Our integrated PIF-CGE framework considers both the growth-poverty and policy-growth relationships. It allows a comprehensive identification of key sectors and key policies programs by assessing the cost of generating growth, unlike most of the previous analyses. The proposed framework could be very insightful in the context of high and persistent poverty in Africa, and given the limited evidence on the impacts of government policy responses.

The application of the method on Senegal data reveals that more budget resources would be required to promote technical progress in non-agricultural sectors compared to Agriculture. In fact, promoting technical progress in non-agricultural sectors is costly compared to the agricultural sector. Moreover, the calculation of Pro Poor Growth (PPG) Elasticities shows that the highest potentials to reduce poverty are found for Agriculture, especially livestock and export crops. Results also show that some non-agricultural sectors have potentials for pro poor growth. The most productive policy programs among the CAADP pillars are related to investments in road infrastructures, research and development, and agricultural extension services. However, the complete effectiveness of the key polices in reducing poverty will depends substantially on the implementation strategies. Ultimately, our projected technical progress does not include potential prices and weather shocks, particularly in the agricultural sector.

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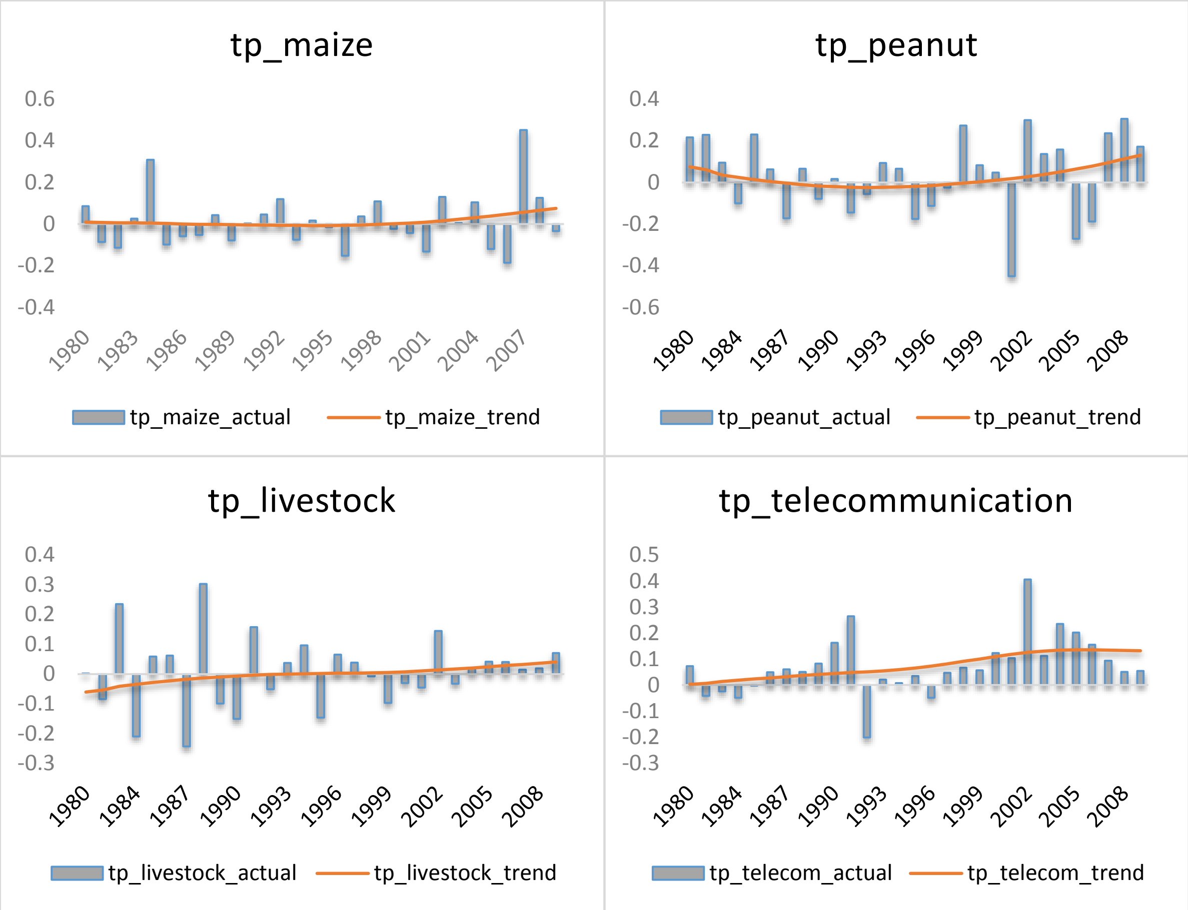
Appendix

Table V. A.1: The general structure of the Senegalese economy

Sectors	*GDP share*	*Employment share*	*Export share*	*Import share*
Primary sector	16.1	47.4	11.2	7.0
Agriculture	7.0	26.4	3.2	6.1
Food Ag.	5.6	17.2	1.2	5.7
Industrial Ag.	1.4	9.2	2.0	0.3
Livestock	5.1	16.5	0.0	0.3
Forestry	1.1	2.5	0.1	0.1
Fishing	2.8	2.1	7.9	0.6
Secondary sector	23.9	14.7	64.1	85.3
Mining	2.2	0.9	8.9	9.9
Food processing	5.8	5.2	14.8	17.6
Industry	10.0	3.8	34.8	52.3
Other industries	6.0	4.8	5.6	5.5
Tertiary sector	60.0	37.9	24.7	7.7
Trade	16.7	25.8	0.0	0.0
Telecommunication	7.3	0.2	5.4	1.3
Business services	5.3	3.5	6.2	3.1
Health and Education	4.4	2.8	0.7	1.3
Other services	26.4	5.7	12.4	1.9

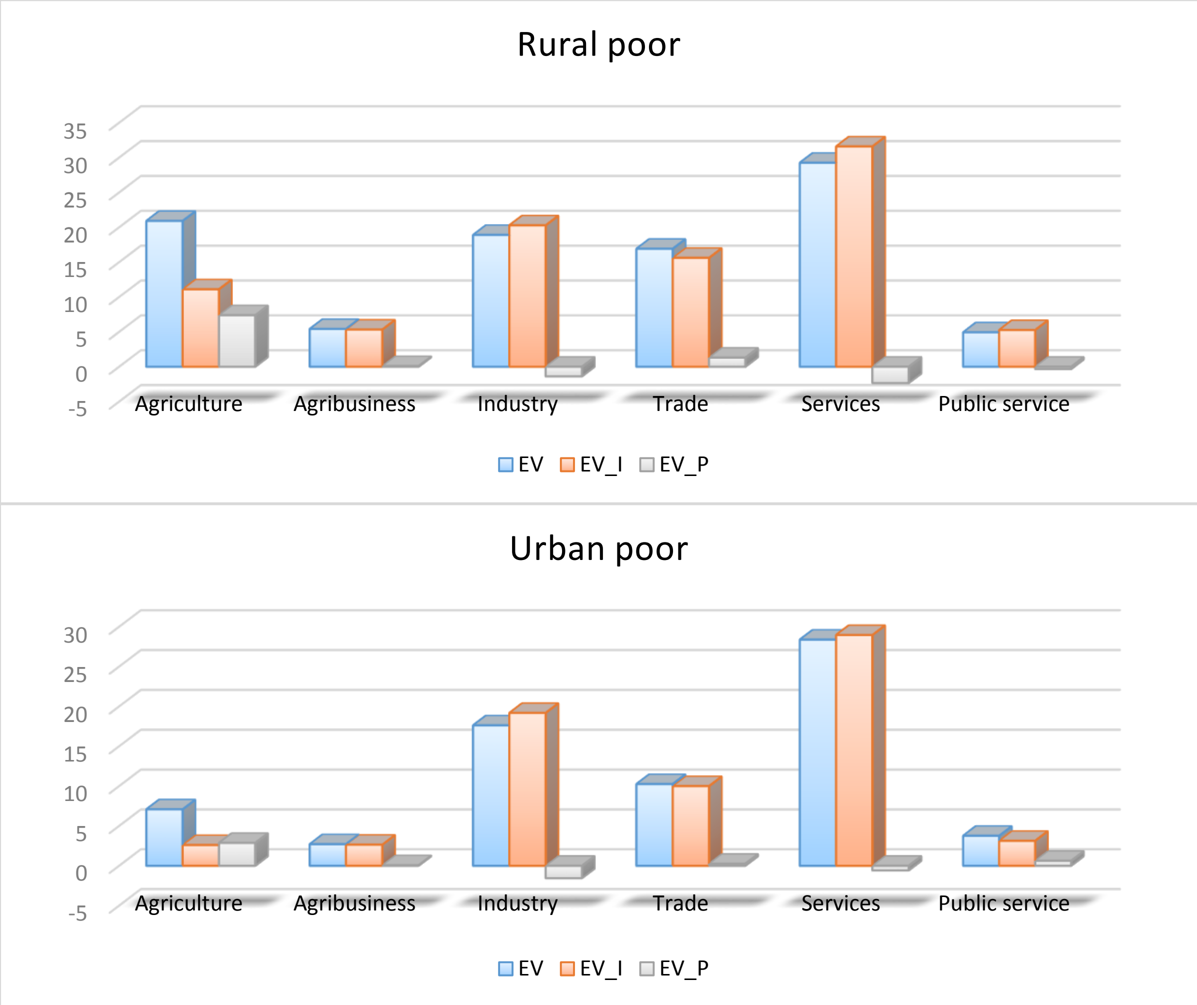
Note: GDP, employment, export and import shares from the SAM are presented
Source: Authors

Figure V.A.1: Observed technical progress for selected sectors in Senegal



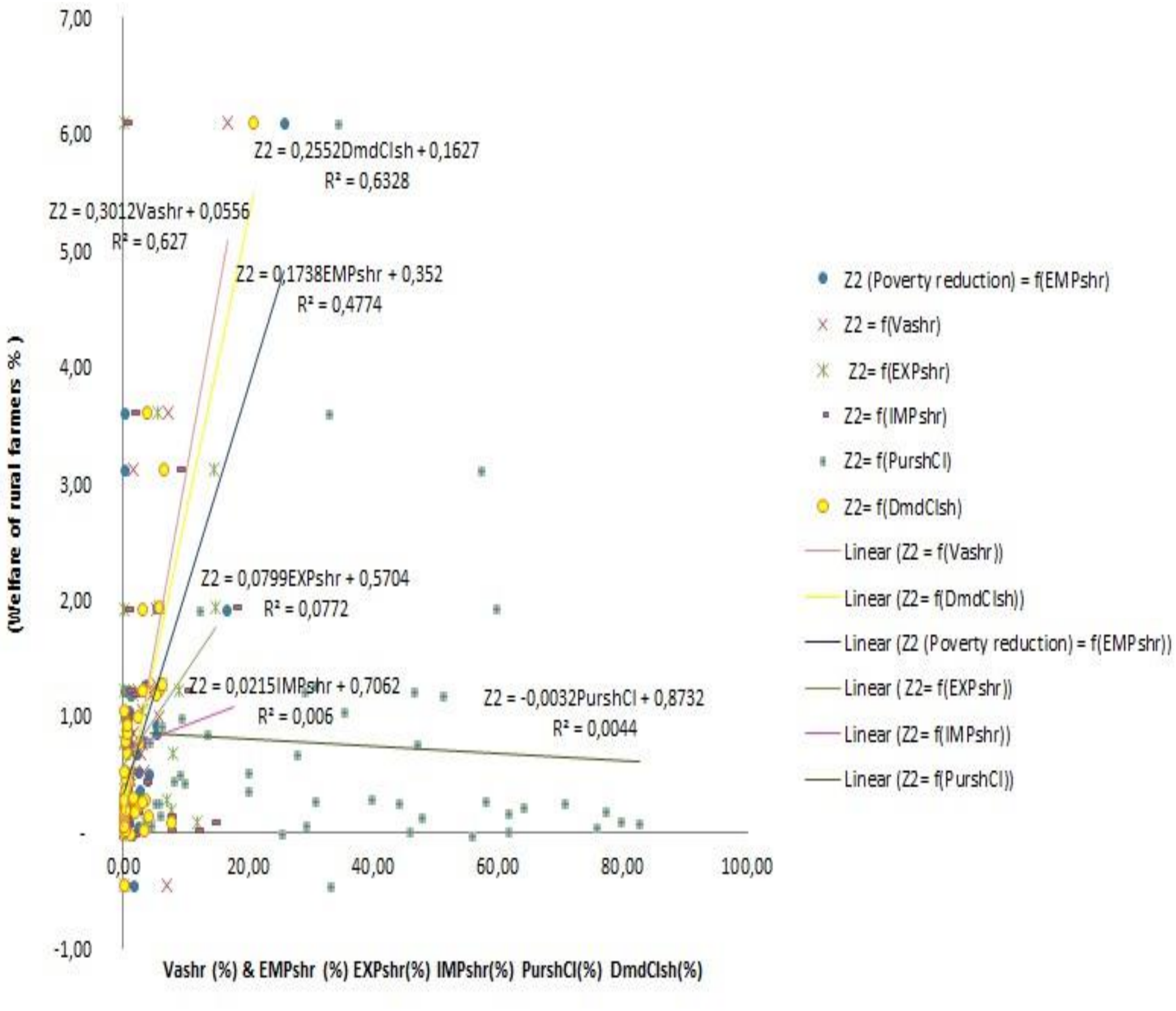
Source: Authors

Figure V.A.2: Decomposition of the PGE in income and price effects: Rural and Urban households in Senegal



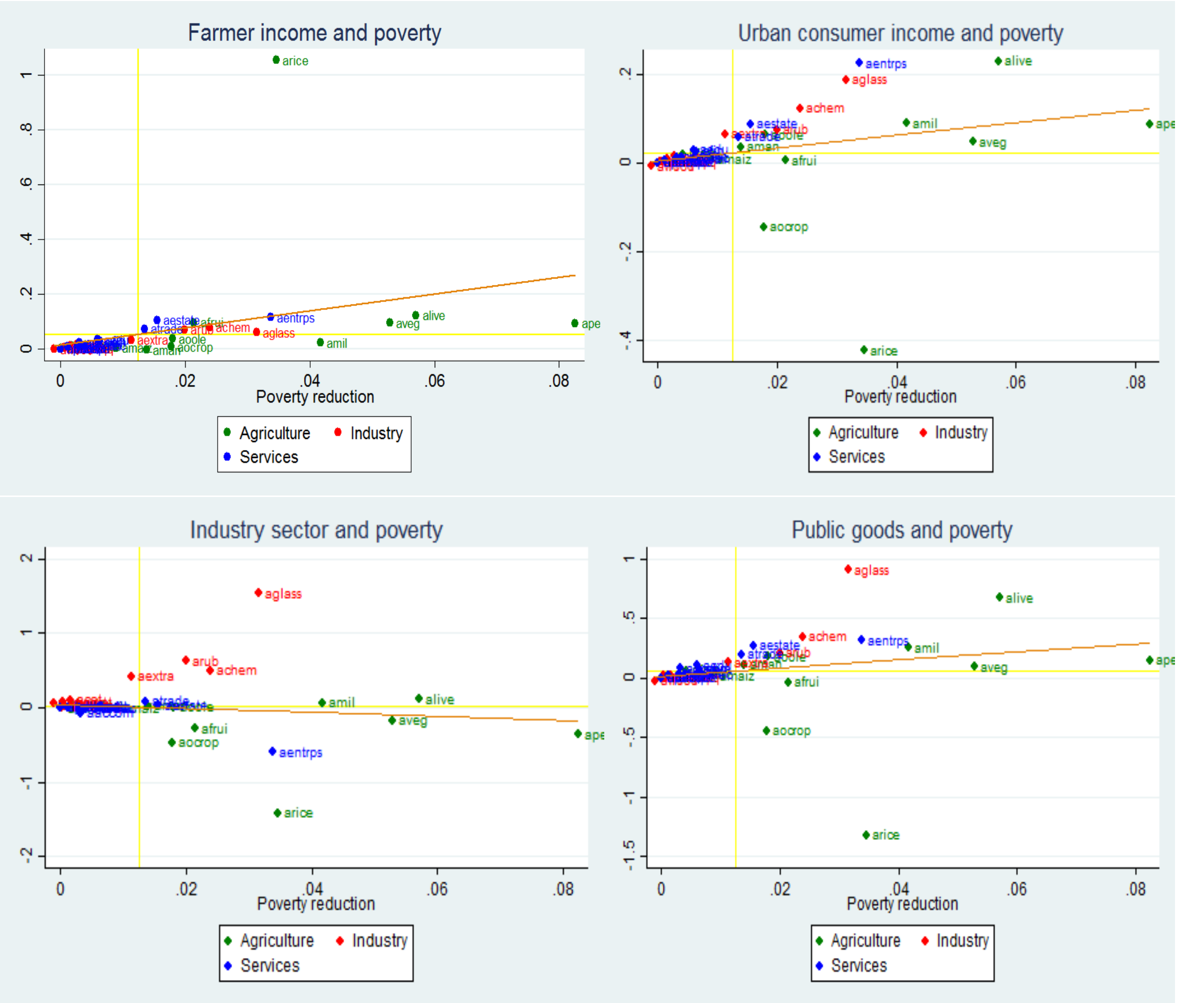
Note: EV = Equivalent Variation, EV_I = Income effect and EV_P = Price effect
Source: Authors

Figure V.A.3: Drivers of the PGE for Senegal



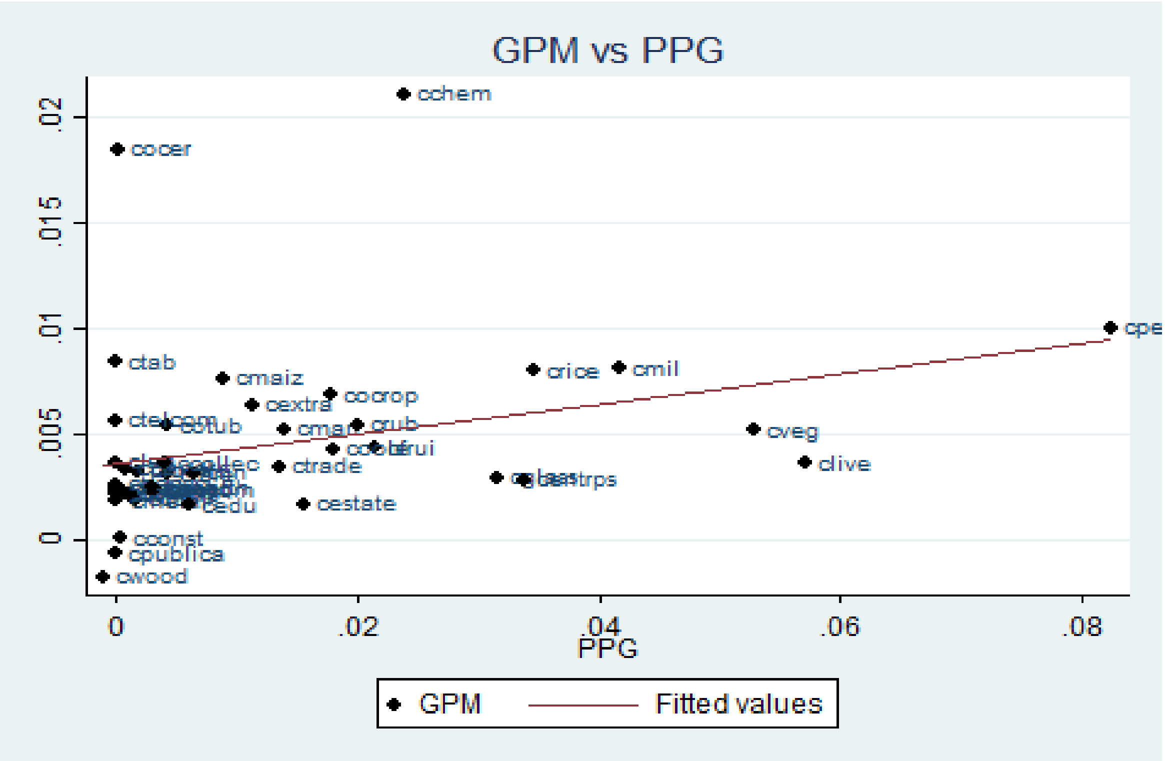
Source: Authors

Figure V.A.4: PPG-elasticities for Z_k and poverty reduction in Senegal



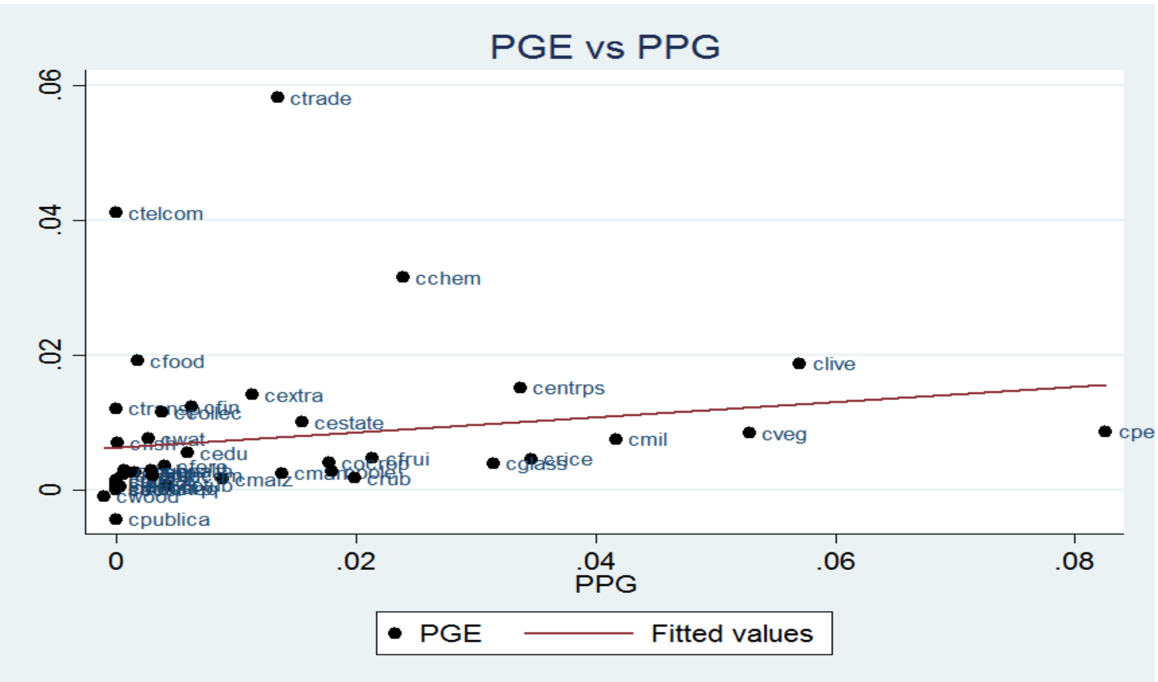
Source: Authors

FigureV.A.5: GPM vs PPG elasticities



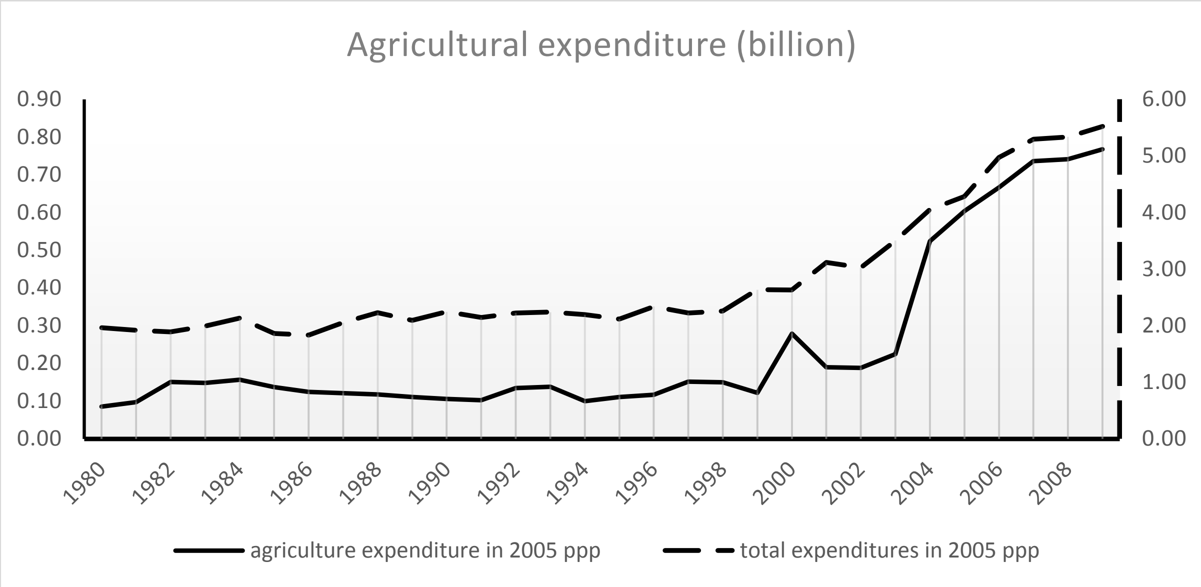
Source: Authors

Figure V.A.6: PGE vs PPG elasticities



Source: Authors

Figure V.A.7: Agricultural Public expenditure



Source: SPEED data

Table V. A.2: Overview CAADP policy programs

Policies	water	land	pr-crop	pr-animal	pr-export	Inf-road	inf-storage	Research_Dev	Extension	Non-agr
	water	land	farm management policies for food crops	farm management policies for animals	farm management policies for export crops	investments in road	storage related infrastructure	Research and development	Extension services	investments in the non-agricultural sector
	(γ_1)	(γ_2)	(γ_3)	(γ_4)	(γ_5)	(γ_6)	(γ_7)	(γ_8)	(γ_9)	(γ_{10})

V. A.1. The HP cyclical filter

$$\min_{g_t} \sum_{t=1}^{T} c_t{}^2 + \lambda\,((g_{t+1} - g_t) - (g_t - g_{t-1}))^2$$

$$\Leftrightarrow \min_{g_t} \sum_{t=1}^{T} (T_t - g_t)^2 + \lambda\,((g_{t+1} - g_t) - (g_t - g_{t-1}))^2$$

The first order condition of the maximization problem takes the following form.

2. $(T_t - g_t) - 2\lambda\ [g_{t+1} - g_t) - (g_t - g_{t-1})] + 4\lambda\ [g_{t+1} - g_t) - (g_t - g_{t-1})] - 2\lambda$ $[g_{t+2} - g_{t+1}) - (g_{t+1} - g_t)] = 0$

Manipulating this first order condition leads to

$T_t = [\lambda\,(1 - B)^2\,(1 - B^{-1})^2 + 1\,]\,g_t = \mathrm{F(B)}\,g_t$

Where B is backshift operator with $B^n\, T_t = T_{t-n}$

$g_t\; = \text{G(B)}\, T_t$ with G(B) = F(B) $^{-1} = \frac{1}{\lambda\,(1-B)^2\,(1-B^{-1})^2 + 1}$

The cyclical component $c_t = T_t - g_t$ = (1− G(B)) T_t = (1 − F(B) $^{-1}$) T_t= $\frac{\lambda\,(1-B)^2\,\left(1-B^{-1}\right)^2}{\lambda\,(1-B)^2\,(1-B^{-1})^2 + 1}\, T_t$

$c_t\; = C(B)\, T_t$ With $C(B) = \frac{\lambda\,(1-B)^2\,\left(1-B^{-1}\right)^2}{\lambda\,(1-B)^2\,(1-B^{-1})^2 + 1}$

The cyclical filter's Fourier transform $\tilde{C}(\omega)$ allows the analysis of the filter in frequency domain.

After using the following expressions

$e^{\mp\, i\omega}$ = cos ω $\mp i.\sin\omega$ and $e^{-\,i\omega} + e^{\,i\omega}$ = 2 cos ω

We get

$\tilde{C}(\omega)$ = (1 − F($e^{-i\omega}$) $^{-1}$) = $\frac{4\lambda\,[1-\cos(\omega)]^2}{1+4\lambda\,[1-\cos(\omega)]^2}$

The cyclical filter has a zero weight at the zero ferequency and assigns a weight close to one for high frequencies (for more details see King and Rebelo, 1989).

V. A.2. Decomposition of welfare variation into price and income effects

Assuming a Stone Geary utility function that gives rise to the Linear Expenditure System (LES) in the CGE model, the mathematical decomposition of the EV is as follows:

EV = $e^{LES}\,(PQ_c^0,\; \nu_{\,LES}\,(PQ_c^1\,, YI^1)$ - $e^{LES}\,(PQ_c^0,\; \nu_{\,LES}\,(PQ_c^0\,, YI^0)$

EV = $e^{LES}\,(PQ_c^0,\; \nu_{\,LES}\,(PQ_c^1\,, YI^1)$ - YI^0

Where $\nu_{\,LES}$ is the corresponding indirect utility function, PQ_c^0 and YI^0 the initial price of the good c and the initial income, PQ_c^1 and YI^1 the price and the income after a policy scenario, and e^{LES} the money metric indirect utility function.

To evaluate the price effect, we include the situation where the prices are PQ_c^1 and the income equals the initial income level YI^0.

The price effect is

EV^P= $e^{LES}\,(PQ_c^0,\; \nu_{\,LES}\,(PQ_c^1\,, YI^0)$ - YI^0 (3)

EV = $e^{LES}\,(PQ_c^0,\; \nu_{\,LES}\,(PQ_c^1\,, YI^1)$ – $e^{LES}\,(PQ_c^0,\; \nu_{\,LES}\,(PQ_c^1\,, YI^0)$ + $e^{LES}\,(PQ_c^0,\; \nu_{\,LES}\,(PQ_c^1$ $, YI^0)$ - YI^0

Then, EV $=$ EV^I $+$ EV^P , where EV^I is the income effect.

Following the LES specification, we have

$$EV = \prod_{c=1}^{C} \left({PQ_c^0}/{PQ_c^1} \right)^{\beta_c} (YI^1 - \sum_{c=1}^{C} \gamma_c PQ_c^1) - (YI^0 - \sum_{c=1}^{C} \gamma_c PQ_c^0)$$

$$EV^P = \prod_{c=1}^{C} \left({PQ_c^0}/{PQ_c^1} \right)^{\beta_c} (YI^0 - \sum_{c=1}^{C} \gamma_c PQ_c^1) - (YI^0 - \sum_{c=1}^{C} \gamma_c PQ_c^0)$$

$$EV^I = \prod_{c=1}^{C} \left({PQ_c^0}/{PQ_c^1} \right)^{c} (YI^1 - YI^0)$$

Where γ_c and β_c are respectively the minimum consumption level and the budget share of the good c.

Chapter VI

Harmonized Budget Programming Reforms in Africa: Senegal's Experience of MTEF

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Abstract

In the countries of the West African Economic and Monetary Union, the implementation of the 2009 Directives pertaining to the harmonized framework for public financial management is a major policy focus. The Medium-Term Expenditure Frameworks (MTEFs) have been used as tools for multi-year budget programming for over a decade in Africa. Their rapid spread throughout Africa raises questions about their impact. This article uses quantitative methods to provide an initial assessment of the MTEFs as applied in Senegal in the light of its main objectives by using non-parametric statistics. Beyond budget allocation to specific sectors and programs, the question on how effectively the policy programs are implemented crucially determines the impact on poverty reduction.

Ultimately, the study shows that the MTEF approach has significant potential, which remains untapped.

JEL Codes: H6, E62, E63, E65.

Keywords: Budget, Regional Integration, Medium-Term Expenditure Framework, WAEMU, Senegal.

VI. MTEF

VI.1. Introduction

The mitigated success of poverty reduction strategies has shown the importance of improved budget management through better linkage to the budget. Public expenditure programming could not ignore the development priorities nor macroeconomic challenges. With the emergence of the Managing for Results (MFR) paradigm in the 1990s, several African countries started adopting Medium-Term Expenditure Framework (MTEF), multi-year budgetary programming tools and programme budgets to move from resource-based budget to budget outcome, and thus improve their public expenditure management.

Within the WAEMU (West African Economic and Monetary Union), the new guideline laws on finance, adopted in June 2009, provide for an additional stage in this process, giving these tools a true legal character and placing them at the core of budget procedures.

The new tools for multi-year budgetary programming thus contribute to the improvement of the definition and application by states of convergence criteria, both guiding the macroeconomic management of member states and guaranteeing the efficacy of financial and economic policies. Implementation of the harmonized public finance framework guidelines of WAEMU member states is thus a major pillar of economic integration policy aimed at spreading good practices in the area of budget management.

WAEMU members have opted for harmonious adoption of modern management instruments such as the medium-term expenditure framework, functional classification and the social dimension of public finance, mainly under the poverty reduction strategic framework.

The three-year rolling MTEF should be the tool to improve the implementation of policies by strengthening the linkage between policies and the budget. The MTEF should allow public expenditures programming to take into account the priorities of development and macroeconomic constraints by integrating the medium-term vision to the preparation of estimates that have been based on a resource -based approach and not outcome-based.

Adoption of the MTEF approach by Senegal and several African countries stems from a desire to improve budget performance. Initiated in Senegal in 2004, the MTEF initially covered four pilot ministries (Education, Health, Justice, and Environment) and was subsequently expanded to 14 ministries. Gradually, it was extended to other sectors in keeping with government priorities.

This study determines to which extent MTEF adoption has improved budget discipline and predictability as well as resource redeployment to priority sectors as stated in the Poverty Reduction Strategy Documents (PRSD). It also analyzes the linkages between the various infra-three-year budget programming exercises of this instrument. Contrary to the earlier works on MTEF, the approach adopted for this study gives priority to the non-parametric statistics to analyze the evolution of budgetary variables.

This analysis shows that the predictability did not improve at the global level, for the ministries with a Sectoral Medium-term Expenditure Framework (SMTEF) as well as for the ministries without a SMTEF. The absence of redeployment towards most of the priority sectors compared to the period preceding SMTEF is also analyzed. However, since its establishment, there is a gradual increase for some priority sectors as Education, Environment and Transports. It should also be noted that there is an existing relationships between the budgetary programming of the period with the same MTEF version and between those of corresponding years for the versions produced in 2009 and 2008. This shows that budgetary programming are realized on the basis of those done for the preceding years. The budgetary discipline evaluated within the frame of the primary balance did not evolve as significantly as with the adoption of this approach.

This chapter is divided into three parts: Section VI.2 briefly presents the MTEF approach; Section VI.3 analyses the MTEFs of some African countries based on the empirical studies conducted; and Section VI.4 analyses the impact of the MTEF approach in Senegal in terms of budget discipline, budget predictability, and sector allocation.

VI.2. A Multi-Year Budget Programming Tool

The definition commonly adopted, mainly by Le Houerou and Taliercio (2002) or Holmes and Evans (2003), and drawn from the World Bank's Public Expenditure Management Handbook, is the following: 'The MTEF consists of a top-down resource envelope, a bottom-up estimation of the current and medium-term costs of existing policy and, ultimately, the matching of these costs with available resources' (World Bank, 1998).

In other words, the MTEF is a hierarchical envelope of resources that is consistent with macroeconomic stability and certain strategic priorities. It facilitates estimation of the medium-term costs of policies as well as decision-making that harmonizes costs with available resources.

The MTEF is a triennial or multi-year cycle programming and budget expenditure control instrument. It must be rolling, and should cover all expenditures, regardless of their nature or financing source. It prepares estimates for the budgeted year (N+1) and for subsequent years (N+2, N+3). Hence, the multi-year character of the MTEF addresses the annuality constraint of the budget: although the budget is voted annually, state commitments go beyond the budgeted year. The MTEF is also a mechanism adapted to results-based management (RBM), based on autonomous decision-making by managers and under which budget allocations are directed towards specific targets whose achievement is measured by performance indicators.

MTEF implementation stages are as follows:

- Update of the macroeconomic framework and establishment of the indicative amounts of revenue and expenditure;
- Review of sectoral programmes and definition of priorities;
- Fixing of indicative sectoral ceilings;
- Preparation of the Sectoral Medium-Term Expenditure Frameworks (SMTEFs);
- Preparation of the general MTEF and finance law;
- Approval and/or inclusion in the finance law.

The starting point for a multi-year approach is undoubtedly the preparation of a Medium-Term Expenditure Framework that essentially comprises estimates of the main public finance aggregates, the main macroeconomic indicators, the general level of revenue and expenditure, and the definition of general medium-term budget objectives.

More precisely, the MTEF is aimed at enhancing the efficiency of inter-sectoral resource allocation and ensuring the future budgetary impact of allocated resources addresses macroeconomic framework constraints. This objective is targeted by developing tools that allow for policy implementation in the budget while focusing on priority sectors. The enhancement of predictability starts with respect of ceilings by the authorities. MTEF determines the sectoral budget for each ministry/institution by estimation. Its goal is to indicate the amount of financial resources needed in the medium term, usually three to five years, for the execution of an existing policy. Extending the planning horizons makes it possible to move beyond annual differential budgets which make it difficult to adopt new guidelines and programmes, and are not very flexible.

Another objective of MTEF is to provide better programme management visibility and improve public expenditure performance by instituting a performance monitoring framework. In this approach, a distinction is made between the general MTEF which makes projections for the entire envelope of available resources and sectoral medium-term expenditure frameworks (SMTEFs) used essentially to estimate the cost of sectoral programmes.

VI.3. MTEF in Africa

Poverty eradication is a priority for African countries. Efforts to combat poverty are accompanied by a set of innovations in the area of budget management, as the budget is a key tool for economic policy implementation. Nonetheless, studies have shown that public expenditure execution and control in most countries, particularly in Africa, is often inadequate.

Budget preparation and execution processes are also affected. The efficient involvement of members of parliament in most Sub-Saharan African (SSA) countries is obstructed through limitation of the information provided to them and over-centralization of executive power. Although budget policy debates (BPD) are organized, there are many countries where parliament does not have the possibility for debating on budget policies and guidelines prior to budget review. Meanwhile, budget execution is generally characterized by inadequate control, and regulation laws that sometimes take a decade to be adopted by the parliament.

Some SSA countries have initiated and continue to initiate reforms and adopt tools to eradicate these shortcomings and thus improve public expenditure management. Introduction of the general MTEF into WAEMU dates back to the early 2000s following initiatives taken by other countries of the region in the mid-1990s: Ghana in 1996 and Guinea in 1997 (UNDP/ Development Strategies and Public Finances, 2010). MTEF adoption has spread rapidly in SSA (Table VI.1).

Table VI.1: MTEF adoption in WAEMU and Africa

Country	Year of Adoption	Country	Year of Adoption
WAEMU Member Countries			
Burkina Faso	2000	Niger	2007
Benin	2001	Togo	2009
Mali	2005	Cote d'Ivoire	2010
Senegal	2004	Guinea Bissau	No general MTEF
Non-WAEMU Countries			
Uganda	1992	Ethiopia	2004
Ghana	1996	Swaziland	2004
Malawi	1996	Zambia	2004
South Africa	1997	Cape Verde	2005
Mozambique	1997	Madagascar	2005
Guinea	1997	Chad	2005
Gabon	1998	Mauritius	2005
Kenya	1998	Sierra Leone	2005
Tanzania	1998	Cameroon	2006
Rwanda	1999	DRC	2006
Namibia	2000	Lesotho	2006
Mauritania	2003	Nigeria	2006

Source: UNESCO (2007), UNDP/POLE, Africa region country economists and Public Expenditure Management Thematic Group.

Within WAEMU, member states are at different levels of MTEF development. The approach was started in Burkina Faso, Benin and Mali to improve the conduct of public policy by ensuring the adequacy and control of expenditure relative to revenue. Countries like Côte d'Ivoire, Guinea-Bissau and Togo have problems implementing this instrument, probably due to a limited production of statistical data to ensure a good macroeconomic framework and shortcomings in budget systems caused by recent socio-political strife.

Impact assessments of MTEF in Africa are few, and introduction of MTEF is quite recent in most of WAEMU countries. On the 25 MTEF that existed in 2002, up to 90 percent were adopted between 1997 and 2001. Le Houerou and Taliercio (2002) were the first to conduct an empirical analysis of MTEF adoption in Africa by comparing MTEF in nine African countries. They relied on the trends of indices and key budget variables such as the Budget Deviation Index (BDI), that is 'the sum of the absolute values between the approved budget and the executed budget expressed as a percentage of the approved budget' and the budget balance before and after MTEF adoption to compare the countries in their sample. The Budget Deviation Index is used to estimate the gap between the executed amounts and the approved allocations.

Houerou and Taliercio (2002)'s study showed that budget deficits in South Africa and Tanzania during the MTEF period were lower than those of other countries in the study. However, these deficits were not very different from those recorded prior to MTEF application. From the above, they concluded that, considering the available data, MTEF did not lead to a reduction in budget deficit. But their analysis did not take into account the prevailing economic situation at that time. The hypothesis that the MTEF enhanced resource allocation in the major priority sectors was confirmed by Tanzania, South Africa and Uganda which were the countries that had the most developed MTEFs at the time. Countries like Ghana did not. The BDI study for Tanzania found tangible evidence to conclude that MTEF enhanced budget predictability. It concludes that MTEF alone cannot improve public expenditure management. The BDI study recommend that MTEF should serve as a supplement rather than a substitute to conventional budget management reforms and should also take into account the existing capacity within the countries.

While studying Uganda's MTEF, Bevan and Palomba (2000) found that MTEF were successful in ensuring macroeconomic stability, and confirmed sector allocation in priority sectors. Their result depended on the introduction of measures enabling future limits to be consistent with low inflation for all the expenditures. However, Uganda's MTEF has a certain number of shortcomings. Studies by Schiavo-Campo (2008) and Allen (2009) highlighted the mixed results of MTEF introduction in Africa. They noted that there are positive lessons to learn from the MTEF experience in Africa (raising consciousness about the importance of a multi-year approach in the budgetary programming, concentration on the efficacy of the budgetary expenditures), including failures linked to a premature implementation, lack of approval, inefficient spending and failure of the budgetary control, among others. Allen takes a critical look at budget programs and PSRD as a means to achieve the MDG and a tool for resource allocation. He considers that these initiatives lead to ritualist practices and produce a large amount of databases that unfortunately are redundant and unused.

VI.4. MTEF and Budget Programming in Senegal

Most of the methodological approaches used in the few impact assessment studies in existence are based on comparing the averages of budget variables before and after MTEF implementation. To address these methodological shortcomings, an approach based on non-parametric statistics is adopted. Non-parametric tests are more relevant when the series distribution is unknown and when the number of observations is limited. This approach is appropriate for the study, given the short data series for most of our variables and especially for the post-MTEF period. The MTEF's contribution to budget management and project efficiency will be analyzed by comparing approved and executed amounts, the various projections of matching fiscal years, budget variations and sector allocations.

The data used are from the database of the Integrated Public Finance Management System (PFMS) of the Senegalese government, of the Directorate of forecast and economic studies of the Ministry of Economics and Finances of Senegal, and the World Bank. The tests are generally based on data for the 2000-2009 period. Budget predictability is then determined by conducting the Spearman and Kendall (KS) tests on MTEF and budget projections and on budget implementation under schedule.

The Kolmogorov-Smirnov and Mann-Whitney/Wilcoxon tests are used for the independent samples. The objective of the other tests is to look for any differentiation variables between the pre- and post-MTEF years. The following sections present the results on MTEF impact with formulation of the following research hypotheses:

- H1: MTEF improved budget predictability;
- H2: The volume of allocations to priority sectors increased during the MTEF period compared to the pre-MTEF period;
- H3: MTEF has a positive impact on budget balance;
- H4: Budget discipline has consequently improved with the adoption of MTEF;
- H5: There has been a steady increase in allocations to certain priority sectors since MTEF was instituted;
- H6: MTEF programming takes account of the programming done under a previous MTEF;
- H7: Projections for three years of the same MTEF are linked;

- H8: The budget variances of ministries under SMTEF are narrower than those of non-SMTEF ministries;
- H9: There is concordance between MTEF priorities and budget priorities (in terms of sector allocations).

These are the main hypotheses that are tested in the study.

VI.4.1. Budget discipline

The tests conducted make it possible to identify any significant difference in the values of variables or indices before and after MTEF adoption. This first series of tests is conducted on data that covers the 2000-2009 and 2007-2009 post-MTEF period. The zero hypothesis to be tested is H0: The distribution pattern of the variable is the same before and after MTEF adoption.

The alternatives depending on the variables tested are:

- Alternative hypothesis H1: The central tendency of the variable after MTEF adoption is different from the tendency before MTEF adoption.
- Hypothesis H1': The central tendency of the variable after MTEF adoption is higher (or lower) than the tendency before MTEF adoption.

Table VI.2 presents the results of the unilateral tests on budget balance. The probability accorded to the unilateral test is the half of the probability accorded to the bilateral test. The Wilcoxon tests clearly confirm the increase in total revenue and total expenditure when MTEF is implemented. There is practically no interlinking between the values of these series for the two periods (Figure VI.A.1, Table VI.A.3 and Table VI.A.4). Tested variables don't display ex-aequo rankings.

Table VI.2: Mann-Whitney/Wilcoxon test on certain budget variables

Variable	Average ranking Pre	Average ranking Post	Mann-Whitney U	Wilcoxon W	P-value	Test result at 5%
Basic balance (net of HIPC, MDRI)	6.57	3	3.0	9	0.06	No evidence ~ Non-rejection of H0
Total revenue, base 96	4	9	0.0	28	0.008	Rejection of H0
Total expenditure, base 96	4	9	0.0	28	0.008	Rejection of H0
Primary balance	5.71	2.5	2	5	0.111	Non-rejection of H0

Source: Authors' calculations based on Government data.

An analysis of the test results shows that MTEF did not lead to an evolution of the deficit which is expressed by the basic balance net (Heavily Indebted Poor Countries - HIPC initiative and Multilateral Debt Relief Initiative- MDRI) and the primary balance. Hence, hypothesis H3 has not been proven. MTEF has no impact on the primary balance.

VI.4.2. Budget programming and predictability

The years MTEF N,3; MTEF N+1,2; MTEF N+2,1 (in terms of forecasts) are compared to see whether MTEF generally takes account of the allocations made in a previous MTEF. Hence, it will be possible to determine whether there is a link between the budget programming of the years presented below.

Table VI.3: Rolling three-year programming method

MTEF Version	Programmed Fiscal Year		
2007	2007 MTEF 2007, 2007	2008 MTEF 2007, 2008	2009 MTEF 2007, 2009
2008	2008 MTEF 2008, 2008	2009 MTEF 2008, 2009	2010 MTEF 2008, 2010
2009	2009 MTEF 2009, 2009	2010 MTEF 2009, 2010	2011 MTEF 2009, 2011

Source: Authors

The following relations of the rolling three-year programming method are analysed.

- Second-year budget programming of the MTEF prepared in 2007 (MTEF 2007, 2008) and first-year programming of the MTEF prepared in 2008 (MTEF 2008, 2009);
- Second-year budget programming of the MTEF prepared in 2009 (MTEF 2009, 2010) and third-year programming of the MTEF prepared in 2008 (MTEF 2008, 2010);
- Third-year budget programming of the MTEF prepared in 2007 (MTEF 2007, 2009), second-year programming of the MTEF prepared in 2008 (MTEF 2008, 2009) and first-year programming of the MTEF prepared in 2009 (MTEF 2009, 2009).

Correlation test results are set out in the tables below:

Table VI.4: Links between the corresponding years of the budget programming exercises

Link tested	MTEF 2007, 2008 *R* MTEF 2008, 2008	MTEF 2008, 2010 *R* MTEF 2009, 2010
N	5	8
Spearman's Rho ρ	0.6	1
p-value ρ	0.28	0.0 ***
Kendall's tau τ	0.4	1
p-value τ	0.32	0.001 ***
Decision	Non-rejection of H0	Rejection of H0

Note: ***) rejection of H0, threshold at 1% and **) rejection of H0, threshold at 5%. The zero hypothesis is H0: Programming exercises are independent.

Source: Authors

Table VI.5: Links between the three corresponding years of the budget programming exercises

Tested link	MTEF 2007, 2009 *R* MTEF 2009, 2009	MTEF 2008, 2009 R MTEF 2009, 2009	MTEF 2007, 2009 *R* MTEF 2009, 2009
N	5	11	5
Spearman's Rho ρ	0.1	0.78	0.3
p-value ρ	0.87	0.004 ***	0.62
Kendall's tau τ	0.0	0.63	0.2
p-value τ	1	0.006 ***	0.62
Decision	Non-rejection of H0	Rejection of H0	Non-rejection of H0

Source: Authors' calculations based on Government data.
Note: ***) rejection of H0, threshold at 1% and **) rejection of H0, threshold at 5%.

The test results (Table VI.4 and VI.5) reveal a link between second-year projections of the MTEF prepared in 2008 and first-year projections of the MTEF prepared in 2009 (MTEF 2008, 2009 and MTEF 2009, 2009). The same applies between third-year projections of the MTEF prepared in 2008 and second-year projections of the MTEF prepared in 2009 (MTEF 2008, 2010 and MTEF 2009, 2010). However, some disconnect is observed between second-year programming of the MTEF prepared in 2007 and first-year programming of the MTEF prepared in 2008. The third year of MTEF 2007 is neither linked to the second year of MTEF 2008 nor to the first year of the MTEF 2009.

Concluding from the above, there is no link between allocations of the first MTEF (2007) and those of the second MTEF (2008). This disconnect between the ministerial programming of two inter-linked MTEF is no longer apparent between the second (2008) and third (2009) versions of the MTEF. Hence, it can be imagined that it was only during preparation of the 2009 MTEF that the programming of budget allocations as of date *t* started picking up from the programming done in *t -1*, i.e. from preparation of the MTEF of the previous year. Hence, hypothesis H6 is partially proven. There was an improvement of the programming process from 2009, probably due to learning by practice, taking into account the lessons learnt from previous fiscal years.

Programming Exercises Link

The existence of a link between programming exercises for the years N, N+1 and N+2 within the same MTEF reflect the internal coherence of projections and the effective implementation of the short-term policy vision. Apart from the information it will provide on the link between the fiscal years programmed within the same MTEF, this analysis, once it confirms the existence of the link, will make it possible to assess the variation in amounts allocated to priority sectors so as to determine whether MTEFs encourage the allocation of a growing share of resources to these sectors.

Table VI.6: Link between budget programming exercises within the same MTEF

Tested link	MTEF 2007, 2007 *R* MTEF 2007, 2008	MTEF 2007, 2008 *R* MTEF 2007, 2009	MTEF 2008, 2008 *R* MTEF 2008, 2009	MTEF 2008, 2009 *R* MTEF 2008, 2010	MTEF 2009, 2009 *R* MTEF 2009, 2010
N	5	5	11	11	11
Spearman ρ	1	0.9	0.92	0.93	0.76
p-value ρ	0.0 ***	0.04 **	0.0 ***	0.0***	0.006***
Kendall τ	1	0.8	0.78	0.85	0.67
p-value τ	0.01 **	0.05	0.001 ***	0.0***	0.004***
Decision	Rejection of H0	Rejection of H0	Rejection of H0	Rejection of H0	Rejection of H0

Note: ***) rejection of H0, threshold at 1% and **) rejection of H0, threshold at 5%.

Budget allocation programming exercises for years within the same MTEF are highly correlated (Hypothesis H7 is proven). Hence, the budget programming exercises for years N+1 and N+2 are based on the allocations for year N (Table VI.6). Besides, it should not be very far from the year N budget. This is verified subsequently.

MTEF and budget predictability

The average relative Budget Deviation Index is used to evaluate MTEF's contribution to budget predictability. This index (calculated in the ministries) is similar to the BDI (Moon's Budget Deviation Index) in terms of its target, but different in terms of methodology, because it is defined as simply the average of the relative budget variances of the ministries concerned. It will be calculated for 2008-2009, the post-MTEF period (the period for which SIGFIP[43] data on budget execution by authorization is available) and for 2004-2006, the period that immediately precedes the institution of MTEF. Furthermore, relative analysis gives a clearer idea of the magnitude of budget deviations between two ministries.

[43] Système Intégré de Gestion des Finances Publiques, e.g. Public Finance Management System

However, it should be noted that the index is calculated in the ministries and institutions and that certain ministries whose structures have changed (ministries split up or merged during the 2004-2010 period) were deliberately excluded. This will make it possible to have deviation indices calculated for the same entities before and after MTEF implementation so that the comparison should not be skewed in advance. The average index over the post-MTEF period is 47 percent compared to 53.8 percent over the 2004-2006 period.

The analysis cannot be limited to a mere comparison of these statistics. Hence, 14 ministries are considered and the average (relative) variances between their initial and executed amounts are calculated and compared as a percentage of the planned amount for the 2007-2009 or 2008-2009 post-MTEF period and the 2004-2006 pre-MTEF period. The unilateral sign tests and the unilateral Wilcoxon test for matched samples have been used.

Table VI.7: Test on budget variances (authorization) before and after MTEF adoption

Sign Test N=14		Matched Wilcoxon Test N=14	
Negative differences [c]	6	Negative rankings	6
Positive differences	8	Positive rankings	8
		Average ranking+: 7.63 Average ranking-: 7.33	
		Z	-0.53 [a]
p-value	0.39[b]	p-value	0.31

Source: Authors' calculations based on Government data.
Note: a) based on negative rankings; b) binomial distribution used; c) Difference = Pre-MTEF variance – Post-MTEF variance. The number of tied rankings is zero.

The results of these two tests (Table VI.7) lead to the conclusion that the average relative budget variances of the 14 ministries during the post-MTEF period were generally equal to those obtained over the last three years preceding MTEF implementation.

It is also important to gauge the impact of producing a sectoral MTEF (SMTEF) on overall predictability. Hence, average relative variances will be calculated and compared for a sample of seven ministries covered by an SMTEF for the 2007-2008 period.

Table VI.8: Test on budget variances (authorizations) before and after MTEF Adoption (Ministries under MTEF since 2007/2008)

Sign Test N=7		Matched Wilcoxon Test N=7			
Negative difference [c]	2	Negative ranking	2		
Positive difference	5	Positive ranking	5		
		Average ranking+:	4	Average ranking-:	4
		Z	-1.01 [a]		
p-value	0.22[b]	p-value	0.18		

Source: Authors' calculations
Note: a) based on negative rankings; b) binomial distribution used; c) Difference = Pre-MTEF variance – Post-MTEF variance; the number of tied rankings is zero;

The results in Table VI.8 lead to the conclusion that, during the 2008-2009 period, the average relative budget variances of the seven ministries under SMTEF in 2008 were generally equal to those obtained over the last three years preceding MTEF implementation. To conclude the impact of SMTEF implementation on overall budget variance trends during the MTEF period, the same method was applied, as a placebo measure, to ministries which, right up to 2010, had no SMTEF. The results of the tests also revealed average relative variances for ministries without MTEF that were generally equal to those of the pre-MTEF period.

After noticing that ministries under SMTEF did not experience an improvement in budget predictability in terms of overall execution from 2004-2006 to 2008-2009, a comparison was made between the relative budget variances of ministries with an SMTEF and those without an SMTEF. Indeed, it is equally important to assess the predictability status of ministries covered by an SMTEF compared to the other ministries.

This was done by applying a Mann-Whitney/Wilcoxon test followed by a Kolmogorov/Smirnov test on the average budget variances during the MTEF period (2008-2009) between two groups, G1 and G2, composed respectively of ministries under an SMTEF since 2007/2008 and ministries without an SMTEF until 2010. These tests (Table VI.A.5 and Table VI.A.6) show that the average relative variances of Group G1 are equal to those of Group G2. Compared to ministries which are not yet covered by an SMTEF, ministries under SMTEF since 2007/2008 do not have a smaller average relative variance. Hence, hypothesis H8 has not been proven.

In summary, the test results obtained in terms of predictability are as follows:

- The average relative budget variances of the 14 ministries tested in the post-MTEF period are generally equal to those obtained over the last three years preceding MTEF implementation;
- The average relative budget variances of the seven ministries under SMTEF since 2007 or 2008 in 2008-2009 are generally equal to those obtained over the last three years preceding MTEF implementation;
- For ministries not covered by an SMTEF until 2010, the average relative variances of the period corresponding to MTEF adoption in Senegal are generally equal to those of the period preceding MTEF implementation; and
- Compared to ministries which are not yet covered by an SMTEF, average relative variance for ministries under SMTEF since 2007 or 2008 are not smaller.

From these results, it can be concluded that overall budget predictability did not improve after MTEF implementation, and that the impact of SMTEF adoption by ministries is not significant overall, as regards predictability. Research hypothesis H1 has not been proven.

VI.4.3. Sector allocation

The MTEF is also evaluated in terms of its sectoral resource allocation. The idea is to find out whether MTEF implementation leads to a redeployment of budget appropriations to priority sectors. These sectors cover domains that are government priorities. They were identified through the memorandum of economic and financial policies of 30 May 2008, the PRSP and documentary research. The memorandum identifies social and infrastructure sectors as priority domains.

The PRSP identified new priorities related to transport infrastructure and energy to boost growth. In its projections, the MTEF allocates the same volume of resources to the ministries as the budget, although its allocations deviate from those of the approved budget and executed budgets for certain ministries. MTEF second and first year allocations to various ministries under SMTEF tally with budget allocations. These budget allocations indirectly reflect the priority given to various sectors after budget execution (as shown in Tables VI.A.1 and VI.A.2 in the annex). Hypothesis H9 is relatively proven.

Besides, the data and documents show that the first year of finalized budget programming for ministries under SMTEF tallies with the budget but does not always tally with the programming exercises for the first SMTEF years. Most of the budget programming exercises for ministries under SMTEF for the second and third years tally with SMTEF projections. Budget execution also follows this ranking of ministries according to allocation amounts.

It can also be noted that programming exercises for priority sector allocations for the years within the same MTEF are not always on the increase. This may not mean the priority given to a particular sector/ministry has diminished; it could stem from the projections of available resources provided by the macroeconomic framework.

Having found that the resource allocation priorities of the MTEF approach match those of the budget, albeit with sometimes huge variances for second year projections, it would be interesting to see whether the effective amount of allocations to priority sectors increased in the MTEF period compared to the previous period.

Hence, the shares of these sectors before and after MTEF adoption are compared. The Mann-Whitney/Wilcoxon test for independent samples is applied to effective (authorized) amounts as a percentage of the total budget executed for the various priority sectors.

Table VI.9: Wilcoxon/Mann-Whitney test on priority sector share trends

Variable Sectors	Pre n_1	Post n_2	Average ranking Pre	Average ranking Post	Mann-Whitney U	Wilcoxon W	P-value	Decision at 5%
Health [b]	3	4	6	2.5	0	10	0.03	Rejection of H0
Education	3	4	4.7	3.5	4	14	0.31	Non-rejection
Transport	3	4	4	4	6	16	0.57	Non-rejection
Environment & Sanitation [b]	3	4	6	2	0	10	0.03	Rejection of H0
Energy [a]	3	4	2	5.5	0	6	0.02	Rejection of H0
ICTs [b]	3	4	6	2.5	0	10	0.09	Rejection of H0

Note: The tested variable does not show any tied rankings; [b]) decline in share; [a]) increase during the MTEF period. The zero hypothesis is H0: The share of sector S before MTEF adoption is equal to its share after MTEF adoption.

The test results (Table VI.9) show that the MTEF did not generate a redeployment of resources to priority sectors such as health, education, transport and environment/sanitation compared to the pre-MTEF period. Allocations to the posts/telecommunications and ICT sub-sector did not also increase with MTEF implementation. Only the energy sector share increased in the overall budget. Although the overall education sector share in the budget did not change after MTEF implementation, the shares of the health, ICT and environment sectors declined in the overall budget. Therefore, during the MTEF period, the Senegalese Government's budget choices did not favor certain sectors deemed to be priorities. Hence, hypothesis H2 has not been proven.

However, this general finding can be put in context by considering the factors that could account for the non-deployment of resources to these sectors between the two periods. Such factors include the completion of certain major projects prior to MTEF implementation (e.g. the 'Jaxay' flood victims' resettlement plan of 2005, the Independence programme, the public transport bus procurement project, the review of the electoral register, the rehabilitation of the national road network.).

Despite the stability or decline in the amount of allocations to sectors such as education, health and transport compared to the pre-MTEF period, there was progressive deployment to priority sectors since the effective implementation of MTEF in 2007.

The following table presents the annual growth rate, from 2007 to 2010, in the share of allocations to these various sectors as a percentage of the overall executed budget.

Table VI.10: Percentage variation in sector expenditure

Sectors\ Fiscal Years	2008-2007	2009-2008	2010-2009
Education	30.8 %	8.5 %	13.5%
Health	-4.2%	1.1%	26.2%
Transport	9.2%	66%	7.7%
Environment/ Sanitation	16.21%	15.6%	59.6%

Source: Calculations based on Government data

During the MTEF period, the government increasingly gives priority to the education, environment and transport sectors. Redeployment in favor of these sectors is progressive. To a certain extent, this can be attributed to the MTEF because a correlation was previously observed between MTEF, budget and execution priorities. Hypothesis H5 is therefore proven. Furthermore, it is not possible to state that MTEF led to redeployment of resources to these sectors compared to the pre-MTEF period because the sectors sometimes record larger shares, as evident in the test results provided in Table VI.9.

VI.5. Conclusion

Results-oriented management is stated in terms of budgetary programming with the adoption of a mid-term spending framework or budget program by several public administrations worldwide. Several government services in Africa have reviewed their approach to budgeting in order to address the problems that bedevil their budget systems. The MTEF emerged as a tool for improving budget management performance. This tool of budget programming is designed for improving budget discipline and predictability as well as ensuring a connection between the budget formulation process and development strategies. Truly effective in Senegal in 2007, this tool has been evaluated in this study, with a focus on its generic objectives.

As in most African countries, the analysis shows that despite a few achievements, certain objectives could not be attained. Predictability did not improve overall for ministries with or without an SMTEF. There was no redeployment of resources towards most priority sectors compared to the pre-MTEF period. Nevertheless, since the MTEF was instituted, there has been a steady increase in allocations to certain priority sectors like education, the environment and transport. Also noteworthy are the linkages between the budget programming exercises for the years within the same MTEF versions and between those of the years in versions produced in 2009 and 2008. This shows that budget programming exercises are conducted based on the programming exercises for previous years. Budget discipline, evaluated through the primary balance, did not significantly change after MTEF adoption.

The main challenges that government authorities in most of African countries must address are completion of the establishment process with the institution of a comprehensive MTEF, compliance with approved budgets by the ministries, improvement and extension of SMTEF to ministries without such framework. What is important is focusing on the efficiency and efficacy of public expenditures. Despite the spread of the MTEF approach in Africa due to the increased political will of states, regional institutions and partners, there are still numerous challenges to be addressed before the countries can fully benefit from the potential generated by MTEFs.

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Appendix

Table VI.A.1: Second year MTEF allocations, budget allocations, and executed allocations

Tested link	MTEF share 2008, 2009 R budget share 2009	MTEF share 2008, 2009 R execution share 2009
Number of ministries concerned	9	9
Spearman's Rho ρ	0.68	0.76
p-value ρ	0.02**	0.008 ***
Kendall's tau τ	0.55	0.61
p-value τ	0.02**	0.01**
Decision	Rejection of H0	Rejection of H0

Source: Authors.
Note: **) Significant correlation at 5% threshold; ***) Significant correlation at 1% threshold.

Table VI.A.2: Comparison of projections, budget and actual

Tested link	MTEF share 2008, 2008 R execution share 2008
Number of ministries concerned	10
Spearman's Rho ρ	0.69
p-value ρ	0.01 **
Kendall's tau τ	0.60
p-value τ	0.008***
Decision	Rejection of H0

Source: Authors.
Note: **) Significant correlation at 5% threshold; ***) Significant correlation at 1% threshold.

Table VI.A.3: Budget expenditure category trends before and after MTEF adoption (as percentage of GDP)

Variables	Total expenditure	Recurrent expenditure	Salaries and wages	Transfers and subsidies	Debt interest	Capital expenditure	Basic balance (net of HIPC, MDRI)	Primary balance
Pre-MTEF	22.1	13.59	5.72	3.34	1.28	8.13	0.94	-0.33
Post-MTEF	31.16	18.98	7.25	5.59	0.94	12.01	-0.97	-3.5

Source: Authors.

Table VI.A.4: Revenue trends (as percentage of GDP)

	Pre-MTEF	Post-MTEF
Total revenue and grants	20.3	26.5
Budget revenue	18.1	23.5
Tax revenue	17.2	22.4
Non-tax revenue	0.87	1.1
Grants	2.2	2.9

Source: Calculations based on Government data.

Table VI. A.5: Wilcoxon/Mann-Whitney test on average relative budget variances (authorizations) between G1 and G2, 2008-2009

Variable	Average ranking G 1 n_1=7	Average ranking G2 n_2=7	Mann-Whitney U	Wilcoxon W	P-value	Test result at 5%
Average relative variances	7.86	7.14	22	50	0.40	Non-rejection of H0

Source: Authors' calculations based on Government data.
Note: The variables tested do not show any tied rankings. Zero hypothesis H0: Average relative variance of ministries under SMTEF since 2008 = Average relative variance of ministries without an SMTEF until 2010.

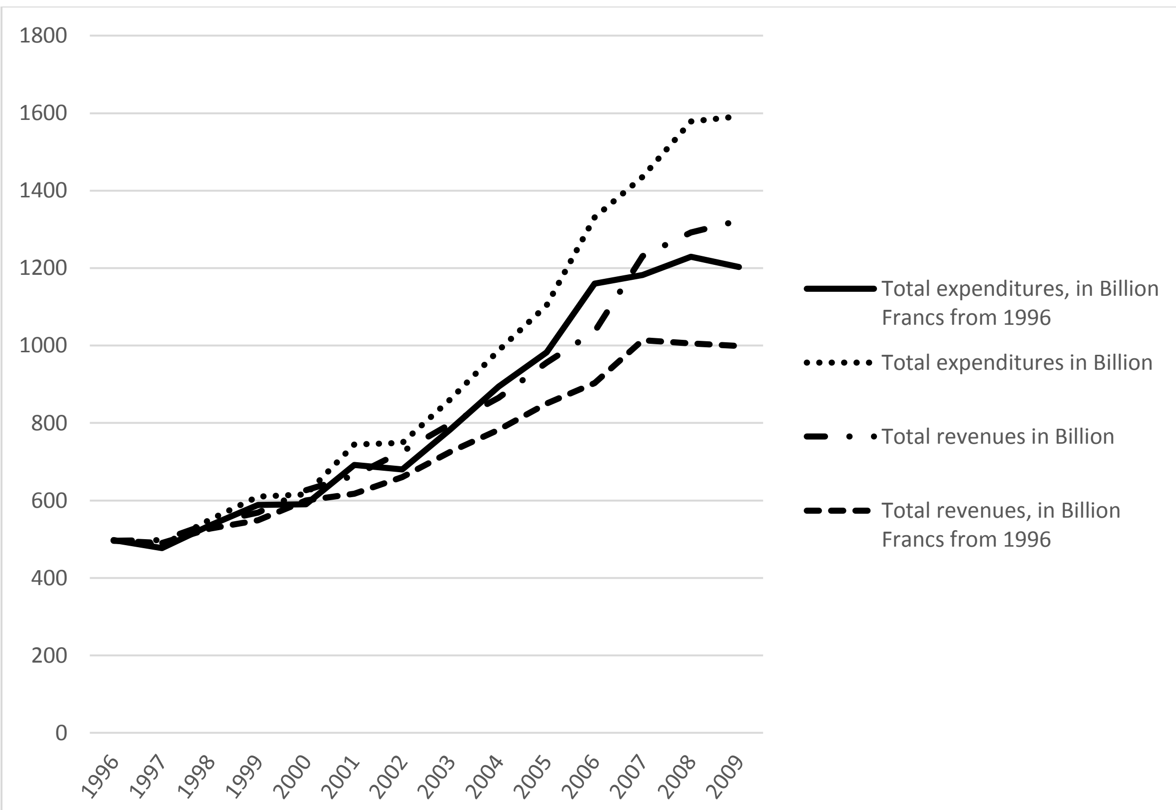
Table VI.A.6: Kolmogorov Test on average relative budget variances (authorizations) between G1 and G2, 2008-2009

Variable	Negative difference[d]	Positive difference	Absolute difference	Kolmogorov -Smirnov Z	P-value	Test result at 5%
Average relative variances	-0.28	0.14	0.28	0.53	0.96	Non-rejection of H0

Note: [d]) the differences correspond to the most extreme differences; the test is bilateral.

Source: Authors

Figure VI.A.1: Overall Expenditure and Overall Revenue Trends



Source: Authors

Chapter VII

Conclusion and Outlook

This dissertation consists of 5 contributions that address various aspects of policy-growth-poverty linkages and budget allocation from an economic perspective by using quantitative methods. The results obtained in this dissertation contribute to better understand how policies translate into growth and in turn, into achievement of policy goals like poverty reduction.

Government Expenditures, Health Outcomes, and Marginal Productivity of Agricultural Inputs: The Case of Tanzania

This contribution estimates empirically the impact of the changes in specific sub-categories of health expenditures at the district level on health status among farm households and the resulting effect on the marginal productivity of agricultural inputs, using the most recent nationally representative data for Tanzania. The study controls for heterogeneity of individuals, measurement errors on the health variables and endogeneity through the combination of a general structure covariance model and a two-stage residual inclusion method. The results highlight the fundamental importance of health. Farmer productivity is positively linked to health status of farm households that is impacted differently by different categories of government expenditures on health services. Efforts should be made by the government in this direction to avoid loss of agricultural productivity that can result from illness, especially with malaria. The analysis conducted in this contribution could be expanded to include other types of disease as well as more categories of expenditure in the health sector. Expenditures in other social sectors can also be included in future work.

An interesting analysis could be to run simulation at the macroeconomic level to assess the poverty impacts and long-term growth generated from the changes in the composition of health expenditures. This can be done by using a dynamic CGE model linked to a household microsimulation model. The parameters estimated in this paper can be inputted into a CGE model with the health sector disaggregated according to the sub-categories of health expenditures. Besides, the work can also be applied using other health indicators such as calorie intake, Body Mass Index (BMI) that might be more accurate *manifest variables* for the latent variable of household health status.

Catastrophic out-of-pocket payments for health and poverty nexus: evidence from Senegal

The purpose of this paper was to analyze the determinants of catastrophic household out-of-pocket health spending and its implications on poverty using Senegal as a case study. Quantification of these factors is necessary because it can provide a key to understanding household poverty and the problem of the health system in order to give useful insights to policy makers.

This study shows evidence that some households are affected by catastrophic out-of-pocket health expenditures and warrants the necessity for the government to assist them financially. Results also show that national poverty estimates should be considered as slightly overestimated when the impoverishing effects of catastrophic expenditures are not considered. A future research agenda could be to explore how the same idea could be applied to payroll taxes or any other expenditure that risks impoverishing households, but is unfortunately considered in the calculation household total expenditures often used as a proxy for household income.

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

This contribution provides an empirical evidence on the role of health investments in productivity. It also explores the long-term impact of policies assisting household against the catastrophic out-of-pocket health payments, taking the specific case of Senegal over the period 2011-2020. The simulation results indicate that policies reducing the cost and promoting consumption of health goods have a significant and positive impact on the agricultural sector growth and important spillover effects on the rest of the economy. It is essential to have an efficient health care system that does not put the entire financial burden of health services on households, especially the poor and most vulnerable groups, such as rural and urban agricultural households. The model could be extended to a life cycle model allowing households to smooth their health investment over time. The general equilibrium price substitution and income effects, the consumption and the saving are important to determine whether households spend more or less in health goods. However, we believe that it would be more realistic to include stochastic and parametric uncertainty in the behavioral demand for health care. A first attempt was done in this direction with the inclusion of a discrete error term in the equation of the household demand for health, allowing to simulate response to exogenous health shock.

Identifying key sectors and key policies of a PPG-strategy: A linked PIF and CGE-approach

This contribution estimates the impact of spending on policy programs on the growth and poverty reduction by combining empirical and expert data. A Policy Impact Function (PIF) is specified for each sector in each country and its parameters are estimated using conventional methods. The calculations of marginal budget productivity of public spending have shown that it is more costly to promote technical progress in the non-agricultural sectors compared to the agricultural sector. Besides, the application of the method to Senegal reveals that agricultural sectors appears to be more promising in generating poverty reduction. Beyond Agriculture, considerable potentials are found in some non-agricultural sectors.

The paper assessed the impact of desegregated agricultural policy programs within CAADP on sectoral productivity growth, while keeping economic investment in non-agricultural policies at the aggregated level. Further work will be to look at specific kinds of non-agricultural expenditures like health spending as treated in chapter II and IV. In fact, we could extend the work to other types of investment in human capital like education and social safety nets.

The CGE elasticities and multipliers might be overestimated due to the assumption of perfect mobility of the labor made in the model. The movements of workers from the rural to urban areas in order to be engaged in the expending non-agricultural sectors are often subject to high non-linear transaction costs that are not integrated in the model. Likewise, the withdrawal of workers from non-agriculture sectors to the simulated growing agricultural sectors might not be too realistic for all labor types. Poverty reduction might also be overestimated because of the equal income distribution resulting from additional growth within the different household types in the CGE model. In the real world, the growth is often in favor of the richest households. The model could be extended to better integrate market imperfections and more realistic distributional effects of income growth.

Furthermore, the empirical application of the Bayesian Alternative to Maximum Entropy could be extended by providing an estimation of the standard errors of the parameters. This could be done by proceeding in a manner similar to the approach used in Robillard and Robinson (1999) which specifies a set of values for the support distributions of the error terms.

Finally, the results of the simulation need to be interpreted with caution. The simulations do not integrate at the ends the other factors that can affect growth like prices and weather shocks in the agricultural sector. The estimated policy impact functions are partially based on prior information from experts' views that might be too optimistic in evaluating the efficiency of public spending.

Harmonized Budget Programming Reforms in Africa: Senegal's experience with MTEF

The Medium Term Expenditure Framework (MTEF) emerged in order to improve the budget management and allocation in many countries in Africa, including Senegal. This contribution revisited the recent development of the tool in Africa and conducts a midterm review using non-parametric statistics and with a particular interest in Senegal. The results show that predictability did not improve overall for ministries, the MTEF did not improve the budget discipline, and no increase of the resources allocated to priority sectors has been significantly observed compared to the previous period. However, some achievements has been noted such as a coherence of budget projections for the corresponding years in the rolling three-year programing method and an observed steady increase in the allocation to priority sectors since the MTEF has been adopted. This study provides a pioneer work for the evaluation of the MTEF in Senegal, but the limitation in the number of observations constitutes a weakness as the tool is quite recent. In further work, more rigorous impact assessment techniques could be employed to better evaluate the potentials and the achievements of this instrument. The analysis could also be done using an economic classification of the budget. However, doing this will require an effort to match budget spending on policy programs and economic sectors as the MTEF is only done to this date at the ministry level. While waiting for such extension, this first study shows evidence that efforts should be made in order to fully benefit from the potential generated by the MTEF and therefore achieve more effective management.

The research conducted in this dissertation can help governments, policy analysts and all development planners, especially in Agriculture, to fully understand the potentials for poverty reduction. This can help reduce the political performance gap with an efficient understanding of policies supporting Agriculture like the CAADP. This research can provide guidance for an efficient implementation of pro-poor growth strategies, particularly the evaluation, and the follow-up of the ongoing policies. The results shed light on the identification of strategic agricultural policy programs, sectoral priorities, and indirect agricultural policies in the health sector in order to foster sustainable economic growth and promote poverty reduction. The findings should also be of interest for both academics and stakeholders. The proposed Policy Impact Function is an appropriate tool for explaining the current political performance gap and analyzing current and future investment plans.

This dissertation brings valuable contributions to the literature on health and agricultural productivity nexus, budget allocation, and agricultural investment options. Furthermore, the consideration and the evaluation of the characteristics of the political actors like their specific political beliefs helped integrate country specific conditions in the economic analyses.

Curriculum vitae

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Since 2011 **Senior Research Analyst (current position)** - Research Analyst - Senior Research Assistant at IFPRI (International Food Policy Research Institute), West and Central Africa Office (WCAO), Dakar

2013 Ad hoc reviewer for Journal of Economic Behavior and Organization (JEBO), Agricultural Economics Journal, Reviewer for the African Growth and Development Policy (AGRODEP) Modeling Consortium, Reviewer at National School of Statistics and Economics (ENSAE)/Jury member.

2012 Teaching Development Economics in ENSAE
Teaching Macroeconomics in ENSAE

2011 Working Group at the French Institute for Research for Development - IRD - on access to drinking water: measurement indicators

Teaching Econometrics under Eviews and VBA (Visual Basic Application) in ENSAE-Junior Entreprise
Macroeconomics teacher for the training sessions for the common entrance exam in the African Schools of Statistics

2010 Internship at United Nations Development Program (UNDP-Regional Centre for West Africa and Central ASRO-WACA)
Evaluation of the Medium Term Expenditure Framework (MTEF) and Technical Committee of WAEMO for the validation of the Organic Law on the Finance Bill

Education

2013-2015: Christian Albrechts University of Kiel/Germany, PHd Researcher in Economics. In parallel with my full-time job as a researcher at the International Food Policy Research Institute (IFPRI).

2008-2011: National School of Statistics and Economic Analysis (ENSAE) - Engineer in Statistics and Economics.

2007-2008: Gaston Berger University - Bachelor degree in Computer Science / applied Science.

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