Heterogeneous responses to heterogeneous food price shocks in Senegal: insights from a CGE

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ABSTRACT

In the wake of the 2008 food crisis, prices of food staples in Senegal rose, with a new wave driven by international price shocks and a decline in productivity; these effects caused sub-optimal performance in the agricultural sector. This paper attempts to identify the implications of these recent price movements on the economy and on the welfare of general households. Our results show that non-agricultural households in rural areas are hurt the most by changes in the prices of staple foods; in urban areas, it appears that higher food prices may substantially affect agricultural households. The simulated low-magnitude changes in transaction costs in the agricultural sector have an impact on poverty.

Keywords: food prices, food security, productivity, poverty reduction, agriculture, Computable General Equilibrium Model

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The views expressed here are of my own and do not reflect those of IFPRI. All errors are mine.

INTRODUCTION

The recent increases of food prices and the last disappointing performance in agricultural sector put pressure on global food security.

In all the continent government tried to respond to these shocks by setting a set of strategic reforms such as suppression of import taxes. In Senegal, as in many other countries, the new wave of price hikes in 2011 raise concern as the country depends heavily on agriculture and food imports. This upward trend creates a tremendous regain of interest in analyses examining potential impacts of food price movements on the economy and checking whether they are beneficial or detrimental for households.

Senegal is vulnerable with its double dependence (alimentary dependence and dependence on energy). The food crop production estimated at 1 132 787 tons does not meet Senegalese's need evaluated at 2 333 886 tons. The production of the staple food generally covers barely 30% of consumption needs and the country relies on imports to satisfy the demand, especially for rice.

The trend of the general increase of the world price is accentuated by bad agricultural seasons beyond the international price movements. The production of 2007/2008 decreased by 24% compared to the previous year. The year 2011 was perturbed by irregularities of the rainy season with a bad repartition of the precipitation over time and across the country. As a result of this it was observed a decrease of cultivated land by 25% compared to the agricultural season of 2010 and 15% compared to the last five years. Industrial agriculture as well as food crop agriculture was affected. Indeed, the overall land allocated to cereals standing at 1 136 916 ha is marked by a 23% decline compared to 2010 and by 16% compared to the short term past trends. Groundnut that constitutes a major crop in Senegal observed a deeper decrease by 60% compared to 2010 and 31% compared to the trends of the period 2006-2011 with production of 768 478 tons (DAPSA, 2011). In a country where the majority of farmers relies heavily on rainfed agriculture these situations have considerable implication for the economy with marked disparities between zones. The cereal prices increaseat is estimated to 22% compared to the average of the last five years.

Facing up to these price increases government have initiated several programs. Good policy analyses need to incorporate the situation in agricultural sector regarding the available quantities, factors and the functioning of the market. This analysis should identify and plan appropriate response options to recent trends and price evolution prospects.

Commodity price transmission from international to domestic markets may differ widely across the regions given the regional disparities in infrastructure development and applicability of consumers or producers price supports in the different areas and markets. Prices variation also depends on the household characteristics (De Janvry et al, 1991). Producers in the different zones will respond to the shock, reallocating factors and reacting to changes of opportunity cost between the family and marketed labors. A bulk of studies applied a general equilibrium framework to analyze the impact the impact of food price shocks (Warr, 2008; Arndt et al, 2008; Van Campenhout et al, 2013; Estrades et Terra, 2011; Boysen et Matthews, 2012, Rutten et al, 2013).

Existing studies report varying results that might depend on the structure of the different economies. Estades and Terra (2011) by applying a CGE, found that an increase in commodity prices in 2006-2008 has a positive effect on the economy of Uruguay resulting from benefits obtained through a growth in export activities but affects the already poor population than become poorer. Similar findings are noted by Warr (2008) who found in Thailand that an increase in the price of rice has a negative impact on poverty. The shock has a positive impact on the overall economy coming from export gain but increase poverty level. In Mozambique, poverty also increases a result of shocks of higher food and fuel prices with a heterogeneous effect between rural and urban area (Arndt et al., 2008). In a more recent study, Nkang et al (2013) has investigated the impact of a rise in the price of imported food on agriculture and household poverty in the case of Nigeria by means of CGE model. Their study concludes that a rise in import price of food increased domestic output, but with a negative effect on the domestic supply of other agricultural commodities and it increase of poverty.

In their analysis on development issues of the free State Province of South Africa, Bahta et al (2014) found that the agricultural sector plays a significant the role of poverty alleviation and improving income distribution by using a CGE model and simulating negative external shocks such as an increase in the international oil price.

This paper attempts to cast a new light by assessing the heterogeneous impacts of food price increases in Senegal on both demand and supply side while also considering the complexity in causes to bring an adequate response. Using a CGE and the most recent data available in Senegal we will see the economy-wide effect as well as microeconomic impacts of changes in international prices. The analysis will also be extended by simulation shocks that may affect directly domestic prices such as increases in transaction cost, evolution of labor and land productivity or crop yields. The future evolution of the economy and the changes in population welfare induced by changes in crop yields under different scenarios that may occur will be analyzed in addition, in the context of increase of government willingness to undertake actions against food insecurity. The purpose is to shed light on the impacts of recent trends of food prices on households' welfare and on the economy, leading us further to see the policy implications of international and domestic prices changes.

Boccanfuso and Savard (2009) used a CGE to look at the impact of the 2008 food crisis both in Senegal and in Mali. Using household survey (ESAM I, 1994/1995), their simulations show that the rural households seem to bear the brunt of the external shocks and show also a positive impact on urban households. However, we find less realistic their simulations based on land expansion as their model doesn't really distinguish land as a specific factor. We somewhat revisit and extend their analyses by looking at the other crops shocks as we know that price increases are not generally focused on one particular crop and also by considering net trade status for some crops. Impact of shocks on income changes and supply responses also may vary considerably across household groups and but also spread beyond consumers to producers across regions and by type of speculation.

Our analysis by using the more recent household poverty survey in Senegal (ESPS II, 2011) wants to check for heterogeneous responses that may exist across the country in both the production side and the demand side. This is possible with the many-to-many mapping of activities in the model and the disaggregated demand side. The use of a more recent household survey data can help to encompass the real effect of food price changes based on more realistic assumptions on price evolution in the modelling.

A deeper analysis of the impact of the food price shocks in the economy will be led. The analysis will also involve many types of speculations. Investigations that try to assess the economy-wide effect of price shocks are not numerous, however some authors have looked at the price transmission process within the country. Badiane et al. (2010) in a local perspective used a dynamic model for price formation that uses estimates of special integration across the local markets to assess the responses of local price market to policy. Their empirical findings indicate that a liberalization of groundnut prices allowing domestic prices to reflect their international levels will change the prices in the border city of Dakar, which happens to be the central market that determines prices in the local market of the producing regions.

The outline of this article is as follows. Firstly, we will present the agricultural sector in Senegal. Secondly the analytical framework will be presented and estimates and discussions of the results will follow.

1. Key structural features of the Senegal agricultural economy

In Senegal, agriculture is the main economic activity in rural areas (60% of the population live in rural areas), accounting for around 45% of the workforce in 2012 (EPSPS, 2011) with a contribution to GDP of around 15% in general. Nevertheless, the sector faces several problems and the production growth fell from the late 1960s. The annual growth rate of the national GDP between 2005 and 2008 is around 3.5% that is below the government target of 7% as specified in the Strategy of Accelerated Growth (SCA).

Agriculture has a great potential to contribute to the reduction of food insecurity. The Senegalese government has adopted a set of strategic directions and has undertaken a series of measures to boost agricultural development and improve living conditions of the farmers. This voluntary option of the government toward development has resulted in the follows: establishment of the SCA (Accelerated Growth Strategy), implementation of the initiatives REVA (Return to Agriculture) and GOANA (Great Offensive for Food and Abundance), the adoption and promulgation of the Agro - Sylvo - Pastoral Orientation Law (LOASP) and the National Programamme of Agricultural Investment (PNIA) so that the sector experienced enough good performance. However, during the last years, especially in 2011, agriculture sector and households become highly vulnerable to the rainfall season that lower productivity and also affected by changes in world commodity prices.

Regarding poverty reduction and human development indicators, Senegal has experienced mixed results. The proportion of those living below the poverty line changed from 50.8 in 2005 to 46.7% in 2011.

Senegalese agriculture is mainly rainfed and seasonal. The peanut sector is the engine of the rural economy and is cultivated in 40% of the available land in the country and contributes to the national trade development, livestock feeding, export earnings. Along the past decade peanut production fluctuates with a sharp and a decreasing trend from about 895000 tons in 2000/2001 to a low peak of 265,000 tons in 2002/2003 and 331,000 tons in 2007/2008. The poor performance in the the peanut sub-sector is explained by a decrease in productivity and by an unfavorable international context marked by declining prices.

Senegal is among the world's leading exporters of peanut. Smallholders or agricultural actors in general combine food crops (rice, millet, maize etc.) and industrial crops (peanut, tomato, cotton, sugar cane etc.).

Senegal is a net importer of rice and heavily depends on the international rice market. The Aggregate rice consumption level stood at 800 000 tons in 2007.

Table 1: Agricultural structure table

Variable (%) Crop	Value added share	Production share	Employment share	Export share	Export as Share of domestic demand	Import share	Imports as Share of domestic demand

Maize	0.20	0.10	0.60	0.00	0.00	0.20	32.90
Rice	0.60	0.30	2.70	0.30	11.80	3.40	78.00
Millet	0.90	0.50	3.00	0.00	0.00	0.00	0.08
Other cereals (fonio)	0.00	0.01	0.02	0.00	0.00	0.00	5.40
Manioc	0.50	0.30	1.40	0.00	0.00	0.05	29.40
Cow pea & other roots	0.10	0.07	0.40	0.00	0.00	0.10	10.40
Vegetables	1.50	0.90	4.80	0.40	6.40	0.30	3.10
Fruits	1.50	0.90	3.80	0.20	2.10	0.09	49.30
Peanuts	1.00	0.60	3.20	0.60	1.90	0.00	2.90
Others oils	0.70	0.40	1.10	0.00	0.00	0.00	9.10
Other crops (industrial tomato. Sugar cane etc.)	0.50	0.30	2.30	0.60	26.60	0.70	73.10
Livestock and hunting	5.80	3.40	15.40	0.00	0.00	0.00	43.90
Forestry/Forest exploitation	1.30	0.90	0.10	0.10	1.40	0.07	60.60
Fisheries	3.40	2.50	2.50	6.80	19.60	0.70	29.90
Agriculture	17.80	11.00	41.30	9.10	6.40	5.60	13.50
Non-agriculture	82.20	89.00	58.70	90.90	13.60	94.40	29.90

Source: Author from the model

2. Modeling framework

Computable General Equilibrium (CGE) models are a standard tool of analysis widely used to assess distributional impacts of policies by simulating the functioning of the whole economy.

The CGE model used in this paper is the IFPRI standard model developed by International Food Policy Research Institute (IFPRI) and documented in Lofgren (2002). The CGE is calibrated using the 2011 agricultural social accounting matrix that was built within this analysis. A social accounting matrix is a comprehensive, economy wide data framework, giving a coherent presentation of the transaction within agents that take place in an economy (households, activities, government and the rest of the world).

The IFPRI standard model incorporates features of particular importance in the developing countries and some of them are applicable in our study such as explicit treatment of the transaction cost for commodities that enters in the market sphere, separation between production activities and commodities with a many-to-many mapping that allows any activity to produce multiple commodities and any commodity to be produced by multiple activities and taxes disaggregated by tax type each of which forwards its revenue to the core government account.

A brief presentation of the model is done while a detailed model description can be found in Löfgren et al. (2002). This latter paper includes the mathematical model statement with an equation-by-equation presentation, its features and its data requirement.

The CGE model follows the level of disaggregation provided in the detailed agricultural Social Accouning Matrix (SAM) that we built.

The CGE has eleven agricultural commodities accounts defined in the SAM. The aggregated agricultural sector is completed by the Livestock, Forestry and Fisheries accounts. Detailed information about the non-agricultural sectors (industry and services) is also provided and the model aims assesses to capture the linkage between all these sectors.

The model is written as a set of simultaneous equation, including several nonlinear equations, defining the behavior of the different agents.

The model assumes that each producer maximizes its profits by choosing the quantities such as the marginal revenue product of the different factors is equal to their rents. The structure of the production technology has at the top level a constant elasticity of substitution (CES) function of the quantities of value-added and aggregate intermediate input. The latter itself is a CES function of factors, whereas the former is a Leontief of disaggregated intermediate inputs.

Households in the model are categorized in our analyses into height groups depending on the residence location, their activity and their poverty status. They receive payment from the factors of production and transfers and use these incomes to purchase goods and services, save, pay taxes and transfers to the other institutions. Linear expenditure system (LES) demand functions resulting from a Stone-Geary utility function specification is used to model the behavioral functions of household consumption.

As previously said, thegovernment is disaggregated into a core government account and different tax accounts. The government uses incomes from tax collection and received transfers from the others instructions to purchase commodities (government consumption) and to distribute transfers to the other institutions. The last institution is the rest of the world that supplies imports to Senegal and purchases exports from Senegal.

An aggregated domestic output from the outputs of different activities of a given commodity is computed through a CES function to take into account imperfect substitutability between these outputs.

The aggregated domestic output is allocated between domestic sales and exports using a constant elasticity of transformation (CET) to reflect the imperfect transformability between these two types of sales. The price received by domestic suppliers for exports is expressed in domestic currency and adjusted for the transaction costs (to the border) whereas the supply price for domestic sales is equal to the price paid by domestic demanders minus the transaction costs of domestic marketing (from the supplier to the demander) per unit of domestic sales. An Armington function is used to model imperfect substitutability between domestic output supplied for the domestic market and imports (Löfgren et al., 2002). The equations of the models are presented in the appendix.

The disaggregation of the accounts includes the following features: disaggregation of agricultural account into 11 crops plus livestock, fishing and forestry, disaggregation into 14 regions on the crop production side, disaggregation of households into height 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.

This disaggregation allows us to take into account heterogeneity that may exist regarding the poverty status of households and their sources of income (transfer payments, capital, labor and land incomes and foreign income). Indeed, it is widely recognized that there is a significant linkage between household geographical locations (rural vs urban), their sources of income and their overall income levels.

This also helps to consider differences of production structure that might exist across the country and can be interesting when analyzing how governments have prioritized their infrastructure expenditures not only across crops but also across regions. The disaggregation at the regional level was motivated mainly by the fact that production quantities for different crops where available at regional level and Senegal's regions are somewhat counterpoints of economic interest regarding crop production. But, there may have some spillover effects. The regional special division of production activity suits when we want to assess the different regional policies implemented by the government that are location and crop specific.

The agricultural activity accounts represent multiproduct firms as representing different regions that produce a combination of agricultural commodities. Contrary to the most frequent approach (one-to-one mapping between activities and commodities) this disaggregation will provide a model where at least one activity produces more than one commodity and/or at least one commodity is supplied by more than one activity.

Millet is the most widely grown cereal in Senegal. Kaolack, Kaffrine and Fatick are mainly the regions where millet is grown. These regions constitute also the core of the groundnut basin and millet and peanut are usually interchanged. Sorghum is the second rainfed cereal in the country. Fonio is almost exclusively produced in Sedhiou, Kedougou and Kolda.

Rice occupies the first place in the Senegalese diet as being the mostly commonly consumed and purchased on markets by 90% of rural and urban households[2]. Aggregate rice consumption level stood at 800 000 tons in 2007. However, as a large rice importer, Senegal depends on international rice markets.

The principal zones of production are in the Senegal River Valley and in the Anambé basin for the irrigated rice and in the Casamance zone (Ziguinchor, Kolda, and Sedhiou) for the rainfed production.

Dakar and Thies regions of Niayes and the Senegal River Valley are the places where vegetable production is the most oriented. These areas also with the region of ziguinchor are the most important zones where fruits are produced. Table 2 provides list of the agricultural sub-sectors and the activities present in the model.

Table 2: Agricultural commodities and sectors in the model

Agricultural sub-sectors	**Non-agricultural sub-sectors**	
	Industrial sub-sectors	**Services sub-sectors**
Maize	Mining	Trade
Rice	Food processing and beverages	Repair services
Millet	Tabacco products	Hotels and catering
Other cereals (fonio)	Textiles manufacturing	Transport
Manioc	Leather manufacturing	Post and telecommunications
Cow pea & other roots	Wood	Financial service
Vegetables	Paper	Real estate services
Fruits	Petroleum products	
Peanuts	Chemical products	Activity of business services
Others oils	Rubber products	
Other crops (industrial tomato, sugar cane etc.)	Glass and pottery	Activity of public administration
Livestock and hunting	Metallurgy	Education and training
Forestry/Forest exploitation	Machinery & equipment	Health activity and social action

[2] Global vulnerability, food security and nutrition analysis /AGVSAN, 2010

Fisheries	Construction of transport material	
		Community & other private services
	Others construction	
	Electricity, Water & Gas	
	Construction	

Source: Author

To assess the impact of growth on poverty using headcount, depth and severity measurement we use a micro-simulation model which takes into account the poverty distribution in the country. The model is based on the 2011 poverty monitoring survey ESPS II (Enquête de Suivi de la Pauvreté au Sénégal),. Endogenous changes in consumption resulting from the CGE model are passed down to the household by linking each of the household in the micro simulation model to the corresponding household in the CGE.

The 2011 poverty monitoring survey aims to draw poverty profiles and to highlight the socioeconomic characteristics of the different social groups.

It is a random sample survey at the 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 17891 households with 5953 households constituting the sub-sample from which the questionnaire on expenditures was administrated. Our study is based on this sub-sample that gives a representative poverty measure in Senegal.

The method is a non-parametric micro simulation based on cross entropy (Robillard and Robinson, 1999). The calculated poverty indexes evaluated in the micro simulation module are the FGT (Foster-Greer-Thorbecke) family of poverty measures that propose summary indicators of the extent of poverty.

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

For $\alpha = 0$ the FGT index collapses to the headcount ratio P_0 , the most widely used statistics that measures the proportion of the population that is poor but does not show how poor the poor are. For $\alpha = 1$ gives the poverty gap index (P_1) that measures the extent to which individuals fall below the poverty line as 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 $\alpha = 2$ yields the severity by squaring the normalized gap (P2) and thus weighs the gap by the gap.

The cost of basic need approach is used to define the poverty line. This method first estimates the cost of acquiring enough food for adequate nutrition, 2400 calories per adult per day and then adds the cost of other essentials.

Based on the past magnitude of the increases of the food prices in Senegal driven also by the 2008 food crisis we exogenously simulate international price shocks as well as shocks affecting domestic prices.

The widespread effect of these simulations on the economy and on the welfare of the population will be assessed. When modeling international import price shocks we also try to consider that the economy wide effect and increases in poverty are likely to be less severe when taking account the food exporting status or net trade status of the country, holding constant other factors such as inequality in land distribution. Considering this, simulations combining both evolutions of import and export prices are implemented.

Among the shocks that are likely to affect the domestic price we can note those on agricultural productivity (labor, land or total factor productivity).

The impact of external shocks of world oil prices in agriculture sector and non-agricultural sectors that use fuel intensively will be examined, this but may largely depends on the degree of incorporation of technologically advanced equipment in agricultural food production process. Higher oil prices lead to higher fuel prices that may impact the cost of farming.

International Food Policy Research Institute (IFPRI) mentioned a strong link between rising oil prices and commodity price escalation[3]. However the World Bank reported in 2010 that the impact of biofuels on food prices has been overstated[4]. There is no evidence that oil price shocks have been associated with an increase in food prices.

But, it is more evident to demonstrate that an increase in fuel price may lead to an increase in food price, rather than the opposite. This is because higher oil prices translate into higher fuel prices that may incur additional costs. In addition, following Van Campenhout et al., 2013 simulations corresponding to changes in transaction costs and agricultural productivity shocks will be implemented. In general, earlier studies have not included specific transaction costs in their analyses even if changes in oil price

[3] IFPRI, Global Food Crisis, 2010

[4] World Bank Development Prospects Group, Placing the 2006/08 Commodity Price Boom into Perspective, July 2010

somewhat may affect indirectly transaction costs. The productivity scenarios reflect the recent worsening of crops yield, especially in 2011/2012 by taking account the magnitude for the different crops. Simulation assumptions are presented in table 3.

Table 3: Simulation designs

Price shock on		**Rice**	**Groundnut**	**Maize**	**Food processing**	**Scenarios**
Cereal crops & food		35% (i)	10% (e)	22% (i) 8% (e)	5%	Combined
Cereal crops		35% (i)	10% (e)	22% (i) 8% (e)		Combined
Rice shocks		35% (i)				
Groundnut exports			10% (e)			
Maize				22% (i) 8% (e)		
Processed food					5%	
Agricultural supply	Productivity scenarios					Based on crop yields
Transaction cost						5%
Oil products						30%

Note: e: export price. i: import price.

Source : Author

For each scenario, the variables of interest that are shifted by using the experiment parameters specified above are presented in the table below.

Table 4: Simulation descriptions

Simulation names	**Description**	**Simulation names**	**Description**
SIM_PROD_1	Shock on land productivity for cereal crops	**SIM_RICE**	Shock on rice price

SIM_PROD_2	Shock on land productivity in peanut sector	**SIM_PEA**	Shock on groundnut price
SIM_PROD_3	Combined shock on land productivity in agricultural crops	**SIM_CEREAL**	Combined changes on cereals and Peanut prices
SIM_PROD_4	Decline of overall agricultural total factor productivity	**SIM_FOOD**	Shock on food processing prices
SIM_TRANSAC	Increase of transaction costs	**SIM_CEREAL_ FOOD**	Combined simulation for cereals, groundnuts and food processing goods.
SIM_OIL	Oil price increase		

Note: The experiment parameters for the shocks are presented in Table 3.

Source: Author

Food crops have not performed well recently, mainly in 2011 with the substantial yield declines. To capture these trends we simulated crop yield decreases. We targeted decline of 9% for rice, 20% for millet and 26% maize (SIM_PROD_1). These figures are based on crop yield data computed from the 2011 agricultural household survey conducted by the Department of Analysis and Prevision of Agricultural Statistics (DAPSA). SIM_PROD_3 and SIM_PROD_4 respectively simulate negative shock on land productivity for agriculture crops (a decline of 20%) and 10% decline on agricultural[5] total factor productivity.

3. Results and discussions

3.1. Macroeconomic impact of food price shocks

The macroeconomic effects of food price changes may impact the level of per capita income which is the key factor of the welfare measurement analyzed later in order to assess implications in terms of poverty and food security.

[5] Agriculture as a whole, including livestock, fishing and forestry

The results of the simulation are consigned in Table 4. Absorption decreases in all the simulations as a result of the combined effect on GDP and the rade deficit. The effects are also negative in terms of investment.

SIM_CEREAL_FOOD shows the largest decrease in Agricultural GDP at factor costs (-2.6%). A movement of international prices of commodities such as maize or rice causes a decline of export as a result of behavioral changes of consumers and producers following the shift of different prices. When looking at the sub sectorial level, higher import prices discourage imports and tend to boost domestic production in these sub-sectors experiencing the largest increase of price.

International declining price of rice contributes the most to the observed effect in the combined simulation (SIM_CEREAL_FOOD).

Table 5: Macroeconomic impacts of international food price shocks

Simulations Variable	Initial Value	SIM _RICE	SIM _PEA	SIM _CEREAL	SIM _FOOD	SIM_CEREAL _FOOD	SIM_ TRANSAC	SIM _OIL
Absorption	8048.29	-1.90	-1.06	-3.13	-0.36	-3.28	-0.17	-2.37
Private consumption	5733.17	-2.29	-0.45	-3.04	-0.54	-3.30	-0.33	-2.28
Investment	1611.20	-1.33	-3.73	-4.82	0.15	-4.65	0.34	-3.73
Exports	1742.21	-4.29	-7.09	-10.82	0.81	-9.81	0.24	0.29
Imports	-2954.07	-3.26	-2.90	-6.18	-0.47	-6.37	0.14	-3.64
GDP market price	6836.43	-1.91	-1.81	-3.77	-0.01	-3.61	-0.20	-1.15
Net Indirect Taxes	956.79	-3.14	-4.74	-7.49	-0.56	-7.78	-2.48	-5.07
GDP at factor cost	5879.64	-1.71	-1.33	-3.17	0.08	-2.93	0.18	-0.51
GDP at factor cost Agriculture	1048.33	-0.79	-2.37	-2.55	-0.015	-2.60	-1.50	1.16

Note: Absorption = GDP + Imports – Exports = Consumption + Investment + Government spending

Source: Author, results from the model

The different changes in consumer prices in the different agricultural subsectors are shown in the following table. Considering the scenario where import price and export prices of the cereals, groundnuts and food processing goods (SIM_CEREAL_FOOD) are simulated we find that rice, maize and vegetable experienced the largest price increase. Prices of all the agriculture commodity increase as famers might reallocate resources to absorb the shocks.

Only changes in cereals and Peanut (SIM_CEREAL) are sufficient to have a spillover effect on the price of food processing products. The magnitude of this change increase when combining change in import prices of food processing products with change in cereals and peanut imports and export prices.

Transaction cost hike (SIM_TRANSAC) raises prices of almost all agricultural commodities pointing out the importance of transport development to mitigate the effect of food price hikes.

We found also that oil price increases (SIM_OIL) escalate only price in sub-sectors such as mining, chemical manufacture, glass manufacture, construction, water and electricity and transport (Appendix A1). The link between oil price and agricultural prices appears largely driven by macroeconomic determinants of these prices rather than the pass-through from oil prices. The effect on agricultural prices is limited by the fact that sectors that have experienced the highest price increases are those of the secondary and tertiary sectors especially those listed above. These are more capital and machinery dependent compared to the agricultural sector and therefore are immediately affected by the oil price hikes. However, as resources are limited, a decline of the activities in these sectors might reorient the resource, especially displaced labor towards the agricultural sector. The resulting shift of the production in the agricultural sector leads to a price decrease that might outweigh the effect on transaction costs. The neutrality of agricultural prices to oil price movement may be due to the relatively low energy intense production processes compared to other sectors. The non automatic increase of agricultural price following oil price shock is consistent with findings some findings in the literature (Nazlioglu and Soytas ,2011).

Table 6: Consumer prices of composite good

Simulations Crops	SIM _RICE	SIM _PEA	SIM _CEREAL	SIM _FOOD	SIM_CEREAL _FOOD	SIM _TRANSAC	SIM _OIL
Maize	0.47	1.26	5.64	-0.77	4.83	1.41	-1.19
Rice	20.31	-1.09	22.27	-0.68	18.83	0.87	-0.43
Millet	0.54	2.94	3.35	-0.82	2.58	1.68	-1.51
Other cereals	-0.02	1.07	0.94	-0.75	0.24	2.57	-0.92
Manioc	0.87	3.16	3.91	-0.83	3.09	0.3	-1.44
Cow pea & other roots	0.55	1.64	2.05	-0.78	1.31	0.41	-1.09
Vegetables	1.91	2.26	4.13	-0.83	3.18	-0.17	-1.33
Fruits	1.08	2.21	3.18	-0.82	2.32	1.05	-1.54
Peanuts	0.65	-1.5	-0.6	-0.84	-1.57	1.53	-1.8
Others oils	0.87	2.3	3.15	-0.84	2.29	0.3	-1.59
Other crops	0.51	0.41	0.74	-0.77	-0.00	0.42	-1.26
Food processing	0.5	-0.22	0.37	1.35	1.62	-0.05	-0.71

Source: Author, results from the model

Note: All price changes are expressed relative to a Consumer Price Index.

The esults show some inequalities in land and income distribution that may lead to difference in poverty across the country as a result of price shocks (Appendix A2). Results show marginal increases in returns to non-educated labor and to land in the simulations of international agricultural food price shocks.

However, not all the households across the countries benefit from this. The region of Saint-Louis experiences the greater evolution. Higher food prices in the combined international price shocks stimulate demand for non-educated labor.

The returns for the other types of labor are affected negatively. Agricultural capital increases also in SIM_CEREAL_FOOD as a result of demand extension toward export goods and the import competing goods. But shock in food processing prices expressed independently tends to have the opposite effect on factors. International oil price shock (SIM_OIL) decreases the return for all the factors except non-educated labor that are less likely to be in sector that are more fuel dependent.

The results of simulations on agricultural productivity shocks that affect domestic price are presented in table 6. Agricultural GDP contracts in all of the scenarios reflecting a decline of productivity. However, productivity shocks that affect only staple food don't lead necessarily to a decline of the national GDP contrarily to shocks affecting the agricultural sector as a whole, considering livestock and fishing.

This shows the importance of these latter which are generally left behind in the policy programs like the Comprehensive Africa Agriculture Development Program (CAADP), despite its relative importance in agricultural sector.

Table 7: Macroeconomic impacts of productivity shocks

	INITIAL	SIM _PROD_1	SIM _PROD_2	SIM _PROD_3	SIM _PROD_4
Absorption	8048.29	0.05	-1.65	0.06	-1.03
Private consumption	5733.17	-0.22	-1.88	0.03	-1.61
Investment	1611.20	1.02	-1.55	0.23	0.62
Exports	1742.21	1.52	-2.92	0.51	1.67
Imports	-2954.07	0.89	-1.72	0.30	0.99
GDP market price	6836.43	0.05	-1.94	0.08	-1.21
Net Indirect Taxes	956.79	-0.02	-1.99	0.15	-0.72
GDP at factor cost	5879.64	0.07	-1.93	0.06	-1.29
GDP at factor cost Agriculture	1048.33	-2.12	-4.23	-0.58	-10.03

Source: Author, results from the model

The prices of the crops affected by the shocks increase compared to the non-affected sub-sectors, as a result of the contraction of the domestic production (for example in SIM_PROD_1 cereals crop experienced hikes in their prices, peanut in SIM_PROD_2). Price level in Food processing sector also increases and therefore raising concerns about food security.

Table 8: Agricultural commodity prices

Simulations Crops	SIM _PROD_1	SIM _PROD_2	SIM _PROD_3	SIM _PROD_4
Maize	11.80	0.44	0.37	2.04
Rice	1.17	-0.01	0.54	-0.22
Millet	18.76	1.10	0.75	3.51
Other cereals	-0.35	-0.26	0.04	-1.23
Manioc	-0.66	1.58	1.08	5.96
Cow pea & other roots	13.00	1.08	0.78	3.49
Vegetables	-1.02	1.04	0.88	5.76
Fruits	-0.72	0.69	0.55	4.52
Peanuts	-0.34	57.18	0.74	4.00
Others oils	-0.72	0.36	-0.15	6.21
Other crops	-0.58	0.09	-0.11	2.71
Food processing	0.15	0.56	0.02	0.13

Source: Author, results from the model

3.2. Impact on poverty

The poverty implications of the simulations are derived to see the extent to which shocks affect households. Price changes may affect poverty and exacerbate food insecurity through many channels like change in factor returns and income, availability of local goods for consumption, change of the purchasing power, reconfiguration of labor market and reallocation of factors and substitutability between products. Household-level micro simulations capture the heterogeneous effects of food price changes on the net real incomes and take into account their situation of net seller or not buyer of the different households. The impacts of selected simulations on the welfare of rural, urban, agricultural and non-agricultural households are shown in table 8 using the FGT class of poverty measures presented earlier.

The results reveal that poverty increase in all the household categories when facing up to a simultaneous international price hikes affecting foods. In urban area results indicate that higher food price may substantially affect agricultural household group which tend to contain initially a large share of the poor in the urban sample and produce a small quantity of food while imported and marketed food account for a considerable share of their spending what may lower their real disposable income. This is consistent with findings in the literature (Dessus et al., 2008; Wodon et al., 2008). The urban non-agricultural households are generally involved in other activities that are less subject to international price changes. They experienced an increase in poverty of 0.9 points of percentage, whereas it has been noted a change by 1.1 points of percentage for urban agricultural households.

Concerning rural area, results show that non-agricultural households are hurt the most by changes in food price mainly driven by international food staple prices. The large share of consumption of non-marketed commodities (home consumption) for agricultural households make minor the effect of price hikes compared to rural non-agricultural households. Rural non-agricultural household and urban agricultural household group record also the higher increase in poverty gap and poverty severity compared to the initial references of poverty measures.

The final change on the poverty measures depends on the contribution of these different household groups to the overall poverty. The decline of welfare at the national level is in phase with the general diminishing of the factor incomes observed in the earlier results. The impacts will be more severe with higher spikes in staple food prices.

Rural agricultural households registered the highest increase in poverty with a small increase in transaction costs.

The results of the simulations implemented for evaluation of the welfare implication of recent crop yield changes demonstrate that productivity decline also affects the poverty especially for those living in rural areas.

Yield improvement tends to shrink the poverty level. Simulations don't explicitly take into consideration adaptation such as the increase of the amount of fertilizer used or again irrigation that may attenuate effects on households' welfare. However, the model allows substitution between factors and assumes that technology of production may vary by areas and by crop.

There is a need for policy that can mitigate these shocks reflecting current trends on prices and crop yields.

Table 9: The FGT poverty indices for the household groups

		Initial poverty rate	SIM_CEREAL _FOOD	SIM _TRANSAC	SIM _PROD_1
Headcount P0					
	Senegal	46.7	1.0	0.1	0.4
	Rural ag	61.1	0.4	0.2	1.5
	Rural non-ag	54.5	0.9	0.1	0.5
	Urban ag	43.0	1.1	0.1	1.8
	Urban non-ag	32.7	0.9	0.1	0.4
Poverty Gap P1					
	Senegal	14.5	0.5	0.1	0.3
	Rural ag	18.8	0.2	0.1	0.8
	Rural non-ag	18.5	0.6	0.1	0.3
	Urban ag	13.0	0.5	0.1	0.8

	Urban non-ag	9.0	0.4	0.1	0.2
Poverty Severity P2					
	Senegal	6.6	0.3	0.0	0.2
	Rural ag	8.2	0.1	0.1	0.5
	Rural non-ag	9.0	0.3	0.0	0.2
	Urban ag	5.6	0.3	0.1	0.4
	Urban non-ag	3.8	0.2	0.0	0.1

Source: own calculations

Conclusion

This paper extends existing research in the literature analyzing the impact of staple food price hikes on the economy and the welfare of the households. This is done in the case of Senegal, using the most recent household survey data and drawing heterogeneous scenarios based on international price and productivity-related domestic price shocks.

The focus should be put on issues related to decreasing of productivity of staple food crops in Senegal as they constitute the key factors for households' revenue and consumption. We have also concerning some policy programs to bear in mind that we have to look to agriculture as a whole. GDP evolution facing to a context of productivity decline is driven by the performance not only in crop food sub-sectors but also in livestock and fisheries sector.

As our results indicate that the impacts of food price shocks are marked by heterogeneity regarding factor income distribution, household location and activity, policy option in response to food price hikes should be targeted to optimize the impact on poverty reduction. These policies can include cash transfers to vulnerable households to improve their purchasing power without risk of reducing the revenue of food crops for net supplier households or having disincentive effects on local production by lowering producer food prices. Policies should not have negative spillover effects such that the incomes of net seller are deeply affected.

Results show that non-agricultural households are hurt the most by changes in international food staple prices in the rural area whereas in urban area results indicate that higher food price may substantially affect agricultural households. The simulated low magnitude change in transaction costs faced by households, generally due to remoteness and infrastructure quality, has an impact on poverty, especially in rural areas, albeit marginally. Lowering transaction costs could have substantial welfare effects and public investments may hold great potential to alleviate poverty by creating more market opportunities for smallholders. Communication and storage facilities can stimulate the spatial integration of market factors and of the farms' production and increase their market participation as targeted by the National Rural Infrastructure Project (NRIP). Sustainability of infrastructure also has to be ensured by reinforcing the internalization process of the different beneficiaries.

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Appendix

Model description

Price, production and trade blocks

$$QINT_{c\,a} = ica_{ca} \cdot QINTA_a \tag{1}$$

$$PINTA_a = \sum_{c \in C} PQ_c \cdot ica_{ca} \tag{2}$$

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

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

$QVA_a = \alpha_a^{va} \cdot \left(\sum_{f \in F} \delta_{f\,a}^{va} \cdot \left(QF_{f\,a}\right)^{-\rho_a^{va}} \right)^{-\frac{1}{\rho_a^{va}}}$	(3)
$W_f \cdot \overline{WFDIST}_{fa} = PVA_a \cdot \left(1 - tva_a\right) \cdot QVA_a \cdot \left(\sum_{f \in F'} \delta_{f\,a}^{va} \cdot \left(QF_{f\,a}\right)^{-\rho_a^{va}} \right)^{-1} \cdot \delta_{f\,a}^{va} \cdot \left(QF_{f\,a}\right)^{-\rho_a^{va}-1}$	(4)
$QVA_a = iva_a \cdot QA_a \quad a \; in \; ALEO$	(5)
$QINTA_a = inta_a \cdot QA_a \quad a \; in \; ALEO$	(6)
$PA_a \cdot (1 - ta_a) \cdot QA_a = PVA_a \cdot QVA_a + PINTA_a \cdot QINTA_a$	(7)
$QXAC_{a\,c} = \theta_{a\,c} \cdot QA_a$	(8)
$PA_a = \sum_{c \in C} PXAC_{ac} \cdot \theta_{ac}$	(9)
$QX_c = \alpha_c^{ac} \cdot \left(\sum_{a \in A} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{\;-\rho_c^{ac}} \right)^{-\frac{1}{\rho_c^{ac}-1}}$	(10)
$PXAC_{a\,c} = PX_c \cdot QX_c \left(\sum_{a \in A'} \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}} \right)^{-1} \cdot \delta_{a\,c}^{ac} \cdot QXAC_{a\,c}^{-\rho_c^{ac}-1}$	(11)
$PE_c = pwe_c \cdot EXR - \sum_{c' \in CT} PQ_c \cdot ice_{c'c}$	(15)
$QX_c = \alpha_c^t \cdot \left(\delta_c^t \cdot QE_c^{\rho_c^t} + (1 - \delta_c^t) \cdot QD_c^{\rho_c^t} \right)^{\frac{1}{\rho_c^t}}$	(16)
$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} \cdot \frac{1 - \delta_c^t}{\delta_c^t} \right)^{\frac{1}{\rho_c^t - 1}}$	(17)
$QX_c = QD_c + QE_c$	(18)
$PX_c \cdot QX_c = PDS_c \cdot QD_c + PE_c \cdot QE_c$	(19)
$PDD_c = PDS_c + \sum_{c' \in CT} PQ_{c'} \cdot icd_{c'c}$	(20)
$PM_c = pwm_c \cdot \left(1 + tm_c \right) \cdot EXR + \sum_{c' \in CT} PQ_{c'} \cdot icm_{c'\,c}$	(24)

$QQ_c = \alpha_c^q \cdot \left(\delta_c^q \cdot QM_c^{-\rho_c^q} + (1-\delta_c^q) \cdot QD_c^{-\rho_c^q} \right)^{-\frac{1}{\rho_c^q}}$	(25)
$\dfrac{QM_c}{QD_c} = \left(\dfrac{PDD_c}{PM_c} \cdot \dfrac{\delta_c^q}{1-\delta_c^q} \right)^{\frac{1}{1+\rho_c^q}}$	(26)
$QQ_c = QD_c + QM_c$	(27)
$PQ_c \cdot (\ 1 - tq_c\ ) \cdot QQ_c\ =\ PDD_c \cdot QD_c + PM_c \cdot QM_c$	(28)
$QT_c = \sum_{c' \in C'} \left(icm_{c\,c'} \cdot QM_{c'} + ice_{c\,c'} \cdot QE_{c'} + icd_{c\,c'} \cdot QD_{c'} \right)$	(29)
$\overline{CPI} = \sum_{c \in C} PQ_c \cdot cwts_c$	(30)
$DPI = \sum_{c \in C} PDS_c \cdot dwts_c$	(31)
Institution block	
$YF_f = \sum_{a \in A} WF_f \cdot \overline{WFDIST}_{f\,a} \cdot QF_{f\,a}$	(32)
$YIF_{i\,f} = shif_{i\,f} \cdot \left[YF_f - trnsfr_{row\,f} \cdot EXR \right]$	(33)
$YI_i = \sum_{f \in F} YIF_{i\,f} + \sum_{i' \in INSDNG'} TRII_{i\,i'} + trnsfr_{i\,gov} \cdot \overline{CPI} + trnsfr_{i\,row} \cdot EXR$	(34)
$TRII_{i\,i'} = shii_{i\,i'} \cdot (1-MPS_{i'}) \cdot (1-\overline{tins}_{i'}) \cdot YI_{i'}$	(35)
$EH_h = \left(1 - \sum_{i \in INSDNG} shii_{i\,h} \right) \cdot \left(1 - MPS_h \right) \cdot (1-\overline{tins}_h) \cdot YI_h$	(36)
$PQ_c \cdot QH_{c\,h} = PQ_c \cdot \gamma_{ch}^m + \beta_{ch}^m \cdot \left(EH_h - \sum_{c' \in C} PQ_{c'} \cdot \gamma_{c'h}^m \right)$	(37)
$QINV_c = IADJ \cdot \overline{qinv}_c$	(38)
$QG_c = \overline{GADJ} \cdot \overline{qg}_c$	(39)
$EG = \sum_{c \in C} PQ_c \cdot QG_c + \sum_{i \in INSDNG} trnsfr_{i\,gov} \cdot \overline{CPI}$	(40)

$YG = \sum_{i \in INSDNG} \overline{tins}_i \cdot YI_i + \sum_{f \in F} tf_f \cdot YF_f + \sum_{a \in A} ta_a \cdot PA_a \cdot QA_a + \sum_{c \in CM} tm_c \cdot pwm_c \cdot QM_c \cdot EXR + \sum_{c \in C} tq_c \cdot PQ_c \cdot QQ_c + \sum_{f \in F} YIF_{gov\,f} + trnsfr_{gov\,row} \cdot EXR$	(41)
System Constraint block	
$QQ_c = \sum_{a \in A} QINT_{c\,a} + \sum_{h \in H} QH_{c\,h} + QG_c + QINV_c + qdst_c + QT_c$	(42)
$\sum_{a \in A} QF_{f\,a} = \overline{QFS}_f$	(43)
$YG = EG + GSAV$	(44)
$\sum_{c \in CM} pwm_c \cdot QM_c + \sum_{f \in F} trnsfr_{row\,f} = \sum_{c \in CE} pwe_c \cdot QE_c + \sum_{i \in INSD} trnsfr_{i\,row} + FSAV$	(45)
$\sum_{i \in INSDNG} MPS_i \cdot \left(1 - \overline{tins}_i\right) \cdot YI_i + GSAV + EXR \cdot FSAV = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$	(46)
$MPS_i = \overline{mps}_i \cdot \left(1 + MPSADJ\right)$	(47)
$TABS = \sum_{h \in H} \sum_{c \in C} PQ_c \cdot QH_{c\,h} + \sum_{c \in C} PQ_c \cdot QG_c + \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$	
$INVSHR.TABS = \sum_{c \in C} PQ_c \cdot QINV_c + \sum_{c \in C} PQ_c \cdot qdst_c$	
$GOVSHR.TABS = \sum_{c \in C} PQ_c \cdot QG_c$	

Table A1: Impacts on price in non-agricultural

Simulation Prices	SIM_RI ECE	SIM_ PEA	SIM_CE REAL	SIM_F OOD	SIM_CEREA L_FOOD	SIM_TRA NSAC	SIM_ OIL
Mining	-0.50	-1.26	-1.64	-0.68	-2.26	-0.21	0.80
Tabaco products	2.32	3.53	4.38	-0.78	3.65	-0.40	-2.32
Textiles manufacturing	-0.53	-0.21	-0.81	-0.70	-1.43	-0.26	-1.10
Leather manufacturing	-0.37	-0.23	-0.64	-0.61	-1.19	-0.27	-0.62
Wood	-0.17	0.29	0.07	-0.72	-0.60	-0.29	-1.45
Paper	-0.67	-1.04	-1.70	-0.67	-2.30	-0.18	-0.34
Petroleum products	-0.42	-1.49	-1.80	-0.66	-2.42	-0.16	19.03

Chemical products	-0.48	-0.15	-0.63	-0.72	-1.27	-0.33	0.45
Rubber products	-0.49	-0.89	-1.35	-0.67	-1.97	-0.21	-0.31
Glass and pottery	-0.77	0.58	-0.33	-0.76	-0.95	-0.39	3.81
Metallurgy	-0.42	-1.10	-1.47	-0.66	-2.10	-0.18	-0.72
Machinery & equipment	-0.36	-1.80	-2.05	-0.63	-2.67	-0.10	-0.30
Construction of transport material	-0.34	-1.50	-1.76	-0.64	-2.39	-0.14	-0.42
Others construction	-0.71	-0.43	-1.20	-0.70	-1.81	-0.21	-0.39
Electricity Water & Gas	-0.82	-1.22	-2.03	-0.67	-2.62	-0.15	7.69
Construction	-0.73	-0.23	-1.03	-0.72	-1.64	-0.27	0.25
Trade	-0.14	1.32	1.03	-0.76	0.35	-0.48	-1.54
Repair services	-0.53	-0.53	-1.10	-0.69	-1.73	-0.24	-0.77
Hotels and catering	0.70	2.48	2.90	0.49	3.16	-0.22	-1.30
Transport	-0.50	-0.02	-0.59	-0.71	-1.22	-0.31	3.07
Post and telecommunications	-1.26	-1.26	-2.54	-0.68	-3.10	-0.11	-1.17
Financial service	-1.14	-1.09	-2.29	-0.65	-2.83	-0.13	-0.76
Real estate services	-1.62	-1.50	-3.19	-0.68	-3.71	-0.05	-2.21
Activity of business services	-1.24	-1.08	-2.38	-0.67	-2.92	-0.13	-1.22
Activity of public administration	-0.95	-0.53	-1.57	-0.70	-2.16	-0.19	-1.31
Education and training	-0.78	-0.11	-1.01	-0.70	-1.61	-0.25	-1.92
Health activity and social action	-0.81	-0.44	-1.32	-0.68	-1.91	-0.22	-1.35
Community & other private services	-0.37	1.15	0.62	-0.76	-0.03	-0.46	-1.68

Source: Author

Table A2: Factor income changes

Simulations Factors	SIM _RICE	SIM _PEA	SIM _CEREAL	SIM _FOOD	SIM _CEREA_FOOD	SIM _TRANSAC	SIM_OIL
No educated	-0.26	0.88	0.54		0.61	-0.19	0.16
Primary labor	-0.05		-0.06		-0.05	0.02	-0.01
Secondary labor	-0.05	-0.13	-0.20	0.01	-0.18	0.06	-0.10
Professional & tertiary labor	-0.07	-0.50	-0.56		-0.57	0.11	-0.12
Non-agricultural capital	-0.03	-0.39	-0.39		-0.40	0.07	-0.02
Agricultural capital fland-dakar	0.28	0.13	0.46	-0.02	0.41	-0.07	0.07

fland-diourbel		0.01	0.01	0.01
fland-fatick		0.01	0.01	0.01
fland-kaolack		0.01	0.01	0.01
fland-kolda	0.01		0.01	0.01
fland-louga				
fland-saint-Louis	0.12	-0.03	0.12	0.09
fland-tambacounda			0.01	0.01
fland-thiès	0.01	-0.01		
fland-ziguinchor				
fland-matam	0.02		0.02	0.01
fland-kaffrine		0.02	0.02	0.02
fland-sedhiou	0.01		0.01	0.01

Source: Author