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Global Biofuel Production and Poverty in Senegal

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Abstract

Assessing the potential effects of a world biofuel boom on a non-oil producing economy like Senegal and on its households is relevant when it comes for policymakers to make a trade-off between fossil energy and biofuel. In this paper, we run a simulation, based on a dynamic, general-equilibrium model for the period 2006-2020, to capture the effects of the boom of biofuel in the world market on growth and poverty in Senegal. Our results suggest that, due to decreasing prices, imports increase for crude oil, tradable services and non food industries. Valued-added of biodiesel and bioethanol decreases while it increases for most the sectors, in particular those which are more energy intensive. Poverty is quite constant for the first sub-period but it declines thereafter. The households living in urban areas experienced a more deep decrease in their poverty headcount than the one of rural areas.

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Introduction

During the past years, biofuels have received a lot of attention, given its potential to contribute to energy security, fight again global warming and rural development in general. Following the surge in oil prices that occurred in 2008, many countries have implemented biofuel policies as an alternative for traditional oil energy. Also, several countries are adopting higher biofuel consumption mandates (for example, 30 percent of transport energy in the United States must come from biofuels by 2022) or setting biofuel subsidies and special tax arrangements (Caramel, 2009).

These policies have increased the global biofuel production five-fold over the last two decades. During 2000-2007, global production of biofuel tripled in volume. In 2007-2008, the share of ethanol in global gasoline increased from 3.8 to 5.5 percent, while the share of biodiesel in diesel increased from 0.9 to 1.5 percent (Coyle 2007).

Biofuel expansion, however, leads to many debates (Arndt, Pauw and Thurlow, 2010). Many analyses show that biofuels can reduce greenhouse gases (Cohen et al. 2008; Coyle 2007), rise agricultural commodity prices[1] (Mitchell 2008; Paarlberg 2010), and trigger concerns for food security and poverty around the world (IFPRI 2008; Rosegrant 2008; Ewing and Msangi 2009). Another issue is that the effects of biofuels and the higher prices that their emergence may cause on developing countries differ from country to country, therefore benefiting some nations and hurting others (Jikun, Yang, Rozelle, Msangi and Weersink, 2009). Similarly, within a given country, households can be differently affected over the time.

The opportunities for investing in biofuels in Africa is abundant. However, their exist little evidences on the true potential and the extent of the trade-offs between land and labor (Arndt, Pauw and Thurlow, 2010). Food security is not only producing sufficient quantities of food within countries. In some cases, biofuel feed stocks displace other crops (particularly food crops), and the implication of this should be carefully weighed. Moreover, household income and the advantages of increased trade and lower dependence on oil imports may yield positive effects on households in term of net nutritional benefits and poverty reduction.

Like most of the non-oil producing countries, Senegal is highly dependent on world market supplies. Policymakers have sought to find alternatives to fossil fuels (oil and gas in particular), which have experienced a steady rise in prices. Since the surge of oil prices in 2008, policy makers have expressed the view of developing biofuels production as a substitute to fossil energy. Implementing a biofuel policy is supposed to address energy security issue sought by policymakers. Supplying bioethanol and biodiesel to the domestic market based on the local production of sugarcane and jatropha seems to be the main options of policymakers.Therefore, it is important to understand the effects of such policy decision.

Due to rapid biofuel production, efforts have been made to model its impact using partial equilibrium approach (Collins, 2008, Lipsky 2008 & Mitchell, 2008) or general equilibrium approach (Dixon, Osborne and Rimmer, 2007; Rosegrant *et al.* 2008, Arndt, Pauw and Thurlow, 2010, Arndt et al., 2008).

Given the complexity of the impact and the important feedback effects, computable general equilibrium (CGE) models are thus well suited for the study of bioenergy/biofuel shocks or policies. They have been widely employed to issues of international climate policies (Cohen et al., 2008 & Coyle, 2007) and biofuel impacts (for example. Arndt et al., 2008, Rosegrant *et al.,* 2008, Arndt, Pauw and Thurlow, 2010 & Chakravorty et *al*., 2011). Kretschmer B, and Peterson S. (2008) provide an excellent survey of literature on the different approaches used to integrate bioenergy into Computable General Equilibrium Models. The different methods are categorised into three approaches: the “implicit approach”, the “latent technologies approach” and the “desegregation SAM approach”—and the authors critically assessed their respective advantages. The “implicit approach” (Dixon, Osborne and Rimmer, 2007) is a rather ad-hoc approach that does not explicitly model bioenergy production technologies, but instead prescribes the amount of biomass necessary for achieving a certain production level[2] . The “latente technologies approach” includes biofuel

[1] Because of the increasing demand by the biofuel sector for feedstocks

[2] It would for instance comply with a biofuel policy target).

production in the model using production technologies that are not active in the base year of the model, but can become active at a later stage or in counterfactual scenarios. Different "latent technologies approach" is used to model bioenergy in CGE models dealing with the first-generation of biofuel (Kretschmer et al., 2008), second-generation of biofuels (Reilly and Paltsev, 2007) and those incorporating biofuel in trade (Gurgel et al., 2007).

The third generation of CGE biofuel models has great potential and focuses on disaggregating bioenergy production sectors directly from a social accounting matrix (SAM), which is the underlying data structure of CGE models (Hertel, Tyner and Birur, 2008 (with the GTAP model), Arndt et al., 2008 & Arndt, Pauw and Thurlow, 2010 (with the IFPRI model)). With this approach, a substitution between biofuels and other energy products can be done with the CGE model. The Senegalese model relies on the latter approach.

We built a dynamic computable general equilibrium (DCGE) model to assess the potential effects of a world biofuel boom on senegal's economic growth and poverty pattern over the next decade. The model is linked to a survey-based microsimulation module that estimates impacts on income poverty.

Section 2 provides a background on Senegal's economy and the challenges of world biofuel production for the economy. Section 3 discusses the methodology developed for assessing the impact of global biofuel production pathways on the Senegalese household. Section 4 provides the results. The final section concludes on the main findings of the research.

1. Background

Table 1 shows the structure of the Senegalese economy in 2005, which is the base year of the economic model. Services have the most important contribution to GDP (61%); 58% to employment and 65% to capital. It also contributes to 31% of total exports. The contribution of industry is estimated at 23.5% of the GDP and 26.3% of the total employment.

Table 1. Structure of Senegalese's economy in 2005

	Share of total (%)					Exports intensity (%)	Imports penetration (%)
	GDP	**Labor**	**Capital**	**Exports**	**Imports**		
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**16.16**	**24.03**
Agriculture	**15.15**	**16.00**	**14.43**	**1.69**	**9.73**	**0.03**	**0.22**
Millet	2.68	2.99	2.41	0.01	0.02	0.08	0.34
Maize	0.69	0.56	0.80	0.01	0.44	0.39	22.87
Rice	0.58	0.21	0.89	0.02	5.05	0.80	77.25
Vegetables	0.96	1.20	0.76	0.3	0.6	7.88	20.75
Fruits	0.88	0.98	0.79	0.1	0.5	3.81	18.73
Coton	0.08	0.10	0.06	0.1	0.0	10.78	0.00
Arachide	2.24	2.48	2.04	0.0	0.0	7.87	31.51
Jatropha	0.01	0.02	0.01	0.0	0.0	12.91	0.00
Cansugar	0.12	0.19	0.06	0.0	0.0	0.00	0.00
Canetha	0.00	0.00	0.00	0.0	0.0	15.38	0.00
other primary	2.87	3.55	2.29	1.0	3.1	0.29	0.00
Elevage	4.05	3.73	4.31	0.2	0.1	0.98	0.79
Industry	**23.56**	**26.37**	**21.17**	**67.46**	**81.45**	**0.28**	**0.43**
Fishing	1.93	2.41	1.52	9.8	1.4	83.25	53.77
Oil	0.32	0.45	0.21	1.87	2.59	30.34	43.79
Sugar	0.53	0.54	0.52	0.0	1.5	0.71	44.90
other food processing	6.32	8.35	4.58	13.4	14.6	20.15	40.98
PRefined petrol	0.29	0.14	0.42	9.9	0.0	64.59	0.00
Biodiesel	0.06	0.05	0.07	0.1	0.0	11.51	11.51
Bioethanol	0.00	0.00	0.00	0.0	0.0	7.14	7.14
Crude oil	0.00	0.00	0.00	0.00	7.13	0.00	100.00
Other industries	14.11	14.42	13.84	32.4	54.2	23.44	41.00
Private services	43.40	31.24	53.75	30.85	**8.82**	12.74	6.41
Goverment service	**17.89**	**26.39**	**10.66**	**0**	**0**	0.00	0.00

Source : Authors's calculation from the senegalese 2005 SAM

Industry sector is dominated by food processing (excluding oil), which accounts for 6.3% of the national GDP and a 8.35% of total employment. It is followed by nonfood industries which mainly include the construction subsector. The fishing sector contributes to around 2% to both GDP and employment. In contrast, the agriculture sector generates 15% of GDP and 16% of total employment. Senegalese farmers mainly produce staple grains (millet and maize), peanuts, as well as fruits and vegetables. Agriculture is a weak exporter and agricultural exports focus on three main products: cotton (10.78%), vegetables (7.88%) and peanuts (7.87%). Most of the country's agricultural foods are imported (rice, maize, vegetables and fruits).

Even if biofuel sector is at an early stage of development in Senegal, Jatropha has long been part of the traditional agricultural culture in Senegal. It is planted as a fence (*haie vive*) and used at the village level for medicinal purposes. However, since the Government announced the Special Biofuel Program 2007-2112, jatropha has appeared to be a potentially profitable sector for farmers. The private sector has started investing in jatropha plantations. After this announcement, many foreign investors have made requests to obtain agricultural land for jatropha plantations and production. The development of a commercial jatropha-based biodiesel industry is still at a very early stage, also taking into account that there are no dedicated oil extraction mills or biodiesel processing plants. As per bioethanol, Senegalese Sugar Company (CSS) installed a 60,000 litres/day distillery in 2007, but has not been able to supply the domestic market because of

regulatory and infrastructural deficiencies in the blended fuel market—andtransportation and storage problems related to the oil company, Société Africaine de Raffinage (SAR) (Evans, 2010).
Based on the 2005 SAM, crude oil imports which is the main input of refined oil sector accounted for 7.13% of total imports. Exports of refined oil represented a share of 9.9% of total exports. Hence, petroleum products are important in senegalese foreign trade. On the supply side, refined oil sector seems to be input-intensive, as only 7.16% of its production is allocated to value added, and returns to factors. By contrast, even though the biofuel sector is at an early stage, about 80% of jatropha and ethanol production are devoted to value added. Sectors energy intensive use can be a channel through which shocks in biofuel production can affect Senegalese economy. From data, its appears that crude oil is exclusively an intermediate consumption for the *refined petroleum* sector, whereas biodiesel is mainly used by the sectors of tradable services and other industries as an input. Refined petroleum is an intermediate consumption mainly used by the following sectors: fishery, sugar processing, non-food industries, rice, tradable and non-services.
Oil price changes can also affect households through their basket consumption where petrolum-based products have a significant contribution. Hence, in an economy where 50% of household are poor, biofuel expansion can induce significant price and income changes. Energy policy may therefore be crucial in the pursuit of MDGs in an economy where reducing poverty by half is the main goal.

2. Methodology

2.1 The model

The dynamic Senegalese model described below has been developed based on the dynamic Exter-DS model of Annabi, Cockburn and Decaluwé (2004). A number of features have been added to the Exter-DS model for this study: a Government budget block; the inclusion of public capital and land factors; an export demand function; and the endogenous growth of total factor productivity.
According to this, the new theories of economic growth came mainly from the criticisms of Solow's theory that technological progress was exogenous.whereas it was endogenous due to investments made by agents. This criticism led to a reevaluationwhich gave rise to the endogenous growth theory, andfocusing on four factors that endogenously explain economic growth. According to Barro (1990), economic growth derives from investment in public infrastructure. It is therefore public capital that explains economic growth. This author has shown that public infrastructure is a growth factor that generates increasing returns over the long term because of the positive externalities they generate for the benefit of companies. For Romer (1990), research and development is the most important engine of economic growth. According to this author, economic growth would result from an activity of innovation, by agents who hope to benefit from it. This research corresponds with that of J. A. Schumpeter (1883-1950), because the fundamental incentive for innovation is linked to the temporary monopoly it confers on producers of new goods. On the other hand, for Lucas (1988), the "self-sustaining" nature of growth is possible, due to the human capital that makes technological progress endogenous. Moreover, technical progress and innovation (as measured by total factor productivity) are made by researchers or engineers, whom are also the product of an investment in human capital. In another research, Romer (1986), attributes economic growth to the accumulation of physical capital. He further proposes a model based on externalities between firms—and investment in new technologies being the starting point for new learning through practice (improvement of existing equipment, engineering work, increase in competence of workers, etc.).
The new characteristics like the endogenized total factor productivty (TFP) are inspired by Lucas (1988), Romer (1990) and Barro (1990) approach. However, they require some adjustment to the existing equation and the addition of a new one.
The total public capital stock creates for each activity a positive externality that affects the total productivity of the sector. The TFP is also affected by the distribution of public investment between human capital, research-development and infrastructures, which depends on policymakers' decisions (1). Therefore, the TFP is endogeneously determined and is supposed to be a function of

human capital (KH), research-development (RD), infrastructures (IP) and the ratio between the total public capital and the sectorial private capital (KDpubG/KDpriv):

$$A_{tr}^{t} = \overline{A_{tr}^{t}}\left[\left(KH_{tr}^{t}\right)^{\varepsilon_k} * \left(RD_{tr}^{t}\right)^{\varepsilon_r} * \left(IP_{tr}^{t}\right)^{\varepsilon_i} * \left(\frac{\mathrm{KDpubG}^{t}}{\mathrm{KDpriv}_{tr}^{t}}\right)^{\varepsilon_k}\right] \quad (1)$$

The process of capital accumulation is modeled endogenously. The stock of sectorial private capital at the end of the period is equal to the previous period stock minus capital depreciation of the period to which the volume of capital accumulated during the period is added. The rate of sectorial capital accumulation at period t is an increasing function of the cost - profit ratio of the capital of the same period, to a decreasing rate. Population growth is exogenously implemented within the model based on separately calculated growth projections. It is assumed that a growing population generates a higher level of consumption demand and therefore raises the supernumerary income level of household consumption. It is also assumed that the marginal rate of consumption for commodities remain unchanged, implying that new consumers have the same preferences as existing consumers. Labor supply is equal to the sum of labor demand. Transfers, labor, Government consumption and the minimum level of consumption are also exogenously determined between periods.

The model includes three broad macroeconomic accounts: the current account, the Government balance, and the savings and investments account. In order to ensure equilibrium in the various macro accounts, it is necessary to specify a set of 'macro-closure' rules which provide a mechanism through which adjustment is assumed to take place.

The ratio between current account and GDP is assumed to be fixed. The exchange rate and inventories are fixed, as is the propensity for institutions to save. Public expenditures are also assumed to be fixed in real terms during the first period. However, they increase at the same rate as the population grows. Government savings, transfers, and labor supply follow the same pattern. Therefore, these different variables are fixed during the first period.

Although the Government and current account closures can be selected based on current Government policies, and the choice of a savings-investment closure is less obvious. As Senegal cannot borrow without any limits mainly due to convergence criteria established by the West African Economic and Monetary Union (WAEMU), the long-term savings-investment linkage is characterized by exogenous savings with no feedback response from investment behavior. Therefore, the model adopts a savings-driven closure, in which the savings rates of domestic institutions are fixed, and investments adjust in a passive manner to ensure an equal level of equilibrium between savings and investment spending.

2.2 The Poverty module

The standard CGE model generally covers a limited number of categories of households, thus restricting its use in the analysis of poverty and distribution of revenue. More and more analysts choose to establish a link between the CGE model and data from a nationally representative household survey to analyze the microeconomic impacts of macroeconomic policies and shocks.[3] Our analysis uses a top-down micro-accounting approach which proved more appropriate in the case of this study, given the difficulty in reconciling micro-households data with those of the SAMs. We first replicated the monetary poverty profile for the base year while taking into consideration the national poverty line. After the simulation, the change in consumption expenditures is computed from the CGE model and used to estimate new expenditures of real households in the survey. The poverty line is also updated through a change in consumer price indexes generated from the CGE model. Then, new poverty rates are estimated for the simulation.

[3] Davies (2009) provides an exhaustive review of the literature regarding the techniques of reconciling the macro-modeling with poverty and inequality analysis.

Poverty analysis is done based on the Pα Poverty index approach of Foster, Greer and Thorbecke (1984) (2):

$$P_{\alpha}=\frac{1}{n}*\sum_{i=1}^{p}\left(\frac{z-y_i}{z}\right)^{\alpha} \quad (2)$$

where z is the poverty line; yi is the mean expenditure of the household i; α is a coefficient expressing the level of aversion against poverty; n is the total number of individuals; and p is the total number of poor within the population. Poverty index is computed based on the following variable of interest *expenditure per equivalent-adult*. Àt the base year (2005), the poverty line defined by the statistical office[4], based on the household survey (République du Sénégal, 2005) is 923.71, 661.76 and 561.22 FCFA/day/equivalent-adult, in Dakar, and the other cities and rural area, respectively.

2.3 Data

2.3.1. The basic structure of the SAM

The CGE model is calibrated to a 2005 SAM (Cabral, Cisse and Sarr, 2008) which was constructed using information from an input-output table (IOT) and a household survey performed in the same year (National Statistics and Demographics Agency, ANSD).

In The SAM, production activities include agriculture, groundnut oil industries, other agri-food industries, other (non agri-food) industries, tradable services and non-tradable services. The agricultural sector is further disaggregated into twelve sub-sectors: millet/sorghum, maize, rice, vegetable, fruit, groundnut, cotton, jatropha, sugarcane, livestock, fishing and the rest of agriculture. The households are categorised into eight categories: households in Dakar as well as households in other cities; rural households of groundnut belt (ZBA); rural households of livestock area (ZSP), rural households of eastern Senegal (ZSO), rural households of Casamance (ZS), rural households of Niayes and rural households of Senegalese river (ZF).

2.3.2. Integrating the biofuel sector in the SAM

Biofuels production is currently at a minimal level in Senegal. The statistics on biofuel in the base year 2005 are very weak for some sectors (jatropha, sugarcane) and are inexistent for biodiesel and biofuel. To integrate biofuel sector in the SAM, we follow Arndt, Pauw and Thurlow (2010) and Arndt et al., (2008) approach. Some assumptions are made to introduce biodiesel sectors in the SAM. During the 2008-2009 period, the total area under cultivation of jatropha was estimated at 5293 ha. According to data collected in India, the yield of jatropha varies between 1.5 and 2 tons/ha. If the yield is set at 1.5 tons/ha, it gives 7939.5 tons of production. The unit cost of seeds was estimated at 100 FCFA / kg. As the selling price varies between 400 FCFA / kg and 600 FCFA / kg, a minimum producer price of 400 CFA / kg is set. Hence, production is estimated at 3,176 million FCFA in 2008-2009. In the base year which is 2005, we assume that 20% of this production was obtained. Therefore, the supply was valued at 635.16 million FCFA. The goal of Senegalese policymakers was tao set 320,000 ha to produce 3.2 million tons of jatropha by 2012. This production should help bring into market 1.134 billion liters of biodiesel (Dia et al., 2009). Priced at 105 euros per 100 liters, this potential production is estimated at 19.696 billion FCFA. If we suppose that only 20% of this production is assumed to be available in 2005, supply of biodiesel produced through traditional and secular channels and also through experimental productions[5] is then estimated at 3.939 billion FCFA.
Ethanol production is mainly due to the activities of CSS, for which a distillery was launched in 2007 with a capacity of 60,000 liters/day. This is equivalent to a production of 21 900 m^3 per year. The coefficient of conversion of sugarcane into molasses is equal to 1 ton of sugarcane to 35 kg of

[4] Direction de la prévision et des statistiques
[5] pilot experiments of Sococim company

molasses—and 1 ton of molasses gives 270 tons of alcohol, considered as ethanol. Therefore, 21 900 00 m^3 of ethanol is supposed to come from 81 111.1 tons of molasses and this requires 2 317 460 tons of sugarcane. As CSS's production of sugarcane is estimated at 829 490 tons in 2005, we assume that the company's required input for the distillery's maximum production capacity is set at 36%.

The technology for the sector of refined petroleum (mainly represented bySAR) is represented in the Senegalese input-output table. As for the biodiesel sector production, we assume that the share of value added in the production is about 60% of which 40% is allocated to labor and 60% to capital. However, we assume that the structure of its intermediate consumption is quite similar to the one of refined oil. In the bioethanol sector, we assume that the share of production allocated to the value added is 28% of which 25% is allocated to labor and 75% to capital. The structure of its intermediate consumption is also assumed to be almost similar to that of refined oil.

3. Simulation, results and discussion

In the "Reference Scenario", we assume that global biofuels production expands only beyond 2005. We simulate the impact on Senegalese economy through changes occurring in international markets of all items driven by a boom in world market biofuel supply. The simulation assumes that only market forces drive growth in biofuels from the base scenario. The predicted world price changes[6], computed from GTAP model by IFPRI, are given in Table 2. We combine the effects of both import and export price of all commodities under the assumptions of high elasticities. Sectoral effects, as well as effects on returns to factor and poverty are also assessed.

[6] Senegal is small economy and then a price taker. Therefore, world prices (imports and exports prices) are given for Senegalse economy. From a model, IFPRI has generated the future trend of world price for several induced by a boom in the biofuel sector.

Table 2: Price changes for Senegalese economy induced by a world biofuel boom, 2006-2020 (in % w.r.t the BAU)

Products	**Imports prices**			**Exports prices**		
	2006-2010	2011-2015	2016-2020	2006-2010	2011-2015	2016-2020
Rice	0,24	0,34	0,32	0,28	0,42	0,54
Wheat	0,57	0,81	0,92	0,60	0,95	1,14
Maize	0,76	1,11	1,56	2,85	3,55	4,13
Other Grain	0,61	0,96	1,25	0,53	0,91	1,20
Vegetable&fruits	0,35	0,51	0,58	0,47	0,68	0,75
Soybean	1,01	1,36	1,60	1,26	0,96	2,50
Other oilseeds	0,83	1,24	1,79	1,54	2,20	3,30
Sugar	0,22	0,40	0,58	0,43	0,65	0,69
Pfb	0,32	0,58	0,84	0,45	0,78	1,01
Other crops	0,32	0,58	0,79	0,49	0,83	1,07
Frorestry	0,12	0,05	0,18	0,09	0,00	0,15
Beef&Mutton	0,15	0,31	0,38	0,20	0,38	0,39
Pork&Poultry	0,20	0,35	0,29	0,21	0,40	0,35
Milk	0,00	0,07	-0,01	0,01	0,11	0,05
Fishery	0,20	0,14	0,19	0,24	0,16	0,24
Processed food	0,05	0,13	0,07	0,06	0,15	0,11
Other primary industry	-0,12	-0,10	-0,23	-0,11	-0,07	-0,20
Coal	-0,13	0,00	0,06	-0,13	0,13	-0,02
Oil	-0,46	-0,50	-0,61	-0,50	-0,52	-0,62
Gas	-0,23	-0,19	-0,19	-0,22	-0,17	-0,17
Oil_products	-0,34	-0,35	-0,49	-0,55	-0,57	-0,68
Electricity	-0,04	-0,03	-0,09	-0,04	-0,06	-0,08
Fertilizer&Pesticide	-0,06	-0,02	-0,14	-0,05	0,01	-0,12
Energy intensive industies	-0,06	-0,01	-0,14	-0,05	0,03	-0,14
Other industries	-0,03	-0,02	-0,09	-0,03	-0,02	-0,08
Bio-ethanol	-0,33	-0,37	-0,46	-0,06	-0,17	-0,39
Bio-diesel	-0,47	-0,50	-0,59	-0,02	-0,23	-0,53
Road transportation	-0,10	-0,06	-0,22	-0,09	-0,08	-0,21
Water transportation	-0,10	-0,07	-0,20	-0,10	-0,07	-0,18
Air transportation	-0,11	-0,08	-0,21	-0,10	-0,09	-0,19

Source: Hang and al. (2012).

3.1 Effects on imports, exports and sales on domestic market

Based on assumptions of biofuel boom in the world market, oil import prices decrease slightly during all three sub-periods: 2006-2010, 2011-2015 and 2016-2020. Import prices decrease also for coal, other primary industries, gas, fertilizer and pesticide, products from energy intensive industries, tradable services. For all other products, import prices increase—but except for crude oil, tradable services and non food industries, imports decrease. Due to significant weight of the group of the products and services for which imports increase, total imports increase also (table 3).

Table 3: Changes in imports w.r.t. business-as-usual (in %)

	Relative import share in 2005	Share of imports in composite good in 2005	Simulatiion
Millet/sorghum	0,019	0,34	-4,95
Maize	0,435	22,87	-4,71
Rice	5,052	77,25	-0,54
Vegetables	0,551	20,75	-3,88
Fruits	0,457	18,73	-3,82
Other agricultural Products	3,146	30,77	-2,09
Livestock	0,075	0,79	-2,24
Fishery	1,403	53,77	-1,12
Food oil	2,589	41,00	-0,48
Other food industries	14,629	37,09	-0,34
Sugar	1,46	44,9	-2,17
Other industries	54,235	41,07	0,23
Crude oil	7,129	100,00	0,56
Tradable services	8,820	6,41	1,17
Total imports	100	23,66	0,50

Source: Senegalese SAM, 2005 and authors's simulations

Due to real exchange rate depreciation, exports increase for all products, except for refined oil, biofuel and tradable services (table 4). The most important increases are those experienced by maize, vegetables, fruits and groundnut. The total exports also increased.

Table 4: Changes in exports w.r.t. business-as-usual (in %)

	Relative export share in 2005	Shareof export s on production in 2005	Simulation
Millet/sorghum	0,007	0,08	1,24
Maize	0,010	0,39	7,32
Rice	0,020	0,80	1,63
Vegetables	0,295	7,88	4,18
Fruits	0,129	3,81	3,93
Cotton	0,083	10,78	1,47
Groundnut	0,026	0,29	3,87
Other agricultural Products	0,959	7,62	1,82
Jatropha	0,007	12,91	1,40
Sugarcane	0,000	15,38	0,00
Livestock	0,153	0,98	0,66
Fishery	9,839	83,25	2,54
Food oil	1,872	23,44	0,67
Other food industries	13,415	23,08	0,33
Sugar	0,02	0,71	2,24
Other industries	32,357	20,22	0,32
Refined oil	9,899	64,59	-0,14
Biodiesel	0,058	11,51	-0,71
Bioethanol	0,001	7,14	-1,00
Tradable services	30,850	12,74	-0,48
Total exports	100	15,89	0,89

Source: Senegalese SAM, 2005 and authors's simulations

As export of refined oil decreased, its supply is directed to the local market. Therefore, local sales of refined oil increase. Local sales of biodiesel decreased as its production declined (table 5). Local sales of jatropha decreased, while sugarcane increased mainly due to sugar-related activities. Generally, total domestic sales increase.

Table 5: Changes in local sales w.r.t. bau (in %)

	Simulation
Millet/sorghum	0,15
Maize	1,83
Rice	2,00
Vegetables	1,05
Fruits	0,85
Cotton	0,27
Groundnut	0,28
Other agricultural Products	1,04
Jatropha	-0,10
Sugarcane for sugar	1,73
Sugarcane for ethanol	0,31
Livestock	0,30
Fishery	1,75
Food oil	0,43
Other food industries	0,31
Sugar	1,44
Other industries	0,39
Refined oil	1,41
Biodiel	-0,05
Bioethanol	0,00
Crude oil	-
Tradable services	0,02
Total domestic sales	1,76

Source: Authors's simulations

3.2 Sectoral effects

Under assumed boom in biofuel production in the world market, production and value added of jatropha is quite stagnant, while sugarcane increases slightly (but seems to profit the sugar sector more). Hence, the biodiesel and bioethanol production, and valued-added decreases, while refined oil increases (table 6). By contrast, the most important increases in value added are experienced by some of the most energy intensive sectors like fishery, rice and sugar. The value added of tradable services is quite constant.

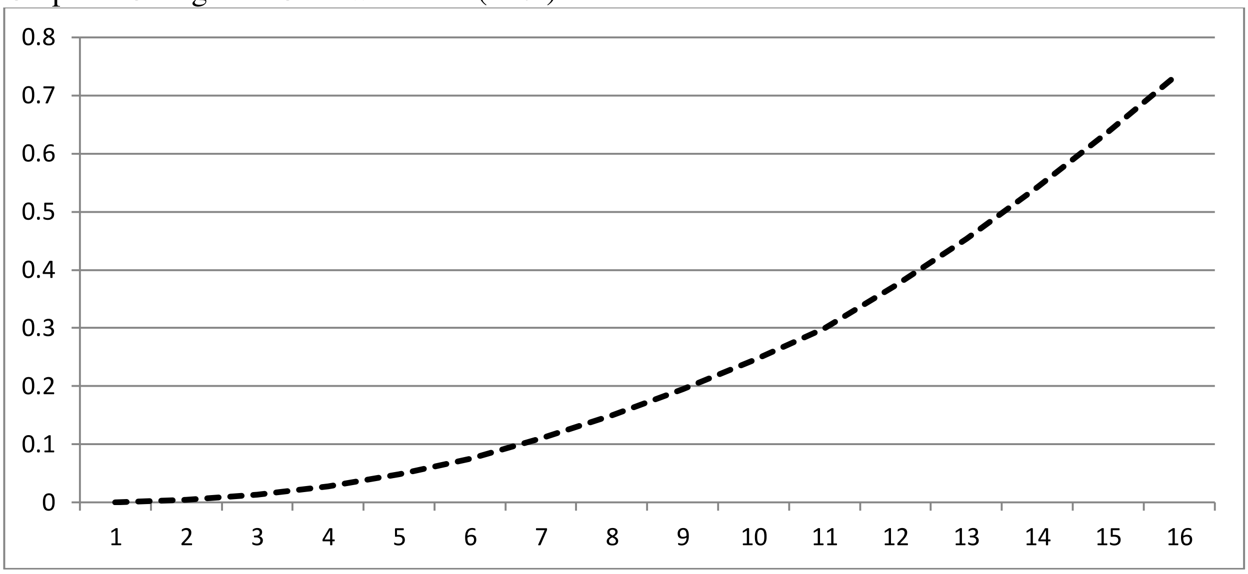
Table 6: Changes in value added w.r.t. bau (in %)

	GDP share in 2005	Simulation
Millet/sorghum	2,68	0,15
Maize	0,69	1,85
Rice	0,58	2,00
Vegetables	0,96	1,36
Fruits	0,88	1,01
Cotton	0,08	0,35
Groundnut	2,24	0,30
Other agricultural Products	2,87	1,08
Jatropha	0,01	0,01
Sugarcane for sugar	0,12	1,73
Sugarcane for ethanol	0,00	0,33
Livestock	4,05	0,31
Fishery	1,93	2,37
Food oil	0,32	0,50
Other food industries	6,32	0,32
Sugar	0,53	1,45
Other industries	14,11	0,38
Refined oil	0,29	0,56
Biodiesel	0,06	-0,12
Bioethanol	0,00	-0,14
Crude oil	-	-
Tradable services	43,40	-0,05
Non Tradable services	17,89	0,00
Total	100	0,74

Source: Senegalese SAM, 2005 and authors's simulations

The GDP increases during the whole period as returns to all factors increase in the economy (graph 1).

Graph 1: Changes in GDP w.r.t. bau (in %)



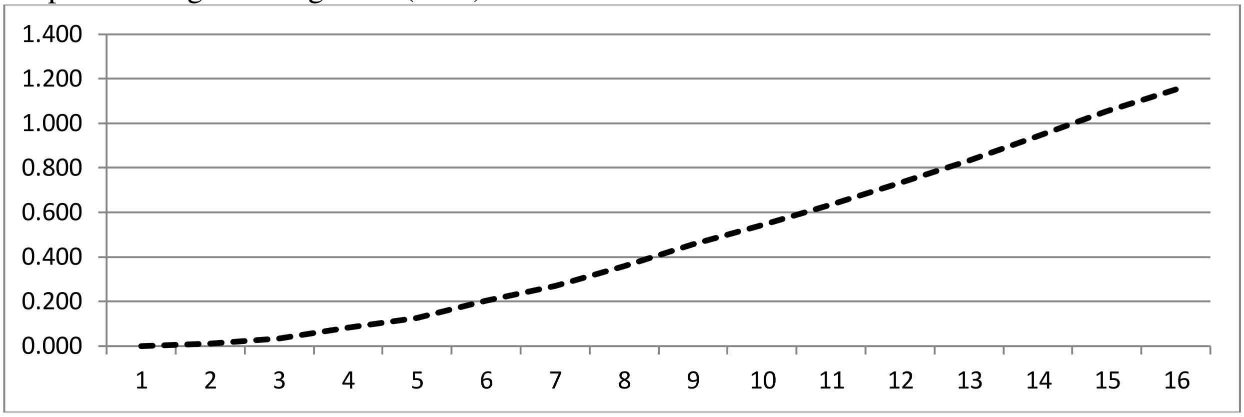
Source: Calculations of authors based on simulation results.

3.3 Returns to factors

Agricultural capital is more concentrated in groundnut, millet/sorghum, rice and other type of agricultural sub-sectors. Agricultural capital is specific to the agricultural sector and does not move to other sectors. Services and industries use the largest share of labor within the economy. Changes in factor demand and wage returns will depend on how all the sectors are affected by the shock. The analysis of returns to factors suggest that wages rate increase w.r.t. the BAU during the whole period as observed in the graph 2. One can also observe that the trend of returns to non-agricultural capital is quite flat—and returns to agricultural capital has increased during the whole period (graph 3).

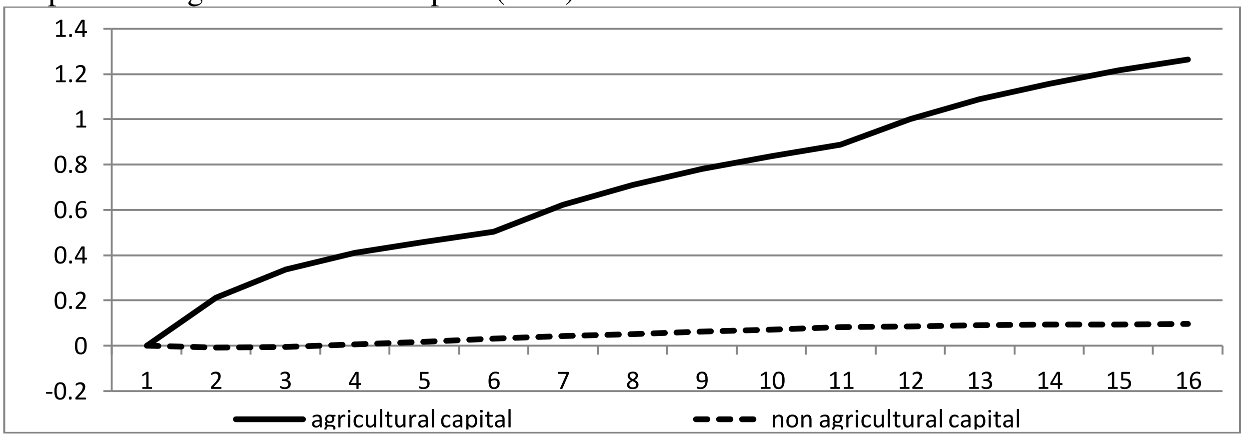
Due to a quite stagnant production and value added of jatropha (except for the second sub-period), no significant changes are recorded for returns to jatropha land (graph 4). Returns to sugarcane land have increased during the whole period due to increasing supply of sugar which enhanced sugarcane production. However, rice land experienced the most significant increase.

Graph 2: Changes in wage rate (in %)



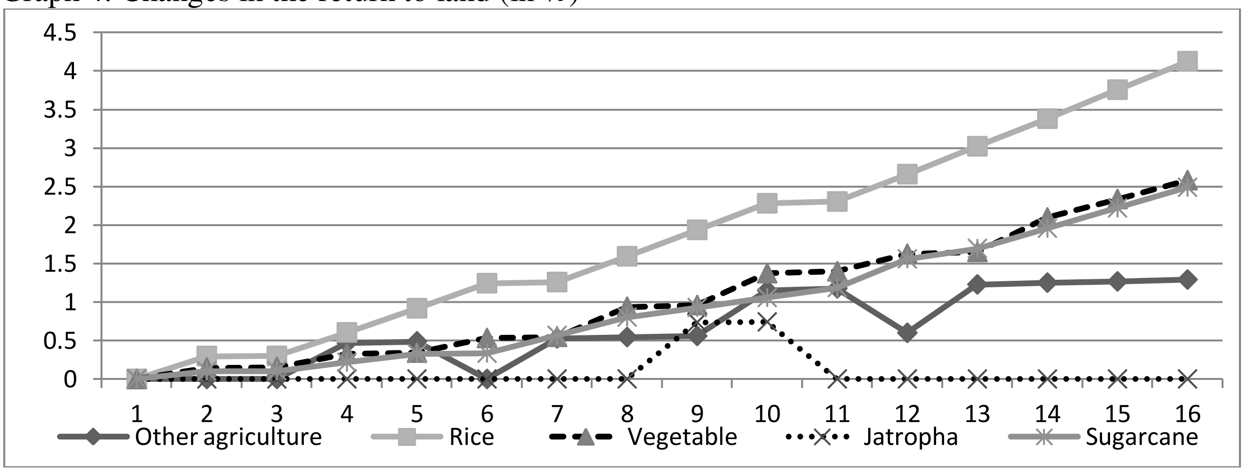
Source: Calculations of authors based on simulation results.

Graph 3: Changes in returns to capital (in %)



Source: Calculations of authors based on simulation results.

Graph 4: Changes in the return to land (in %)

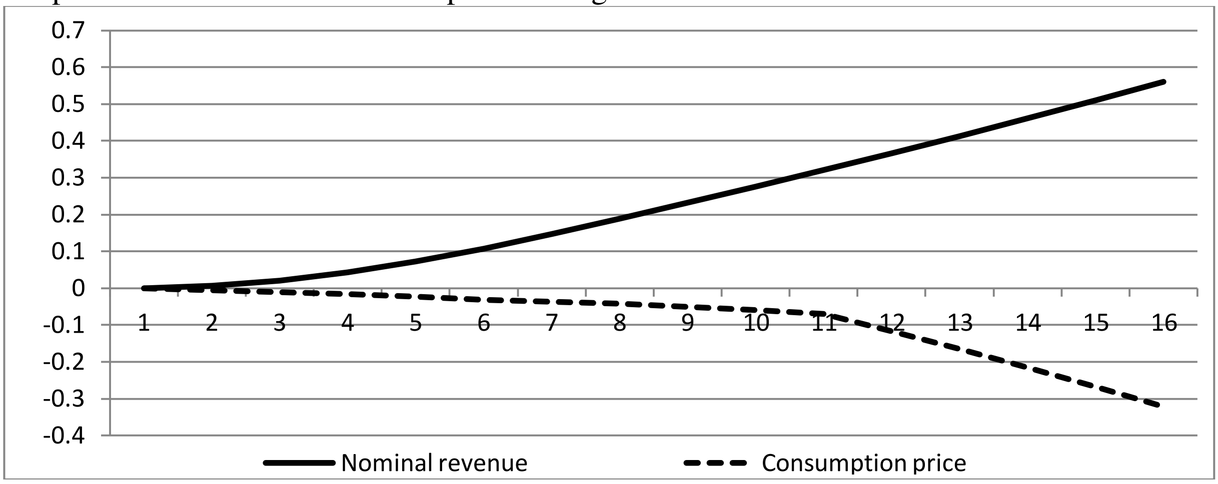


Source: Calculations of authors based on simulation results.

3.4 Poverty effects

Changes in the returns to factors have effect on nominal income and consumer price on the basket consumption of households. Compared to the baseline, the nominal income increase with a higher effect at the end of the period. By contrast, the price decreases in the whole period and relatively more at the end of the period (graph 5).

Graph 5: Household revenues and prices change w.r.t to the baseline scenario

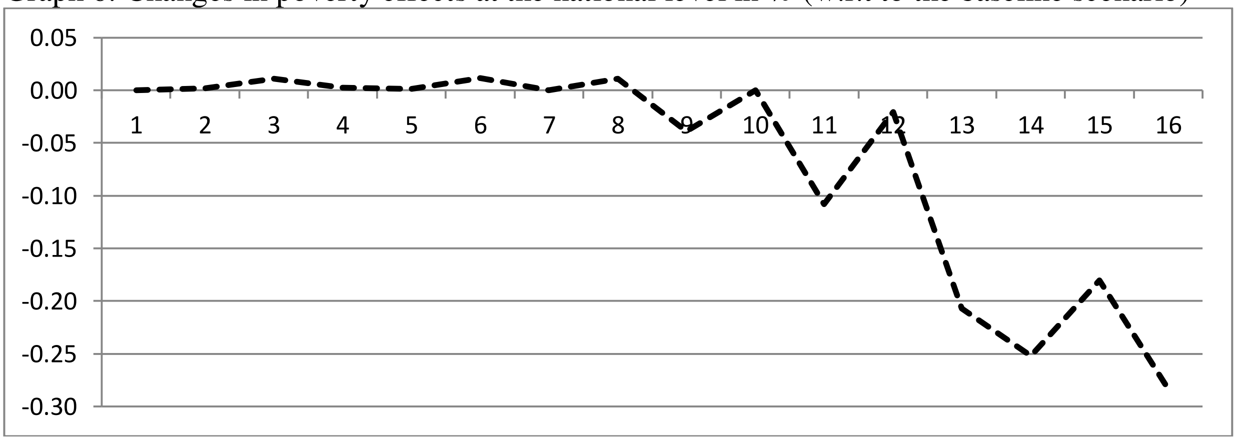


Source: Calculations of authors based on simulation results.

The impact of prices and revenues are also reflected in poverty outcomes. Due to the trend price variations in Senegal that comes from world biofuel boom, net income and price induces a constant trend of poverty during the first half of the the period, but a declining trend during the second half of the period.

The trend of poverty is quite constant during the first half of the period, but it declines during the second part of the period. Decline in poverty headcount is higher in Dakar than the other cities and rural areas (graph 6).

Graph 6: Changes in poverty effects at the national level in % (w.r.t to the baseline scenario)



Source: Calculations of authors based on simulation results.

Conlusions

In this paper, we first built a dynamic general-equilibrium model to address the impact of boom of biofuel in the world market on growth and poverty pattern in Senegal. We then run a simuation based on results that are generated by IFPRI from a global GTAP CGE model. The simulation captures the effects of world market prices changes within the context of the Senegalese economy.

Based on assumptions of biofuel boom in the world market, oil import prices decrease slightly. Import prices decrease also for coal, other primary industries, gas, fertilizer and pesticide, products from energy intensive industries, tradable services. For all other products, import prices increase. Therefore, except for crude oil, tradable services and non food industries, imports decrease. Due to their significant share in imports, the total imports increase. Due to a real rate of exchange rate depreciation, exports increase also for most of the products—and this induces a rise in total exports. Valued-added of biodiesel and bioethanol decreases, while it increases for most other sectors, particularly those which are more energy intensive. This comes from the fact that jatropha supply is quite stagnant while the production of sugarcane benefited the sugar sector more, unlike bioethanol production, which decreases. Those changes explain the one observed for returns to factors and also for households income and consumption prices,and hence poverty.

The trend of poverty is quite constant during the first half of the period, but it declines during the second part of the period. The households of Dakar gain from this shock as they experienced decreased poverty headcount, compared to other cities and rural areas in Senegal.

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