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**Global Biofuel Production and Poverty in Senegal**

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1. **Introduction**

During the past years, biofuels have received many attentions since they were supposed to to contribute to energy security, fight again global warming and hence rural development. Following the surge in oil prices that occurred in 2008, many countries have implemented biofuels policies and consider their development as an alternative for traditional oil energy. Thus, many countries are adopting or setting higher biofuel consumption mandates (for example, 30 percent of transport energy in the United States must come from biofuels by 2022) or biofuel, subsidies and special tax arrangements (Caramel, 2009).

These policies have increased the global biofuel production five-fold over the last two decades (Earth Policy Institute 2010). During 2000–2007, global production of biofuel tripled in volume (Coyle 2007). 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 (UNEP 2009).

Biofuel expansion, however, leads to controversy (Channing, Pauw and Thurlow, 2010). Many analyses show that biofuels can reduce greenhouse gases (Cohen et al. 2008; Coyle 2007). The increasing demand by the biofuel sector for feedstocks has also contributed to the significant rise of agricultural commodity prices particularly since 2006 (Mitchell 2008; Paarlberg 2010; Westhoff 2010, Schlenker, 2010, Almirall, Aufhammer and Berck, 2010). This price increase, has then triggered concerns for food security and poverty around the world (FAO 2008a; IFPRI 2008; Rosegrant 2008; Headey and Fan 2008,Tangermann 2008; [Ewing](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VP6-4TY8WHJ-1&_user=3837164&_coverDate=06%2F30%2F2009&_alid=1368041903&_rdoc=44&_fmt=high&_orig=search&_cdi=6198&_sort=r&_docanchor=&view=c&_ct=1277&_acct=C000054348&_version=1&_urlVersion=0&_userid=3837164&md5=1ae12a5a02fe0ef0438d599efce3996e" \l "vt1#vt1) and [Msangi](http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6VP6-4TY8WHJ-1&_user=3837164&_coverDate=06%2F30%2F2009&_alid=1368041903&_rdoc=44&_fmt=high&_orig=search&_cdi=6198&_sort=r&_docanchor=&view=c&_ct=1277&_acct=C000054348&_version=1&_urlVersion=0&_userid=3837164&md5=1ae12a5a02fe0ef0438d599efce3996e" \l "vt2#vt2) 2009, de Hoyos and Medvedev 2009).

The effects of biofuels and the higher prices that their emergence may cause on the populations of developing countries differ from a country to another, helping some people, while some other ones are hurted (Jikun, Yang, Rozelle, Msangi and Weersink, 2009). Similarly, within a given country, households can be differently affected.

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 adress 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 for policymakers to choose between

Jatropha has long been part of the traditional agricultural scene in Senegal, being planted as a fence (*haie vive*) and used at the village level for medicinal purposes. However, since the Government announced the Special Biofuel Program 2007-12, Jatropha appears 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 access to agricultural land for jatropha production purpose. The development of a commercial jatropha-based biodiesel industry is still at a very early stage, with 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, including transportation and storage problems concerning the oil company Société Africaine de Raffinage (SAR) (Evans, 2010).

Senegalese imports are dominated by oil products, machinery and cereals. In 2009, oil imports accounted 410 billions of cfa which represented a share of 19% of total imports. Exports of refined oil accounted 208 billions of cfa which represented a share of 23% of total exports (République du Sénégal, 2009). Hence, petroleum products are an important share of foreign trade. On the supply side, refined oil sector seems to be input intensive as only 34% of its production is allocated to value added and hence to returns to factors. However, even though the biofuel sector is at an early stage, about 80% of jatropha and ethanol production are devoted to value added. Oil price changes affect household through their basket consumption where petrolum products have an important weight. Hence, in an economy where 50% of household are poor, biofuel expansion can induce important price and income effects. Therefore, energy policy may be crucial in the pursuit of MDGs in an economy where reducing poverty by half is the main goal.

Thanks to the rapidly biofuel production, efforts has been done in modeling its impacts using partial equilibrium approach (Collins, 2008, Lipsky 2008, Mitchell, 2008) or general equilibrium approach (Dixon, Osborne and Rimmer, 2007; Reilly and Paltsev, 2007; Banse et al. 2008; Boeters et al., 2008; Kretschmer et al., 2008; Rosegrant *et al.* 2008, Channing, Pauw and Thurlow, 2010, Channing Arndt and al, 2008). The general equilibrium models generate long-term impacts and take into account interactions between various economic sectors and agents while considering the macroeconomic constraints under which they operate. Thus they are well suited for the study of biofuel production impact. However, most of them have no explicit accounting for a biofuel supply and demand sectors limiting their capabilities to capture the complexities of global biofuel and food markets impacts. Efforts have been done to integrate bioenergy sectors in the SAM underlying the CGE models (Taheripour et al., 2007; Birur, Hertel and Tyner, 2008; Channing Arndt and al, 2008, Channing, Pauw and Thurlow, 2010).

This paper uses a dynamic computable general equilibrium (DCGE) model of Senegal to estimate the potential effects of a morld biofuel boom on the senegaleses economic growth and poverty patern over the next decade. The model is linked to a survey-based microsimulation module that estimates impacts on income poverty.

The section 2 provides a background on the Senegalese’s economy and the challenges of biofuels world’s production for the economy. Section 3 discusses the methodology developed for assessing the impact pathway of biofuel development from world markets to the household level. The section 4 presents the results of our modeling efforts. The final section concludes on the main study’s findings.

**2. Modeling impact on growth and poverty of biofuel production**

**2.1. Background on the integrating of bioenergy into the computable general equilibrium models**

Bioenergy cannot be evaluated independently of the rest of the economy as the internal external feedback effects are important. 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. Channing Arndt and al, 2008, Rosegrant *et al.* 2008, Channing, Pauw and Thurlow, 2010, Ujjayant Chakravorty and *al*., 2011). Bettina Kretschmer and Sonja Peterson (2008) provide an excellent survey of literature on the different approachs used to integrate bioenergy into Computable General Equilibrium Models. Grouping the different methods into three approachs: the “Implicit approach”, the Latent technologies approach and the desegregation SAM approach, the authors critically assess their respective power.

The “implicit approach” (Dixon, Osborne and Rimmer, 2007, Banse et al., 2008) is a rather ad-hoc approach that avoids an explicit modelling of bioenergy production technologies but instead prescribes the amount of biomass necessary for achieving a certain production level (that would for instance comply with a biofuel policy target). The Latente technologies approach includes biofuel production in the model using production technologies that are not active in the base year of the model but that can become active at a later stage or in counterfactual scenarios. Different latent technologies approachs is used to model bioenergy in CGE models: some dealing with the first-generation of biofuel (Boeters et al., 2008, Kretschmer et al., 2008), those dealing with second-generation biofuels (Reilly and Paltsev, 2007) and those incorporating biofuel trade (Gurgel et al., 2007). The third generation of biofuel CGE models wich is well promised intends to disaggregate bioenergy production sectors directly from a social accounting matrix (SAM) underlying data structure of CGE models (.Taheripour et al., 2007 and Hertel, Tyner and Birur, 2008 with the GTAP model ; Channing Arndt and al, 2008 and Channing, 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 this later approach.

**2.2. The core of the CGE 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 endogenous growth of total factor productivity, the inclusion of public capital and land factors, and an export demand function. These new characteristics required some adjustment to the existing equation and the addition of a new one.

The model is designed as a set of simultaneous linear and non-linear equations, which define economic agents’ behavior, as well as the economic environment in which these agents operate. This environment is represented by market equilibrium conditions, macroeconomic balances, and dynamic updating equations.The model belongs to the recursive dynamic strand of the dynamic CGE literature, which implies that its agents’ behavior is based on adaptive projections rather than on the forward-looking projections that underlie alternative inter-temporal optimization models. Since a recursive model simulates one period at a time, it is possible to separate the *within-period* component from the *between-period* component, where the latter dictates the model’s dynamics. In the following sections, we present an overview of the model’s structure.

## 2.2.1. Within-period Specification

The within-period component describes a one-period static CGE model. The following description of this model is divided into the derivation of production, prices, institutional incomes and demand, foreign exchanges and Government budget. Equilibrium is maintained through a series of system constraints which are discussed at the end.

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### Production and Prices

The model identifies 21 productive sectors or activities that combine primary inputs with intermediate commodities to determine a level of output. The three inputs identified in the model include private capital, public capital and labor. Producers in the model make decisions in order to maximize profits subject to constant returns to scale, with the choice between factors being guided by a constant elasticity of substitution (CES) function. This specification allows producers to respond to changes in relative labor and private returns to capital factors by smoothly substituting between available factors so as to derive a final value-added composite. Profit maximization implies that factors generate income where marginal revenue equals marginal cost based on endogenous relative prices.

As in Cabral, Cisse and Diagne (2010), the total factor productivity (TFP) is endogeneously determined and is supposed to be a function of human capital, research-development, infrastructures, the ratio between the total public capital and the sectorial private capital and the sensitivity of the TFP to all of those factors specified with elasticities. The total public capital stock creates for each activity a positive externality that affects the total productivity of the sector. The TFP will then be affected by the distribution of public investment between human capital, research-development and infrastructures. It will also be affected by the level of externality that the sector perceives, in terms of benefits, and the elasticity of TFP with respect to all factors.

Graph 1: Production Technology1

Sector Output

Leontief

Intermediates

Value added

CES

Composite capital

Labor

Leontief

Public capital

Private capital

1 ‘CES’ is a constant elasticity of substitution aggregation function. ‘Leontief’ is fixed shares.

Graph 2 traces the flow of one commodity from its market supply to its final demand. The supply of a particular commodity from each producer is combined to derive aggregate commodity outputs. This aggregation is regulated by a CES function which allows consumers to substitute between the various producers supplying a particular commodity, in order to maximize the utility from consumption subject to relative supply prices.

Substitutions between domestic and foreign market production are possible. The producer’s decision is dictated by a constant elasticity of transformation (CET) function, which distinguishes between exported and domestic goods, and by doing so, captures any differences in time or quality between the two products. Profit maximization drives producers to sell in those markets where they can achieve the highest net returns. These returns are based on domestic and export prices (where the latter are determined by the world price times the exchange rate and are adjusted for any taxes).

The final ratio of exports to the consumption of domestic goods is determined by the endogenous interaction of relative prices for these two commodity types.

Domestically produced commodities that are not exported are supplied to the domestic market. Substitutions between imported and domestic goods are possible with a CES Armington specification (Armington, 1969). Such substitution can be performed both in final and intermediates usage. Under the small country assumption, Senegal is assumed to face an infinitely elastic global supply at fixed global prices. The final ratio of imports to domestic goods is determined by the cost of minimizing decision-making of domestic consumers based on the relative prices of imports and domestic goods (both of which include relevant taxes).

Graph 2: Commodity Flows1

Aggregate Commodity Output

CET

Aggregate Exports

Aggregate Imports

Domestic Sales

CES

Composite Commodity

Household Consumption

+

Government Consumption

+

Investment

+

Intermediate Use

1 ‘CES’ is a constant elasticity of substitution aggregation function. ‘CET’ is constant elasticity of transformation function.

The final composite good, containing a combination of imported and domestic goods, is supplied to both final and intermediate demand. Intermediate demand, as described above, is determined by technology and by the composition of sectorial production. Final demand is contingent to institutional incomes and the composition of aggregate demand.

### Institutional Incomes and Domestic Demand

The model distinguishes between various institutions within the Senegalese economy, including companies, the government, and 8 types of households. The household categories are disaggregated across areas (2 urban households for Dakar and the other cities and 6 rural households following the 6 agro-ecological areas). Graph 3 summarizes the interactions between institutions in the model.

The primary source of income for households and firms are factor returns generated during the production process. The supply of capital is fixed within a given time-period and across sectors, thus implying that capital earns sector-specific returns. Labor supply is assumed to be perfectly elastic at a given real wage. Final factor income also includes intra-households remittances and remittances received from (and paid from) abroad.

Households and companies generate factor incomes proportional to the implied share of each factor stock that they control. Companies are sole recipients of public capital income. Households in each income category are assumed to have similar preferences, and are therefore modeled as ‘representative’ consumers. In addition to factor returns, which represent the bulk of household income, households also receive transfers from other households, the government, other domestic institutions, and the rest of the world. Household disposable income is net of personal income tax (based on fixed rates), savings (based on fixed marginal propensities), and remittances. Consumer preferences are represented by a linear expenditure system (LES) of demand, which is derived from the maximization of a Stone-Geary utility function subject to a household budget constraint. Given prices and income, these demand functions define real household consumption of each commodity. The LES specification allows for the identification of supernumerary household income that ensures a minimum level of consumption.

Graph 3: Institutional Income and Domestic Demand

Aggregate

Factor Income

Labor

Public capital

Private capital

Transfers

Households

Enterprises

Government

Taxes

Taxes

Taxes

Consumption

Consumption

Goods Market

Investment

Savings

Savings

Savings

Savings

Borrowing

Transfers

Remittances

Remittances

Transfers

Rest of World

The government generates most of its revenues from direct and indirect taxes, and then spends it on consumption and transfers to households. Both of these payments are fixed in real terms. The difference between revenues and expenditures is the budget deficit. Although not shown in graph 3, the government also remits payments to the rest of the world. In the current model, the government’s role as a consumer is treated separately from the generation of government services. The latter is specified as an activity that generates services for which the government institution is the primary consumer.

Households, firms, government and foreign saving represented by the current account balance are collected into a savings pool used for investment. The sum of total investments and inventories in value is equal to the sum of savings expressed in local currency generated by households, companies, the government and the rest of the world.

There is no explicit modeling of the financial sector within a particular time-period, with savings equaling investment as per the *ex post* accounting identity. This implicitly assumes that the interest rate adjustment is necessary to ensure that savings equals investment in equilibrium. The disaggregation of investment into demand for final commodities is completed using fixed shares, with changes in aggregate investment leading to proportional increases in the demand for individual commodities. Therefore there is no real compositional shift in investment following changes in relative commodity prices.

Production is linked to demand through the factor returns and the payment of this income to domestic institutions. Balance between demand and supply for both commodities and factors are necessary in order for the model to reach equilibrium. This balance is imposed on the model through a series of system constraints.

### System Constraints and Macroeconomic Closures

Equilibrium in the goods market requires that demand for commodities equals supply. Aggregate demand for each commodity includes household and government consumption spending, investment spending, and export and demand for transaction services. Supply includes both domestic production and commodity imports. Equilibrium is attained through the endogenous interaction of domestic and foreign prices, and the effect that shifts in relative prices have on sectoral production and employment, and hence institutional income and demand.

Balancing factor demand and supply is based on factor market characteristics. As discussed above, capital is fully utilized and is sector-specific. The labor market is assumed to be competitive. Alternatively, the supply of this factor is responsive to changes in actual wages, which adjust to ensure the same level of equilibrium for demand and supply.

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 growth. 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, 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. However, the inclusion of dynamics into the model allows past investments to influence economic growth, and thereby the level of savings available for investments in the current period. The model’s dynamics are discussed below.

Finally, the exchange rate is chosen as the numeraire. The model is also homogenous of degree zero in prices, implying that doubling all prices does not alter the actual allocation of resources.

## 2.2.2 Between-period specification

While the static model described above is detailed in its representation of the Senegalese economy within a particular time-period, its inability to account for second-period considerations limits its assessment of the full effect of policy and non-policy changes. For example, the model is unable to account for the second-period effect that current investment changes have on the subsequent availability of capital. In attempting to overcome these limitations, the static model is extended to a recursive dynamic model in which selected parameters are updated based on the modeling of inter-temporal behavior and results from previous periods. Current economic conditions, such as the availability of capital, are thus endogenously influenced by past outcomes, but remain unaffected by forward-looking expectations. The dynamic model is also exogenously updated to reflect demographic changes that are based on observed or separately-calculated projected trends.

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 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 Senegalese dynamic model is treated as a series of equilibria, each one representing a single year. By performing the above policy-independent dynamic adjustments, the model produces a projected or counterfactual growth path. Policy changes can then be expressed in terms of changes in the relevant exogenous parameters and the model is re-solved for a new series of equilibria. Difference between the policy-based growth path and the counterfactual’s can then be interpreted as the economy-wide impact of the modeled policy.

**2.2.3 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.[[5]](#footnote-6) 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.

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



where z is the poverty line, yi the mean expenditure of the household i; α a coefficient expressing the level of aversion against poverty, n the total number of individuals, p 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[[6]](#footnote-7), based on the household survey (ESPS, 2005) is 923.71, 661.76 and 561.22 FCFA/day/equivalent-adult respectively in Dakar, the other cities and rural area.

**2. 3 Data and description of the economy**

**2.3.1. The basic structure of the SAM**

The CGE model is calibrated to a 2005 social accounting matrix (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). The resulting SAM is used to feed the general-equilibrium model described above so that the initial equilibrium reproduces the base-year values from the SAM. The parameters for demand, supply and trade functions are taken from Cabral, Cisse and Diagne (2010).

In The SAM, production activities include agriculture, groundnut oil industries, other agri-food industries, as well as 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 distinguished into eight categories: households in Dakar as well as households in other cities, rural households of groundnut belt (ZBA), of livestock area (ZSP), of eastern Senegal (ZSO), of Casamance (ZS), of Niayes and of Senegalese river (ZF).

**2.3.2. Integrating the biofuel sector in the SAM**

Biofuels are currently little produced in Senegal and so there is initially no biofuels sector in the 2005 social accounting matrix. Thestatistics on biofuel in the base year are very weak for some sectors (jatropha, sugarcane) and are quite inexistent for some of these sectors (biodiesel and biofuel). To integrate biofuel sector in the SAM, we following Channing, Pauw and Thurlow (2010) and Channing Arndt and al, 2008 approach. Some assumptions are made to introduce biodiesel sectors in the SAM. During the 2008-2009 crop years, the total area under cultivation of jatropha was estimated at 5293 ha (Dia et al., 2007). According to data collected on 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 is made. Therefore the supply is valued at 635.16 million FCFA. The policy goal of Senegal is to sow 320,000 ha to produce 3.2 million tons of jatropha by 2012. This production should help to bring to market a range of 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[[7]](#footnote-8) is then estimated at 3.939 billion FCFA.

Ethanol production is mainly due to the Senegalese Sugar Company (CSS), which opened in 2007, a distillery with a capacity of 60,000 liters/day. This is equivalent to a production of 21 900 m3 per year. The coefficient of conversion of sugarcane into molasses is equal to 1 ton of sugarcane to 35 kg of molasses. And 1 ton of molasses gives 270 tons of alcohol considered as ethanol. Therefore 21 900 00 m3 of ethanol is supposed to come from 81 111.1 tons of molasses and require 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 production is set at 36% required input for the distillery maximum capacity.

The technology of refined petroleum sector mainly represented by the African Refining Company (SAR) is given by 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.

**2.3.3. The structure of the Senegalese economy**

Senegal is classified as least developed countries with more than half of the population leaving under the poverty line (50.7 percent). In the last decade, the economy was marked by the rapid development of the services sector fuelled by the telecommunication business. The table1 gives the gross domestic product (GDP) growth, and the contribution of the sectors to GDP growth from 1980 to 2010. Between 1985 and 1993, despite the adjustment program in the medium and long term (PAMLT), economic activity in real terms grew annually by 2.3%. This rate of growth is only slightly above the population growth (2.4%). With the currency adjustment that occurred in 1994, the situation has changed significantly and the domestic economic activity recorded a favorable trend in subsequent years. GDP growth is estimated at 5.4% in 1998 and stands at 6.5% in 1999. In the period after 2000, the growth rate still recorded significant levels but remained relatively instable. While 2003, 2004 and 2005 was marked by strong GDP growth; it is otherwise in the years 2002, 2006, 2008 and 2009 where it has been marked by contraction in activity under the influence of climate and energy shocks and the financial crises. Consequently, the average growth rate of GDP has fallen in the last ten years below that of the population, making more difficult the efforts against poverty.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Table 1**: Senegal, Trend of some macroeconomic indicators, 2001-2008 | | | | | | | | | | | | | |  |  |  |  |
|  | **1980-1984** | **1985-1993** | **1994-1999** | **2000-2010** | **1998** | **1999** | **2000** | **2001** | **2002** | **2003** | **2004** | **2005** | **2006** | **2007** | **2008** | **2009** | **2010** |
| Constant GDP  growth (%) | 2.4 | 2.3 | 3.8 | 4.1 | 5.4 | 6.5 | 3.7 | 3.2 | 0.2 | 7.2 | 6.2 | 5.7 | 2.3 | 4.9 | 4.4 | 3.0 | 4.3 |
| GDP Share (%) |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Primary sector | 22.4 | 22.3 | 20.6 | 16.8 | 19.2 | 20.47 | 20.2 | 19.6 | 15.7 | 17.2 | 16.6 | 17.1 | 15.2 | 13.6 | 15.5 | 17.1 | 17.3 |
| Secondary sector | 19.5 | 20.6 | 22.4 | 22.6 | 23.2 | 21.99 | 22.2 | 22.8 | 24.0 | 23.2 | 23.1 | 22.7 | 22.5 | 23.0 | 21.8 | 21.4 | 21.7 |
| Tertiary sector | 58.1 | 57.1 | 57.0 | 60.6 | 57.6 | 57.5 | 57.6 | 57.5 | 60.3 | 59.6 | 60.2 | 60.2 | 62.3 | 63.4 | 62.8 | 61.5 | 61.1 |
| Contribution  to GDP growth |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Primary sector | 0.4 | 0.5 | 0.6 | 0.4 | 0.19 | 2.623 | 0.4 | 0.1 | -3.9 | 2.7 | 0.5 | 1.4 | -1.5 | -0.9 | 2.5 | 2.2 | 0.9 |
| Secondary sector | 0.6 | 0.6 | 0.9 | 0.9 | 1.73 | 0.23 | 1.0 | 1.3 | 1.2 | 0.9 | 1.4 | 0.9 | 0.3 | 1.6 | -0.3 | 0.3 | 1.2 |
| Tertiary sector | 1.3 | 1.1 | 2.3 | 2.8 | 3.5 | 3.628 | 2.2 | 1.7 | 2.9 | 3.6 | 4.3 | 3.5 | 3.5 | 4.2 | 2.1 | 0.5 | 2.3 |
| Source: ANSD. | | | | | | | | | | | | | |  |  |  |  |

The sectoral composition of GDP shows that the services has consistently provided more than half of GDP (61% during the period 2000-2010, against 58% in 1980-1984) and is mainly the engine of the growth as highlighted by the sectors’ contribution to growth rate of GDP in graph 4). The contribution of industry, which was estimated at 19.5% between 1980 and 1984, reached 22.6% during the period 2000-2010. By contrast, the agricultural sector share declines from 22.4% to 16.8% during the same periods. The contribution of both the agriculture and the industry to growth is globally low during the whole period.

Graph 4**:** Senegal, Sectors ‘contribution to growth, 2000-2010.

Source: Estimated from national accounts.

Table 2 shows the structure of the Senegalese economy in 2005, which is the base year of the economic model. No surprisingly, the services have the most important contribution to GDP (61 percent) and employment 58 percent and capital (65 percent). It contributes to 31 percent of the whole exports. The contribution of secondary sector is estimated at 23.5% of the GDP and 26.3% of the total employment.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Table 2. Structure of Senegalese’s economy in 2005 | | | |  |  | **Exports  intensity (%)** | **Imports  penetration (%)** |
|  | Share of total (%) | | | | |
|  | **GDP** | **Employment** | **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 |
| **Industrie** | **23.56** | **26.37** | **21.17** | **67.46** | **81.45** | **0.28** | **0.43** |
| Fisching | 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 |
| PetrolRaffine | 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 |
| PetrolBrut | 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 |

Industry sector is dominated by food processing (excluded oil), which accounts for 6.3 percent of the national GDP and a 8.35 percent of the whole employment. It is followed by non food industries which include mainly the construction sub sector. The fishing sector contributes to around 2% both to the GDP and the employment. In contrast, agriculture sector generate 15 percent of the gross domestic product (GDP) and 16 percent of total employment. Senegalese farmers produce mainly staple grains (millet and maize), peanuts, as well as fruits and vegetables. Agriculture is weak exporter and agricultural exports are concentred in 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).

**Energetic intensity**

One of the channel through wich biofuel production can affect Senegalese economy is the sectorial energetic intensity. Table A1 shows that raffined petroleum is an intermediaite consumption mainsly used by the following sectors: fishery, sugar, non food industries, rice, tradable and non services[[8]](#footnote-9). Biodiesel is mainly used by the sector tradable services and other industries as an input for production purpose. Crude oil is exclusively an intermediate consumption for the *rafined petroleum* sector.

# 3. Results

In the “Reference Scenario”, we assume that global biofuels production expands only beyond 2005.We simulate the impact on Senegalese economy of 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 prices variations are given in Table A2. 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 then assessed.

# Effects on imports, exports and sales on domestic market

Under assumed 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. Therefore, 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 | Sim |
| 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 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 the one experienced by maize, vegetables, fruits and groundnut. The total exports increased also.

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

|  |  |  |  |
| --- | --- | --- | --- |
|  | Relative export share in 2005 | Shareof export s on production in 2005 | Sim |
| 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 simulations

As export refined oil decreased, its supply is reoriented to the local market. Therefore local sales of refined oil increase. Local sales of biodiesel decrease as its production declined (table 5). Local sales of jatropha decreased while the one of sugarcane increased due mainly to sugar activity. More generally, total domestic sales increase.

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

|  |  |
| --- | --- |
|  | Sim |
| 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: Simulations

**Sectoral effects**

Under assumed boom in biofuel production in the world market, biodiesel and bioethanol production and valued-added decrease while the one of refined oil increases (table 6). 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. This sector concentrated an important share of non agricultural capital for which price has increased.

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

|  |  |  |
| --- | --- | --- |
|  | GDP share in 2005 | Sim |
| 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 simulations

The GDP increases during the whole period as returns to all factors increase in the economy (graph 5).

Graph 5: Changes in GDP w.r.t. bau (in %)

Source: simulations

**Returns to factors**

Capital used in agriculture 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. The analysis of returns to factors suggests that wages rate increase w.r.t. the BAU during the whole period as observed in the graph 6. This trend is similar to the one reflected by the GDP (graph 5). However, increasing GDP observed seems to be also induced by rising returns to agricultural capital. One can observe that if the trend of returns to non agricultural is quite flat, retunrs to agricultural capital has increased during the whole period (graph 7).

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 8). Returns to sugarcane have increased during the whole period due increasing supply of sugar which pulled sugarcane production. Rice land is the one which experienced the more significant increase.

Graph 6: Changes in wage rate (in %)

Source: simulations

Graph 7: Changes in returns to capital (in %)

Source: simulations

Graph 8: Changes in the return to land (in %)

Source: simulations

**Poverty effects**

Changes in the returns to factors have in turn effects on nominal income and consumer price. Both the changes in household’s revenues and consommer price are very low. Compare to the baseline, the nominal revenues increase very slightly in the biofuel simulation, with a higher effect at the end of the period. In contrast the price decreases in the whole period and relatively more after the 13th year.

Graph 9: Senegal, household revenues and prices change w.r.t to the baseline scenario

Source: calculations of authors based on simulation results.

The prices and revenues effects are also reflected in poverty outcomes. Income and price effects induce a constant trend of poverty during the first half of the the period but a declining one during the second half of the period.

Graph 10: changes in poverty effects at the national level in % (w.r.t to the baseline scenario)

Source: calculations of authors based on simulation results.

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 11: Changes in poverty effects in main areas in % (w.r.t to the baseline scenario)

Source: calculations of authors based on simulation results.

Within the rural area, the poverty effets differ from one group to another depending on periods. Households from southern Senegal (casamance), eastern Senegal and Groundnut belt are those who experienced the deepest fluctuations. Increases in poverty level are more important for those groups during the first period while drops in poverty headcount are more significant for those categories during the second half of the period.

Graph 12: Changes in poverty effects in rural areas in % (w.r.t to the baseline scenario)

Source: calculations of authors based on simulation results.

**Conlusions**

In this paper, we first build 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 a global GTAP CGE model. The simulation captures the effects of world market prices changes within the context of Senegalese economy.

Under assumed 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 significant share of import products that underwent an increase, the total imports increase. Exports increase for most of the products and induce a rise in the total exports. Valued-added of biodiesel and bioethanol decreases while it increases for most the sectors, in particular those which are more energy intensive. 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 experienced a more deep decrease in poverty headcount than the one of other cities and rural areas. Households from southern Senegal (casamance), eastern Senegal and Groundnut belt are those who experienced the deepest fluctuations. Therefore increases in poverty are more important for those groups of household during the first period while drops in poverty observed during the second half of the period headcount are more significant for those categories.

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**Annex**

Table A1: Sectorial energy intensity in 2005 (in %)

|  |  |  |
| --- | --- | --- |
| Sectors | Relative shares of each sector in total refined petroleum consumption | Share of energy in the  total inputs of the sector |
| Millet/sorghum | 0,00 | 0,00 |
| Maize | 0,03 | 2,48 |
| Rice | 0,17 | 3,45 |
| Vegetables | 0,07 | 1,36 |
| Fruits | 0,04 | 0,90 |
| Cotton | 0,14 | 3,15 |
| Groundnut | 0,09 | 0,68 |
| Other agricultural | 0,00 | 0,00 |
| Jatropha | 0,00 | 0,00 |
| Sugarcane for sugar | 0,00 | 0,00 |
| Sugarcane for ethanol | 0,00 | 0,00 |
| Livestock | 0,00 | 0,00 |
| Fishery | 6,17 | 13,00 |
| Food oil | 0,02 | 0,03 |
| Other food industries | 2,82 | 1,39 |
| Sugar | 0,62 | 5,45 |
| Other industries | 57,07 | 5,90 |
| Refined oil | 0,00 | 0,00 |
| Biodiesel | 0,00 | 0,00 |
| Bioethanol | 0,00 | 0,00 |
| Crude oil | 0,00 |  |
| Tradable services | 29,70 | 3,42 |
| Non Tradable services | 3,07 | 3,44 |
| Total | 100,00 |  |

Source: calculations from the Sam

Table A2: price changes for Senegalese economy induced by a world biofuel boom, 2006-2020 (in %)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | 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 |

1. Economic and social research consortium (CRES) [↑](#footnote-ref-2)
2. Economic and social research consortium (CRES) [↑](#footnote-ref-3)
3. Economic and social research consortium (CRES) [↑](#footnote-ref-4)
4. Internation Food Policy Research Institute (IFPRI) [↑](#footnote-ref-5)
5. Davies (2009) provides an exhaustive review of the literature regarding the techniques of reconciling the macro-modeling with poverty and inequality analysis. [↑](#footnote-ref-6)
6. Direction de la prévision et des statistiques [↑](#footnote-ref-7)
7. pilot experiments of Sococim company [↑](#footnote-ref-8)
8. Transport services represent almost 85% of tradable services in terms of refined petroleum consumption. [↑](#footnote-ref-9)