Establishment of an Equilibrium Model for Analyzing Sectoral Agricultural Policy in Benin

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Introduction

The World Bank in its 2008 World development report stated on the need of more investment in African agriculture to halve by 2015 the proportion of people living in extreme poverty and suffering from hunger. Thus, effective agricultural policy is necessary to achieve the objectives of the recovery. This study was conducted to provide appropriate technical tools for the formulation and implement agricultural policy in Benin in order to make more effective decisions and actions.

It will allow government to develop regulatory tools to influence the efficiency of agricultural markets or to change the allocation s of factor endowments and results in order to set the agriculture as the basis of growth and economic development.

This paper will first present the history of agricultural policy in Benin, the recent performance development, an overview of modeling tools in the sector. The specification of the partial equilibrium model for Benin agriculture will be presented followed by some key findings and issues.

In conclusion some recommendations will be made to improve the data collection system in order the outputs of the models and to use them as decision making support tools.

Development policies and agricultural performance in Benin since 2006

Prior to independence the agricultural organization was a kind of community-based social system of production. Some management actions has been settled by the colonial authorities with the creation of the first Department of Agriculture in 1958, two years before independence.

From 1960 to 1972, the new authorities attempted to develop a better organization the sector by creating agricultural cooperatives and village groups, and promoting rural youth through the strengthening of legal framework.

From 1972 to 1990, thanks to the Marxist-Leninist ideology, the authorities opted for the socialist development choice with the government launching direct development interventions.

From 1991 to 2005, the period of democracy and structural adjustment options, liberalization was the way chosen for economic development through the development of private sector alongside with the public sector.

Since 2006, a new strategic plan for the agriculture sector (PSRSA) has been developed with for specific objectives to ensure efficient production and sustainable management of farms in order to contribute to growth and food security, and to ensure the competitiveness of production and access to markets and products through the promotion of agricultural sector.

In terms of performance, the agricultural GDP at constant prices fell steadily, moving in the opposite direction to GDP, showing a dynamic economy where the agricultural sector is supplier of raw material pushes the others.

Agricultural policy analysis tools

A model allows to summarize the different effects, sometimes contradictory, of an economic policy, and to quantify them. As simplified form of the relations on the market, the model may then allow to describe, given the equilibrium constraints, the impacts of shocks, both internal and external, and to propose decision-making based on facts.

There are three approaches of equilibrium analysis: the global equilibrium (by considering only one market on which the supply is equal to demand), the general equilibrium (which consider a multi-market model where the total sum of supply is equal to the total sum of demand) and the partial equilibrium (which also is a multimarket model which realizes simultaneously the equilibrium of supply and demand on each market).

The partial equilibrium considered in this study is a multi-market equilibrium of a single market of products, group of products or articulated markets: the agricultural market

Specification of the model

Several tools have been developed both at national, regional or international levels. Some of them are: the AGLINK model of OECD, the MAGALI model developed by France, the AROPAJ model developed by the European Union, etc.

Three agricultural subsectors have been identified and a model has been constructed for each of them.

The animal chain

The form of the model is as follow:

(1)

$$\begin{cases} \ln Qo_{it} = A_o + a_1 \ln X_{7it} + a_2 \ln X_{12it} + a_3 \ln X_{12i(t-1)} + a_4 \ln Qd_{it} + a_5 \ln Qd_{i(t-1)} + u_{it} \\ \ln Qd_{it} = B_o + b_1 \ln X_{8it} + b_2 \ln X_{9it} + b_3 \ln X_{10it} + b_4 \ln X_{11it} + b_5 \ln X_{12it} + b_6 \ln X_{13it} + b_7 \ln X_{14it} + v_{it} \\ \ln Qo_{it} = \ln Qd_{it} \quad (\textit{partial equilibrium condition}) \end{cases}$$

Where Q_o = Quantity supplied; Q_d = Quantity demanded; X_7 = Agricultural Investments; X_8 = Population size; X_9 = GDP per capita; X_{10} = Nominal effective exchange rate;

X_{11} = Unemployment rate; X_{12} = Price of the agricultural product; X_{13} =Inflation rate; X_{14} = Interest rate.

A similar model has been specified for the **fishing sector**

The vegetable sector

The form of the model is as follow:

(2)

$$\begin{cases} \ln Qo_{it} = C_o + c1 \ln X_{1it} + c2 \ln X_{2it} + c3 \ln X_{3it} + c4 \ln X_{4it} + c5 \ln X_{5it} + c6 \ln X_{6it} + c7 \ln X_{7it} + c8 \ln X_{12it} \\ + c9 \ln X_{12i(t-1)} + c10 \ln X_{3i(t-1)} + c11 \ln Qd_{it} + c12 \ln Qd_{i(t-1)} + u_{it} \\ \ln Qd_{it} = d_o + d1 \ln X_{8it} + d9 \ln X_{9it} + d10 \ln X_{10it} + d11 \ln X_{11it} + d12 \ln X_{12it} + d13 \ln X_{13it} + d14 \ln X_{14it} + v_{it} \\ \ln Qo_{it} = \ln Qd_{it} \quad (\textit{partial equilibrium condition}) \end{cases}$$

Where Q_o = Quantity supplied; Q_d = Quantity demanded; X_1 = cropped area, X_2 = rainfall; X_3 = yield; X_4 = Quantity of fertilizer; X_5 = Quantity of pesticide; X_6 = Quantity of herbicide; X_7 = agricultural Investments, X_8 = population size; X_9 = GDP per capita; X_{10} = Nominal effective exchange rate; X_{11} = unemployment rate; X_{12} = Price of the agricultural product; X_{13} =Inflation rate; X_{14} = Interest rate.

For each sector, after, several iterations and robustness tests, a final model has been specified.

Estimates and results

Finally a system of simultaneous equations with a Cobb Douglas functional form has been estimated. The interdependence between the functions of supply and demand has made opting for a Two-stage least squares (TSLS) method with as instrumental variables with a stepwise approach: lagged variables (lagged Quantity Demanded, GDP, investment, etc.) The database is constituted of the time series from 1980 to 2008. The models were ran with the Eviews 6 package.

Some main products had been modeled such as: the livestock industry represented by beef, sheep and poultry, the fishing industry represented by shrimp and fish and the vegetable sector represented by cotton, corn, rice and pineapple. The outputs are summarized in the following table

Key outputs

Estimates results in the Animal sector

	Coef	Prob	R2	Prob(F-stat)
Beef				
1) tsls ldde_avo c lprix_vo @ linv lpib_cr_h lprix_vo(-1) ldde_avo(-1)	0,647817	0,0011	0,649226	0,001149
2) tsls ldde_avo c lprix_vo @ linv lpib_cr_h lprix_vo(-1)	0,650988	0,0001	0,69868	0,000129
3) tsls ldde_avo c lprix_vo @ linv lpib_cr_h ldde_avo(-1)	0,651429	0,0011	0,648524	0,001114
4) tsls ldde_avo c lprix_vo @ linv lpib_cr_h	0,625073	0,0002	0,703694	0,000213
Sheep				
1) tsls lQ_aov c lprix_ov @ lpib_cr_h linv lprix_ov(-1) lQ_aov(-1)	0,099859	0,0626	0,242691	0,062599
2) tsls lQ_aov c lprix_ov @ lpib_cr_h linv lprix_ov(-1)	0,118881	0,0203	0,305475	0,02029
3) tsls lQ_aov c lprix_ov @ lpib_cr_h linv lQ_aov(-1)	0,07949	0,1831	0,238839	0,183142
4) tsls lQ_aov c lprix_ov @ lpib_cr_h linv	0,199814	0,1497	0,098868	0,149651
Poultry				
1) tsls ldde_avo c lprix_vo @ linv lpib_cr_h lprix_vo(-1) ldde_avo(-1)	2,168005	0,0016	0,455813	0,001578
2) tsls ldde_avo c lprix_vo @ linv lpib_cr_h lprix_vo(-1)	2,20228	0,0014	0,455061	0,001398
3) tsls ldde_avo c lprix_vo @ linv lpib_cr_h ldde_avo(-1)	2,183336	0,0016	0,455507	0,001646
4) tsls ldde_avo c lprix_vo @ linv lpib_cr_h	2,231938	0,0014	0,454211	0,001393

Estimates results in the** Fishing **sector

	Coef	**Prob**	**R2**	**Prob(F-statistic)**
Shrimp				
tsls lQ_hcr c lprix_hcr @ linv lpib_cr_h lpib_cr_h	-6,580805	0,437	0,598312	0,437002
Fish				
tsls lQ_aov c lprix_ov @ lpib_cr_h linv lprix_ov(-1)	-2,695289	0,0106	0,413247	0,010552

Estimates results in the** Vegetable **sector

	Coef	**Prob**	**R2**	**Prob(F-statistic)**
Maïze				
1) tsls lQ_vma c lprix_vma @ lpib_cr_h linv_md lprix_vma(-1) lQ_vma(-1)	1,503441	0,0013	0,189896	0,001259
2) tsls lQ_vma c lprix_vma @ lpib_cr_h linv_md lQ_vma(-1)	1,524439	0,0013	0,173436	0,001277
3) tsls lQ_vma c lprix_vma @ lpib_cr_h linv_md	1,713818	0,0007	0,147775	0,000708
Cotton				
1) tsls lQ_vco c lprix1_vco @ lpib_cr_h linv_md lprix1_vco(-1)	0,492805	0,2664	0,138445	0,266428
2) tsls lQ_vco c lprix1_vco @ lpib_cr_h linv_md	0,476509	0,2999	0,136301	0,299855
Rice				
1) tsls lQ_vri c lprix_vri @ lpib_cr_h linv_md lprix_vri(-1)	-2,220144	0,1456	0,56414	0,145639
2) tsls lQ_vri c lprix_vri @ lpib_cr_h linv_md	-2,250142	0,1583	0,56416	0,158323
Pineapple				
1) tsls ldde_van c lprix_van @ lpib_cr_h linv_md lprix_van(-1) ldde_van(-1)	4,592149	0,0055	0,599099	0,005546
2) tsls ldde_van c lprix_van @ lpib_cr_h linv_md lprix_van(-1)	4,40651	0,0105	0,510222	0,010482
3) tsls ldde_van c lprix_van @ lpib_cr_h linv_md ldde_van(-1)	5,936993	0,0039	0,541789	0,00391
4) tsls ldde_van c lprix_van @ lpib_cr_h linv_md	7,314508	0,0041	0,350884	0,004098

The tables above show in that the equilibrium has been realized in some the sectors, but for some of them such cotton, rice it was not possible to attain this equilibrium. Several factors may explain this situation such institutional factors (governance, quality and/or availability of data, the

presence of the Nigerian market which allows informal and illicit trade, etc.)

Conclusion

This study is a good exercise of application of modeling in the agricultural sector to support decision making with scientific tools. The outputs show that it is possible to forecast the both prices and quantities expected by deriving price elasticity from the estimated parameters and using small computer application.

The results of this study highlight the role of prices, as the main instrument for regulating the different markets. The study results also show that the equilibrium of certain markets is far from being achieved because of failure of supply or demand. It is therefore imperative to redefine the fields of intervention mainly by the prices, which are the only variables that influence significantly the equilibrium of the different markets.

But there are still several limits and brakes to overcome. Some of them are related to the huge lack of data for some series, mainly macro economic data and to the quality of the agricultural data.

The fail in realizing the first agricultural census is an eloquent example. That is why the authorities of this key development sector of the national economy are urged to implement a solid and permanent system of agricultural data collection. It urges to establish a monitoring system of farms Benin, in order to collect and analyze data on the socio-economic organization, the allocation and distribution of factors and resources. This will allow improving the modeling system and studying the microeconomic behavior of rural populations with regard to the different agricultural policies. The experience of the national statistical council should be very important to exploit.

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ABSTRACT

In order to implement an agricultural policy based on tools for rational decision making, a partial equilibrium model has been implemented on behalf of the authorities in charge of agriculture. The objective is to stimulate demand and supply of major agricultural products. The partial equilibrium model constructed is decomposed according to supply and demand of main agricultural commodities and is implemented with a series of statistical data on the period 1980-2008. The estimates were made using the two-stage least square method for solving simultaneous equations systems. Three equations constitute the model: an equation of agricultural supply, an equation of demand for agricultural products and an equation of equilibrium (the equilibrium condition states that supply equals demand).

The main variables involved are prices, quantities produced or demanded, exports, imports, historical yields, rainfall, exchange rates, growth rates, population, and other macroeconomic variables. To take account of expectations of economic agents (consumers, producers and state) lagged variables were considered: thus, the delayed price, quantity demanded delayed, the gross domestic product and investment have been used as instrumental variables. Under the assumption that consumers and producers are price takers in the various markets concerned, the equilibrium on each of these markets is obtained by making endogenous the price or the quantity supplied or demanded.

Different commodities have been modeled in three different fields: Animal field, vegetable and fishing industry sector and scenarios were explored. It comes out from these econometric estimates that the prices of the products play a key role as a principal tool of regulation of the various agricultural markets. Thus, for the prices, partial equilibrium, the quantities supplied and demanded are significantly influenced, which has a tangible impact on the surplus of each of the agents involved.

The food crisis occurred in 2008, following the surge in prices of essential commodities has highlighted the pivotal role of certain crop sectors (maize, rice). Indeed, the rise in prices is nothing but the result of an imbalance between supply and demand of agricultural products. The availability of a forecasting tool as this forecasting model allows therefore a rational decision making.

However, a good model requires reliable and current statistical data. But the statistics used in this model are not always complete, on time or data quality does not always meet expectations. It is therefore imperative to review the system of collection of agricultural data. Unfortunately, the difficulties encountered with the National Agricultural Census, a first in Benin, failed to have some relevant statistical information. A major effort must be made at the national system of agricultural statistics to make available to the team modeling the relevant and reliable data needed. This is why recommendations are made in this direction.

Keywords: *Agriculture; partial equilibrium model; census and data quality; forecast prices*