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Taxation of Moroccan agriculture: an analysis of the sensitivity of the results of a dynamic computable general equilibrium model

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Taxation of Moroccan agriculture: an analysis of the sensitivity of the results of a dynamic computable general equilibrium model

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Agriculture has always been the subject of close attention from governments in Morocco, owing among other reasons to its relationships with other sectors, its importance in foreign trade and its role in providing foodstuffs in rural and urban areas. Indeed, agriculture accounts for 15 to 20% in GDP and employs 44% of the labor force. If we add food processing, its contribution to GDP and employment amounts to 15% and 50%, respectively. However, Moroccan agriculture suffers from low productivity, low yields and high logistics, and production costs. For these reasons, agriculture has enjoyed tax exemptions to encourage and promote private and foreign investments. Nevertheless, the tax advantages became a source of distortions and inefficient allocation of investments and resources toward this sector. To analyze the implementation impact of a new system of agricultural taxation, we built a dynamic multi-sectoral computable general equilibrium (CGE) model. This model is more preferable and suitable than macro-econometric or partial equilibrium economic models because of its dynamic structure, which makes it possible to catch the intertemporal effects of taxation on the well-being of farmers and on the economy as a whole. In addition, we run an unconditional sensitivity analysis to prove that the variability of the model as a whole is not too significant after simultaneous modification of all the parameters. To do this, the Gaussian Quadrature Method is implemented as developed by Arndt, De Vuyst and Preckel, and Piet.

Keywords: optimal taxation; agricultural sector; computable general equilibrium model

1. Introduction

In the early 80s, Morocco launched structural adjustment programs, trade liberalization and policy reforms and the managed economy was gradually abandoned. During the 90s and beyond, the effects of these reforms on the industrial sector were observed. As in other countries, agriculture was the most difficult sector to promote.

Hence, the agricultural sector has always been the subject of close attention from governments for a number of reasons. First, agriculture plays an essential role in rural and overall economic development, due to its size and its relationships with the rest of the economy including the food industry, catering, and hotels. Indeed, agriculture contributes 15% of GDP and 44% of total employment. If we add food processing, its contribution to GDP and employment increases at 20% and 50%, respectively.

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Furthermore, agriculture constitutes the livelihood of the majority of poor rural populations and the main provider of the most important foodstuffs in both rural and urban areas. The effects of food prices are certainly felt by the majority of the population whose income is near or below the average.

We also note that multiple tax incentives were granted to the agricultural sector. Agriculture still benefits from a system of tax exemption which aims to promote, attract, and develop private financial interventions in the sector in the form of direct investments. For example, two years ago, the agricultural and fishing sectors benefited from tax derogations in Morocco representing about 13.4% of the total measures identified in this year.

Furthermore, it should be highlighted that the primary role of taxation is undoubtedly to generate, in the most neutral way and with the least possible distortions, revenues required for the government budget. However, taxation should fulfill its budgetary role and conciliate between objectives that could be contradictory at times. The proliferation of exemptions and derogatory regimes, observed in previous years, go against these principles. After all, the tax advantages can be a source of distortions and an inefficient allocation of investments and resources.

Today, and besides the question concerning the position of Moroccan agriculture in the economy which led to the design and implementation of the Green Morocco Plan (PMV), it should be noted that the question of its taxation received more attention from the government and the public alike.

To clarify the interest of this topic, several analytical questions can be asked. Would it be possible to remove all the tax exemptions for the agricultural sector? When and how? Are we supposed to introduce a value-added tax (VAT), given that farmers and ranchers already bear a VAT on the inputs they use in production? Would it be appropriate to raise the tax exemption of agricultural income and, if so, what would the impact of this measure be on farmers' income especially the small ones? Would it be appropriate to submit the agricultural profits generated by agricultural companies operating essentially in irrigated agriculture to corporation tax? What would the implications of these measures be on the allocation of productive resources and social well-being, including middle and rich farmers as well as small farmers who represent 90%? What would the repercussions of these measures be on the government's budget? Should the government maintain tax exemption for small farmers in the future? In addition, our investigation focuses on anticipating challenges to better guide our choices of development of the agricultural sector in the short term as well.

To answer these questions, we built a dynamic multi-sectoral computable general equilibrium (CGE) model in order to quantify the impact of the taxation of the agricultural sector on the economy and on the distribution of income. This model is more preferable than macro-econometric or partial equilibrium ones. We also used an unconditional sensitivity analysis to ensure that the variability of the model is not too big after simultaneous modification of all the parameters. To do this, the Gaussian quadratic method is implemented as developed by Arndt (1996), De Vuyst and Preckel (1997), and Piet (2002).

This paper is organized as follows. The second section will present the budgetary provisions, tax, and customs applicable to agriculture. The third one gives the analytical framework of optimal taxation of goods and incomes required to model the effects of agricultural taxation. The fourth section presents the principal blocks of the model and describes the social accounting matrix (SAM). The calibration, scenarios, and simulation results will be examined in the fifth section. The sixth section however discusses the analytical method and the application of the unconditional procedure of the sensitivity analysis of the results of the model. The last section is devoted to the results and recommendations.

2. Budgetary provisions, tax, and customs applicable to agriculture

During the 60s, the majority of farmers were exempted from the agricultural tax applicable at the time. The tax bases remained narrow and the maintenance of the low rates on agricultural income were a major cause of the non-effectiveness of this tax. Indeed, the share of agricultural tax income did not exceed 1% in total. Even worse, this tax was not collected in the early 80s as it coincided with a severe drought. The year 1984 was marked by the Royale decision, which exempted the agricultural sector of all taxes until 31 December 2000. In 2000, this exemption was further extended twice until 2013,[1] the time required to upgrade the sector in the context of the PMV. Also, the King in his speech of 30 July 2013 decided to tax large agricultural companies and continue to exempt small and medium-sized farmers from all forms of taxes, awaiting for a better visibility of the outcome of this reform.

2.1. Budgetary provisions

While producer's prices were liberalized on most markets, distortions still exist for wheat and sugar which benefit from support measures provided by the State through a special fund, known as the 'Fund of prices support for certain foods'. Moreover, subsidies are granted to agricultural investments. These subsidies are provided by the Agricultural Development Funds (FDA).

The Agricultural Development Funds, which was adopted by the Ministry of Agriculture, constitutes a budgetary support besides the State budget. This account was established by the Finance Act of 1986, which was amended in 2007. These funds aim to contribute (1) to granting subsidies and incentives for private investment in the agricultural sector and (2) to financing operations related to purchase, storage, transport, and distribution of barley in particular during drought and the upgrading of the agricultural chain. This financial assistance from the State supported by the funds is distributed to the farmers through the 'Credit Agricole du Moroc' (CAM).[2]

The Price-Support of Certain Foods Funds, which was adopted by Ministry of Finances, was created in 1995 to track the operations related to the protection of certain basic agricultural products.

The correlation between price increase of those products on the international market and the revenue decline of tariff equivalents thereto is illustrated in Table 1.[3]

2.2. Tax provisions

With regard to tax provisions, it should be noted that the determination of tax exemption of the agricultural activity is most evident destined for export. The goal is to reduce the pressure on prices and possibly to improve their competitiveness in foreign markets. In any case, on the upstream, the principal inputs (fertilizers, seeds, pesticides, etc.), the

Table 1. Average prices and receipts in millions of dirhams for sugar and common wheat.

	Raw sugar		Common wheat	
	Average prices $/T[a]	Receipts in million dirhams	Average prices $/T	Receipts in million dirhams
2008	376	518	302	3
2009	427	322	190	301
2010	478	250	231	648[b]

[a]Average price of importation of raw sugar cost and freight ($/T);
[b]Average price of common wheat for the first half of 2011:172 $/T.

livestock and the various agricultural equipments are exonerated from the VAT, and in most cases, from tariffs and taxes on importation.

In our opinion, the exemptions have led to an erosion of the tax base, which has increased the tax burden on an ever smaller number of taxpayers. This erosion is prejudicial knowing that about half of the informal sector consists of agricultural activities, a total of 40% of GDP.

The latest report on the tax expenditure prepared by the General Directorate of Taxes (DGI)[4] evaluates the exemptions granted to the agricultural and fishing sector as VAT increased to 4.2 billion dirhams in 2012 and 4.1 billion dirhams in 2013 for 23 evaluated measures. Thus, over the last two years, the agricultural and fishing sector was the sector having profited most from derogatory tax measures in 2013.

This leads to the question of the effectiveness of exemptions as an instrument of economic policy, particularly with respect to the promotion of investment. In this regard, experience has shown that in tax policy, foreign investors expect a simple, transparent, and stable system. The exemptions affect their decisions only in a marginal way.[5] Even worse, the VAT exemptions relating to the agricultural activities have encouraged farmers to support vestiges of VAT in their intermediate consumptions. For example, an exempted stockbreeder supports permanently VAT on veterinary consultations or on compound feeds for livestock. In the case where the final product is exempt from VAT, Moroccan agricultural producers are thus penalized by a negatively effective protection because of the persistence of VAT on intermediate consumptions, and absence of VAT on imported products competing with local production. VAT exemption leads therefore to a decrease in farmers' income while the majority of poor farmers earn their livelihood thanks to these agricultural activities.

In Morocco, as in other countries, experience has shown that VAT is not suitable as an instrument for redistribution, nor is it an effective tool for sectoral interventions. When different rates and multiple exemptions are used to accommodate sectoral claims or to serve social objectives, the VAT logic is weakened. It becomes a complex tax, a source of distortions and inefficiency, and contributes less to the budget. In contrast, a great majority of VAT recently implemented are founded on a much simpler structure.

3. Analytical considerations drawn from the theory of optimal taxation

Having analyzed the problems of agricultural activities in production and export and having shown the budgetary, fiscal and customs efforts in favor of the agricultural sector, we will try, in this section, to present the theoretical bases of optimal taxation that will underpin our quantitative study.

On the whole, the economic literature raises two great interrogations concerning optimal taxation. Two fundamental conclusions arise from the work of Ramsey (1927) and Atkinson and Stiglitz (1980):

- There is interest, from the point of view of the well-being to tax more strongly the goods whose demand is inelastic to price than the goods whose demand is elastic. The framework of analysis is standard and supposes that markets are competitive and without externalities and that goods are taxed, but not work;
- In extreme cases, the optimal tax system is characterized by the tax rate on goods that are inversely proportional to the price elasticities of demand (Atkinson & Stiglitz 1980).

It is worth noting that 'The law of inverse elasticity' is a special case of the law of Ramsey, which is of a greater practical interest. Ramsey's rule has the advantage of being easily understood. However, the framework of the representative agent produces a result that goes against the common sense of social justice. Indeed, since the optimal tax system implies higher tax rates on goods that have a demand with relatively inelastic price, it means that the basic goods are usually the most heavily taxed. Nevertheless, the share of these goods is higher in the poor households' budget. Therefore, Ramsey's rule and inverse elasticities lead to an increase in the fiscal pressure on the budgets of poor households. If the goal of minimizing the tax impact is achieved, it comes at the expense of equity.

Indeed, the question of taxation remains of interest. If goods with the same price elasticities of demand are taxed at a uniform rate, then the same effect can be achieved by applying a proportional rate on income. This way, indirect taxes can, in principle, replace direct taxes (Stern, 1984).

In the case of agricultural products, and according to the rule of optimal taxation, since the price elasticities of demand are almost the same, we suggest the following: (1) to tax the agricultural products with a uniform VAT rate, (2) to heavily tax agricultural products (demand is inelastic to price) for reasons of efficiency and tax administration, and (3) to replace the tax on agricultural income for a uniform VAT rate.

In addition, from an equity point of view, the analysis of optimal taxation must then be extended to the context of a multi-agent economy where agents differ by their particular income levels (Diamand & Mirrlees, 1971).

In terms of optimal income taxation, the work of Mirrlees was a turning point. Diamond and Mirrlees (1971) developed the first theory of optimal taxation in a multi-agent framework. The hypotheses of the analysis remain essentially the same. One of the most important conclusions is that marginal tax rates should be lower whereas income increases. The study of Diamond and Mirrlees, despite being solid in theory, it is difficult to implement in practice.

The question of the appropriate combination between the taxation of goods and income has led to some confusion (Stern, 1984). Several economists have acknowledged that the allocative effect of direct taxes is less than the one accomplished by indirect taxation. Nevertheless, both could cause deadweight loss. It is generally believed that the work effort will increase once switching from an income tax applied to the labor factor to an indirect tax, which is not true. Basically, any price increase in VAT, combined with improved income (through the elimination of the income tax) would keep work incentives weak. After all, taxation of income is better than taxation of goods under certain special conditions.

If we have an optimal linear tax on income, and individuals have an identical behavior but different rates of wages, the direct utility function should then have the form of the Stone Geary, linear expenditure system (see Section 4.3). Also, for the optimal indirect taxes to be uniform, the important conditions should be that (1) the Engel curve is linear and identical (i.e., all goods have a constant marginal propensity to consume) and a minimum required consumption x0 and (2) there is weak separability between leisure and work. According to Deaton (1979), if both conditions are satisfied, then the taxes on the goods must be uniform (as is the case of agricultural products).

The second theorem states that incase of optimal nonlinear taxes on income and different wage rates, then weak separability implying a marginal rate of substitution between goods is independent in relation to work.

All in all, the choice of the optimal combination between the two types of taxes is not easy to establish; so other authors, such as Brennan and Buchanan raised the issue differently: rather than trying to make a difficult choice between various taxes, governments should seek to optimize the collection of taxes. For this reason, several researchers assess the fiscal reforms using a model approach which helps overcome the opposed effects.

4. Presentation of the model

The model used is a dynamic multi-sectoral CGE built by Shoven and Whalley (1984, 1992) and Decaluwé, Martens, and Savard (2001). Three agents, namely consumers, producers, and the public authorities were introduced. Considering the economic relations with other countries, the rest of the world is added as a fourth agent.

To deal with agricultural taxation, the model has been built to assess the effects on the economy and income redistribution. The model also allows evaluating the effects of certain strategic choices in terms of tax policy. Six agents are considered, namely the small, medium, and rich farmers, producers, governments, and the rest of the world.

4.1. The productive sector

The Moroccan economy as described in the model is composed of 24 sectors which are all represented by ‘S’. There are two agricultural production techniques: the agricultural irrigated noted ‘IA’ and the nonirrigated areas noted ‘NIA’. In addition, subsectors for the food industry, other industries, market services, and public administration are included (Figure 1).

4.2. Companies behavior

Since the model is dynamic, we have introduced a function of production with increasing returns to scale and an endogenous parameter of scale. This parameter is calibrated on the ratio of public to private capital. A block of equations expressing the sequential dynamics for our model is presented, too. These elements constitute an innovation compared to the static CGE.

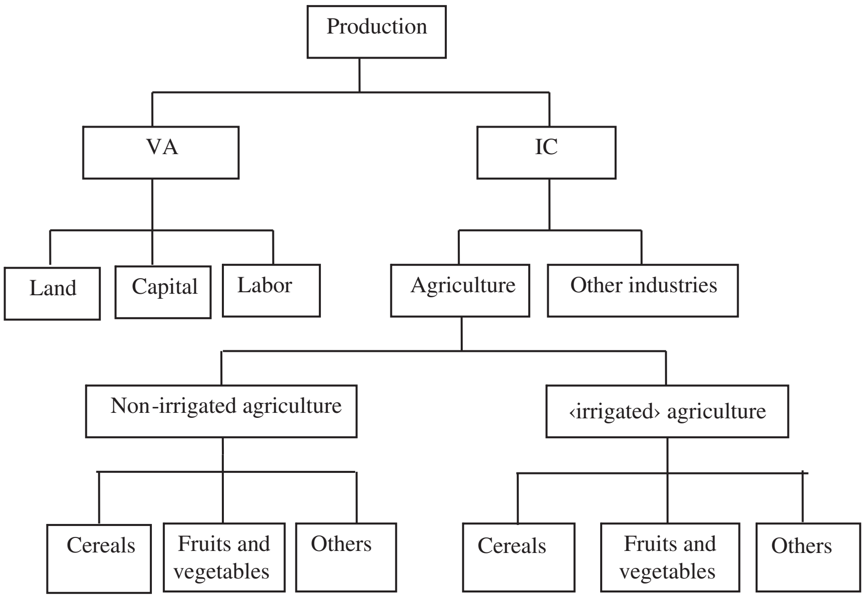

Figure 1. Schematic overview of the agricultural production system.

For each of the 24 sectors of the Moroccan economy, subscripted by i. The behavior of companies is expressed by a representative firm, each using a technology with no constant returns and operates in imperfect competition.

The production of sector i is a combination, in fixed proportions of added-value and intermediate consumptions. Thus, we specify a production function of the Leontief type as follows:

$$Y_i = \min\left[\frac{CI_i}{oi_i}, \frac{V_i}{v_i}\right], \tag{1}$$

where CI_i represents the total intermediate consumption of sector i and V_i the added-value of this same sector. Parameters oi_i and v_i are the technical coefficients of the Leontief function. They respectively represent the quantities of intermediate goods and added-value necessary to the production of goods i. As a matter of fact, they are subject to the restrictions[6]: $0 < oi_i < 1$, $0 < v_i < 1$ and $v_i + oi_i = 1$.

Then, the added-value is modeled in the form of a Cobb–Douglas function for sector i as follows:

$$V_i = A_i T_i^{\eta} K_i^{\beta_i} L_i^{\alpha_i}, \tag{2}$$

then, we note 'T_i', 'K_i', 'L_i' stand for land, capital, and labor respectively.

A_i is a parameter of scale specific to sector i and α_i the share of the incomes of the capital factor in the added-value of good i. The function supposes increasing returns scale. The total productivity of the factors breaks up into two elements: a first which represents the externality of the public investment of which the effect passes through the ratio on public/private capital expressed as follow: $\left(\frac{K^G}{\sum_i K^i}\right)^{\varphi}$, a second element of technical progress exogenous, $A_i = A_0\left(\frac{K^G}{\sum_i K^i}\right)^{\varphi}$.

The production function for agriculture is expressed, as for the other sectors, with increasing returns to scale because the public infrastructure facilitates the increase in production and the productivity of the agricultural branches. Beyond the short-term effects of the variation of public expenditures on investment or on consumption and another variables, the consequences in the medium term have been considered.

Nominal GDP is the sum of the value-added in all sectors:

$$PIB = \sum_{i \in S} P_i^V V_i \tag{3}$$

4.3. Households behavior

From a modeling point of view, it is generally a question of building for each class of households '*h*' and/or for the whole households the utility functions represent their well-being.

A part from analytical considerations drawn from the theory of optimal taxation the functions of utility used in this model are provided by the extended linear expenditure system (ELES). They are extensions of the ordinary functions of the linear expenditure system (LES), also known as the functions of Stone Geary, in that they add to the ordinary LES a pseudo dimension of inter-temporality by integrating households' savings as representative of future consumption. Compared to the functions of the ordinary LES usually used in CGE models, the ELES functions have the property that the shares of total budget of the products are not constant but vary with goods prices and available income. In the same way, the income elasticities are not unitary: they are generally located between 0 and 1 for normal goods and higher than 1 for luxury ones. The indicators of well-being of farmers in terms of equivalent and compensatory variation derived from the utility function of the Stone Geary type are presented in Appendix 1.

For the class of households '*h*' the utility function ELES is written:

$$\ln(U_h) = \sum_{i=1}^{n} \mu_{i,h} \ln(CM_{i,h} - \theta_{i,h}) + \mu s_h \ln(SM_h) \tag{4}$$

With

$$\sum_{i=1}^{n} \mu_{i,h} + \mu s_h = 1$$

Where U_h represents the consumer's utility; CM_h is the total product's consumption i; $\theta_{i,h}$, the autonomous consumption i; SM_h expresses households' savings h; μ_i and μs express, respectively, the marginal propensities of consumption and the marginal propensity of savings.

Each representative consumer h spends their available income in various types of goods in their fixed share of income μ_i. One thus has:

$$\sum_{i+1}^{n} CM_{i,h} Pc_i + SM_h = RDM_h \qquad (5)$$

The following equation expresses the demand of goods i by household h:

$$CM_{i,h} = \theta_{i,h} + \frac{\mu_{i,h} RDMS_h}{Pc_i} \qquad (6)$$

Where $RDMS_h$ represents the supernumerary income of the household class considered, i.e., the income remaining after acquisition of the minima of subsistence. The supernumerary equations of income define respectively the values of the budgets allocated by household classes to their consumption in total expenditure, as well as their savings.

$$CM_{i,h} = \sum Pc_i . CM_{i,h} \qquad (7)$$

$$SM_h = RDM_h - CM_h \qquad (8)$$

$$C_i = \sum_h CM_{i,h} + \frac{\beta g_i CG}{Pc_i} \qquad (9)$$

The well-being variation measurement of the total economy can be approximated through an indicator of the social cost. We can therefore take as indicators of the social cost of well-being the weighted average of the individual equivalent variation (VE) of the three classes of households considered:

$$CMS = \sum_h VE_h . \psi \qquad (10)$$

The parameters ψ weighting the proportions of each household class in the total population. This measurement of the difference in utility takes as a base the current prices. It also determines which variation in income at these current prices would be equal to the modification on utility. On the whole, a gain (respectively a loss) of well-being is measured by a positive VE (respectively negative).

4.4. Prices

The most significant element of the model is the way prices of the agricultural produce are modeled: the durum wheat and the common wheat and sugar. The State subsidies the product i which is taken into account in the following equation:

$$P_i = Pw_i e \ (1 + \tau_i^{dd}) \ (1 + \tau_i^{ind}) \ (1 + \tau_i^{s}) \qquad (11)$$

The representative consumer is supposed to make a distinction between the goods according to their geographic origins of production. Thus, the Moroccan consumer considers as imperfectly substitutable two intrinsically identical goods, since one is produced in Morocco and the other abroad.[7] In other words, we suppose that on the market, the elasticity of substitution is constant for any couple of goods competing on the same market.

The representative household determines the quantities to consume of each goods by maximizing its utility (Equation 6) under a budgetary constraint. The overall expenditure is equal to the amount spent on the goods originating from the two areas (Morocco and the Rest of the World that are indexed by m and r with $M = \{m, r\}$). This constraint cannot exceed the resources of the household, W^m.

The budget constraint is written as follows:

$$\sum_{k \in M} p_{ih,k} x_{ih,k} W^h \tag{12}$$

Household income is made up of a constant share λ^h, capital income, household wages w_h and transfers of the State T^E and those received from the Rest of the World T^r. Ultimately, we have:

$$W^h = \lambda^h \sum\nolimits_i r_i K_i + w_h \sum\nolimits_i L_{ih} + T^E + T^r \tag{13}$$

The income of the representative household is not entirely consumed. Indeed, a part is allocated to transfers to the Rest of the World TRM^v and another to savings S. Implicitly, since investment is exogenous, the savings adjust to investment so that investment equals savings.

4.5. Public authorities

The behavior of the public authorities is not explicitly modeled.[8] The State is considered to levy four types of taxes (indirect taxes, customs duties, tax on households income, and tax on companies income), which are used to finance the State's expenditures.

Its receipts are thus composed of: (1) indirect taxation:

$$\text{RTI} = \sum\nolimits_i \tau_i^{va} [q_{ih,m} x_{ih,m} + (1 + \tau_i^{dd}) e_i^{mr} x_{ih,r}] \tag{14}$$

(2) Customs duties:

$$\text{RDD} = \sum_i \tau_i^{dd} e_i^{mr} q_{ih,r} x_{ih,r} \tag{15}$$

and (3) Direct taxes on households and companies:

$$\text{RTD} = \tau_{dh} W^h + \tau_{de} W^e \tag{16}$$

Let us note that public expenditure consists of consumption expenditure and investment in addition to debt service and transfers carried out in favor of various agents.

4.6. Sequential dynamics of the model

The contribution of this paper is integrate the dynamic aspects into the model. Thus, the supply of labor increases at the fixed rate of 3% per annum. This rate corresponds to the average demographic growth of Morocco, supposing that the majority of workers coming from the Rest of the World are Moroccan migrants. One thus postulates that migration increases at the same rate as the remaining population. Moreover, public investment in period T is determined exogenously and contributes to the increase in public capital of the following period after allowing for depreciation of 2.5% per annum. Private investment is distributed among the sectors according to fixed parameters provided by the initial relative equipment in physical capital of each sector.

As in the case of public sector, private investment increases the stock of capital K_i, which is depreciated at the same rate as that of public investment. Accordingly, the dynamic equations of the model are as follows:

$$L^s_{t+1} = L^s_t \cdot (1+n) \tag{17}$$

$$TRM^h_{t+1} = TRM^h_t \cdot (1+n) \tag{18}$$

$$K^G_{t+1} = K^G_t \cdot (1-\theta) + IG^{v0}_t \tag{19}$$

$$K^i_{t+1} = K^i_t.(1-\theta) + \delta^i IP^{v0}_t \tag{20}$$

$$\frac{I^p_t}{PIB_t} = b\frac{I^p_{t-1}}{PIB_{t-1}} + c\ln\frac{PIB_t}{PIB_{t-1}} + d\frac{IG_t}{PIB_t} \tag{21}$$

With:
L^s_t: Supply of labor force;
n: Annual growth rate of the working population;
TRM^h_{t+1}: Transfers of the rest of the world to households;
K^G_t: Public capital;
IG_t: Public investment (value);
IG^{v0}_t: Public investment (volume);
θ: Rate of depreciation of public and private capital of sector i;
K^i_{t+1}: Private capital of sector i;
I^p_t: Total private investment (value);
IP^{v0}_t: Private investment (volume);
δ^i: Coefficient of allocation of the investment among the sectors of production.

5. Calibration, scenario, and simulations results

What fiscal measures can be implemented to minimize the negative potential effects of taxation of the agricultural sector? We can show that the government cannot completely eliminate these effects but only reduce them. Table 2 lists their contents.

Table 2. Scenarios for appropriate tax regime for the agricultural sector.

Scenario 1	Introduce for the whole agricultural sector VAT, income tax, and corporate tax with production subsidy from the ADF
Scenario 2	Introduce for the 'irrigated' subsector the VAT, income tax, and corporate tax with production subsidy from ADF
Scenario 3	Preserve the exemption from VAT for the whole agricultural sector and introduce income tax and corporate tax only on agricultural income
Scenario 4	Preserve the exemption from VAT for the 'irrigated' subsector and introduce income tax and corporate tax only on agricultural income

ADF, agricultural development fund.

The accounting framework of the model is provided by the SAM of the Moroccan economy built from input–output table (IOT) of 2009 published by the High Commission for Planning in 2010. For brevity we will not describe all transactions from the IOT to the matrix in question. The data of the Ministry of Agriculture, Forestry and Fisheries are presented in Appendix 2 for each of the 24 agricultural sectors.

5.1. Results

To simplify the presentation, we have focused on the macroeconomic variables and highlighted the main effects of each type of taxation.

The introduction of VAT, income tax, and corporate tax in the agricultural sector (simulation 1) would increase the resources of public treasury and thus foster improvement in the budget deficit. However, such a measure would reduce household income by 5% and contribute to a deterioration of their well-being (–1.6% of GDP). Mean income of poor households would fall dramatically, particularly because of the induced effects on prices and production costs, while at the same time involving an increase in unemployment. Wealthy households are also facing a contraction in their income (–3.5%). Private consumption would decrease by 2%, against the backdrop of higher prices (+2.5%). Also, private savings would be reduced by 1.8%, in favor of public savings that should improve by 4%. Overall, GDP would decline by 0.9%.

In simulation 2, the restriction on the application of VAT, income tax, and corporate tax in irrigated agriculture would be favorable for poor households, who are concentrated in the nonirrigated areas. By contrast, the effects of this measure on the middle and rich households would still be significant. In fact, their income would decrease by 3%. They would also face an increase in their production costs, which would, in turn, affect their welfare negatively.

It should also be noted that the taxation of the irrigated sector implies a decline in the competitiveness of agricultural products. Total private consumption would be curbed by 1% and exports would slightly decrease by 0.7%. For the public accounts, savings would increase by 2.5%, and the budget deficit would fall by 1.2% of GDP.

In simulation 3, the introduction of the income tax and corporate tax in agriculture induces a fall in private consumption (–1.5%). Poor and middle households would see their savings and consumption decline also. Overall, poor households should give nearly 0.5% of their income to the government accounts. This is how public resources would increase by 1.9%. Taxation of agricultural income would also make the sectors less attractive. This would have adverse effects on both domestic and foreign investments. As a result, domestic production would decrease by 1.2%.

In simulation 4, the limited application of income tax and corporate tax in irrigated areas preserves the purchasing power and incomes of poor households, but total household consumption is generally reduced (–1%). This is due to lower income in middle and rich households. However, public resources would improve by 2% of GDP. In the end, this measure would result in a slight inflationary effect and a decline in agricultural production by 1.5%. A contraction in exports and a strengthening of imports would be observed.

Finally, the four simulations show the negative effects of the application of such a system of taxation on agriculture. GDP contraction is certainly less strong when restricted to irrigated area, but the impact on the welfare and income of rural households is not negligible. The exemption of poor categories, facing weather and logistical constraints, will be a necessity.

In all simulations, it should be stressed that the implementation of a suitable policy for the agricultural sector will generate an effect only after a one-year delay. In other words, the revenue of poor and medium farmers will improve only one year after implementation of the tax on the sector. Hence, taxation of the agricultural sector should be introduced gradually by hectare and should target agricultural enterprises that keep records, and provide services in return, including social insurance.

6. Sensitivity analysis

In general, the sensitivity analysis consists of studying the robustness of the simulations obtained. Indeed, when a CGE is calibrated, it is not possible to fix, with certainty, the value of each parameter. It is particularly the case of elasticities which we evaluate in a more or less *ad hoc* way. The uncertainty regarding their true values generates an uncertainty regarding the results.

6.1. Overview of the analytical method

The sensitivity analysis consists in measuring the sensitivity of the final results by evaluating the impact of the modifications of the parameters' values on the values of the variables. Two types of procedures can be distinguished:

(1) Systematic and conditional sensitivity analysis; for example, Harrison, Jones, Kimbell, and Wigle (1993), who studied the effect of the final solution of unilateral perturbations of each parameter.
(2) Systematic and unconditional sensitivity analysis; for example, Harrison, Jones, Kimbell, and Wigle (1993), who examined a range of values of the parameters by taking into account their possible interactions. This last approach is thus more rigorous since it considers the cross effects between the various variables (Piet, 2002).

Several projections have recently been made relating to unconditional analysis. Thus, Harrison and Vinod (1992) developed an approach by Monte Carlo sampling based on the *a priori* specification of a distribution for each parameter. Arndt (1996) and De Vuyst and Preckel (1997) on the other hand, extended the previous procedure by using the Gaussian Quadrature Method, usually used for the numerical calculation of integrals. The latter has the advantage of being more sparing in calculations and is based on properly exact replications, and not approximated by the model, contrary to the approaches of Harrison and Vinod which underestimates the variability of the parameters (De Vuyst & Preckel 1997).

Using an unconditional sensitivity analysis, we want to check that the variability of the model as a whole is not too significant even in the event of simultaneous modification of all the parameters. To do this, the Gaussian Quadrature Method is implemented according to the approach of Arndt (1996), De Vuyst and Preckel (1997), and Piet (2002).

Every model can be summarized with the vector function $G(X, \theta) = 0$ where X is the vector of the output variables and θ that of the parameters. The vector of the solutions, that we note x^*, is thus a function of θ: $x^* = x^* (\theta)$. So the uncertainty relating to the vector of the parameters refers directly to the solutions of the model. The unconditional sensitivity analysis precisely consists of estimating the error relating to the vector of the model's solutions compared to the error relating to the parameters, while taking into account the effects of interaction with the latter. It consequently amounts to estimating the moments (we stopped generally with the expectation and the variance) of the vector x^* and this, according to the hazard θ. So, we show that the expectation of the model's solutions is a function of the potential values of the vector's parameters:

$$\mathrm{E}[x^*(\theta)] = \int_{\omega} x^*(\theta) g(\theta) d\theta \tag{22}$$

Where $G(\theta)$ represents the density of the random vector absolutely continuous θ and ω indicates the area of integration. [The Gaussian Quadrature Method makes it possible to evaluate the integral (Equation 22).] Following Arndt (1996) and Piet (2002), there will be need to estimate the distribution of the parameters, with a quadrature with order 3, which bases itself on the formula of Stroud.

6.2. Application of the unconditional procedure

We carry out first of all the calculation of the square for all the 21 elasticities of the model (three elasticities for each of the seven sectors). We also evaluate 42 points of square: $K = 1, \ldots, 144$. Lastly, we obtain the values of three elasticities for each of the seven sectors and of the 42 points of squarture; that is to say, a matrix with dimension 144 × 82.

The following step involves simulating the model once again. We concentrate then on the vectors of solutions generated by the model in terms of average and standard deviation coefficients.

Table 3 hereafter indexes all the results concerning the output variable 'the small farmers' well-being'.

Table 3. Output values obtained by the Gaussian Quadratic Method (variable 'small farmers' well-being').

1	299,377.8	49	417,966.5	97	531,021.89
2	302,371.6	50	420,056.3	98	533,677.00
3	305,395.3	51	422,156.6	99	536,345.38
4	308,449.3	52	424,267.4	100	539,027.11
5	311,533.7	53	426,388.7	101	541,722.25
6	314,649.1	54	428,520.7	102	544,430.86
7	317,795.6	55	430,663.3	103	547,153.01
8	320,973.5	56	432,816.6	104	549,888.78
9	324,183.3	57	434,980.7	105	552,638.22
10	327,425.1	58	437,155.6	106	555,401.41
11	330,699.4	59	439,341.3	107	558,178.42
12	334,006.3	60	441,538.1	108	560,969.31
13	337,346.4	61	443,745.7	109	563,774.16
14	340,719.9	62	445,964.5	110	566,593.03
15	344,127.1	63	448,194.3	111	569,425.99
16	347,568.3	64	450,435.3	112	572,273.12
17	351,044	65	452,687.4	113	575,134.49
18	354,554.5	66	454,950.9	114	578,010.16
19	358,100	67	457,225.6	115	580,900.21
20	361,681	68	459,511.8	116	583,804.71
21	363,489.4	69	461,809.3	117	586,723.74
22	365,306.9	70	464,118.4	118	589,657.35
23	367,133.4	71	466,439.0	119	592,605.64
24	368,969.1	72	468,771.2	120	595,568.67
25	370,813.9	73	471,115.01	121	598,546.51
26	372,668	74	473,470.58	122	601,539.25
27	374,531.3	75	475,837.94	123	604,546.94
28	376,404	76	478,217.13	124	607,569.68
29	378,286	77	480,608.21	125	610,607.53
30	380,177.4	78	483,011.25	126	613,660.56
31	382,078.3	79	485,426.31	127	616,728.87
32	383,988.7	80	487,853.44	128	619,812.51
33	385,908.6	81	490,292.71	129	622,911.57
34	387,838.2	82	492,744.17	130	626,026.13
35	389,777.4	83	495,207.89	131	629,156.26
36	391,726.3	84	497,683.93	132	632,302.04
37	393,684.9	85	500,172.35	133	635,463.55
38	395,653.3	86	502,673.21	134	638,640.87
39	397,631.6	87	505,186.58	135	641,834.07
40	399,619.8	88	507,712.51	136	645,043.24
41	401,617.8	89	510,251.08	137	648,268.46
42	403,625.9	90	512,802.33	138	651,509.80
43	405,644.0	91	515,366.34	139	654,767.35
44	407,672.2	92	517,943.17	140	658,041.19
45	409,710.6	93	520,532.89	141	661,331.40
46	411,759.2	94	523,135.55	142	664,638.05
47	413,818.0	95	525,751.23	143	667,961.24
48	415,887.0	96	528,379.99	144	671,301.05
Theoretical average (simulation 1) = 1,041,071.5			Theoretical average (simulation 2) = 1,042,354.2		
Empirical average = 955,911.6			Standard deviation = 31,432.04, average = 0.087875		

Examination of Table 3 reveals that the model is relatively stable. Indeed, a variation of 20% of all the parameters generates an increase of the well-being of the households of 8.8%. This means that, even if uncertainty remains as to the true value of certain parameters, it affects only in a very insignificant manner the direction and the value of the results.

Finally, it is possible to define a confidence interval on the variable 'well-being'. To do this, we used the Bienayme–Chebyshev inequality, which is stated as follows: if X is a random variable admitting a moment in order 2, then for any $K > 0$.

$$P(|X - E(X)| \geq k) \leq \frac{\mathrm{Var}(X)}{k^2}$$

Consequently, *mutatis-mutandis*, by considering a level of significance it follows that the 'true average' μ of the level of well-being is included in the following interval:

$$P(924,479.6 < \mu < 987,343.6) \geq 0.95$$

It appears immediately that the 'theoretical' averages obtained starting from simulations 1 and 2 are included in this interval.

7. Conclusion and recommendations

The debate on agriculture taxation in Morocco is becoming increasingly fruitful, centered as it is on how farmers should be taxed. For a long time, they have enjoyed a variety of incentives and grants and have been exempt of direct and indirect taxes for principal inputs (manures, seeds, products plant, etc.), livestock, and various farm equipments.

In this paper, we have used a dynamic multi-sectoral CGE in order to investigate the effects of application of a VAT, income tax, and corporate tax in the agricultural sector. Using an unconditional sensitivity analysis, it was possible to prove that the variability of the model is not significant even after simultaneous modifications of all the parameters.

The main results show that the application of such a system of taxation has negative effects during the year of implementation. GDP contraction is certainly less strong when restricted to irrigated areas, although the impact on the welfare and income of rural households is not negligible.

However, the implementation of a suitable taxation model for the agricultural sector will generate positive effects if delayed for one year. In other words, the income of poor and medium farmers will improve only one year after implementation of the tax on the sector. Hence, taxation of the agricultural sector should be introduced gradually by hectare, and should target companies that keep record. It should also provide services in return, including social insurance. The exemption of the poor who face weather and logistical constraints, should be preserved.

Taxation must play a structuring role in favor of the development of the agricultural sector by defining a technical plan for the fiscalization of the sector. This paper indicates that it would be wise to set up suitable methods regarding agricultural VAT, reinforce farmers' competitiveness through profitable economic policies.

Notes

1. Article 7 of the Finance Act No. 40-08 for the fiscal year 2009 and Article 7 of the Finance Act No. 43-10 for the fiscal year 2011.

2. Ministry of Economy and Finance (2012), "Annual Report on the Special Treasury Accounts", Paper presented in the Occasion of the Finance Act Project of 2014, pp. 77–84.
3. Ministry of Economy and Finance (2012), "Annual Report on the Special Treasury Accounts", Paper presented in the Occasion of the Finance Act Project of 2012, pp. 38–41.
4. Ministry of Economy and Finance (2012), "Annual Report on the Special Treasury Accounts", Paper presented in the Occasion of the Finance Act Project of 2012.
5. A study conducted by the IMF and on a large number of countries has shown that the most advanced countries and better integrated into the global economy have structures more rational tax incentives, such as tax holidays.
6. The strict positivity of the coefficients imply that sector *i* production requires at the same time intermediate inputs and value-added.
7. This assumption is known as the Armington assumption (see Armington, 1969). It makes it possible to take into account prices differences between identical goods but locally produced or imported. It represents an alternative compared to both 'traditional' work (local and foreign products are perfectly homogeneous, the elasticity of substitution being infinite) and 'structuralist' (the differentiated products are perfectly complementary, the elasticity of substitution being zero).
8. In the sense where the public authorities do not adopted an optimizing behavior.

References

Armington, P. (1969). A theory of demand for products distinguished by place of production. *IMF Staff Papers, 16*, 159–176.

Arndt, C. (1996). *An introduction to systematic sensitivity analysis via Gaussian Quadrature*. GTAP Technical Papers, Purdue University.

Atkinson, A., & Stiglitz, J. E. (1980). *Lectures on public economics*. New York, NY: McGraw-Hill.

Deaton, A. S. (1979). Optimally uniform commodity taxes. *Economics Letters*, *2*, 357–361.

Decaluwé, B., Martens, A., & Savard, L. (2001). *Economic development policy and the general equilibrium models calculable*. Canada: Press of the University of Montreal.

De Vuyst, E. A., & Preckel, P. V. (1997). Sensitivity analysis revisited: A quadrature-based approach. *Journal of Policy Modeling, 19*, 175–185.

Diamand, P. A., & Mirrlees, J. A. (1971). Optimal taxation and public production I: Production efficiency. *The American Economic Review*, *61*(1), 8–27.

Harrison, G. W., Jones, R., Kimbell, L. J., & Wigle, R. (1993). How robust is applied general equilibrium analysis? *Journal of Policy Modeling*, *15*(1), 99–115.

Harrison, G. W. & Vinod, H. D. (1992). The sensitivity analysis of applied general equilibrium models: Completely randomized factorial sampling designs. *The Review of Economics and Statistics, 74*, 357–362.

Piet, L. (2002). *Spatial distribution of a CGE model to study the localization of agricultural activities at a sub-national level*. (PhD thesis). National School of Rural Engineering, Water and Forestry.

Ramsey, F. P. (1984). A contribution to the theory taxation. *The Economic Journal*, *37*(145), 47–61.

Schubert, K. (1993a). Models of calculable general equilibrium: A review of the literature. *Political Review of Economy, 103*, 775–825.

Schubert, K. (1993b). Les modèles d'équilibre général calculables: une revue de la littérature [The computable general equilibrium models: A review of literature]. *Revue d'Economie Politique, 103*, 775–825.

Shoven, J. B., & Whalley, J. (1984). Applied general equilibrium models of taxation and international trade: An introduction and a survey. *Journal of Economic Literature, 22*, 1007–1051.

Shoven, J. B., & Whalley, J. (1992). *Applying general equilibrium*. Cambridge: Cambridge University Press.

Stern, N. (1984). The theory of reform and Indian Indirect Taxes. *Journal of Public Economics*, *25*, 259–298.

Appendix 1. Indicator of equivalent and compensatory variations used in the model to measure well-being of households

The equations of the indirect utility are derived thereafter while replacing $CM_{i,h}$ and SM_h in the equations, by their corresponding expressions of Equation (A1):

$$UI_h = \prod_i \left[\frac{\mu_{i,h}}{Pc_i}.(RDM_h - \sum_i Pc_i.\theta_{i,h})\right]^{\mu_{i,h}} . \left[\mu s_h.(RDM_h - \sum_i Pc_i.\theta_{i,h})\right]^{\mu s_h} \tag{A1}$$

The functions of expenditure are defined by the Equation (A2), considering a given vector of price PC:

$$DEP_h(Pc, UI_h) = \left(\frac{UI_h}{\mu s_h^{\mu s} \prod_i \mu_{i,h}^{\mu_{i,h}}}\right) . \prod_i Pc_i^{\mu_{i,h}} . \sum_i Pc_i.\theta_{i,h}).RDM_h \tag{A2}$$

To appreciate the profit or the loss of well-being for each category of households h consecutive to a modification of the prices and incomes, we built an indicator of VE of household within the meaning of Hicks (equivalent variation of household).

The principle in is simple, i.e., the function of indirect monetary utility $UI(Pc^1; Pc^0, RDM^1)$ which measures the sum (monetary) of which the consumer, confronted with the vector of the prices Pc, need would have to be at least as well as if the vector of the prices were equal to Pc^0 and its income equal to RDM^1. Function UI is thus identically equal to the function of expenditure $DEP(Pc^1; U(Pc^0; RDM^1))$:

$$UI(Pc^1; Pc^0, RDM^1) \equiv DEP(Pc^1; U(Pc^0; RDM^1)) \tag{A3}$$

Where $U(Pc^0; RDM^1)$ the level of utility associated with the income represents RDM^1. The VE is then defined by:

$$VE = DEP\left[Pc^0, UI(P^1, RDM^1)\right] - DEP\left[Pc^0, UI(P^0, RDM^0)\right] \tag{A4}$$

$$VC = DEP\left[Pc^1, UI(P^0, RDM^0)\right] - DEP\left[Pc^1, UI(P^1, RDM^1)\right] \tag{A5}$$

In these two equations, figures 0 and 1 return respectively to initial equilibrium and counterfactual. One can notice that the term $DEP\left[Pc^0,\ UI(P^0,\ RDM^0)\right]$ of the Equations (A4) and (A5), the term $DEP\left[Pc^0,\ UI(P^0,\ RDM^0)\right]$ of the equation, correspond respectively to RDM^0 and RDM^1. Thus, starting from Equations (A1) and (A2), it becomes:

$$VE_h = \left(\frac{UI_h(Pc^1, RDM_h^1)}{\mu s_h^{\mu s} \prod_i \mu_{i,h}^{\mu_{i,h}}}\right) . \prod_i \left(Pc_i^0\right)^{\mu_{i,h}} . \sum_i Pc_i^0.\theta_{i,h}) - RDM_h^0 \tag{A6}$$

$$VE_h = RDMS_h . \prod_i \left(\frac{P_i^0}{P_i^1}\right)^{\mu_{i,h}} - RDMS_h^0 \tag{A7}$$

In the same way:

$$VC_h = RDMS_h . \prod_i \left(\frac{P_i^1}{P_i^0}\right)^{\mu_{i,h}} - RDMS_h^1 \tag{A8}$$

Appendix 2. Sectors, symbol, and production value

Sectors	Symbol	Production
Durum wheat	DW	4394.69
Common wheat	CW	2929.80
Barley	BAR	2929.80
But seed	BSE	2929.80
Rice	RIC	4394.69
Sugar beets	SBE	7324.49
Sugarcane	SCA	7324.49
Oleaginous seeds	OSE	8789.39
Crude fiber	CFI	2929.80
Berseem	BER	4394.69
Citrus fruits	CFR	2929.80
French olives	FOL	8789.39
Grapes	GRA	2929.80
Dates	DAT	10,254.29
Other fruits	OFR	2929.80
Other products	OPR	2929.80
Breeding	BRE	4394.69
Forests	FOR	11,719.18
Fishing	FIS	21,973.47
Others agricultural	OAGR	29,297.97