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When Water is No Longer Heaven Sent : Comparative Pricing Analysis in an AGE Model*

B. Decaluwé†, A. Patry‡, and
L. Savard†

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Département d'économique,
Université Laval

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Abstract

In this paper we present an applied general equilibrium model with special features that allows for comparative analysis of different pricing schemes. We look at Boiteux-Ramsey Pricing, Marginal Cost Pricing as well as an arbitrary water pricing increase for agriculture sectors. A standard AGE was adapted by explicitly modeling water production with its different technologies. Water demand of different users also needed to be refined since it is generally modeled with fixed coefficient with no substitution allowed. Results show that the choice of applying one policy over another can rely on water management authority (or government) objectives. Considering welfare criteria and water conservation objectives, Boiteux-Ramsey pricing seems to be the best alternative. Moreover, we show that BRP clearly becomes more advantageous the more rigid (small capacities to substitute water for other inputs) the economy and the efficiency of MCP decreases as the economy become more rigid.

Keywords: Water, Taxation, Incidence, Computable General Equilibrium Model, Boiteux-Ramsey Pricing, Marginal Cost Pricing.
JEL classification: C68, Q25, Q26, H21

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[†] CRÉFA, Université Laval, G1K 7P4, Québec, Canada, email : bdec@ecn.ulaval.ca.

[‡] Industry Canada, Ottawa, Canada

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1. Introduction

Since early civilization, accessibility to water has been of great concern to government authorities. During the time of ancient Rome, important distribution aqueducts were built to supply water to the population. Nine great aqueducts poured water into the Imperial City at a rate similar to some reservoirs of our time. The importance of these infrastructures at that time can be illustrated by the following quotation taken from a third-century book on Roman aqueducts: « Will anyone compare the idle Pyramids, or those other useless, though much renowned structures of the Greeks, with these many indispensable aqueducts? » [1]

In modern civilizations, water continues to be the basis of life for living beings. In most countries of the world, large infrastructures continue to be built to improve the accessibility of the resource for the population. However, these infrastructures and their maintenance are extremely expensive.

People view water as a public good and the state as responsible for its harvest and distribution among the population and different water consumers. However, this type of reasoning has greatly contributed to the water scarcity problem on our planet. In the field of economics, calls are made for the regulation of the demand side so as to stop the hemorrhage of our resource instead of investing in reservoirs and pumping installations. This type of reasoning is far from prevalent in the minds of consumers who benefit from favorable water tariffs. In fact, we find a particularly important lobby against increased water tariffs in the agricultural sector.

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[1] Sextus Julius Frontinus, from his third-century book on the Roman aqueducts, De Aqueductibus Urbis Romae.

In general, the price for irrigation water is far less than the one charged to households and other industries. When it exists, the price reflects a fraction of the cost or economic value of irrigated water. This type of pricing results in extensive waste in regions where water scarcity prevails. These distortions necessarily lead to a non-optimal use of the resource among consumers.

Most of the studies that put an emphasis on water tariff reforms for the resource have restricted their analysis to a partial equilibrium framework (Agthe and Billings (1987) and Tisdell (1996)), and consequently, have ignored the general interdependence mechanism of an economy and the retroaction effects of agents following a change in the production and demand structure. We think that a study of a tariff reform should be done by examining the interdependence effects of the economy as to measure more precisely the consequences on resource allocation and social welfare. To do so, we use an applied general equilibrium (AGE) model of the Moroccan economy. Morocco is faced with recurrent shortages of its resources given the considerable distortions in the allocation between consumers. The approach that we consider in this paper can be adapted to other countries faced with a similar situation.

2. Morocco's Hydraulic Resources

Over the last few decades, Moroccan authorities have been forced to give greater attention to the depletion of their water resources. An excessive and persistent demographic growth, an increasing urbanization and marked inequalities in the economy, such as grants to agriculture, are some of several factors that are responsible for the increased pressure on the resource.

The renewable hydraulic resource comes from 150 billions m^3 per annum of rain. From this precipitation, 30 billions m^3 represents the efficient rain of the country. This efficient rain can either flow into riverbeds or infiltrate the underground water table. The volume of the rain regenerating the rivers amounts to 20 billions m^3 and the rain regenerating the underground water table totals 10 billion m^3. Under favorable economic and technical conditions, 16 billions m^3 can currently be mobilized on the Moroccan territory (Mriouah (1992)).

The spatial variability of the Moroccan climate creates important regional disparity in the accessibility to water. We can divide the different zones of the country into 2 main regions: the northern region and the southern region. The potential water supply is much greater in northern region than in the southern part of the country. In the northern region, we can count three sub-zones: the Atlantic, Oriental and Mediterranean. These three sub-zones contain 90.8% of the country's surface water and 64.4% of the ground water. The remaining supply is found in the southern region.

The resource's supply-demand gap is presently positive in the northern region and negative in the south. Forecasts indicate that the balance will be negative for the entire country by the year 2020. The deficit should reach 200 million m^3 with a growth in the demand for water of 4% per year (Goldin and Roland-Holst (1995)).

To escape the catastrophic impact of such a deficit, the Moroccan government has undertaken an ambitious program to deal with the increasing demand. The program proposes the construction of a large dam and 6-10 small-to-medium dams per year to increase the country's water storage capacity (Water Power and Dam Construction, National Profile (1991)). With these efforts and the investments made in irrigation distribution lines, the budgetary share of public investments linked to water supply should increase from 25% to 60% by the end of this century (Goldin and Roland-Holst (1995)). In the long-term, these massive investments cannot be a sustainable answer for current water demand management.

Morocco’s water demand management policies are almost non-existent in their effects. As in other African countries and also in developed countries in North America and Europe, pricing policies favor farmers with preferential rates for irrigation water. The price for irrigation water is well below that charged to other users.

Three main reasons are usually evoked to explain these types of policies (Ayub and Kuffner (1994)). First, water tariffs have always been highly subsidized. The inertia of the consumption habit makes it very difficult to increase tariffs to respectable levels when they are extremely low. Second, an increase in the price of water would clash with the fight against unemployment. Unemployment is a major concern in countries similar to Morocco. An increase in the price of irrigation water would undoubtedly have a negative effect on the agricultural sector and consequently on rural households. This shock could inadvertently create an important exodus of rural households to already overpopulated urban regions. The last justification is based on the food self-sufficiency policies pursued by most developing countries. An increase in water tariffs to the agricultural sector would contradict the basic principle of these policies. An increase in irrigation price would most likely discourage agricultural output.

For these reasons, authorities have had difficulties reforming pricing schedules for water demand. Governments adopt more shortsighted programs by using more politically correct tools, such as building dams and wells, among others, to fight against the increasing demand for water.

3. Water Pricing and Production

Theoretically, in a partial equilibrium state, the Pareto optimal prices would be equal to the marginal cost of producing water. However, given the cost structure of producing water (natural monopoly with important fixed costs), this type of pricing can lead to surpluses. But, more generally, it leads to deficits. Consequently, authorities have to finance these deficits through taxes. The taxation methods are almost all distorted[2], therefore a second best optimum should be considered. Ramsey (1927) and then Boiteux (1956) proposed a taxation formula that was further formalized by Baumol and Bradford in (1970). The method is commonly known as Boiteux-Ramsey pricing (BRP). It has been widely used in various fields of application by numerous authors[3]. As stated by Baumol and Bradford (1970), the pricing method consists of setting quasi-optimal prices for each market such that they deviate from the marginal cost inversely proportionate to the demand price elasticity in the given market. In other words, an inelastic demand will support higher prices under this pricing scheme.

The second best pricing method would be the prescription if the situation would be applied in a partial equilibrium state. However, most taxation schemes are applied in general equilibrium where branches as well as agents are interconnected with each other. We adopt the general equilibrium framework while taking into account that the objectives of governments can be threefold. First, they might want the most optimal resource allocation, second, they would have objectives with respect to the level of deficits of water management authorities and finally, the most important objective in the context of growing water scarcity, reducing water consumption to prevent further depletion of the resource[4]. Governments or water management authorities (WMA) are then faced with these objectives and different water pricing options. As stated earlier, the current water pricing system in Morocco is very distorted, leads to large deficits and over-consumption of water. Three pricing options will be analyzed in an applied

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[2] The exception is a lump sum tax, but this form of taxation is seldom used for practical reasons.

[3] For further theoretical discussion see Dierker (1991), and for applications see Zajak (1974), Tam (1988), Wilson (1989), Cuthbertson and Dobbs (1996), Resende (1997), Kennet and Gabel (1997) and Ebert (1998) among others.

general equilibrium framework: RBP, MCP and an arbitrary increase in agricultural prices of water. From partial equilibrium results, we expect that RBP will lead to a zero deficit (from WMA), an important reduction of water consumption, MCP will improve the allocation of water between users (same prices for all users), and reduce water consumption. The arbitrary increase in agricultural water prices should reduce curent distorted prices, reduce consumption and reduce WMA deficits. The impact on real GDP in all cases is unclear due to the numerous general equilibrium effects.

3.1. Marginal Cost Pricing

The marginal cost pricing approach implies that the marginal cost of producing water equals the marginal benefit of consumption. In our model, we have three demands for water: (i) residential, (ii) industrial and (iii) agricultural, which in turn are broken down given the different regions and branches in our model. The equation defining the marginal pricing approach for each demand is the following:

$$1- \qquad Pw^{d}_{eau} = mc_{eau} \cdot$$

3.2. Boiteux-Ramsey Pricing

In the BRP method, the government's objective is to maximize consumer surpluses while imposing a budgetary equilibrium on water authorities[5]. We first suppose a water

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[4] In this paper, we do not attempt to evaluate the optimal level of water production, this must be done with appropriate dynamic analytical tools. We only suppose that the authorities have a general objective of reducing water consumption since the present consumption level could lead to large water deficits.

[5] Other fixed budgetary objectives could be imposed without substantially changing the problem. In that case the right hand side of the budget constraint would simply be fixed to the objective. We also consider the case of

demand function $XD^d(Pw^d)$ as a function of water prices Pw^d, where d = household, industries and agriculture. The problem is presented as follows:

$$2\text{-}\qquad \max \sum_{d}^{n} \int_{0}^{XD_d} XD^d(Pw^d) - Pw^d\, XD^d$$

$$s/t \ \sum_{d}^{n} Pw^d\, XD^d - TC = 0$$

The following first order conditions are obtained:

$$3\text{-}\qquad Pw^d - mc + l\left(Pw^d + XD^d \frac{\partial Pw^d}{\partial XD^d} - mc \right) = 0$$

$$4\text{-}\qquad \sum_{d}^{n} Pw^d\, XD^d - TC = 0$$

Where mc is the marginal cost, TC is the total cost and l the langrange multiplier. Rearranging (3) we obtain:

$$5\text{-}\qquad \frac{Pw^d - mc}{Pw^d} = \frac{l}{1+l}\frac{1}{e_d},\ \text{with}\ x = \frac{l}{1+l}$$

With e_d being the price elasticity of demand for each water consumer and represented and calculated in the following manner:

$$6\text{-}\qquad e_d = -\frac{\partial XD^d}{\partial Pw^d}\frac{Pw^d}{XD^d}$$

Solving Equation (5) for Pw^d we obtain the Boiteux-Ramsey price equation for each market:

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partial equilibrium and do not derive the general equilibrium problem to simplify the program since our main objective is not to find the second best optimum but to compare pricing tools generally proposed in partial equilibrium.

7-
$$Pw^{d} = \frac{mc}{1 - \frac{x}{e_{d}}}$$

Where x is the Ramsey weighted number

Equation 7 determines the BRP for *n-1* market. Given the budgetary constraint, the last market price is determined endogenously by using the second first order condition. The price equation of the n^{th}market can then be used to solve x with Equation 8:

8-
$$x = e_{n}\left(\frac{Pw_{eau}^{n} - mc}{Pw_{eau}^{n}} \right)$$

This procedure consists of imposing a budgetary equilibrium on water authorities and generating RBP prices from the base year equilibrium. The results will permit us to measure the impact on water users and the general equilibrium effect on other micro and macroeconomic variables. With the RBP, we have a total of *d* prices for water. The discrimination is based on the elasticity of demand of each consumer as stated previously and not on socio-politico criteria. Once the BRP are generated, other simulations can be combined with these new BRP, such as rainfall changes and external trade liberalization among others.

3.3. Water Production in Morocco

In Morocco, the production of water is principally made up of surface water retrieved by dams. However, in periods of drought caused by the arid climate or by poor water management programs, reservoirs are fully exploited and can be at critical levels. During these periods, water management authorities (WMA) have to use other types of water harvesting methods. In a first stage, they use more efficient surface water collection methods and, in a second stage, water pumping stations are exploited more intensively and at a certain level their output could dominate the surface water output.

Thus, we distinguish two types of production in water technology. The first, *Eb (type I)*, represents the water produced by dams already in place. In our model, $\overline{K}$ is the physical capital invested in dams needed to produce *Eb*. In this part of the technology, the unit costs of producing (surface) water are constant.

We define *Wat (type II)* as the second type of production. *Wat* represents the combination of water production using more efficient efforts in retrieving surface water and water from pumping stations. To produce a quantity of *Wat*, we use a composite input, *Kl*, defined as a combination of capital, *K*, and labour, *Ld*. The use of these two inputs implies a more efficient production of water by using better techniques for retrieving surface water and for pumping underground water.

Production costs for water are characterized by decreasing marginal costs (*mc*), for the first type of production when water produced from dams dominates. When water produced from underground wells dominates, marginal costs are increasing. WMA are responsible for producing, distributing and commercializing the water resource. In the production process they must take into account both types of technologies and their cost function properties. The utilities production structures are illustrated in figure 1.

Insert Figure 1: Here

The stylized facts of water production in Morocco presented above lead us to adopt the following hypothesis. Since there are important distinctions in the hydro-geographic, geological and rainfall characteristics, we decomposed water production into two distinct regions; the North and the South. From Figure 3, we have *Xs* that is an aggregate of Eb_{eau} (*type I*) and *Wat* (*type II*) related via an additive function. EB_{eau}, is defined by a fixed relation to its capital stock, $\overline{K}_{eau}$. The second type is characterized as a Weibull technology, which has a composite factor, Kl_{eau}, as an input. The composite factor, Kl_{eau}, is defined by a Leontief (fixed coefficient) between capital K_{eau} and labour Ld_{eau}.

We define the description of the functional forms adopted as follows. The production function for *type I* is:

$$9\text{-} \qquad Eb = c\,\overline{K}^{m} + h\,rain,$$

where c is a scale parameter, $\overline{K}$ is the fixed capital used in dams already in place and m is the Cobb-Douglas parameter. The second component of the equation introduces the exogenous rainfall effect, where h is the share of the rainfall that contributes to the increase in the water level of the reservoirs and rain is the exogenous rainfall variable.

For *type II* production we assume that the public authorities must resort to variable production factors which are capital (*K*) and labour (*Ld*). Figure 2 depicts the output of water, *Wat,* as a function of the composite factor *Kl* for the two regions. Below the inflection point, production from dams dominates and to the right of the inflection point production from pumping stations dominates.

Water production will have a variable marginal productivity. In the first part of production of *type II*, the composite input will generate increasing marginal productivity. In this interval, more efficient surface water recuperation techniques (dredging of water basins, repair and maintenance of distribution system, etc.) are used intensively. As surface water becomes scarce and difficult to capture, groundwater pumping becomes more dominant in production. The pumping technology is characterized by decreasing marginal productivity. When using the pumping technology, greater productive resources are needed to produce additional units of water. As production increases, the flow of water is reduced and the distance to the resource increases. Thus, more fuel is needed to pump the same amount of water from the underground reserves to the surface. In the second interval of this type of production, the decreasing marginal productivity of the pumping technology dominates the increasing marginal productivity of dam production. The two-interval water production function is depicted in Figure 2.

Insert Figure 2 : Here

To describe the two-interval technology, we use the Weibull function presented in Equation 10.

$$10\text{-} \qquad Wat_{eau} = \Psi\left(1 - e^{-\left(\frac{Kl_{eau}}{f_{eau}}\right)^{z}}\right)$$

Parameter Ψ is the upper limit of the function or the maximum of the available water in each region. This upper limit is decomposed into two exogenous components:

$$11\text{-} \qquad \Psi = (v_{eau} - urain_{eau}),$$

where v is the maximum available water in normal rainfall situations, u is the share of rainfall which increases the level of efficient rainfall and $rain$ is the exogenous rainfall variable. Parameters z and f define the symmetry of the Weibull. The value of z has an important role in determining the inflection point as well as in determining the steepness of the curve (Sharif and Islam (1981)). In a less pronounced fashion, f, which is a scale parameter, also influences the steepness of the curve[6].

The two-interval water production technology is nested in these three parameters. Given that no direct information is available for the values of z and f, they will be calibrated by taking into account Morocco’s water endowment and its actual potential capabilities of harvesting.

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[6] For a detailed description of the calibration procedure for the Weibull parameters see Decaluwé et al. (1998).

4. Applied General Equilibrium Models and Water Management

AGE modeling has rarely been used to analyze water management policies. A first model was presented by Berck, Robinson and Goldman (1991) in which they study the impact of investment policies aimed towards the distribution of water in the San Joaquim Valley of California in the United States. This model is disaggregated into 14 production branches with 6 of them being agricultural sectors. The model measures change in water endowments and its effect on the economy. In this model, the authors define water as an exogenous stock with only agriculture consuming water. A simulated reduction in water production generates a substitution from agriculture to the livestock sector accompanied by a decrease in GDP, as well as a reduction in agricultural income and labour demand.

On their part, Goldin and Roland-Holst (1995), study the relation between trade reform and water management policies in Morocco. Their AGE model has four branches, two of which are agricultural. These two agricultural branches are disaggregated on the basis of arid and humid zones. They simulated three scenarios; an increase in water tariffs for agriculture, a reduction in import duties and a combination of the first two. From the last simulation, they conclude that this policy option will result in a reduction in the water demand, an increase in the GDP and an improvement in household income. In spite of interesting results they impose restrictive hypotheses in their model. Namely, using a production function for agriculture branches that does not allow substitution between water and other intermediate consumption or primary factors. Moreover, there is no production of water; they assume that the economy has a fixed endowment of water. Finally, water is only consumed by the agricultural branches.

Decaluwé et al. (1998) depart from the standard model and apply a model that integrates specific water production technology, substitution between intermediate agricultural inputs and allows for possibilities of simulating exogenous rainfall variation. They simulate arbitrary water price increases, reduction in subsidies to water management authorities and a reduction in average rainfall. They found that a 10% increase in water prices reduces water demand by approximately 8% and reduces GDP by 0.13% as well as the subsidies to WMA. The increase in prices are arbitrary and more efficient water pricing mechanisms could be investigated. We start from Decaluwé et al. (1998) and introduce a number of changes that will allow us to analyze different water pricing scenarios. In the next section we highlight the main features of our model.

4.1. The Moroccan AGE model

The model is inspired by the Decaluwé et al. (1995) general equilibrium models which in turn follow the modeling guidelines put forward by Shoven and Whalley (1984) as well as Decaluwé et al. (1998). As presented in the previous section, modifications were made to capture stylized facts of water production in the model. As for the production technology of the other production branches, a detailed presentation of their technology is put forward farther on in this section.

Four types of agents are incorporated in the model. They are household, firm, government and rest of the world (ROW). We present the household utility function as Cobb-Douglas Linear Expenditure System (CD-LES). This utility function allows for the introduction of incompressible consumption in the household consumption basket.

To take into account the spatial variability of water in the model, we divided the country into two distinct regions. The northern region is the area abundant in water and the southern region is the arid part of the country. This regional disaggregation applies for water as well as for agricultural and industrial branches. Both regions produce similar commodities linked by a CES function and sold on national and international market as a composite commodity.

Considering the importance of water demand by the agricultural branches, it is imperative to refine the production behavior (demand for inputs) of the branches in order to capture the impact of water policies. Therefore it is essential to have a production technology which allows for substitutability between primary factors and a certain intermediate level of consumption. According to Just (1991), substitution between primary inputs is crucial for an appropriate analysis of questions linked to water management. We incorporate the possibility of substitution in the agricultural production function by using a nested constant elasticity of substitution (CES) function (figure 3).

Insert Figure 3: Here

At the first level of the structure, the first nest combines the primary factors; capital (K_{ag}) and land ($Land_{ag}$). Following Burniaux et al. (1988), Boyd and Newman (1991) and Boyd et al. (1992), we linked capital to land using a CES. The second nest of the first level characterizes the relationship between fertilizer (Fer_{ag}) and water (Eau_{ag}). An explicit relation between water and fertilizer is crucial in an agricultural production structure (Hexem and Heady (1978)). Furthermore, empirical studies indicate that the potential for substitution can be greater between intermediate consumption than between primary factors (Hertel et al. (1989)).

At the second level of the structure, we model the relationship between the intermediate composite good, (Cie_{ag}) and the composite input Kc_{ag}, by linking them with a CES. At the third level, a CES combines the composite Ip_{ag} with labour, (Ld_{ag}). By specifying the nested CES as described above, an external shock disturbing agricultural water consumption will trickle down to other intermediate consumption as well as primary factors via the four CES. At the last level of the structure, we combined the composite Rx_{ag}, with the other intermediate consumption (Cia_{ag}), using a Leontief to give us the final production for the agricultural branch. The substitution elasticity parameters for this production structure were drawn from Binswinger (1974), Ray (1982), Debertin et al. (1990) and Ali et al. (1992).

For the industrial branches, production is defined by a Leontief function at the top level, linking the value-added (*Va)* to the total intermediate consumption (*Cit)*. The *Va* is modeled as a C-D function of capital (*K)* and labour (*Ld)*. As for the relationships between the intermediate consumption, we introduced more flexibility (than in standard models[7]) by supposing that the industrial producers could substitute intermediate consumption directly or indirectly when relative prices of inputs change. Figure 4 presents the production structure of the industrial branches.

Insert Figure 4: Here

The service branches are modeled in a standardized fashion, where the production is a Leontief of *Va* and the *Cit*. The value added is a C-D of *K*, and *Ld*, and *Cit* is a Leontief (fixed coefficient) of individual intermediate consumption.

The Social Accounting Matrix (SAM) used in this paper was constructed using the Martens (1995) SAM of Morocco. The main modifications brought to the SAM are a regional disaggregation of the branches and the incorporation of water and fertilizer production branches[8]. The information concerning the production and the demand for the resource were based on Mriouah (1992).

5. Water Pricing Scenarios

Seven scenarios were simulated on the base year equilibrium. The first consisted of generating the BRP from the base year. In this simulation actual prices were replaced by the

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[7] In standard AGE modeling, intermediate consumption is assumed to be linked by a fixed coefficient with value added.

BRP by adding the equations' corresponding BRP as well as the own-price elasticity equations. The second scenario consisted of repeating the first and redistributing the gains from the new BRP (elimination of the subsidies to the water management authorities) through a uniform reduction of the distorted production tax (*tx*). For this simulation, the government's deficit (*Sg*) is exogenous and the uniform tax level is endogenous. In the third scenario, the gains were redistributed to the household by a reduction in their income tax level[9]. The fourth simulation is a MCP simulation. The fifth is the MCP simulation with the gain going to the producers via a uniform reduction in the production tax. As in the second simulation, *tx* is endogenous and *Sg* is exogenous for this simulation. The sixth is MCP with the gain being redistributed to the household (income tax endogenous and *Sg* exogenous). The last scenario is an arbitrary 10% increase in the agricultural prices of water with no redistribution. The results of these scenarios are presented in Table1[10].

Insert Table 1: here

5.1. Boiteux-Ramsey Pricing (1st Simulation)

In the BRP scenario, water prices increase substantially for all of the agricultural branches (*Pwa* for the north and *Pwa* for the south). In the north, the citrus branch had the strongest increase with an increase of 98,53%. In the south, the largest increase was in food crop agriculture with a 26,46% increase. Other water consumers (household and industries) face a strong decrease in the water prices. Prices for households decreased by 47,10% in the

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[8] Information for regional disaggregation was provided by T. Abdedkhalek of the "Institut National de Statistique et de l'Économie Appliqués" in Rabat, Morocco.

[9] In the second scenario, the production tax produces more distortion than the income tax since there is only one household and the tax levels differ greatly from one sector to the other., and therefore the results should reflect this fact.

south and by 25,81% in the north[11]. Water prices for industrial use drop by 39,01% in the south and by 26,11% in the north. We also note that the government deficit significantly decreases from 4,7 to 3,9 billion Dirhams. As for income, government revenues increased slightly by 0,55% mainly generated by an increase in the taxes on capital given that the return to capital increases significantly. An essential objective of this policy is also reached. We observe an important reduction in total water demand reaching 39,69% in the north and 11,86% in the south.

The strong increase in water prices for the agriculture branches had a dramatic impact on their level of output. The drop in output ranges from between 1,48% for the southern food crop branch, and 9,19% for the citrus branch. As a consequence of this reduction of agricultural output, factors were released from the agricultural sector and taken up by the other sectors thereby increasing their production. We note that the production by the fertilizer branch increases given the increase in demand by the agricultural sectors permitted by the substitution effect between water and fertilizer in their production process. This sector increases its production by 41,32%. As for the other sectors, the increases are 0,23% for services, 1,15% for the southern industrial branch and 1,11% for the northern industrial branch.

This simulation also produced a somewhat surprising result insofar as the equivalent variation decreases by 760. This strong drop of the household's *EV* is caused by the strong increase in agricultural prices (since these sectors face higher water prices). Since the agricultural goods compose an important portion of the commited expenditures or "subsistence minima" s leads to an important drop in the supernumerary income. This pricing method is should be more efficient than the actual pricing scheme, we expected an increase in the *EV*. In

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[10] With the chosen closure (exogenous current account balance and nominal exchange rate) the real GDP in the model is constant. Our analysis allows with to measure the reallocation impact of the different water pricing policies.

fact, one element of efficiency (elimination of subsidies to WMA) is not included in the simulation and therefore part of the benefits of the pricing method is not carried on to the agents. This case is presented in the second simulation where the gains are redistributed via an endogenous uniform reduction in production tax.

5.2. BRP with production tax decrease (2nd simulation)

In the second scenario, the gains from the BRP are transmitted to the producers through a uniform reduction in production taxes. The reduction in taxes is obtained by making the government's deficit exogenous and the production tax rate (uniform) endogenous.

The interesting result from this simulation is the reversal of the EV which becomes positive with an increase of 33.19. The two sources of this improvement come from the increase in the wage (versus a decrease in the first simulation) and the reduction of prices of commodities of the commited expenditure. We also note a stronger reduction in water consumption (-12,18%) in the south than in the first simulation. In the north, the reduction in water consumption (-39,67%) is practically the same as in the first simulation. The subsidies to water-producing authorities are again eliminated but the government deficit is now held constant. The increases in the price of water for agriculture are marginally larger for all agricultural branches but the decreases in water prices for other water consumers are smaller. The other results are similar to the previous simulation, however the highly taxed branches benefit more from this policy. The industrial and fertilizer branches have a higher tax burden when compared to the agricultural branches. For example, the industrial branches improve their situation when compared to the first; an increase of 1,15% to 1,47% in the south and of

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[11] Note that we have one aggregate household that consumes two water commodities at two different prices. We did not decompose in two households since the regional (North-South) information was not available.

1,11% to 1.41% in the north. The citrus branch for its part (low tax burden) goes from –9,19% to –9,70%.

5.3. BRP with Income Tax Decrease (3nd simulation)

In this scenario, benefits from BRP are transmitted to the consumers via an endogenous decrease in income tax. The reduction in income tax generated by the simulation is 22,59%. The impact on the equivalent variation are almost identical to the previous case 32.23. The improvement in the household welfare is transmitted directly via the decrease in income tax and not through the wage or prices. As for water consumption and water prices, results are almost identical to the first simulation. The negative effects on the agricultural branches are slightly attenuated since the household, benefiting from this policy, attributes an important weight on its total consumption of agricultural goods. This is explained by the fact that this simulation consists in transferring the gains from *Sg* (or equivalently gains from total investment, *It*) to household consumption. In other words, there is a shift of the *It* demand component (first simulation) to the household demand component (third simulation). Consequently, results shows that total investment went from an increase of 2,34% in the first simulation, to 0.41% in the third, and that household consumption increased from –0,32% in the first to 0.55%.

5.4. Marginal Cost Pricing (4th Simulation)

In this fourth simulation, the impact of MCP is analyzed. Results indicate that with the same prices charged to all water consumers in each region, the impact on the *EV* is negative but the impact is not as strong as in the first scenario (-171.64 vs –760.00). However, the reduction in water consumption is far less than in the three previous simulations; –7.96% in the south and –4.89% in the north. As for the subsidies to WMA they were reduced by only

18.58% in the north (compared to a 100% reduction in the first three simulations) and increased significantly in the south by 90.95%. Given that the initial level of the subsidy in the south represents only a small share of the total subsidy, the combined north-south reduction is only 16.99%. The reduction in the government deficit is also much smaller than in the first simulation (11.61%). Since water prices fell less drastically than in the BRP scenarios, the negative impacts on agricultural branches are consequently smaller.

5.5. MCP with Tax Decrease (5th and 6th Simulations)

By comparing these two simulations with the second and third simulations, we can conclude that the effects are similar. The major difference is that the degree of improvement is more moderate since the gains (reduction of *Sg*) in the MCP simulation are smaller than the gains of the BRP simulation. Comparing simulation two with five we notice that the improvement in the *EV* is 793.19 (improvement between the first and second scenario) for the second versus 530.99 for the fifth and for the third and sixth the improvements are 792.23 versus 528.20 respectively. This disparity is a consequence, of the smaller reduction in the production tax level and income tax level; 18.98% versus 28.16% and 14.99% versus 22.59%, respectively.

5.6. Arbitrary Water Price Increase for Agriculture Branches

This simulation consists of increasing water price for agricultural use by 10%. For this scenario, results show a reduction in *EV* of 135.00 and only a modest reduction in water consumption (7.02% in the north and 0.24% in the south). The subsidies to WMA also decreased in both regions slightly by 15.03% in the north and 13.56% in the south. The combined reduction is smaller than in the MCP scenario. This scenario is less efficient in attaining the initial objectives of reducing water consumption and subsidies then the two other pricing policies and has significant negative impact on the households *EV*.

5.7. Sensitivity Analysis

The same set of simulations was performed on the model but with the substitution elasticity parameters (of all production CES) reduced by 25%. The objective was to compare these scenarios in more rigid economy[12]. The results were quite interesting. For the MCP, results are practically identical and less positive for the fifth and sixth simulation, but results for the BRP show improvement in the welfare measure for the three scenarios. For the second and third simulation the improvements are more the twofold. Generally the results show that the model is quite robust to changes in elasticities of substitution[13].

________ Insert Table 2: here

As for the total impact on water demand (or production), the consumption is reduced by 17,82% in the south and 34,87% in the north. In this case, the reduction was stronger in the south and smaller in the north. Since the water production in the north is much more important (in terms of volume produced), the total water demand decreased by 5,6% more in the BRP scenario than in the MCP scenario.

6. Conclusion

In this paper, we developed an AGE model that allows a comparative analysis of alternative water pricing policies to replace actual inefficient water pricing policies, which are

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[12] A more rigid economy makes reference to an economy with weaker capabilities of substitution between water inputs and other production inputs and consequently of weaker own-price elasticities of water demand for all water consumers other than households.

leading to the depletion of water resources combined with important deficits of WMA. Three pricing policies were simulated, namely BRP, MCP and an arbitrary increase in agricultural water prices. Results reveal that BRP combined with a reduction in distorted production taxes (simulation 2) is the most efficient in reducing water consumption with a positive impact on *EV* and eliminating WMA subsidies. MCP has a more positive (or less negative for the fourth scenario) impact on the *EV* but is not as efficient in reducing water consumption and does not eliminate subsidies (natural monopoly). As for the arbitrary increase in agricultural water prices it generates negative effect on *EV* and only small reductions in water consumption and subsidies to WMA.

Since any increase in agricultural water prices is an extremely sensitive political question, it is imperative to clearly understand the impact of pricing policies on the economy as a whole. In general, all pricing policies will have a negative impact on agricultural production since actual prices are highly subsidized. Results show that the agricultural sector will be strongly affected by these price increases and that gains from BRP on the *EV* are conditional on reducing distortions in the economy arising from the benefits obtained from new prices.

It is also important the interpret the results of this paper in the context of this given model with it’s specific structure, parameters and closure hypothesis. Changing some of these elements could lead to different conclusions. Moreover, the initial production point on the marginal cost curve for the northern region (left of the minimum) likely leads to results being better with the MCP versus the BRP (for some variables). Re-calibrating the model on a dryer base year could lead to very different set of results. Given this, we still demonstrate the importance of measuring the impact of these policy changes on water demand, water subsidies

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[13] Further sensitivity analyses were performed on the model and results are available upon request from the authors.

household welfare but also on the agents that gain and the ones that lose. This is key in implementing these highly sensitive policies.

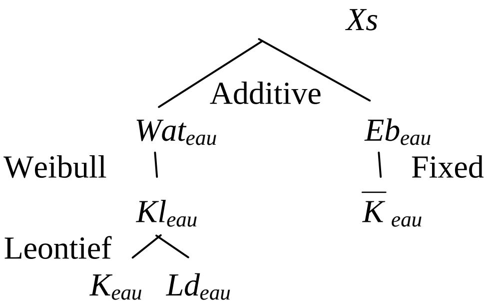

Figure 1: Water Production Structure

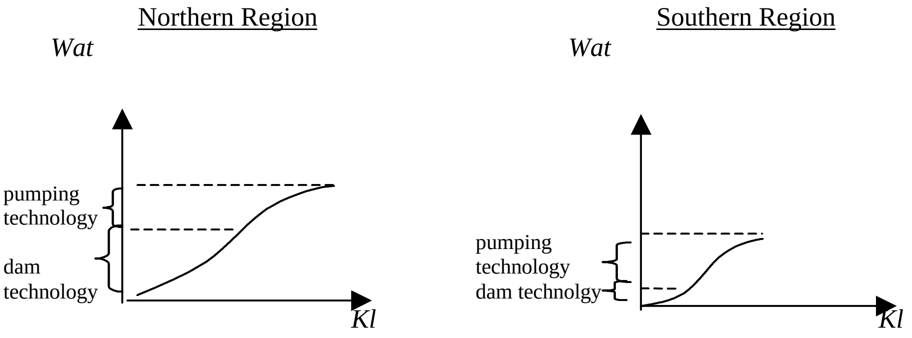

Figure 2 : *Type II* Water Production

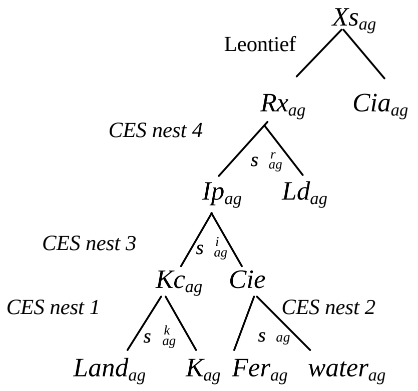

Figure 3 : Agricultural Production Structure

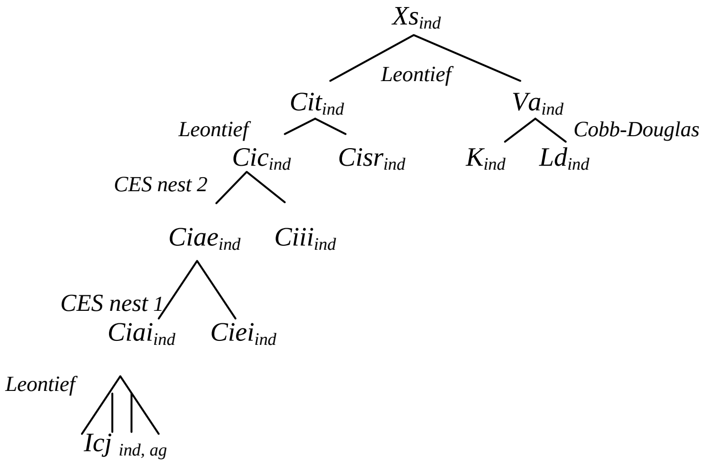

Figure 4 : Production Structure for Industrial Branches

Table 1: Simulation Results

			Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5		Simulation 6		Simulation 7	
Variables	Branches	Base Year	Level	%	Level	%	Level	%	Level	%	Level	%	Level	%	Level	%
w		1.000	0.995	-0.51	1.006	0.56	0.996	-0.44	1.013	1.28	1.020	2.01	1.013	1.32	0.998	-0.18
Pwh	EN	1.400	1.039	-25.81	1.050	-25.01	1.040	-25.73	0.761	-45.63	0.769	-45.11	0.761	-45.61	1.400	0.00
Pwh	ES	1.800	0.952	-47.10	0.963	-46.50	0.953	-47.07	0.965	-46.37	0.972	-45.98	0.966	-46.36	1.800	0.00
Pwi	EN	1.400	1.034	-26.11	1.044	-25.41	1.035	-26.04	0.761	-45.63	0.769	-45.10	0.761	-45.61	1.400	0.00
Pwi	ES	1.800	0.976	-45.79	0.986	-45.23	0.976	-45.77	0.965	-46.37	0.972	-45.98	0.966	-46.36	1.600	0.00
It		35.047	35.866	2.34	35.391	0.98	35.189	0.41	36.122	3.07	35.804	2.16	35.661	1.75	35.166	0.34
Ch		83.465	83.194	-0.32	84.031	0.68	83.921	0.55	84.585	1.34	85.158	2.03	85.068	1.92	83.333	-0.16
Yh		100.993	100.666	-0.32	101.679	0.68	100.726	-0.26	102.349	1.34	103.042	2.03	102.381	1.37	100.834	-0.16
Sh		14.017	13.972	-0.32	14.112	0.68	14.094	0.55	14.205	1.34	14.301	2.03	14.286	1.92	13.995	-0.16
Yg		22.730	22.854	0.55	22.054	-2.97	22.048	-3.00	23.126	1.74	22.582	-0.65	22.580	-0.66	22.729	0.00
Sg		-4.700	-3.894	-17.16	-4.700	0.00	-4.700	0.00	-4.155	-11.61	-4.700	0.00	-4.700	0.00	-4.543	-3.35
Ty		1.000	1.000	0.00	1.000	0.00	0.774	-22.59	1.000	0.00	1.000	0.00	0.850	-14.99	1.000	0.00
Tx		1.000	1.000	0.00	0.718	-28.16	1.000	0.00	1.000	0.00	0.810	-18.98	1.000	0.00	1.000	0.00
Cab		7.997	7.997	0.00	7.997	0.00	7.997	0.00	7.997	0.00	7.997	0.00	7.997	0.00	7.997	0.00
P^{index}		1.000	1.003	0.33	1.008	0.85	1.004	0.39	1.016	1.55	1.019	1.91	1.016	1.58	0.999	-0.05
EV				-760.00		33.19		32.23		-171.64		359.35		356.56		-135.00
Xs	AUGRS	4.847	4.708	-2.86	4.685	-3.33	4.687	-3.30	4.798	-1.02	4.780	-1.37	4.783	-1.32	4.821	-0.53
Xs	GRAIS	2.711	2.658	-1.97	2.665	-1.70	2.668	-1.59	2.688	-0.86	2.692	-0.69	2.695	-0.60	2.700	-0.40
Xs	MARAS	1.447	1.425	-1.48	1.433	-0.97	1.433	-0.96	1.438	-0.62	1.443	-0.28	1.443	-0.27	1.442	-0.32
Xs	AUGRN	9.088	8.720	-4.04	8.679	-4.50	8.682	-4.47	8.970	-1.29	8.938	-1.64	8.943	-1.59	9.029	-0.64
Xs	GRAIN	6.715	6.521	-2.89	6.539	-2.61	6.545	-2.53	6.645	-1.04	6.656	-0.87	6.662	-0.79	6.683	-0.48
Xs	MARAN	2.625	2.551	-2.83	2.563	-2.36	2.564	-2.34	2.601	-0.93	2.609	-0.63	2.610	-0.59	2.613	-0.46
Xs	AGRUN	2.152	1.954	-9.19	1.943	-9.70	1.955	-9.15	2.081	-3.32	2.070	-3.80	2.081	-3.29	2.118	-1.58
Xs	SERNM	21.522	21.617	0.44	21.360	-0.75	21.603	0.38	21.248	-1.27	21.078	-2.06	21.241	-1.31	21.559	0.17
Xs	INDS	17.406	17.606	1.15	17.662	1.47	17.557	0.87	17.456	0.29	17.494	0.50	17.424	0.10	17.449	0.25
Xs	INDN	104.134	105.290	1.11	105.603	1.41	104.994	0.83	104.405	0.26	104.619	0.47	104.212	0.07	104.385	0.24
Xs	FERN	1.013	1.431	41.32	1.488	46.97	1.417	39.93	2.246	121.81	2.294	126.50	2.231	120.28	1.010	-0.24
Xs	ES	0.382	0.336	-11.86	0.335	-12.18	0.336	-11.87	0.351	-7.96	0.350	-8.26	0.351	-7.97	0.355	-7.02
Xs	EN	1.993	1.202	-39.69	1.202	-39.67	1.200	-39.77	1.895	-4.89	1.886	-5.35	1.893	-5.02	1.826	-8.35
Xs	SERM	63.488	63.632	0.23	63.747	0.41	63.811	0.51	63.224	-0.42	63.304	-0.29	63.344	-0.23	63.550	0.10
Sve	EAUN	0.614	0.000	-100.00	0.000	-100.00	0.000	-100.00	0.500	-18.58	0.497	-18.98	0.499	-18.62	0.522	-15.03
Sve	EAUS	0.009	0.000	-100.00	0.000	-100.00	0.000	-100.00	0.017	90.95	0.017	89.07	0.017	90.90	0.008	-13.56
mc	ES	1.016	0.914	-10.06	0.925	-8.97	0.914	-10.01	0.965	-4.96	0.972	-4.27	0.966	-4.94	0.951	-6.35
mc	EN	0.744	0.871	16.98	0.883	18.57	0.872	17.16	0.761	2.25	0.769	3.24	0.761	2.29	0.749	0.65
Pwa	AUGRN	0.600	1.191	98.53	1.198	99.67	1.192	98.62	0.761	26.85	0.769	28.09	0.761	26.91	0.660	10.00
Pwa	GRAIN	0.600	1.134	89.04	1.142	90.39	1.135	89.17	0.761	26.85	0.769	28.09	0.761	26.91	0.660	10.00
Pwa	MARAN	0.600	1.151	91.81	1.159	93.10	1.152	91.92	0.761	26.85	0.769	28.09	0.761	26.91	0.660	10.00
Pwa	AGRUN	0.600	1.120	86.59	1.128	87.99	1.120	86.72	0.761	26.85	0.769	28.09	0.761	26.91	0.660	10.00
Pwa	AUGRS	0.800	1.006	25.71	1.015	26.89	1.006	25.76	0.965	20.66	0.972	21.54	0.966	20.69	0.880	10.00
Pwa	GRAIS	0.800	1.000	25.04	1.010	26.24	1.001	25.09	0.965	20.66	0.972	21.54	0.966	20.69	0.880	10.00
Pwa	MARAS	0.800	1.012	26.46	1.021	27.63	1.012	26.51	0.965	20.66	0.972	21.54	0.966	20.69	0.880	10.00

*Values are in billion Dirhams (except for prices)

Table 2: Simulation Results for Rigid Economy

			Simulation 1		Simulation 2		Simulation 3		Simulation 4		Simulation 5		Simulation 6		Simulation 7	
Variables	Branches	Base Year	Level	%	Level	%	Level	%	Level	%	Level	%	Level	%	Level	%
w		1.000	0.997	-0.31	1.008	0.77	0.998	-0.24	1.011	1.15	1.018	1.83	1.012	1.19	0.998	-0.16
Pwh	EN	1.400	0.926	-33.87	0.938	-33.03	0.927	-33.79	0.759	-45.77	0.766	-45.30	0.759	-45.75	1.400	0.00
Pwh	ES	1.800	0.955	-46.95	0.966	-46.32	0.955	-46.92	0.973	-45.97	0.979	-45.59	0.973	-45.96	1.800	0.00
Pwi	EN	1.400	0.985	-29.66	0.995	-28.94	0.986	-29.60	0.759	-45.77	0.766	-45.30	0.759	-45.75	1.400	0.00
Pwi	ES	1.800	0.982	-45.47	0.992	-44.90	0.982	-45.44	0.973	-45.97	0.979	-45.59	0.973	-45.96	1.600	0.00
It		35.047	35.890	2.41	35.412	1.04	35.209	0.46	36.010	2.75	35.719	1.92	35.587	1.54	35.159	0.32
Ch		83.465	83.320	-0.17	84.165	0.84	84.052	0.70	84.457	1.19	84.988	1.83	84.904	1.72	83.345	-0.14
Yh		100.993	100.818	-0.17	101.840	0.84	100.879	-0.11	102.194	1.19	102.837	1.83	102.225	1.22	100.848	-0.14
Sh		14.017	13.993	-0.17	14.135	0.84	14.116	0.70	14.184	1.19	14.273	1.83	14.259	1.72	13.997	-0.14
Yg		22.730	22.861	0.58	22.056	-2.97	22.050	-2.99	23.079	1.53	22.578	-0.67	22.576	-0.68	22.727	-0.01
Sg		-4.700	-3.888	-17.28	-4.700	0.00	-4.700	0.00	-4.198	-10.69	-4.700	0.00	-4.700	0.00	-4.550	-3.21
Ty		1.000	1.000	0.00	1.000	0.00	0.773	-22.70	1.000	0.00	1.000	0.00	0.862	-13.83	1.000	0.00
Tx		1.000	1.000	0.00	0.717	-28.31	1.000	0.00	1.000	0.00	0.825	-17.52	1.000	0.00	1.000	0.00
Cab		7.997	7.997	0.00	7.997	0.00	7.997	0.00	7.997	0.00	7.997	0.00	7.997	0.00	7.997	0.00
P^{index}		1.000	1.004	0.44	1.010	0.96	1.005	0.49	1.014	1.37	1.017	1.71	1.014	1.40	1.000	-0.04
EV				-707.35		88.48		88.05		-156.03		333.72		330.73		-129.69
Xs	AUGRS	4.847	4.737	-2.28	4.715	-2.73	4.715	-2.71	4.806	-0.85	4.791	-1.15	4.793	-1.12	4.826	-0.43
Xs	GRAIS	2.711	2.670	-1.52	2.677	-1.24	2.680	-1.14	2.692	-0.69	2.697	-0.52	2.698	-0.46	2.702	-0.32
Xs	MARAS	1.447	1.429	-1.24	1.436	-0.72	1.436	-0.72	1.439	-0.53	1.444	-0.21	1.444	-0.21	1.443	-0.28
Xs	AUGRN	9.088	8.776	-3.43	8.736	-3.86	8.738	-3.85	8.988	-1.10	8.960	-1.40	8.964	-1.36	9.039	-0.53
Xs	GRAIN	6.715	6.554	-2.39	6.574	-2.10	6.578	-2.03	6.657	-0.86	6.669	-0.69	6.672	-0.63	6.688	-0.40
Xs	MARAN	2.625	2.559	-2.52	2.571	-2.06	2.572	-2.03	2.604	-0.83	2.611	-0.54	2.612	-0.52	2.615	-0.41
Xs	AGRUN	2.152	1.999	-7.11	1.989	-7.57	2.000	-7.07	2.097	-2.56	2.089	-2.92	2.098	-2.53	2.126	-1.20
Xs	SERNM	21.522	21.575	0.25	21.316	-0.96	21.560	0.18	21.278	-1.13	21.119	-1.87	21.271	-1.17	21.555	0.15
Xs	INDS	17.406	17.569	0.93	17.622	1.24	17.519	0.65	17.452	0.27	17.486	0.46	17.422	0.09	17.441	0.20
Xs	INDN	104.134	105.075	0.90	105.377	1.19	104.779	0.62	104.391	0.25	104.580	0.43	104.212	0.08	104.339	0.20
Xs	FERN	1.013	1.483	46.47	1.540	52.11	1.469	45.06	2.095	106.88	2.139	111.19	2.082	105.58	1.011	-0.21
Xs	ES	0.382	0.345	-9.53	0.344	-9.76	0.345	-9.54	0.356	-6.74	0.355	-6.96	0.356	-6.75	0.361	-5.43
Xs	EN	1.993	1.385	-30.52	1.385	-30.52	1.383	-30.60	1.908	-4.27	1.902	-4.54	1.906	-4.36	1.864	-6.48
Xs	SERM	63.488	63.552	0.10	63.666	0.28	63.731	0.38	63.254	-0.37	63.326	-0.26	63.364	-0.20	63.535	0.07
Sve	EAUN	0.614	0.000	-100.00	0.000	-100.00	0.000	-100.00	0.501	-18.35	0.499	-18.67	0.501	-18.39	0.525	-14.39
Sve	EAUS	0.009	0.000	-100.00	0.000	-100.00	0.000	-100.00	0.014	57.53	0.014	54.38	0.014	57.39	0.008	-6.75
mc	ES	1.016	0.932	-8.26	0.944	-7.10	0.932	-8.21	0.973	-4.25	0.979	-3.58	0.973	-4.23	0.964	-5.08
mc	EN	0.744	0.812	9.06	0.823	10.55	0.813	9.18	0.759	1.98	0.766	2.88	0.759	2.02	0.747	0.41
Pwa	AUGRN	0.600	1.157	92.92	1.165	94.22	1.158	93.03	0.759	26.53	0.766	27.64	0.759	26.57	0.660	10.00
Pwa	GRAIN	0.600	1.094	82.33	1.103	83.79	1.095	82.46	0.759	26.53	0.766	27.64	0.759	26.57	0.660	10.00
Pwa	MARAN	0.600	1.112	85.40	1.121	86.81	1.113	85.52	0.759	26.53	0.766	27.64	0.759	26.57	0.660	10.00
Pwa	AGRUN	0.600	1.078	79.61	1.087	81.11	1.078	79.75	0.759	26.53	0.766	27.64	0.759	26.57	0.660	10.00
Pwa	AUGRS	0.800	1.005	25.63	1.014	26.81	1.005	25.68	0.973	21.56	0.979	22.42	0.973	21.59	0.880	10.00
Pwa	GRAIS	0.800	1.001	25.11	1.010	26.31	1.001	25.16	0.973	21.56	0.979	22.42	0.973	21.59	0.880	10.00
Pwa	MARAS	0.800	1.010	26.21	1.019	27.37	1.010	26.26	0.973	21.56	0.979	22.42	0.973	21.59	0.880	10.00

*Values are in billion Dirhams (except for prices)

1 Appendix

1.1 Equations

Water Production Technology

$$\begin{aligned}
Ld_{eau} &= lio_{eau} Kl_{eau} \tag{1}\\
K_{eau} &= lio_{eau} Kl_{eau} \tag{2}\\
Kl_{eau} &= \phi_{eau} Log(\frac{\Psi_{eau}}{\Psi_{eau} - Wat_{eau}})^{\frac{1}{\zeta_{eau}}} \tag{3}\\
\Psi_{eau} &= \varpi_{eau} + \varrho_{eau} rain_{eau} \tag{4}\\
Wat_{eau} &= Xs_{eau} - Eb_{eau} \tag{5}\\
Eb_{eau} &= \eta_{eau} rain_{eau} + \chi_{eau} \overline{K}_{eau}^{\mu_{eau}} \tag{6}\\
ct_{eau} &= \overline{r}_{eau} \overline{K}_{eau} + Pkl_{eau} Kl_{eau} \tag{7}\\
mc_{eau} &= \overline{r}_{eau} + \frac{Pkl_{eau} \phi_{eau} Log\left(\frac{\Psi_{eau}}{\Psi_{eau} - Wat_{eau}}\right)^{\frac{1}{\zeta_{eau}} - 1}}{\zeta_{eau}\left(\Psi_{eau} - Wat_{eau}\right)} \tag{8}
\end{aligned}$$

Other Industries Production Technology

$$\begin{aligned}
Va_{gi} &= A_{gi} Ld_{gi}^{\alpha_{gi}} K_{gi}^{1-\alpha_{gi}} \tag{9}\\
Ld_{gi} &= \frac{Pva_{gi} \alpha_{gi} Va_{gi}}{w} \tag{10}\\
K_{gi} &= \frac{Pva_{gi}(1 - \alpha_{gi}) Va_{gi}}{rd} \tag{11}\\
Cit_{gi} &= \frac{io_{gi} Va_{gi}}{v_{gi}} \tag{12}\\
Xs_{gi} &= \frac{Cit_{gi}}{io_{gi}} \tag{13}
\end{aligned}$$

Agricultural Production Technology

$$\begin{aligned}
Kc_{ag} &= B_{ag}^{k}\left[\delta_{ag}^{k} K_{ag}^{-\gamma_{ag}^{k}} + (1 - \delta_{ag}^{k}) Ter_{ag}^{-\gamma_{ag}^{k}}\right]^{-\frac{1}{\gamma_{ag}^{k}}} \tag{14}\\
Ter_{ag} &= \left(\frac{1 - \delta_{ag}^{k}}{\delta_{ag}^{k}}\right)^{\sigma_{ag}^{k}} \left(\frac{ra}{rt_{ag}}\right)^{\sigma_{ag}^{k}} K_{ag} \tag{15}\\
Cie_{ag} &= B_{ag}\left[\delta_{ag} water_{ag}^{-\gamma_{ag}} + (1 - \delta_{ag}) Fer_{ag}^{-\gamma_{ag}}\right]^{-\frac{1}{\gamma_{ag}}} \tag{16}\\
water_{ag} &= \left(\frac{\delta_{ag}}{1 - \delta_{ag}}\right)^{\sigma_{ag}} \left(\frac{Pq_{fer}}{Pwater_{ag}}\right)^{\sigma_{ag}} Fer_{ag} \tag{17}\\
O_{ag} &= water_{ag} - \rho_{eau} rain_{eau} \tag{18}\\
Ip_{ag} &= B_{ag}^{i}\left[\delta_{ag}^{i} Kc_{ag}^{-\gamma_{ag}^{i}} + (1 - \delta_{ag}^{i}) Cie_{ag}^{-\gamma_{ag}^{i}}\right]^{-\frac{1}{\gamma_{ag}^{i}}} \tag{19}\\
Cie_{ag} &= \left(\frac{1 - \delta_{ag}^{i}}{\delta_{ag}^{i}}\right)^{\sigma_{ag}^{i}} \left(\frac{Pkc_{ag}}{Pce_{ag}}\right)^{\sigma_{ag}^{i}} Kc_{ag} \tag{20}
\end{aligned}$$

$$Rx_{ag} = B^r_{ag}\left[\delta^r_{ag} Ip_{ag}^{-\gamma^r_{ag}} + (1-\delta^r_{ag}) Ld_{ag}^{-\gamma^r_{ag}}\right]^{\frac{\Gamma_1}{\gamma^r_{ag}}} \tag{21}$$

$$Ld_{ag} = \left(\frac{1-\delta^r_{ag}}{\delta^r_{ag}}\right)^{\sigma^r_{ag}} \left(\frac{Pxi_{ag}}{w}\right)^{\sigma^r_{ag}} Ip_{ag} \tag{22}$$

$$Xs_{ag} = \frac{Cia_{ag}}{ha1_{ag}} \tag{23}$$

$$Cia_{ag} = \frac{ha1_{ag} Rx_{ag}}{ha2_{ag}} \tag{24}$$

Intermediate Consumption

$$Icj_{ai,ga} = fij_{ai,ga} Cia_{ag} \tag{25}$$

$$Icj_{l,srv} = aij_{l,srv} Cit_{srv} \tag{26}$$

$$Icj_{ind,indu} = Ciii_{indu} \tag{27}$$

$$Icj_{eaun,indn} = Ciei_{indn} \tag{28}$$

$$Icj_{eaus,inds} = Ciei_{inds} \tag{29}$$

$$Icj_{eaun,fern} = Cife_{fern} \tag{30}$$

$$Icj_{ind,fern} = Ciii_{fern} \tag{31}$$

$$Icj_{agr,indu} = aca_{agr,indu} Ciai_{indu} \tag{32}$$

$$Icj_{svm,infe} = Cisr_{infe} \tag{33}$$

$$Ciae_{ind} = B^{ae}_{ind}\left[\delta^{ae}_{ind} Ciai_{ind}{}^{\gamma^{ae}_{ind}} + \left(1-\delta^{ae}_{ind}\right) Ciei_{ind}^{-\gamma^{ae}_{ind}}\right]^{-\frac{1}{\gamma^{ae}_{ind}}} \tag{34}$$

$$Ciei_{ind} = \left(\frac{1-\delta^{ae}_{ind}}{\delta^{ae}_{ind}}\right)^{\sigma^{ae}_{ind}} \left(\frac{Pagr_{ind}}{Pwi_{es}}\right)^{\sigma^{ae}_{ind}} Ciai_{ind} \tag{35}$$

$$Cic_{ind} = B^{iae}_{ind}\left[\delta^{iae}_{ind} Ciae_{ind}^{-\gamma^{iae}_{ind}} + \left(1-\delta^{iae}_{ind}\right) Ciii_{ind}^{-\gamma^{iae}_{ind}}\right]^{-\frac{1}{\gamma^{iae}_{ind}}} \tag{36}$$

$$Ciae_{ind} = \left(\frac{1-\delta^{iae}_{ind}}{\delta^{iae}_{ind}}\right)^{-\sigma^{iae}_{ind}} \left(\frac{Pciae_{ind}}{Pq_{ind}}\right)^{-\sigma^{iae}_{ind}} Ciii_{ind} \tag{37}$$

$$Cic_{fern} = B^{ie}_{fern}\left[\delta^{ie}_{fern} Cife_{fern}^{-\gamma^{ie}_{fern}} + \left(1-\delta^{ie}_{fern}\right) Ciii_{fern}^{-\gamma^{ie}_{fern}}\right]^{-\frac{1}{\gamma^{ie}_{fern}}} \tag{38}$$

$$Cife_{fern} = \left(\frac{1-\delta^{ie}_{fern}}{\delta^{ie}_{fern}}\right)^{-\sigma^{ie}_{fern}} \left(\frac{Pwf}{Pq_{ind}}\right)^{-\sigma^{ie}_{fern}} Ciii_{fern} \tag{39}$$

$$Cisr_{infe} = ci1_{infe} Cit_{infe} \tag{40}$$

$$Cic_{infe} = ci2_{infe} Cit_{infe} \tag{41}$$

$$\tag{42}$$

CES and Northern and Southern Commodities

$$Xst_{yl} = B^c_{yl}\left[\delta^c_{yl} Xs_{sud}^{-\gamma^c_{yl}} + (1-\delta^c_{yl}) Xs_{nord}^{-\gamma^c_{yl}}\right]^{\frac{\Gamma_1}{\gamma^c_{yl}}} \tag{43}$$

$$Xst_{xl} = Xs_{xi} \tag{44}$$

$$Xst_{h2o} = Xs_{eau} \tag{45}$$

Price Elasticities

$$
\begin{aligned}
Ela_{ag} &= -\sigma_{ag} && (46)\\
Elin &= -\sigma^{ae}_{indn} && (47)\\
Elis &= -\sigma^{ae}_{inds} && (48)\\
Elfn &= -\sigma^{ie} && (49)\\
Elmn &= -\left(\frac{\beta^{c}_{eaun}Ch}{C_{eaun}Pwh_{en}}\right) && (50)\\
Elms &= -\left(\frac{\beta^{c}_{eaus}Ch}{C_{eaus}Pwh_{es}}\right) && (51)
\end{aligned}
$$

Boiteux-Ramsey Pricing

$$
\begin{aligned}
Pwa_{an} &= \frac{mc_{en}}{1+\frac{\xi_{en}}{|Ela_{an}|}} && (52)\\
Pwa_{as} &= \frac{mc_{es}}{1+\frac{\xi_{es}}{|Ela_{as}|}} && (53)\\
Pwh_{en} &= \frac{mc_{en}}{1+\frac{\xi_{en}}{|Elmn|}} && (54)\\
Pwh_{en} &= \frac{mc_{es}}{1+\frac{\xi_{es}}{|Elms|}} && (55)\\
Pwi_{en} &= \frac{mc_{en}}{1+\frac{\xi_{en}}{|Elin|}} && (56)\\
Pwi_{es} &= \frac{mc_{es}}{1+\frac{\xi_{es}}{|Elis|}} && (57)\\
Pwf_{en} &= \frac{mc_{en}}{1+\frac{\xi_{en}}{|Elfn|}} && (58)
\end{aligned}
$$

Income and Savings

$$
\begin{aligned}
Yh &= w\sum_{i} Ld_i + P^{index}Tgm + eTwm + \lambda^{tm}\sum_{ag} rt_{ag}Ter_{ag} && (59)\\
&\quad +\lambda^{km}(\sum_{ag} raK_{ag} + \sum_{in} rdK_{in} + \sum_{eau} \overline{r}_{eau}\overline{K}_{eau})\\
Ydh &= Yh(1-\tau^{yh}) && (60)\\
Yf &= \lambda^{kf}(\sum_{ag} raK_{ag} + \sum_{in} rdK_{in} + \sum_{eau} \overline{r}_{eau}\overline{K}_{eau}) && (61)\\
&\quad +\lambda^{tf}\sum_{ag} rt_{ag}Ter_{ag} + P^{index}Tgf\\
Yg &= \tau^{yh}Yh + eTwg + \sum_{vt} Txs + \sum_{im} Txm_{im} + && (62)\\
&\quad \tau^{k}[\lambda^{tf}\sum_{ag} rt_{ag}Ter_{ag} + \lambda^{kf}(\sum_{ag} raK_{ag} + \sum_{in} rdK_{in} + \sum_{eau} \overline{r}_{eau}\overline{K}_{eau})]
\end{aligned}
$$

$$Txs_{vt} = \tau^{x}_{vt} Pg_{vt} Xst_{vt} \tag{63}$$

$$Txm_{im} = \tau^{m}_{im} Pwm_{im} e M_{im} \tag{64}$$

$$Sh = mpsYdh \tag{65}$$

$$\begin{aligned} Sf = {} & Yf - Tfw - \tau^{k}[\lambda^{tf} \sum_{ag} rt_{ag} Ter_{ag} \\ & + \lambda^{kf}(\sum_{ag} raK_{ag} + \sum_{in} rdK_{in} + \sum_{eau} \overline{r}_{eau} \overline{K}_{eau})] \end{aligned} \tag{66}$$

$$Sg = Yg - P^{index} Tgf - eTgw - P^{index} Tgm - Cg - \sum_{h2o} Sve_{h2o} \tag{67}$$

$$\begin{aligned} Sve_{h2o} = {} & P_{eau} Xs_{eau} - Pwh_{h2o} C_{h2o} - \sum_{ag} Pwa_{h2o} O_{h2o} \\ & - Pwi_{h2o} Ciei_{h2o} \end{aligned} \tag{68}$$

Demand

$$Ch = Ydh - Sh \tag{69}$$

$$C_{ae} = \theta^{c}_{ae} + \frac{\beta^{c}_{ae}(Ch - \sum_{l} Pq_{l} \theta^{c}_{l}) + \beta^{g}_{ae} Cg}{Pq_{ae}} \tag{70}$$

$$C_{h2o} = \theta^{c}_{h2o} + \frac{\beta^{c}_{h2o}(Ch - \sum_{l} Pq_{l} \theta^{c}_{l}) + \beta^{g}{}_{h2o} Cg}{Pwh_{h2o}} \tag{71}$$

$$Intd_{ai} = \sum_{ri} Icj_{ai,ri} \tag{72}$$

$$Intd_{h2o} = \sum_{gi} Icj_{h2o,gi} + \sum_{ag} O_{ag} \tag{73}$$

$$Intd_{fer} = \sum_{gi} Icj_{fer,gi} + \sum_{ag} Fer_{ag} \tag{74}$$

$$Inv_{mar} = \frac{\beta^{i}_{mar} It}{Pq_{mar}} \tag{75}$$

Price

$$Pva_{gi} = \frac{P_{gi} Xs_{gi} - \sum_{vt} Pq_{vt} Icj_{vt,gi} - Pi_{h2o} Icj_{h2o,gi}}{Va_{gi}} \tag{76}$$

$$Pm_{im} = Pwm_{im}(1 + \tau^{m}_{im})e \tag{77}$$

$$Pe_{mar} = \frac{Pwe_{mar} e}{(1 + \tau^{e}_{mar})} \tag{78}$$

$$Pq_{im} = \frac{Pd_{im} D_{im} + Pm_{im} M_{im}}{Q_{im}} \tag{79}$$

$$Pq_{nim} = \frac{Pd_{nim} D_{nim}}{Q_{nim}} \tag{80}$$

$$Pg_{mar} = \frac{Pd_{mar} D_{mar} + Pe_{mar}(1 + \tau^{e}_{mar}) Ex_{mar}}{Xst_{mar}(1 + \tau^{x}_{mar})} \tag{81}$$

$$Pg_{svnm} = \frac{Pd_{svnm} D_{svnm}}{Xst_{svnm}(1 + \tau^{x}_{svnm})} \tag{82}$$

$$Pkl_{eau} = \frac{rdK_{eau} + wLd_{eau}}{Kl_{eau}} \tag{83}$$

$$Pw_{eau} = \frac{Pkl_{eau} Kl_{eau}}{Wat_{eau}} \tag{84}$$

$$\bar{r}_{eau} = \frac{Peb_{eau} Eb_{eau}}{\overline{K}_{eau}} \tag{85}$$

$$P_{eau} = \frac{\bar{r}_{eau} \overline{K}_{eau} + Pw_{eau} Wat_{eau}}{Xs_{eau}} \tag{86}$$

$$Pkc_{ag} = \frac{Pxi_{ag} Ip_{ag} - Pce_{ag} Cie_{ag}}{Kc_{ag}} \tag{87}$$

$$rt_{ag} = \frac{Pkc_{ag} Kc_{ag} - raK_{ag}}{Ter_{ag}} \tag{88}$$

$$Pce_{ag} = \frac{Pq_{fer} Fet_{as} + Pwater_{ag} water_{ag}}{Cie_{ag}} \tag{89}$$

$$Pwater_{ag} = \frac{Pa_{h2o} O_{ag} + \rho_{eau} Prain_{eau} rain_{eau}}{water_{ag}} \tag{90}$$

$$Pxi_{ag} = \frac{Prx_{ag} Rx_{ag} - wLd_{ag}}{Ip_{ag}} \tag{91}$$

$$Prx_{ag} = \frac{P_{ag} Xs_{ag} - \sum_{ai} Pq_{ai} Icj_{ai,ag}}{Rx_{ag}} \tag{92}$$

$$P_{yi_{nord}} = \left(\frac{Xs_{sud}}{Xs_{nord}}\right)^{\frac{1}{\sigma^c_{yl}}} \left(\frac{1 - \delta^c_{yl}}{\delta^c_{yl}}\right) P_{yi_{sud}} \tag{93}$$

$$P_{yi_{sud}} = \frac{Pg_{yl} Xst_{yl} - P_{yi_{nord}} Xs_{nord}}{Xs_{sud}} \tag{94}$$

$$P_{xl} = Pg_{xl} \tag{95}$$

$$P^{index} = \sum_i \beta^x_i Pq_i \tag{96}$$

$$Pagr_{ind} = \sum_{agr} \frac{Pq_{agr} * Icj_{agr,indu}}{Ciai_{ind}} \tag{97}$$

$$Pciae_{indn} = \frac{Pagr_{indn} Ciai_{indn} + Pwi_{en}\ Ciei_{indn})}{Ciae_{indn}} \tag{98}$$

$$Pciae_{inds} = \frac{Pagr_{inds} Ciai_{inds} + Pwi_{es}\ Ciei_{inds}}{Ciae_{indn}} \tag{99}$$

$$\tag{100}$$

Foreign Trade

$$Xst_{mar} = B^T_{mar} \left[\delta^T_{mar} Ex_{mar}^{\gamma^T_{mar}} + (1 - \delta^T_{mar}) D_{mar}^{\gamma^T_{mar}}\right]^{\frac{1}{\gamma^T_{mar}}} \tag{101}$$

$$Xst_{svnm} = Q_{svnm} \tag{102}$$

$$Ex_{mar} = \left(\frac{Pe_{mar}}{Pd_{mar}}\right)^{\sigma^T_{mar}} \left(\frac{1 - \delta^T_{mar}}{\delta^T_{mar}}\right)^{\sigma^T_{mar}} D_{mar} \tag{103}$$

$$Q_{im} = B^S_{im} \left[\delta^S_{im} M_{im}^{-\gamma^S_{im}} + (1 - \delta^S_{im}) D_{im}^{-\gamma^S_{im}}\right]^{-\frac{1}{\gamma^S_{im}}} \tag{104}$$

$$Q_{nim} = D_{nim} \tag{105}$$

$$M_{im} = \left(\frac{\delta^S_{im}}{(1-\delta^S_{im})}\right)^{\sigma^S_{im}} \left(\frac{Pd_{im}}{Pm_{im}}\right)^{\sigma^S_{im}} D_{im} \tag{106}$$

$$\begin{aligned} Cab = {} & \sum_{im} Pwm_{im} M_{im} + \frac{1}{e} Tfw + \frac{1}{e} Tgw \\ & + \frac{1}{e} \lambda^{kw} \left(\sum_{ag} raK_{ag} + \sum_{in} rdK_{in} + \sum_{eau} \overline{r}_{eau} \overline{K}_{eau} \right) \\ & - Twm - Twg - \sum_{mar} Pwe_{mar} (1 + \tau^e_{mar}) Ex_{mar} \end{aligned} \tag{107}$$

Equilibrium

$$Ls = \sum_i Ld_i \tag{108}$$

$$Kta = \sum_{ag} K_{ag} \tag{109}$$

$$Ktd = \sum_{in} K_{in} \tag{110}$$

$$It = Sf + Sh + Sg + eCab \tag{111}$$

$$Q_{vt} = C_{vt} + Intd_{vt} + Inv_{vt} \tag{112}$$

$$Xst_{h2o} = C_{h2o} + Intd_{h2o} \tag{113}$$

2 Sets for branches and commodities

l		vt	mar	ai	h2o	im	nim	xl	yl	ac
augr	Other culture	x	x	x		x			x	x
grai	Grain	x	x	x		x			x	x
mara	Food crops	x	x	x					x	x
agru	Citrus	x	x	x			x	x		x
ind	Industry	x	x			x			x	x
fer	Fertilizer	x	x			x		x		x
eaun	Water north	x	x		x			x		
eaus	Water south	x			x			x		
svm	Service					x		x		x
svnm	Public services						x	x		x

i		ag	in	ri	eau	gi	xi	yi	id	sud	nord
augrs	Other culture south	x		x				x		x	
grais	Grain south	x		x				x		x	
maras	Food crops south	x		x				x		x	
augrn	Other culture north	x		x				x			x
grain	Grain north	x		x				x			x
maran	Food crops north	x		x				x			x
agrun	Citrus north	x		x			x				x
inds	Industry south		x	x		x		x	x	x	
indn	Industry north		x	x		x		x	x		x
fern	Fertilizer north		x	x		x	x		x		x
es	Water south		x		x		x			x	
en	Water nord		x		x		x				x
serm	Services		x	x		x	x				
sernm	Public services		x	x		x	x				

3 Variables and parameters

Endogenous Variables

Prix

w	wage	ra	agricultural capital input price
rd	industrial capital input price	rt_{ag}	land price
Pkc_{ag}	composite price of Kc_{ag}	Pxi_{ag}	composite price of Ip_{ag}
$Prxag$	composite price of Rx_{ag}	Pce_{ag}	composite price of Cie_{ag}
Pva_{gi}	value added price	P_i	production price of branch i
Pg_l	composite price of Xst_l	Pq_l	composite price of Q_l
Pm_{im}	import price	Pe_{mar}	export price
Pd_l	domestic price	p^{index}	consumption price index
$Pwater_{ag}$	agricultural water price (produced and rain)	Pkl_{eau}	composite price of Kl_{eau}
$Pagr_{ind}$	composite price of $Ciai_{ind}$	$Pciae_{ind}$	composite price of $Ciae_{ind}$
Pw_{eau}	production price of Wat_{eau} (production *type* II)	$\overline{r}_{eau}$	price of capital used in the production of water of *type* I
Pyi_{nord}	production price nortern good	Pyi_{sud}	producer price southern good

Ramsey Prices and elasticities

Ela_{ag}	water demand elasticity agricultural	$Elin$	water demand elasticity industry north
$Elfn$	water demand elasticity fertilizer	$Elis$	water demand elasticity industry south
$Elmn$	water demand elasticity household north	$Elms$	water demand elasticity household south
Pwa_{an}	agricultural Ramsey price north	Pwa_{as}	agriculture Ramsey price south
Pwh_{en}	household Ramsey price north	Pwh_{es}	household Ramsey price south
Pwi_{en}	industrial Ramsey price north	Pwi_{es}	industrial Ramsey price south
Pwf_{en}	fertilizer Ramsey price north	ξ	Ramsey weighted number

Production et inputs

Va_{gi}	value added	Xs_i	production
Wat_{eau}	water production of *type* II	Eb_{eau}	water production of *type* I
Xst_l	total production of l	K_i	demand for capital
Ld_i	demand for labor	Kc_{ag}	composite input of K_{ag} and Ter_{ag}
Ip_{ag}	composite input of Kc_{ag} and Cie_{ag}	Rx_{ag}	composite input of Ip_{ag} and Ld_{ag}
Cie_{ag}	composite input of $water_{ag}$ and Fer_{ag}	Cia_{ag}	other intermediate consumption of agriculture
O_{ag}	intermediate consumption of water by agricutural branch	Fer_{ag}	intermediate consumption of fertilizer by agricultural branch
$water_{ag}$	total water consumption by agricultural branches (produced water and rain)	Kl_{eau}	composite input of K_{eau} and Ld_{eau}
		Ψ_{eau}	asymptote of the Weibull
$Icj_{l,j}$	sectorial intermediate consumption	Cit_i	total intermediate consumption
$Ciii_{indu}$	industry industry intermediate consumption	$Ciei_{indn}$	water industry (north) intermediate consumption
$Cife_{fern}$	water fertilizer intermediate consumption	$Ciei_{inds}$	water industry (south) intermediate consumption
$Ciii_{fern}$	industry fertilizer intermediate consumption	$Ciai_{indu}$	agri. industry (south) intermediate consumption
$Ciae_{ind}$	composite intermediate consumption	Cic_{ind}	composite intermediate consumption industry
$Cife_{fer}$	composite intermediate consumption fertilizer	Cic_{fer}	composite intermediate consumption fertilizer
$Cisr_{infc}$	*Leontief* intermediate consumption		

Endogenous Variables (continued)

Water production cost

ct_{eau}	total cost of water production eau	mc_{eau}	marginal cost of water production eau

Demand

$Intd_{mar}$	intermediate demand	Inv_{mar}	investment
Ch	household consumption	It	total investment
C_l	consumption of l		

Income and savings

Yh	household income		
Ydh	household disposable income	Yf	firm income
Yg	government incomet	Sh	household saving
Sf	firm saving	Sg	government saving
Txs_{vt}	production taxes	Txm_{im}	import taxes
Sve_{h2o}	grants to water production		

Foreign

Ex_{mar}	export	D_l	domestic good
Q_l	composite good $Armington$	M_{im}	import

Exogenous variables

$\overline{K}_{eau}$	capital used in production of water of $type\ I$	Ls	labor supply
		$rain_{eau}$	rain variation
Kta	agricultural capital supply	Ktd	industrial capital supply
Ter_{ag}	land	Cg	government consumption
Tgf	government transfer to firm	Tgm	government transfer to household
Tgw	government transfer to rowe	Twg	row transfer to government
Twm	row transfer to household	Tfw	firm transfer to row
Pwm_{im}	import world pricee	Pwe_{mar}	export world price
e	exchange rate	Pwh_{h2o}	household water tarrif
Pa_{h2o}	agricultural water tarrif	Pi_{h2o}	industrial water tarrif
Cab	current account balance	Peb_{eau}	production price of $Eb_{eau}(type\ I)$
$Prain_{eau}$	rain price		

Parameters

Production parameter

lio_{eau}	technical coefficient technique of *Leontief* between K_{eau} and Ld_{eau}	tio_{eau}	technical coefficient *Leontief* between K_{eau} and Ld_{eau}
ϕ_{eau}	*Weibull* parameter	ζ_{eau}	*Weibull* parameter
μ_{eau}	$Cobb - Douglas$ parameter for water production Eb_{eau}	χ_{eau}	scale coefficient for water production Eb_{eau}(type I)
ϖ_{eau}	l *Weibull* asymptote parameter	B_{ag}	CES scale parameter CIE_{ag}
δ_{ag}	distributive share of CES Cie_{ag}	γ_{ag}	CES substitution parameter Cie_{ag}
σ_{ag}	CES elasticity ofsubstitution Cie_{ag}	B^{k}_{ag}	CES scale parameter Kc_{ag}
δ^{ac}_{ind}	CES distributive share $Ciae_{ind}$	γ^{ac}_{ind}	CES substitution parameter $Ciae_{ind}$
σ^{ae}_{ind}	CES elasticity of substitution $Ciae_{ind}$	B^{ae}_{ind}	CES scale parameter $Ciae_{ind}$
δ^{iac}_{ind}	CES distributive share Cic_{ind}	γ^{iac}_{ind}	CES substitution parameter Cic_{ind}
σ^{iac}_{ind}	CES elasticity of substitution Cic_{ind}	B^{iac}_{ind}	CES scale parameter Cic_{ind}
δ^{ic}_{fern}	CES distributive share Cic_{fern}	γ^{ic}_{fern}	CES substitution parameter Cic_{fern}
σ^{ic}_{fern}	CES elasticity of substitution Cic_{fern}	B^{ic}_{fern}	CES scale parameter Cic_{fern}
δ^{k}_{ag}	CES distributive share Kc_{ag}	γ^{k}_{ag}	CES substitution parameter Kc_{ag}
σ^{k}_{ag}	CES elasticity of substitution Kc_{ag}	B^{i}_{ag}	CES scale parameter Ip_{ag}
δ^{i}_{ag}	CES distributive share Ip_{ag}	γ^{i}_{ag}	CES substitution parameter Ip_{ag}
σ^{i}_{ag}	CES elasticity of substitution Ip_{ag}	B^{r}_{ag}	CES scale parameter Rx_{ag}
δ^{r}_{ag}	CES distributive share Rx_{ag}	γ^{r}_{ag}	CES substitution parameter Rx_{ag}
σ^{r}_{ag}	CES elasticity of substitution Rx_{ag}	$aij_{l,gi}$	input-output coefficient
$fij_{ai,ag}$	input-output coefficient of agricultural branches	$ha1_{ag}$	*Leontief* technical coefficient between Rx_{ag} and Cia_{ag}
$ha2_{ag}$	*Leontief* technical coefficient	α_{gi}	$Cobb - Douglas$ parameter
$ci1_{in,fe}$	*Leontief* technical coefficient between Rx_{ag} and Cia_{ag}	$ci2_{in,fe}$	*Leontief* technical coefficient
A_{gi}	$Cobb - Douglas$ scale parameter	v_{gi}	*Leontief* technical coefficient *Leontief* between Cit_{gi} and Va_{gi}
io_{gi}	*Leontief* technical coefficient between Cit_{gi} and Va_{gi}	B^{c}_{yl}	CES scale parameter Xst_{l}
		σ^{c}_{yl}	CES elasticity of substitution Xst_{l}
δ^{c}_{yl}	CES distributive share Xst_{l}	γ^{c}_{yl}	CES substitution parameter Xst_{l}
β^{x}_{i}	weight parameter for price index	$aca_{agr,indu}$	*Leontief* between $Ciai_{indu}$ and $Icj_{agr,indu}$

Income parameter

λ^{km}	household share of capital income	λ^{tm}	household share of land
λ^{kf}	firm share of capital income	λ^{tf}	firm share land income
λ^{kw}	row share of capital income		
τ^{yh}	income tax rate	τ^{k}	firm tax rate
τ^{m}_{im}	import tarrif	τ^{c}_{mar}	export tax rate
τ^{x}_{vt}	production tax rate	mps	household marginal propensity to save

Consumption parameter

θ^{c}_{l}	minimum consumption of the utility $LES - CD$	β^{c}_{l}	share of good l in total household consumption
β^{g}_{l}	share of good l in government consumption	β^{i}_{l}	share of good l in total investment

Foreign trade parameter

B^{T}_{ag}	CET scale parameter foreign trade	δ^{T}_{ag}	CET distributive parameter foreign trade
γ^{T}_{ag}	CET substitution parameter foreign trade	σ^{T}_{ag}	CET elasticity of transformation foreign trade
B^{S}_{ag}	CES scale parameter *Armington*	δ^{S}_{ag}	CES distributive share *Armington*
γ^{S}_{ag}	CES substitution parameter *Armington*	σ^{S}_{ag}	CES elasticity of substitution *Armington*

Rain parameter

ϱ_{eau}	adjustment coefficient of rain variation for water production Wat_{eau}(type II)	η_{eau}	adjustment coefficient of rain variation for water production Eb_{eau} *(type I)*
ρ_{eau}	adjustment coefficient of rain variation forr agricultural production		

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