An Applied General Equilibrium Model to Assess the Impact of National Tax Changes on a Regional Economy

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The authors wish to thank the support of network grant XT2000-33 and the research project SEC2000-0390. The first author thanks the research project IEA-00. The second author is also grateful to research project SGR2001-164.

This paper was finished while the first author was visiting the Regional Economics Application Laboratory (REAL), University of Illinois at Urbana-Champaign. This author wishes to thank Prof. G.J.D. Hewings, Director of REAL, and the components of the REAL Seminar by their suggestions. The usual disclaimer applies.

ABSTRACT

This paper presents two versions of an applied general equilibrium model for the regional economy of Andalusia, Spain, that differ in the Public Sector behavior. We intend to exemplify the use of a model with these characteristics to analyze the impact that the reform of the personal income tax (Act 40/98) implemented in Spain as a whole would have had on the Andalusian region in particular. Such an important tax reform is bound to affect the behavior of the agents in this economy, both in the microeconomic and the derived macroeconomic spheres. The general character of the tax reform under analysis and the relations among the different economic agents advise us to use models with these characteristics to study the effects of this reform. The models is of the neoclassical variety and include not only the productive sectors of the economy but also the foreign sector and the government, which are usually absent from theoretical general equilibrium models. Both versions of the model are calibrated by using a Social Accounting Matrix of Andalusia for 1995.

Keywords: applied general equilibrium models, social accounting matrix, fiscal policy, economic influence, regional economy.

JEL: C670, D570, R150

1. Introduction.

The reform of direct taxation in Spain, exemplified by the personal income tax, implemented in the 1999 fiscal year was bound to affect the patterns of behavior of economic agents, particularly of consumers, since it modified their choice sets. Since this reform did not affect the tax rates of all consumers uniformly, its effects should be studied in a context that allows us to capture the adjustments all consumers undertake under their new budget situation as well as the overall effects on the economy induced by the adjustment mechanisms which make an economic equilibrium possible.

Several studies based on micro-simulations have been carried out in Spain to assess and quantify the effects of fiscal reforms at a regional level, for instance Lasheras et al. (1994), Castañer et al. (1998), and De las Heras et al. (2001). These studies, however, mainly dealt with welfare indicators and/or income inequality indices, thus ignoring the overall economic impact that a fiscal reform, or any other alteration of the tax legislation, will have on the major macromagnitudes of the regional economy under analysis.

This limitation, however, can be overcome by using one of the most suitable tools for the study of the effects of a wide-range fiscal reform, namely, applied general equilibrium models. In the last twenty-five years, these models have been profusely used to analyze government economic policies, both in developed and developing countries (Shoven & Whalley (1992)). An analysis based on applied general equilibrium models permits to capture the changes in the spheres of production and consumption, as well as in income distribution, in response to changes in a given

economic policy, since these models explicitly include the framework of interdependence of all markets in an economy.

Our aim here is to evaluate the possible effects of the tax reform in a subset of the Spanish economy, namely, the Andalusian region. In order to achieve this objective, we present an empirical model of the regional economy developed in accordance with the methodology of applied general equilibrium analysis. The model is then numerically implemented by using a SAM database of the region for the year 1995 (SAMAND95, Cardenete (2000)).

This paper is organized as follows. In the next section, we present the main characteristics of our model and its two versions. Then we proceed to comment on the basic features of the simulations that are carried out and to include the tables summarizing the main results obtained. Finally, we draw the main conclusions and at the same time we set forth the limitations of the analysis, as well as the research lines that we feel should be explored for its improvement. We also add an appendix with a summary description of some of the main equations of the model.

2. The model.

Any applied general equilibrium model should at least three basic elements. The first one is the formulation of a theoretical model of the economy; the second one is the numerical specification of the functional parameters that are embedded in the model; the third one is the use of an algorithm that computes the alternative equilibrium states in different policy scenarios.

2.1. Model characteristics.

The nature of the economic situation that is to be studied should suggest the key elements that have to be used in the design of the model. A general requirement is that the model should capture the basics of the economic reality under discussion while at the same time not being so structurally detailed as to make the analysis impossible or very difficult. A specific requirement is that, since we intend to assess the reform of the direct tax system, the model should be detailed in regard to households, with a minimum disaggregation of consumers according to, for example, their income levels.

Basically, our model includes a disaggregation of 25 production sectors and 4 representative consumers. The government is also an economic agent whose functions are to levy taxes on transactions among the rest of agents, to supply public goods, to transfer income to the private sector, and to demand goods and services from the private sector. The foreign sector is a simplified agent that includes three trading partners (Rest of Spain, European Union and Rest of the World). Finally, although the model is static, it includes a savings and investment sector. This enables us to account for an activity (savings from the point of view of agents as consumers and other agents, and investment from the point of view of final demand) that cannot be separated from the flows of income the model attempts to capture.

It is also worth noticing that in the model relative prices, activity levels of the production sectors and foreign deficits are endogenous variables. The deficit of the public sector is modeled under a double behavior: first, we take the public deficit to be endogenous whereas the public sector activity level (purchases of goods and services and transfers) are endogenous (scenario I). Alternatively, the second option considers

the public deficit as exogenous with activity levels being endogenous (scenario II). These two versions of the macroeconomic closure rule resume two of the most important ways of representing the public sector behavior. Either we fix the public sector activity level and let the public deficit adjust, or else we keep the public deficit at the given base level and let purchases and transfers adjust to match government tax income.

The equilibrium of the economy will determine the values taken up by these variables. In the next section, we will specify how the agents take their decisions and we will explain the concept of equilibrium in further detail.

2.2 Producers.

The production sphere of the economy is represented by 25 production sectors, whose objective is to maximize after-tax profits, subject to specific technological constraints. Each productive sector produces a homogeneous good using a constant-returns-to-scale technology. This means that there will be no excess profits. Under these conditions, the key elements for a description of the behavior of production sectors are conditional input demand functions.

The inputs to the production function are two: domestic production Xd_j, and imports $Xrow_j$, using a production technology with factor substitution of the Cobb-Douglas variety. Domestic output is obtained as a combination in fixed proportions (Leontief technology) of intermediate inputs and a composite primary factor, *value added* (VA_j). Value-added is produced by combining the primary factors, labor and capital, using a Cobb-Douglas technology.

2.3 Consumers.

The model includes four different types of consumers that are classified according to their source of income. Each consumer's income $h=1,..4$ is the result of the sale of the endowments of productive factors, namely, labor L_h and capital K_h, from which they receive a salary w and a capital remuneration r. Every consumer also receives transfers from the public sector TPS_h (pensions, social benefits, unemployment benefits, etc..) and transfers from the rest of the world $TROW_h$. All this gross income is reduced by the social contributions directly paid by workers WC_h and by the effective direct taxation on income DT_h. Thus, disposable income for each consumer can be written as follows:

$$YDISP_h = Gross\ Income - Total\ Direct\ Taxes$$

$$YDISP_h = w L_h + r K_h + cpi\ TPS_h + TROW_h - DT_h (r K_h + cpi\ TPS_h + TROW_h) - DT_h (w L_h - WC_h\ w L_h) - WC_h\ w L_h \quad (1)$$

where cpi is a consumer price index which updates transfers in the public sector according to the changes in prices in general. Notice that in defining disposable income, we need to distinguish between taxable and non-taxable earned income, since social contributions by consumers are exempted, under the current fiscal legislation, from the personal income tax.

Consumers' preferences are described by a Cobb-Douglas utility function, defined for consumption goods CD_{jh} and savings SD_h. Consumers maximize the utility of both goods subject to disposable income $YDISP_h$, which determines their budget constraint. Thus,

$$\text{maximize} \qquad U_h(CD_{jh}, SD_h) \;?\; (\overset{25}{\underset{j?1}{?}} CD_{jh}^{?_{jh}})SD_h^{?_h}$$

$$\text{s.t.} \qquad p_j CD_{jh} \;?\; invp\, SD_h \;?\; YDISP_h \qquad (2)$$

where $?_{jh}$ y $?_h$ represent the share coefficients corresponding to consumption goods and savings, respectively.

2.4 The public sector.

The public sector demands goods and services, collects taxes, and supplies transfers to private agents. The assumptions on the public deficit, allow us to obtain two versions of the model. In the first version, the activity level of the government remains constant, although the value of the public expenditure may vary as a result of changes in prices, and the deficit, *PD*, is endogenously determined (scenario I). In the second one, the public deficit, *PD*, remains constant, and the activity level of the government is endogenously determined (scenario II). Thus,

$$PD \;?\; R \;?\; \overset{4}{\underset{h?1}{?}} TPS_h\, cpi \;?\; \overset{25}{\underset{j?1}{?}} GD_j\, p_j \qquad (3)$$

where tax revenues, *R*, are determined by all different taxes –direct and indirect ones– (see equations (A.5) to (A.10**)** in Appendix). Both government transfers TPS_h and public expenditure GD_j are exogenously (or endogenously) determined, so that the model is subject in both cases to macro closure rules.

2.5 The foreign sector.

Since our analysis is based on the Andalusian regional economy, the foreign sector is modeled in a simple, aggregated way, namely, as a single foreign sector that includes the three trade partners. The levels of activity of the foreign sector are fixed exogenously, whereas the trade deficit is endogenously determined. We have chosen this way of macroeconomic closing for the model to be consistent with the concepts of government and public deficit established in subsection 2.4 above.

Thus, the macroeconomic closure function for the foreign sector can be written as follows:

$$ROWD \; ? \sum_{j?1}^{25} rowp \, IMP_j \; ? \sum_{h?1}^{4} TROW_h \; ? \sum_{j?1}^{25} rowp \, EXP_j \qquad (4)$$

where $ROWD$ is the trade deficit, IMP_j and EXP_j are the demand for imports and exports, $TROW_h$ are the transfers from the rest of the world, and $rowp$ is the aggregated price index of the rest of the world.

2.6 Savings and investment.

Investment is a good produced with a fixed-coefficients technology, whose inputs are the sales of the productive sectors to the investment sector. The output level of the investment sector is determined by total savings in the economy so as to satisfy the macroeconomic rule that total investment equals total savings:

$$\sum_{j?1}^{25} INV_j \, pinv \; ? \sum_{h?1}^{4} SAV_h \, pinv \; ? \; PD \; ? \; ROWD \qquad (5)$$

where INV_j is the investment level of sector j, SAV_h is the saving level of the consumer h, and $pinv$ is an aggregated investment index price.

2.7 Equilibrium.

The two versions of the model (floating deficit + fix expenditure, and fix deficit + floating expenditure) follow the standard Walrasian concept of equilibrium. In equilibrium, supply must be equal to demand in all non-labor markets. In addition, the levels of activity of the foreign sector are fixed.

About labor and capital demands, we consider that firms minimize the production cost of a value-added composite. In the capital market we consider that supply is perfectly inelastic. On other hand, in the labor market, we suppose that the supply is perfectly elastic but real wages are sensitive to the unemployment rate. We consider that the real wage must satisfy the following condition:

$$w/cpi = \left((1-u)/(1-\bar{u})\right)^{-\alpha} \qquad (6)$$

where u and $\bar{u}$ are the unemployment rates in the simulation and in the benchmark equilibrium, respectively, and α is a constant that represents the grade of flexibility of the real wage. In our case it is set equal to 1.

Following the Walrasian tradition, an equilibrium is a price vector, an allocation, and a level of tax revenues such that consumers maximize utility, producers maximize after-tax profits, government tax revenues are equal to the amount of taxes paid by all

economic agents, all non-labor markets clear, the public deficit is endogenous (or exogenous), and so is the foreign deficit given fix export levels.

3. Database and calibration.

The numerical specification of the parameters in the model has been carried out by using the data in a Social Accounting Matrix for Andalusia (*SAMAND95*). Calibration consists, as is well known, in determining a set of coefficients and parameters which, under the conditions derived from the optimization problems of agents, allows the model to replicate the database as a benchmark equilibrium of the regional economy. We obtain the following set of parameters after calibration: a) the technical coefficients of production sectors, both domestic and foreign; b) the technical coefficients for primary factors that produce the unitary value-added; c) the share coefficients of the utility functions for consumers; and d) the tax parameters which allow us to define the effective tax rates for all taxes, both direct and indirect.

The units used to express the economic variables in equilibrium have been chosen, for the sake of convenience, in such a way that all prices and levels of activity are unitary in the benchmark equilibrium.

Finally, regarding the database, we have expanded *SAMAND95* as regards *Consumers*, disaggregating these in four different types. This disaggregation has been done according to Uriel et al. (1994) Social Accounting Matrix for Spain in 1990. A disaggregation based on a more recent *SAM* would have been more suitable, but Uriel et al. is the only one available at the moment. Thus, the four consumers in *SAMAND95*

are: *Rural Consumers* (*RC*), *Urban Salaried Consumers* (*USalC*), *Urban Self-Employed Consumers* (*USelfC*), and *Rest of Urban Consumers* (*RoUC*).

4. Simulations.

The simulations we have carried out with the applied general equilibrium models for the Andalusian economy analyze the reform of the personal income tax in 1999 (Act 40/98). More specifically, what we attempt to capture are the effects this reform would have had on the Andalusian economy should it had been implemented in the year 1995, which is the date of the more recent database available. We analyze the effects on prices, levels of investment, levels of activity, and other macroeconomic aggregates, as well as the compensating and equivalent variations of the different types of consumers, intending to capture their effect on consumers' welfare.

Since direct tax rates obtained from the calibration of *SAMAND95* are not nominal but effective, we could not simulate the reform by using the new marginal rates introduced by the reformed personal income tax. Additionally, consumers were not disaggregated by income level or average tax base but by income type or source. For these reasons, we have followed Castañer et al. (1998) and adopted their estimation of the reduction for the Andalusian region, measured in variation rate on average effective rates. According to their estimation, this reduction amounts to 17.21 percent for Andalusia.

The results obtained by perturbing the equilibrium with the reduction of the effective direct tax for each type of consumer are shown in the comparative tables below (before and after the reform). As we stated above, we present two applied

equilibrium models, one with the public deficit as an endogenous variable and the other with the public deficit as exogenous.

(Table 1)

In Table 1, we compare the composition of the GDP, from the point of view of income and expenditure, in both types of model. If we analyze the GDP from the point of view of expenditure, it can be seen that GDP is increased in magnitude in nominal terms, and all items increase except "Investment" that falls, when the public deficit is endogenous (scenario I). In the second version of the model (scenario II), in contrast, half of the items increase, "Consumption" and "Investment" whereas the other half fall, "Government Expenditure" and "Foreign Sector".

Regarding the distribution of percentages relative to total GDP, notice that the tendency is the same, namely, participation in "Consumption" rises. It is worth remarking that "Investment" increases considerably its percentage in scenario II, something that could be expected given that "Government Expenditure" falls and *PD* is fixed.

If we analyze the GDP from the point of view of income, in nominal terms, we observe an antagonistic behavior in all of the items. In scenario I, we observe a generalized decrease in the following magnitudes: "Labor", "Employer's Contribution to Social Security", "Tariffs" and "VAT". On other hand, "Capital" and "Net Production Taxes" increase in scenario II, "Labor" and "Capital" remain constant and

the rest of items move in the opposite direction of scenario I. The percentage distribution of GDP between its composing items remains constant.

Since the simulation is of a fiscal type, it is worth analyzing the changes in the revenues from the different taxes, before and after the reform, shown in Table 2. We observe that total tax revenue decreases in net terms. The decrease revenue is more noticeable when PD is endogenous, since the tax burden is lower than in the other version of the model (0.238% for scenario I, and 0.241% for scenario II). It is again worth remarking the different behavior of items "Taxes on Production" and "VAT".

(Table 2)

Regarding the influence of the reform on activity levels, these increase in general an in both versions, particularly in the sectors "Water", "Textile and Leather", "Commerce", and "Other Services", which increase by about 1 percent. The increase in the sector "Other Services", which includes, among others, the services related to financial mediation, insurance, pension schemes, etc., perhaps provides evidence that part of the increase in disposable income is transferred to different financial products.

On the other hand, the sectors whose activity is reduced to a greater extent are, surprisingly, "Building Materials" and "Construction" (which fall by 3 percent), although these sectors typically reflect economic prosperity in any economy. This is confirmed by the data regarding investment level, according to which value added decreases 4.5 percent.

With regard to consumers, we observe an increase in disposable income for the four types of consumers, due to the reduction in tax burden. In both models due to the reduction in the tax burden, produces an increase in consumers' disposable income, being the *Urban Salaried Consumer* the one who benefits most from the reduction in the direct income tax. The possibility of factor substitution will produce a transfer in the use of the "least profitable" factor, labor, to the "most profitable" factor, capital.

Additionally, in order to measure consumer welfare, we have calculated both the *equivalent variation* and the *compensating variation*. Notice that the price index, which takes the wage rate as the *numeraire*, increases by 2.1 percent in the model under scenario I and remains constant in scenario II, which could be expected due to the positive impact a reduction in direct fiscal burden are bound to have. Accordingly, all consumers, who experience an increase in their disposable income, and both *equivalent* and *compensating variation* too, improve thanks to the welfare measures, being the *Urban Salaried Consumer* the one who benefits the most. Both versions show comparable increases in disposable income for the four types of consumers, with a bit of more noticeable in scenario II.

(Table 3)

(Table 4)

A final observation is that the unemployment rate in the Andalusian economy, around 39 percent in 1995, remains practically constant after the tax reform, with a slight increase that pushes it close to 40 percent in scenario I, and a decrease in scenario

II down to 34 percent. One of the reasons for these undesirable results can be traced to some of the structural problems that plague the Andalusian labor market.

5. Conclusions.

We have developed an applied general equilibrium model of the Andalusian economy to analyze the impact of the 1999 enacted income tax reform, with two different versions. These models have enabled us to draw several conclusions on the basis of a number of variables and macro magnitudes: consumer prices, investment levels, activity levels, GDP (both from the point of view of expenditure and income), disposable income, and unemployment. Given these results, the model also allows us to evaluate the welfare effects on the different type of consumers by way of the compensating and equivalent variations. A model with these characteristics generates a great amount of information, which can be summarized as follows.

Firstly, consumer prices of the various goods or services, in relative terms and according to the *numeraire*, as well as the rest of the defined prices (capital, import goods and investment goods) seem to be sensitive to the reform under scenario I. In the other version of the model -scenario II- however, prices remain practically constant.

In both versions, sectorial activity levels show discrepancies with regard to their magnitude and direction. Production sectors of direct consumer goods (including financial sectors) are the most favored ones, whereas sectors related to physical investment ("Construction" and related sectors) are those affected the worst.

There is a reduction in the personal income tax revenue due to the reduction in effective tax rates. In net terms, there is a reduction in total revenue. Moreover there is a different behavior in increase or decrease terms, between both versions of the model.

It is remarkable that the investment level is reduced in scenario I, because of the increase in public deficit derived from the decrease in the tax burden. Thus, according to the closure formula we have used, there is a reduction in the tax burden so as to adjust to total savings. This provides support for the opinion of most macroeconomists, who think that an increase in public deficit has a discouraging effect on investment. On other hand, in scenario II, there is an increase of this account following the same explanation.

Disposable income, quantified by taking salary as *numeraire*, improves for all four types of consumers, due to the reduction in the tax burden. In any case, the improvements are not substantial, being the *Urban Salaried Consumer* the one who benefits most from the reform in both models.

Regarding GDP, notice that it increases in nominal terms due to the reduction in the direct tax burden, but at the same time some of its components increase and other decrease, both from the point of view of expenditure and income.

As a general conclusion, we must point out that the reform has an overall positive effect on the economy, as it is shown by the reported macroeconomic variables. However, the results of this simulation exercise must be cautiously interpreted, due to the great number of simplifications that have been necessary to develop it. In addition, statistical data sources possess great limitations with regard to updating. Despite these

facts, we are able to draw several important and relevant conclusions from the static analysis we have carried out. All applied economic models are always subject to this kind of constraints. In the future, it is our aim to improve the model on several respects, such as its technical structure. However, the most important task is to elaborate statistical sources that are better suited to the requirements of the model. This would include the disaggregation of consumers according to income levels, as well as updating the database *SAMAND95* with a new Input-Output Table designed by the regional statistics services, or else with non-survey techniques, such as *RAS* or cross entropy methods.

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7. Tables.

Table 1. GDP regarding expenditure and income (in millions of pesetas).

	Before Reform	After Reform (PD=endogenous)	After Reform (PD=exogenous)
Consumption	6276491	6371454	6363934
	69.59%	70.60%	70.36%
Investment	255465 4	2434257	3004547
	28.32%	26.97%	33.22%
Government Expenditure	2001000	2003007	1906067
	22.18%	22.19%	21.07%
Foreign Sector	-1811312	-1784717	-2230204
	-20.09%	-19.77%	-24.65%
GDP-expenditure	**9019023**	**9041094**	**9044344**
Labor	3190651	3185049	3190651
	35.37%	35.29%	35.27%
Capital	4534521	4548018	4534521
	50.27%	50.40%	50.13%
Employer's Contribution to	1119033	1116816	1130537
Social Security	12.40%	12.37%	12.49%
Tariffs	97693	97490	102742
	1.08%	1.08%	1.13%
Net Production Tax	-520351	-518191	-55507
	-5.74%	-5.74%	-6.13%
VAT	597476	594819	640966
	6.62%	6.60%	7.08%
GDP-income	**9019023**	**9041094**	**9044344**

Source: *SAMAND95.*

Table 2. Effects on direct and indirect tax revenues (in millions of pesetas).

	Revenue before Reform	Revenue after Reform (PD=endogenous)	Revenue after Reform (PD=exogenous)
Taxes on Production	-520351	-518191	-555074
Tariffs	97693	97699	102742
Employer's Contributions to Social Security	1190033	1116814	1130537
VAT	597476	594819	640966
Personal Income Tax	698747	579103	578492
Workers' Contributions to Social Security	281902	281407	281902
Total Taxes	2274500	2151442	2179565
Tax Burden	0.252%	0.238%	0.241%

Source: *SAMAND95*.

Table 3. Effects of the tax reform on consumers with PD=endogenous (in millions of pesetas).

	Disposable Income (before Reform)	Disposable Income (after Reform)	Equivalent Variation	Compensating Variation
Rural Consumer	2017082	2036659	16177	16204
Urban Salaried Cons.	4290128	4378901	81321	81460
Urban Self-Employed Cons.	1277426	1297974	18436	18466
Rest of Urban Cons.	1341502	1344473	712	713

Source: *SAMAND95*.

Table 4. Effects of the tax reform on consumers with PD=exogenous (in millions of pesetas).

	Disposable Income (before Reform)	Disposable Income (after Reform)	Equivalent Variation	Compensating Variation
Rural Consumer	2017082	2033677	16995	16995
Urban Salaried Cons.	4290128	4376097	85969	85969
Urban Self-Employed Cons.	1277426	1294442	17016	17016
Rest of Urban Cons.	1341502	1342175	673	673

Source: *SAMAND95*.

8. Appendix.

PRODUCERS

Total Production. Cobb-Douglas Technology:

$$Q_j \; ?? _j Xd_j^{?_j} Xrow_j^{(1??_j)} \qquad \text{(A.1)}$$

where

Q_j is the total output of sector j,

Xd_j denotes domestic production of sector j,

$Xrow_j$ denotes foreign production of sector j,

$?_j$ are the shift parameters of sector j,

$?_j$ are the share parameters of sector j.

Domestic Production. Leontief Technology:

$$Xd_j \; ? \; \min(X_{1j} / a_{1j}, X_{2j} / a_{2j}, ..., X_{25j} / a_{25j}, VA_j / v_j) \qquad \text{(A.2)}$$

where

X_{ij} is the quantity of good i necessary for the domestic production of good j,

a_{ij} are the technical coefficients that measure the minimum quantity of this factor necessary to produce one unit of good j,

VA_j denotes the value added by sector j,

v_j are the technical coefficient that represents the minimum quantity of value added necessary to produce one unit of good j.

Regarding value added, the combination of primary factors, labor and capital, adopts a Cobb-Douglas technology:

$$VA_j \; ? \; ? \; _j L_j^{?_j} K_j^{(1??_j)} \qquad \text{(A.3)}$$

where

$?_j$ are the scale parameters of sector j,

$?_j$ are the share coefficients of the Cobb-Douglas technology of sector j, respectively,

L_j denotes the labor factor of sector j,

K_j denotes the capital factor of sector j.

CONSUMERS

Cobb-Douglas Utility Function:

$$U_h(CD_{jh}, SD_h) \; ? \; (\overset{25}{\underset{j?1}{?}} CD_{jh}^{?_{jh}}) SD_h^{?_h} \qquad \text{(A.4)}$$

where

CD_{jh} is consumption of good j by consumer h,

SD_h. is saving by consumer h,

$?_{jh}$, $?_h$ represent the participation coefficients corresponding to consumption goods and savings, respectively.

PUBLIC SECTOR

Indirect Taxes:

Taxes on production, $R_{P,}$

$$R_P \; ? \sum_{j?1}^{25} ?_j (\sum_{i?1}^{n} a_{ij} p_i Xd_j \; ? ((1 ? EC_j) wl_j \; ? \; rk_j) VA_j) \qquad \text{(A.5)}$$

where

$?_j$ is the tax rate on production of sector j,

EC_j is the Social Security contribution by employers of sector j.

Social Security contribution by employers, R_{LF} ,

$$R_{LF} \; ? \sum_{j?1}^{25} EC_j wl_j VA_j \qquad \text{(A.6)}$$

Tariffs, $R_{T,}$

$$R_T \; ? \sum_{j?1}^{25} t_j rowp \; a_{rwj} \mathrm{Q}_j \qquad \text{(A.7)}$$

where

t_j, is the tax rate for all transactions with the foreign sector j,

$a_{rw\,j}$ denote the technical coefficients of import goods of sector j,

rowp represents a weighted price index which accounts for changes in the prices of imported products and services.

Value Added Taxes, $R_{VAT:}$

$$R_{VAT} ? \sum_{j?1}^{25} VAT_j (1 ? ?_j)(\sum_{i?1}^{n} a_{ij} p_i Xd_j ? ((1 ? EC_j) wl_j ? rk_j) VA_j) ? \sum_{j?1}^{25} VAT_j (1 ? t_j) rowp\, a_{rmj} Q_j \qquad \text{(A.8)}$$

where

VAT_j is the *ad valorem* tax on good j, which taxes both domestic and foreign production.

Direct Taxes:

Social Security contribution by employees, R_{LC},

$$R_{LC} ? \sum_{h?1}^{4} WC_h wL_h \qquad \text{(A.9)}$$

where

WC_h is the Social Security contribution by employees.

Direct Income Taxes, R_I,

$$R_I ? \sum_{h?1}^{4} DT_h (wL_h ? rK_h ? cpi\, TPS_h ? TROW_h ? WC_h L_h w) \qquad \text{(A.10)}$$

where

DT_h denotes the tax rate on income for consumer h,

TPS_h denotes transfers from Public Sector for consumer h (pensions, social benefits, unemployment benefits, …),

$TROW_h$, denotes transfers from the rest of the world for consumer h.