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AN APPLIED GENERAL EQUILIBRIUM MODEL TO ASSESS THE IMPACT OF NATIONAL TAX CHANGES ON A REGIONAL ECONOMY

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This paper presents two versions of an applied general equilibrium model for the regional economy of Andalusia, Spain, that differ in the closure rule adopted to describe the behavior of the public sector. We use the model with 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. The model is of the neoclassical variety and includes 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. The analysis shows that the reform is not self-financing, not even partially, despite governmental claims. It also indicates that there is a positive but smaller than anticipated economic stimulus. In welfare terms, we find that the category of Urban Salaried consumers is the one that benefits the most in real income terms.

1. Introduction

In 1999 the Spanish government enacted a wide-ranging reform of the personal income tax. This reform aimed at reducing marginal tax rates across the board for all families and was devised by the government as a global stimulus package for the economy. The political justification for the reform was, basically, the fulfilment of the electoral program of the right-of-center governing party. The stimulus, if successful, was thought that it would generate new employment hereby increasing payroll taxes and reducing unemployment benefits but was not expected to be fully self-financing. The effects of this tax reform 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 that 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 deal with welfare indicators and/or income inequality indices, thus ignoring the overall economic impact that this fiscal reform, or any other economy-wide alteration of the tax structure for that matter, will have on resource allocation and the derived major macro-magnitudes of the regional economy.

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 applied general equilibrium analysis 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 a representation of the framework of interdependencies among all markets in an economy.

On the empirical side, we should mention that applied general equilibrium models for the whole Spanish economy have been constructed by Kehoe et al. (1988, 1989) but ours is one the first models developed with a regional perspective in mind. Our aim therefore is to evaluate the possible effects of the tax reform in a subset of the Spanish economy, namely, the Andalusian region. This analysis is in principle feasible since Andalusia is one of the few regions in Spain for which a Social Accounting Matrix (SAM) has been constructed. In addition, under the current democratic constitution regions enjoy a high level of governing and legislative autonomy and recognition and can somehow be considered—for analytical purposes—as 'small countries' within the country. In order to achieve this objective, we present a 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 Social Accounting Matrix database of the region for the year 1995 (SAMAND95, Cardenete (2000)).

This paper is organized as follows. In section 2 we present the main characteristics of our model and its two versions while Section 3 summarizes the database and the calibration procedure. Then we proceed in Section 4 to comment on the basic features of the performed simulations and we present a few tables that describe some of the main results that are obtained. Finally, we draw the main conclusions and at the same time we discuss the limitations of the analysis, as well as the research lines that we feel should be explored for its improvement.

2. The model

Any applied general equilibrium model should at least have three basic elements. The first is the formulation of a theoretical model of the economy; the second is the numerical specification of the functional parameters embedded in the model; and the third 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, in our case, is that since we intend to assess the distributional impact of the reform of the direct tax system, desirably the model should include a minimum level of detail as far as consumers disaggregation is concerned.

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 income and 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' or 'Rest of the world' sector is a simplified agent that includes three trading partners (the Rest of Spain, the European Union and the All other countries). Finally, although the model is static, it includes a savings and investment sector the behavior of which follows a simple but commonly used rule in applied general equilibrium. 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 isolated from the flows of income the model attempts to capture.

In the model relative prices, activity levels of the production sectors, the unemployment rate and the foreign deficit are all 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) is kept at the initial level (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 all these variables. In the next sub-sections, we will describe more fully agents' characteristics and behavior and 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 the description of the behavior of production sectors are conditional input demand functions.

The inputs to the production function are of two types: domestic production Xd_j, and imports from the three trading partners that we denote by $Xrow_j$. These partially substitutable inputs yield total output using a production technology with Armington input 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 that we call *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 ($h=1,..,.4$) that are classified according to their income source. For each consumer, income 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 (these are retirement 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:

$$YDISP_h = \text{Gross Income} - \text{Total Direct Taxes}$$

$$\begin{aligned} YDISP_h = {} & w L_h + r K_h + cpi\, TPS_h + TROW_h - DT_h (r K_h + cpi\, TPS_h + TROW_h) \\ & - DT_h (w L_h - WC_h\, w L_h) - WC_h\, w L_h , \end{aligned} \qquad (1)$$

where cpi is a consumer price index that updates transfers in the public sector according to an average change in prices. 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 tax legislation, from the personal income tax.

Consumers' preferences are described by Cobb-Douglas utility functions defined on consumption goods CD_{jh} and a savings good (future consumption) SD_h. Consumers maximize the utility of both goods subject to disposable income $YDISP_h$, which, along with final commodity prices, determines their budget constraint. Thus,

$$\begin{aligned} &\text{maximize} && U_h(CD_{jh}, SD_h) = \left(\prod_{j=1}^{25} CD_{jh}^{\alpha_{jh}}\right) SD_h^{\beta_h} \\ &\text{s.t.} && p_j CD_{jh} + invp\, SD_h = YDISP_h , \end{aligned} \qquad (2)$$

where α_{jh} y β_h represent the share coefficients corresponding to consumption goods and savings, respectively, and p_j are present consumption prices and $invp$ is the price of the savings/investment good.

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 public deficit, PD, is endogenously determined (scenario I). In the second one, the deficit PD remains constant and so the activity level of the government is endogenously determined (scenario II).

Thus,

$$PD = R - \sum_{h=1}^{4} TPS_h cpi - \sum_{j=1}^{25} GD_j p_j , \tag{3}$$

where total tax revenues in turn, R, are determined by all different taxes – direct and indirect ones. The tax revenue function includes the following six tax categories:

$$R = R_P + R_{LF} + R_{LC} + R_T + R_{VAT} + R_I , \tag{4}$$

where R_P is total net indirect production taxes, R_{LF} is the part of the Social Security contributions paid by employers with R_{LC} being the part levied on working consumers, R_T represents tariffs, R_{VAT} is the consumption value-added tax, and R_I is personal income tax collections. For each tax category, its collections level depends on equilibrium prices and quantities and effective tax rates.

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 trading partners. The level of export activity of the foreign sector is fixed exogenously, whereas the trade deficit is endogenously determined given that imports are also endogenous. Thus, the macroeconomic closure rule for the foreign sector can be written as follows:

$$ROWD = \sum_{j=1}^{25} rowp\, IMP_j - \sum_{h=1}^{4} TROW_h - \sum_{j=1}^{25} rowp\, EXP_j , \tag{5}$$

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 an aggregate price index for the traded commodities.

2.6 Savings and investment

Following the activity analysis tradition, we model investment as an activity that is produced with a fixed-coefficients technology and whose inputs are the sales of the productive sectors to the investment sector. The output level of the investment activity is driven by total savings in the economy so as to satisfy the macroeconomic rule that total investment equals total savings from all sources (private, public and external to the region). Using previous notation we have:

$$\sum_{j=1}^{25} INV_j\, invp = \sum_{h=1}^{4} SAV_h\, invp + PD + ROWD , \tag{6}$$

where INV_j is the investment level of sector j, and SAV_h is the savings level of consumer h. In static models the inclusion of an investment sector needs to be seen simply as a modeling closure device that guarantees that in counterfactual equilibrium all flows are accounted for and balanced. Without this condition, in fact, we could not recreate a balanced SAM depicting a new simulated equilibrium.

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.

About labor and capital demands, we consider that firms minimize the production cost of the 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 up to the level of total labor endowment where it becomes inelastic. There is also a feedback between the real wage rate and the unemployment rate. This feedback somehow represents rigidities in the labor market that are related to unions' power or other friction inducing factors (see Oswald (1982)). The simple specification that we adopt picks up in a stylized way some of the labor market rigidities that have been affecting the regional economy. We consider that the real wage satisfies the following feedback condition:

$$w/cpi = \left[(1-u)/(1-\overline{u})\right]^{1/\phi}, \tag{7}$$

where u and $\overline{u}$ are the unemployment rates in the simulation and in the benchmark equilibrium, respectively, and ϕ is an elasticity constant that represents the degree of flexibility of the real wage. In our case it is set equal to 1.

An equilibrium is a price vector, an output vector, an unemployment rate, and a level of tax revenues such that prices follow the unit cost rule, consumers maximize utility, producers maximize after-tax profits, government tax revenues are equal to the amount of taxes paid by all economic agents, and all non-labor markets clear. In addition, in the first version of the model the public deficit is endogenous (and expenditure is fixed) whereas in the second version the opposite holds—expenditure is endogenous and the deficit is fixed.

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 that, under the first order 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 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 the direct and the indirect ones.

The units we use 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* to include a finer classification of *Consumers* that comprise four different types. This disaggregation has been done according to the data in a Social Accounting Matrix for Spain in 1990 developed by Uriel et al. (1994). A disaggregation based on a more recent *SAM* would have been more suitable, but Uriel et al. is the only official one available at this 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 tax reform (Act 40/98) took place in 1999 but we use a 1995 SAM for the analysis. This time-distance discrepancy is most of the time an unavoidable, but quite common, restriction in the implementation of applied general equilibrium analysis. The results should therefore be interpreted *as if* the tax reform had taken place in 1995. A comparison between the main macro aggregates in the 1995 SAM and the data in the Regional Income and Products Accounts, whenever this ends up being possible, is called for and would help to indicate to what extent the 1995 simulation results can somehow be safely 'adapted', or not, to 1999.

The models compute the effects on relative prices, production and consumption activity levels, unemployment rate, and tax collections, as well as the derived macroeconomic aggregates and welfare distributional effects. Welfare changes are measured using the money-metric Equivalent Variation index.

The personal income tax rates obtained from the calibration of the models using *SAMAND95* are not statutory but effective rates. The reform, however, introduces new statutory marginal and average tax rates. Additionally, consumers are not disaggregated by income level or average tax base but by their income source. Unfortunately, we did not have access to the tax databases to implement a mapping between our effective households' tax rates and their actual tax profile. Therefore, we have followed Castañer et al. (1998) and have adopted their estimation of the reduction for the Andalusian region, measured in variation rate on average effective rates. According to their estimates, the tax reform translates to an average reduction of 17.21% in effective tax rates in Andalusia. This is the reduction that has been applied to our four consumers' types. In reality, however, their net tax liabilities are quite different in the benchmark data. Effective tax rates are 3.8% for the *RC* type, 8.6% for *USalC*, 5.9% for *USelfC* and a low 0.2% for the *RoUC* type (this class includes mainly retirees with very low nominal rates). Within each consumer type we have in fact an aggregation of many different consumer sharing the basic defining trait, and this precludes us from distinguishing in a sensible way consumer-specific tax reductions. We have performed, however, some sensitivity analysis to elucidate the degree of variation in the results.

We perturb the initial equilibrium implementing the reduction of the effective direct tax rate for each type of consumer are shown in the comparative tables below (before and after the reform). As stated above, we present two versions of the applied equilibrium

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

In Table 1, we compare the composition of the GDP, from the point of view of income and expenditure, in both versions of the model. Overall GDP is moderately stable in nominal terms. As expected, due to the newly freed incomes the share of Private consumption increases and does it in fairly equal terms in both scenarios. Its implicit empirical elasticity relative to the tax change is close to –0.06. Each percent point reduction in the effective income tax rate would increase Private consumption in approximately 0.06%. Since investment is savings-driven, its behavior is, not surprisingly, directly related to the public sector closure assumption. This assumption does not seem to bear, however, on the income composition of GDP. Labor income falls and business income increases very slightly in both scenarios suggesting a subtle but small shift of the tax burden towards labor.

Table 1. GDP: expenditure and income (in billions of pesetas)

	Before Reform	After Reform (PD=endogenous)	After Reform (PD=exogenous)
Consumption	6276.49	6371.45	6386.45
	69.59%	70.63%	70.65%
Investment	2554.65	2434.26	2632.95
	28.32%	26.98%	29.12%
Government expenditure	2001.00	2003.01	1875.33
	22.18%	22.20%	21.74%
Foreign sector	-1813.12	-1784.72	-1856.04
	-20.09%	-19.78%	-20.53%
GDP-expenditure	9019.02	9024.02	9038.69
Labor income	3190.65	3185.04	3174.70
	35.37%	35.29%	35.12%
Capital income	4534.52	4548.01	4573.11
	50.27%	50.40%	50.59%
Employer's Contribution to Social Security	1119.03	1116.81	1116.87
	12.40%	12.37%	12.35%
Tariffs	97.69	97.49	98.94
	1.08%	1.08%	1.09%
Net Production Tax	-520.35	-518.19	-529.49
	-5.74%	-5.74%	-5.85%
VAT	597.47	594.81	604.56
	6.62%	6.60%	6.68%
GDP-income	9019.02	9024.01	9038.69

Source: *SAMAND95.*

Table 2 shows the composition of government tax income. We observe that total tax revenue decreases in net terms (about 1% in nominal terms). This is essentially due to the fall in income tax collections, over a hundred billion pesetas. Indirect taxation remains globally about the same after the direct tax reform showing the lack of self-financing capacity of the tax reform regardless of the closure rule. It is however worth remarking the small but different behavior of the Value-added tax and Production taxes. This could be traced to the reduction in government production purchases in the fix deficit version.

With regard to consumers, we observe in Tables 3 and 4 an increase in disposable income for all four types of consumers, due to the reduction in tax burden. These newly freed incomes do not accrue equally to all households and the *Urban Salaried Consumer* type is the one who benefits most from the tax reform. This is so both in terms of new disposable income and in terms of welfare as measured by the Equivalent Variation. All consumers benefit from the reform but they do not benefit equally and this result is independent of the model version used.

We have performed some sensitivity exercises to check the dependency of the results to the selected tax policy. We have run simulations where the effective income tax rate has been modified two percentage points upwards and downwards. Lack of space precludes showing the alternate simulations here but we can report that the general direction of the results remains unchanged. In terms of welfare, for instance, the Equivalent variation interval for *Urban Salaried Consumer* goes from 71.88 to 90.77 in scenario I (endogenous public deficit), an approximate ±12% change relative to the initial estimate. Similar figures apply to the rest of households and the relative ordering of effects is unaltered.

Table 2. Effects on tax revenues (in billions of pesetas)

	Revenue before Reform	Revenue after Reform (PD=endogenous)	Revenue after Reform (PD=exogenous)
Taxes on Production	-520.35	-518.19	-529.49
Tariffs	97.69	97.49	98.94
Employer's Contributions to Social Security	1119.03	1116.82	1116.87
VAT	597.48	594.82	604.56
Personal Income Tax	698.74	579.11	580.29
Workers' Contributions to Social Security	281.90	281.41	280.49
Total Taxes	2274.49	2151.46	2151.66

Source: *SAMAND95.*

Table 3. Effects on consumers' net income, with PD=endogenous (in billions of pesetas)

	Disposable Income (before Reform)	Disposable Income (after Reform)	Equivalent Variation
Rural Consumer	2017.08	2036.66	16.18
Urban Salaried Cons.	4290.13	4378.90	81.32
Urban Self-Employed Cons.	1277.42	1297.97	18.44
Rest of Urban Cons.	1341.50	1344.47	0.71

Source: *SAMAND95*

Table 4. Effects on consumers' net income, with PD=exogenous (in billions of pesetas)

	Disposable Income (before Reform)	Disposable Income (after Reform)	Equivalent Variation
Rural Consumer	2017.08	2042.61	15.82
Urban Salaried Cons.	4290.13	4384.40	73.03
Urban Self-Employed Cons.	1277.43	1304.58	21.11
Rest of Urban Cons.	1341.50	1349.47	1.51

Source: *SAMAND95.*

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. The main purpose of the analysis has been to use the induced microeconomic resource allocation shift to obtain the changes in the main macroeconomic aggregates and in real income distribution. A model of these characteristics generates a great amount of information, which can be summarized as follows.

There is a reduction in total government revenue as a result of the reduction of effective rates in the personal income tax. The reform, contrary to government claims, is shown to be not even partially self-financing. The economy does seem to benefit from the stimulus but at a much smaller pace than expected. This conclusion is robust to the closure rule specification.

Investment behaves differently in both versions. In scenario I investment falls because of the increase in the public that follows from the decrease in the tax burden and the corresponding adjustment of savings through the closure rule. This seems to provide some support for the opinion of most macroeconomists who think that an increase in public deficit has a discouraging effect on investment. On the other hand, in scenario II, there is an increase in investment whose explanation lies on the opposite behavior of the public deficit.

Disposable income, quantified by taking the wage rate as the unit of nominal measurement –*numeraire*– improves but unequally for all four types of consumers due to the reduction in the tax burden. The improvements are not spectacular, being the *Urban Salaried Consumer* the one who benefits most from the reform in both versions.

As a general conclusion, we must point out that the reform has an overall slight positive effect on the economy, as it is shown by the reported macroeconomic variables. However, the results of this simulation exercise must be interpreted with caution due to the great number of simplifications that have been necessary to develop the model. In addition, the statistical database possesses considerable limitations in regard to its timeliness. All applied economic models are always subject to this kind of constraints. Despite these facts, we feel the model is useful to help us understanding the economic processes triggered by the tax reform. In the future it is our aim to improve the model on several respects, such as its technological structure and its supporting database. The latter includes a most important task that should aim at elaborating statistical data more suitable to the requirements of the model, for instance a finer disaggregation of consumers according to income levels. The updating of the database *SAMAND95* with a new Input-Output Table designed by the Regional Statistical Office, or else with non-survey techniques, such as *RAS* or cross entropy methods can also be undertaken and would clearly yield a better data platform to perform more up to date analysis.

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