

VALIDATING POLICY INDUCED ECONOMIC CHANGE
USING SEQUENTIAL GENERAL EQUILIBRIUM SAMs

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ABSTRACT

We present a novel sequential approach that explores the capacity of CGE models to track down policy induced economic changes and their ability to generate contrastable data. We use an empirical SAM of the region of Andalusia, in the south of Spain, to construct an initial CGE model. This model is then perturbed with a set of policy shocks related to EU Structural Funds invested into Andalusia. These shocks are accompanied by some parameter adjustments that pick up the main external changes not explained by the model. We generate a sequence of model produced virtual SAMs. We then compare the last virtual SAM in the sequence with a new available empirical SAM. This allows us to check relatedness, for the same year, between the model produced and the empirical SAMs. The results show a good fit to the empirical data which provides further support to the CGE modelling tool.

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1. Introduction

Computable General Equilibrium models (CGE) have become a tool in addition to econometrics based models for the assessment of the implications of policy decisions, and especially so when the interest rests in obtaining detailed information of a microeconomic and sectoral nature.

CGE models are richer in economic structure but have a less sound statistical foundation than econometric models (Whalley 1985). Thus the typical disaggregated implementation characteristic of CGE models allows researchers to study sectoral interdependence and general equilibrium repercussions in depth but results cannot be statistically tested given the usual nature of the CGE approach. Nevertheless, CGE models might be connected, in a way, to econometrics since elasticities are usually imported from the empirical literature. Moreover, the availability of larger and better elasticities databases for a specific region or time period would definitely help in achieving more conclusive model results.

The present work falls within the context of ex-post validation of CGE models. In general, by validation we mean the ability of CGE models to track down policy changes and external shocks, once these have actually taken place. If this line of inquiry turns out to be successful, simulation results can signal directions to improve model structure and to produce better simulation fits. This would provide a further empirical backing of CGE models, in addition to their being based on sound and generally accepted microtheory.

There have not been many contributions in the literature checking the empirical validity of CGE models. Thus any efforts to fill this gap could no doubt provide some new indications of the analytical power of the CGE methodology. Following a

chronological approach, we find the initial point of Johansen (1960) who outlined a relevant question: how well do multisectoral models perform? Focussing on this idea, Polo and Sancho (1993) checked the macroeconomic performance of a CGE calibrated to a Social Accounting Matrix of Spain for 1988. After updating a group of exogenous variables, they found out that their model captured adequately the major macro developments that occurred in the Spanish economy, increasing their confidence in the results derived from their CGE model. Improving on this line of research, Kehoe et al (1995) looked beyond aggregate magnitudes and centered their analysis on detailed microeconomic results, the essence after all of what CGE models are about. They compared their model resource allocation results with empirical data for a 10 year period. They also updated a few external major shocks affecting the Spanish economy and found their model was a good enough conditional predictor for actual changes in sectoral activity levels and relative prices under a variety of model scenarios (i.e. closure rules and labour market characteristics).

Inspired on similar ideas, Fox (1999) worked on Brown and Stern CGE model of the Canada-U.S. Free Trade Agreement (Brown and Stern 1989). He found that the model performed well for changes in trade flows, whereas additions of appropriate macroeconomic shocks were necessary to improve the simulation results for output and employment. A more technical review on validation techniques was addressed by Kleijmen (1995). This author surveys verification and validation of models, especially focusing on simulation models in operations research.

Some years later and deepening on what may be called the predictive ability of models, Kehoe (2005, chapter 13) reinforced the idea of the need and relevance of some type of ex-post model checking as an indirect indicator of the accuracy of results produced by CGE modeling tools. Kehoe used three static CGE models to evaluate the

effects of NAFTA and undertook a comparison of model results with actual data. From this comparison some model weaknesses were revealed—in particular, an underestimation of sectoral impacts—and their identification helped in ‘fine tuning’ the initial models with the aim, of course, of improving their predictive ability. In a similar research, Domingues et al (2008) studied the welfare results of alternative free trade areas in MERCOSUR countries, dealing with the sensitivity to shocks under different degrees of intra-blocs trade liberalization. This paper showed that trade elasticities were important parameters driving the model's results and, for example, welfare gains for Argentina and Uruguay were found to be very sensitive to these parameters.

Moving to other policies, a research for agriculture markets was undertaken by Valenzuela et al (2007) that focused on the ability of a CGE model to reproduce observed price volatility. They concluded again that patterns in the deviations between model predictions and validation criteria could be used to identify the weak points of a model in order to improve its specifications with firmer empirical foundations.

Energy oriented CGE models have also paid attention to this issue. Beckman et al (2011) have recently worked on validation of a widely utilized global CGE model—GTAP-E. By comparing model generated petroleum price distributions with observed five-year data, they come to the conclusion that energy demand in GTAP-E is far too price elastic over this time framework. After incorporating the latest econometric estimates of energy demand and supply elasticities, they found the model to perform more satisfactorily. Partridge and Rickman (2010) expressed a similar concern in relation to regional development policies. They provided government authorities with a reliable and complementary analytical tool, which is especially suited for the evaluation of economy-wide policies.

In the context of regional policies evaluation and the role to be played by CGE models, Giesecke and Madden (2013) have highlighted a number of challenges that should face modellers in the near future, such as interregional factor mobility, trade and transport, government impact on regional economies, or regional migration and investment, among others, that would provide models with interesting tools for an in depth policy-relevant regional economic analysis. They are also quite aware of the limitations that could be found under such an ambitious approach, requiring a huge and complex database, including a multiregional input-output table or detailed social accounting information. A wide range of new elasticity coefficients might be estimated as well. Moreover, they point out that econometric research conducted by Turner et al (2012) from previous work of Bilgic et al (2002) has found out that regional Armington and labour-capital substitution elasticities might not differ significantly from the corresponding ones in a national or international framework when a fine industrial disaggregation is considered.

Dixon and Rimmer (2013) focus on the idea that validation is a keystone for improving the potential of CGE forecasts. They claim that the analysis, besides being computationally sound, should strive to be based on accurate up-to-date data and should try to capture the main institutional characteristics of the corresponding economy. In order to achieve these ambitious goals, modellers should undertake a set of simulations that would often reveal model weaknesses, by means of testing, for instance, baseline forecasting against reality.

Our approach here follows the previous line of research. Our thesis statement consists of introducing a novel method—sequential general equilibrium SAMs—that improves estimates compared to those from calibrating single-period CGE models. This is due to the sequential SAMS method's ability to control for other shocks over

the extended time period under study. We compare our new method using the example of convergence funds given to the Andalusian economy and we evaluate that policy in the light of our improved model estimates.

We use, in other words, a sequence of comparisons based upon the construction of yearly SAMs (Social Accounting Matrix) built from the results generated by a sequence of CGE model implementations. From a baseline regional SAM for Andalusia, a calibrated CGE model is built. A policy shock is introduced and a simulation is run. From the counterfactual equilibrium a virtual SAM reflecting the new equilibrium is built. The virtual SAM is used again in order to introduce a new policy shock. The process is repeated for the number of years the European regional policy is enacted. At the end, a virtual SAM reflecting the sequenced equilibrium is available and a comparison with an actual empirical SAM for the same year, or the previous years if available, is undertaken. From the comparison one should be able to identify and assess the role played in the economy attributable to the yearly injected external shocks while at the same time checking the predictive ability of the CGE model built to represent the region's economy.

The type of policy shocks we consider are related to European Structural Funds commonly known as 'Cohesion Funds'. These funds respond to European Union aid earmarked for promoting capital improvements, both in physical infrastructures and human capital. In the last 25 years the region of Andalusia has been the recipient of about 40,000 millions of Euros in European Union aid. This amount has been distributed through the implementation of several Multiannual Financial Frameworks—or MFF in the policy jargon. The most recent ones are the 2000-06 and 2007-13 MFF, already finished, whereas the current one started in 2014 and will finish in 2020. The previous two MFFs will presumably be the last ones in which the region will be

receiving a significant financial aid since Andalusia will stop being priority convergence, or Objective 1 Region, in the near future. The fact that Andalusia's GDP is expected to be above the 75% lower bound for average European Union GDP will considerably restrict the access to further regional convergence funds in subsequent periods.

We examine, because of data availability, the distribution of funds into the region in the 2000-05 sub period of the 2000-06 MMF. For the initial year 2000 and the terminal year 2005, two empirical regional SAMs for Andalusia are available (SAMAND2000, SAMAND2005). From the initial empirical SAM, we construct a chained sequence of virtual SAMs ($VSAM_t$, $t=2000, \dots, 2005$) using the counterfactuals of a CGE model. The first sequence of virtual SAMs incorporates exclusively the policy changes associated to the disbursement of funds. Since in the actual economy other changes will also take place, we will introduce their feedbacks as well so that they play a role into the production of virtual SAMs. We can see this complementary procedure as a robustness check that gives us a way to contextualize and appraise the results beyond the strict static nature of the CGE model.

When tracking economic variables over time using an economic model, CGE or otherwise, we should consider and decide which assumptions are needed regarding relevant modelling issues such as the behaviour of capital accumulation or technical progress, among other factors.

For this purpose, the paper is organized as follows. The next Section describes the nature and level of structural funding in Andalusia promoting different types of investments. In section 3 we discuss the characteristics of the regional CGE facility representing the economy of Andalusia. Section 4 presents the battery of simulations and illustrates the way additional feedbacks are introduced into the model, focusing in

providing updates in the behavior of capital accumulation and dealing with thoroughly selected elasticities. In Section 5 we present and discuss the derived empirical results. Finally, we conclude in Section 6.

2. The European convergence funds

When Spain became a full-fledged member of the then called European Economic Community, back in the mid 80's, Andalusia was classified as an Objective 1 Region as far as European regional policies were concerned. The fact that Andalusia's GDP per capita was below the 75 percent lower bound (in terms of the Community's average GDP per capita) gave rise to a large and sustained financial disbursement of regional convergence funds. In broad terms, these funds were aimed at correcting the structural disparities in physical infrastructures and human capital levels between developing Andalusia and the developed European areas. Thus several Regional Development Plans were devised so that funds would be earmarked to improve the underprovided regional physical infrastructure, which were in fact a hindrance to a more fluid set of intersectoral productive relationships and an obstacle to a more dynamic economic interconnection with other areas and trade partners. Likewise, the low qualification of the labour force was an impediment as well for reaching productivity improvements and creating a better trained and hence more cost efficient labour force.

The *Integrated Operational Program for Andalusia 2000-06* (IOPA), managed by the regional economic authorities, describes the financial plan regarding the European convergence funds and indicates the distinct action priorities and the corresponding distribution of funds for each priority and each year. The program stipulates the endowment granted by the executive branch of the European Commission and specifies the required Spanish co-financing by both the national and regional

governments. All these funds have been classified into two categories. The first one includes the *European Regional Development Fund* (ERDF) and the *European Agricultural Guidance and Guarantee Fund* (EAGGF), since in both cases these funds are used to promote investment in physical capital goods. The second category of funds groups all those being transferred from the *European Social Fund* (ESF) and that relate to improvements in the skills of the human capital in the region. The quantification of the IOPA for the period 2000-06 shows the level of executed expenditures to reach a grand total of 11,708.90 millions of Euros. Of these, nearly 70 percent correspond to financial aid directly disbursed by the European authorities. From a detailed analysis of the nature of these funds and their time installment, they have been distributed into the two above-mentioned categories for the corresponding periods. The level of resources assigned to the improvement of physical and human capital can be seen to be, respectively, of 88.9 and 11.1 percent of the grand total aggregate. Further quantitative details regarding recipient sectors and period adscription can of course be requested from the authors.

Despite being a quite new line of research, some multi-sectoral models have already been developed in order to assess the impact of European Structural Funds at a regional level. Sharify and Batey (2006), for instance, use linear programming models under a Social Accounting Matrix database to evaluate the impact of expenditure policies. At the Spanish level, Lima and Cardenete (2006) identify satisfactory results regarding the structural funds management for the nineties in the region of Andalusia. For the period 2000–2006, these funds contributed considerably to the generation of regional GDP, while showing that the investment in physical infrastructures turned out to be more efficient than that devoted to foster employment and human capital formation. Monrobel et al (2013) find similar results for the region of Madrid. Recently,

Cardenete et al (2013) have made a first attempt to introduce elements of dynamics in the regional modelling setup in order to explore further possible conclusions.

3. The CGE model

In this section, we build a CGE model based on a Social Accounting Matrix (SAM) as main database. SAMs are a tabular representation of all bilateral value flows for a given period and a given sectoral classification within an economy. They improve data available in an interindustry table since a SAM, in addition to capturing these relations, closes the circular flow of income circuit by way of integrating the links between primary factors' income, households' income and the demand for final goods and services.

Stone (1962) was the precursor in promoting the use of this type of data when he published the first SAM for the U.K. Numerous analytical applications of SAM databases have been used in the literature and selecting any sample for citation would most likely be unfair to the many non-cited ones. An enunciation of some of the typical applications, which include issues related to developing economies, poverty eradication, multiplier analysis in its most general meaning, economic influence, cost and price analysis, CGE model calibration, and many more, should therefore suffice.

All of the Social Accounting Matrices that will be used in this paper have the same account structure. This is required since a sequence of virtual SAMs will be generated using the results of the CGE model that represent the regional economy, and these virtual SAMs will in turn be used for posterior model calibration. The initial regional SAM for 2000 is based on work by Cardenete et al (2010). It was used for studying some environmental issues and it therefore contemplated a wider disaggregation of the energy subsector, an aspect which is not required here. Its

structure has therefore been adapted by way of aggregating the energy sectors. The final empirical SAM available for 2005 follows the same account structure and it is due to Cardenete and Fuentes (2009). Both of these SAMs will distinguish 29 different accounts and of these 21 correspond to production units, while the rest represent the typical accounts for a representative household: two non-produced inputs—labour and capital—a capital account for savings and investment flows, a government account, two tax accounts that aggregate indirect and income tax figures, and a foreign sector account.

Our analysis relies in the use of a static CGE model of the region that incorporates rules of behavior for the standard economic agents—households and production units—as well as for the government and the foreign sector. Optimizing behavior that follows competitive rules translates into a set of equations that describe the way demand and supply functions operate in the economy. Any empirical model—and CGE models are of course no different—reflects always a tradeoff between tractability and technical complexity. In our case, the size of the model depends directly upon the size of the base Social Accounting Matrix for 2000 in Andalusia. Using the base regional SAM for 2000, a first CGE model is calibrated. Its most representative characteristics are succinctly described henceforth.

3.1 Production

Similar firms are grouped in sectors and each one produces a homogenous good that is used to satisfy intermediate and final demand by all agents. Each productive sector is assumed to behave competitively and thus they maximize after-tax profits subject to their technological constraints while taking prices for goods and factors as given. Production functions are assumed to be nested. At the first level, total output X_j

for each of the 21 production sectors is a Constant Elasticity of Substitution (CES) aggregate that combines two inputs: domestic production XD_j , and imports, $IMPO_j$:

$$X_j = \beta_j \cdot \left(\alpha_{j1} \cdot XD_j^{\rho_j} + \alpha_{j2} \cdot IMPO_j^{\rho_j} \right)^{\frac{1}{\rho_j}} \quad (1)$$

with β_j being an efficiency parameter, and α_{ji} being productivity parameters. The substitution parameter ρ_j is related to the substitution elasticity through the relationship $\rho_j = 1 - 1/\sigma_j$. At this level of the nesting, the substitution elasticity σ_j corresponds to the so-called Armington (1969) elasticity between domestic and imported goods. This elasticity has been calculated using empirical values for three European countries provided by Welsh (2008) that have been weighted using the shares between sectoral imports and sectoral output. We can rewrite Expression (1) in the somewhat easier format:

$$X_j = \left((\theta_{j1} \cdot XD_j)^{\rho_j} + (\theta_{j2} \cdot IMPO_j)^{\rho_j} \right)^{\frac{1}{\rho_j}} \quad (2)$$

simply by taking $\theta_{ji} = (\beta_j \cdot \alpha_{ji})^{1/\rho_j}$. The adopted values of σ_j for each production sector are shown in table A1 in the Appendix at the end of the paper.

The second level of the nesting provides domestic production XD_j as a result of combining intermediate inputs X_{ij} with a composite factor called Value Added, VA_j , following the fixed proportions typical of a Leontief technology:

$$XD_j = \min \left(\frac{X_{1j}}{a_{1j}}, \frac{X_{2j}}{a_{2j}}, \dots, \frac{X_{nj}}{a_{nj}}, \frac{VA_j}{v_j} \right) \quad (3)$$

where X_{ij} is the quantity of good i necessary for the domestic production of good j at level XD_j , a_{ij} are the technical coefficients that measure the minimum quantity of this factor necessary to produce one unit of good j , and v_j are the technical coefficients that represent the minimum quantity of value added necessary to produce one unit of good j .

Finally, at the third level of the nesting, Value-added VA_j is produced by combining the two primary factors, labour L_j and capital K_j , using a CES function as well:

$$VA_j = \beta_j \cdot (\alpha_{j1} \cdot K_j^{\rho_j} + \alpha_{j2} \cdot L_j^{\rho_j})^{\frac{1}{\rho_j}} \quad (4)$$

For simplicity of notation, the same parameter symbols are kept and the same interpretation holds here in (4) as in (1) but, needless to say, in the actual model implementation the adopted and calibrated parameter values will of course be different. The values taken for the sectoral elasticities σ_j are shown in table A2 of the Appendix. In short, for the Spanish economy the 21 production sectors have been classified into three large categories—with small, medium and high elasticities of substitution—following the suggestion of Fæhn et al (2009).

3.2 Consumption

The model includes a representative consumer whose gross income Y is the result of the sale of the endowments of productive factors labour L_j and capital K_j to the different j production units. From this sale households receive a salary w and a capital remuneration r . In addition the representative consumer also receives transfers from the public sector TPS (pensions, social benefits, unemployment compensation, etc.) and from the rest of the world $TROW$. In order to calculate disposable income, $YDISP$, the initial amount of income is reduced by the effective direct tax rate DT on total income:

$$Y = \sum_j K_j \cdot r + \sum_j L_j \cdot w + TPS + TROW \quad (5)$$

$$YDISP = (1 - DT) \cdot Y \quad (6)$$

Savings, S , are a fraction of households' net income calculated using the marginal propensity to save mps . The budget devoted to consumption is what remains once

savings have been detracted from the level of disposable income. It is assumed that the representative consumer maximizes a Cobb-Douglas utility function, defined for consumption goods C_j subject to a budget constraint:

$$\begin{aligned} \text{Max } U(C_j) &= \prod_j C_j^{\alpha_j} \\ \text{s. t. } YDISP - S &= \sum_j P_j \cdot C_j \end{aligned} \quad (7)$$

3.3 The public sector

The government collects direct and indirect taxes. Using its income the government demands goods and services from the production units, DG_j , and it also pays unemployment compensation to the idle labour endowment as well as other social transfers. The difference between government revenues and expenditures results in the public deficit PD , if negative, or government surplus, if positive. There is a part of these government transfers which is endogenously determined (namely, unemployment compensation) depending on the level of the unemployment rate, an endogenous variable in the model. The rest of transfers are considered to be fixed in volume but they are updated in value according to the evolution of a consumers' price index. In the macroeconomic closure rule, public purchases of goods and services and unemployment subsidies are taken to be endogenous while keeping the public deficit at a given level.

3.4 The foreign sector

The model of the regional economy needs to be completed with the inclusion of a 'foreign' sector whose base import and export flows correspond to the empirical registered data in the initial SAM. The approach here is very simple given the characteristics of our database and the foreign sector is modelled as an aggregated single sector with no distinctions in terms of trade areas and no analysis of migration

flows. We consider the Andalusian economy as a small economy and we incorporate a single foreign sector account as representative of the rest of the world. All the European flows are channeled through in the model outside the foreign sector and thus there is no actual need for a disaggregation. Domestic output and imported output are considered to be partial substitutes using the Armington (1969) assumption.

The activity levels for foreign demand, or exports of good j , are fixed exogenously, $EXPO_j$. On the other hand imports, $IMPO_j$, are endogenously determined through the cost minimization of the first nesting of the production function as in (1) above, i.e. the Armington assumption. As a result the trade deficit $ROWD$ is an endogenous magnitude in the model. The macroeconomic closure function for the foreign sector can therefore be written as follows:

$$ROWD = \sum_j IMPO_j \times rowp - \sum_j EXPO_j \times rowp - TROW \quad (8)$$

Here $TROW$ is the level of net transfers from the rest of the world, and $rowp$ is an aggregated ‘world’ price index for the good traded with the rest of the world.

3.5 Savings and investment

There is an investment commodity in the model that behaves as a Cobb-Douglas function following the restriction:

$$\begin{aligned} \text{Max } U(INV_1, \dots, INV_{21}) &= \prod_j INV_j^{\theta_j} \\ \text{s.t. } \sum_j INV_j \cdot P_j &= S + PD + ROWD \end{aligned} \quad (9)$$

with P_j being the price in sector j , S private savings, PD the public deficit, and $ROWD$ the rest of the world deficit. Notice that this is an extension (allowing for some price effects and substitution) of the analysis developed by Kehoe et al (1988) to deal with investment.

The investment level in sector j , INV_j , is therefore price responsive whereas the aggregate level is endogenously determined by the addition of all sources of savings, i.e. private, public and foreign. The value of aggregate investment demand is therefore given in equilibrium by:

$$I = \sum_j INV_j \cdot P_j \quad (10)$$

3.6 The labour market

The model contemplates the possibility of labour not being fully utilized in equilibrium. The reason can be found in the presence of some rigidity in the labour market that does not allow for a full flexibility in the way the real wage reacts to the presence of less than optimal labour requirements. The stylized way that Kehoe et al (1995) propose as a proxy for labour market adjustments between the real wage and the unemployment rate is adopted here. It takes the form:

$$\frac{w}{cpi} = \left(\frac{1-u}{1-u^*} \right)^{\frac{1}{\phi}} \quad (11)$$

In Expression (11) u is the (endogenous) unemployment rate and u^* is the benchmark unemployment rate. In the left-hand side w/cpi is the real wage, i.e. the nominal wage rate corrected by the consumers' price index cpi . The parameter ϕ is an elasticity that measures the degree of flexibility in the adaption of the real wage to the unemployment rate. In the simulations we will use the empirical value of 1.25 estimated by Andrés et al (1990).

3.7 Equilibrium

The model follows the standard Walrasian concept of equilibrium enlarged to include the tax and expenditure activities of the public sector and the import-export activity of the foreign sector (see Scarf and Shoven (1984), Ballard et al (1985), or

Shoven and Whalley (1992) for further details relating to actual implementation). An equilibrium is a price vector for goods and for primary factors, an allocation represented by a vector of activity levels for all involved sectors, a level of the unemployment rate, and a level of tax revenues such that consumers maximize their utility for current and future consumption, producers maximize after-tax profits, the unemployment rate weighs down labour supply so that it is equal to the labour demand by all productive units, capital demand equals capital supply, all demands for final and intermediate goods equal the respective supply of goods, and government tax revenues are equal to the amount of taxes paid by all economic agents. Because of Walras' Law, one of the equilibrium equations is redundant. It is therefore needed to select and exogenously fix one of the variables to make the equilibrium system conformal between the number of independent equations and the number of variables. The price of the capital good, r , is used as the model's *numéraire*.

The model has been coded using algebraic GAMS (*General Algebraic Modeling System*) and equilibrium is achieved as the solution of running a fictitious nonlinear optimization program. In the software code all the equilibrium conditions appear as restrictions of the nonlinear program while the objective function picks up the maximization of regional GDP. These types of models are well behaved regarding their functional forms, they have unique solutions and the equilibrium solutions enjoy the property of parameter continuity (Kehoe and Whalley, 1985) and thus comparisons of alternative equilibriums are justified and well founded.

3.8 Database and calibration

The simulation strategy requires the numerical specification of a first CGE model for the initial 2000 period. The empirical regional SAM of Andalusia for the year

2000 is used along with sensible literature values for some of the model elasticities to calibrate the initial model. Calibration consists, as is well known, in using the available data to determine a set of parameters which, under the conditions derived from the optimization problems of agents, allows the model to exactly replicate the empirical database as the benchmark equilibrium for the regional economy. After the model is calibrated, the whole set of literature elasticities in the consumption and production sides of the economy are taken as fixed for subsequent simulations runs.

Once the initial model has been calibrated, it is subjected to policy shocks that reflect the yearly disbursement of the European cohesion funds. As a result of the policy shock incorporated in say period t the CGE model provides a counterfactual and from it, a virtual SAM for $t+1$ is reconstructed. This virtual SAM, $VSAM_{t+1}(e_t^*)$, where e_t^* is a symbolic representation of the counterfactual equilibrium variables in t is then used to calibrate a second stage CGE model for period $t+1$. Again, the new policy shock for $t+1$ is injected into the system and the procedure is repeated for $t+2$, and so on until the last policy shock corresponding to 2005 is injected. To compensate for nominal price increases all the virtual SAMs are correspondingly deflated to the year 2000. The same deflation is applied to the last period empirical SAM for 2005. This way all values are expressed in year 2000 prices. See Figure 1 below where the sequence of equilibrium and SAMs are depicted in a graphical way.

(Figure 1 around here)

4. Simulations

The total European funds received in the region have been classified, as mentioned before, in two broad categories depending on whether they are used as investment in physical capital or in promoting human capital through formation and labour training. These funds are also distributed over the reference 2000 to 2005 periods. Table 1 shows

the time and type distribution of these funds. The external policy induced shocks will be incorporated into the model as a yearly increase in the available supply of primary factors—labour and capital, which are expressed in normalized euros in the model. If K_t and L_t represent the available stocks of capital and labour in period t and $F_{K,t}$ and $F_{L,t}$ represent the annual additions, as indicated in table 1, the following sequence for primary factors will ensue:

$$\begin{aligned} K_{t+1} &= F_{K,t} + K_t \\ L_{t+1} &= F_{L,t} + L_t \end{aligned} \tag{12}$$

We use in the model the standard normalization that equates one euro with one (implicit and redefined) unit of good. This responds to the need to have index numbers to measure equilibrium changes when initial values are expressed in standard units. Labour and capital are then expressed in euros in the database and model, that is, the value of the structural funds and the labour or capital supply can be summed up. For example, when we shock the model with structural funds devoted to labour (F_L), we increase the amount of money available for labour supply in order to enlarge the labour force in the regional economy. This injection (in addition with the one of funds devoted to capital investment) produces a new equilibrium in the economy.

Different scenarios are explored and two distinct types of simulations are considered. The first one will be termed ‘unguided’ and the sequence of chained simulations runs will incorporate exclusively the distribution of funds as indicated in Expression (12). With the help of these simulations, one can get an appraisal of the role played by the distributed funds from the European Union into the evolution of the regional GDP over the studied period. The additional effects of a set of simulations that will be referred to as ‘guided’ are also explored. These are aimed at capturing the role played by other economic changes affecting the economy in addition to those of the European funds. For instance the capital stock in period t goes through a process of

depreciation while at the same time capital goods in the form of investment are added to the capital stock. We adopt the econometric estimate of Denia et al (2002) for the Spanish economy, which is based on a novel approach that estimates the depreciation rate of capital as an additional parameter in the production function. Hence, a depreciation rate, $DepK$, of 4.5 percent in the evolution of the capital stock is introduced in the CGE model. The new sequence for the capital stock in this ‘guided’ case will be given by:

$$K_{t+1} = F_{K,t} + K_t \cdot (1 - DepK) + I_t \quad (13)$$

A second ‘guided’ simulation run contemplates the substitution of the unemployment rate that the model yields by the actual rate taken from official statistics. This is an attempt to control for the deviations in this leading indicator which, incidentally, is reaching outrageously high values lately (see Usabiaga, 2004, for a discussion on the rigidities of the labour market in the region). Apart from updating unemployment rates, the model is also updated introducing the empirical data on unemployment compensation disbursed by the government. Finally, these two ‘guided’ simulations are combined into a third ‘guided’ simulation run, that incorporates all these major data updates.

(Table 1 around here)

5. Results

We present two sets of results. The first one shows the evolution of GDP whereas the second one illustrates the trends in the unemployment rate. The results summarized in Figure 2 depict the actual and the CGE simulated evolution of real GDP in the region for the 2000-05 periods, under the above described simulation scenarios. A first observation is that regional GDP has increased about 25 percent in the five year period with growth rates picking up some speed as the economy approached the latter

years. Reading the results of the ‘unguided’ simulation, the recursive CGE-SAM approach explains about 93 percent of the actual 2005 real GDP. The results, however, deviate more from the empirical data as time progresses, with initial deviations close to 1 percent and final figures being around 7 percent.

When the updates are refined and the capital endowments incorporate the additional data, as laid out in Expression (13), the recursive model results under this first ‘guided’ simulation become considerably closer to actual data. In this case, the model projected real GDP reaches almost 98 percent of the actually observed 2005 empirical GDP. This closeness between the recursive model results and actual end of period data strongly suggests that the growth in the capital endowments, physical and human, when incorporated into a recursive CGE model is a good proxy for explaining the aggregate changes in the regional GDP. The help attributable to the second ‘guided’ simulations that relate to updates in unemployment data, however, seem to have very small, almost negligible, effects. Given this very minor effect, it is no surprise that the cumulative effects in the third ‘guided’ simulations are quite similar to the first one.

(Figure 2 around here)

A comparison between actual and model projected values for the unemployment rates appears in Figure 3. Once again, we verify that the closest approximation comes from the capital endowments ‘guided’ simulation runs. The ‘unguided’ simulation projects a 16.67 percent unemployment rate, almost three percent points above the actual 13.8 official rate in 2005. When updates in the labour data are introduced, the projected ‘guided’ rate of 15.02 percent is closer to the empirical rate but still more than one percent point above it. When the simulations are ‘guided’ using the updates in the capital endowments, the recursive projected rates get very close and almost indistinguishable, i.e. 13.68 and 13.78 percent, to the empirical end of period rate of

13.8 percent. The recursive model works better to track down the empirically observed values when the updating relies in the adjustment of the pools of primary factors, physical and human capital.

(Figure 3 around here)

We consider that the reception of structural funding has been the most important shock affecting the Andalusian economy during the period of study. Moreover, we have complemented this initial shock improving the capital factor behaviour. This guided simulation has finally contributed to getting our results closer to the empirical ones. We have also learnt about the accuracy of our model, discarding some other updates as the ones in unemployment that have had a little contribution to a better approximation to empirical data.

We perform a final validation check comparing actual gross and sectoral output of the region with the projected levels according to the ‘unguided’ and ‘guided’ simulation runs in Table 2. Results for gross output tend to coincide with the previous observations for GDP and unemployment. In the ‘unguided’ simulations, the level of approximation between the simulation result and the empirical data is 89 percent whereas the ‘guided’ one with capital factor updates improves the score considerable, reaching 93 percent of the overall output level. Once again, updating some of the labour data has little if any impact. We can conclude that our CGE model slightly underestimates sectoral output growth, but a much better approximation is addressed with factor capital updates.

(Table 2 around here)

As one of the utilities of CGE models is their capacity to capture information from a sectoral point of view, we have analyzed sectoral outputs behaviour. Attending specific sectors, we focus on simulations with refinements in K , where we get the

closest results in comparison with reality. The model produces nearly the same values as the empirical figures in Livestock (2), Chemical Industry (10), Machinery, Vehicles and Transportation equipment (13), Building materials (14) and Other manufacturing (15). The approximation is above the real data in Agriculture (1), Extractives (4), Textiles and leather (8), Wood manufactures (9), Transports and Communications (18), Sale-oriented services (20) and Non-sale oriented services. The rest of sectors register values below the real ones. Fifteen out of twenty-one sectors register values around an interval of $\pm 15\%$ as maximum. One again, there are no relevant changes on sectoral output when introducing unemployment rate in the recursive procedure.

6. Concluding remarks

In this paper we have explored the extent of predictive ability of CGE models. To this effect, we have performed an ex-post validation check using a recursive general equilibrium model, built upon a chain of yearly Social Accounting Matrices. The first SAM is an empirically available one and it is used for the calibration of the first CGE model. After introducing external policy shocks related to European Union regional convergence policies, a sequence of virtual SAMs is built using the counterfactual equilibria that are, in turn, used for the subsequent CGE model calibration of newer periods. This combined SAM-CGE recursive modeling strategy allows the construction of a sequence of projected model results that can be compared, year by year, with empirical data. Using a five year period, it has been possible to visualize the predictive ability of the general equilibrium model. In addition, this ability can be partially enhanced by providing supplementary model feedbacks that reflect further changes beyond those directly induced by the injection of the European funds. This is the case of

the adjustments in the capital endowment (through depreciation and investment), or the unemployment level and the corresponding compensation transfers.

Using a set of four ‘unguided’ and ‘guided’ simulations, one concludes that the regional recursive model yields quite good approximations to actual empirical data in GDP, labour use and gross output, and specially so when the ‘unguided’ simulation is helped by the ‘guided’ one incorporating the refinements in the physical capital endowment. As an example related to GDP, the ‘unguided’ simulation helps to explain nearly 93 percent of the actual effect of GDP in 2005, whereas this figure goes up to close to 98 percent using the mentioned ‘guided’ simulation. This is quite a good fit, even when, *strictu sensu*, this fit cannot be interpreted in any statistically meaningful sense. Also, yearly GDP deviations between model results and actual data are small and in many cases this value is smaller than 1 percent. Overall predictive ability goes therefore hand in hand with sufficiently good yearly approximations.

The ‘guided’ simulations that update data on unemployment levels and compensations are not equally good. Thanks to this less successful updating attempt, however, relevant information is learnt that indicates the direction that model improvements should possibly take for increasing its predictive ability. This is a valuable ex-post insight that can only arise once a comparison of the model results with the actual empirical data is undertaken.

Although this paper has an obvious methodological focus it is also pertinent to consider, even if briefly, the socioeconomic role played by the European regional convergence funds. The results here clearly indicate the substantial impact these funds have had in Andalusia’s growth, confirming other evidence presented in Lima et al (2010). Precisely because of the huge impact of these funds, the risk of overdependence of the region on them is quite real. The impending cutbacks of these sizeable European

funds that have been accruing into the region will no doubt switch the responsibility to the local actors. On the one hand the national and regional governments, subject to the strict austerity policies that will be inevitably enacted in the next few years, will have to lead in prioritizing the way the remaining lower level of funds will be utilized in order to provide the highest possible returns to society. On the other hand, the critical role of private investors in reinforcing growth and employment is still very much unclear given the surrounding economic uncertainties at the regional, Spanish and European levels.

Some final thoughts on the methodological use of the CGE tool are possibly in order now. Their predictive ability, even when loosely defined as the ability to track down actual change, seems to be adequate. The results here using a recursive CGE-SAM approach seem to reinforce those of Kehoe et al (1995), which were focused to ‘test’ the predictive ability of a one-shot static model, giving additional support to their novel message that ex-post validation is the surest way to go for this class of general equilibrium models. If CGE modeling turns out to be a reliable enough tool, a better and more informed policy making is no doubt possible.

Surely some complementary approaches could be used to further enhance the appraisal of the results. We may think, for instance, of sensitivity analysis for the elasticity parameters, or the inclusion of dynamic patterns by way of introducing technological progress, or the actualization of the data base when available. Undoubtedly, complementary results would indeed arise, and they could turn out to be pertinent in order to provide additional insights to our research. We intend to address these multifaceted and comprehensive extensions in future research.

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Table 1. Distribution of European Structural funds in Andalucía, 2000-05 (In thousands of euros and percentage over Empirical GDP)

FUNDS FOR SIMULATION	2001		2002		2003		2004		2005	
<i>FK</i>	1,456,453.6	88.6%	1,580,185.2	89.2%	1,607,296.8	89.2%	1,535,091.1	89.5%	1,445,798.5	88.8%
<i>FL</i>	187,244.1	11.4%	190,386.3	10.8%	194,002.6	10.8%	179,410.7	10.5%	182,896.9	11.2%
TOTAL AMOUNT	1,643,697.7		1,770,571.6		1,801,299.3		1,714,501.8		1,628,695.3	
Percentage Over Empirical GDP	1.91%		1.90%		1.80%		1.58%		1.39%	

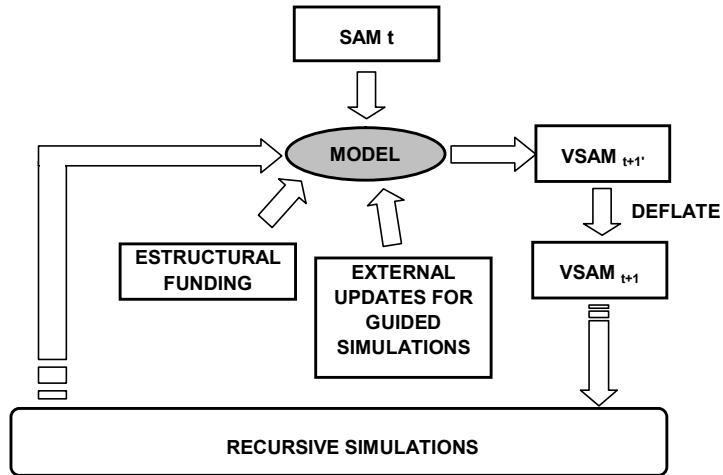
Source: Own elaboration using data from the *Integrated Operational Programme for Andalucía 2000-06* (IOPA), Consejería de Economía y Hacienda (2001), Andalusian regional government

Table 2. Gross and Sectoral Output in Andalucía for 2000-05. Empirical data and model projections (In thousands of euros and percentage over Empirical Output)

	2005 EMPIRICAL	2005							
		UNGUIDED SIMULATION	% OVER EMPIRICAL	GUIDED SIM. (UPDATES IN K)	% OVER EMPIRICAL	GUIDED SIM. (UPDATES IN u)	% OVER EMPIRICAL	GUIDED SIM. (UPDATES IN K&u)	% OVER EMPIRICAL
1 Agriculture	8.874.254	9.715.757	1,09	9.916.038	1,12	9.707.561	1,09	9.897.117	1,12
2 Livestock	2.108.407	2.112.047	1,00	2.162.749	1,03	2.110.505	1,00	2.158.480	1,02
3 Fishing	1.190.229	996.591	0,84	1.032.760	0,87	995.359	0,84	1.029.601	0,87
4 Extractives	5.420.487	5.829.951	1,08	6.036.166	1,11	5.825.370	1,07	6.020.566	1,11
5 Non-energy extractives	2.456.180	2.070.734	0,84	2.182.244	0,89	2.067.861	0,84	2.173.418	0,88
6 Energy production	19.883.356	14.473.824	0,73	14.977.012	0,75	14.461.909	0,73	14.938.110	0,75
7 Food	25.665.215	21.873.755	0,85	22.486.630	0,88	21.849.823	0,85	22.430.146	0,87
8 Textiles and leather	6.399.375	6.839.222	1,07	7.092.681	1,11	6.829.038	1,07	7.069.044	1,10
9 Wood manufactures	3.689.219	4.509.077	1,22	4.719.035	1,28	4.503.363	1,22	4.702.106	1,27
10 Chemical industry	10.338.667	9.994.963	0,97	10.393.143	1,01	10.006.740	0,97	10.383.482	1,00
11 Mining and iron and steel industry	5.352.703	4.399.325	0,82	4.520.700	0,84	4.395.480	0,82	4.510.340	0,84
12 Metal manufactures	4.103.341	2.964.412	0,72	3.151.574	0,77	2.959.143	0,72	3.136.342	0,76
13 Machinery, vehicles and transportation equipment	20.650.990	19.582.943	0,95	20.633.434	1,00	19.554.374	0,95	20.548.846	1,00
14 Building materials	6.084.944	5.697.173	0,94	6.081.867	1,00	5.685.597	0,93	6.049.753	0,99
15 Other manufacturing	8.334.871	7.621.181	0,91	7.960.976	0,96	7.611.545	0,91	7.933.249	0,95
16 Construction	40.950.897	29.401.148	0,72	31.872.590	0,78	29.332.228	0,72	31.672.040	0,77
17 Commerce	32.870.750	29.427.183	0,90	30.552.635	0,93	29.388.574	0,89	30.454.182	0,93
18 Transports and Communications	14.265.350	14.632.656	1,03	15.260.654	1,07	14.617.148	1,02	15.211.675	1,07
19 Other trades	38.129.322	20.710.251	0,54	21.785.044	0,57	20.697.914	0,54	21.715.308	0,57
20 Sale-oriented services	19.774.439	22.302.335	1,13	23.329.791	1,18	22.286.595	1,13	23.258.969	1,18
21 Non sale-oriented services	11.117.577	20.202.499	1,82	21.664.134	1,95	20.379.698	1,83	21.762.287	1,96
Total Output and % over Empirical Output	287.660.574	255.357.029	0,89	267.811.655	0,93	255.265.824	0,89	267.055.060	0,93

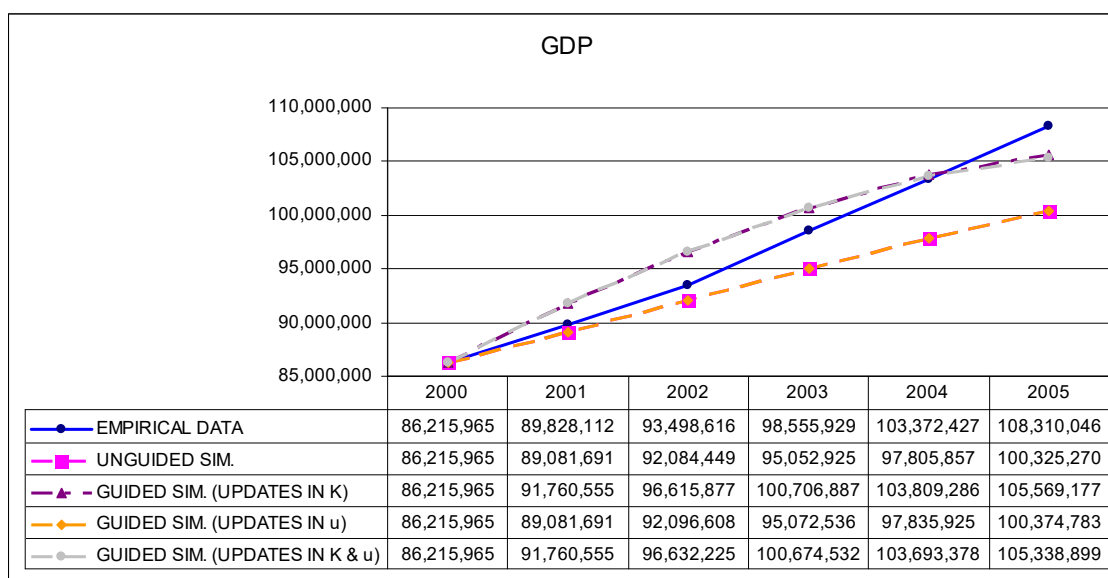
Source: Regional Accounts for Andalucía and recursive CGE model projections

Figure 1. Recursive equilibrium procedure



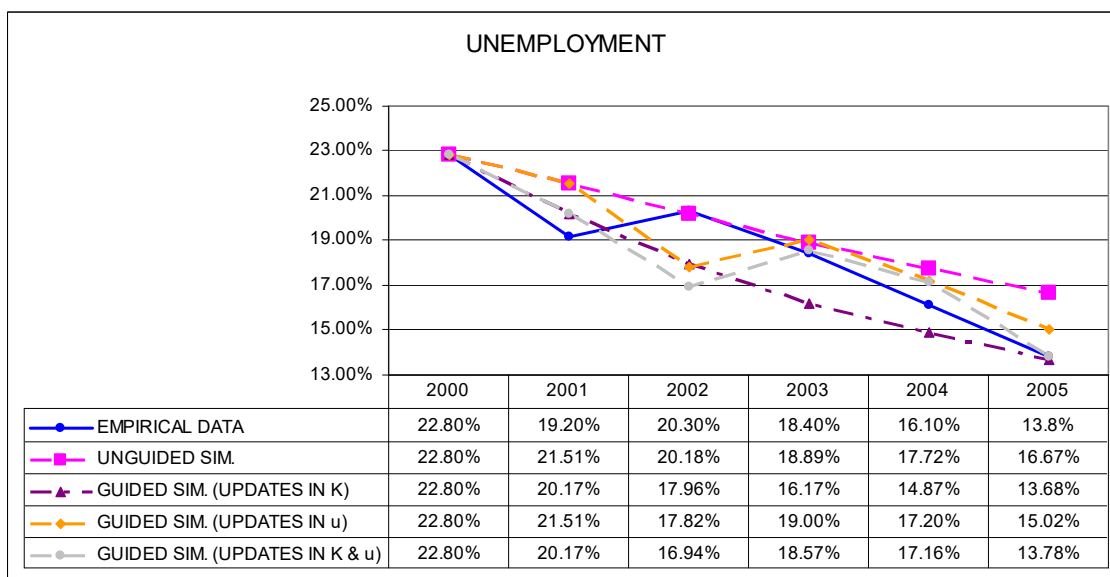
Source: Own elaboration

Figure 2. Evolution of Real GDP in Andalusia for 2000-05: empirical and model projected values (In thousands of euros, deflated to the 2000 base year)



Source: Official Regional Accounts for Andalusia and recursive CGE model projections

Figure 3. Evolution of unemployment in Andalusia for 2000-05: empirical and model projected values (In percentage rates)



Source: Official Regional Accounts for Andalusia and recursive CGE model projections.

Appendix

Table A1. Armington elasticities

SECTORS	IMPORTS/SECTORAL OUTPUT	ARMINGTON ELASTICITIES
1	16.41%	0.288
2	24.42%	0.428
3	38.69%	0.678
4	93.67%	1.642
5	41.93%	0.735
6	5.70%	0.100
7	19.76%	0.346
8	29.42%	0.516
9	45.59%	0.799
10	45.85%	0.804
11	29.59%	0.519
12	21.35%	0.374
13	59.33%	1.040
14	27.32%	0.479
15	24.25%	0.425
16	0.00%	0.000
17	0.33%	0.006
18	13.97%	0.245
19	8.85%	0.155
20	1.34%	0.024
21	0.00%	0.000

AVERAGE ELASTICITY	0.877
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Source: Own elaboration from data provided by Welsh (2008)

Table A2. Labour-Capital substitution elasticities

SECTORS	ELASTICITY OF SUBSTITUTION		
	LOW	MEDIUM	HIGH
1	1		
2	1		
3	1		
4		1	
5		1	
6		1	
7		1	
8		1	
9		1	
10		1	
11		1	
12		1	
13		1	
14		1	
15		1	
16			1
17			1
18			1
19		1	
20		1	
21		1	

0.56	1.2	1.6
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Source: Own elaboration from data provided by Fæhn et al (2005)