Common Agricultural Policy Regional Impact – The Rural Development Dimension

Collaborative project - Small to medium-scale focused research project under the Seventh Framework Programme

Project No.: 226195

WP3.2 Model development and adaptation – Regional CGEs

Deliverable: D3.2.1

Regional CGE model layout with a focus on integration with the partial equilibrium models and modelling of RD measures

DRAFT VERSION

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February 26th, 2010

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Introduction

The core objective of the CAPRI-RD project is the development of a Pan-European tool for regional and spatial policy impact analysis of the Common Agricultural Policy (CAP) with regard to Rural Development (RD) indicators. The framework is the CAPRI model for agriculture. CAPRI is a partial equilibrium (PE) model, first operational in 1999, which is particularly well suited for simulating very detailed scenarios for CAP.

The Finnish computable general equilibrium (CGE) simulation model RegFin also has been developed and used for a long time, but there has up to now not been any connection to CAPRI. Some complementarities between CGE and PE models are obvious: A CGE model is able to predict more general effects for a change in economic policy, and endogenously includes all factor markets, some of which are typically exogenous in a PE model. The level of aggregation is typically higher in CGE than in PE models. For example, the PE model of CAPRI features 36 crops and 16 animal husbandry activities, whereas agriculture is but one aggregate in RegFin. This makes the PE model more suitable to analyse policies directed specifically towards agriculture but there are several other sectors that might be affected by a change in CAP, in particular when considering the growing importance of RD policies.

The purpose of the project is to combine these two models and use their best qualities in development of the simulation framework. The structure of the static RegFin model will be used to construct a CGE layer for CAPRI. The main idea is that for instance the endogenous factor price and consumer income predictions from RegFin replace the corresponding exogenous estimates in CAPRI via an iterative link that guarantees the consistency of the results.

The name of the layer is CGERegEU27+. “Reg” refers to a regional model, which will cover at least the present 27 EU member countries at NUTS2 level. The “+” sign is for possible additional member countries. The CGE models will be single country models around CAPRI. For brevity, the terms “CGE” or “REGCGE” will be used in place of “CGERegEU27+” where no confusion is possible.

In this first deliverable we will discuss three topics on a quite general level. First, we discuss how the RD measures could be modelled in the planned CGE models. The second topic is in presenting the general structure and assumptions of the base CGE model. The last topic will be how to integrate the PE and CGE models so that their best qualities can be combined. A summary will be presented at the end.

The planned combining of a PE model and a layer of CGE models has been only rarely tried. Quite often these experiments have failed. In this project we have two mature models which will improve the odds for success.

Modelling RD measures in a general equilibrium framework

Modelling Pillar 2 measures is undoubtedly a very complex task. Most of the studies which model the effects of the Common Agricultural Policy with general equilibrium models focus on Pillar 1 and ignore the effects of Pillar 2. For example, a recent large study on effects of CAP modelled with use of GTAP by Australian Productivity Commission says that “Rural development spending [Pillar 2] is not modelled because the effects of this class of spending are too complex and uncertain and difficult to value [...]” (Costa et al., 2009: p.2).

Many and complex mix of measures

The complexity of modelling Pillar 2 rural development measures stems from several facts. First, the number of measures is very large. The European Commission allows each country to choose measures from the menu of over 40 of them (see the list in Table 1). Second, since countries have freedom to propose their own sets of measures they differ in terms of number and funds devoted to them. For example Finland’s Rural Development Programme (RDP) 2007-2013 proposes 6 measures under axis 1 while Poland’s almost twice as many, i.e. 10 measures (see RDP Finland 2007-2013 and RDP Poland 2007-2013). This causes large differences in proportions of funds devoted to particular groups of measures too. For example Ireland devotes 10,3% of the RD funds to axis 1, 79,6% to axis 2, and 10% to axis 3 while Belgium does almost the opposite - it devotes 48,1% to axis 1, 35,9% to axis 2 and 8,7% to axis 3 (EC, 2008). Third, the measures are very heterogeneous, in terms of the policy instruments they represent (investments subsidies, input subsidies, transfers, etc) and the goals they want to achieve (economic, environmental, social, etc.). Fourth, countries could choose the administrative level of implementation of the RDPs so that in 27 countries there are 88 RDPs since some countries have chosen to implement them regionally: There are 2 regional RDPs for Belgium, 5 for France, 14 for Germany, 21 for Italy, 3 for Portugal, 17 for Spain, 4 for the United Kingdom and for the rest of the countries there is one national RDP (EC, 2008).

Table 1 List of all RDP measures under 2007-2013 RDPs

111	Vocational training and information actions
112	Setting up of young farmers
113	Early retirement
114	Use of advisory services
115	Setting up of management, relief and advisory services
121	Modernisation of agricultural holdings
122	Improvement of the economic value of forests
123	Adding value to agricultural and forestry products
124	Cooperation for development of new products
125	Infrastructure related to agriculture and forestry
126	Restoring agricultural production potential
131	Meeting standards based on Community legislation
132	Participation of farmers in food quality schemes
133	Information and promotion activities for producer groups
141	Semi-subsistence farming
142	Producer groups
143	Direct Payment (Bulgaria + Romania)
211	Natural handicap payments to farmers (mountain areas)
212	Payments to farmers in areas with handicaps (not mountain)
213	Natura 2000 payments and linked to Directive 2000/60/EC
214	Agri-environment payments
215	Animal welfare payments
216	Non-productive investments
221	First afforestation of agricultural land
222	First establishment of agroforestry systems on agri. land
223	First afforestation of non-agricultural land
224	Natura 2000 payments
225	Forest-environment payments
226	Restoring forestry potential and introducing prevention ...
227	Non-productive investments

311	Diversification into non-agricultural activities
312	Business creation and development
313	Encouragement of tourism activities
321	Basic services for the economy and rural population
322	Village renewal and development
323	Conservation and upgrading of the rural heritage
331	Training and information
341	Skills acquisition and animation for Local Development Strategies (LDS)
411	Implementing LDS (competitiveness)
412	Implementing LDS (environment/land)
413	Implementing LDS (quality of life/diversification)
421	Implementing cooperation projects
431	Running the local action group, skills acquisition, animation
511	Technical Assistance

For the above reasons, the main issue is the accuracy with which it is possible to model the measures. Modelling them one by one would require tremendous resources and is likely to result in a very nontransparent model, whence some sort of aggregation seems appropriate.

Proposed and used groupings

So far there were many attempts to aggregate the measures in order to construct homogenous groups. First and foremost there is grouping proposed by European Commission, which divides all the measures into 4 axes with additional subdivision within each of them (Council Regulation, 1968/2005). According to this proposition the axis1 gathers all the measures supporting competitiveness (111-115, 121-126, 131-133, 141-143), axis 2 gathers the measures devoted to environment protection (211-216, 221-227), axis 3 gathers measures aiming to improve quality of life and increase diversification of rural incomes (311-313, 321-323, 331-341) and axis 4 gathers all measures related to LEADER (411-413, 421, 431), and the last category is technical assistance (511). This grouping however does not allow modelling the measures directly within a CGE framework because it is based on goals criteria rather than economic incentives. However, the latter is needed because the model “understands” only the economically driven factors.

Another grouping of the measures was presented by Dwyer (2005). She proposed five groups: a) Compensatory aids (offered as regular annual payments to farmers under multiannual contracts, usually for the provision of environmental management); b) Investment aids (covering some proportion of the total cost of a one-off or short-term programme of investment activity on a farm or for a farmer, such as training); c) Other capital-related support (such as low- or no-interest loan facilities to enable farmers to make investments); d) Collective investments in agricultural infrastructure (such as irrigation or land restructuring, which may bring direct or indirect efficiency gains to individual farm businesses services), e) Project aids (offered to collective or community projects which are likely to offer only indirect support to farmers). According to the author type (a) includes such measures as LFA, Agri-environmental aids, aids for the afforestation of farmland and all other aids paid per hectare of land affected; type (b) and (c) gather all measures which enable farmers to improve the profitability of their businesses thus enabling cost savings or improved productivity over time (however not necessarily it has to be with respect to agricultural but also non-agricultural ones); aid under type (d) is addressed to improving agricultural efficiency in relation to resource use, but the effect of investment will be indirect, so multiple farms benefit from one investment, and to varying degrees; for aid in category (e), the effect on farming will be indirect, hence predicting the likely consequences for farming of this kind of support is very difficult (Dwyer, 2005).

Another interesting grouping was proposed by Nowicki et al. (2009). The authors composed 10 groups of measures following their intervention logic (see Table 2). Group 1 are measures supporting human capital; group 2 are measures supporting physical capital; group 3 gathers measures addressed to Less Favored Areas (LFA); group 4 gathers measures addressed to Natura 2000; group 5 comprises Agri-environmental programs; group 6 has all measures addressed to forestry sector, group 7 and 8 are measures strengthening respectively diversification and rural development; group 9 is all LEADER's measures and group 10 is Technical Assistance. These groups were designed for the study by Nowicki et al (2009), and were assessed using four models of different types, complemented with a qualitative assessment, but do not seem straightforward and ready to use in our study.

It would be difficult (if possible at all) within the present CGE-PE framework to model such groups like e.g. "general rural development" or "diversification" because they are still too heterogeneous and have no immediate or direct link to particular sector or input within our general equilibrium setting. In other words, it is not clear what could represent a general rural development or diversification in our models. Second such groups as LEADER or Technical assistance have too little funds on their own to allow for meaningful simulation results, so we should not treat them as separate groups.

Table 2 Groups of Rural Development measures in Nowicki, et al. (2009)

Class	**Measures contained**
(01) Human Capital	111-115,131-133,141-142
(02) Physical Capital	121-126
(03) LFAs	211-212
(04) Natura 2000	213, 224
(05) Agri-environment	214-216
(06) Forestry	221-223, 225-227
(07) Diversification	311-313
(08) General Rural Development	321-323, 331,341
(09) LEADER	411-413,421,431
(10) Technical Assistance	511

There were more categorizations proposed in the literature. For example Rowiński (2007) proposed 5 groups for all 2007-2013 RDP measures, which are closer to the actual role that the measures plays such as: a) food economy development b) natural environment development, c) non-agricultural sectors development, d) incomes and social transfers, and e) technical aid. Finally, a study by Zawalińska (2009) proposed grouping within CGE framework dividing RDP measures into only 4 broad categories: a) investments subsidies in infrastructure, b) investment subsidies in human capital, c) direct transfers and d) land subsidies.

From all the grouping and categorizing exercises some common conclusions can be drawn. First, there are several ways to group the measures and none can a priori be judged to be better than the others. Second, each categorization serves a particular purpose. So as long as the purpose is clear and the grouping is consistent with that, the categories are acceptable. Since our purpose is to model the measures in general equilibrium framework (or more precisely within the combined partial and general equilibrium framework), we have to group the measures according to the criteria that the model “understand”, i.e. the economic drivers.

Proposition for a grouping in this project

We propose a grouping which links to the general equilibrium model’s features such as sectors, factors and economic variables, and also adopt the categories’ names from the previous studies. The grouping is presented in Table 3. We propose 5 major categories of policy instruments which further subdivide according to targeted sector(s) into altogether 10 fairly homogeneous groups of measures which can be simulated together. Instruments in group 1 are subsidies for investments in human capital so they increase productivity (not only labor productivity but also indirectly other factors’ productivity) in either agricultural or other services sector; instruments in group 2 are subsidies for investments in physical capital in such sectors as construction, agriculture, forestry, and food processing; group 3 gathers measures implemented in form of direct income transfers for individual farmers or groups of farmers, and they in addition have productivity positive effects. For example in case of “early retirement” (measure 113), this productivity effect stems from the consolidation of land and better management skills of younger generation taking over the farms from old generation. In case of “producer groups” (measure 142), the positive productivity effect stems from consolidation of agricultural output and applying higher quality standard by a group rather than individual farmers; group 4 can be called compensatory aids (following Dwyer, 2005), and is granted in form of land subsidies either in agricultural or forestry sector; group 5 gathers output subsidies in other services sector since it combines measures aiming to increase non-agricultural activities in rural areas, which are mainly materializing in a services sector.

Table 3 Treatment of Rural Development measures in general equilibrium framework

Type of policy instrument	Linked to the Model through sector/input:	Variables for parametrization*:	Measures contained
1.Investment subsidies in human capital (IS_HC)	1) Total factor productivity in Agriculture	aprim (IND, REG)	111, 114-115,131-133
	2) Total Factor Productivity in Other services sector		341, 411-413, 421, 431, 511
2.Investment subsidies in phisical capital (IS_PC)	3) Construction sector	xinv (COM, REG), xtot(IND, REG)	112, 121, 131, 141, 321-323
	4) Agriculture and Forestry		125-126
	5) Forestry		122, 127
	6) Food processing		123
3. Direct transfers (DT)	7) Income + Total factor productivity in Agriculture	wfacinc(REG), aprim(IND, REG)	113, 142
4. Compensatory aids (CP)	8) Land subsidies in Agricultural sector	delLNDTAXRATE, (IND, REG)	143, 211-216, 222-225
	9) Land subsidies in Forestry sector		221, 226
5. Output subsidies (OS)	10) Other services	delPRDTAXRATE(IND, REG)	311-313

Source: Author's own proposition. * = Variable name in RegFin, IND = sector, REG = region.

Since the PE component of CAPRI is on the one hand capable of modelling agricultural measures in a more detailed way, but on the other hand does not explicitly contain all other sectors, we propose to use a different grouping. The grouping for the PE model contains only the measures that are relevant for agricultural firms in the short or medium term (excluding investments) and we propose to use three groups, broken out of the category 4. "Compensatory aids" proposed for the CGE model, each of which can be linked with different production activities and technologies inside the PE model, and the impacts of which will be communicated to the CGE model via the link. The groups proposed for the PE model are:

- LFA payments: measures 211, 212
- Natura 2000 payments: measure 213, 224
- Agri-environmental payments: measure 214-216

In order to parameterize the above groups of measures, we need to have information on regional (NUTS2) money spent for each measure in each country. Besides, for all measures in group 1 we need to translate the money spend into the equivalent of the productivity shock in agricultural and other services sectors. For group 2 we relate the money spent for these measures into investments or production increase in affected sectors. As for group 3 we need to increase factor income and productivity in agricultural sector. Group 4 relates to land subsidies in agricultural and forestry sectors, and there the detailed implementation is done in the PE model and not further discussed here. Group 5 measures promote output increase in non-agricultural services in rural areas.

The parameterization necessarily will have to be based on some assumptions because we model the future spend (2007-2013, or even 2014-2020) and one cannot be sure in advance how much funds really will be spend on each measure nationally (since countries make amendments in their RDPs and shift funds from some measures to the others) and even more so regionally (in countries where are no regional RDPs the regional distribution of funds is usually demand driven, and as such hard to predict). The regional assumptions will be drawn, however, from the previous RDPs 2004-2006 and the indicative budget allocations reported in the regional RDPs for 2007-2013 because most of the measures are repeated from those previous programmes and because the features of the regions (and so their demand for certain measures) should be fairly stable.

Efficient simulation with two models

Last but not least, two issues should be stressed. First, even if all of the RDPs can be modelled through CGE layer, some are naturally easier to model within CAPRI. Among them are especially those related to land as LFA, Agri-environmental measures and Natura 2000 programs. So even if there are examples of modelling them within CGE framework we can choose to simulate them within CAPRI. For example modelling LFA within CGE framework was attempted by Gelan and Schwarz (2008), and by Giesecke, Horridge and Zawalińska (2010). The latter study models LFA as a land rental subsidy. The model distinguishes LFA and nonLFA land and allows the supply of LFA land to respond endogenously to movements in the post-tax rental price of LFA land, with nonLFA land supply being fixed. So this reflects the situation that LFA support prevents giving up the agricultural land, and LFA areas would decline in the absence of the support.

Concluding, we attempt to model all RDP funds (the whole budget 2007-2013) through the layer of CGE models with some measures possibly being simulated individually (e.g. compensatory payments such LFA, NATURA 2000, and Agri-Environmental programs) through CAPRI, while the rest of them being grouped and modelled through CGE layer of the model.

Regional model layout

We will present the base CGE model or RegFin in its general form in words and graphs. We leave the mathematical and programming details for later deliverables.

CBA, IO and CGE approaches

There are many quantitative methods in addition to PE models for quantifying effects from policy changes. Davis et. al. (2002) list input output, expenditure system, SAM, and CGE models. We exclude two middle ones because they are/can be implemented in a CGE model. We also add Cost Benefit Analysis (CBA) which is also commonly known. This presentation aims at describing and comparing the CGE method to other alternative methods.

CBA is a valuable tool because even the listing of cost and benefit items is interesting and educating. There are many problems in valuing and discounting the costs and benefits. The criteria, the benefit cost ratio (BCR) is clear. If BCR > 0, the policy or any change like a project should be realised. The opposite is true for BCR < 0, and in a case of BCR = 0, the criteria is inconclusive. Ackerman and Heinzerling (2001-2002) is a good summary of what CBA is and is not. Their opinion of using the method for analysis of public policy is extremely critical. Bureau and Mahe (2008) feel the opposite and see that a more systematic use of CBA before implementing regulations would help. Our opinion is that CBA is too controversial and unreliable for our purposes for CAP related assessments.

Input-Output (IO) or Leontief models have a long tradition. There are too vast literature to reference here, so we only mention some points. The standard IO model is pretty easy and streight forward to use. Statistics Finland has even published input and employment coefficients, disaggregated to direct and indirect effects (see www.stat.fi). Even big consultancy firms use these numbers in analysing any topic. There are many critics that claim the method has serious flaws. The postulation is that the method is based on unrealistic assumptions: linearity, no resource restrictions and fixed prices. A real economy do not behave like this. It is also seen that IO measures gross effects, whereas net effects should be the criteria. In other words, IO does not take into account the possible negative and positive effects which happen else where in the economy. The results are therefore misleading and usually too large or small compared to the true effect. Our opinion is that IO models are too restricted for purposes of this project.

CGE models were developed to over come weaknesses of the older linear techniques. They take into account the fact that the decision making rules of economic actors (households, public sector) are/can be non-linear. They account for resource restrictions, such as a limited amount of labour and capital in a region. The modelling of the public sector incomes and expenditure are included. Also reactions of domestic and foreign trade and investments are modelled. Prices are typically endogenous and serve as engines of adjustment toward new equilibrium after a change in policy. CGE is nowadays the main stream of applied economic research on national and regional level when the target is to quantify the consequences of a wide-spread shock, such as a change in CAP or regional policy etc. It is important to realize that our base model is NOT an IO model, it only uses the good data from regional input output tables as most CGE models.

Structure of the base CGE model

The base model has been explained to some extent in Törmä (2008), Rutherford and Törmä (2009) and in Törmä and Lehtonen (2009). The applications have dealt with rural development, regional and CAP policies. In the two first articles the authors present a summary of regional CGE models and mention their applications. Törmä and Lehtonen (2009) analyse consequences of changing the allocation between output, capital and land subsidies in implementing the CAP reform for Finland. The focus was in agriculture related sectors, food economy in general and on the welfare effects of the socio economic groups like farmers.

Behaviour of actors and money flows

The following figure shows how the base model describes the real economy.

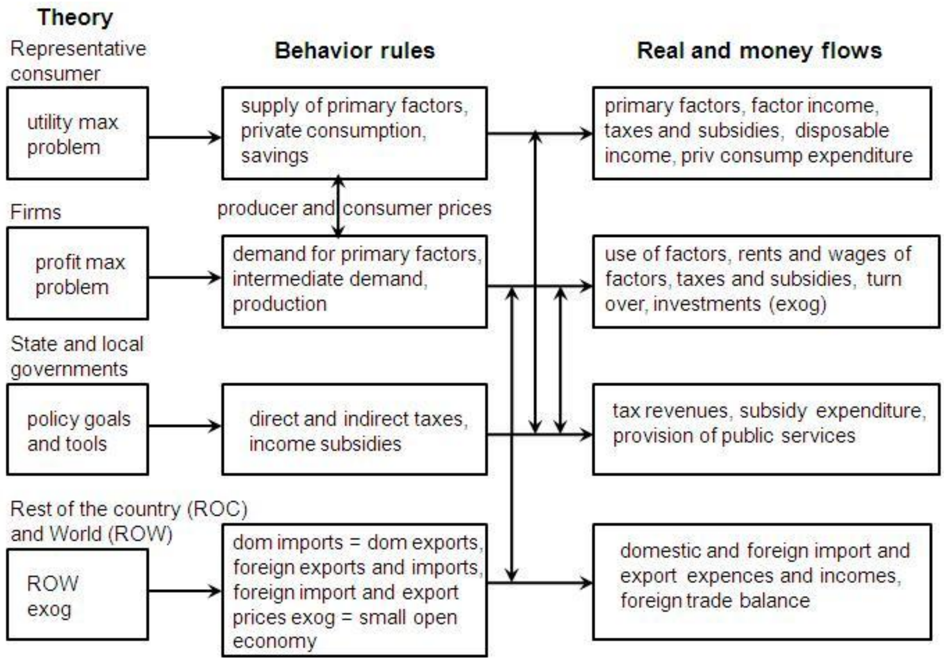


Figure 1. Roles of actors in the base model.

There are four domestic agents that follow their own interests. Each region has one utility maximizing representative consumer that owns all primary factors or capital, labour and land endowments. He/she sells the corresponding services at the factor markets and earns capital and land rents and wages. This factor income minus taxes plus transfers from the state and local governments sum up to disposable income. The consumer uses this either in private consumption or savings.

Firms maximize profits and produce only one sector specific output. They demand primary factors and buy them and the intermediate commodities they need in production from the factor markets. Factor prices are determined in this trading process. Consumer prices are determined in the commodity markets when the demand from the consumer meets the firms' supply. These prices include taxes and subsidies. Investments are exogenous and must be equal to savings.

State and local governments do not participate in production, but they buy services produced by the firms. The public sector has policy goals and tools, which are direct and indirect taxes, subsidies and transfers. The governments collect tax revenues but also have subsidy and transfer expenditures. Public services are financed through net tax revenues. The public sector has relations via net taxes to both the representative consumer and firms.

There are three region consepts in the model: own region, all other regions of the country (ROC) and rest of the world (ROW). The two other regions are accounted for only via aggregate domestic and foreign trade. Changes of relative prices affect choices in trade. Domestic goods and services, often intermediates are imported if the own region is in deficit or cannot satisfy the required demand in production. The own region will export in aggregate terms to the domestic markets to earn income. Domestic trade must be in balance over the country for every sector by definition.

A small open economy is assumed, so foreign import and export prices are exogenous. The own region will import from abroad if some sector is in deficit and export if there is a sector that is in surplus. It will export abroad to earn income. Foreign trade need not balance by sector. There are thus two common pools, a domestic and foreign one where the trade takes place.

The adjustment mechanism

Leon Walras did not believe in the ceteris paribus assumption, but demanded that the economy must be seen as an inter connected entity with all of its markets significant. Prices are not fixed but flexible and will adjust until the economy and all of its markets have reached new equilibrium after a shock. The Walrasian principle assumes "everything affects everything in the economy".

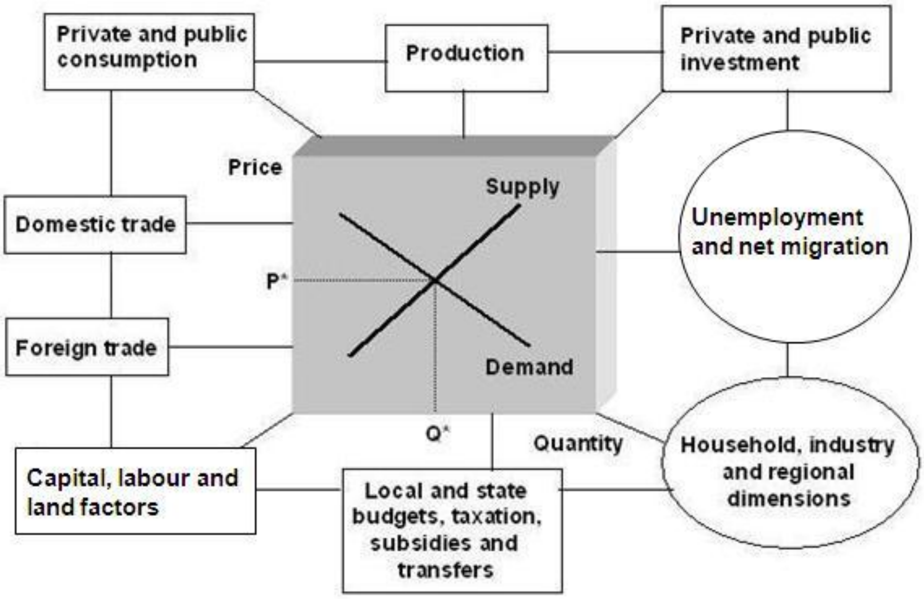


Figure 2. Structure and equilibrium mechanism of the base model.

All key elements are represented in the figure. Different markets of the economy are inter connected via money flows. Supply and demand meet in all markets and the equilibrium prices and quantities are determined. General equilibrium only exists if all markets are in equilibrium at the same time.

There is one exception in the current model: the labour market can be out of equilibrium, so there can be unemployment. The base model can therefore be called quasi-Walrasian. Unemployment is often a serious problem, so there are grounds to account for it. Other features can be modelled, such as net migration. The user of the model should decide to which extent the sectors and region are to be aggregated.

Nested production and consumption structure

In CGE models it is customary to express the sequential decision making of the producer as a nested structure. This makes it possible to weight price related choices with substitution elasticities, which can have different values. The base model is a five nests system. Relative prices are the driving force, so we read the system in a bottom-up way.

The first nest is aggregate capital which consists of capital and land. The decision of an optimal mix between factors depends on the quantity of aggregate capital and relative factor prices weighted by the constant elasticity of substitution (CES). In the second nest aggregate capital is optimally combined in a similar way to labour forming value added. The third nest shows how local output is a Leontief combination of value added and the intermediate goods. In these nests technical change can be capital, land, labour, primary input, or all-input augmenting.

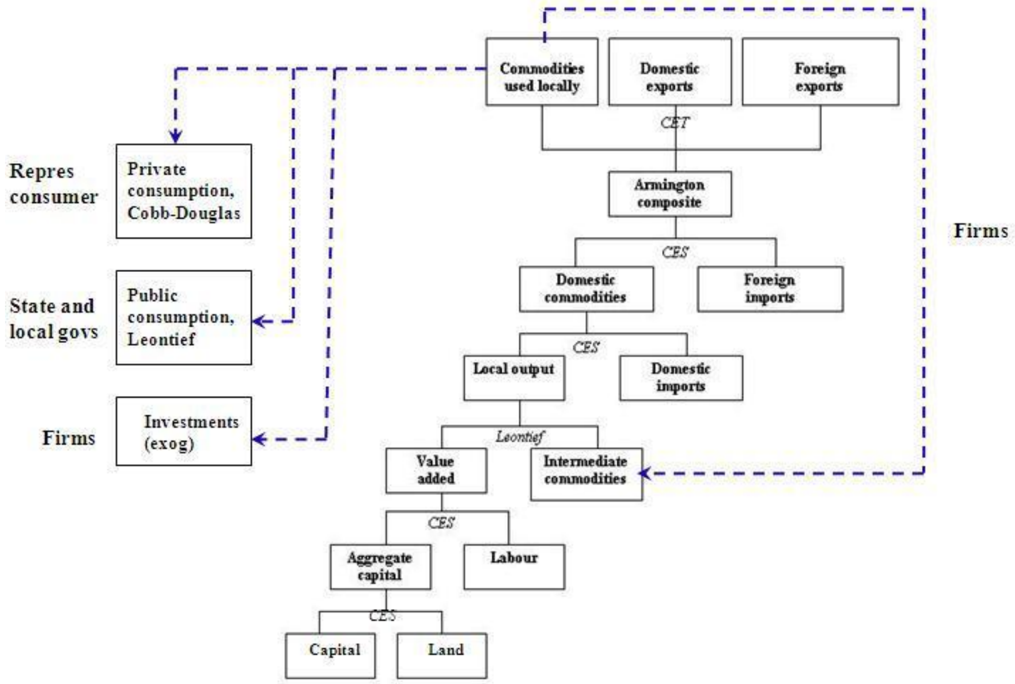


Figure 4. Sequence of optimal choises.

There are still nests four and five left. In the former, the producers need domestic imports, which are CES substitutes for local output. This forms domestic commodities. The demands for the components depend on the quantity of domestic commodities and the price ratios. In the last nest producers choose in a similar way the optimal mix between domestic commodities and foreign imports. The last aggregate is called the Armington composite. The name comes from an assumption Armington (1969) introduced. It postulates that domestic and foreign goods are qualitatively different, so imperfect substitutes.

We stated earlier that the base model has three region concepts. The Armington aggregate or total supply has to be either used locally or exported to ROC and/or ROW. The allocation depends on the corresponding relative prices according to the constant elasticity of transformation (CET) functions. Local commodities are used as intermediate goods, in private and public consumption, investments and in domestic and foreign exports. Private consumption depends of disposable factor income and relative consumer prices in a Cobb-Douglas form. Public consumption is a Leontief combination of the Armington goods.

Factor markets and unemployment

Labour is region specific, and wages are assumed to be sticky and follow national consumer prices. In the corporatist wage negotiation system labour unions tend to secure at least steady real wages. The base model gives for the labour unions possibilities to set wages above their equilibrium level. As the demand for labour is partially dependent on the real wage and there are substitution possibilities with capital and land, there might become over supply of labour, so classical unemployment. Labour force is exogenous in benchmark, but will change if net migration (out minus in migration) changes. The regional/national GDP per capita ratio and the regional/national unemployment rate differences explain net migration according to an estimated pooled cross-section and time series regression. Capital is both region and sector specific. Land is used only in agriculture. The base model distinguishes between owner and user/firm factor prices.

Taxation, subsidies and transfers

The base model has many kinds of ad valorem factor and output taxes, subsidies and transfers. The corresponding average tax rates are added to the pre tax prices. The counterparts of taxes are subsidies. The model operates by using their sum or net tax rates. The tax on capital is the profit tax of firms and that on labour the payroll tax. The land factor also has a corresponding net tax rate.

In excess of indirect taxes, there are lump sum direct taxes. The municipality tax is paid to the local government and the state income tax to the state government. There are also transfers from the two governments to the representative consumer.

SAM and the elasticities

The data base comprises the regional Social Accounting Matrices (SAMs), which are based on regional IO tables. They are the core of the regional SAMs because they efficiently present a summary of money flows between the actors, sectors and primary factors of the economy. Data about the number of employed, unemployment rates, net migration, income taxes and subsidies to/from the local and state governments from the benchmark year are also needed. All numbers have been obtained from the official data bases of Statistics Finland, such as national and regional accounts. Even more data is needed if the regional IO tables are not available. In the AFLQ regionalizing technique (Flegg and Webber 2000; Tohmo 2004; Bonfiglio and Chelli, 2008; see also D2.2.1) is used as a hybrid method, one needs additional variables from regional statistics, such as: total intermediate use, wages and salaries, value added, investments and total output.

Sectoral values for the substitution elasticity between capital, labour and land have been estimated from Finnish time-series data. Other substitution/transformation elasticities are estimates from foreign econometric studies and the CGE literature and range typically from 2 to 4.

Comparative-static simulation framework

Our base model is static, which means that we only know for a shock what effects happen between the benchmark year and the unknown year after full adjustment. Only the comparative-static comparisons between initial and new equilibrium can be made. This is of course valuable in analysing the allocation, macro and welfare effects caused by a

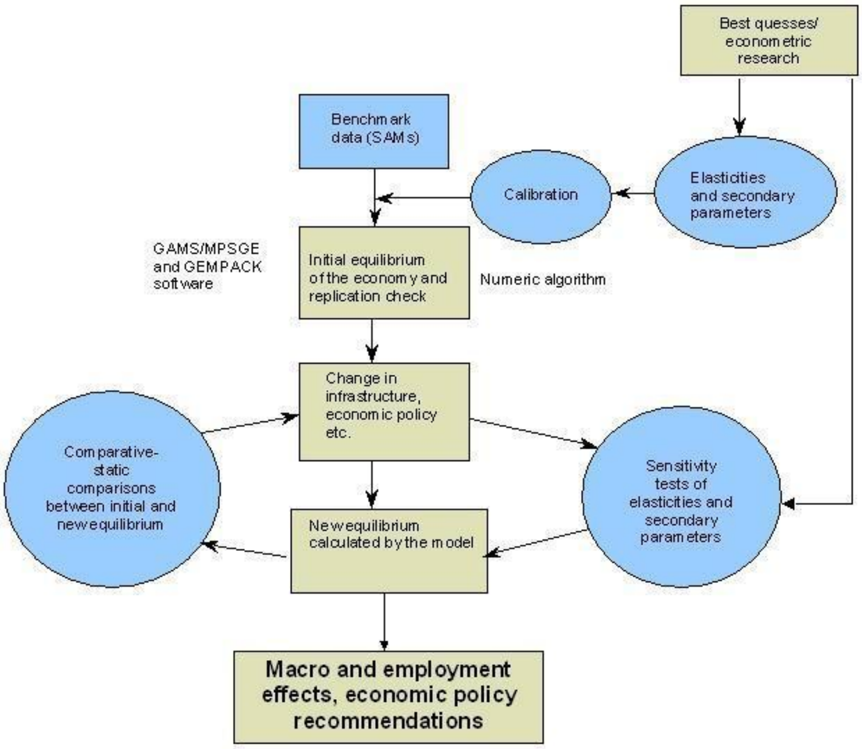


Figure 3. Iterative simulations and comparisons.

policy change. In a dynamic model we would simulate the path for instance on a year to year basis toward the new equilibrium.

The starting point of the analysis is the SAM, which is constructed for one so-called benchmark year. This means that CGE models are lighter in their data requirements, so their maintenance costs are lower compared with econometric or macro models. The analysis then continues, and the values for the parameters are specified. These are divided into two parts: primary and secondary. The primary parameters are typically substitution elasticities, and their values are taken from estimates of the econometric research or typically used values from the literature.

The secondary parameters are different efficiency and distribution parameters. Their values are dependent on the values of the primary parameters and are calibrated to a level that reproduces the benchmark data as a base case solution of the CGE model. The model is well behaved when it passes this replication check. One should always keep in mind that the results of any numeric economic model are usually quite sensitive with respect to the parameter values chosen. Systematic sensitivity analysis (SSA) should always be conducted.

Mathematically, a CGE model is a system of linear and non-linear definition, equilibrium and behaviour equations. The model is built by using the GAMS/MPSGE (Rutherford, 1998) or GEMPACK (Brooke et. al., 2005) software, which are high-level programming languages.

The next step is to parameterise the changes in economic and other policies. After the changes have been fed into the model, the numeric algorithm will find new equilibrium prices and quantities for the production factors (capital, labour and land) and all goods and services. At this point the researcher has two solutions for the model: the benchmark equilibrium and the new equilibrium that prevails after the changes in economic policy have been made. It is then possible to do comparative-static calculations to find out how much the changes in the policy have affected the key variables, such as GDP, employment, income, consumption, investments etc.

The last phase in the CGE analysis is to give economic policy recommendations. Through model simulations the researcher can provide the decision makers with solid calculations and recommendations that will improve their ability to make better decisions.

Integration of partial and general equilibrium models

Motivation

Linking partial and general equilibrium models to exploit their individual advantages is a methodological challenge for many integrated research projects with a focus on the interactions between agriculture and other sectors of the economy. The CAPRI (Common Agricultural Policy Regional Impact, Britz 2008) and GTAP (Global Trade Analysis Project, Hertel 1999) modelling systems and their respective databases were used in the past to combine a high level of detail for the agricultural sector with economy-wide feedbacks on product and factor markets. Basically three approaches for the model integration were used in the projects mentioned above. First, the sequential implementation of scenarios, where one model`s outcome served as input for the subsequent model runs (Scenar2020, SENSOR). Second, the systematic, iterative calibration of structural model parameters as developed within the SEAMLESS project (Jansson et al. 2009). This approach ensured the harmonized simulation behaviour of both models for matching endogenous variables. Third, the direct combination of CAPRI and economy-wide data from EuroStat to generate a database compatible with GTAP, but with a higher degree of detail for the agricultural sector as done by the European Commission´s Institute for Prospective Technological Studies (AgroSAM, Mueller et al. 2009).

In this work, we apply the second approach; iterative recalibration. In that approach, the CGE model is used to determine endowment factor prices, consumer expenditure and other variables that are shared across sectors. The agricultural sector in the CGE is more aggregated than the partial equilibrium (CAPRI) model. Therefore, it is considered an approximation to CAPRI, and the approximation is iteratively adapted to the (aggregated) results of iterative solves of CAPRI. In the partial model CAPRI, many variables are treated as exogenous whereas they are endogenous in the CGE model (prices of labour, capital and chemical inputs). In such cases, the parameters of CAPRI are iteratively shocked with the results of the CGE model.

Since the technical implementation of the linkages is beyond the scope of this paper, we focus here only on the implementation within the CGE model, with the aim to develop a consistent method for implementing the RD policy measures, in particular avoiding double counting of the effect of the measures implemented in CAPRI.

Only the three aggregated measures LFA, N2k and AgEnv plus the effect of investments on technical progress are implemented in the PE model, whereas the CGE model implements all measures. Hence, the effects of all other measures are transmitted to the PE model via factor prices, whereas impacts on agriculture of those three measures are transmitted to the CGE model where it refines the overall impact of the RD programme.

Review of the link with CAPRI

The iterative linkage between the PE and CGE components requires:

1. Updating parts of the coefficients / exogenous drivers in the two models based on information passed from the other components.
2. Solving the models based on the updated information.
3. Calculating the information to pass, and send in an appropriate definition and format to the other model.

It was decided to concentrate initially on the most important linkages to early obtain a working prototype model, and then refine the linkages in the course of the project. The following items were deemed essential for the link:

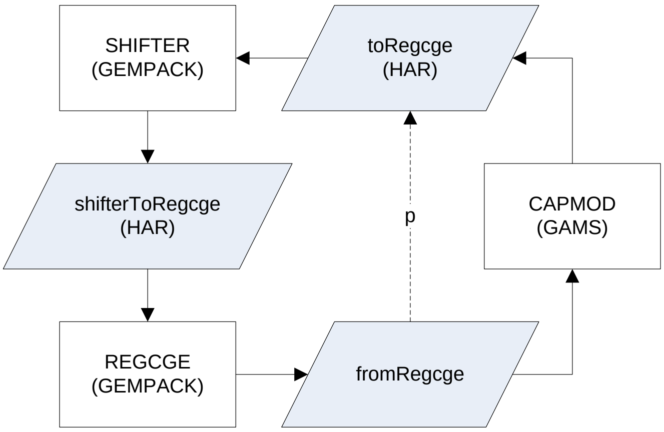
1. Update of the coefficients in the production function of CGE for agriculture to match the output of PE, the intermediate demand from PE, and labour, capital and land demands. As primary agriculture is one sector in CGE, the regional results from PE available for many different agricultural production activities must be aggregated into price and quantity indices representing all of agriculture. All data are passed as percentage changes compared to the original calibration point. As labour and capital are currently not yet explicitly modelled in CAPRI, some intermediate solution must be found, e.g. assuming that relative change in the PMP cost terms (see Britz 2008) is equal to a relative change in labour and capital demand.

2. Changes in GDP from CGE, aggregated to Member States, to feed into the demand system in the CAPRI market model. As changes in GDP for EU Member States during simulation are assumed to be of minor importance for the market of agricultural products due to relatively low price elasticities, it was decided to refrain from a sequential update of the demand system of REGCGE. However, in order to allow some more harmonized demand response of the two models to changes in GDP and the agricultural price index, it is proposed to switch from the present CD demand system in RegFin to a LES demand in REGCGE and calculate the price and income elasticities from CAPRI and the GTAP model.

3. It was considered important to pass changes in import and export prices resulting from policy shocks in CAPRI such as agricultural trade liberalization over to REGCGE. In order to do so, the exogenous import and export prices in REGCGE must be shocked. That requires some change in REGCGE where the import price carries no commodity index and can be interpreted as the exchange rate.

4. Value added value chain for agricultural products including value added tax. In CAPRI, consumer prices for “raw product equivalent” are used, and calculated from consumer expenditure surveys and GDP. The difference between these consumer prices and farm gate prices in the calibration point defines a per unit margin which is kept fixed during simulations, with the only exemption of dairy and oilseed crushing. In REGCGE, the SAM is built such that consumers buy directly from agriculture (but only to a small extent) and from the food processing industry, so that part of the value added chain is also hidden in consumption of service produced by the transport and other sector industries. Value added tax is not broken down by commodity. Given these differences, passing of information would require a lot of additional assumptions, so that it was judged that the probable gain in accuracy was too low.

Figure 4 outlines the proposed linkages between the model components. Square boxes denote algorithms, whereas rhomboid shapes are data sets. CAPMOD is the combination of the supply and market components of CAPRI, the inner workings of which are described in detail elsewhere.



Contents of fromRegcge:

plabpt	Price of labour including tax
pcappt	Price of capital including tax
phou	Consumer price index
xint	Intermediate input consumption

(to be extended with household expenditure)

Contents of toRegcge:

plabpt	Price of labour including tax
pcappt	Price of capital including tax
parm	Price of domestic use intermediate
xint	Intermediate input demand
ptot	Output price index of agriculture
xtot	Total output of agriculture

Contents of shifterToRegcge

alab	Shift in labour productivity
acap	Shift in capital productivity
aint	Shift in productivity of intermediate goods

(all in percent change from baseline)

Figure 4: Flow of information between principal components.

With reference to figure 4, the iterations start with the component CAPMOD, which also has the role of controlling the other components. In what follows, we will use lower case names to denote percentage changes in variables, whereas the upper case version of the same variable denotes the absolute value. This may seem odd to the partial modeller, but is commonplace in the CGE world.

Step 0: Initialize

The first time that CAPMOD is solved, there will be no results available from REGCE. Therefore, all variables are initialized to zero, implying zero percent change:

plabpt = 0
pcappt = 0
alabex = 0
acapex = 0
aintex = 0

Step 1: Solve CAPMOD

CAPMOD takes the fixed percentage changes in labour and capital prices (plabpt, pcappt), and investment driven (exogenous) technical change in capital, labour and variable inputs (alabex, acapex, aintex) and maps them into parameters of CAPMOD. That mapping is the subject of another paper, and thus not further elaborated on here. After computing the shock, CAPMOD is solved for a new partial equilibrium, and the resulting final outputs (xtot), output prices (pcost), intermediate input uses (xint) and intermediate input price indices (parm) are aggregated to the level of the entire agricultural sector. In brief, this step can be described by the vector-valued function

(xtot,pcost,xint,parm,xlnd,plnd) = F(plabpt,pcappt,alabex,acapex,aintex)

The result is stored in the database “toRegcge”, together with the prices (plabpt, pcappt, phou) that were used to compute the solution.

CAPMOD also determines if the iterations should be terminated. The criterion is (essentially)

IF SQR(xtot(i) – xtot(i-1)) < δ, THEN terminate, ELSE goto step 2

for a small positive number δ.

Step 2: Shocking the CGE model

The results of CAPMOD need to be translated into a shock of the CGE model. This is done by a closure swap, which means that some parameters of the model are solved for, while keeping some (an equal number) of the variables fixed at the levels suggested by CAPMOD. In particular, we swap (fixed $\leftrightarrow$ endogenous)

plabpt $\leftrightarrow$ alaben
pcappt $\leftrightarrow$ acapen
parm $\leftrightarrow$ ainten

Furthermore, a particular partial closure of the CGE model is constructed by fixing total output and price of the agricultural sector by fixing total production (xtot), output price (pcost), intermediate input use (xint) and agricultural land use and price (xlnd, plnd) to the results of CAPRI. In order to obtain a square equation system, we also need to add the condition xcap = xlab, i.e. the adjustment of labour and capital use that is needed in order to account for the production and output prices delivered by CAPMOD should be equally split between labour and capital. A refined CAPMOD model with explicit labour and capital use would relax that assumption.

Summarizing, the algorithm SHIFTER solves

(alaben, acapen, ainten) = G(xtot,pcost,xint,parm,xlnd,plnd,plabpt,pcappt)

Step 3: Solving the CGE model

The full CGE model can now be shocked with the technical shifters (alaben, acapen, ainten) derived from CAPMOD. Note that in particular, some RD investment measures are implemented as affecting the productivity of the factors of production. That effect need to be added to the technical shifters derived from CAPRI. Letting trdlab, trdcap and trdall denote the investment subsidies for labour, capital and all factors of production, we write the relationship between investment and technical change

(alabex,acapex,aintex) = F_{inv}(trdlab,trdcap,trdall), and further specify the total productivity change as the sum of the investment effect plus the shift derived from CAPMOD

alab = alaben + alabex
acap = acapen + acapex
aint = ainten + aintex

Denoting the entire CGE model by the function H, and ignoring all variables and parameters not figuring in the link, we then solve for

(plabpt,pcappt) = H(alab,acap,aint)

Productivity shocks

Shocks to the productivity arising from investment spending are exogenous to both models, and pose a special problem with the iterative link, because they interfere with the same mechanism that is used to obtain the iterative recalibration, namely the technical shifters of the CES production tree of the CGE. When the CGE model is run “stand-alone”, shifting the technical coefficients in response to investments is technically straightforward. However, when the PE model is introduced, those very same coefficients are needed in order to calibrate the model to the aggregate outcome of CAPRI, and any existing shifters are overwritten. If the CAPRI-results already contain the technical change, the effect on the technical shifters should incorporate the effect of the policies correctly. The key challenge is then the labour and capital use by agriculture, which is not a standard output of CAPRI. The key challenge in the link is therefore to augment the CAPRI data set to reproduce the aggregate labour and capital use of the CGE model. That is, however, also a problem that is treated in deliverable 3.1.5.

LFA, N2k and Agri-environment

The specifically agricultural measures LFA, N2k and AgEnv are implemented in the PE model in greater detail than in the CGE model. As such, the iterative recalibration handles their implementation. Since CAPRI is an equilibrium model, one cannot assign the effect of the measures in CAPRI and indirectly on the CGE model directly to a particular variable. Nevertheless, it is possible to draw up the main channels by which the CGE model is influenced by the measures via the iterative link.

The LFA and N2k measures, which are not strongly related to technological choices of the farmers, map into new average tax rates of agriculture, in combination with a potentially changed production mix resulting from the potential reallocation of production among geographical regions. The agri-environmental payment has an additional impact on production technology, because in many cases a lower intensity is required in order to claim the payments.

In addition, different countries and regions bias or target their agri-environment programs to particular sub-sectors, like grazing animals (France) or arable farms (UK). In such cases, also the production mix of agriculture may be influenced. The aggregated effect of all those changes should be reflected in the aggregate output, input use, prices and tax rates of agriculture, and therefore also be indirectly included in the CGE model via the link with CAPRI.

Summary

In this first deliverable we have discussed three topics. First, how the RD measures could be modelled in the planned CGE models. The second topic was in presenting the general structure and assumptions of the base CGE model. The last topic was how to integrate the PE and CGE models so that their best qualities can be combined.

Many challenges lies in parameterization of RD measures within CGE framework combined with PE. There are two many of individual Pillar 2 measures to model them individually, so 10 groups in CGE and 3 groups in PE were proposed to tackle the whole RDP budget for 2007-2013. The additional difficulty stems from the fact that we will need to apply regional shocks on all variables proposed.

CGE-models are nowadays the main stream of applied economic research on national and regional level when the target is to quantify the consequences of a wide-spread shock, such as a change in CAP or regional policy. The older linear techniques don't fulfil the scientific standards of this project, so a layer of single country CGE models for the CAPRI.

We have described the blue print of the base CGE RegFin model. The behaviour of actors and their money flows, the adjustment mechanism via flexible prices, the production and demand structures, the role on taxes, subsidies and transfers, The SAM and the elasticities have been discussed. Also, the comparative-static nature of the base model has been highlighted.

The conclusion is that the base model can handle quite much of the scenarios that are planned to do in the CGE model layer. There are certain details that has to be developed, but all in all the base model is a good starting point for the project.

An algorithm for integration of the models by iterative recalibration algorithm has been developed, building on existing procedures in the literature. The algorithm uses the detailed representation of agriculture in the partial equilibrium model (PE) of CAPRI to iteratively recalibrate the behavioural and technical parameters of the agricultural sector in the regional CGE model, and also uses simulated factor price changes of the CGE to shock the PE model.

Annex 1 – Compilation of the AgroSAMs

The objective of the AgroSAM project, carried out at the Institute for Prospective Technological Studies (IPTS), was to create a set of Social Accounting Matrices (SAM) with a disaggregated agricultural sector for the 27 EU Member States. This objective was pursued by combining national Supply- and Use Tables (SUT) with data from the agricultural sector model CAPRI.

The final AgroSAM has been built by following three main stages. First, consolidated macroeconomic indicators for EU27 have been compiled. Second, different datasets from EuroStat have been combined into a set of SAMs with aggregated agricultural and food-industry sectors. Third, these sectors have been disaggregated based on CAPRI data.
At all three stages datasets had to be balanced. The methods applied for the balancing of the datasets draw heavily on the concept of Cross Entropy estimation (Golan et al., 1994). Particularly the structural deviations of agricultural sector and economy-wide data created a need to specify in which cases comparatively large deviations from recorded agricultural data could be tolerated, and in which cases not. For this purpose, Cross Entropy procedures proved to be extremely useful.

The integration of the CAPRI database with SUT tables represents probably the most relevant achievement of the AgroSAM project. Even though this is not the chosen approach of the CAPRI-RD project to link the CAPRI model with a general equilibrium model, it seems useful at this stage to further elaborate on this approach as well.

The integration of CAPRI into a complete and consolidated set of SAMs for the EU27 raised a number of challenges that can reveal to be relevant even for the CAPRI-RD project. The first main challenge is due to the level of details of the CAPRI database, its format and its division between agricultural and food processing activities. Firstly, CAPRI was too detailed for the scope of AgroSAM Moreover, CAPRI contains data on manure production and use, fertilizer consumption, set-aside, milk quotas which are extremely demanding to be transformed into a SAM framework. Secondly, the CAPRI database does not follow the "activity to commodity" typical structure of SAMs. Thirdly, the CAPRI database does not take into account other activities apart from agricultural ones. This represents a difficulty related to sectors as wine, meat and milk which are considered as processed food by the European System of National Accounts (ESA) and end-of-pipe agricultural products by CAPRI.

The AgrosSAM construction is based on the following main three steps.

1-Rearrangement of the CAPRI database into a SAM structure

The SAM structure distinguishes strictly between activity and commodity accounts. In this first step food processing activities, not present in the CAPRI database, were added to a

PrioriSAM. The sectors added are: beef, pork, sheep and goat meat, poultry meat and wine.
The comparison of the activity accounts built on top of the CAPRI and ESA databases revealed that, despite some relevant differences in coverage and definition, the CAPRI database can be considered as a reliable source of information. Particularly, produced and trade quantities of agricultural goods, activity levels, output and input coefficients and basic prices are the most reliable values. On the contrary, it seems that the food industry is represented to a limited extent in the CAPRI database.The CAPRI database is mainly used to retrieve data on domestic output by sectors, intermediate demand, final consumption, exports, taxes and subsidies on production and import, while the prior information on value added, total production values and total absorption come from both CAPRI database and ESA. Other sources, as PRODCOM, are utilized to complete these sources when they are not exhaustive as in the case of the food industry sectors.

2-Construction of an unbalanced PrioriSAM

The unbalanced PrioriSAM was constructed by merging the re-arranged CAPRI database with a previously built SAM. This previously built SAM was based on the input-output tables and the institutional accounts mainly provided by EuroStat.
In this second step CAPRI and ESA database, both expressed in a SAM structure, are merged. This step cannot be done directly, because ESA data are expressed on a mixture of basic and purchaser's price while the CAPRI database is measured only at basic prices. The PrioriSAM has been populated following a compilation procedure that is fully documented in the AgroSAM report (Mueller et al., 2009).

3-Balancing of activity and commodity account totals and balancing of the PrioriSAM

The final matrixes are balanced through a cross-entropy approach, combined with a multiplicative disturbance term. The balancing process is constrained by ESA totals and CAPRI totals. The accounting schemes of these two databases deviate and as the national SUT tables in ESA95 format are the main input of the PrioriSAM, the control totals related to the CAPRI database have been associated with an error term. Nevertheless, the analysis of final data reveals that in 62% of the cases the deviation between final and a priori data are within a very narrow range, with most of the deviations being in a 20% range. As expected, the largest deviations are found in residual accounts as "other cereals', "other crops" and "other animals".

For further details on all the technical details related on the construction of the SAMs see Mueller, Perez-Dominguez, Gay, (2009), Construction of Social accounting Matrices for EU27 with a Disaggregated Agricultural Sectors (AgroSAM), JRC Scientific and Technical Reports.

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