Modelling the impacts of alternative CAP scenarios through a system dynamics approach

Elias Giannakis[a], Sophia Efstratoglou[b], Demetris Psaltopoulos[c]

a Post-Doctoral Fellow , Energy, Environment and Water Center, The Cyprus Institute, 20 Konstantinou Kavafi Street, 2121, Nicosia, Cyprus, Phone: 00357 22208683, Email: e.giannakis@cyi.ac.cy

b Emeritus Professor, Department of Agricultural Economics and Rural Development, Agricultural University of Athens, Iera Odos 75, 118 55, Athens, Greece, Email: sefst@aua.gr

c Professor, Department of Economics, University of Patras, 26504 Rio, Greece, Phone: 2610 969986, Email: dempsa@upatras.gr

Abstract

Policy makers concerns for post-2013 CAP create significant interest in the investigation of alternative CAP scenarios impacts on rural areas. Capturing complex economic, social and environmental interactions associated with changes in the CAP requires a holistic and integrated approach. Hence, a system dynamics model integrating agriculture, environment, rural economy and human resources is developed and applied in a typical Greek rural area. Model results indicate that alternative CAP paths could generate very different rural impacts, depending on the territorial characteristics of the rural region. This supports the conclusion that policy makers should considerably take regional specificities into account when designing agriculture and rural development policy interventions.

Keywords: *CAP, policy impact assessment, system dynamics model, dynamic input-output model, rural development*

JEL Classification: *C61, C67, Q18, R11, R58*

1. Introduction

Being one of the core and oldest policies of the European Union (EU), the Common Agricultural Policy (CAP) has been substantially reformed several times since the early 1990s. The desire to increase market orientation of EU agriculture and adapt to societal demands have been the main drivers behind subsequent CAP reforms (European Commission, 2009), which have considerably changed the weight of the different objectives of the CAP, as well as the instruments utilized to achieve these objectives. Earlier reforms in the 1990s responded to these calls and dealt with problems such as overproduction, the high cost of CAP support and international trade tensions. The shift from product support to producer support has been the core element of these earlier reforms.

Subsequently, increasing demands by EU citizens for a continuous supply of food products characterized by high quality and safety and produced according to higher environmental standards, which also promote the delivery of public goods by European agriculture, the enlargements of the EU and the "need" for the CAP to comply with the objectives of the Lisbon and Gothenburg strategies, triggered a further reform in 1999 (Agenda 2000) and a radical reform in 2003/2004 (Ramos & Gallardo, 2010). Decoupled direct payments linked to environmental, animal and plant health standards (cross compliance) were introduced as a way to provide income support to producers which can nowadays determine their production strategies through responding to market signals.

The reforms of the CAP product and producer support (Pillar 1) were accompanied by a gradual reform of EU rural development policy (Pillar 2). More specifically, EU rural areas have attracted increased attention by policy makers in the last two decades, in an effort to respond to structural change, which is reflected by (amongst others) the diminishing economic importance of agriculture, the impacts of residential, recreational and touristic developments, and increasing environmental concerns. This policy focus has been "embodied" into significantly greater EU expenditure on rural development measures and an effort to implement these interventions in a more "integrated" framework (Thomson & Psaltopoulos, 2005).

Nowadays, the CAP is a "multi-dimensional" form of public intervention structured around two complementary pillars (Pillars 1 and 2), provides a safety net to a market-oriented European agriculture and in parallel, promotes the restructuring of farming, the sustainable management of natural resources and (ultimately) the balanced territorial development of European rural areas (European Commission, 2010). Taking account of the challenges facing the CAP, the communication issued by the Commission on the "CAP towards 2020" (European Commission, 2010) and the Commission proposals on direct payments and market support (Pillar 1) and rural development (European Commission, 2011a; 2011b; 2011c) re-assure the multi-dimensional and complementary objectives of the future CAP (viable food production; sustainable management of natural resources and climate action; balanced territorial development) and suggest policy options as well as changes in present CAP instruments for attaining these objectives in an efficient manner.

The aforementioned policy changes have been "accompanied" by an increased attention in the evaluation of policy impacts. Besides official requirements by the European Commission on the *ex-ante* (and also mid-term and *ex-post*) impact assessment of main policy initiatives, considerable progress on model development has resulted in the emergence of several independent and EU-funded policy evaluation research efforts, often based on economic models (for a thorough review, see Psaltopoulos et al., 2011). These economic models often attempt to assess the sectoral (e.g. firm level) and/or economy-wide impacts of policy-specific public expenditure at both the national and regional levels. However, despite their current popularity, their impacts on policy decision making are often limited due to several inherent factors, which amongst others, include constraints in their capacity to assess a wide range of policy evaluation indicators specified by the Commission which in turn, reflect multidimensional public intervention objectives such as those pursued by the "new" CAP.

Within this context, and taking into account the multi-dimensional nature of the CAP objectives, the increased complementarity between Pillars 1 and 2 and the significant diversity of EU rural areas this paper aims at the *ex-ante* evaluation of the impacts of alternative post 2013 CAP scenarios in a rural area of Greece (prefecture of Trikala). To do so a system dynamics model is developed featuring four inter-linked subsystems, namely agriculture, environment, regional economy and human resources. Four alternative CAP scenarios are specified and analyzed through a linear programming model which determines agricultural land use, farm income and associated environmental repercussions, a dynamic input-output model estimating scenario-specific economy-wide impacts and an age-cohort demographic model which produces study-area-specific population and migration projections for up to 2020. In this framework, perhaps in contrast to several alternative modelling approaches, this model allows the estimation of impacts associated with complementary CAP objectives such as farm competitiveness, environmental protection and territorial development.

The next section provides the background to the study area, presenting information on the socio-economic structures of Trikala and CAP implementation in this region. Section 3 presents the methodology, namely the system dynamics model structure and behavioural properties, and its application to the study area. Section 4 deals with the specification of alternative CAP scenarios while Section 5 presents impact analysis results. The paper ends with conclusions drawn from this analysis and discusses policy implications of estimated policy impacts, useful to policy makers.

2. Background to the study area

The prefecture of Trikala (NUTS 3) was selected as a study area on the basis of its following characteristics; Trikala is a predominantly rural area according to the OECD classification (OECD, 1994) located in central Greece and a rather typical Greek rural area dependent on both intensive and extensive farm production systems, a strong food processing industry, rich natural resources and rural tourism potential, with all these interacting in its development process. Its land area (3,384 km^2) is mostly classified as mountainous (86%), while population amounts to 138,047 inhabitants (2004). Population density is nearly half of the national average one.

Local economic activity still depends rather heavily on agriculture, despite the decline in its total importance in terms of output and employment in recent decades (30% of the labour force is still employed in agriculture). Land morphology and water resources allow both the intensive and extensive cultivation of its agricultural land, which amounts to 60,000 ha. The main farming systems that prevail in Trikala agriculture are: extensive arable farming system including low-input arable crops such as cereals mostly in the hilly and mountainous areas; intensive arable farming system including crops which are highly intensive in terms of input and water use, such as cotton, sugar beet, maize and tobacco farmed in plains; extensive livestock (sheep, goat and cattle grazing systems) which takes place mainly in the mountains.

The secondary sector is based on traditional small and medium-sized enterprises (SMEs) which mainly process local farm output and provide inputs to farmers and on the construction sector while the tertiary sector is gradually expanded mainly in the form of tourism-related units and public services.

Environment in this rural region is of high importance and concern to policy makers as the area is rich in natural resources and valuable rural amenities (forest, water resources, traditional architecture and cultural sites), which constitute a rich potential for the development of rural tourism and recreation activities. Approximately 31% of its land is covered by forest and 61% designated as Natura 2000.

Average annual CAP spending in Trikala during 2000-2006 amounted to 72.7 million euro (in current prices; Table 1), which accounts for 5.7% of average regional GDP during the same period. Most of these funds (58%) were directed to Pillar 1 and mostly concern cotton, livestock premia and direct aids. Pillar 2 funds (42%) were mainly allocated as follows: 26.1% on actions improving the competitiveness of agriculture (Axis 1), 11.4% on environmental sustainability (Axis 2), 2.2% and 2.5% respectively on Axis 3 and Leader +. It's useful to note that almost 50% of Pillar 2 funds were allocated on two measures the less favoured area compensatory allowances and the early retirement. Pillar 1 subsidies per farmer in Trikala for 2000-2006 were lower than the national average (20,545 euro compared to 32,417 euro), while Pillar 2 spending per farmer in the same period was at about the same level with the national one (14,942 euro per farmer compared to 14,635 euro per farmer nationally).

Table 1: *CAP funding in Trikala in periods 2000-2006 & 2007-2013 (current prices)*

	2000-2006		**2007-2013**	
CAP	**Annual average expenditure (mil €)**	**%**	**Annual average expenditure (mil €)**	**%**
Pillar 1	42.1	57.9	39.1	55.5
Pillar 2	30.6	42.1	31.4	44.5
Axis 1	19.0	26.1	18.2	25.8
Axis 2	8.3	11.4	8.1	11.5
Axis 3	1.6	2.2	3.1	4.4
Leader	1.8	2.5	2.0	2.8
Total	72.7	100	70.5	100

Source: Ministry of Agriculture; Ministry of Economy.

For the programming period 2007-2013, financial resources under CAP in Trikala were reduced by 3% compared to 2000-2006. As indicated in Table 1, allocation of financing between Pillar 1 and Pillar 2 has remained almost similar (compared to 2000-2006) with a minor shift of resources from Pillar 1 to Pillar 2. Allocation of funds to Pillar 1 was reduced by 7% in favour of Pillar 2, but funding under Pillar 1 dominates. As for Pillar 2 distribution, Axis 1 funding maintains the highest share despite the slight decline by 4.2%, Axis 2 remains at same levels, while Axis 3 almost doubled its funding. Finally, Leader funding under programming period 2007-2013 has increased by 11%.

3. Methodology

3.1 System dynamics analysis

The selection of an ‘appropriate’ evaluation technique mainly depends on the policy actions to be evaluated and on the focus of the evaluation. As already noted, the strong interrelationships between agriculture, environment and wider economic activity in rural areas have largely shaped the new CAP. Hence, a method which can portray (at least to some extent) these interactions can very well be an “appropriate” tool for evaluating the multi-facet impacts of the CAP.

System analysis is a simulation modelling technique for capturing, understanding, and discussing complex issues and problems, based on the examination of the linkages and interactions between the elements that compose the entirety of the system. In a rural development context, system analysis could well be a suitable framework for the study of interactions between policy developments and the behaviour of rural agents (farmers, entrepreneurs, households), and the assessment of the effects of this behaviour on variables such as land use, agricultural activity, environment, demography and local (wider) economic activity. Within this context, the effects of alternative CAP options on the above-mentioned variables are analysed and assessed here, through the utilization of a system analysis framework, based on a multi-modelling context that reflects complex interrelationships within a rural system. Further, in order to analyse the interdependence of these relationships, the system analysis model developed here combines two main tools, namely a general equilibrium model (input-output) and an optimization model (linear programming).

As changes in agricultural policies affect farmers’ decisions and influence allocation of resources (land and labour) among farming activities, a linear programming approach seems to be a rather ‘appropriate’ tool to reveal farmers’ optimal behaviour. Changes in the agricultural sector, derived from an optimization procedure, induce effects on the environment and on the rest of regional economy making necessary the consideration of the whole regional system, the structure and interdependencies of which can be captured with the use of regional input-output (IO) analysis.

As these changes induce further effect on the regional society e.g. population movements, in- or out-migration, a human resources model (demographic model) seems relevant to capture such repercussions, and is thus, also developed here.

3.2 Model structure and behaviour

The objective of this section is to present the modelling framework adopted in this study for investigating the impacts of alternative CAP scenarios in the rural economy of Trikala. Within the context of a system analysis approach, four basic subsystems are defined here, namely, Agriculture, Environment, Regional Economy and Human Recourses. The specification of the elements, key variables and interrelationships of these subsystems is carried out here through the use of specific methodological tools.

Relevant to a multi-sectoral rural development approach, interdependence within an economic system plays an important role. Input-Output (IO) analysis can be a useful tool for portraying such interdependences, as it incorporates sectoral analysis into a macroeconomic framework, thus creating a basis for the evaluation of development policies to national or regional goals such as GDP and employment. IO analysis has been extensively applied to the evaluation of development policy actions in rural areas, with indicative application examples including Psaltopoulos & Thompson (1993), Midmore & Harrison-Mayfield (1996), Mattas et al. (2010) and Giannakis & Efstratoglou (2011).

Here, economic structures specific to the regional economy are portrayed through a dynamic regional IO model which highlights linkages and interdependences between and within production sectors and also has the “general equilibrium” capacity to quantify policy impacts in terms of economy-wide changes in employment, output and incomes. In turn, a dynamic analytical approach (in opposite to a static one) provides insights on how economy’s structure works over time and enlightens the ways or even whether the economy will reach an equilibrium status following impacts originating from policy changes.

Linear programming (LP) can constitute a tool for economic analysis of agricultural policy, as it takes into consideration relationships between farm resources and agronomic constraints as well as synergies and competition amongst production activities (Hazell & Norton, 1986) in the context of an economic optimization process. Whilst its limitations are well-known, this technique has proved to be quite robust on the analysis of policy impacts on land use (Hanley et al., 1998) and the investigation of the nature and degree of agricultural and environmental tradeoffs (Gibbons et al., 2005). This rather “traditional” method has also been preferred to (e.g.) econometric modelling and a means to investigate the effects of partial or full decoupling of farm subsidies (Salvatici et al., 2000). LP models have been used extensively for the assessment of economic and environmental effects of CAP reforms (Donaldson et al., 1995; Fearne et al., 1994; Topp & Mitchell, 2003; Pacini et al., 2004; Acs et al., 2010) while Mattas et al. (2005) employee LP and IO analysis for the examination of CAP changes.

In this application, the behaviour of the local agricultural sector, as well as certain environmental repercussions of this behaviour are captured through the use of a LP model, which allows the optimal allocation of land and labour uses between different (i.e. intensive or extensive) farming systems by maximizing total gross margin subject to several constrains.

Considering that LP and IO analyses results determine both agricultural and non-agricultural labour demand, it is necessary to explore the demographic dynamics of the study area and interface total labour demand to total labour supply. This is done through the construction of a demographic model which determines population and labour supply (economically active population). The demographics of the study area are determined by an age cohort survival algorithm which combines births, deaths and migration (Hannon & Ruth, 2001).

The conceptual structure of the modelling approach developed here is represented in Figure 1.

The formalization of the above linkages between policies, farm land uses, production of private and public goods of agriculture, economic and social performance of study area has been done with the use of a system dynamics modelling software called Stella (ISEE, 2007). This analytical method for *ex-ante* impact assessment provides a set of tools to understand the structure and behaviour of complex systems (Kassa & Gibbon, 2002). System dynamics models are formulated as systems of ordinary differential equations that are continuously solved using numerical integration at a specified

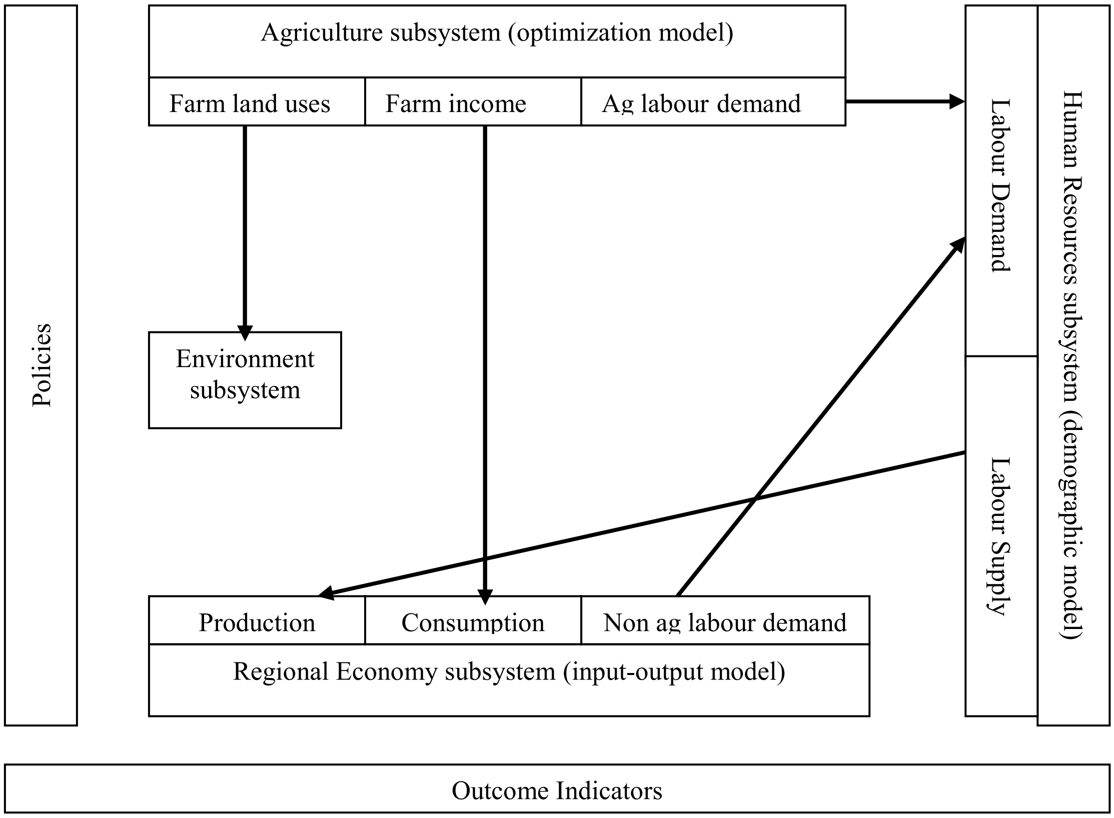

Figure 1: *Structure of the model*

time-step interval. Unlike static economic models in which the equation controlling variables describe their equilibrium levels, system dynamics models describe processes by which variables change as they tend toward to (or away from) their equilibrium. Thus, it can be argued that they are designed and best used to increase overall problem understanding and to improve the efficacy and accuracy of policy decision making and evaluation (Sterman, 2000).

Particularly, the system dynamics model of this study is used to simulate the behaviour of a rural region in terms of its economy, demography, agriculture and environment and to analyze the impacts of alternative CAP scenarios on it. The model is demand driven for regionally produced goods and services. Unlike many economic models, it is also partially supply-oriented in terms of its agricultural subsystem. Specifically, agricultural policy changes affect the optimal allocation of land use which in turn generates changes in the supply of the agricultural commodities and non- commodities, agricultural income and agricultural employment.

In detail, optimal land use determines the amount of labour employed in agriculture through the use of labour land coefficients, agriculture's inputs purchases through the use of the IO coefficients (being produced either within the region or imported) and agricultural incomes. It also determines the production of private and public goods and services derived from agriculture, and measured through specific environmental indicators consisting thus the subsystem of Environment.

The Agriculture subsystem links to the Regional Economy subsystem through agricultural labour demand, purchases of locally-produced inputs and generation of income which induces additional demand for regionally produced products, generating several rounds of effects on the regional economy. Linkages between these two subsystems transmit the effects of CAP changes to the regional economy, generating estimates on farm activity, environment, and economy-wide economic activity (output, employment, income) including labour demand.

The Human Resources subsystem provides estimates on study area population by age cohorts, by integrating births, deaths and ageing, while labour supply is determined within this subsystem by population and labour force participation rates. Migration (in or out) is induced in response to regional labour demand (both agricultural and non-agricultural determined by the LP and IO analyses) relative to labour supply.

3.3 Application: Model subsystems

3.3.1 Regional economy subsystem

The regional economy subsystem is described by a regional dynamic IO model based on Leontief (1953) and adapted by Johnson (1986) and Bryden et al. (2011). In a dynamic context, production and consumption in an economic system move toward equilibrium at a rate which depends on the difference between demand and supply, which in turn is a function of the unplanned change in inventories because of changes in demand. Here, the rates of consumption and production are dynamically linked through changes in inventories of goods and services. An increase in consumption draws down inventories but induces a production response equal to the new consumption plus the decline in inventories. Typically, dynamic IO models impose a capacity constraint on production by making production equal to the minimum of consumption requirements (including replenishment of inventories). In the dynamic IO model developed here, this feature is ignored due to lack of information on sectoral capacity and capital coefficients. Instead, production is constrained by available labour creating a short lag in production response, as labour supply responds to new labour demand. The primary driver of the regional economy and the main linkages between agriculture and regional economy is demand for (consumption of) regionally-produced goods and services including consumption by households. Total consumption of regionally produced commodities is the sum of intermediate and final demand. Intermediate demand comes from (a) agricultural inputs generated from the Agriculture subsystem and (b) inputs of non-agriculture sectors originating from the Regional Economy subsystem. Particularly, intermediate demands by non-agricultural sectors are determined by IO coefficients and the production in each of these sectors while intermediate demand of the agricultural sector is determined by agricultural output and the sector's input coefficients. Final demand is calculated based on its initial values increased by annual growth rates. Final demand is disaggregated into exports, demand for fixed capital formation (investment), agriculture income changes due to commodity price changes and subsidies, planned inventory changes and changes in exogenous expenditures induced by policy changes in regional economy. The basic equation of input-output analysis in equilibrium conditions is:

$$GDP^{E} = IO * GDP^{E} + C^{P} + EXP + INVEST + \dot{INVENT}^{E} \quad (1)$$

E superscript indicating that variables are at their equilibrium levels; GDP production;

IO input-output coefficients; C^P public consumption; EXP exports; $INVEST$ investment; $IN\dot{V}ENT^E$ planned change in inventory.

In this study, agriculture and specifically farming systems are exogenized from the regional IO model as they are in fact captured through a LP model (see below). Hence, equation (1) is modified as follows:

$$GDP^E = IO * GDP^E + C^P + EXP + ADEM + INVEST + IN\dot{V}ENT^E \quad (2)$$

where $ADEM$ demand by the farming systems exogenized for regional output.

The regional economy subsystem is based on the regional IO table constructed for Trikala. The construction of the regional IO table was based on the Greek IO table for year 2000 (NSSG, 2004) which includes 59 sectors of economic activity. This national table was updated to 2004 with the application of the RAS method (Miller & Blair, 2009) and aggregated into 18 sectors in order to reconcile the discrepancy between employment data available at the regional and national levels, respectively.

For the construction of the regional IO table, the GRIT regionalization technique, developed by Jensen et al. (1979) and widely used in recent years for rural economic analysis (indicative applications include Johns & Leat (1987); Psaltopoulos & Thomson (1993); Tzouvelekas & Mattas (1999); Ciobanu et al. (2004); and Mattas et al. (2009) was applied.

As the regional economy is much more open than the national economy and more dependent on exports and imports not only to international but also to interregional trade the GRIT technique was considered as the most suitable technique to avoid the underestimation of the interregional trade and hence the overstatement of regional multipliers based on the collection of superior data. Alternatively, the construction of a many-region (interregional or multiregional) model capable to capture the important interregional linkages could surpass the above acknowledged weakness of the regional models, but such a model was beyond the scope of this paper.

Mechanical estimates of regional IO coefficients were superiorized through a survey of 80 local businesses specific to certain sectors of the Trikala economy and specifically to agriculture, food manufacturing, trade and tourism. The selection of the sampled sectors was based on two criteria: (a) the significance of these sectors for the regional economy and (b) the existence of strong intersectoral linkages with the agricultural sector (Czamanski and Malizia, 1969). Agriculture was disaggregated into four farming systems that include the various types of farming and production intensity and which are: extensive arable crops, extensive livestock, intensive arable crops and other agricultural system. The final IO table for Trikala consists of 21 sectors (Appendix A).

3.3.2 Agriculture and environment subsystems

A LP model of arable crops supply is developed to assess the CAP impacts on the study area's arable crop sector in terms of agricultural income; agricultural employment; land use allocation and environmental indicators (Giannakis, 2011). Taking into consideration that arable crops in Trikala represent almost all utilized agricultural land (94%), it was decided that extensive and intensive arable farming systems, as described in section 2, are exogenized from the regional input-output model in order to investigate in depth the impact of CAP changes in the allocation of the agricultural land. Agricultural land uses is a primary economic driver in this model as it determines the supply of the agricultural commodities and the agricultural employment.

The objective function which maximizes the total gross margin of arable crops in the study area is denoted as:

$$Z = X_j \cdot \left[Y_j \cdot (P_j + S_{yj}) + S_j \right] - X_j \cdot (LR_j \cdot W + VC_j) \quad (3)$$
$$for\ j = 1 \ldots n$$

where n number of arable crops; Z total gross margin of arable crops; Xj land of arable crops; Yj yield of arable crops (tones/ha); Pj price of agricultural products (euro/tonne); Syj subsidy per unit of product (euro/tonne); Sj land subsidy (euro/ha); LRj employment requirements of arable crops (hours/ ha); W wage (euro/hour); VCj variable cost (euro/ha).

Parameters used in the regional LP model are yields, prices, subsidies and variable costs as appearing in regional statistics (Prefecture of Trikala, 2004; 2007). Arable crops included in the analysis are: *{Xj} = {durum wheat, soft wheat, barley, alfalfa, maize, tobacco, cotton, sugar beet}*. These crops are distinguished to extensive (durum wheat, soft wheat, barley) and intensive (cotton, maize, alfalfa, tobacco, sugar beet). This distinction is based on agrochemical input and water requirements information obtained from FADN.

Optimization is subject to a number of constraints concerning resource availability (land), agronomy (rotations), policy (quotas) and demand (contractual agreements). The feasible space is defined by the constraints below: *limits to available land; limits to available irrigated land; quotas on tobacco; contracts determining sugar beet production; bi-annual rotation for four-year alfalfa cultivation; calibration constraint*.

In the regional optimization model three environmental indicators are also specified in an effort to assess CAP impacts on agriculture's environmental performance. Literature review includes a long list of possible indicators which can imprint the pressures of agriculture on environment and more specifically on biodiversity, water pollution and landscape amenity value (OECD, 2001; FAO, 2003; Payraudeau & Van der Werf, 2005; Herzog et al., 2006). In this effort, indicators used are:

(a) *Percentage of utilized agricultural land under low-input farming systems*: extensive farming systems distinguished in terms of low usage of agrochemical inputs and water (OECD, 1997) are recognized as positively contributing to biodiversity maintenance (Bignal & McCracken, 1996; Stoate et al., 2001). Therefore increase of agricultural land under extensive crops imprints a reduction of pressures put on biodiversity.

(b) *Surplus of nitrogen applied over that used by plants* (in tonnes per ha per annum): the intensification of farming contributes to the increase of nitrogen concentration on underground water (De Klein & Ledgard, 2001). Even though it is difficult to estimate the leaching of nitrogen to surface or underground water due to the fact that this is affected by several factors including soil, height of rainfall, cultivation practices, quantity and season of fertilization, there is an assumption here that 30% of the applied quantity of nitrogen fertilizers is not absorbed by crops, resulting in the pollution of surface and underground water (Neufeldt & Schäfer, 2008). Therefore, a reduction of nitrogen residuals can be interpreted as reduction of pressure on water quality. Data on nitrogen use were derived from regional statistics (Prefecture of Trikala, 2004; 2007).

(c) *Shannon index*: The Shannon index is an entropy measure of land use diversity. Increase of the Shannon index imprints increase of landscape diversity which contributes positively to its ecological and aesthetical value (Thenail, 2002).

Mathematically the index is calculated as follows:

$$Shannon\ Index = -\sum_{j=1}^{n} p_i \ \ln p_i \tag{4}$$

where n number of crops; p_i proportion of area of i crop to total land.

The Shannon index is equal to zero when agricultural land is covered by one crop and increases as the number of different crops increases (McGarigal & Marks, 1995). The range of Shannon index values for the nine arable crops of study area Trikala varies between {0-2.2}.

3.3.3 Human resources subsystem

The demographics of the study region are determined by a cohort survival algorithm which combines births, deaths and migration. The cohort-survival procedure is disaggregated into four age cohorts (0-19 years, 20-39 years, 40-64 years, and 65 and over), while births are determined by the annual rate of birth among families aged 20-39. Population ageing procedure is determined by the transfer-in and transfer-out flows, while transition coefficients from one age cohort to the next are equal to 1/cohort size. Data on birth rates, death rates, unemployment rates and economic active population were derived from regional statistics (NSSG, 2005). Finally, migration is also derived within the subsystem as a balance between regional labour demand and labour supply.

4. Policy scenario specification

As already noted, the aim of this study is to apply a system dynamics approach to the ex-ante evaluation of the impacts of alternative CAP scenarios in rural regions. This ex-ante assessment considers the impacts of Pillar 1 and Pillar 2 interventions, which constitute local responses to CAP challenges in the 2007-2013 period as well as the prospects of the next programming period 2014-2020.

Taking into account that regional IO table was constructed for 2004 (i.e. before the implementation of 2003/2004 CAP reform), it was decided that the base year of model simulation should be 2004 and in turn that the horizon for the model scenario impacts should be 2020. This time-period 2004-2020 is justified in terms of taking into consideration the post 2013 the CAP prospects, and also contains an adequate time period for CAP intervention to operate and produce secondary/long-run economic impacts. Also, as the aim of the scenario analysis is to compare the economic, social and environmental impacts of alternative “paths” of Pillar 1 and 2 measures with those of the current policy context, the baseline of this analysis is associated with Pillars 1 and 2 as implemented in 2007-2013 programming period and is specified as follows:

Scenario 0 - Baseline Scenario (2007-2013): This baseline scenario aims at the impact assessment of the current CAP implemented in the study area between 2007 and 2013. To this end, there is an adjustment to the IO and LP models in order to reflect changes initiated by the 2003/2004 reform of CAP. Specifically, Pillar 1 subsidies set to zero and equivalent direct payments are transferred to households. Also, due to decoupling, there have been changes in farm land uses and an increase of extensive farming systems at the expense of intensive (see Table 3). With regards to Pillar 2, the IO model is shocked according to 2007-2013 allocation of funds to different priority Axes.

Scenario 1 – Reduction (50%) of Pillar 1 support and full decoupling: This Scenario takes into account the current CAP orientations and assumes a reduction in farm support. Hence, Pillar 1 support is reduced by 50% from 2007 onwards and the 'saved' funds are reallocated to Pillar 2 in proportion to existing Axis spending; Also, a full decoupling of Pillar 1 is assumed.

Scenario 2 – All Pillar 2 under Axis 1: In this Scenario Pillar 2 spending aims at the promotion of agricultural competitiveness, thus all Pillar 2 funds are channelled through Axis 1. Pillar 1 flows remain at the same levels as in the Baseline Scenario (Scenario 0).

Scenario 3 – All Pillar 2 under Axis 2: In this alternative Scenario all Pillar 2 spending aims at improving the environment and is re-allocated to Axis 2, while Pillar 1 spending respects Baseline conditions. Furthermore, a subsidy of 250 euro per hectare is assumed in favour of extensive farming systems in the context of the extensification of agricultural production.

Scenario 4 – All Pillar 2 under Axis 3: In this Scenario, all Pillar 2 spending targets to encourage the diversification of rural economy and the improvement of quality of life in rural areas. All Pillar 2 funding in 2007-2013 and beyond is channelled through Axis 3, while Pillar 1 flows respect Baseline conditions.

Pillar 1 and Pillar 2 spending flows, under the alternative scenarios, are modelled as follows: (a) Pillar 1 spending is treated as decoupled payments (direct payments to farmers) transferred to the final demand of the IO Households sector as change in exogenous expenditures, while coupled payments (e.g. cotton) are "inserted" into the LP model as support to specific crops; (b) Pillar 2 spending is classified according to the demand it creates for sectoral output. Specifically, for Axis 1, 50% of the spending represents income for the Households sector (eg. early retirement), while the rest 50% are mainly benefits for Agriculture, Construction and Trade. The vast majority of Axis 2 spending (90%) benefits the Households sector (eg. less favoured areas compensatory payments) and the rest the environment (extensification production subsidy), while for Axis 3 spending, sectors such as Construction (90%) and tourism-related Services (10%) benefit.

5. Model results

Table 2 presents the initial values of the key variables of the model for the base year 2004. Also, it presents Baseline Scenario (Scenario 0) policy impacts on agriculture, environment, demographics and regional economy on selected variables (output indicators).

The *Baseline Scenario* projects the 2007-2013 policy patterns into the post -2013 CAP period, specifically 2014-2020. The implementation of 2003/2004 CAP reform caused significant changes in agriculture as reflected in 2007 output indicators levels (Table 2). LP model results show that extensive arable crops increase by 16.4% (from 11,900 ha to 13,847 ha) in expense of intensive (from 31,200 ha to 29,253 ha). This is mostly due to the significant increase of soft wheat from 2,155 ha to 6,957 ha while durum wheat decreases by 28% (from 6,896 ha to 4,951 ha). Soft wheat had almost disappeared in the last decade dominated by durum wheat cultivation in dry fields because of the special subsidy earmarked for this crop. The integration of this subsidy in the Single Farm Payment does not affect farmers' crop mix decisions among cereals thus soft wheat becomes competitive.

Table 2. *Baseline Scenario projections of main output indicators (in absolute values)*

	2004	2007	2013	2020
Demographic Indicators				
Population	138,047	140,699	148,948	153,078
Ageing Index*	0.81	1.09	1.44	1.77
Migration	-4,211	986	-2,355	-1,249
Regional Economy Indicators				
Employment	45,204	48,864	51,632	53,485
Regional GDP (in thous. €)	3,706,033	4,029,849	4,308,118	4,463,952
Per Capita Income (in thous. €)	8.96	9.55	9.70	9.75
Agriculture Indicators				
Extensive Arable Land (in ha)	11,900	13,847	13,847	13,847
Intensive Arable Land (in ha)	31,200	29,253	29,253	29,253
Gross Margin (in €)	47,393,820	27,446,850	27,446,850	27,446,850
Agricultural Employment	2,460	2,024	2,024	2,024
Environmental Indicators				
Biodiversity Index	0.276	0.32	0.32	0.32
Water Pollution Index	21,562	20,870	20,870	20,870
Shannon Index	1.696	1.668	1.668	1.668

* Ageing index is the ratio of population over 65 years old to population up to 19 years old.
Source: Authors' Calculations.

Intensive crops like cotton decrease significantly from 14,223 ha to 12,068 ha (-15%), whereas crops like tobacco and sugar beet seem to disappear. However, intensive crops that increase include alfalfa (12.5%) and maize (4.3%). This reallocation of farm land from intensive arable to extensive arable crops results to a significant decline of farm incomes (total gross margin of arable crops fell by 42% in 2004-2007 due to decoupling) and an 18% decrease in agricultural labour demand. Farm land reallocation improves the biodiversity index by 14.3%, and the water pollution index decreases by 3.2% showing a reduction on pressures put on water quality as total nitrogen leaching to surface and underground water was eliminated from 21,562 tn to 20,870 tn. On the other hand Shannon index presents a slight decrease from 1.696 to 1.668

showing a small increase of landscape homogeneity which negatively affects its aesthetic value.

Despite the significant decline of farm incomes (gross margins) due to the decoupling of Pillar 1 support, overall effects for the regional economy seem positive. Regional GDP, employment and population seem to increase between 2004-2007 by 8.7%, 8.1% and 1.9%, respectively. This can be explained by the effects of the Single Farm Payment transfers to households (which then increase their consumption) and also by the weak backward linkages of agriculture with other sectors of the local economy. Projections for 2013 and 2020 follow the same trends as it is shown from the relevant output indicators in Table 2.

Table 3 presents the effects of alternative CAP scenarios on the outcome indicators of the model in comparison to Baseline Scenario (Scenario 0) in the year 2020.

The 50% cut of Pillar 1 funds from 2007 onwards and the transfer of these funds to Pillar 2 in combination with full decoupling (Scenario 1) seems to generate a rather significant effect on local agriculture (Table 3). Full decoupling of subsidies results in an increase of low intensity arable land by 30.5% and a 14.4% decrease of high intensity arable land. Total gross margins decline by 4.7% and agricultural employment by 22.7%. As for environmental indicators, biodiversity index increases by 31.2% due to land reallocation in favour of extensive arable crops, while pressures on water quality decrease by 13.3% due to the reduction of nitrogen applications. The Shannon index decreases by 15.4% due to the disappearance of some crops (tobacco and sugar beet)

Table 3: *Percentage changes of alternative CAP scenarios to Baseline Scenario (Baseline Scenario=100) for the year 2020.*

	Scenario 1 (50% cut of Pillar 1)	**Scenario 2 (All Axis 1)**	**Scenario 3 (All Axis 2)**	**Scenario 4 (All Axis 3)**
	2020	**2020**	**2020**	**2020**
Demographic Indicators				
Population	99.32	100.06	97.84	100.58
Ageing Index	100.23	99.99	100.55	99.93
Migration	97.82	100.14	93.80	101.30
Regional Economy Indicators				
Employment	99.35	100.06	97.92	100.58
Regional GDP	100.00	100.02	100.13	100.18
Per Capita Income	100.29	99.86	103.25	98.82
Agriculture Indicators				
Extensive Arable Land	130.45	100.00	194.75	100.00
Intensive Arable Land	85.59	100.00	55.15	100.00
Gross Margin	95.32	100.00	118.09	100.00
Agricultural Employment	77.32	100.00	54.11	100.00
Environmental Indicators				
Biodiversity Index	131.25	100.00	196.88	100.00
Water Pollution Index	86.70	100.00	67.82	100.00
Shannon Index	84.59	100.00	99.58	100.00

Source: Authors' Calculations.

imprinting the decline of landscape heterogeneity. On the other hand, model projections show that negative effects on the farm sector specific to this Scenario, do not seem to exert any pressure on the regional economy in comparison to the Baseline (Table 3).

The reallocation of Pillar 2 funds into Axis 1 (Scenario 2) creates marginal impacts compared to those associated with the other Scenarios, as the majority of outcome indicators remain similar to Baseline estimates, with the exception of out- migration which increases by 0,14% and per capita income which declines by 0,14%. *The reallocation of Pillar 2 expenditure to Axis 2 (Scenario 3)* results into significant increase of the extensive arable cropland (95%) in expense of the intensively cultivated land which decreases by 45%. The gross margin of arable crops increases also significantly by 18% but this is accompanied by a serious decrease of agricultural employment (by 46%). Environmental indexes also improve significantly as biodiversity index increases by 97% and water pollution index decreases by 32.2%. Regional income increases in this scenario are marginal, while there is a slight decline in regional employment.

Finally, *Scenario 4 (all under Axis 3)* seems to have a comparatively notable impact on the regional economy compared to other Scenarios. An increase in regional GDP, employment and population is projected, this being consistent with the aim of the Axis 3 to promote diversification of the local economy and quality of life. No changes are projected (compared to the Baseline) on agricultural and environmental indicators, as this Scenario does not involve a different Pillar 1 path (compared to the Baseline).

6. Conclusions

This paper aimed at the construction of a holistic, integrated, system-dynamic model and its application for assessing the impacts of alternative CAP scenarios on agriculture, environment, regional economy and human resources in a typical Greek rural area.

Results have shown that alternative CAP prospects generate different rural impacts. A reduction of Pillar 1 payments, combined with full decoupling and modulation seems to have greater effects on farm incomes, land uses and commodity production, while local environment benefits mostly from the extensification of agricultural production strengthening also the joint production of public goods. Despite the negative effects on the farming sector, at least in this case, the overall regional economy seems to succeed in increasing regional GDP, employment and population due to the weaker backward linkages that extensive arable farming system creates relative to intensive one (Giannakis & Efstratoglou, 2011).

With regards to the reallocation of Pillar 2 funds among different priority Axes, it seems that the most favourable for regional development Scenario is Scenario 4 (all under Axis 3) which promotes diversification of the local economy (regional GDP and employment growth) and improvement of quality of life. This is explained by the high multipliers of Construction and Tourism-related Service sectors. The reallocation of Pillar 2 in favour of Axis 2 (Scenario 3) seems to have the greater positive effects on the environment, due to the further extensification of agricultural production, while LFA subsidies (income transfers) induce positive impacts on the local economy (regional GDP and per capita income).

Further, although findings are case-specific, this analysis can perhaps facilitate interesting conclusions and policy implications on post-2013 CAP impacts on rural areas which still significantly depend on agriculture. In this context, different future orientations for the CAP are associated with different-mixed impacts on agricultural activity, the environment and total economic activity in such an area. A reduction of Pillar 1 funding and a dedication of Pillar 2 spending on Axis 2 generate negative effects on local agriculture, but benefit the local environment and economy-wide incomes. On the other hand, a more "productive" orientation of Pillar 2 affects positively local employment (compared to the current CAP) but does not create any positive or negative effects on the environment of this region.

As a conclusion it can be perhaps argued that this multi-modelling approach allows (a) a "multi-dimensional" assessment of CAP impacts in a rural system, (b) it captures linkages and simultaneous interactions between agriculture, environment, regional economy and human resources in a rural area and (c) it quantifies policy impacts specific to each of the above four rural sub-systems and their interrelationships and feedbacks. Hence, such an approach can be a useful tool to policy makers currently highlighting the multi-dimensional and complementary objectives of the future CAP such as viable food production, sustainable management of natural resources, and balanced territorial development (European Commission, 2010).

Considering the broad regional differences among rural areas and the complex interactions that prevail in economic, social and environmental structures and taking into consideration that alternative CAP prospects generate different rural impacts, it can be argued that policy makers should aim at a CAP reform that accommodates more for regional differences in order to stimulate and promote further CAP's effectiveness in rural areas.

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Appendix A

Table A1: *NACE codes of sectors of economic activity of Input-Output Table for Trikala, 2004*

NACE codes	Sectors of economic activity
01	Extensive arable
01	Extensive livestock
01	Intensive arable
01, 02, 05	Other agricultural system
10--14	Mining
15, 16	Food manufacture
17, 18, 19	Textile
20, 21, 22	Wood and paper
23,24, 25	Chemical and plastic products
26	Non metal products
27, 28	Metal products
29-37	Machinery and equipment
40, 41	Electricity, gas and water
45	Construction
50, 51, 52	Trade
55	Tourism
60-64	Transportation
65-67, 70-74	Banking-Financing
75	Public administration
80	Education
85, 90-93, 95	Other services