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Evaluating CAP alternative policy scenarios through a system dynamics approach in rural areas of Greece

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Abstract
Current considerations for the post-2013 CAP create the need for the investigation and evaluation of alternative CAP scenarios and their effects on agriculture, environment and regional development in EU rural areas. To this end, a system-dynamics model is developed and utilized to evaluate the impacts of alternative CAP scenarios in a Greek rural area (prefecture of Trikala). This particular model features four basic subsystems (agriculture, environment, regional economy and human resources) specified and analyzed through a linear programming model, a dynamic input-output model and an age-cohort demographic model, respectively. Four alternative policy scenarios are specified, dealing with possible developments on Pillars 1 and 2. Model simulations produce scenario-specific effects for the 2007-2013 period, and up to 2020 in the form of changes in land use and farm output, environmental indicators associated with farm activity, economy-wide impacts and impacts on local population. Results show that different future orientations for the CAP are associated with different impacts on agricultural activity, the environment and total economic activity in this area. A reduction of Pillar 1 funds 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 positively affects local employment (compared to the current CAP) but does not create any positive or negative effects on the environment of this region

Keywords: CAP, policy impact assessment, rural development, system dynamics

JEL Classification: C61, C67, Q18, 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, 2009a), 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 this reform process, as support prices were first cut in 1992 and compensatory direct payments were introduced in 1994 to compensate for potential farm income losses.

Later, 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 subsequent enlargements of the EU (especially that of 2004), 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 of the CAP (Ramos and Gallardo, 2010) in 2003/04. Decoupled direct payments were introduced as a way to provide income support to producers which can nowadays determine their production strategies through responding to market signals. These payments are linked to environmental, animal and plant health standards (cross compliance) and together with decoupled payments, contribute to the provision of public goods by EU agriculture.

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 an 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 and Psaltopoulos, 2005).

In recent years, two EU Regulations have played a major role in facilitating this new policy-approach in rural development. The Agenda 2000 Regulation 1257/99 (European Commission, 1999) specified a menu of rural policy measures to be implemented ‘at the most appropriate geographical level’, and attempted to restructure, simplify and widen the then existing policy framework. Following the radical reform of the CAP in 2003/2004, Regulation 1698/2005 (European Commission, 2005) further reinforced EU rural development policy, through introducing a single funding and programming instrument (EAFRD), and a new strategic RDP approach which emphasized the complementarity between Pillars 1 and 2 (European Commission, 2006). Also, Regulation 1698/2005 specified three major objectives of EU rural development intervention, namely, improving competitiveness of agriculture and forestry (Axis 1), improving the environment and the countryside (Axis 2) and improving the quality of life in rural areas and encouraging diversification of economic activity (Axis 3).

Finally, the above reforms were further reinforced by the 2008 CAP Health Check agreement (European Commission, 2009b; 2009c; 2009d) which in the case of Pillar 1, extends the decoupling of farm support, abolishes intervention mechanisms for certain products and arable set-aside, increases milk-quotas leading to their abolition in 2015, provides assistance to farm sectors with special problems, and adds new requirements and simplifies cross compliance. In Pillar 2, additional funding is provided through increased modulation rates, while intervention domains are extended in the fields of climate change, renewable energy, water management, biodiversity and innovation.

Nowadays, the CAP is a “multi-dimensional” form of public intervention structured around two complementary pillars, 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). The implementation of these reforms has improved the market orientation of EU agriculture; support to producers (% PSE) decreased from 39% in 1986-88 to 23% in 2007-09, the share of trade-distorting support in the PSE fell from 92% in 1986-88 to 34% in 2007-09 and the cost imposed on consumers (% CSE) fell from 36% in 1986-88 to 8% in 2007-09 (OECD, 2010). Additional funds for rural development also seem able to target important objectives such as improvements in farm competitiveness and provision of public goods and promote the balanced development of rural areas.

Taking account of the challenges facing the CAP a recent communication issued by the Commission on the "CAP towards 2020" (European Commission, 2010) re-assures 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 suggests broad 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 in the EU 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 which suggests the need for a variety of policy approaches, this paper aims at the ex-ante evaluation of the impacts of alternative 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 future scenarios associated with the CAP 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 study area. Section 3 presents the methodology, namely the system dynamics model structure and behavioral properties, and its application to the study area. Section 4 deals with the specification of alternative CAP scenarios and presents impact analysis results. The paper ends with conclusions drawn from this analysis and discusses policy implications of estimated policy impacts.

2. BACKGROUND TO THE STUDY

The prefecture of Trikala (a NUTS 3 area) is located in central Greece and is a predominantly rural area according to OECD classification (OECD, 1994). Its land area of 3,384 km^2 is mostly classified as mountainous (86%). As indicated in Table 1, the population of Trikala amounted to 138,047 inhabitants in 2001 and remained rather stable between 1991 and 2001 (-0.6% total change). Population density (40.8 inhabitants per km^2) is very low compared to the national average (83.1 inhabitants per km^2).

Trikala is a rural area with relative high level of remoteness and difficulties on access (due to inadequate infrastructure), factors that have significantly contributed to its economic backwardness. However, this mountainous remote region is also endowed with rich natural resources and valuable rural amenities (fertile agricultural land, 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.

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 all low-input arable crops such as cereals mostly in the hilly and mountainous areas; intensive arable farming system including highly intensive in terms of input and water use crops 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 mountainous areas.

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 the construction sector. Since the early 1990s, there has also been gradual expansion of the tertiary sector mainly in the form of tourism-related units and public services. The employment share of the primary sector declined from 37% in 1991 to 30% in 2001, while the share of employment in the service sector increased from 42% to 50%, and that of manufacturing remained rather stable from 21% to 20% (Table 1).

Being an Objective 1 region, Trikala has benefited from structural development funding (Regional Authority of Thessaly, 2000), and agricultural support (CAP Guarantee) and especially development policies (Pillar 2, Regional and National Operational Programmes, Leader, etc.) have all contributed to the further restructuring and diversification of Trikala's local economy.

Table 1. Profile of Prefecture Trikala and Greece, 1991-2001

	Trikala		Greece	
	1991	2001	1991	2001
Population	138,946	138,047	10,259,900	10,964,020
Density (inhabitants/km2)	41.1	40.8	77.8	83.1
% Population change	-0.6		6.9	
Employment	45,034	47,177	3,571,957	4,622,822
% Primary	37	30	20	15
% Secondary	21	20	25	23
% Tertiary	42	50	55	62

Source: Population Census, NSSG (1991, 2001)

Average annual CAP spending in Trikala during the period 2000-2006 amounted to 72.7 million euro (in current prices; Table 2), 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, 11.4% on environmental sustainability (what is not called 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 less favoured area compensatory allowances and 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 amounts to 14,942 euro per farmer compared to 14,635 euro per farmer nationally.

Table 2. CAP funding in Trikala in periods 2000-2006 & 2007-2013 (at 2004 prices)

CAP	2000-2006		2007-2013[i]	
	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, planned financial resources under CAP in Trikala were reduced by 3% compared to 2000-2006. As indicated in Table 2, allocation of planned funds 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 planned funding maintains the highest share despite the slight decline by 4.2%, Axis 2 remains at same levels, while Axis 3 almost doubled its planned 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[ii]. 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 facilitate the consideration of these relationships, the system analysis tool developed here combines two elements, 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 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. IO analysis can be a useful tool for portraying such interdependence, 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 and Thompson (1993), Midmore and Harrison-Mayfield (1996), Mattas *et al*. (2010) and Giannakis and 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 changes in employment, output and incomes. Dynamic 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 coming from policy changes.

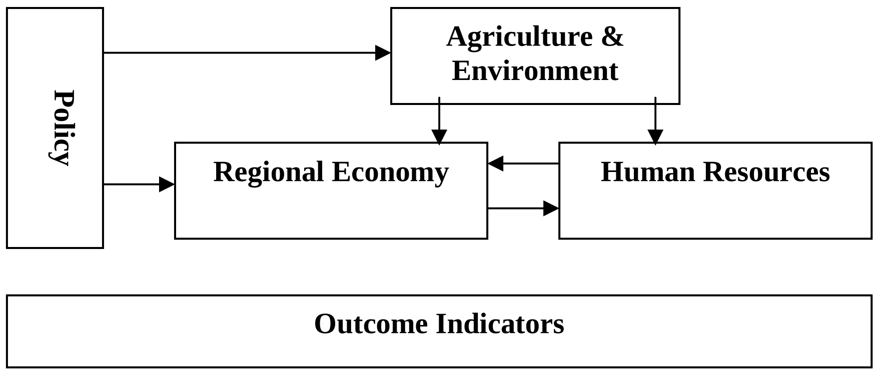
Linear programming (LP) can constitute a tool for economic analysis of agricultural policy, as it takes into consideration relationships between farm resources and agronomic constraints as well as synergies and competition amongst production activities (Hazell and Norton, 1986) in the context of an economic optimization process. Whilst its limitations are well-known, this technique has proved to be quite robust on the analysis of policy impacts on land uses (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). Also, 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 and Mitchell, 2003; Pacini *et al.*, 2004; Acs *et al.*, 2010).

Here, 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. Furthermore, this tool also allows the specification of environmental indicators related to different land uses and farming systems.

Considering that LP and IO analysis determines 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 that 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 and Ruth, 2001).

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

Figure 1: Structure of the model



The system dynamics model of this study is built on Stella software (ISEE, 2007) and 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[iii]. The model is demand driven for regionally produced goods and services, including consumption by households. Unlike many economic models, it is also partially supply-oriented in terms of its agricultural subsystem. Specifically, policy changes affect the optimal allocation of land uses which in turn generate changes in the supply of the agricultural commodities and non-commodities, agricultural income and agricultural employment. The integration and link of the effects of this optimal allocation into the regional economy through the input-output model reflects the 'supply driven' nature of agriculture.

In detail, optimal land use determines the agricultural labour needs through the use of labour/land coefficients. It also determines agricultural production of private goods and farm income, but also the production of public goods which are measured through environmental indicators. The Agriculture subsystem links to the Regional Economy subsystem through farm 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.

Estimates on study area population by age cohorts is obtained by integrating births, deaths and ageing, while labour supply is determined by the population and the labour force participation rates through the assumption that people over 65 years do not participate in the labour force. Migration (in or out) is induced in response to regional labour demand (both agricultural and non-agricultural determined by the LP and IO analysis) relative to labour supply. The Human Resources subsystem links to the Regional Economy subsystem for the imposition of a labour constraint in production level as described below.

3.3. Application: Model subsystems

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 Johnson *et al*. (2008). 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 is in turn a function of the unplanned change in inventory 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. In the dynamic IO model developed here a labour constraint is imposed on production[iv] by making production equal to the minimum requirements of consumption creating a short lag in production response as labour supply response to new labour demand.

The primary driver of the regional IO model is demand for regionally produced goods and services. Total regional output for a sector is the sum of intermediate outputs and final demand for the products of that sector. Final demand is disaggregated into exports, investment, agriculture's final demand and planned inventory change. The basic equation of input-output analysis in equilibrium conditions is:

$$GDP_{i,1}^{E} = IO_{i,i} * GDP_{i,1}^{E} + C_{i,1}^{P} + EXP_{i,1} + INVEST_{i,1} + IN\dot{V}ENT_{i,1}^{E}$$

$for\ i = 1...s$

where s number of sectors; E superscript indicating that variables are at their equilibrium levels; $GDP_{i,1}$ production in each sector; $IO_{i,i}$ input-output coefficients; $C_{i,1}^{P}$ public consumption; $EXP_{i,1}$ exports; $INVEST_{i,1}$ investment; $IN\dot{V}ENT_{i,1}^{E}$ planned change in inventory in each sector.

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

$$GDP_{i,1}^{E} = IO_{i,i} * GDP_{i,1}^{E} + C_{i,1}^{P} + EXP_{i,1} + ADEM_{i,1} + INVEST_{i,1} + IN\dot{V}ENT_{i,1}^{E}$$

where $ADEM_{i,1}$ 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 and 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 and Leat (1987); Psaltopoulos and Thomson (1993); Tzouvelekas and Mattas (1999); and Ciobanu *et al*. (2004).

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).

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. Taking into consideration that arable crops in Trikala represent almost 94% of utilized agricultural land, it was decided that extensive and intensive local farming systems, as described in section 2, are exogenized from the regional input-output model.

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

$$Z = X_j \cdot \left[Y_j \cdot (P_j + S_{yj}) + S_j \right] - X_j \cdot (LR_j \cdot W + VC_j)$$

$for\ j = 1...n$

where n number of arable crops; Z total gross margin of arable crops; X_j land of arable crops; Y_j yield of arable crops (tones/ha); P_j price of agricultural products (euro/tone); S_{yj} subsidy per unit of product (euro/tn); S_j land subsidy (euro/ha); LR_j employment requirements of arable crops (hours/ ha); W wage (euro/hour); VC_j 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: *{X_j} = {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 its requirements on agrochemical input and water obtained from FADN.

Optimization is subject to a number of constraints concerning resource availability (land, labour), agronomy (rotations), policy (quotas) and demand (contractual agreement). 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. In the literature there is 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 and 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 and 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 and Ledgard, 2001). Even though it is difficult to estimate the leaching of nitrogen to surface or underground water due to the fact that is affected by many factors like 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 and Schäfer, 2008). Therefore, a reduction of nitrogen residuals can be interpreted as reduction of pressure on water quality.

(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:

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

where n number of crops; pi 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 and Marks, 1995). The range of Shannon index values for the nine arable crops of study area Trikala varies between {0-2.2}.

3. The Human Resources Subsystem

The demographic model of the human resources subsystem 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 derived from regional statistics (NSSG, 2005).

4. POLICY SCENARIO ANALYSIS

4.1. 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 under the 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 the improvement of 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 the quality of life in rural areas. All Pillar 2 funding in 2007-2013 and beyond is channelled through Axis 3, while Pillar 1 flows remain at the same levels as in the Baseline Scenario.

Pillar 1 and Pillar 2 spending flows under the alternative scenarios are modelled as follows: (a) Pillar 1 spending is treated as decoupled payments transferred to IO Households sector, while coupled payments (e.g. cotton) are inserted into the LP model; (b) Pillar 2 spending is classified according to the demand it creates for sectoral output. Indicatively, for Axis 1 there are benefits for Construction, Trade and Households (e.g. early retirement), for Axis 2 for Households (eg. Less favoured areas support), while for Axis 3, sectors such as Construction and Services benefit.

4.2. Results

Table 3 presents the initial values of the key variables of the model for the base year 2004. Also, it presents the Baseline Scenario (Scenario 0) policy impacts on agriculture, environment, demographics and regional economy of the study area on selected variables named output indicators.

Table 3. 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

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

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[vi] (Table 3). 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. 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 extensive arable to intensive arable crops results to a significant decline of farm incomes (total gross margin of arable crops fell by 42%, between 2004-2007 due to decoupling) and a decrease of agricultural labour demand by 18%. With respect to environment, farm land reallocation improves the biodiversity index by 14.3%, and the water pollution index decreased 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 aesthetics value.

Despite the significant decline of farm incomes (gross margins) due to the decoupling of Pillar 1 support, the 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 Payments transfers to households (which then increase their consumption) and also by the weak backward linkages of agriculture with the 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 3.

Table 4 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 4). 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. The Shannon index decreases by 15.4% due to the disappearance of some crops (tobacco and sugar beet) 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 seem not to exert any pressure on the regional economy in comparison to the Baseline (Table 4).

Table 4. 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

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) had as a result the increase of extensive arable cropland by 95% in expense of intensive which decrease by 45%. Gross margin of arable crops increases significantly by 18% but this is accompanied by a serious decrease of agricultural employment (by 46%). As for environmental indexes, biodiversity index increases by 97% and water pollution index decreases by 32.2%. Shannon index decreases slightly by 0.4%. Regional incomes increase marginally, 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 that specific 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 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).

5. DISCUSSION AND CONCLUSIONS

The system dynamic approach and the construction of more holistic and integrated models with multi-modelling techniques (LP, IO, demographic model) have resulted in some key findings which can be important in the context of current discussions on the post- 2013 CAP orientation (European Commission, 2010). In terms of the magnitude of effects, the fact that annual CAP spending accounts for only 5.7% of GDP in Trikala, results, as rather expected, into the estimation of rather marginal impacts on the regional economy, with the exception of agriculture, associated with changes in the CAP.

However, results show that alternative CAP prospects generate different impacts, at least in the case of this local economy. The 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 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 maintaining regional GDP, employment and population. With regard 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) and improvement of quality of life. 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 production while environmental subsidies induce further positive effects on the local economy (regional GDP and employment).

To conclude, this analysis has shown that different future orientations for the CAP are associated with different-mixed impacts on agricultural activity, the environment and total economic activity in this area. A reduction of Pillar 1 funds 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.

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[i] 2007-2013 funding concerns planned allocation of funds (planned) and not real spending.
[ii] The system dynamics approach of this paper has benefited from the European Research project 'Towards a Policy Model for Multifunctional Agriculture and Rural Development' (TOPMARD) in which the authors participated as members of the Greek research team.
[iii] System dynamics models are systems of differential equations. Unlike to static economic models in which the equations controlling variables describe their equilibrium levels, system dynamics models describe the processes by which variables change as they tend toward (or away from) their equilibrium.
[iv] The capacity constraint in production is ignored because of lack of data on sectoral capacity and capital purchase coefficients
[v] The optimization is written in GAMS code (Brooke *et al.*, 1998) and for the resolution the CPLEX algorithm was used.
[vi] Optimal crop mix from linear programming model is quite satisfactory and very closed to the observed crop levels, which indicate the validity of the arable sector model for projections.

APPENDIX

Table 1. 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