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Optimal combination of energy crops under different policy scenarios; The case of Northern Greece

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HIGHLIGHTS

- A stochastic and a deterministic LP model is formulated.
- The role of CAP is vital in generated income.
- Imports and cultivated areas are subsidy neutral.
- The regime of free market results in lower income acquired from the potential crop mix.
- Non – financial motivation is a key determinant of the farmers' attitude towards energy crops.

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ABSTRACT

Energy crops production is considered as environmentally benign and socially acceptable, offering ecological benefits over fossil fuels through their contribution to the reduction of greenhouse gases and acidifying emissions. Energy crops are subjected to persistent policy support by the EU, despite their limited or even marginally negative impact on the greenhouse effect. The present study endeavors to optimize the agricultural income generated by energy crops in a remote and disadvantageous region, with the assistance of linear programming. The optimization concerns the income created from soybean, sunflower (proxy for energy crop), and corn. Different policy scenarios imposed restrictions on the value of the subsidies as a proxy for EU policy tools, the value of inputs (costs of capital and labor) and different irrigation conditions. The results indicate that the area and the imports per energy crop remain unchanged, independently of the policy scenario enacted. Furthermore, corn cultivation contributes the most to iFncome maximization, whereas the implemented CAP policy plays an incremental role in uptaking an energy crop. A key implication is that alternative forms of motivation should be provided to the farmers beyond the financial ones in order the extensive use of energy crops to be achieved.

1. Introduction

The role of bioenergy as a means of energy needs satisfaction is an issue widely surveyed by different scientific fields. Given the increasing trend for energy demand in the European Union (EU), the mitigation of greenhouse gas effect asks for further use of environmental friendly energy sources in order to diminish the dependency on fossil fuels. The reduced foreign energy dependence along with the improved rural economies and the achievement of environmental goals are a few of the advantages in the use of bioenergy recorded (Zafeiriou et al., 2014). Within this context, the EU has strongly supported first generation biofuels in the name of energy security however, a number of studies have questioned their positive impact on greenhouse gas emissions (GHG) emission reduction over the last few years. The continuous escalating global agricultural prices along with the indirect land use change and the increasing demand for biofuels resulted in global intensification effects (Deppermann et al., 2016; Grethe et al., 2013). Still, the motives for up-taking energy crops are still active and based on income, income distribution, as well as, the regional development for less disadvantageous countries (Keeney, 2009).

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The major issue arisen from the adoption of energy crops is the indirect land use change that actually has two dimensions. The first is related to food security while the second is the encumbrance in carbon emissions generated by the particular process. In particular, the increasing demand for bioenergy has led to a competition for agricultural land use with food, feed, and fiber production, which affects the GHG emissions through the direct and Indirect Land Use Changes (ILUC). Emissions attributed to land use change are mostly expected to take place outside the EU, where the additional production is likely to be realized at the lowest cost. In the case that this production is realized through the use of additional land, its conversion could lead to substantial greenhouse gas emissions being released given that high carbon stock areas such as forests are affected as a result (Directive 2009/28/EU, 2009).

The EU has confronted climate change and the greenhouse gas effect with different policy measures embodied to two Directives, supposed to be valid until 2020. The first one, the renewable energy directive (RED), has set a 10% target for renewable energy in transport, whereas the second one, the fuel quality directive (FQD), aims at a 6% reduction in the carbon footprint of transport fuels. In practice, these two policy schemes have led the EU countries to subsidize and mandate biofuels to meet the aforementioned targets, provided that they reduce emissions compared to fossil fuels. Both Directives have rules for calculating the direct carbon emissions from biofuels but without considering ILUC emissions. This creates serious problems, since according to calculations in global terms, 15% of the total greenhouse gas emission is attributed to ILUC, while the estimated indirect land-use change emissions from EU biofuel consumption in 2020 are likely to represent a very small share. This share is estimated to 0.1% annually according to the International Food Policy Research Institute dedicated to the analysis of Biofuel policies and land use related policies (IFPRI-MIRAGE-BioF), (E4Tech, 2009).

Bearing in mind the aforementioned framework and EU Directives, the cultivation of energy crops should be in accordance with the principles of food security and the production of renewable resources as a means of mitigating the greenhouse gas effect. The role of income in the adoption of energy crops seems to be vital as energy crops are not conventional crops and entail high risk. Thus, a farmer's decision becomes sensitive to risk as farms do normally behave in a risk averted manner (Zafeiriou and Karelakis, 2016; Alexander and Moran, 2013; Balezentiene et al., 2013; Gómez-Limón et al., 2003; Wallace and Moss, 2002). The objective of the present study is twofold; first, an endeavour is made to determine the most attractive structure of cultivation, including energy crops in terms of income, as well as the selection among sunflower, and rapeseed (irrigated). Second, through the application of linear programming (LP), corn is compared to energy crops in terms of financial returns under five different policy scenarios for the regional unit of Evros in Greece. This study is expected to provide answers for the up-take of an energy crop along with corn and to identify what particularly determines the adoption of an energy crop; the risk as expressed by the EU subsidies *or* the higher net income without including the subsidies?

The remainder of the paper is organized as follows; a literature review on biofuels production and energy crops is presented in Section 2, the third section presents the materials and methods employed. In Section 4 the main results of the study are discussed whereas the final section concludes.

2. Literature review

Until recently, nearly all biofuels have been mainly produced with first generation production technologies based on the cultivation of traditional agricultural commodities including cereals, vegetable oils or sugar crops. Some of the crop types, discussed before, are dedicated energy crops (Bioenergy, IEA, 2009), which are expected to be the main share of future bioenergy supplies. The bioenergy production and the repercussions of indirect land use change, caused mainly by biofuels policies, continue to be an issue of conflict in the international literature. The arguments related to the unintended consequences of production and use of biofuel including other potential economic, social, and environmental impacts, effects on food security, environmental justice, and biodiversity conservation (López-Bellido et al., 2014; Jaradat et al., 2010; De Gorter and Just, 2010).

Energy crops are strongly competed by other more standard uses of farmland, and consequently if profit and ease of provision their product to the market is not an allure for individual farmers, their selection is not an expected result (Mola-Yudego et al., 2014; Panoutsou, 2007). Though the financial reasons are not the sole ones. To be more specific other non financial reasons have been mentioned that attract or repel farmers for the adoption of an energy crop. Some of these reasons are: the ease of management, lack of the appropriate machinery, time that the land should be committed, soil quality issues, a power plant investment-to construct and operate combined heat and power plants that use energy crops as fuel while many others can be mentioned (Glithero et al., 2013; Alexander et al., 2013). Furthermore, farmers' personal preferences play a role on the adoption of energy crops that vary not only between farmers but also with time based on past experience. A perception worth mentioning is the farmer's preference on diverse production systems based on the fact that they become able to utilize more efficiently the niche space of the production system (Havlík et al., 2011). Consequently, reducing resource losses and enhancing environmental performance may well become an achievable target, a useful strategy in the design of novel, sustainable agro-ecosystems (Weih et al., 2014; Malézieux et al., 2009), especially in the case of energy crops. Though, besides the agro-environmental dimension of energy crops, their adoption is the result of interaction among financial returns, along with other higher returns of competing activities. Thus, the increasing price of an alternative crop (i.e wheat) the preceded time period (Chatzinikolaou et al., 2015; Sherrington et al., 2008) may well motivate the selection of an energy crop. According to Villamil et al., (2008), a farmer's decision may also be affected by the dissemination of information on technical and agronomic aspects of cultivation, including also economic returns and contract agreements on energy crops. Currently, a small number of species is used for the production of first generation biofuels.

In the past few years an ample of studies can be mentioned, conducted to develop decision tools for the efficient management of agro-forestry resources (Ballarin et al., 2011). Manos et al. (2013) provide a review of the Information Architecture (IA) tools applied for the assessment of the EU policies in agriculture and environment, analyzing and classifying them according to the policy that they have been applied to and by the impacts that they have been measured. The Multiple Criteria Decision Analysis (MCDA) is a dominant tool in operational research. Applications of MCDA techniques on agricultural sector have been proposed by Romero and Rehman (2003), while among the wide range of different techniques the most suitable ones for agro – forestry resource management as alleged by Elfkih et al. (2009) are the Multiple Objective Decision Making approaches (MODM), due to the necessity for the optimization of several objectives simultaneously for the handling of such problems. Another technique employed by Ballarin et al. (2011) is the multi – period Weighted Goal Programming model for the identification of the optimal land use combinations for the achievement of the simultaneous optimization of two objectives farmer's income maximization and net biomass energy production.

Using a 15-year time period they confirmed a trade-off among the two optimization targets, i.e., high income optimization through the adoption of traditional agricultural crops and the high energy production via intensive wood production.

The corner stone of the use of LP in the field of energy crops is the work by Sherrington and Moran (2010), who used an existing farm scale LP implemented in Microsoft Excel. Rozakis et al. (2013), with the assistance of an integrated model, presented the agricultural supply of biomass with ethanol processing for a Greek region. According to their findings, the economic performances as well as the environmental cost-effectiveness of bioethanol, are affected by the parameters of agricultural policies. Moreover, the agricultural policies aiming to decouple subsidies from production are in favour of cultivation in biomass for energy purposes. In another work, Kremmydas et al. (2011) employed a web based Spatial Decision Support System (web SDSS) for the region of Thessaly, the most significant arable cropping region in Greece, aiming to evaluate selected energy crop supply. The particular methodology used an optimization model to support the decision process, incorporating user input from the web user interface then launching mathematical programming profit maximizing farm models. Land use has been explored using Multi Criteria Decision Making (MCDM) models (Chang et al., 1995) and statistical analysis using Generalized Linear Models (GLM) (Aspinall, 2004). Accordingly, the present study proposes an optimization tool using LP for a disadvantageous and purely rural regional unit, that of Evros located in Northeastern Greece in order to determine the optimal crop mix based on the income criterion under the three policy scenarios implemented within the regime of CAP.

3. Materials and methods

The present manuscript involves the regional unit of Evros and the methodology was employed on data derived from the existing literature. In particular, we formulate linear programming models in order determine the mix of energy crops that maximizes the agricultural income for the region under study. The selection of the mathematic tool implemented, the normative mathematical programming is attributed to lack of efficient data for novel crops such as the energy crops, given that more complex methodology such as positive mathematical programming asks for more observed base data in order to incorporate activities (Arriaza, 2003).

3.1. Data

In this section the data of the model are presented. This model refers to three energy irrigated crops, namely *Helianthus annuus* (Crop 1), *Brassica napus* (Crop 2) and *Zea mays*, (Crop 3). Also, 5 policy tools implemented through CAP consisting different scenarios are studied in Fig. 1.

Two models are employed for the achievement of the objective of the study. To be more specific, LP_1 one is deterministic while LP_2 is stochastic (it includes a noise factor in demand and in price of the crops used). The parameters of the two LP models including the net profit, the area cultivated the variable cost as well as the upper bound area, the price, the fertilizer, and the quantity of irrigation water as well as demand (constraints) are employed in order to determine maximum profit that is provided by the particular area and imports. The values of the parameters in the two aforementioned models are presented in Tables 1–3, while Fig. 2 illustrates the values of the noise factor employed in the second model. What has to be mentioned in the particular case is the fact that all the policy scenarios have a null impact on net profit and

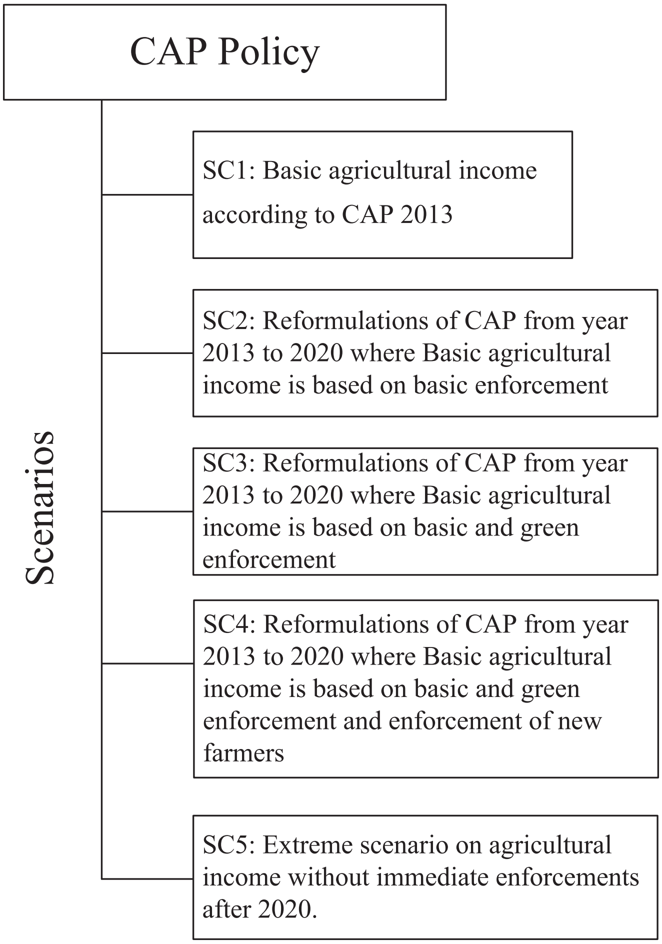

Fig. 1. Scenarios for CAP policy.

Table 1
Net profit(GM_j^{sc}). and variable cost (VC_j^{sc}) of cultivation j (€/ha).

	Sunflower	Rapeseed	Corn
Net profit	120	120	222.3
Variable Cost	56.2	95.92	150.7

Table 2
Subsidy of cultivation j (€/ha) for each scenario sc (S_j^{sc}).

	Sunflower	Rapeseed	Corn
SC1	29.4	29.4	34.3
SC2	22.5	22.5	22.6
SC3	40.2	40.3	40.4
SC4	45.8	45.9	45.1

Table 3
Parameters of the study, area upper bound, price, fertilizer, water and demand for each cultivation j.

	Sunflower	Rapeseed	Corn
A_j^U (€/ha)	150,000	55,000	170,000
p_j(€/kg)	0.4	0.37	0.18
F_j(kg/ha)	25	20	72,4
W_j(kg/ha)	1,323,591.5	1,564,244.5	1,564,244.5
D_j(kg×10^8)	1.8	1.8	1.8

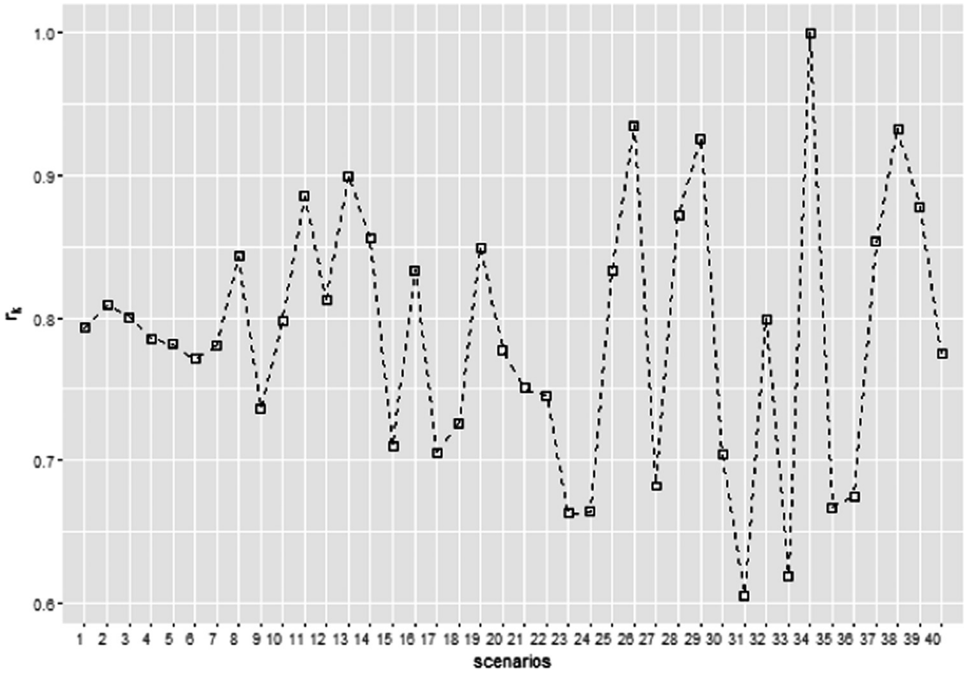

Fig. 2. Values (probability) of noise factor (r_k).

variable cost of every energy crop used in the present study. Furthermore, Tables 2 and 3 present the alternative values of the parameters used in the model for each different scenario.

3.2. Mathematical formulation

In order to derive the optimal area of each cultivation ($j = 1, \ldots, n$), as well as, the products derived, the following Linear Programming model is proposed. The model is formulated with objective function (1) and constraints (2) – (9). The objective function (1) provides income as a function of net profit, cultivation j (GM_j), subsidy of cultivation j (S_j) and variable cost of cultivation j (VC_j). Furthermore, the last term denotes the revenue that consists of price of each product derived by cultivation j and the corresponding quantities (Q_j).

Model LP1

$$max\ Income = \sum_{j=1}^{n}\left[\left(GM_j + S_j - VC_j\right)\cdot A_j + p_j\cdot Q_j - M\cdot I_j\right] \tag{1}$$

s.t.

$$A_j \le A_j^U, j = 1, .., n \tag{2}$$

$$A_j \ge 1, j = 1, .., n \tag{3}$$

$$\sum_{j=1}^{n} A_j \le \max_j\left\{A_j^U\right\} \tag{4}$$

$$\left(F_j + W_j\right)\cdot A_j \ge \beta_j\cdot A_j, j = 1, \ldots, n \tag{5}$$

$$Q_j = \beta_j\cdot A_j, j = 1, \ldots, n \tag{6}$$

$$Q_j + I_j = D_j, j = 1, \ldots, n \tag{7}$$

$$Q_j \ge 0, j = 1, \ldots, n \tag{8}$$

$$A_j \ge 0, j = 1, \ldots, n \tag{9}$$

In the LP model presented above, optimal values for cultivation area are restricted by the available land; constraint (2) imposes an upper bound restriction (A_j^U) on the area of cultivation j (A_j). In order to ensure that all cultivations will be used, a lower bound to the area of cultivation j (A_j) is set to 1 *ha* as illustrated in constraint (3). Total cultivated area must be less than the maximum available area as in constraint (4). Constraint (5) models the productivity procedure that takes place since each cultivation needs specific amount of fertilizers (F_j) and water (W_j) being linked to the corresponding product; $\beta_j$is a conversion factor linking area and yield of each product. The right hand side of constraint (6) is the quantity produced of each product derived from cultivation j. Demand (D_j) and supply should meet, while variable $I_j$measures any shortfall in demand, capturing the imports that must be brought to get into an equilibrium as in constraint (7). Constraints (8) and (9) state that variables A_j(area of cultivation j) and Q_j(amount of products derived from cultivation j) are non-

Table 4
Results for profit per crop and policy tools implemented scenario (€)$\left(GM_j^{sc} + S_j^{sc} - VC_j^{sc}\right)\cdot A_j^* + p_j^{sc}\cdot Q_j^*$

	SC1	SC2	SC3	SC4	SC5
Crop1	31980000	30945000	33600000	34440000	27570000
Crop2	9046400	8666900	9645900	9953900	7429400
Crop3	48692308	46892308	49630769	50353846	43415385

negative. A penalty factor (M) is assigned to shortfall variable I_j, where $M$is a very large positive number ($M >> 0$).

In land use policy, several scenarios are examined regarding net profit, governmental subsidy and variable. As prices fluctuate over time, a different representation is introduced for each product derived by cultivation j. Each scenario is introduced in LP$_1$ model as follows:

for $sc = 1, \dots, E$

$$Income = \sum_{j=1}^{n}\left[\left(GM_j^{sc} + S_j^{sc} - VC_j^{sc}\right)\cdot A_j + p_j^{sc}\cdot Q_j - M\cdot I_j\right] \tag{10}$$

s.t.
(2)–(9)
end for

In model LP$_1$, a new index (sc) has been introduced in order to model the different policies that are reflected over objective coefficients. The problem is solved iteratively for all scenario representations. The notion behind introducing scenarios in the objective coefficients (policies) is to derive conclusions as to how policies affect the cultivation area and products for each cultivation j.

Finally, in order to further analyze the fluctuation of prices, a "noise" factor (r_k) is introduced in the second term of objective function ($p_j^{sc}\cdot Q_j$), indicative of the stochastic process that the prices follow. Also, this stochastic process characterizes the behavior of demand therefore in order to model demand fluctuations a noise factor is introduced in constraint (12). The new LP (model LP$_2$) is formulated as follows:

Model LP2
for $sc = 1, \dots, E$
for $k = 1, \dots, K$

$$max\ Income = \sum_{j=1}^{n}\left[\left(GM_j^{sc} + S_j^{sc} - VC_j^{sc}\right)\cdot A_j + r_k\cdot p_j^{sc}\cdot Q_j - M\cdot I_j\right] \tag{11}$$

s.t.
(2)–(8)

$$Q_j + I_j = r_k\cdot D_j,\ j = 1, \dots, n \tag{12}$$

end for
end for

In objective function (11), r_k is a value drawn from uniform distribution as follows:

Step 1: Assuming that there is an array (g_k) of continuous numbers from 0 to 0.4 with incremental increase of 0.01 ($g = 0.001, 0.002, \dots, 0.39, 0.4$).

Step 2: The probability of randomly drawn numbers from uniform distribution is the following:

$$r_k = \frac{U\left[1 - g_k, 1 + g_k\right]}{\arg\max_k\left\{U\left[1 - g_k, 1 + g_k\right]\right\}},\ k = 1, \dots, E$$

4. Results - discussion

In this section, the results concerning alternative profit of the proposed models (model LP$_{1,}$ and model LP$_2$) are presented in

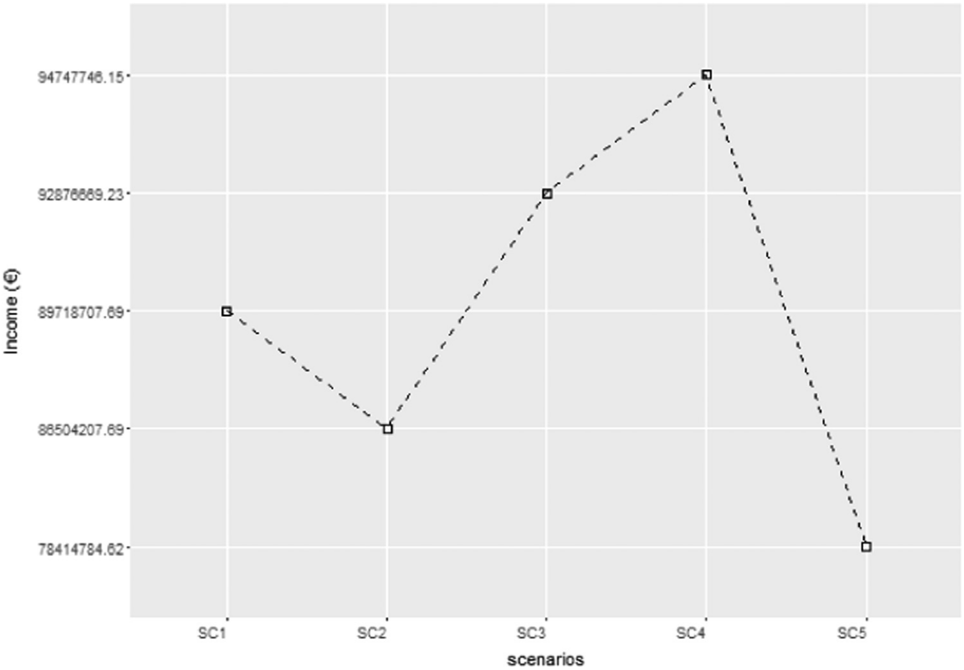

Fig. 3. Income for all crops per CAP scenario *sc*.

Table 4 and for all the estimated model parameters are visualized in Figs. 3–8. In each of the two models, decision about solutions of area (A_j), imports (I_j) and agricultural income (*Income*) are presented analytically for each model and each policy scenario in the following paragraphs.

4.1. Model LP_1

The results of the study indicate that the area per energy cultivation remains unchanged, independently of the policy scenario enacted. This means that the policy tool imposed does not affect the energy cultivation area per scenario. Therefore the aforementioned public interventions do not motivate the farmers to change the structure of the crop mix initially selected. The particular result implies that different type of measures for instance risk limitation through insurance that is probably the best known risk pooling tool. Furthermore, regarding the imports per each energy crop, the CAP policy financial tools seem to have a no effect. The exception is the regime of free market (last scenario), under which the quantity of imports is equal to zero, thus the production satisfies the demanded quantities for each energy crop. This result implies that in case no financial assistance is provided the domestic supply may well be adequate for the domestic demand under the same restrictions valid in the local economy. Finally, as can be seen in Fig. 3, the first two examined scenarios seem to provide approximately the same income (88111457.69€); scenarios 3 and 4 improve income while the lowest value for income is reported for scenario 5 under conditions of free market without any form of policy intervention. The implementation of green aid seems to be an effective policy tool for the promotion of energy crops, a result that is in line with that of (Rozakis et al., 2013) regarding the positive impact of policy..

The low values of rights for the regional unit of Evros and given that the mean value is lower than the mean value in Greece under the regime of direct payments in 2013 results in expectations for the majority of the farmers for an increase in their revenues until the mean value of the rights reach 60% depending on the periphery they belong. This fact provides a reasonable interpretation for the increase in farm income validated with the new CAP 2013-2020.

The next Table 4 provides the contribution of each energy crop to total income is shown per policy scenario and per cultivation. According to our findings, the sunflower presents the lowest income values while for the case of rapeseed presents the largest values are estimated. In the scenarios examined, the largest income value per energy crop is estimated for scenario 4 (SC4) while the lowest income is confirmed for scenario 5 (SC5) as already illustrated in Fig. 2. Thus, the financial assistance seem to play a major role in income generation for the case of energy crops but as already mentioned above is not a determinant for their selection that may well lead to indirect land use change.

4.2. Model LP_2

Concerning the second model, two different sub-scenarios are examined the one concerns the impact of the implementation of policy tools on income (financial assistance), of each energy crop (*sc*) and the second is related to the price and demand(*k*) fluctuation as synopsized in the noise factor (r_k). As evident according to the results LP2 the cultivation area is not changing per policy scenario (*sc*) and noise realization (*k*) for energy crops 1 and 2. This result implies that neither financial assistance nor shocks in the market (price or demand fluctuation) seem to be effective in area cultivated with energy crops. Apparently, the impact of financial motivation is extremely limited according to our results and therefore alternative policy tools should be selected in order to motivate the adoption of energy crops. These tools are parts of an entity aiming to the provision of public goods that may be environmental as carbon storage and climate stability or social such as food security or rural vitality (an important public good for our case). Measures of this type with different grade of impact on delivery of public goods in agriculture worth mentioned are the following; Measures with direct impact on environmental goods such as Life+ (Agriculture focused projects), Structural Funds

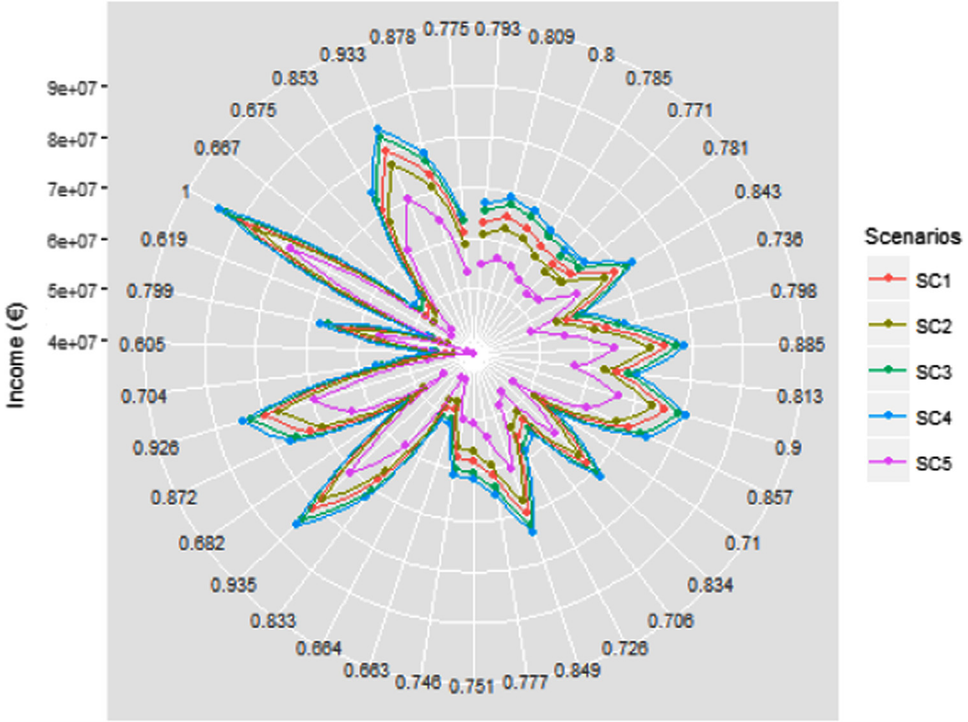

Fig. 4. Income per scenario *sc* and each noise realisation scenario *k* for all examined crops.

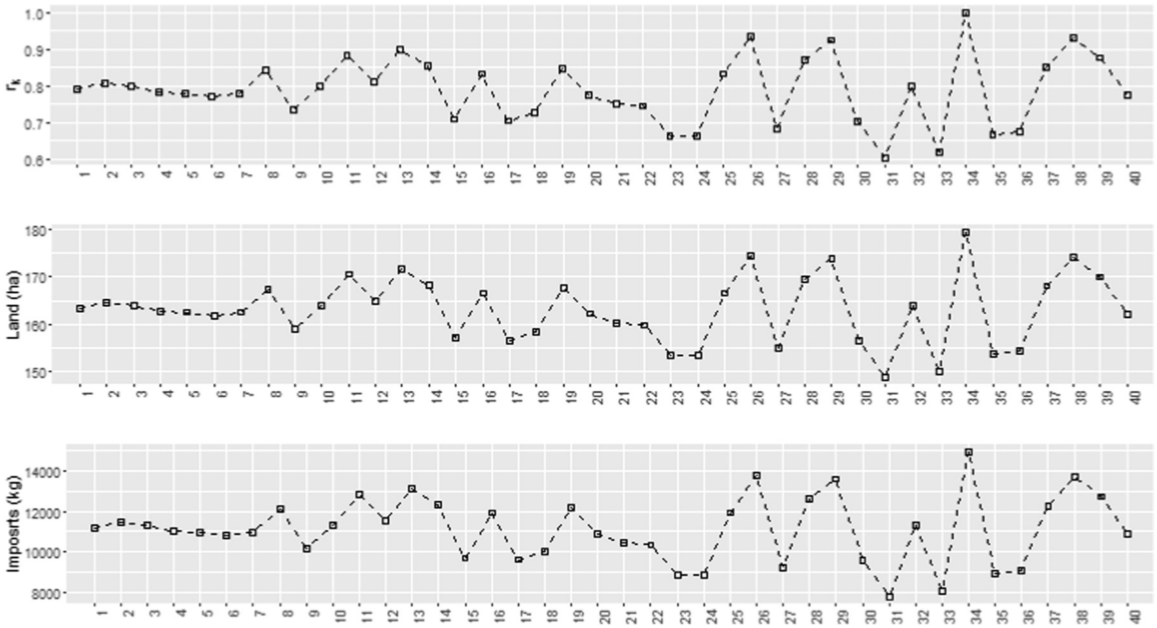

Fig. 5. Noise factor (r_k), values for land (A_j^*) and values for imports (I_j^*) for each noise realization scenario k.

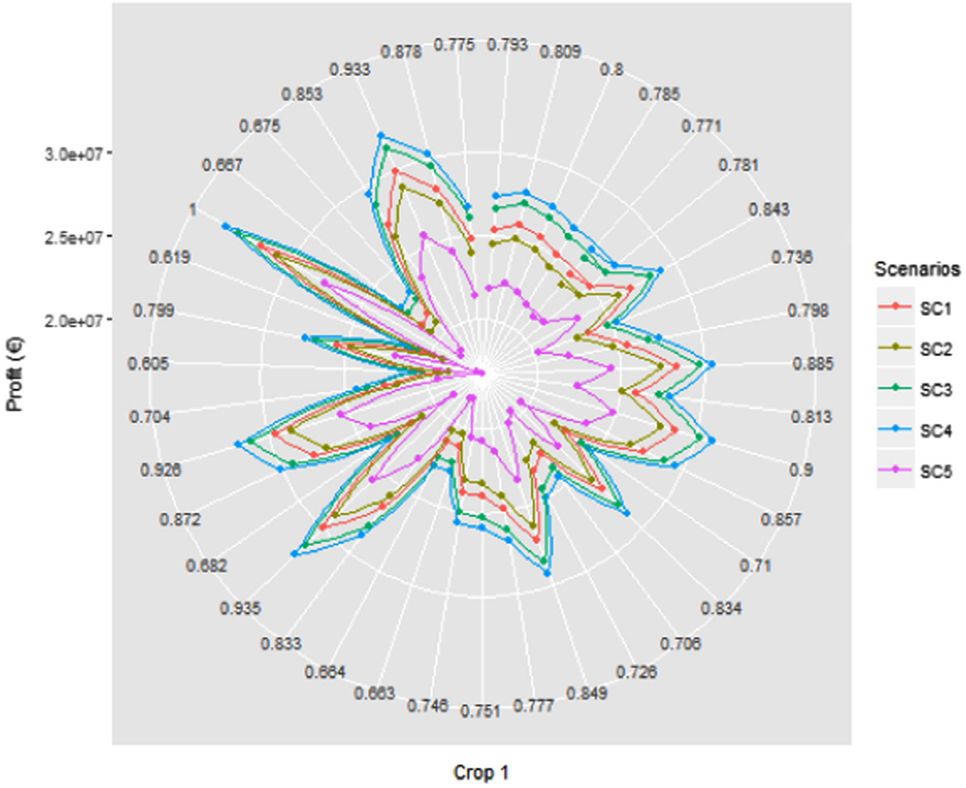

Fig. 6. Results for profit per crop, scenario and noise realization for Crop 1 $(€)\left(GM^{sc}_{j=1}+S^{sc}_{j=1}-VC^{sc}_{j=1}\right)\cdot A^*_{j=1}+r_k\cdot p^{sc}_{j=1}\cdot Q^*_{j=1}$.

(Projects aiming at the preservation of the environment), measure with a partial focus on delivery of public goods as for instance farm modernization, Advice and training measures, and finally measures with no direct impact on delivery of public goods such as Diversification.

On the other hand for the case of corn sensitivity per realization and not per policy implemented is confirmed. Thus the financial assistance provided to young farmers adopting environmental friendly practices along with the basic subsidy may have an impact on the area covered by the particular cultivation. The particular result may well be attributed to the fact that corn is not a dedicated energy crop but also serves as a food. Furthermore, demand fluctuations as synopsized in different values of the noise factor show that there is no balance between supply and demand for the energy crops therefore imports are a necessity to satisfy the current demand. The import quantity seem to be unrelated to the policy scenario enacted. On the other hand, the demand is satisfied per each noise realization for the corn. Therefore, equilibrium in the local corn market is validated, though the results are not similar for the case of other energy crops. Furthermore, based on the

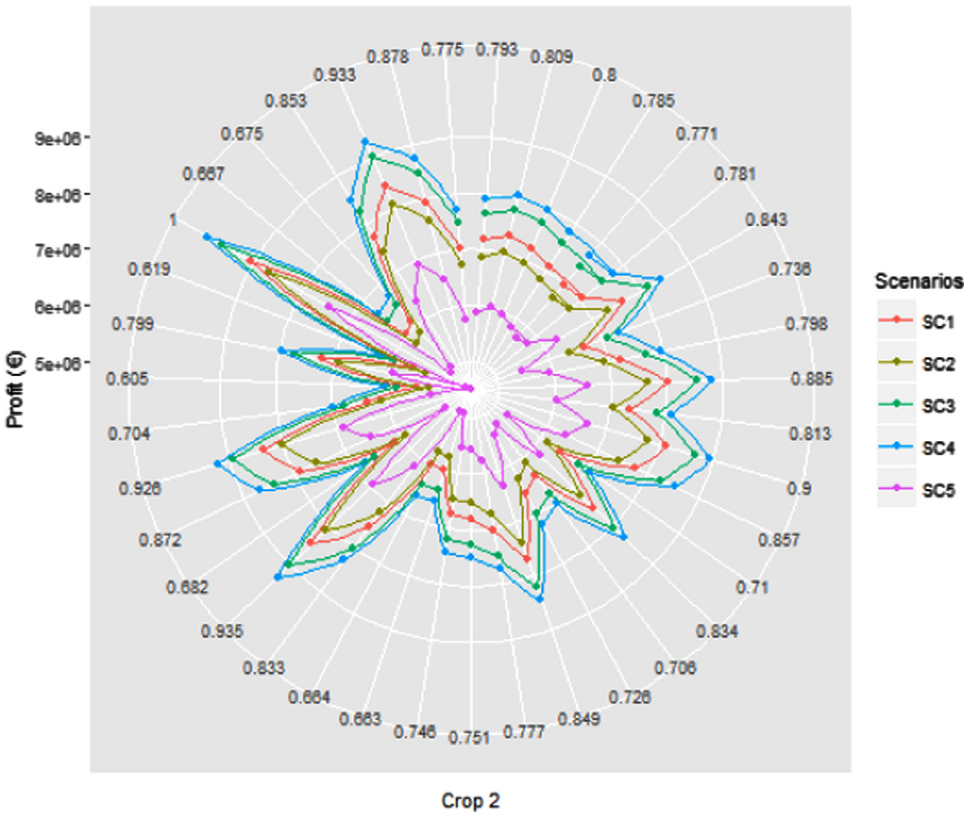

Fig. 7. Results for profit per crop, scenario and noise realization for Crop 2 (€)$\left(GM_{j=2}^{sc}+S_{j=2}^{sc}-VC_{j=2}^{sc}\right)\cdot A_{j=2}^{*}+r_k\cdot p_{j=2}^{sc}\cdot Q_{j=2}^{*}$.

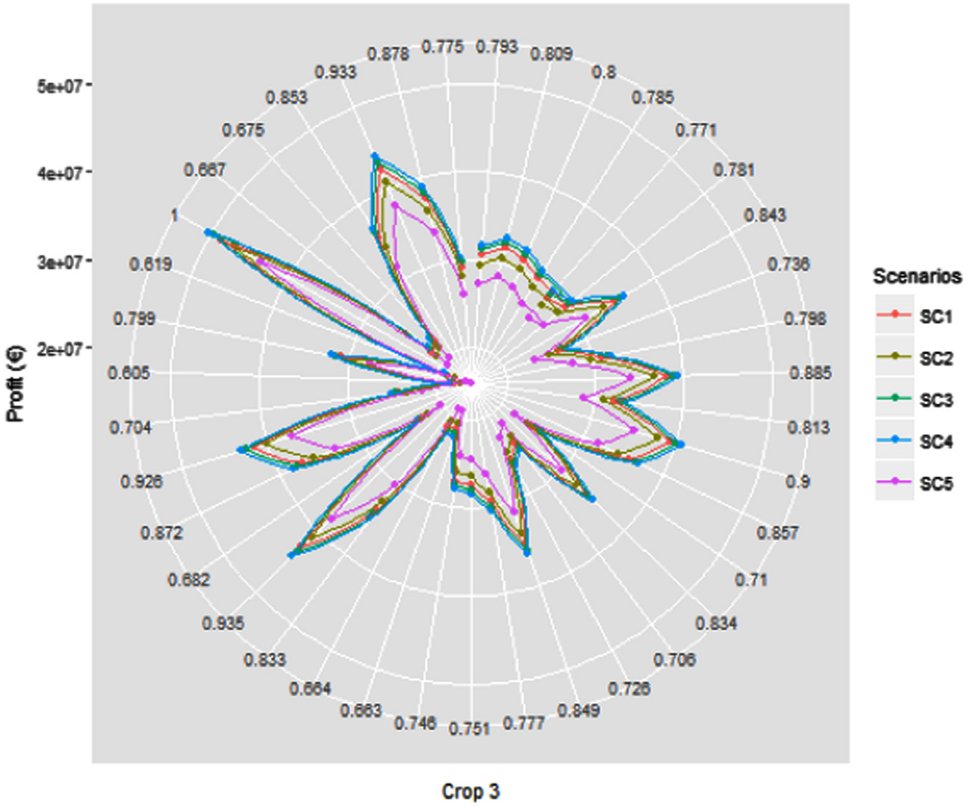

Fig. 8. Results for profit per crop, scenario and noise realization for Crop 3 (€)$\left(GM_{j=2}^{sc}+S_{j=2}^{sc}-VC_{j=2}^{sc}\right)\cdot A_{j=2}^{*}+r_k\cdot p_{j=2}^{sc}\cdot Q_{j=2}^{*}$.

results of the second model the same results can be concluded.

Fig. 4 depicts the overall score in terms of income per each scenario and noise realization. According to the results illustrated in Fig. 4, highest income is recorded when noise realization is equal to 1 (100%) and for all noise realizations (k), policy scenario SC4 provides the largest value. This result gives us the impression that the particular policy scenario is the only one that may have a positive impact on income but the results are not clear concerning the area covered by each crop or the imports needed to satisfy the domestic demand. In Fig. 5 the probability of noise factor (r_k) along with the aggregated values for land variable (A_j) and for imports variable (I_j) for each noise realization scenario $k$derived from model LP2. It is concluded that both variables are driven by stochasticity as both line plots (for area and imports variable) follow the same line with noise factor.

When decomposing the results per each CAP scenario and each noise realization scenario, the results imply limited impact of the existing policy measures, in the form of financial assistance, to the development of the crop mix; this may well result in income maximization particularly in the case of energy crops. The results for profit per crop and noise realization are demonstrated in Figs. 6–8 providing an overview of the contribution of each crop taking into account the impact of stochasticity. Both the deterministic and the stochastic models converge to the same result.

Implicitly, both models validate the impact of financial assistance on income generation but certainly not to land use distribution while under free market conditions no income motivation seem to be confirmed for energy crops with exception that of the conventional crop used in our study.

Energy crops may well replace the conventional crops less if they are becoming a profitable choice but more if other measures that promote the provision of public goods either environmental or social are taken. Furthermore, it can be a wise choice for low productivity areas. Finally, it can be a profitable substitute for crops cultivated in fertile soils and irrigated areas, namely corn (Papadopoulos et al., 2015). Dedicated energy crops may well replace and support the farm income in cultivations with high rights' value and with the CAP reforms 2013–2020 that expected to reduce the direct aids while they can be used as a second cultivation from the farmers and to fulfill the conditions of the green subsidies in less fertile soils and irrigated areas in order the problem of dissertation to be eliminated. Furthermore, perennial non-food crops are suggested for the region as well as for the entire EU given their suitability for a wide range of climate and agronomic conditions. Though the farmers' final decision is determined by a number of factors including soil conditions, climate conditions, particularities of the farmer (past experience, personal preferences) communication between individuals as well as knowledge on new technologies.

Finally, there are two parameters of the problem under review that have not been mentioned above. First the development of biofuel second generation technologies appropriate for lignocellulosic energy crops, which are alleged to contribute in a positive way to sustainability in biomass production. Despite their advantages in terms of economic and agronomic aspects the long rotation period may lead to significant changes in the existing land use. Second, in order to meet the targets set by the EU, a member state should use biofuels with high greenhouse gas savings demonstrated by rigorous life cycle assessment (LCA) (Weih et.al, 2014).

5. Conclusions – policy implications

The present paper aims to assess the impact of different policy tools implemented by the CAP on the mix of energy crops as formatted in a remote and disadvantageous area. Two LP models were employed; a deterministic and a stochastic one that reflects fluctuations on prices and demand. Similar results are taken from both models while the existing financial tools seem to be ineffective in land allocation despite their income impact.

A combination of financial and non-financial measures have to be taken, aiming at changes in the farmers' perceptions on energy crops. Food security should be a priority, along with energy production based on renewable resources, since the increasing demand for energy and for food is a reality. Especially, in a country that goes through a severe crisis, the financial issue seems to be vital for the adoption of the energy crop. Furthermore, the selection of an energy crop should be based not only on the criterion of increasing renewable energy production, but also on increasing the production of agricultural products used for food in order their increasing demand to be satisfied within the next decades.

The results of the present study should be considered within the context of the limitation that it does not take into consideration time specific conditions of the location, given that it is focusing only on financial motives. Therefore, a possible avenue for future research may financially compare the first and second generation biofuels for a disadvantageous area. Moreover, a quantitative survey may assist the investigation of the farmers' perception on non-financial motivation measures for the adoption of an energy crop. The particular issue could be a subject of future survey in order a global perception of farmers motivation to be formatted.

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