CAP regionalization scheme in Greece: A rapid policy assessment method

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Paper prepared for presentation for the 162nd EAAE Seminar
The evaluation of new CAP instruments: Lessons learned and the road ahead

April 26-27, 2018
Corvinus University of Budapest
Budapest, Hungary

Abstract: The last CAP reform provides Member States the option to apply the Basic Payment Scheme in finer scale than the national level, termed hereafter as regionalization. We use a farm model that represents almost 90% of the Greek commercial farms for evaluating a wide range of regionalization scenarios. Exploratory Data Analysis is used to get insights from the model results. More specifically we compare the general features of four different types of regionalization schemes, namely a single region, an agronomic based, an administrative based and a hybrid administrative-agronomic regionalization. We also perform a trade-off analysis of selected pairs of policy objectives, e.g. the uniform basic payment unit value vs. the political acceptability, etc.

Keywords: CAP; regionalization; farm model; exploratory data analysis

Introduction

The last CAP reform provides Member States (MS) the flexibility and the discretion to modify the Basic Payment Scheme (BPS) which accounts for over 50% of the Pillar I budget. In so doing, Member States, inter alia, can opt to apply BPS in finer scale than the national level, termed hereafter as regionalization

In the *Direct Payments* regulation (1307/2013), Article 23(1) notes

> *Member States may decide, by 1 August 2014, to apply the basic payment scheme at regional level. In such cases, they shall define the regions in accordance with objective and non- discriminatory criteria such as their agronomic and socio-economic characteristics, their regional agricultural potential, or their institutional or administrative structure.*

Thus, MS can differentiate the unit value of the basic payment (BP) on the basis of national, agronomic or administrative regions that have been defined at the beginning of the programming period. Policy assigned *regionalization regions* (RR) can coincide with administrative or geographic regions but can also be not related to them, such as the case of agronomic criteria where a region is defined on the basis of specific crop areas (e.g. arable or permanent crops). Hence, *regionalization regions* may represent a broader category than administrative or geographic regions and shall not be confused with them.

Six MS (Germany, Greece, Spain, France, Finland and United Kingdom) have regionalized BPS while the rest have applied a uniform national BP unit value. Among the former only Greece has used a purely agronomic criterion while the rest used administrative regions (Henke et al., 2015).

Regionalization can facilitate individual MS policy targets. For instance MS can compensate for disadvantages of specific areas or type of farming by granting them increased BP unit. Also a smooth transition to a national uniform unit value can be accomplished by setting higher unit values for areas or crops that historically received higher subsidies

We use a farm model that represents almost 90% of the Greek commercial farms to run multiple regionalization scenarios. The use of farm models for modeling the new CAP architecture is relevant, especially in the case where farm choices are affected by the employed policy instruments (Moro & Sckokai, 2013). In our case the reallocation of the CAP budget can indirectly impact farm choices by affecting the available working capital. Based on the obtained results, we perform an exploratory data analysis of the general features of the four regionalization scenario types. We also consider a trade-off analysis between the uniform basic payment unit policy goals vs. the preservation of the unit value status quo in order to minimize envy.

The contribution of this paper is threefold. First, it provides a dense and structured conceptual approach for policy analysis of the regionalization schemes, in the sense that a broad range of regionalization scenarios were considered instead of ad hoc "experts' opinion" scenarios. Second, by so doing, the policy design and its assessment is transparent and comprehensive, hence appealing for a broad consultation procedure of the involved agents. Finally it can be extended beyond the current CAP payments regionalization debate, by incorporating parameters describing the different intensity of land use and practices.

Material and methods

The evaluation framework

An overview of the evaluation framework is given in Figure 1. Firstly we build a mathematical programming farm model which represents the 2003-2013 regime, named hereafter as CAP-DECOUP. In turn it is extended to a new model compatible to the 2014-2020 period, termed hereafter as CAP-SFP model. For this latter regime, where the regionalization scheme is applicable, certain alternative regionalization scenarios with many different budget allocations are examined. For each one of them the CAP-SFP model is run and performance indexes of the stated policy goals are recorded. The evaluation method proposed can be easily applied to any regionalization case study as far as the policy goals and their metrics have been defined beforehand.

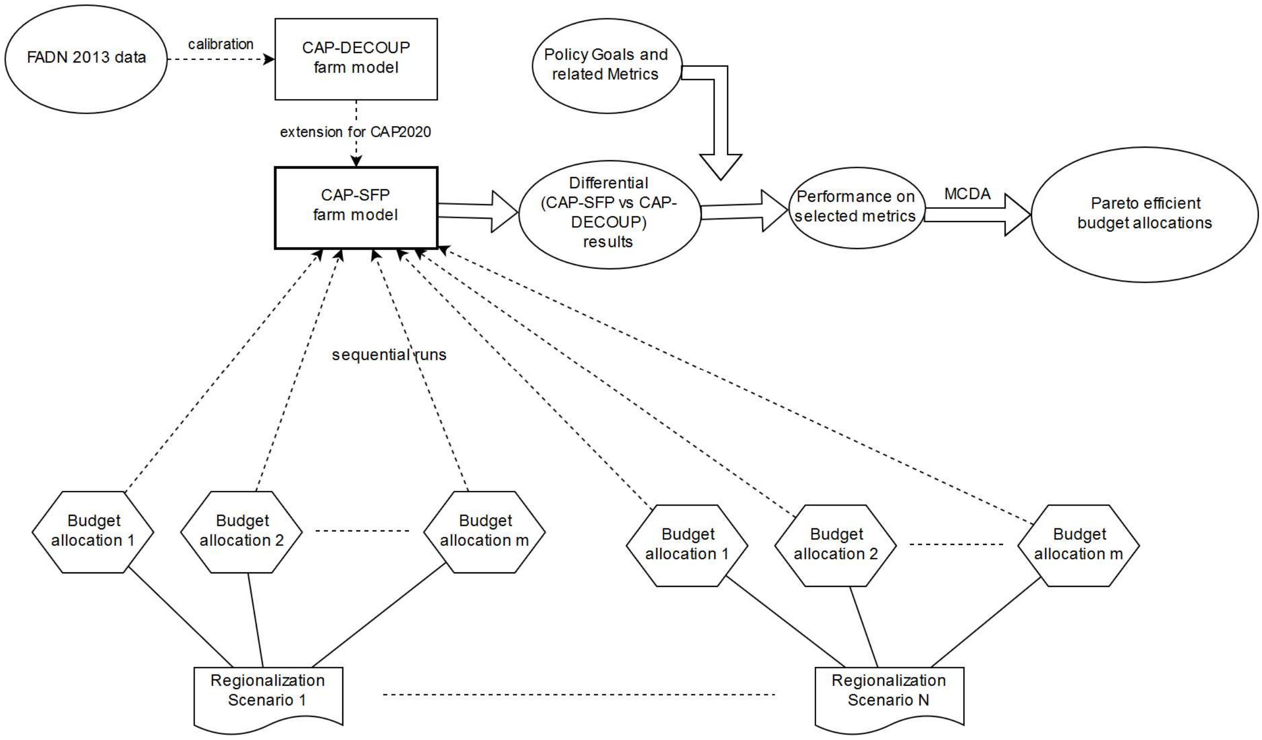

Figure 1, overview of the evaluation method

The farm model

We build a baseline decoupled payment (CAP 2003-2013) farm model where each farm selects an activity plan to maximize their gross margin (eq. 1). Vector c^T contains the gross margins for one hectare of selected activities and vector x is the selected areas (ha) of activities. Farm is also subject to certain constraints (eq. 2) where matrix A contains the resources needed for one unit of an activity and vector b contains the available resource for each constraint. We have modeled the following constraints: total land; irrigated land; labor availability; working capital constraint; farm decision space; permanent crop fixed area; livestock fixed activity; crop rotations; contract crops flexibility constraints; maintain share of main crop flexibility constraint; low-profile crops flexibility constraint. We provide the detailed algebraic form of the model in the Appendix.

$$\max c^T x \quad (1)$$

$$s.t\ Ax \leq b \quad (2)$$

A core assumption of the model is that subsidies are partially or fully channeled to cover working capital requirements. Working capital demand and supply at the farm level, annotated with FADN codes, is depicted in Figure 2

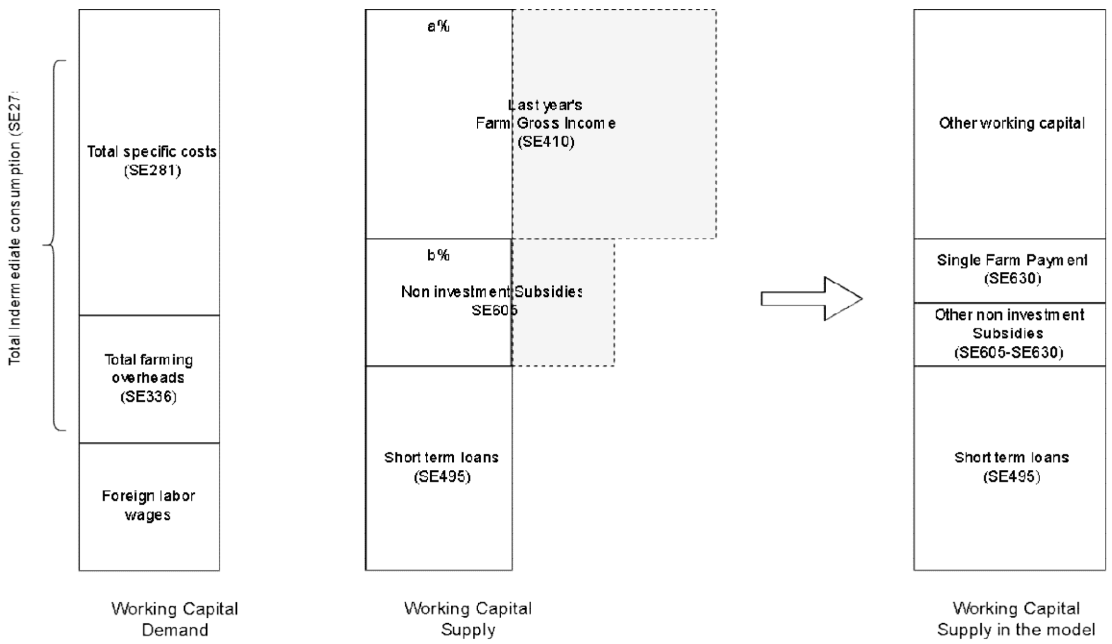

Figure 2, Working capital definition (in parentheses the FADN standard result variable codes)

Total specific costs plus any farming overhead plus any foreign labour wages shall be covered by a share of last year's farm gross income plus a share of subsidies (including direct payments) plus any new short term loans. There is no data on a% and b% shares (see Figure 2). Thus we assume that all received subsidies are used to cover working capital requirements. We also calculate the share of the previous year's gross margin that is used to cover working expenses, named *other working capital*, subtracting short term loans and received subsidies from the total required working capital of the observed crop plan. For the rest of the simulation *other working capital,* *short term loans* and *other non-investment subsidies* are considered to be fixed for each farm. *Single farm payment* can vary across simulations according to the regionalization scenario employed and thus can affect the working capital supply.

The above assumption, although not accurate, provides a good approximation of the contribution of subsidies to the working capital supply. This contribution is essential in the Greek case where the credit system is malfunctioning after the 2009 crisis. Also personal communication with field experts supports the argument that subsidies are a prime source of farm liquidity. Furthermore, as shown in Figure 3, subsidies are an important percentage of gross margin and its total value is comparable to that of intermediate consumption and foreign labor wages. Reducing subsidies, although potentially can be covered by diverting gross margin from family farm consumption demand to working capital demand, will create a short-term credit strain to the farm.

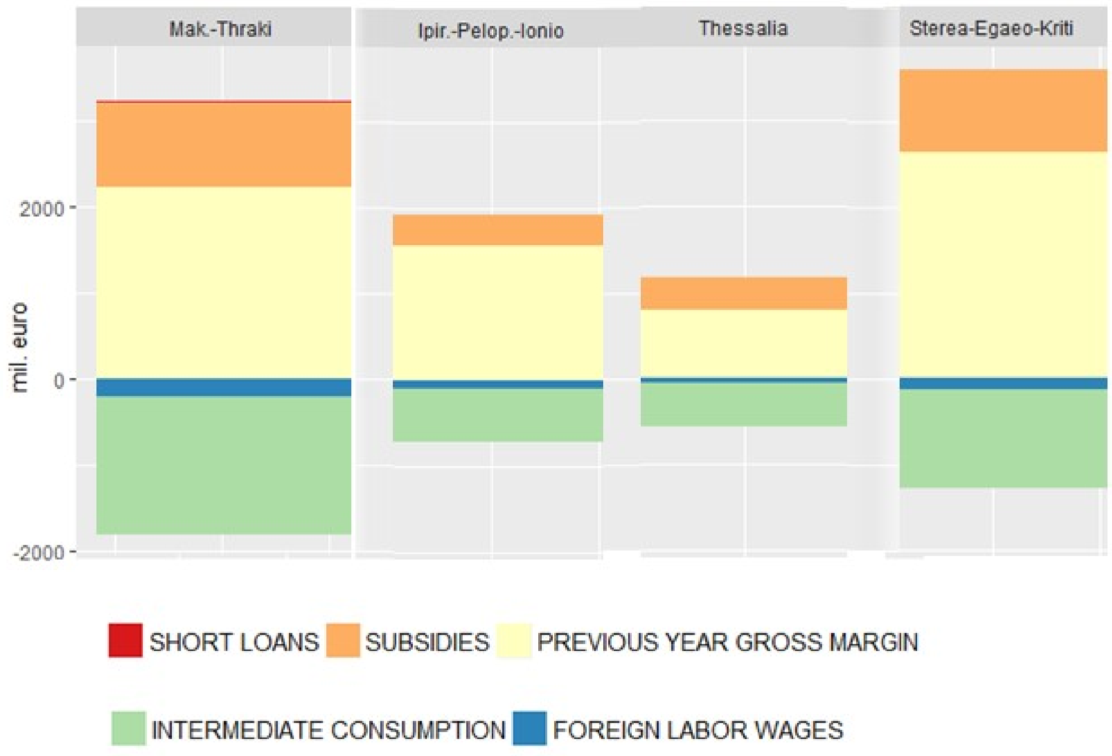

Figure 3, Aggregate weighted demand and supply of working capital in FADN regions

Next we extend the baseline CAP-DECOUP model to represent the new policy architecture. For the extended CAP-SFP model:

(a) We replaced the single payment element with the new Single Farm Payment that equals the sum of the basic payment, the greening payment and the natural constraint areas payment (NCAP);

(b) We augment the baseline model with the greening constraints (95% and 75% crop diversification and ecological focus areas) and assume that all farmers will choose to comply to those in order to receive the corresponding payment;

(c) Since we consider that permanent crop and livestock activities remain constant, the required working capital for those activities is inelastic and the reduction of direct subsidies, which is used for covering working capital requirements, may introduce infeasibilities in the model. Thus we transform working capital constraint by inserting a PC_f^{EXCESS} variable that represent the extra working capital needed for maintaining the same permanent crops level of production. The variable is also inserted in the gross income objective function with an extreme negative coefficient (PC^{GM}).

Modeling regionalization

There are three types of regionalization scenarios, based on how regionalization regions (RR) are defined.

- RRs are administrative-based partitions (e.g. prefecture-based) or socio-economic related partitions (e.g. mountainous vs. non-mountainous areas). The distinctive feature in this case is that each farm is related with only one RR. The farm's basic payment unit value (BPUV) equals to the RR basic payment unit value that the farm belongs to (Eq. 3).
- RRs are agronomic based partitions (e.g. Arable vs. Tree crops). In this case farms can be related to more than one RR, e.g. half of farm area is connected to arable RR and the other half to tree RR. The farm's BPUV equals the average of each agronomic region (agronomic=crop) basic payment unit value weighted by the share of each crop area to total farm area in a reference year, as in Eq. 4.
- RR definition is a hybrid case of the previous two cases. For example when the RRs are mountainous vs. non-mountainous arable crops vs. non-mountainous permanent crops. Then the farm's BPUV is like the second case but the agronomic basic payment unit value can differ from one farm to another, as in Eq. 5.

In order to clarify the above cases and the related mathematical formulation, we provide an illustrative example in appendix B.

administrative-based regionalization

$$BP_f^F = BP_{r(f)}^R \quad \forall f \qquad BP_r^R = BP_r^{BUDGET} \Big/ \sum_{f(r)} TL_f^E \tag{3}$$

agronomic-based regionalization

$$BP_f^F = \frac{\sum_g \sum_{c(g)} \left(BP_g^R \cdot X_{f,c} \right)}{TL_f^E} \qquad BP_g^R = BP_g^{BUDGET} \Big/ \sum_{c(g)} \sum_{f} X_{f,c} \tag{4}$$

Combined regionalization

$$BP_f^F = \frac{\sum_g \sum_{c(g)} \left(BP_{g,r}^R \cdot X_{f,c} \right)}{TL_f^E} \qquad BP_{g,r}^R = BP_{g,r}^{BUDGET} \Big/ \sum_{c(g)} \sum_{f(r)} X_{f,c} \tag{5}$$

where BP_f^F: Basic payment unit value applicable to farm-f (euro/ha)

BP_r^R: Basic payment unit value applicable to administrative region-r, where $r(f)$ is the region of farm-f) (euro/ha)

BP_r^{BUDGET}: The Basic Payment budget for region-r, where $f(r)$ is the set of farms that belong to region-r (euro)

$BP_{g,r}^R$: Basic payment unit value applicable to agronomic region-g under administrative region-g, where $c(g)$ is the crop-set related to g (euro/ha)

$BP_{g,r}^{BUDGET}$: The Basic Payment budget for agronomic region-g under administrative region-g,(euro)

TL_f^E: Total eligible land for farm-f (ha)

$X_{f,c}^B$: Area of crop-c in farm-f in the reference period (ha)

Therefore the policy-makers options regarding regionalization can be decomposed to the following sequential decisions:

a) the regionalization type, i.e. administrative, agronomic or hybrid
b) the allocation of farms and/or crops to the corresponding RRs (defining $f(r)$ and $c(g)$ sets)
c) the allocation of the total budget to the defined RRs (defining BP_r^{BUDGET}, BP_g^{BUDGET}, $BP_{g,r}^{BUDGET}$)

Regionalization scenarios

In this paper we are examining four regionalization scenario-types (Figure 4):

- A non-regionalization (NO-REGION), where all farms get a uniform basic payment per hectare, i.e. a national flat rate.
- An agronomic-based with three regions, arable crops including fallow land, trees and grazing areas (AGRON). It is comprised of 73 budget allocations; all possible combinations of 5% step that sum up to 100%. For instance S2 combination allocates 90% to crops, 10% to trees and 0% to grazing areas. All allocations that were resulting in a single RR to receive more than 200% of the theoretical national flat-rate were removed.
- An administrative-based (ADMIN) where six regions correspond to an agglomeration of NUTS-2 regions. It is comprised of 141 budget allocations. These are all 5% possible deviations from the national flat rate, which is a budget allocation of 22.4% to *Thessaly and Sterea*, 9.1% to *Epirus & W. Macedonia*, 14.7% to *Peloponnese, W. Greece & Ionian islands*, 29.8% to *Central, Eastern Macedonia and Trace*, 9.1% to *Aegean* and 14.9% to *Crete.* We selected not to examine the full range of budget allocation but rather deviations from the flat rate since a decision with large unit value differences between regions are not politically feasible.
- A hybrid regionalization type (HYBRID) with three regions: all crops of Least Favored Areas (LFA), Arable crops of non-LFA areas and Permanent crops of non-LFA areas. It is comprised of all 231 feasible budget allocations with a 5% step.

In all of the above scenario types, all allocations that were resulting in a single RR to receive more than 200% of the theoretical national flat-rate were removed.

In total there are 446 scenarios that are fed into the CAP-SFP model. For each of those scenarios and the unit value and the total value of the Single Farm Payment of each farm is recalculated.

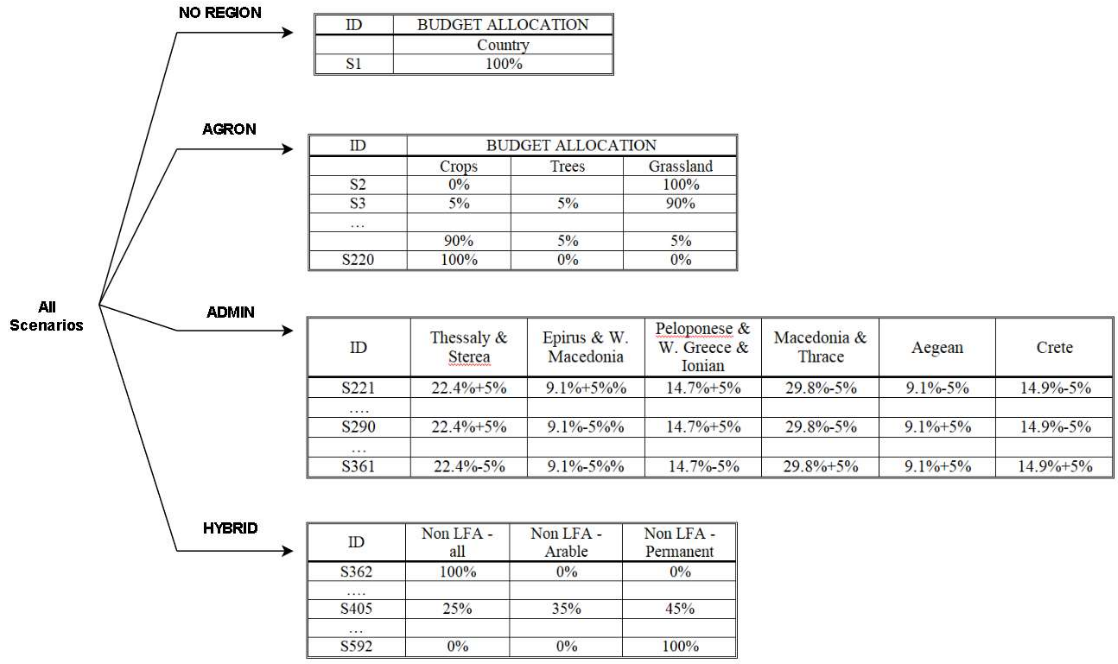

Figure 4, Regionalization scenarios

Policy goals and metrics

The first and necessary step to determine the effects of policies is to a have a clear formulation of the policy goals pursued. Then, for each policy goal, a suitable metric has to be found that will accurately connect the model results and the specific goal.

A clear advantage of using a farm model, rather than a purely accounting approach, is that farms' response to policy measures can be estimated and thus we can elicit relevant response metrics. In our case, as already discussed, the reduction of direct payments affects the farms' working capital availability and thus we can measure the change in fallow land and the missing working capital of permanent crops and livestock sectors.

In this paper, we are partially based on the stated policy goals of the ministry's proposals (Hellenic Ministry of Agriculture, 2012) and draw the policy goals and the corresponding metrics that are given in Table 2.

Table 1, Evaluated policy goals and related metrics

Short Name	Policy Goal Description	Metric	Direction[1]	Category[2]
MISSING CAPITAL	Maintain agricultural activity	Lacking capital for maintaining permanent crops and livestock activities	MIN	ECON
LVSTOCK SUPPORT	Enhance animal sector	Percentage of total budget allocated to livestock farms	MAX	ECON
LFA SUPPORT	Support to farms in Least Favored Areas	Percentage of total budget allocated to farms in LFA	MAX	SOCIAL

SMALL FARM SUPPORT	Enhance the income of small farms	Percentage of budget allocated to the farms in the first quantile of the farm income distribution	MAX	SOCIAL
nonLFA FALLOW	Remove environmental pressure from arable land in non LFA areas	Fallow land in non-LFA areas	MAX	ENVIR
LFA FALLOW	Maintain agricultural activity in LFA areas	Change in fallow land in LFA areas (scaled to 1-100)	MIN	ENVIR
MIN ENVY	minimize the envy between initial allocation and scenarios	Euclidean distance between the current and the scenario distribution of the percentage of budget allocation to each farm	MIN	POLIT
UNIFORM BP	Reach a uniform unit value of basic payment	Gini coefficient of the distribution of the unit value of basic payment across all farms	MIN	POLIT

[1] MIN=minimization is desirable, MAX=maximization is desirable
[2] ECON=Economic criterion, SOCIAL=social criterion, ENVIR=Environmental criterion, POLIT=Political criterion

(a) Maintain agricultural activity and labor in permanent crops and livestock sectors (MISSING CAPITAL). We measure the lacking working capital for maintaining the current area of trees and number of animals respectively. This is further normalized as shown in Eq. 6.

$$Performance_p = \frac{A - min}{max - min} \qquad (6)$$

Where
A: increase of fallow land or lacking capital for regionalization scenario p
min: the minimum increase of fallow land or lacking capital across all evaluated regionalization scenarios
max: the maximum increase of fallow land or lacking capital across all evaluated regionalization scenarios

For example, in the case of arable sector, if we have three regionalization scenarios (A, B, C) and the total lacking capital is 20000, 30000, and 40000 euro, then they are normalized and equal to 0, 0.5 and 1 respectively.

(b) Enhance animal sector (LVSTOCK SUPPORT). The ministry daft report stated that enhanced support of the animal sector in relation to the plant sector is a policy goal. Thus in order to measure this we use the percentage of basic and green payments budget allocated to livestock farms. Livestock farms were considered those of the FADN type of farming.

(c) Support to areas with natural constraints (LFA SUPPORT). Areas with natural constraints contain a relatively high proportion of Greek agriculture (64% according to the Greek Rural Development Programme). Support of farming in these areas has been a CAP objective as an aftermath of the Mansholt report. We want to measure how different regionalization paths affect this group of farms, since they are of interest to policy designers. We use a straightforward metric: the percentage of basic and green payments budget (of the total budget) allocated to those farms.

(d) Enhance the income of small farms (SMALL FARM SUPPORT). Support for small farms has also been a long term objective of the CAP. Nevertheless, contrary to the views that called for a enlargement of the farm size through the provision of incentives, prevailing during the 20th century, the current policy seems to acknowledge the persistence of small farms.

(e) Remove environmental pressure from farming in productive arable land (nonLFA FALLOW). Some of the serious environmental problems created by the CAP, are due to the encouragement of intensification in farming in highly productive agricultural land. Pollution and depletion of natural resources have been the main manifestations of the problem. Leaving the land fallow could alleviate these pressures and enhance biodiversity.

(f) Maintain agricultural activity in areas with natural constraints (LFA FALLOW). Areas with natural constraints in Greece coincide to a large degree with High Nature Value farming systems since 92% of HNV pastures and 84% of cultivated land are found in areas with natural constraints. Farming in HNV areas is essential not only in order to maintain the social vitality but also in order to enhance biodiversity (Terres and Nisini, 2013),

(g) Maintain status quo of historical rights. In the Greek case there is a very diverse situation across farms regarding the basic payment unit value. Thus the immediate abolition of those differences would possibly lead to a politically troublesome situation. We need a metric that measures how different is the distribution of the CAP2020 payments unit value from the pre-CAP2020 distribution. However, any increase or decrease that is applied to all farms shall not be considered to deviate from the status quo, since the difference between farms is of interest to policy makers. For instance in Figure 5, regionalization paths #1 and #2, although they obviously have a different total budget (mean unit value in #2 is lower than in #1) cannot be considered different in terms of the individual farms payments distribution. On the other hand regionalization path #3 is a different distribution.

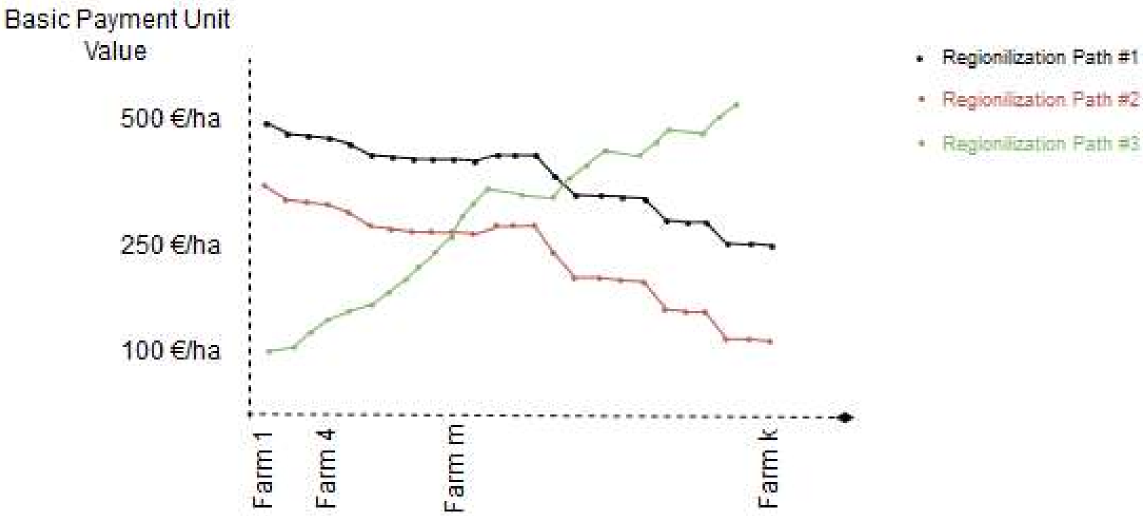

Figure 5, Demonstration of status quo metric

Thus in order to drop the effects of nominal changes in the budget, we transform the payment each farm receives to the percentage of the budget that it receives. Then in order to calculate the difference of the distributions we use the Euclidean distance metric as follows:

$$Performance = d(p,q) = \sqrt{\sum_f (q_f - p_f)^2} \qquad (7)$$

Where
f is the set of all farms
p_f is the share of payments of farm f in the status quo case
q_f is the share of payments of farm f in the evaluated regionalization path case

(h) Reach a uniform unit value of basic payment. A strategic goal of the European commission is that all member countries, eventually, reach a uniform basic payment unit value. Thus we include this policy goal. We use the Gini coefficient of the distribution of the unit value of basic payment to the individual farms. A value of 0 indicates a uniform basic payment unit value while more unequal distributions go towards unity.

Data

The CAP-DECOUP model is calibrated to the 2013 FADN micro database for Greece. We used arable, vegetable and permanent crops and a major part of livestock sector (sheep, goat, dairy and cattle activities). Thus we include 83% of represented farms, 87% of utilized agricultural area and over 88% of the total basic payment amount. We must note that this sample represent ~350,000 farms, only half of the Greek farms that receive direct payments. However FADN represent the vast majority of commercial farms since the excluded farms have an estimated total output value of 2000 euro or less.

The details of the CAP-DECOUP model calibration to the 2013 baseline year are part of the GRIFAM (Greek Individual Farm Model) ongoing project, and can be given upon request. The overall FK index is 0.93 and the per-farm FK index shows a mode around .8, an indication that the calibration of the baseline model provides an acceptable approximation of the observed situation.

Regarding the level of payments for the represented farms; basic payment and green payment amounts to 1.116 billion euro in the baseline year (2013). We keep the same budget for the CAP-SFP model in order to isolate the effect of the transition from the historical model to the new regionalization scheme without any budget reduction effects. For the same reason we did not considered convergence.

We also assumed that the eligible hectares were reassigned and matched the observed 2012 farm plans. Finally the assumed budget allocation between the various CAP2020 components is given in Appendix C.

Results and Discussion

In this phase of our research we are using exploratory data analysis to get insights from the model results. Exploratory Data Analysis (EDA) is an approach for data analysis that employs mostly graphical techniques. Among other targets the analysis aims to maximize insight into a data set, uncover underlying structure and develop parsimonious models. The particular graphical techniques employed in EDA are often quite simple, consisting of various techniques of plotting raw data or simple statistics but mainly positioning such plots so as to maximize human natural pattern recognition abilities, e.g. multiple plots per page (Croarkin et al., 2006).

A comparison of the general features of the four different regionalization scenario types

In figure 6 we give the range of the performance of the different scenario types on each policy goal through box plots. Red box plots regard the ADMIN type of scenario performance; greens are for AGRON and blue are the HYBRID type of scenarios. All policy criteria have been converted to max and thus a higher performance value is better; those criteria with negative performances were originally min-criteria and converted to max by multiplying with -1 (e.g. LFA FALLOW criterion was originally a minimum target and has been converted to a maximum target by multiplying with -1).

Regarding the relative performance of the three scenario types, they are all present a similar behavior, albeit their differences in the performance variability.

The Administrative-based type of scenarios displays the lowest variability. This can be partially attributed to the low variability of the budget allocation of those scenarios. In Figure 7, one can see the budget allocation range for each RR in each scenario type. For instance, the minimum budget allocation over all AGRON scenarios for TREES RR is 0% and the maximum is almost 50%, with the interquantile range been between 8% and 37%. It is obvious that ADMIN scenarios have a very low budget allocation variation, since as already explained, it is not considered realistic to have administrative regions with great unit value differences.

Regarding the performance variability of Agronomic-based and hybrid regionalization, the first type displays clearly a higher outcome range for the majority of the criteria. For a specific criterion, low performance volatility may be positive if the performance range is close to the desired one. In that case policy makers can be sure that the performance of any budget allocation of this scenario type is satisfying for the relevant criterion and thus the criterion can be overlooked. For instance the HYBRID scenario type has a low volatility of 40%-42% in the SMALL FARM SUPPORT policy goal. If this performance range is acceptable, this policy goal can be removed from further analysis and further focused to other goals that present a higher volatility. The previous argument may be rather thin if a certain scenario type presents low volatility performance for a policy goal that however is outside the desired range. […]

Furthermore, in Figure 8, we plot in detail the performance of all scenarios for all policy goal pairs. Blue points are HYBRID types of scenarios. Black points are AGRON scenarios. Grey points are administrative scenarios. The red point is the GREECE scenario (one region with flat rate). On the lower part of the plot the Pearson correlation coefficients are shown.

The previous results regarding the volatility of the three types of scenarios are also obvious in this graph. However more detailed conclusions can be deduced from this figure, regarding the general features of the three types of scenarios.

There are pairs of scenarios where the Pareto frontier has a different shape. For example MISSING CAPITAL vs LIVESTOCK SUPPORT; LFA SUPPORT vs MISSING CAPITAL; LFA SUPPORT vs non LFA FALLOW; LFA FALLOW vs non LFA FALLOW. Thus if policy makers have a special focus on such a pair, the possibilities provided from the different scenario types are diverse. For instance in the LFA SUPPORT vs non LFA FALLOW policy goals pair, if policy, the HYBRID type (blue) can achieve a higher performance regarding the LFA SUPPORT target while AGRONOMIC type is performing better regarding non LFA FALLOW goal.

Also there are certain pairs where one type of scenario clearly dominates the others. For instance for LIVESTOCK SUPPORT vs non LFA FALLOW and SMALL FARM SUPPORT vs non LFA FALLOW, AGRONOMIC type of scenarios is dominant over all others. Te implication is that if policy makers are specifically interested in such a pair, they can explore the budget allocations of only the dominating scenario types.

A trade-off analysis of MIN ENVY and UNIFORM BP

Figure 9 presents the Pareto efficient solutions for this policy goal pair. The national flat rate is the one extreme of the front, exhibiting the best performance in the MIN ENVY goal. The next efficient point is a ADMIN scenario type with a budget allocation more or less analogous to the eligible land allocation (thus unit value is close across RR). All other efficient points are comprised of AGRON scenarios. MIN ENVY (less distance than the current unit value distribution) is achieved when Arable and Tree crops share more equally the budget and grazing areas budget is diminished.

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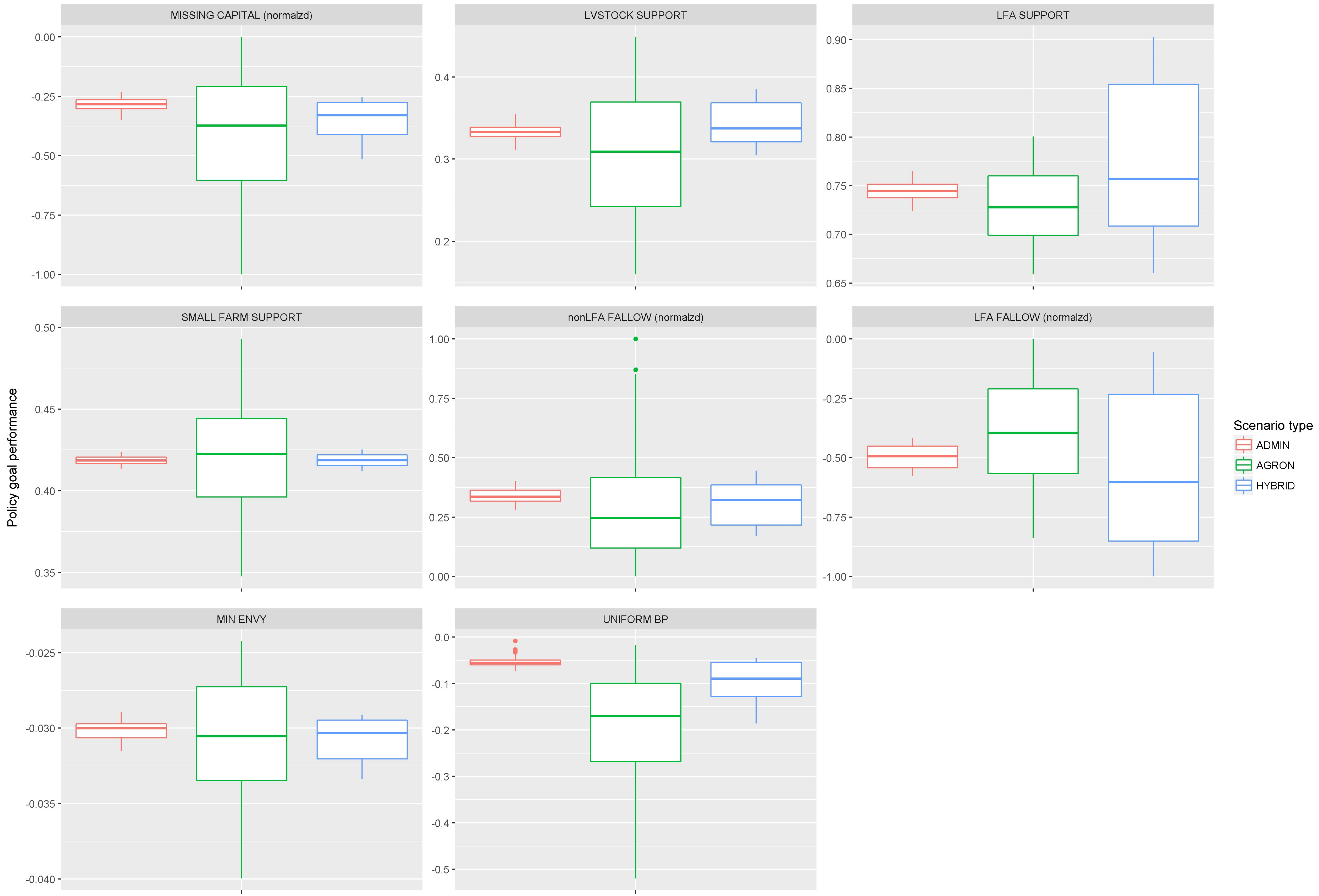

Figure 6, Range of performance of scenario types

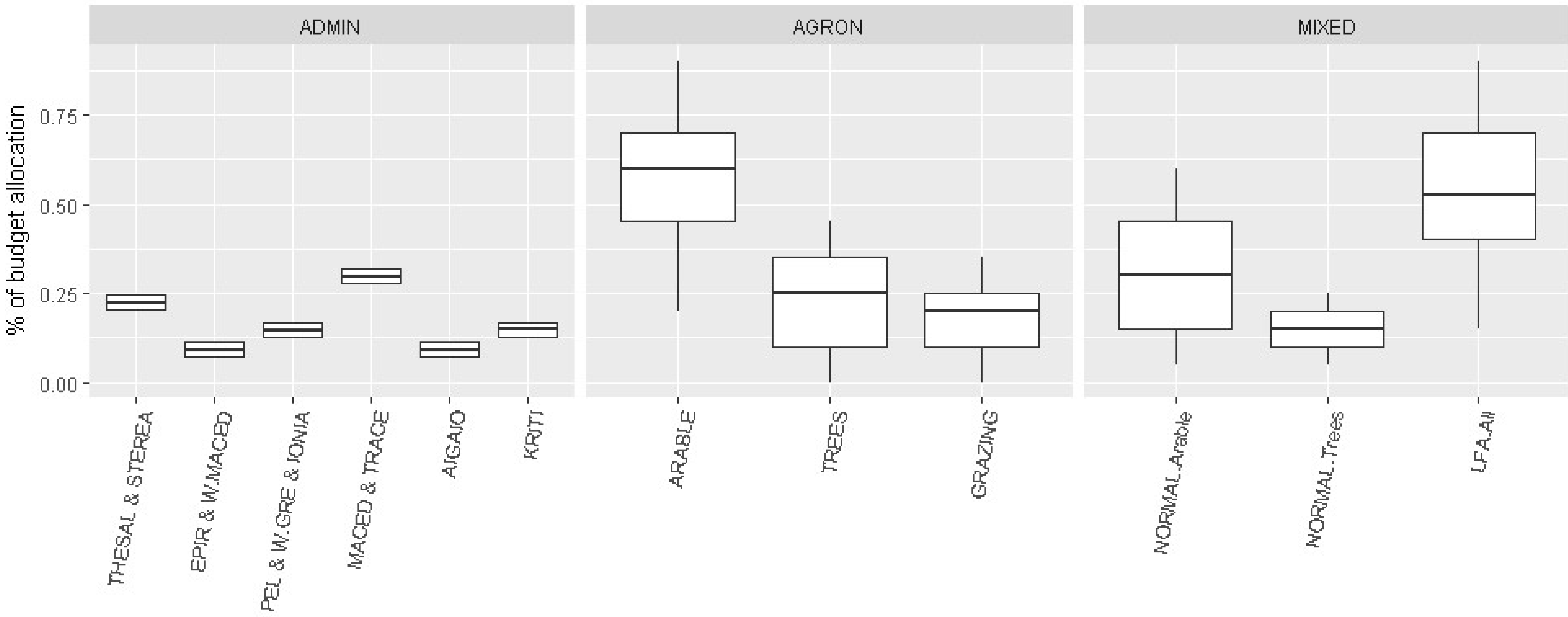

Figure 7, Box plot of budget allocations for each scenario type

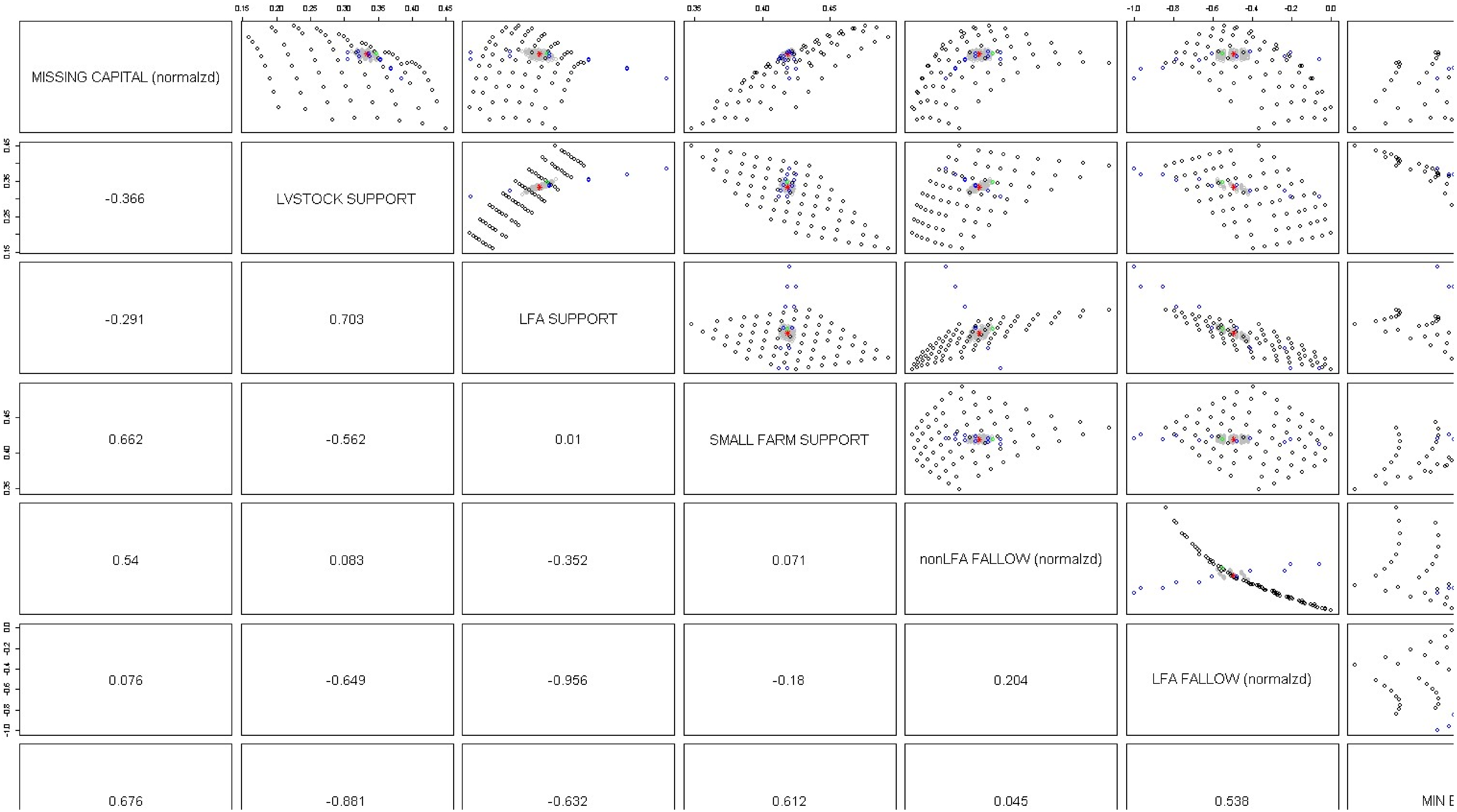

Figure 8, Detailed performance of budget allocations

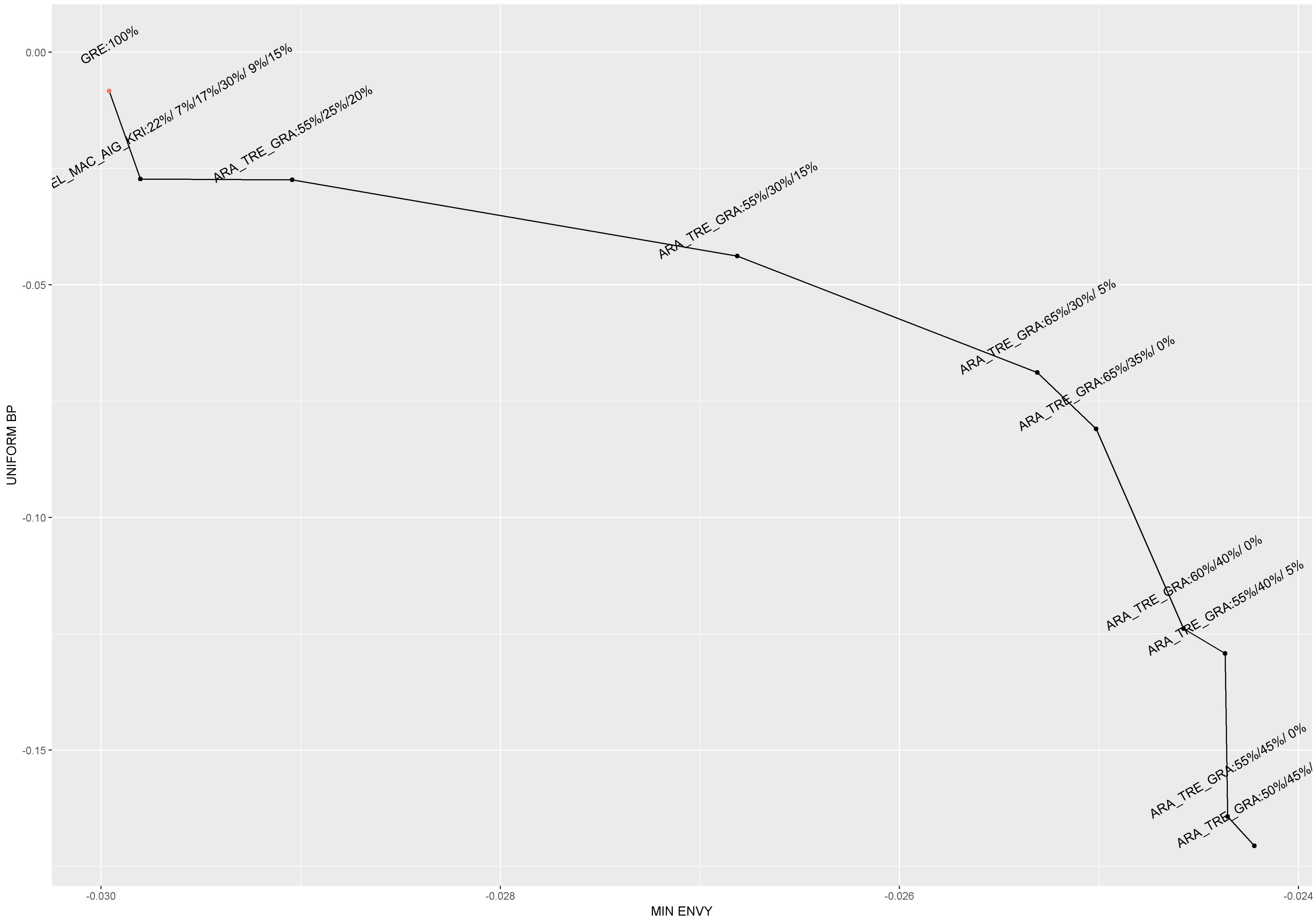

Figure 9, Pareto frontier of MIN ENVY and UNIFORM BP policy goals

Appendix A

$$maxGI = GI^{CROPS} + GI^{LIVESTOCK} + SP \cdot LA^{E} + SO \quad (X)$$

$$GI^{CROPS} = \sum_{c} \left((PR_c \cdot YI_c - VC_c + CP_c) \cdot X_c \right) - LB^{Foreign} \cdot WAGE \quad (X)$$

$$GI^{LIVESTOCK} = SALES^{L} - VC^{L} \quad (X)$$

Variables::
X_c: The area of crop-c (ha)

Sets::
c: crops

Parameters::
PR_c: The price paid to farm f for crop c (euro/tn)
YI_c: The yield of crop c on farm f (tn/ha)
VC_{f,c_r}: Specific crops costs for crop-c on farm f, excluding human labor costs (euro/ha)
CP_c : Coupled payments for certain crops (euro/ha)
LB_c^R: Human labor requirements of crop-c (hour/ha)
$LB^{Foreign}$: foreign labor for farm-f (hours), it is equal to $\sum_c \left(LB_c^{Required} \cdot X_c \right) - LB^{Family}$
$WAGE$: Human labor wage, set to 1.5 (euro/hour)
SP: Single payment value for farm f, based on historical entitlements (euro/ha)
LA^E: Total eligible Land owned by farm f (ha)
SO: Pillar II subsidies for farm-f e.g. agri-environmental, NATURA, less-favored areas, etc. (euro)
$SALES^L$: Livestock sector sales
VC^L: Variable cost of livestock sector

s.t

$$\sum_{c} (X_c) \leq LA^{T} \quad (1.2)$$

$$\sum_{c^I} (X_{c^I}) \leq LA^{I} \quad (1.3)$$

$$\sum_{c} (LB_c^R \cdot X_c) \leq LB^{A} \quad (1.4)$$

Sets:: c^I: Irrigated crops (subset of c)
Parameters::
LA^T: Total Land owned by farm (ha)
LA^I: Total irrigated Land owned by farm f (ha)
LB_c^R: Human labor requirements of crop-c (hour/ha)
LB^A: Available farm labor. It equals the reported labor hours by farm f, including hired and temporary foreign labor (hours)

$$\sum_{c} (VC_c \cdot X_c) + \left(\sum_{c} (LB_c^R \cdot X_c) - LB^F \right) \cdot WAGE \leq \sum_{c} (CP_c \cdot X_c) + SP \cdot LA^E + SO + WC^E \quad (1.5)$$

Parameters:: WC^E: Other than subsidies available working capital for farm-f (euro)

$$X_{c^{IMP}} = 0 \qquad \forall\ c^{IMP} \tag{1.6}$$

Sets:: c^{IMP}: The crops that are impossible for farm to cultivate (subset of c)

$$X_{c^T} = LA^O_{c^T} \qquad \forall c^T \tag{1.7}$$

Sets:: c^T: The permanent crops (subset of c)
Parameters:: $LA^O_{c^T}$: Land observed for crop-c (ha)

$$\sum_{c(rot)} X_{c(rot)} \cdot ROT^{coef}_{c(rot),rot} \geq 0 \qquad \forall rot \tag{1.8}$$

Sets:: rot: the rotation set / $c(rot)$: the crops that are included in a rotation
Parameters:: $ROT^{coef}_{c(rot),rot}$: The rotation coefficient

$$0.8 \cdot LA^O_{c^{CC}} \leq X_{c^{CC}} \leq 1.2 \cdot LA^O_{c^{CC}} \tag{1.9}$$

$$X_{c^{LP}} \leq LA^O_{c^{LC}} \tag{1.10}$$

$$X_c \leq CURRENTSHARE_{c^{MC}} \cdot LA^T \tag{1.11}$$

Sets:: c^{CC}: contract crops (sugar beet, sunflower) / c^{LC}: low profile crops (rye, oats, irrigated durum wheat, irrigated common wheat, dry pulses) / c^{MC}: The main crop, i.e. the one with the higher occupied uaa
Parameters:: $CURRENTSHARE_{c^{MC}}$: The share of the main crop in the total farm area (%)

Appendix B

We present a regionalization illustrative example. A hypothetical country with three farms and a total direct payments budget of 1000 euro is selected. The details for each farm (prefecture it belongs to, if the region is LFA or not, and direct payment rights) are given in the table below.

			Rights (ha)			
	Prefecture	LFA	Arable Crops	Tree Crops	Grazing Areas	Sum
Farm 1	A	Yes	10	2	1	13
Farm 2	B	No	3	1	5	9
Farm 3	C	No	1	10	-	11
		Sum	14	13	6	

We apply an administrative type of regionalization scenario, where Prefecture A is the region #1 with 30% of the budget and prefectures B and C are region #2 with 70% of the budget.

Regionalization Option I, Administrative based			
	Region 1		Region 2
Definition	Prefecture A		Prefectures B+C
Budget Allocation	30%		70%
Budget (euros)	0.3*1000=300		0.7*1000=700
Unit Value (euro/ha)	300/13=23.07		700/(9+11)=35
Farms SFP	Farm 1 13*23.07=	Farm 2 9*35=	Farm 3 11*35=

We apply an agronomic based scenario where arable crops, trees and grazing land are the three distinct regions.

Regionalization Option II, Agronomic based			
	Region 1	Region 2	Region 3
Definition	Arable Crops	Tree crops	Grazing Land
Budget Allocation	50%	30%	20%
Budget (euros)	0.5*1000=500	0.3*1000=300	0.2*1000=200
Unit Value (euro/ha)	500/14=35.7	300/13=23.07	200/6=33.3

Farms SFP	Farm 1 10*35.7+2*23.07+1*33.3=	Farm 2 3*35.7+1*23.07+5*33.3=	Farm 3 1*35.7+10*23.07=

Finally we apply a mixed regionalization type of scenario, where budget allocation is differentiated between arable crops, trees and grazing land and also whether the region is LFA or not.

Regionalization Option III, Mixed			
	Region 1	Region 2	Region 3
Definition	Arable Crops at LFAs	Tree crops and Grazing Areas at LFAs	Non-LFAs (all crops)
Budget Allocation	30%	20%	50%
Budget (euros)	0.3*1000=300	0.2*1000=200	0.5*1000=500
Unit Value (euro/ha)	300/10=30	200/(2+1)=66.66	500/(9+11)=25
Farms SFP	Farm 1 10*30+(2+1)*66.66=	Farm 2 9*25=	Farm 3 11*25=

Appendix C

Table 2, CAP2020 policy components budget allocation

Basic Payment	Green Payment	Young Farmer Scheme	Natural Constraint Areas	Small Farmers Scheme	Voluntary Coupled Payments [1]	Redistributive Basic Payment	National Reserve	Transfer to Pillar II [2]
50%	30%	2%	5%	2%	8%	0%	3%	0%

[1] Voluntary Coupled Payments as in Table 3

[2] We assume that the share that is currently transferred to Pillar II (5%) and is actually devoted to Least Favored Areas will go to NCA that is currently 0%.

Table 3, CAP2020 Coupled Payments for Greece, as used in the model

Crop	Ceiling (m €)	Reference Surface (ha)	Unit value (euro/ha)	Constrained Surface (ha)
Rice	8	30,410	263	30,410
Durum wheat	9	250,000	36	321,827*
Cotton	187.35	250,000	749.38	293,886.6*
Legumes	5	16,500	303	16,500
Sugar beet	5	13,367	374	13,367
Oranges	9	28,500	316	28,500

* We set the final coupled payment to be higher due to the model giving higher than quota surfaces. We reduced the unit value accordingly. This can be attributed to the fact that our baseline model is for 2012 while quotas were assigned with the 2015 status.

Table 4, Observed and model result areas of arable crops

	Observed (ha)	Model (ha)	% diff		Observed (ha)	Model (ha)	% diff
barley	53,689	25,846	-52%	oats	31,224	36,395	17%
cotton	17,234	17,959	4%	peasdrp	1,534	1,612	5%
cottonIR	276,653	256,947	-7%	potatIR	11,625	9,904	-15%
cwheat	94,069	133,471	42%	rapeoil	4,196	2,205	-47%
cwheatIR	2,048	1,309	-36%	riceIR	17,785	14,846	-17%
dwheat	311,201	323,790	4%	rye	5,597	7,143	28%
dwheatIR	10,627	6,361	-40%	sugbetIR	4,870	4,311	-11%
lentdrp	6,092	13,908	128%	sunflr	21,364	23,875	12%
mzegrn	6,785	2,297	-66%	sunflrIR	16,940	14,082	-17%

mzegrnIR	112,934	112,764	0%	tobcco	8,472	12,789	51%
lentdrp	6,092	13,908	128%	tobccoIR	10,441	6,818	-35%
				fallow	81,059	77,806	-4%