The regional model for Mediterranean agriculture

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The Regional Model for Mediterranean Agriculture [1]

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Authorship may be attributed as follows: sections 2, 3 and 4 to Lobianco, sections 1 and 5 to Esposti.

Contents

Abstract

AgriPoliS is a multi-agent mixed integer linear programming (MIP) model, spatially explicit, developed in C++ language and suitable for long-term simulations of agricultural policies. Beyond the mixed integer programming core, the model main feature is the interaction among a set of heterogeneous farmers and between them and the environment in which they operate. In this paper we describe an extension of the model allowing AgriPoliS to deal with typical characters of the Mediterranean agriculture. In particular AgriPoliS was extended to allow a generic number of products and soil types, included perennial crops and products with quality differentiation. Furthermore, it can explicitly take into account irrigation.

Keywords: Mediterranean Agriculture, Common Agricultural Policy, Agent-based Models.
EconLit Classification: *Q120, Q180*

1 Introduction

This paper is part of workpackage 7 ("Modelling Mediterranean agriculture") of the IDEMA research project ("The Impact of Decoupling and Modulation in the Enlarged Union: a sectoral and farm level assessment"), supported by the European Commission under the 6th Research Programme.

To model the impact of the Common Agricultural Policy (CAP) reform, IDEMA uses AgriPoliS[2] [2], a spatially-dynamic agent-based model that explicitly takes into account actions and interactions of a large number of individually acting and heterogeneous agents (that is, farmers).Accordingly, AgriPoliS allows for endogenous structural change and it is particularly suited to analyse the structural, allocative, and distributive effects of policy changes on agriculture of a small region.

Major aims of IDEMA workpackage 7 are: (I) to adapt the AgriPoliS model approach to the Mediterranean farming system; (II) to use the adapted AgriPoliS model to identify the impact of CAP reforms on Mediterranean agriculture.

Adaptation is required as some key characteristics of the Mediterranean agriculture are not implemented in the original AgriPoliS model. These include the presence of different soil types, perennial crop productions (mainly wine, olive oil, and fruits), irrigation adoption and quality traits. This adapted model can be then applied to two Mediterranean (Italian) regional cases to simulate the effects of alternative CAP reform scenarios.

This paper presents the adaptation of AgriPoliS to the Mediterranean regions and the related modelling work, and it is structured as follows. Section 2 introduces the main characteristics of the Mediterranean agriculture in comparison with the continental one. In Section 3, the main CAP measures currently influencing the Mediterranean agricultural production are shortly described. Section 4 describes in detail the modelling work. It is divided in three subsections; the first gives a general overview of the model, the sec-

[2] **Agri**cultural **Poli**cy **S**imulator

ond describes the modelling work to adapt AgriPoliS to any region, not just Mediterranean ones, while the third presents the modelling work required to specifically adapt AgriPoliS to the Mediterranean regions. Section 5 concludes.

2 Main characters of Mediterranean agriculture

By "Mediterranean region" it is usually meant the Mediterranean sea and all its bordering countries (plus Portugal). Thus, this wide area extends between the temperate and the tropical zone. In this paper we consider as Mediterranean countries (Med countries) the following EU25 member states: *Cyprus*, *Greece*, *Italy*, *Malta*, *Portugal* and *Spain*. Though from a strictly geographical point of view also France and Slovenia contain Mediterranean coasts, we exclude these countries from our analysis.

Data presented in this paper refer to 2003 (the last available year for all countries), but they still consider the EU enlargement. This can create problems when comparing data of Med countries with the continental ones. For this reason, in the appendix, we also report 2000 data only including Old Member States, OMS, because the New Member States (NMS) do not equally distribute between the two groups, as the most of them falls within the continental group. Thus, their specific characteristics may actually "disturb" the comparison between Mediterranean and continental agriculture. For example, the presence of farmers in terms of % on total population is just 3.5% higher in Med countries than in continental ones, but it would be 5.3% higher considering only OMS.

2.1 Environmental conditions

The main characteristics of the Mediterranean agriculture are strongly influenced by the specific environmental conditions of the whole region. Its climate is similar to the temperate zone in winter and to the tropical zone in summer. Winter is temperate and rainy, while summer is hot and dry. The typical Mediterranean soil is dry and superficial. If sloped and clay, it may likely face erosion processes.

The articulate contours of the region and the presence of wide mountain areas in the surroundings have two strong consequences. First, rain distribution is highly irregular over years. Vegetation specifically evolved to stand with periodical shortage of water in the warmest period, and to adapt their biological cycles to take advantage of the most favourable years. Many agricultural productions are influenced by this factor. For example, olive production is highly discontinuous among years. Second, climate is quite heterogeneous within the Mediterranean region, with relatively small areas showing a large array of different conditions. This variety, combined with different geomorphology, explains the rich biodiversity and, from an agricultural point of view, the high number of different cultivated species, varieties and qualitative features.

2.2 Land use

Compared with the continental EU, Mediterranean countries are characterised by a higher share of agricultural area. The Utilised Agricultural Area (UAA) in the two groups is 40% and 48% of the total area, respectively. The share of arable and grass land on total land is not significantly different, but in the Mediterranean context a higher presence of perennial crops is observed (Table 1).

Figure 1 confirms, on the output side, the greater relevance of perennial crops in the Mediterranean context together with vegetables. In the continental agriculture the output generated by cereals, other crops (including potatoes, sugar beet and forage) and animals products amounts to 75% of the whole agricultural output, whereas they are just 51% in the Mediterranean context. At the opposite, perennial crops (wine, fruits and olives) plus vegetables and horticulture products count in the continental agriculture only

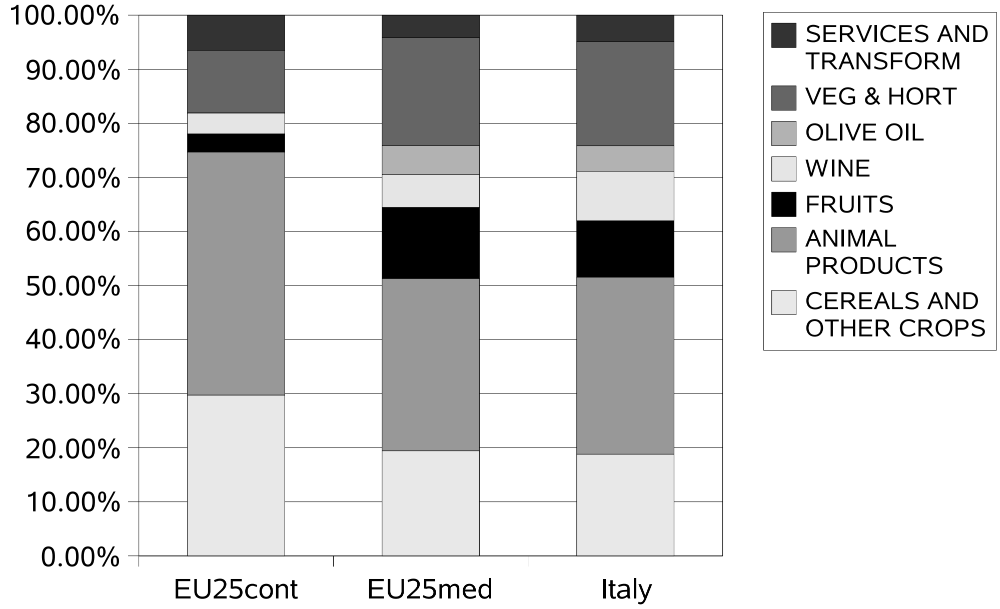
Table 1: Agricultural land use as % on total land

	Total land [1,000 ha]	Arable land	Permanent grassland	Perennial crops	Other land
EU25cont	293,538	24.5%	14.2%	0.7%	60.6%
EU25med	104,014	24.3%	14.2%	9.1%	52.4%
Italy	30,134	26.41%	14.5%	8.9%	50.2%

Source: Eurostat

19% compared with 45% in the Mediterranean output.

Figure 1: Agricultural output shares based on EAA (Economic Accounts for Agriculture)



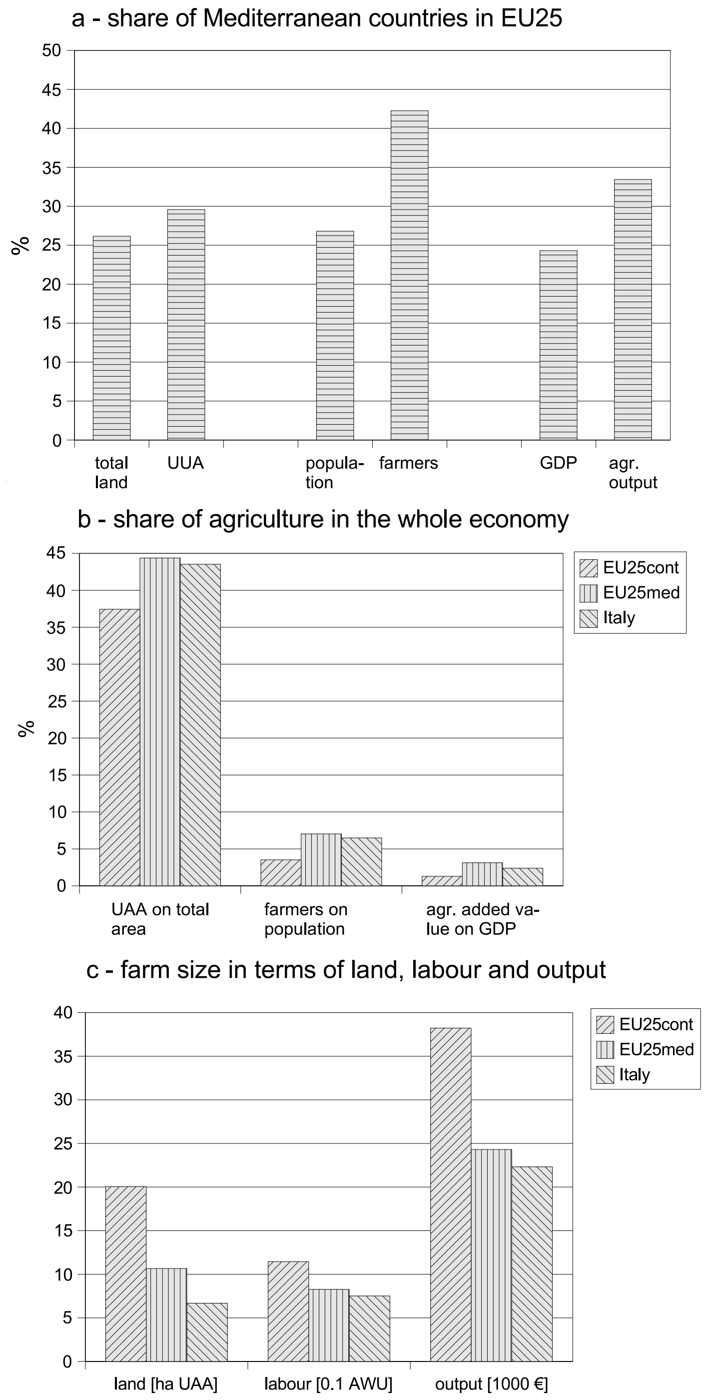
Source: Eurostat

2.3 Farm size

Figure 2 provides a simple insight into the main social and economic characteristics of Mediterranean agriculture. Figure 2**a** reports the share of Med-countries in the (enlarged) EU context. Mediterranean agriculture represents about 30% of the whole EU25 agricultural land, but it shows higher values in terms of output and, above all, of farmers. Figure 2**b** shows how agriculture performs within the whole economy. We can note that on any aspect (land, labour, GDP) agriculture shows a higher share in the Mediterranean countries, to confirm the relatively greater importance this sector still has. Finally, figure 2**c** analyses the farm average size. It definitively demonstrates that Mediterranean agriculture is characterised by much smaller farms, in terms of avg. land and labour units endowment and, above all, in terms of output.

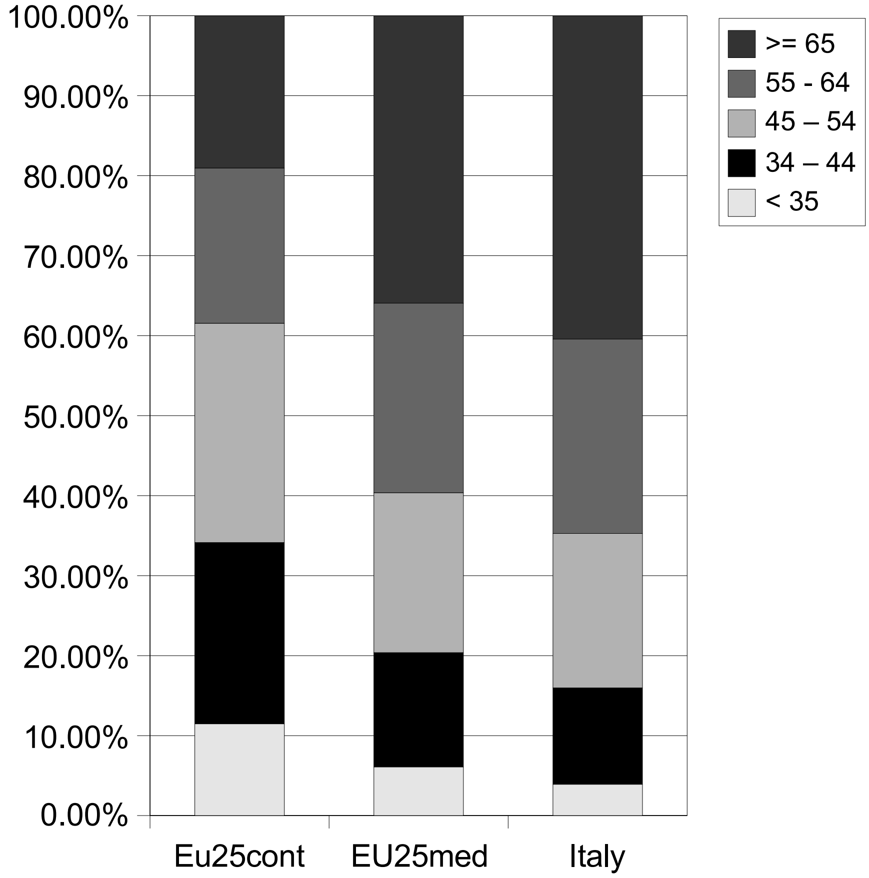
Looking at figure 2 as a whole, it becomes evident that Mediterranean agriculture is relatively more intensive in terms of both *per ha* labour and output, but it is undermined by a strong land fragmentation, making farms too small to generate an acceptable family income. Thus, it is not a surprise that such small farms are unable to attract young farmers. Figure 3 shows the distribution of farmers by age class: in Med-countries 36% of farmers are more than 65 years old, almost double of continental agriculture. Young farmers, that is younger than 35 years old, are only 6% (11% in continental agriculture). Figure 3 also shows how this problem is particularly serious in some Med-countries, for example in Italy where the two mentioned values are 40% and 4% respectively.

Figure 2: Mediterranean agriculture: main characters



Source: EUROSTAT

Figure 3: Farmers by age class



Source: EUROSTAT

3 Common Agricultural Policy and Mediterranean agriculture

3.1 The 2003-2004 CAP reform

In 2003, a major reform of the Common Agricultural Policy (CAP) was agreed. Initially known as the "mid-term reform", the 2003 reform went far behind a simple revion of the previous "Agenda 2000" policy, and with Regulation (EC) 1782/2003 introduced new political instruments, and in particular Single-Farm Payment (SFP) scheme. Following this reform three different types of payment can be recognised: Single-Farm Payment, optional coupled payments (on the base of national decisions), coupled payments.

Single farm payment is an aid scheme provided to farmers, decoupled from production activities but subjected to certain commitments. Its value is calculated in the old member states from the historical records of the previously coupled payments that each farmer received from the EU during a fixed reference period, usually made of three years. Most previous payments concerning the cereal, beef and veal and sheep and goat sectors, now falls within this SFP scheme. Moreover, with Regulation (EC) 864/2004 the original Regulation (EC) 1782/2003 was amended to include new products in the single-farm scheme: cotton, hop, tobacco and olive oil.

Table 2 summarises the national decisions in the Mediterranean countries. It can be noticed that all the Med countries decided for a coupled payments for seed production, recognising the importance that locally produced seeds have for the whole crop sector. Concerning the Tobacco payments the main concern was to maintain this labour-intensive production, also considering that it is typically made in regions with few other labour alternatives. In general terms, with regard to the remaining decoupling decisions, it is possible to distinguish between two groups. On the one hand, Greece and Italy decided for a higher level of decoupling. However, they kept a high rate of "quality" payments, as allowed by art.69 of the same Regulation (see Table 3). On the other hand, Portugal and Spain make a lower utilisation of "quality" payments but decided to keep payments as coupled as possible.

Table 2: Optional coupled payments (based on national decisions)

	Art.	Greece	Italy	Portugal	Spain
Seed aid	70	100%	100%	100%	100%
Arable crops area payment	66				25%
Hops area aid	68bis				
Sheep and goat premiums	67				
- ewe premium				50%	
- sheep and goat premium					50%
Beef and Veal payments	68				
- suckler cow				100%	100%
- slaughter premium calves				100%	100%
- slaughter premium adults				40%	40%
Olive oil[a]	110 octies				6.4%
Tobacco[b]	110 undecies		60%[c]	50%	60%

[a] Greece and Italy apply 5% deduction on olive oil aids for funding programmes established by producer organisations.

[b] From 2010 full mandatory decoupling.

[c] Tobacco is fully decoupled in the Puglia Region.

Source: Reg. 1782/2003, EU Commission

Finally Table 4 shows those CAP payments that remain coupled even after the 2003-2004 reform. Many of these support schemes refer to Mediterranean products, as *durum wheat*, *rice*, *nuts* and *cotton*.

Table 3: Quality payments (proportion on ceilings, art. 69)

	Greece	**Italy**	**Portugal**	**Spain**
- arable crops	10%	7%	1%	
- beef and veal sector	10%	8%	1%	7%
- dairy				10%
- sheep and goat	5%	5%	1%	
- cotton				10%
- olive oil	4%		10%	
- tobacco	2%			5%

Source: Reg. 1782/2003, EU Commission

Table 4: Still coupled payments

	Art.	**Premium [e/unit]**	**EU limits**	**Med limits**	**Italian limits**	**Unit**
Durum wheat	72	40	3,190,000	2,975,000	1,646,000	ha
Protein crop	76	55.57	1,400,000			ha
Rice	79	458.27[a]	392,801	369,561	219,588	ha
Nuts	83	120.75[b]	800,000	780,700	130,100	ha
Energy crops	88	45	1,500,000			ha
Starch potato	93	66.32[c]	1,948,761	1,943	0	tonne
Cotton[d]	110bis	624.78	440,360	440,360	0	ha

[a] Average EU value for the 2005/2006 onward period. Average Med amount is 465.60, Italian value is 453.00.

[b] Upper limit of EU aid. It can be integrated with a national grant for further 120,75 euro/ha and it can be differentiated by different products.

[c] 2005/2006 onward.

[d] This value refer to the coupled part of the cotton aid, while 65% of the previous cotton payments is included in the single-farm payment.

Source: Reg. 1782/2003

3.2 CMOs for fruit, vegetables and wine

Except for nuts, the common organisations of fruit, vegetables and wine markets were not affected by the 2003 CAP reform. Policies on fruit and vegetables emphasise the importance of product standardisation and the role of producer organisations. These organisations can decide when and how much product should be withdrawn from the market. However, a withdrawn limit[3] on the marketed quantity is established. In addition to price stabilisation measures, direct payments are recognised to producers of some processed fruits and vegetables [4], with a EU-level quota system that proportionally lower the support in case of overproduction. Furthermore, Regulation (EC) 2699/2000 established that such aids can not exceed the difference between the world price and the minimum price paid in the EU.

Policies on the wine sector are quite different, particularly for the remarkable attention paid to structural interventions accompanying the market mechanisms. In the wine sector, whereas we can note a overall reduction of both production and consumption, we can still observe a structural shift of demand toward quality wines. A more competitive world wine market strengthened the need of restructuring the supply side to meet the consumer quality expectations. Regulation (EC) 1493/99 included measures to limit the total vineyards area, with both a ban of new plantings and an abandonment premium, but at the same time it established a support system for the restructuring and conversion of current vineyards. Finally, some traditional market aid schemes were maintained to stabilise the market in case of surplus production. Such aids include premiums for private storage of table wine and distillation premiums.

[3] 5% for citrus fruits, 8,5% for apples and pears and 10% for other products.

[4] 34.5 euros/tonne for tomatoes, 47.70 for peaches and 161.70 for pears.

4 The improved AgriPoliS model

4.1 AgriPoliS: an overview

AgriPoliS is a multi-agent Mixed Integer linear Programming (MIP) model, spatially explicit, developed in C++ language with a MS Windows interface. Developed from mid '90s, AgriPoliS aims to cover the whole range of farm activities, from growing specific crops to investing in new machinery or hiring new labour units. Multi-agent models explore how macro-level phenomena emerge from micro-level behaviours of an heterogeneous set of "agents" interacting among themselves and with the environment. Therefore, they are suitable for long-term simulations of agricultural policies.

In AgriPoliS agents are mainly farmers[5]. They have their own goals; in AgriPoliS, the farmer's objective is the maximisation of household income. To achieve this objective, farmers solve a MIP problem that, in some aspects, is specific for each farmer. Outside the linear programming problem, they can also decide to rent other agricultural plots or to release rented land.

Any farmer is explicitly associated to a spatial location. Space is important in the model because it influences transport costs and indirectly makes the farmers interact each other, by competing for the same land plots.

Using this multi-agent approach, AgriPoliS is able to represent the regional agricultural structure as a complex evolving system. Each farmer has its own factor endowment, but farmers also differ in terms of age, spatial location and capacity, that is a "managerial coefficient" representing the heterogeneous farmer managerial abilities.

4.1.1 Model dynamics

The first step of the program is the initialisation of the environment that will "host" the agents. It means to establish which are the available activities, investment possibilities and soil types. The relationship between these items

[5] Other agents in the model perform some specific tasks, e.g. managing land or coordinating product markets.

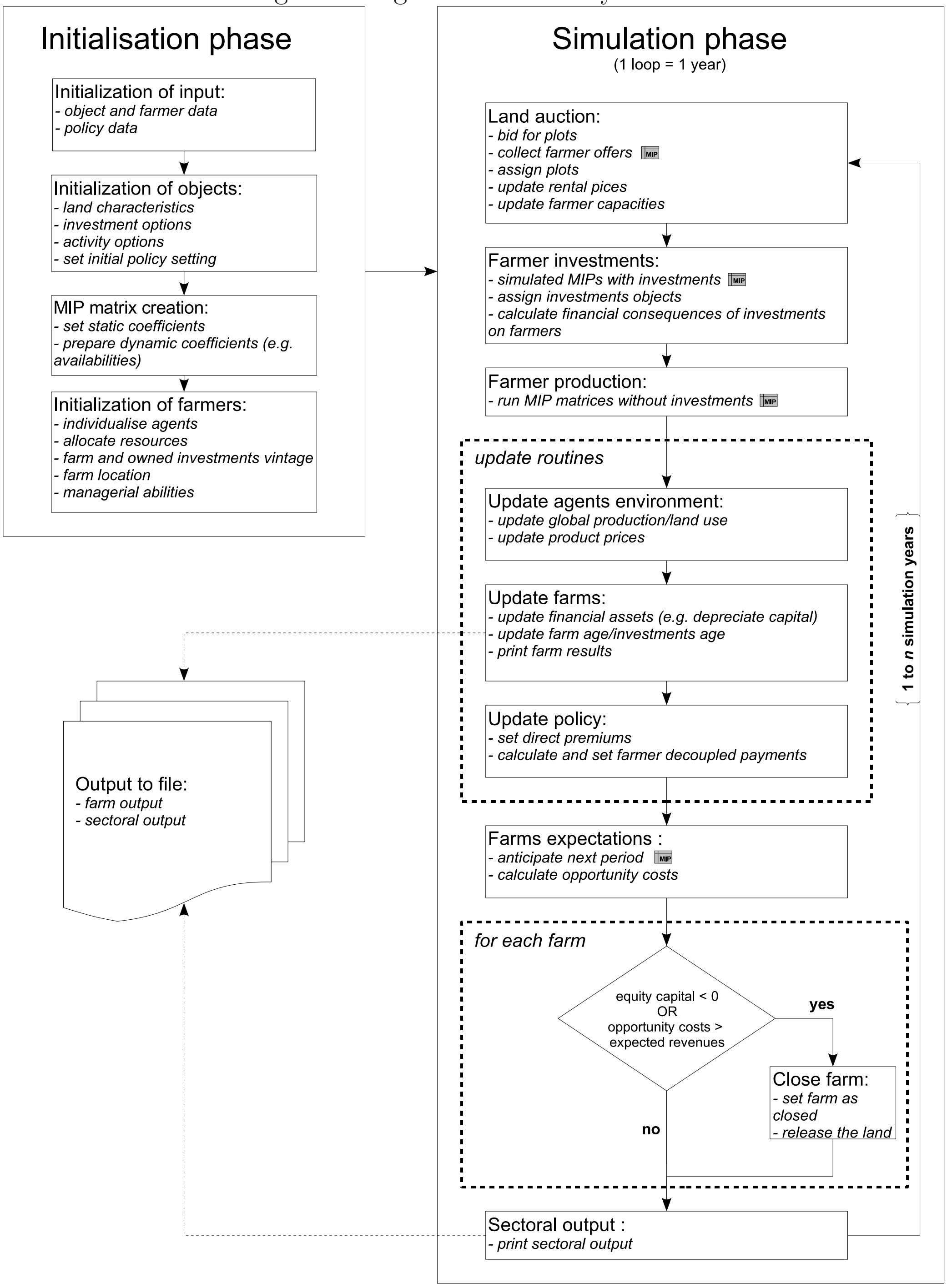
must also be initialised, thus defining the structure of the linear programming matrices available to farmers.

Once the "environment" is established, agents can be initialised too. This second step involves the identification of the heterogeneous agents: allocate resources to them, define their age, as well as the vintage of their assets. Farms must also be localised in the region and plots must be assigned to them. The final initialisation step is to assign the managerial coefficient to farmers.

Most data requested by these steps are collected from FADN (Farm Accountancy Data Network), both in terms of aggregated data (used to calculate the coefficients) and in terms of single-farm records (used to initialise the agents trough an upscaling process that will be described below), while some data (farmers geo-localisation, vintages, managerial coefficients) is randomized within appropriate bounds.

After the initialisation phase is concluded, simulations can be run for the requested years. The reference period for each simulation loop is one year. This is also the assumed perspective of the farmers, that are unable to consider any longer period in their planning activities. However, due to the presence of investments, mid and long-term investment decisions have to be adapted to this limited perspective. Each loop performs the operations described in Figure 4, also allowing farmers to rent new land, to invest, to produce and finally to decide whether to remain in the business or to leave the sector. Specific routines are also executed to update the agent environment, the farm attributes and the policy relevant variables. An example of these functions is updating the asset vintage until it is eventually dismissed whenever overpasses its lifetime. The model is written in C++ language, an object-oriented language capable of representing complex structures in a nearly natural way. Objects contain status properties as well as methods to change such properties. Examples of objects within AgriPoliS are the agents (farmers) and the investment options. Objects can be grouped in classes, e.g. an investment object is part of another object called *InvestmentList* that is,

Figure 4: AgriPoliS model dynamics



Source: Our elaboration on [5]

in turn, a *property* of farmers.

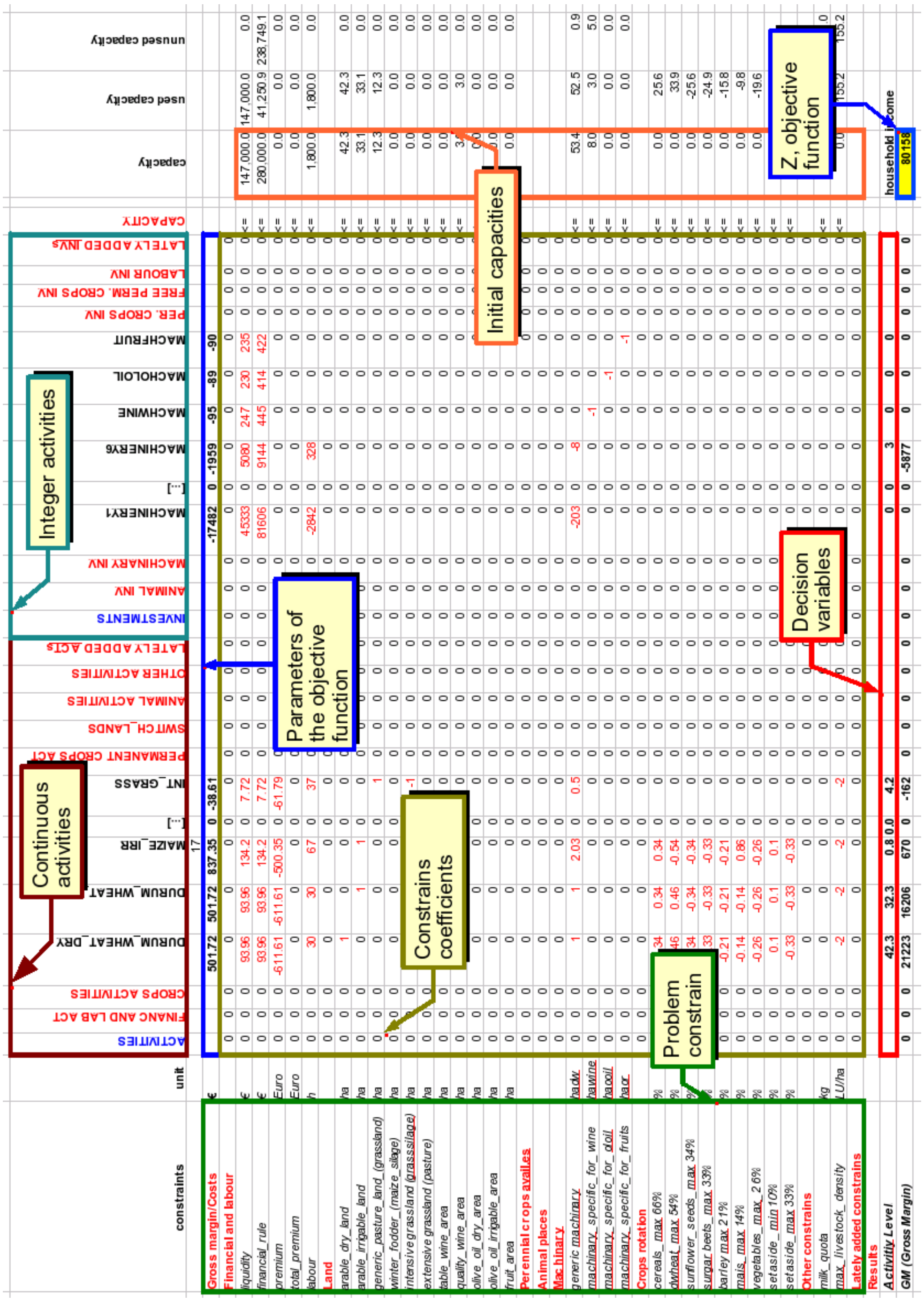
For further details about AgriPoliS and the agent-based models see [1] or [3]; for the object oriented programming paradigm see [6].

4.1.2 Agent decisions

Farmers autonomously make their decisions solving a MIP as shown in Figure 5. Symbol  in Figure 4 denotes a step in the model when one or more MIP have to be computed at the farm level. This happens any time farmers bid for renting a land plot in order to calculate its shadow price, or plan new investments, or produce using the given assets or, finally, anticipate the following period.

From FADN data we can establish the initial farm's endowment: financial assets, availability of land, machinery, animals and so on. From a linear programming point of view, these data represent the problem constrains. Any farmer choose from a list of activity options. We divide them in two categories: activities that can be run entirely within one year and activities that generate results over multiple years (investments). The decision variables are the quantity of these activities the farmer actually implement, once the problem is solved. Investments are bounded to be integer and the same investment type is available in different size-options, allowing scale-effects to emerge in the model. As the farm objective is the maximisation of household income, the parameters of the objective functions are the gross margins of the various activities. Both available resources and activity gross margins differ across farms. While the former is obvious, the latter is a consequence of the heterogeneous managerial coefficients. The matrix of the constraint coefficients links the available activities with their technical requirements. This matrix is initialised in the model initialisation phase, and it is the only part of the MIP that is fixed across farms and over time. For more details about the adopted linear programming technique see [4]. AgriPoliS can also take into account changes of resource endowment and activity gross margins, generated either endogenously to the MIP core, in case these changes occur as a

Figure 5: Mixed integer matrix



consequence of the solving procedure (e.g., an investment improves the number of available activities) or exogenously to it, in case these changes occur in other parts of the model (e.g., renting/releasing land, or as a consequence of market prices changes).

4.2 AgriPoliS: regional adaptation

4.2.1 Regional selection and upscaling

The first step in developing a regional version of AgriPoliS is the choice of a convenient area depending on the modelling purposes. From this region, some tens of "typical farms" are selected and any of them is multiplied by a scaling coefficient to obtain a virtual region. This virtual region contains only typical farms, but its aggregate values are as close as possible to the real one. A 0-coefficient means that the farm is not selected, while a non-0 coefficient implies that the farm becomes one of the typical farms of our virtual region. The key point is to find these scaling coefficients that minimise the difference between the virtual region and the real one. This modelling stage is called "upscaling" and it is well documented in [5]. There are some specific requirements for a real region to be suitable for AgriPoliS:

- Internal homogeneity: AgriPoliS randomly assigns the location of the selected farms within the virtual area and technical coefficients are constant among them. Thus, to generate realistic simulations, we have to keep the variance of productivity as small as possible within the same soil type in the region.

- Number of FADN farms (farm level data requirement): As we use FADN data to select the typical farms, as well to calculate some technical coefficients, we need a great enough number of observations (FADN farms) within the selected region.

- Available regional agricultural statistics: these data are needed to calibrate the upscaling stage with respect to the "real world".

In order to fulfil these requirements, we selected two areas of approximately 50,000 and 30,000 hectares of UAA. Both regions are parts of Italian NUTS3 regions (the "Colli Esini" area in the province of Ancona and the "Piana di Sibari" area in the province of Cosenza, respectively). Further details about these specific regional applications can be found on Deliverable 10 [5] and will be fully documented on Deliverable n.25. Regional data come from the 2000 census data (ISTAT). Before proceeding with the selection of the typical farms, we decided which activities to include in the model in terms of options available to farmers. Having enough FADN farms, we selected the list of products directly from the FADN dataset, by assuming that FADN composition is representative of the regional agriculture. Using FADN data also allows us to separate products typically grown on dry land from those grown on irrigated land. The list of selected products is given in Figure 8. Once the list of products is established, we can proceed with the selection of farms and the upscaling. As mentioned, we need both individual farm (FADN) data and regional data to proceed with these steps. The parameters used to make the upscaling are:

- No. of farms;

- No. of farms by size and farm-type classes;

- UAA and irrigated UAA;

- UAA by farm-type classes;

- Land use {*arable land, grassland, vineyards (table wine and quality wine), olive groves*};

- No. of animals {*beef cattle, pigs*}.

The Italian FADN does not report the number of animals owned by each farm but only the livestock units allocated to each type of livestock activity (e.g. dairy, beef production...). So we can not allocate these livestock units appropriately. Nevertheless, at regional level, data report the distribution of animals by age and category and we can apply this same information to our farms to get farm level data.

4.2.2 Technical and economic parameters

AgriPoliS allows farmers to choose among a large amount of crop and animal activities. For each crop activity, six parameters have to be exogenously defined within the model: direct cost*, direct revenue*, direct premium*, machinery requirement, labour requirement and crop rotation constraint. The asterisk denotes parameters that, though initially exogenous, have some function within AgriPoliS possibly affecting them, thus making them endogenous. Costs, revenues and premiums are calculated from FADN data:

$$(1) \qquad \{cost, revenue, premium\}_{R,p} = \frac{\sum_{i=1}^{n_p} \{cost, revenue, premium\}_{i,p}}{\sum_{i=1}^{n_p} area_{i,p}}$$

where R indicates the region, p the product (activity) and i the individual farm; n_p is the number of farms producing p in the FADN dataset.

In AgriPoliS the machinery requirements to grow the various crops are expressed as an index where the durum wheat requirement is fixed to 1; thus, for example, the machinery level required for vegetables is 2.5, that is two and half times the durum wheat requirement. Data in this respect have been collected from bibliographical sources. Agri-services are also admitted and expressed as units of machinery. Labour requirements are also derived from bibliographical available information, but we integrate them with *ad hoc* assumptions when data are not available (as in the case of some irrigated crops), and we calibrate them running single year simulations. Crop rotation constraints define the upper limit that any particular crop activity can reach on a farm level. Though expression of technical and physical aspects, these constraints are empirically derived from FADN data.

For animals activities, we have neither machinery requirements nor crop rotation constrains. However, we must calculate additional technical parameters: the feeding balance and the livestock units used in the livestock density constraints. With respect to the feeding balance, we assume that forage is exclusively produced within the farm and not traded. In order to provide enough feed to animals, the farmer can allocate the available arable land and grassland to different forage activities like maize silage, intensive grassland or pasture. Thus, the farmer must determine how much land allocated to these activities can actually internally satisfy the feed requirements of the various types of animals. The sub-matrix of relevant coefficients of animal feed requirements is provided on Figure 6.

Figure 6: Sub-matrix on animal feeding requirements

		[...]	CROPS_SILAGE_DRY	CROPS_SILAGE_DRY_IL	INT_GRASS	EXT_GRASS	[...]	BEEF_CATTLE	SUCKLER_COWS	DAIRY	OVINS	[...]
[...]												
arable_dry_land	ha		1									
arable_irrigable_land	ha			1								
generic_pasture_land_(grasslandha					1	1						
- *winter_fodder_(maize_silage)*	ha		-1	-1				$c_{0,0}$	$c_{0,1}$	$c_{0,2}$	$c_{0,3}$	
- *intensive grassland (grasssilage)*	ha				-1	-1		$c_{1,0}$	$c_{1,1}$	$c_{1,2}$	$c_{1,3}$	
- *extensive grassland (pasture)*	ha							$c_{2,0}$	$c_{2,1}$	$c_{2,2}$	$c_{2,3}$	
[...]												

To calculate coefficients $c_{0,0} \ldots c_{2,3} \ldots c_{c,a}$, expressed in [ha], we need four different information: first the overall quantity of feed that each kind of animal requires, expressed in AUE [6]. Then, as the energy requested by animals can be provided utilising various sources (e.g. pasture or silage), we need to know how the share of different kinds of feed is combined to satisfy the animal requirements in that specific region. While the total energy requirement

[6] AUE stand for Animal Unit Equivalent, a standard animal forage requirement measure

by each animal type is relatively constant, the specific composition of their diet can be quite different among regions as it is partially influenced by the resources that are locally available. Finally, on a crop side, we need to know the average yield [ton/ha] and the AUE concentration [AUE/ton] of available forage activities to calculate the area required to feed a single animal:

$$c_{c,a} = \frac{ReqAUE_a * AUEAllocation_{c,a}}{yield_c * EP_c} \quad (2)$$

where:
$c_{c,a}$ = requested area (ha) of crop activity c for animal a;
$ReqAUE_a$ = avg. requested Animal Unit Equivalent (AUE) for animal a (source: bibliography);
$AUEAllocation_{c,a}$ = proportion of animal a AUE requirements obtained from crop c (source: our assumption on the base of the regional characteristics);
$yield_c$ = avg. crop c yield (ton/AUE) (source: calculated from FADN);
EP_c = crop c AUE equivalent (AUE/ton) (source: bibliography).

4.2.3 Investments

Investments for new stables are special activities associated to livestock productions. Stables are modelled assuming fixed lifetime and maintenance costs. Their gross margin is always negative, that is just the costs they generate, but they are mandatory to perform livestock activities: for an animal production to be available at least one stable must be available. In AgriPoliS, new stable investments, as well all investments, are bounded integer, allowing scale effects over different size-options. To keep investment decisions consistent with the production matrix, all associated costs are annualised and a "financial rule" is established, as a constraint, to avoid over-investments [5] [2].

For each investment AgriPoliS identifies five coefficients: *investment capacity, working hours per unit, investment costs, maintenance costs* and *useful life*. Investment capacity defines the size of the investment. We establish six investment-size options for each type of stable. Five of them are obtained running a 5-kmeans cluster analysis on FADN data. The remaining one is set at a 20% higher capacity than the fifth size-option to provide a further option for farms that would eventually increase their size during simulations. Labour requirement is initially set only for the investment size that is prevalent in the region. This value is taken from bibliographical references about the associated livestock activity. Then, a bigger size investments is assumed to have lower labour requirements, while smaller-than-average stables are modelled to be more labour intensive. AgriPoliS does not differentiate among labour types. Therefore, the labour-saving effect of the bigger size is modelled as a *release* of labour. Thus, many farmers could have financial resources to acquire bigger investments and, then, would release labour units for other unrelated activities. Investment coefficients about labour use thus require a careful calibration to take into account such consequences.

Machinery investments are quite similar to new stables, as they are activities sharing the same design: different size-options, negative gross margins and profitable mandatory associated activities. They are annualised to be consistent with one-year activities when the model runs, and they need the same types of investment coefficients than stables. We selected the typical capacity parameters running a cluster analysis on the farm asset data available in our FADN dataset.

Machinery is required to run all the crop activities (including permanent crops) but not for animal activities, where possible machinery costs are already included in the whole stable costs.

4.3 Specific Mediterranean issues: AgriPoliSmed

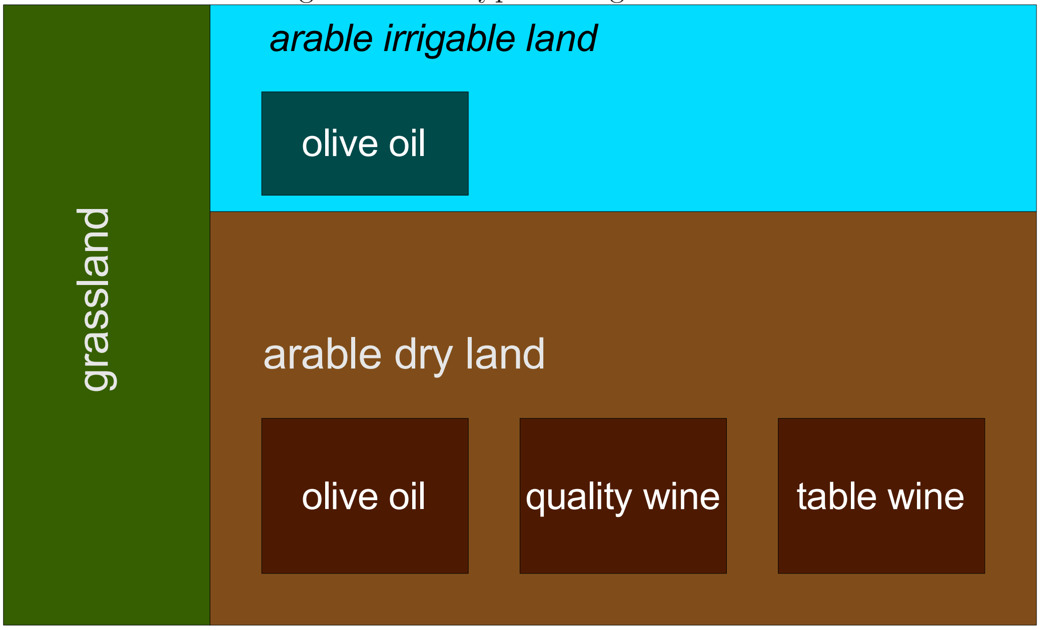
According to the IDEMA workplan, a specific Mediterranean extension of AgriPoliS has been created; we call it AgriPoliSmed. In its current version, it includes 41 constraints and 89 activities, of which those referring to permanent crops are 18 [7]. With respect to AgriPoliS, AgriPoliSmed also models some specific characters of Mediterranean agriculture, specifically wide heterogeneity and inclusion of perennial crops like wine grapes, olives and fruits. In this section, we describe how we adapt the model to these specific characteristics of the Mediterranean context. In some cases, like the introduction of different soil types or the calculation of financial indicators related to perennial crops, it is necessary to change the *source code* of AgriPoliS; in others cases, like the introduction of irrigation and quality differentiation, we have only to change the input data read by the model.

4.3.1 Land use

One main limitation of the original AgriPoliS, when applied within the Mediterranean context, is the presence of only two soil types, arable land and grass land. This makes the model unsuitable to represent the high heterogeneity of Mediterranean agriculture. Thus, AgriPoliSmed allows an arbitrary number of soil types to enter the model; the actual version includes seven soil types. Rather than classified on the base of their physical, chemical or ecological features, we distinguish soil types according to their practical use. Consistently with the original model, soils are initially divided in arable and grassland. Then, we further differentiate arable land according to two criteria: irrigable or not irrigable land (a critical question for many Mediterranean products); suitable or not suitable land for perennial crops. Land available for irrigable and perennial crops is hence fixed in the model; but farmers can temporarily choose to allocate this available land to annual dry crops. Figure 7 shows this basic soil classification. With respect to AgriPoliS, AgriPoliSmed also extends the plot size options, as plots smaller than 1ha are admitted to take into account the typical presence, in the Mediterranean context, of many very small family farms.

[7] 5 pcrops *activities*, 5 pcrops *investments*, 3 pcrops specific machinery *investments* and 5 pcrops to other land *activity* temporary switches

Figure 7: Soil types in AgriPoliSmed



4.3.2 Quality differentiation

As mentioned above, mainly due to different soil and climate conditions, Mediterranean agriculture is highly heterogeneous in terms of product quality. Among the modelled activities, we consider wine as the product with the largest differentiation both in the production process and in the final product. We distinguish between grapes for table wine and grapes for "Quality Wines Produced in Specified Regions" (Quality Wines PSR or VQPRD). In this case, the main difference from the farmer point of view is the location of vineyards: only those located within a well-defined area can produce grapes for a specific quality wine. Once this spatial constraint is satisfied, other requirements have to be satisfied to produce such wines. However, each quality wine has its own very detailed rules and prescriptions. We can not explicitly model all of them. Nonetheless, FADN records allow to model this different quality of wine in terms of different yields, revenues and costs. Based on FADN data and sectoral bibliography, we also admit different parameters in terms of machinery and labour requirements for the two categories.

Furthermore, plots within Quality Wines PSR areas are allowed to have different rental prices and a different impact on the farm financial endowments. While asset values are taken from national statistics, rental prices are endogenous in the model, as they derive from the competition between farmers on the land market.[8]

4.3.3 Irrigation

Unlike quality differentiation, irrigation doesn't influence the final product but strongly changes the production main parameters, that is, costs, labour requirements and yields. We use FADN and census data to distinguish among three categories of products: those cropped on dry land, those that can be cultivated either on dry or on irrigated land, and, finally, those usually grown only on irrigated land. At regional level, we have information only on irrigable land, not on irrigated land. However, the model admits that farmers may grow dry products either on dry or on irrigable land. In this latter case farmers choose to not irrigate their irrigable land. Thus, we can use available data to calibrate and run the model and to simulate different water usage according to different policies. The complete matrix of irrigation options for the various crops is reported in Figure 8.

4.3.4 Perennial crop investments

In AgriPoliSmed, the major adjustment with respect to the original AgriPoliS model concerns perennial crops. Their modelling requires strong modification of how investment objects and investment decisions are included in AgriPoliS. In particular, new stables and machinery investments are modelled in AgriPoliS according to several hypotheses that can not be maintained in the case of perennial crops investments: firstly, they do promptly become productive and then they maintain the same productivity level from the first

[8] AgriPoliS however needs a set of initial values that are usually collected from national statistics.

Figure 8: Irrigation options for any available product

	dry on dry land	dry on irrigable land	irrigated	FADN DATA (percentual points) Colli Esini (Marche)	*irrigated*	Piana di Sibari (Calabria)	*irrigated*
Durum wheat	x	x		47.8	*0.2*	20.5	*2.3*
Soft wheat	x	x		0.3	*0.0*	4.1	*0.0*
Sugar beets	x	x		12.7	*2.3*	0.0	*0.0*
Sunflower seeds	x	x		12.0	*0.0*	0.0	*0.0*
Oat	x	x		0.0	*0.0*	7.6	*6.1*
Maize	x	x	x	2.9	*22.8*	1.0	*49.6*
Crops silage	x	x		0.0	*0.0*	0.0	*0.0*
Barley	x	x	x	1.7	*0.8*	2.1	*18.5*
Vegetables			x	1.2	*27.3*	2.3	*82.1*
Intensive grassland	x			4.6	*0.0*	18.6	*7.1*
Extensive grassland	x			0.2	*0.0*	6.2	*2.1*
Set aside	x			2.1	*0.0*	1.1	*0.0*
Table wine grapes	x			0.8	*0.9*	1.3	*1.4*
Quality wine grapes (DOC)	x			7.1	*0.0*	0.3	*0.0*
Olives for oil	x		x	1.4	*0.0*	16.8	*16.3*
Fruit (oranges)			x	0.0	*0.0*	12.4	*91.0*
OTHER CROPS (not modelled):				5.3		5.6	

Source: Our Figure, FADN

year till the end of the asset useful life; secondly, the financial implications of these investments it is simply derived by modelling an initial cost for the investment, partially funded with debt capital, and then assuming a fixed maintenance cost; finally, they are modelled with a punctual localisation of these assets in the farm, thus avoiding any link between the investment objects and the agricultural plots.

The current AgriPoliS design makes difficult to deal with all these issues without imposing strong and even unaffordable computational requirements.

For example, fully linking plots with new plants also differentiating between owned and rented land would require the introduction of many more activity options and resources in the MIP. Thus, on all these aspects, a compromise has been found between the need of a proper perennial crop modelling and the practical computational limitations.

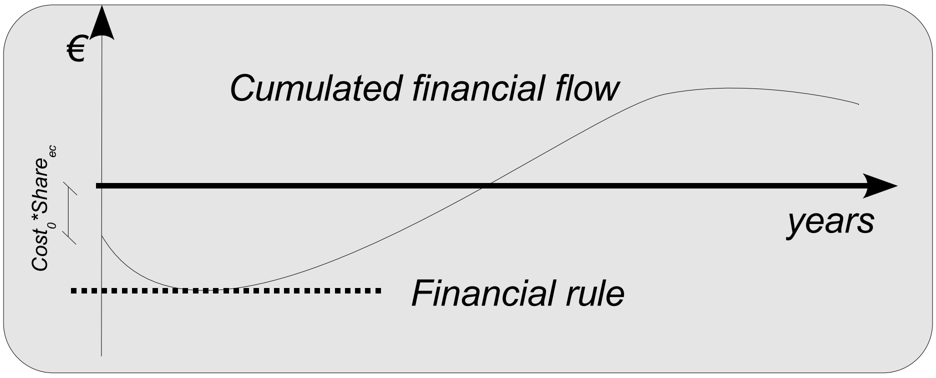
Financial variables To model the financial profile of the perennial crops, we use a "financial rule" in order to "allow" the farmer to evaluate these profitable investments avoiding over-investment and still keeping the limited one-year perspective. In practice, this financial rule is a constraint on the total capital available to the farmer (including debt capital). To calculate this constraint, we have to explicitly consider the time dimension of perennial crop investments and, in particular, the starting planting costs as well the negative income occurring in the initial period of low (or null) yield. Firstly, over the 1,..,n,...N years of useful life, we compute the vector of cumulated discounted financial flows ($CumFinFlow_n$):

$$\begin{aligned} CumFinFlow_n &= CumFinFlow_{n-1} \\ &+ \frac{(Yield_n * MkPrice_n + Premium_n - Cost_n)}{(1+i_{ec})^n} \end{aligned} \tag{3}$$

where:
i_{ec} = interest rate for the equity capital;
$MkPrice_n$ = market price of the perennial crop product.
Secondly, we calculate the financial rule as the minimum value of this vector plus the initial investment cost covered by the equity capital:

$$FinRule = -min\{CumFinFlow_1 ... CumFinFlow_N\} + Cost_0 * Share_{ec} \tag{4}$$

where:
$Cost_0$ = initial costs;



$Share_e c$ = share of the initial investment covered by equity capital. Graphically, the financial rule can be depicted as follows:

Therefore, the financial rule is the maximum amount of own capital, on yearly base, the farm must provide taking into account the initial investment costs and all the subsequent costs before becoming productive. The financial rule drives the farmer's initial investment decision to avoid shortage of capital in the following years. Thus, the following step is the calculation of the required liquidity to cover the financial rule, that is the annualised opportunity cost of the own equity capital:

$$Liquidity = FinRule * f$$

where f is a annualisation factor calculated as:

$$f = \frac{(1 + i_{ec})^N}{(1 + i_{ec})^N - 1} - \frac{1}{N * i_{ec}} \quad (5)$$

To eventually assess whether or not to invest in new plantings and the size of these investments, a final value must be calculated and included in the objective function. It is the average cost of the investment, in AgriPoliS normally obtained as the sum of the maintenance costs, the average deprecation costs and the debt capital costs. However, maintenance costs are skipped for perennial crops as they are already included in the associated production activities and derived from FADN data. Hence, the average (annualised) cost for perennial crops is calculated as:

$$AC = \frac{(FinancialRule + (1 - Share_{ec}) * Cost_0)}{N} + (1 - Share_{ec}) * Cost_0 * f \qquad (6)$$

where the first term of the right hand side is the average depreciation of the whole investment costs while the second term is the cost of debt capital.

Spatial implications of perennial crops Perennial crop activities can be run only on specialised land-types. However, we can not force these "objects" to be allocated in such plots, as they have not any spatial dimension. In other words, the model does not provide any information on where these plantings are located. Nonetheless, we can try to reproduce these spatial implications by adding spatial-related coefficients in the respective MIP sub-matrix. An example for quality wine is provided in figure 9:

Quality wine plantings are a cost for the farmer (negative gross margin) but they are mandatory to run the associated activity. AgriPoliS continuously upgrades the capacity of these plantings, taking into account their lifetime and new investments. Specialised perennial crop land can also be used on a temporary base for arable crop activities, but the opposite does not hold. In fact, suitable land for perennial crops is considered just as a subset of the arable land (see Figure 7), as perennial crops often require further specific space-related characteristics, e.g. exposition. In principle, this design would allow farms to unrealistically continuously alternate, in the same plot, perennial and arable crops. But this effect is avoided by the fact that, in the model, perennial crop investments represent a high proportion of the total production costs of the associated activities, and hence, once the investment decision is taken on a given plot, the activity is maintained for several years.

Technical coefficients In order to calculate the above-mentioned financial variables of the new investment options and of the associated activities, some further technical data are needed. Concerning physical coefficients, the

Figure 9: Sub matrix on wine spatial aspects

	[...]	QWINE PROD. ACTIVITY	[...]	QWINE2ARABLE	[...]	QWINE NEW PLANT	[...]
Gross Margin		pos		0		neg	
[...]							
arable dry land				-1			
[...]							
qwine land		1		1			
[...]							
qwine plant		1				-0.5	
[...]							

first obvious value is the investment lifetime. Here, we consider values that are consistent with the economic life of new plantings, though we acknowledge that the biological life of perennial plants may be much longer (for instance, even thousand years for olive trees). Similarly, yields and technical requirements should refer to new plantings, that are particularly suitable for mechanisation of several operations, rather than old-style labour-intensive plants. In order to calculate the financial values mentioned above (e.g., the current asset values and the costs the farmer incur before the plantings become productive) we need the series of yield over time. These data are taken from the specific literature but some assumptions are still needed. Firstly, we assume that the asset value of the planting linearly grows over time till it becomes fully productive, and thereafter linearly decreases to 0 at the end of lifetime. Secondly, since a vector of year-by-year yield is not available for the plantings in the studied regions, we calculate the average yield from our FADN data and then we reconstruct the time series using bibliographical national data.

With regard to factor requirements, we use bibliographical data for labour while we make some assumptions based on FADN data for machinery. In particular, we assume that 20% of machinery requirements can be specifically attributed to perennial crops, with different machinary for vineyards, for olive fiels and for fruit trees, while the remaining machinery requirements can be shared with the other modelled crops, with a "general purposes" machinary available in different size classes. It must be also noted that agri-services are widely used in the Mediterranean context. Therefore, in AgriPoliSmed they are expressed as hours of services instead of units of machinery, given that from our FADN data we can derive the hours of agri-services bought by farmers as well as their cost. Therefore, here agri-services provide both machinery and the associated labour, while in the original AgriPoliS agri-services provide uniquely machinery.

Other economic and financial variables regarding perennial crops have been computed from FADN data. In particular, to estimate annualised costs we introduce correction coefficients to mimic the higher costs of plantings when over-aged. Since for perennial crops it is not possible to distinguish investment maintenance costs from activity (cultivation) costs, all costs are assigned to the associated activity and the investment maintenance costs are fixed to 0.

Due to the long lifetime of perennial crop investments, it would be unrealistic to assume always the same length for this lifetime and for the debt capital borrowed to fund them. Whenever a shorter length of debt capital is assumed, appropriate financial functions have been included within the AgriPoliS code to allow for the correct calculation of the financial variables (e.g., the asset value and the remaining debt).

Finally, the market price of the associated perennial crop products, as well as their coupled actual subsidies, are derived from available FADN data.

5 Concluding remarks

The Mediterranean agriculture differs from continental agriculture for being more heterogeneous, labour intensive and highly depending on specific environmental factors, particularly water availability. Though such environmental conditions are a weakness in general terms, they can also become an advantage whenever they generate great biodiversity, then expressed in agricultural production in terms of product variety and quality differentiation.

Most typical Mediterranean agricultural activities are strongly labour intensive. Thus, to avoid the social consequences eventually generated by their progressive disappearance on a local base, many Mediterranean products still receive a higher level of coupled subsidies compared with continental products.

Agent-based models have the specific advantage to allow the introduction of this heterogeneity and complexity, as well as to admit in a relatively simple way that both coupled and decoupled measures coexist at the farm level and in the same regional context, where heterogeneous agents may have different SFP levels on the base of their different historical CAP payments. Furthermore, explicit spatial aspects allow the model to take into account plot-level effects.

Consequently, AgriPoliSmed seems appropriate to simulate the complex and composite effects of a CAP regime switch on a small Mediterranean region. In IDEMA Deliverable 25 (August 2006) the application of AgriPoliSmed to the two regional case-studies will be presented. The effect of different levels and forms of decoupled and coupled policy measures on this heterogeneous, labour intensive and environmentally sensitive agriculture will be then analysed, and the AgriPoliSmed potential critically reviewed.

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A Statistical appendix

Table A.1: Land use [ha]

	2003			2000		
	EU25	EU25med	Italy	EU15	EU15med	Italy
Total land	397,552	104,014	30,134	323,428	103,008	30,132
Arable land	97,073	25,253	7,959	71,749	23,330	7,261
Perm. grassland	56,401	14,767	4,377	44,935	14,782	3,418
Perennial crops	11,606	9,494	2,674	9,994	8,482	2,347
Other land	232,472	54,499	15,124	196,749	56,414	17,106

Source: Eurostat

Table A.2: General territorial, social and economic data

	2003			2000		
	EU25	EU25med	Italy	EU15	EU15med	Italy
Total area[a]	398	104	30	323	103	30
UAA[a]	156	46	13	127	47	13
Population[b]	455,846	122,195	57,605	377,023	118,355	56,949
Agr. labour force[c]						
- heads[b]	20,342	8,597	3,738	13,547	8,898	3,964
- AWU[b]	9,161	3,095	1,323	5,688	3,049	1,208
Agr. holdings[b]	9,811	4,330	1,963	6,771	4,674	2,154
GDP[d]	9,823	2,389	1,301	8,609	2,042	1,167
Agr. Output[d]	158	69	29	147	62	28

[a] x1,000,000 hectares

[b] x1,000

[c] Regular labour force

[d] x1,000,000,000 euros

Source: Eurostat

Table A.3: Agricultural output [milions of euro]

		2003			2000	
	EU25	EU25med	Italy	EU15	EU15med	Italy
Cereals and oth. crops	82,730	20,448	8,238	76,685	21,595	8,910
Animal products	127,730	33,538	14,341	116,854	30,943	13,571
Fruits	20,857	13,832	4,576	16,386	11,771	4,340
Wine	14,509	6,422	4,011	16,191	6,644	3,998
Olive oil	5,634	5,634	2,065	5,102	5,102	2,008
Veg & Hort	45,295	21,020	8,442	37,190	16,146	7,512
Services and transf	18,039	4,363	2,141	14,606	3,813	1,671

Source: Eurostat (Economic Accounts for Agriculture)

Table A.4: Farm holders by age class [1,000 heads]

	2003			2000		
	EU25	EU25med	Italy	EU15	EU15med	Italy
< 35	835	217	76	529	310	111
34 - 44	1,788	567	235	1,094	635	263
45 - 54	2,318	841	376	1,469	947	434
55 - 64	2,070	1,024	474	1,539	1,126	504
>= 65	2,650	1,623	788	1,871	1,581	826

Source: Eurostat