Recent dynamics and trends of Portuguese agriculture – a Biplot analysis[1]

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Abstract

The Common Agricultural Policy (CAP) reforms had consequences on European agriculture, leading to changes in the farms' land uses and orientations. In southern Europe these consequences resulted in specific dynamics. In Portugal, several districts show a decline in agriculture, which is important in order to analyse the past dynamics and to identify future trends. The present paper proposes a methodological approach that combines the use of a multivariate Biplot method with a geographic information system (GIS). This approach was applied to the main land uses and crops' dynamics in Portugal's municipalities. Results show that this methodology is able to provide a detailed insight into the main changes in land uses and crops and to identify trends, since it is a very useful tool for policy evaluation and implementation.

***Key-words**: land use, Biplot, geographical information systems, politics, Portugal.*

Résumé

Les réformes de la Politique Agricole Commune (PAC) ont eu des conséquences sur l'agriculture européenne, qui ont déterminé des changements dans l'utilisation des terres et dans les productions agricoles. En Europe du Sud, ces conséquences ont produit des dynamiques spécifiques. Au Portugal, dans plusieurs comtés, on observe un déclin de l'agriculture qu'il est important de considérer afin d'analyser les dynamiques du passé et d'identifier les orientations futures. Dans le présent travail, nous proposons une méthodologie qui combine l'utilisation d'une méthode multi-variée Biplot avec un système d'information géographique (SIG). Cette méthode a été appliquée pour les principales utilisations des terres et dynamiques des cultures dans les municipalités portugaises. Les résultats montrent que la méthode proposée peut nous fournir des informations ponctuelles sur les changements majeurs au niveau de l'utilisation des terres et des cultures et permettre également l'identification des tendances, étant donné qu'il s'agit d'un outil très utile dans l'analyse et la mise en œuvre des politiques.

Mots-clés: utilisation des terres, Biplot, système d'information géographique, politique, Portugal.

1. Introduction

Agriculture and forests cover the majority of European territory, play a key role in determining the health of rural economies as well as rural landscape and give a valuable contribution to sustainable development.

In 2012, agriculture in the EU-27 generated c. 159.4 billion € of added value, which represents 1.4 per cent of the added value for the whole economy. However, the contribution of agriculture fell from 1.8 per cent, a decade earlier (2002), to 1.2 per cent in 2009, before increasing each year through to 2012. The economic importance of agriculture, in added value, was generally much greater in the eastern and south Europe than in the west and north (Eurostat, 2013).

European agriculture is undergoing a deep process of change. The continuous reforms in Common Agricultural Policy (CAP), the volatility of food prices, and the emergence of new driving forces will determine the future of farming activities (Gallego-Ayala and Gómez-Limón, 2011). In fact, CAP has been adapted several times, with significant reforms in recent years. These reforms had strong impacts on the different European Union territories, leading to different behaviours of farmers and inducing several changes in different agricultural systems (Fragoso *et al.,* 2008).

Until the early nineties of the last century, CAP was mainly oriented to support markets. Prices were guaranteed and complemented by export subsidies and import restrictions. The Mac Sharry reform in 1992 (REG. CEE 1765/92 and 1766/92), affected mainly arable crops (cereals, oil seeds and protein crops) and beef meat, and changed radically the way European Union (EU) provides income support to farmers. Guaranteed prices of arable crops and beef meat were progressively aligned with world prices, being this reduction compensated by arable crop area and livestock head payments. For arable crops an obligatory but compensated system of set-aside land was also implemented (Fragoso *et al.,* 2011).

The second CAP reform known as Agenda 2000 was held in 1999 and reinforced the objectives of agricultural competitiveness, sustainability and multi-functionality that guided the previous reform (Fragoso *et al*., 2011).

The 2003 reform (EU REG. 1782-88/03) aimed to reduce the disequilibrium in agricultural markets, enhance agricultural competitiveness, and mitigate environmental impacts, through the decoupling of supports. This reform provided a new support scheme that replaced the arable crop area payments of Agenda 2000 by a single farm payment (SFP) based on historical entitlements and on the compromise of

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keeping land in good agricultural and environmental conditions. In the Health Check, approved in January 2009 (REG. EU 72-4/2009), the decoupling of support was further strengthened. This reform introduces some adjustments in order to simplify CAP, grabs new market opportunities and prepares it to face new challenges (Fragoso *et al*., 2011).

The changes are expected to continue, because they are the result of production systems and technology's evolution and policy orientations. The Rural Development Regulation 2007-13 clearly ties environmental measures to the sixth environmental action program: the strategic lines identify three priorities in what concerns environment and rural areas: biodiversity and agro-forestry systems and traditional landscapes preservation and development, water and climate changes.

In this context, Portugal is a country of southern Europe with different production systems in which the agricultural activity still has a reasonable importance in some regions such as Alentejo, where its weight in the regional GDP is higher than the national value (GPP, 2012). Also, there are some production systems such as the Mediterranean rainfed agriculture that are subject to a high risk due to the variability of the meteorological conditions (Carvalho and Godinho, 2011).

About policy implementation, it is important to identify the main agricultural dynamics on farms' land uses and crops that may be linked to policy options and to identify the future trends.

The Biplot method (Gabriel, 1971) is a useful methodology for this analysis. This is a multivariate data analysis method that has been developed through the years (Cárdenas *et al,.* 2007) and that proved to present better results than the conventional approaches (Galindo Villardón *et al*., 1996). Several studies have been done in different science fields (e.g. Rivas-Gonzalo *et al*., 1993; Martínez-Ruiz *et al*., 2007; García-Talegón*et al*., 1999; Cabrera *et al*., 2006; Castela and Villardón, 2010) but the agricultural data examples' analyses are few (Dorado *et al*. 1999; Martin-Rodriguez *et al*. 2002).

The main objective of this paper is to develop a methodological approach able to identify the individual dynamics of farms' land uses at municipality and regional levels in Portugal, using as basis the potentialities of the Biplot method and developing a geographical analysis of policies' consequences.

This paper is divided into the following sections: in section two, the Portuguese agricultural dynamics in the economy is analysed and the study area is presented; in section three, the analytical framework is discussed; in section four, the technical and empirical implementation of the model is explained; in section five, the results are presented and discussed. Finally, section six stresses the main conclusions of this work.

2. The economic dynamics of Portuguese agriculture

In spite of still being an important economic sector in some Portuguese regions, agriculture has only represented about 2 per cent of the Gross Domestic Product (GDP) over the last decade. In general the agricultural sector has revealed a tendency of a slight decrease in the GDP, from 2.6 per cent in 2000 to 1.6 per cent in 2010. Also, the importance of the agricultural sector in the employment decreased

from 11.5 per cent in 2000 to 10.4 per cent in 2010, revealing a negative evolution in the last decade, in spite of some stabilization over the years 2008-10 (GPP, 2011).

The analysis of the Gross Added Value (GAV), at current prices, considering a longer sequence, shows a rising trend until 1996 and tends to decrease afterwards, although with differences that correspond in general to different meteorological years (INE, 2010).

Unfolding the series analysed in three different decades, it is possible to observe differentiated dynamics of the GAV's growth. In the 90's a decline was observed in volume, but an increase in the amount by which basic prices determined this nominal growth, while the last decade has been marked by a decrease in average value of 2.5 per cent/year, which nullifies the growth in volume observed (INE, 2010).

The growing gap between GAV at basic prices and GAV at producer prices is visible since the early 90s, decreasing from 2006 as a reflection of CAP reform (INE, 2010).

3. The analytical framework

A Biplot is a graphical representation of multivariate data. The concept of a Biplot means that in the graph that represents X, there are two types of markers: markers (vectors) representing individuals and markers (vectors) representing the variables (Gabriel, 1971).

This multivariate analytical technique was proposed by Gabriel (1971) and shows three or more variables together in the same way that a scatter gram shows the distribution of two variables together. According to Gabriel (1971), any matrix of rank two can be displayed graphically as a Biplot which consists of a vector for each row and a vector for each column, chosen such that any element of the matrix is exactly the inner product of the vectors corresponding to its row and its column. If a matrix is of higher rank, one may display it as a Biplot of a rank two matrix, which approximates the original matrix. The Biplot provides therefore a useful tool of data analysis and allows the visual appraisal of a large data matrices structure.

A Biplot is therefore a graphical representation of a data matrix $X_{n\times p}$ using markers 1…., n $a_1 \ldots a_n$ for rows and markers b_1 ; b_j for columns, chosen in such a way that the internal represents the initial matrix x_{ij}, $x_j^i = a_i^T b_j$, or:

$$X \cong AB^T \qquad (1)$$

The initial matrix can be written according to the singular value decomposition:

$$X=UDV' \quad (2)$$

where U is the matrix of Eigen vectors of the matrix XX'; D is the matrix of Eigen values of the previous matrix ordered from the largest to the smallest, and V' is the matrix of Eigen vectors of the matrix X' X.

Therefore, according to Gabriel (1971) the markers of the rows and columns are selected as:

$$G = U_k\Lambda_k^a \quad (3)$$

$$H = V_k\Lambda_k^{1-a} \quad (4)$$

Where *k* determines the dimension of the approximation (typically k=2) and *a* is a constant that can take different values, which lead to different types of Biplots:

JK or RMP - When the value 1 is selected in *a*, the result is called a row metric preserving Biplot (RMP or JK). Therefore, and $G = U_k\Lambda_k$ and $H = V_k$. In this display the distance between pairs of rows is preserved and the display is useful for studying objects.

GH or CMP - When the value 0 is selected in *a*, the result is a column metric preserving Biplot (GH or CMP) and this display preserves distances between the columns, leading to high quality for variables. It is useful for interpreting variance and relationships between variables. Therefore: $G = U_k$ and $H = V_k\Lambda_k$.

SQRT (symmetric Biplot)- It is a compromise obtained when a=1/2. So: $G = U_k\Lambda_k^{½}$ and $H = V_k\Lambda_k^{½}$.

The HJ-Biplot is a symmetric simultaneous representation technique that to a certain extent resembles correspondence analysis, but it is not restricted to frequency data (Galindo, 1986). The method is closely related to the main component analysis, as variance and covariance matrixes are plotted on planes that account for most of the inertia (Garcia-Talegon*et al*., 1999).

It was demonstrated that the HJ-Biplot was able to produce better results than the previous classic Biplot methods proposed by Gabriel (Galindo, 1986). This method achieves an optimum representation quality for both rows and columns, as rows and columns are represented on the same reference system (Galindo 1986; García-Talegón *et al*., 1999; Cabrera *et al.,* 2006). The two main characteristics of this representation are: both markers (rows and columns) can be represented in the same reference system; the quality of representation is the same for rows and columns (Galindo Villardón *et al*., 1996).

A representation HJ-Biplot for a data matrix X containing the units is defined as a graphical representation by multivariate markers j_1, j_2... j_n for lines and h_1, h_2,...h_n for columns of X, selected so both markers may overlap in the same reference system with high quality representation. The lines are represented by dots and the columns by vectors (Galindo, 1986). Thus, the HJ-Biplot, based on singular value decomposition (SVD) of the data matrix, and any real matrix characteristic r ($r \leq \min(n, p)$) may be factored as the product of three matrices such that (Castela and Galindo, 2010):

$$X_{(nxp)} = U_{(n\times r)}\Lambda_{(r\times r)}V'_{(r\times p)} \text{ with } U'U = V'V = Ir \quad (5)$$

where:

$U_{(n\times r)}$ is the matrix of Eigen vectors of XX ';

$V_{(p\times r)}$ is the matrix of Eigen vectors of X'X;

$\Lambda_{(r\times r)}$ is a diagonal matrix of $\lambda_1\lambda_2\lambda_3...\lambda_r$ corresponding to the r eigen values of XX' or X'X.

The elements of are given by:

$$X_{ij} = \sum_{k=1}^{r}\sqrt{\lambda_k u_k v_{jk}} \quad i = 1,2...,n \quad j = 1,2...,p \quad (6)$$

Therefore, using the SVD, the selection of markers for dimension q for lines and columns of matrix X is calculated, as follows:

$$J_{(q)}=U_{(q)(q)} \quad (7)$$

$$H_{(q)}=V_{(q)(q)} \quad (8)$$

For a correct interpretation of the HJ-Biplot, besides the graphical representation, the method implies the analysis of several measures: the relative contribution of the factor to the element expresses the part of the element's variability (row or column) explained by the factor (axis); the quality of representation is the sum of the factor's contribution to the element and only the points with good quality of representation can be interpreted correctly (Garcia-Talegon *et al*., 1999; Cabrera *et al*., 2006).

In the HJ-Biplot representation, the interpretation of the results (Vicente-Villardón W.D.; Silva, 2010) is presented as follows:

1 - The cosine of the angle between the vectors representing the variables in a Biplot is the correlation coefficient between the respective variables. This means that if two attributes are positively correlated, vectors that represent the variables form acute angles. If the ratings of an attribute do not have any relationship with other attribute, the markers that represent the Biplot graphic form a right angle and the correlation between attributes is null. On the other hand if an attribute is inversely correlated with any other, the vectors form obtuse angles;

2 - The distance between row points is interpreted as similarity, and if a row point is close to a column point (variable), this is interpreted as preponderance (García-Talegón *et al*., 1999);

3 - The closer the direction of a variable is to a representative point of an individual and the greater spacing of the individual in relation to the center, the higher the importance of this variable in explaining the results obtained by an individual. Thus, the higher is the value of the projection of an individual on a variable - measured from the center - the higher the value of this variable on the individual and the greater preponderance of the variable in the behaviour or response of the individual's explanation;

4 - Longer vectors represent attributes with higher variance;

5 - The smaller the angle between the defined vectors and markers of an individual and of a variable, the greater affinity between this individual and this variable, in the sense described.

This approach has been largely used. García-Talegón *et al*. (1999) studied the results of the chemical analyses of major and trace elements; Cabrera *et al*. (2006) used the HJ-Biplot to determine the possible relationships among different pollutants; Martínez-Ruiz *et al*. (2007) investigated the way and order in which treatment and aspect contributed to determine changes in a biological community; Castela and Villardón (2010) tried to find spatial homogeneity in the main political trends for Portuguese legislative elections; Marreiros *et al*. (2010) applied the methodology to the analysis of hospitals' efficiency; Alonso *et al*. (2011) analysed the profile of women working in the domestic activities; and Dorado *et al*. (1999) analysed the similarity structures and co-variation patterns of land productivity in Castilla-León, 1991-1995.

Some studies (Oliveira, 2011; Silva, 2010; Marreiros *et al.,* 2010; Dorado *et al*., 1999) also proved that we can represent simultaneously, in the several years, the different territorial units (t1...tm) and not only analyse the individual trends to identify the groups with similar characteristics, using a hierarchical cluster analysis. This means that analyzing the specific movements of units, we are able to identify individual trends and each year's most preponderant land uses.

This analysis can also be complemented combining the HJ-Biplot analysis with a cluster analysis and putting in space the results using a Geographic Information System (GIS).

The methodological approach proposed in this paper uses this combination and identifies the main dynamics and individual trends of each municipality using a GIS to project the results in a geographical analysis.

4. The empirical and technical implementation

The analysis presented in this paper is based on the Portuguese Agricultural Census (AC). We propose the use of the last two censuses: the 1999 and 2009 AC (INE, 2001; INE, 2011).

For the land uses, the following classes were considered: Wooded area without grasslands or crops (WLAN), Non-used agricultural land (UNUT), Temporary crops (TEMP), Fallow land (FO), Permanent crops (PERM), Permanent grasslands (PP) and Other Surfaces (OSF).

Regarding the crops' types, we divided the analysis in two main types of crops (which constitute 2 sets of information): temporary crops and permanent crops. Temporary crops are divided in cereals for grain and dry legumes (CERGELEG) -includes all the rainfed crops intended for grain production-, temporary meadows and forage crops (PTCF), horticultural crops and potatoes (CULTHORE-BAT) and other temporary crops (OCT)-includes all the other temporary crops such as industrial ones and flowers' production. For the permanent crops the following classes were accounted: fresh fruits and citrus (FFECTR), nut fruits (FRCRIJ), olive trees (OLIV), vineyards (VIN) and other permanent crops (OCP).

Portugal is administratively divided into municipalities. The municipalities are probably the most consistent and stable administrative division that exists in Portugal. Actually, Portugal is divided in 308 municipalities. A deliberative body and an executive body manage these municipalities, both directly elected by citizens. The data of 278 municipalities, included in 7 agrarian regions was collected from the two referred AC. In this process three different tables were built: a 556 rows and 7 columns table for the main land uses; a 556 rows and 4 columns table for the temporary crops; and a 556 rows and 5 columns table for the permanent crops. For each of these tables the steps of the methodological approach were applied and an HJ-Biplot representation was built.

For the transformation process we considered the experts' opinions on the final results and selected the following ones: double centering for the analysis of the main land uses and permanent crops and columns standardization for the temporary crops' analysis.

For defining the different homogeneous groups of municipalities, we used the Biplot coordinates to apply a hierarchal cluster analysis method. The Euclidean distances were used as a dissimilarity index (Rajaraman *et al*., 2010: 239-40) and for the linkage method we considered the Ward's method, based on the analysis of variance to evaluate the distances between clusters.

For the technical application of the methodological approach, we used the program Multbiplot Beta version developed by Vicente-Villardón (2013) and available online for the HJ-Biplot method. The final results were analysed geographically using ArcGIS 9.3.

5. Results

5.1. The HJ-Biplot results and the homogenous groups

In HJ-Biplot main land uses analysis, three axes with 78.96 per cent of the accumulated inertia were retained. The relative contributions of the factor to the element are presented in table 1. Axis 1 is highly correlated with permanent grasslands (PP) and represents extensive uses, in which livestock is bred in an extensive way, typifying the extensive cattle farming system. Axis 2 is highly correlated with woodland (WLAN), temporary crops (TEMP) and fallows (FO) and represents the agricultural and reserve system. Finally, axis 3 is correlated with other surfaces (OSF), but also with temporary and permanent crops and represents the general agricultural system.

For temporary and permanent crops two axes were retained with 78.49 per cent and 83.69 per cent of the accumulated inertia, respectively. The relative contributions of

Table 1.*The relative contributions of the factor to the element (main land uses).*

Column	Axis 1	Axis 2	Axis 3
WLAN	255	**642**	61
UNUT	20	15	37
TEMP	241	**504**	235
FO	14	**135**	99
PERM	0	65	**219**
PP	**884**	5	96
OSF	12	133	**434**

Source: model results.

the factor to the element on temporary crops are presented in table 2. Axis 1 is highly correlated with cereals for grain and dry legumes (CERGELEG), temporary meadows and forage crops (PTCF) and other temporary crops (OCT). Therefore, this axis represents traditional rainfed temporary crops. Axis 2 is highly correlated with horticultural crops and potatoes (CULTHOREBAT), representing irrigated crops that are produced in intensive farming systems.

Table 2. *The relative contributions of the factor to the element (temporary crops)*.

Column	Axis 1	Axis 2
CERGELEG	**616**	177
PTCF	**863**	70
CULTHOREBAT	77	**893**
OCT	**354**	90

Source: model results.

The relative contributions of the factor to the element in what concerns permanent crops are presented in table 3. Axis 1 is highly correlated with olive trees (OLIV) and vineyards (VIN) and represents the traditional crops. Axis 2 is highly correlated with fresh fruits and citrus (FFECTR) and nut fruits (FRCRIJ), and therefore represents the fruit production.

Table 3.*The relative contributions of the factor to the element (permanent crops).*

Column	Axis 1	Axis 2
FFECTR	31	**481**
FRCRIJ	2	**439**
OLIV	**875**	121
VIN	**776**	217
OCP	20	34

Source: model results.

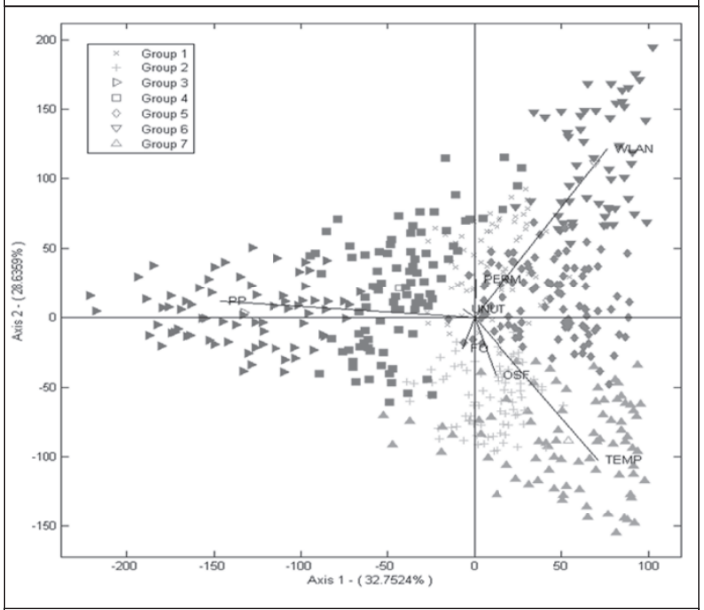
The HJ-Biplot representations and the resulting groups after cluster analysis are presented in Fig. 1, 2 and 3 for the main land uses, temporary crops and permanent crops.

Analysing these representations an inverse correlation between the permanent grasslands and the woodland can be identified in land uses (Fig. 1), which is explained by the fact that there is usually a conversion of woodland areas in permanent grasslands, under the forests. Also there is a correlation between temporary crops and fallow area (explained by the rotations usually practiced) and an inverse correlation between permanent grasslands, woodland area and temporary crops. Finally, permanent crops are correlated with non-used agricultural land.

The following groups of municipalities were identified:

Group 1- Municipalities oriented to permanent crops;
Group 2- Municipalities oriented to temporary crops and other surfaces;
Group 3- Municipalities highly oriented to permanent grasslands;
Group 4- Municipalities with extensive uses oriented to permanent grasslands;
Group 5- Municipalities with mixed uses;
Group 6- Municipalities oriented to forest uses;
Group 7-Municipalities mostly highly oriented to temporary crops.

Fig. 1. *The bi-dimensional HJ-Biplot representation (main land uses).*



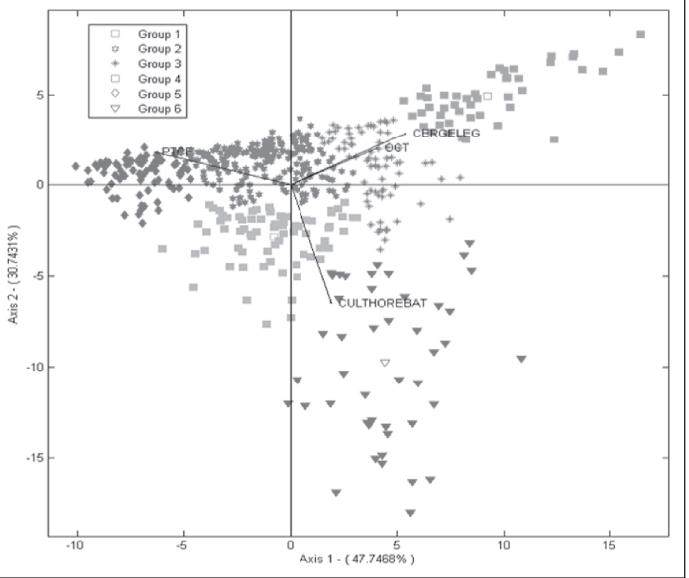
Source: model results.

The HJ-Biplot representation of temporary crops is presented in fig. 2. It can be concluded that there is a correlation between cereals for grain and dry legumes (CERGELEG) and other temporary crops (OCP). There is also an inverse correlation between cereals for grain and dry legumes (CERGELEG) and temporary meadows and forage crops (PTCF) explained by the substitution of grain cereals by forages connected with livestock breeding. The horticultural crops and potatoes (CULTHOREBAT) seem to be inversely correlated with temporary meadows and forage crops (PTCF).

The following groups of municipalities were identified:

Group 1-Municipalities with mixed uses oriented towards irrigated crops;
Group 2-Municipalities oriented to rainfed crops with mixed uses;
Group 3-Municipalities oriented to cereals and dry legumes and other temporary crops;
Group 4-Municipalities highly oriented to cereals for grain and dry legumes;
Group 5- Municipalities highly oriented to forage crops and temporary grasslands;
Group 6-Municipalities highly oriented to irrigated crops namely horticultural crops and potatoes.

Fig. 2. *The bi-dimensional HJ-Biplot representation (temporary crops).*

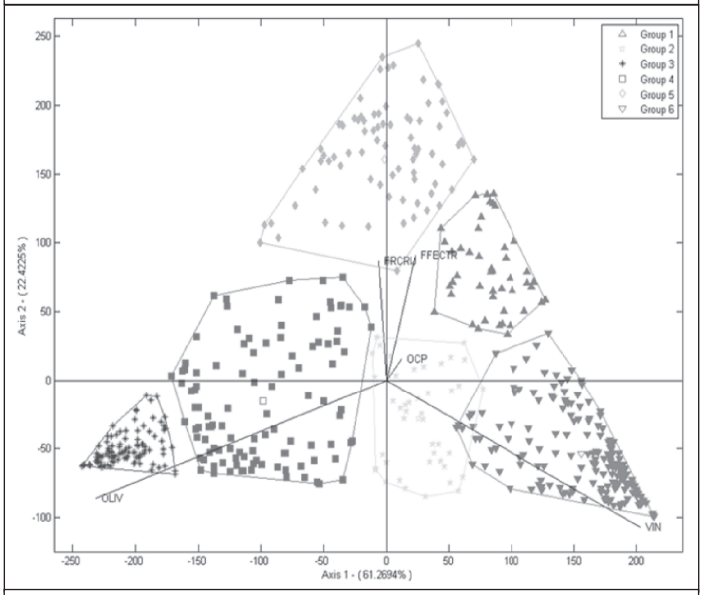


Source: model results.

In what concerns the HJ-Biplot representation of permanent crops (fig. 3) a high correlation between fresh fruits and citrus (FFECTR) and nut fruits (FRCRIJ), which seems to be a consequence of the organization boost both these sectors had over the last ten years. Fresh fruits and citrus sector is finally an organized and well-dimensioned sector and on the nut fruits there was a bet on pine nuts and chestnuts and also a greater organization of these rows. Support to commercialization and competitiveness was also addressed. The olive trees (OLIV) are inversely correlated with vineyards (VIN) as these crops are usually mutually excluded. The following groups of municipalities were identified:

Group 1 - Municipalities oriented to fresh fruits and other permanent crops;
Group 2 - Municipalities with diverse orientations;
Group 3 - Municipalities highly oriented to olive crops;
Group 4 - Municipalities oriented to olive crops;
Group 5 - Municipalities oriented to nuts fruits and fresh fruits;
Group 6 - Municipalities oriented to vineyards and wine production.

Fig. 3. *The bi-dimensional HJ-Biplot representation (permanent crops).*



Source: model results.

5.2. Dynamic analysis and spatial patterns

The results of the municipalities integrated in the homogenous groups were mapped and represented using a GIS, both in the 1999 and 2009 cases, to identify spatial patterns. The combination of these two maps enabled the identification of the municipalities' position and general situation each year (and not smaller individual tendencies inside each cluster).

Regarding the main land uses' spatial patterns in 1999 there is a dominance of group two (municipalities oriented to the production of temporary crops and other surfaces) in the Alentejo and inland. We were also able to identify the dominance of group five (municipalities with mixed uses) on the northwest of Portugal and group four (municipalities with extensive uses oriented to permanent grasslands) on center and south (Algarve). In 2009 group two loses its dominance for group three (municipalities highly oriented to permanent grasslands) and group four (municipalities with extensive uses oriented to permanent grasslands). This means that in these areas there is a process of extensification by substitution of cereals by permanent grasslands; this was also identified in the northeast inland. In the Algarve, group one (municipalities oriented towards permanent crops) becomes more important. So, for the main land uses, the trends were:

T1- Municipalities oriented to temporary crops and other surfaces that became municipalities highly oriented to permanent grasslands (from group two to three). These were farms that traditionally developed rainfed crops in rotation systems, but have abandoned them;

T2- Municipalities oriented to temporary crops and other surfaces that become oriented to extensive uses and permanent grasslands (from group two to four);

T3- Municipalities highly oriented to permanent grasslands that became more oriented to permanent crops (from group three to one);

T4- Municipalities with extensive uses oriented to permanent grasslands, that became oriented to permanent crops (from group four to one);

T5- Municipalities that maintain their orientation;

OT-Other tendencies.

The results are detailed in table 4.

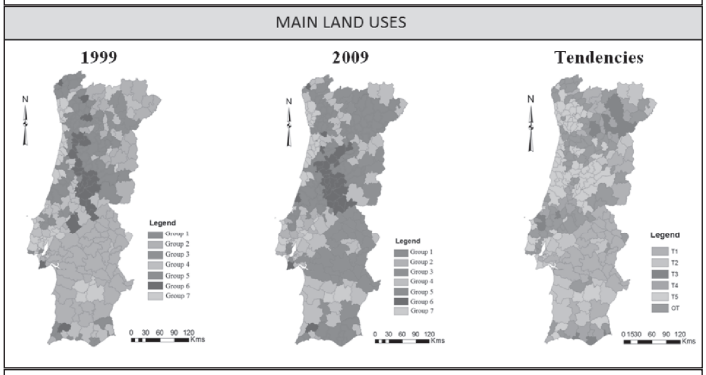
Table 4 - *Municipalities changes between groups (1999-2009) – Main land uses.*

Main land uses	**2009**						
1999	G1	G2	G3	G4	G5	G6	G7
G1	2	1	3	8	1	0	1
G2	3	0	44	24	1	0	1
G3	22	2	0	0	0	0	0
G4	22	5	0	6	0	5	0
G5	1	1	0	7	36	7	5
G6	0	0	1	5	3	17	0
G7	0	2	2	3	6	0	31

Source: model results.

Fig. 4 maps the dynamic analysis of the spatial trends in what concerns the main land uses between 1999 and 2009.

Fig. 4. *Dynamic analysis of the spatial trends: main land uses.*



Source: model results.

Regarding temporary crops in 1999, the southern area of Portugal (namely the Alentejo Region) was dominated by group four (municipalities highly oriented to cereals and dry legumes), while the Portuguese north and inland were dominated by group two (municipalities oriented to rainfed crops with mixed uses). In 2009, group two clearly increased its area namely in the Alentejo, while group four became reduced to a small number of municipalities. Also group five (municipalities highly oriented to forage crops and temporary grasslands) became more important especially in the center inland. These changes reflect the substitution of traditional cereal crops by forage crops and temporary grasslands for livestock feeding (Marques, 2004).

T1-Municipalities oriented to rainfed crops with mixed uses that became highly oriented to forage crops and temporary grasslands (from group two to five);

T2- Municipalities highly oriented to cereals for grain and dry legumes, that became oriented to rainfed crops with mixed uses (from group four to two);

T3- Municipalities oriented to cereals and dry legumes and other temporary crops, that became oriented to rainfed crops with mixed uses (from group three to two);

T4-Municipalities that remained in the same group;

OT-Other tendencies.

The changes between groups are presented in table 5.

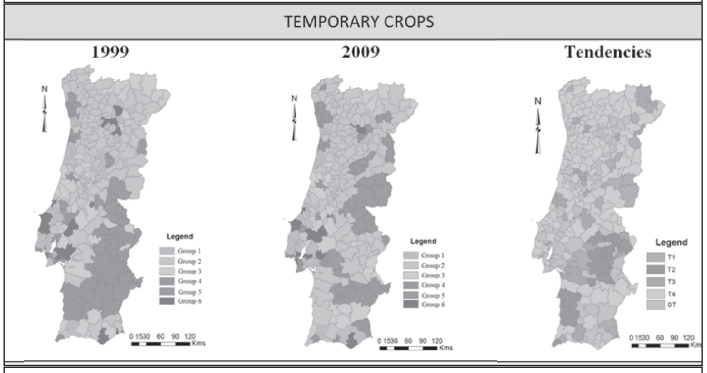
Table 5. *Municipalities changes between groups (1999-2009) – temporary crops*.

Main land uses	**2009**					
1999	G1	G2	G3	G4	G5	G6
G1	20	11	3	0	9	1
G2	1	79	4	1	19	0
G3	3	20	14	1	1	4
G4	0	14	11	9	1	0
G5	2	2	0	0	24	0
G6	6	1	0	0	1	16

Source: model results.

As before, Fig. 5 maps the dynamic analysis of spatial trends in what concerns temporary crops.Finally, for the permanent crops in 1999 there was a clear dominance of group six (municipalities oriented to vineyards and wine production) in northwest and midwest of Portugal (Ribatejo area). Group four (municipalities oriented to olive crops) had relevance in the northern inland and in part of the center, while group three (municipalities highly oriented to olive crops) dominated in the inland and south, in the Alentejo area. Finally, group five (municipalities oriented to nuts and fresh fruits) dominated mostly in southern municipalities, located in the Algarve. In 2009, there are not relevant changes, in spite of a decrease of group three's importance and an increase of group four in some areas. Group five al-

Fig. 5. *Dynamic analysis of the spatial trends: temporary crops.*



Source: model results.

so reveals some changes. For the permanent crops, trends are:

T1- Municipalities highly oriented to olive crops that became less oriented to these crops (from group three to four);

T2- Municipalities oriented to fresh fruits and other permanent crops that became municipalities oriented to nuts fruits and fresh fruits (from group one to five);

T3- Municipalities that remained in the same group;

OT- Other tendencies.

Results are detailed in table 6.

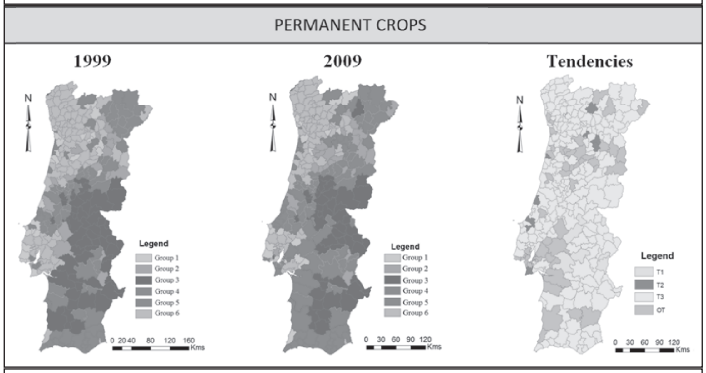
Table 6. *Municipalities changes between groups (1999-2009) – permanent crops*.

Main land uses	**2009**					
1999	G1	G2	G3	G4	G5	G6
G1	10	2	0	2	9	3
G2	0	11	0	6	2	0
G3	0	0	44	8	2	0
G4	0	1	3	40	1	0
G5	2	1	1	5	30	0
G6	7	10	0	1	2	75

Source: model results.

Fig. 6 maps the dynamic analysis of spatial trends in what concerns permanent crops.

Fig. 6. *Dynamic analysis of the spatial trends: permanent crops.*



Source: model results.

6. Conclusions

With the 2003 CAP reform it was expected that a system of progressive reduction of direct payments be introduced, for the years 2005-12. To avoid the abandonment of agricultural land and ensure the maintenance of good agricultural and environmental condition, each State should establish a set of standards. Thus, the single farm payment (SFP) is subject to standards relating to the environment, quality, animal health and animal welfare, as well as the farm's maintenance in good agricultural and environmental condition. Portugal decided to implement the SFP from 2005 (Carvalho and Godinho, 2011) and the results presented in this work are surely a consequence of policy implementation.

The decoupled direct payments have several risks. One of the most important is the risk of ceasing production, bearing in mind that the system allows farmers to receive aid without being required to produce. The risk of abandonment is particularly important in poorer regions, where yields and competitiveness are low.

Analysing the results one can easily conclude that there is, in general, a decrease in temporary crops mainly in the Alentejo area and an increase in municipalities oriented to permanent grasslands. This means that the CAP reform of 2003 led to an increase of extensification, which is higher in the rainfed crops' areas, in which permanent grasslands substitute the cereals. The linkage between these results and the fact that temporary crops have low average productivity, even in the traditionally best areas (not comparable with other European countries, with much better edaphoclimatic conditions) is clear but it is reinforced by the fact that direct payments are completely decoupled for cereals and are only partially decoupled for animal production.

Policy also explains why the extensification trend with orientation to permanent grasslands is not generalized. In the case of Algarve and northeast area, the permanent crops still have support not included in the SFP and these regions do not have historical productions to be included in SFP; this means they don't have an incentive to change and in some cases, mostly in the north, there is a decrease of permanent grassland area for permanent crops. These policies also explain the maintenance of the Algarve municipalities' trend to fresh fruits and the increase of olive crops' importance in several areas.

Our work helps to explain the trends that can be linked with policy options, reinforcing that political intervention by instruments of income stabilization has a strong impact in Mediterranean farms leading particularly to a change on land allocation that can be translated into a reduction of income variability and a change in income levels. The municipalities where different trends are observed reveal clear local advantages.

This study showed that an HJ-Biplot methodology in combination with a GIS provides a tool for policy evaluation. The proposed methodology allowed the identification of changes and main trends on land uses in Portugal, combined with a spatial analysis that can be done even for different agrarian regions.

European society faces multiple and very complex challenges on the beginning of a new programming period. It is known that CAP contributes to economic development and social cohesion by producing food and raw material as well as public goods, such as biodiversity and rural landscape maintenance, sequestration of greenhouse gases, soils and water cycle maintenance.

In what concerns national objectives, it is important to assure that policy instruments contribute to raising the economic value of agricultural and forestry sectors all over the country, which contribute to social cohesion and equity and may preserve a continuity on environmental goods' production and climatic changes and desertification mitigation.

The analysis of policy scenarios based on the proposed methodology will be a powerful tool to analyse policy proposals and different measures.

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