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Abstract

The strategic choices regarding innovation and R&D policy in Portugal have, over the last two decades, produced various positive benefits, in which particularly the regions of Lisbon and Algarve have taken the lead. These are the only parts of the country that converge towards the European average growth rate. The other Lisbon and Algarve have taken the lead, and are the only ones in the country to converge towards the European average growth rate. Other Portuguese regions – despite significant national growth rates in the 1990s and a successful attempt to cope with the EMU – are lagging behind the EU average with respect to gross production, investment and employment generation. Meanwhile, one of the greatest public policy efforts was to diffuse much of the European funds across the entrepreneurial sector. This paper aims to evaluate the firms' contribution to national and regional growth, their obstacles and impacts, and to explain the present performance of Portuguese firms located throughout the country, and to explore those innovation determinants that have a region-specific connotation. In our paper, innovation is used as a major contributor to the policy evaluation process referred to above. To provide a thorough investigation, our analysis defines, on a regional basis, a set of firms' behavioural patterns regarding innovation. In our modelling, we employ a new methodology, viz. the External Logistic Biplot method, which is applied to an extensive sample of innovative institutions in Portugal. Variables such as 'Promoting knowledge', 'Management skills', 'Promoting R&D', 'Knowledge transfer', 'Promoting partnership & cooperation', and 'Orientation of public measures' have been identified as crucial determinants in earlier studies and are now used to describe regional institutional profiles.

Key Words: Regional Asymmetries, Innovation, Firms' Performance, Regional Innovation Systems, Principal Coordinates Analysis, External Logistic Biplot, Voronoi Diagram, Dissimilarity Matrix

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1. Introduction

Regional development gaps

There are sharp regional differences in Portugal. This phenomenon, common to most of the southern European countries, has been extensively studied from the perspective of regional science (Nijkamp, 2009). In the Portuguese case, most of the socio-economic indicators demonstrate that economic activities are becoming more concentrated in the northern and western areas as a result of various structural factors (OECD, 2008). Probable impediments to economic development in the rest of the country include those relating to knowledge flows, referred to as knowledge filters in the current literature (Acs et al., 2004; Audretsch et al., 2006; Stough and Nijkamp, 2009), while there is also a lack of a clear focus on regional innovation systems, as pointed out by OECD (2008).

On the other hand, Portuguese strategic choices regarding innovation and R&D policy have, over the past two decades, produced various positive achievements, in which the regions of Lisbon and Algarve have taken the lead, and are the only ones in the country to converge towards the European average growth rate. Regarding the other Portuguese regions – despite significant national growth rates in the 1990s, as well as a successful attempt to cope with the EMU –, these are lagging behind the EU average with respect to gross production, investment or employment generation. Meanwhile, one of the greatest public policy efforts was to inject a large part of the European funds into the industrial sector. Time has now come to evaluate the firms' contribution to national and regional growth, their obstacles, and impacts.

After more than 20 years' experience in the application of a complete package-scheme of European support measures, Portugal may well serve as a test bed to evaluate the level of success of the European funds for national and regional development purposes. In fact, most of the results appear to be asymmetric by sector and region, although some best practices can be detected. However, several bottlenecks and disappointing results are also observed.

At present, Portugal – a small but diverse country, with weak growth and limited public spending capacity – is marked by a long tradition of centralized governance with no elected regional governance system. Still, it may be considered a credible case study to illustrate paradigm shifts in regional policy:

- ✓ From subsidies targeting the reduction of regional disparities towards investment which supports regional opportunities, in order to enhance territorial competitiveness;
- ✓ From different sectoral approaches to multi-sector place-based approaches;

- ✓ From a dominant role of certain levels of government to a multi-level governance structure involving the co-ordination of national, regional and local interests with different stakeholders.

Our investigation aims to develop an operational method able to map out firms' regional patterns of innovation and, thereby, to facilitate a better understanding of how firms act towards innovation, which attributes they use in this process, and, consequently, whether or not a proper use of public support measures is made. The method used in this paper to reveal such patterns is new.

Considering, in particular, the Portuguese case the present paper also explains that, despite broadly applied regional policies, much European support has been lost because of the present determinants of innovation of Portuguese firms. Located throughout the country, many of them have a region-specific connotation, and display, on a regional basis, irregular and very different behavioural patterns for innovation.

There is a long history of theorizing about the link between regional backwardness and the attitude of firms, in particular, if regionally-embedded companies are of small size in low-tech sectors. Fagerberg (1987) proved that a long-lasting technology gap may explain why growth rates differ among countries and regions.

Notwithstanding the long lasting theoretical debates**,** thus far most of the detected empirical problems have remained unsolved. Clearly, the cyclical nature of the disadvantages of lagging regions, including the European southern peripheries, has attracted the attention of both researchers (Hall and Wee, 1995) and policy makers (Landabaso, 1997). One reason for this is that the role of firms, in particular the smaller ones, in the dynamics of regional growth has not yet been sufficiently investigated. Despite significant efforts made by the Italian School as an offspring of the GREMI group (Camagni, 1991, 1995a, 1995b; Camagni and Maillot, 1999) and, later on, by many other northern European researchers, such as Asheim and Isaksen (2003), still not much is known with certainty regarding the direct contribution of individual firms, or even industrial clusters, to foster regional growth, the analysis of spillover effects being crucial in this regard (Kaiser, 2002; Fischer, 2006).

Because the area of influence of each firm varies, depending on its nature, firms' environments cannot be defined easily from a geographical perspective (Kalandaridis et al., 1995). However, generally speaking, the firm's environment should be associated, firstly, with those agents involved in the historical path-dependent development of skills (Teigland and Schenkel, 2006). Secondly, it should also be established on the basis of many strategic interactions occurring, such as those connections that form productive links within the firm's industrial structure: the cluster, which may be (or not) located in proximity to the firm. Finally, the firm's environment is highly influenced by the nature of the involved public institutions and their regulations – they may facilitate or aggravate the quality of all interactions. In this context, there is much discussion on whether the strategic decision of firms is mainly internally or externally driven, considering that their capabilities to confront uncertainty are frequently oriented toward the future needs of resources and clients. In this context, Langlois and Robertson (1995) developed the idea that "questions of firm strategy and firm boundaries are closely related".

These strategic choices will usually be solved by firms using market solutions, but the question is: through which decision-making process? As shown by Freel (1998), not much is understood about how technologically innovative firms grow, learn, or adapt to transformations in their environments. In his presentation of a conceptual framework of the evolutionary strategic learning, he analyses how innovative small firms accumulate knowledge through learning, which acts as a process of uncertainty-reduction. These processes do not necessarily work to achieve economies of scale, but to gain a better understanding of the cost composition, thereby helping to improve decision making. Acquisition of knowledge sometimes involves the entrepreneur in a form of strategic learning, viewed as an opportunity to access economies of scope rather than scale. Thus, the routines of innovative firms are different from those of their non-innovative counterparts; examples are: different forms of human capital on pre-start knowledge about costs; a greater reliance on external networks for advice and support.

Empirical studies often underline the role of the environment, defined as the local context into which enterprises develop their activities (Keeble, 1997; Freel, 1998). Others emphasize that this unique link is indeed a two-way flow – not only the environment influences the firm to act, but also the firms change the environment in conformity with their own performance (Noronha Vaz et al., 2004).

The literature has advanced the idea that organizational learning and institutional networking work together in the behaviour of innovative firms (Fagerberg, 2003), despite the fact that some observations have proved that firms are reluctant to cooperate locally (Wig and Wood, 1997). As a possible solution, some studies point out the need to have specific networks for technological learning through external sources. There are interfaces which help them to combine sources of technical know-how, information and relations (Stough et al., 2007). The firms are most likely to be organized in institutional local networks, whose existence derives from their capacity to create cohesion or a favourable context for innovation; this cohesion may be represented as some sort of proximity, more cultural and social than geographical (Belotti, 1999).

Hence, the firm's environment appears to be a critical factor for the development or atrophy of the enterprise in many reported studies. For example, a negative effect of the SMEs' environment on innovative activities is observed in an empirical study from Kalantaridis and Pheby (1999), regarding the agglomeration of manufacturing SMEs that failed to transform geographical proximity into an innovative milieu. The authors focused on the experience of Bedfordshire, a county in the UK that was characterized by its proximity to the London markets, the presence of R&D facilities, a considerable agglomeration of engineering SMEs, and the existence of two complementary universities: factors often identified in the literature as conducive to innovative activity. "However, these locational advantages failed to act as the stimulus of a cluster of innovative SME's, the rates of innovative activity in the locality were well below those reported elsewhere in the UK" (Kalantaridis and Pheby, 1999, p.74). In Ireland, in a marginal rural area extending over three counties, a group of 123 start-ups was studied. The owners were asked their opinion on the institutional setting in which they operated their enterprises (McDonagh et al., 1999). Quite often, these owners were born in the local area and came from families who were self-employed. They acknowledged the great help received in establishing their businesses from public agencies (grants), but also underlined other important sources of assistance: attitude of local bank managers, staff commitment, etc. Yet, the main idea emerging from this analysis was the lack of an adequate local entrepreneurial culture – too few people coming forward with business ideas, or the ideas proposed being more often imitative than innovative.

Measuring efficiency in regional development

Measurement of innovative activities became important during the 1990s, when the role of firms in the creation of jobs appeared dominant, and became, together with the emergence of innovations, a topic of broad public interest. In general, statistical surveys have been producing data concerning two debatable proxies for innovation: R&D expenditures and number of patented inventions. Eventually, employment in R&D related activities was also addressed. However, no unambiguous direct measure of innovation outputs has been defined so far. The second topic explored has been the manner in which the market structure may influence the innovative activities, and, conversely, the extent to which technological change has an impact on the size distribution of firms. All scientific results in this discussion have been empirically-oriented, and related to several advanced industrial countries. Very occasionally, a few studies concerned rural or lagging areas (Noronha Vaz et al., 2004). The debate invariably points out that there are considerable ambiguities and inconsistencies in the results of empirical studies which directly relate R&D or patents to innovation (Acs and Audretsch, 1991), even more significantly so in the presence of less favoured areas.

Various innovation output indicators have been defined which refer to the total number of innovations. Kleinknecht and Bain (1993) proposed several methods for collecting data: postal surveys for self-assessment by managers of their innovations, or literature-based counting of innovations (in trade journals). Experience with the first method (in Great Britain, Norway, Denmark, Germany and the Netherlands) and with the second one (in United States, the Netherlands, Ireland) has helped to highlight the problems involved. Most of these methods proved to be quite subjective, making a scientific consensus difficult for general use by the scientific community. When the Community Innovation Survey (CIS) was implemented by EUROSTAT to collect firm-level data on inputs to, and outputs of, the innovation process across a wide range of industries and across Member States and, occasionally, across regions, many advances in the comparative analyses of innovativeness across firms, regions and nations were achieved.

In spite of its limits, the CIS is showing evidence of the actual composition of inputs used by the firms to implement technological change. Their evaluation at the level of all industries shows a breakdown of the expenditures devoted in the EU to innovative activities: formal R&D in labs represents only 41 per cent of the total, product design costs 22 per cent and, trials, tooling-up and training 27 per cent. These figures indicate that there is reason for technological developments and imitations looked for in small firms.

The macro-level empirical data suggest that decision makers are right when they conclude that firms, including the smaller ones, are job creators and engines of economic growth. However, such statements do not help to produce more scientific evidence on the precise role that firms play in growth mechanisms. Within the context of a learning economy, all enterprises have to adapt their technology to new standards of distribution and to logistic channels, in an environment of intensifying competition, mostly to meet the requirements of consumers and public bodies. Big corporations are well organized to learn about and acquire the new inputs, using them first for the dynamics of their own innovative activities (Nonaka and Takeuchi, 1995). A different situation is, however, observed for small firms, whose organization is not so developed for immaterial investments. Nevertheless, it is possible that all small-size enterprises are also able to make some kind of effort to acquire the necessary knowledge to evolve using new technologies, and to adapt their production in line with the industrial and social evolution.

All categories of enterprises are considered within one industry, but they may belong to different regional or local innovation systems with which they are interacting and competing for innovative and market activities, using the same tools and the same knowledge flows (Cooke et al., 1998; Lester, 2006).

In a way, inspired by Grosjean and Crevoisier (1998), it could be argued that such regional or local innovation systems result from historical, path-dependent processes, with high degrees of institutional and organizational specificities (Wright, 1997). Thus, within an industrial context, firms are embedded in a technological regime, defined by the level and type of opportunities for innovations, by the accumulation of technological knowledge, and by vehicles of knowledge transmission. The examination of the technological regime of an industry allows some predictability about the kind of enterprises which may innovate, because of: the possibilities for protecting innovations (appropriability); the strength of a dominant design (opportunity); the nature and the continuity in the learning processes (cumulation); and the *tacitness* of knowledge and the means of transmission used.

The above theoretical framing suggests that regional disequilibria should be studied by means of a better understanding of the regional firms' capacity to dynamically innovate. The fact that such capacity may be quantitatively addressed and analysed helps to support the argument even further. Consequently, this proposed research question will be investigated in our research by addressing in greater detail firms' regional innovation patterns – also considered to be facilitator structures to regional growth and development.

In order to pursue the goal of detecting the patterns referred to above, we have applied our investigation to the Portuguese knowledge and innovation system, identifying it from a set of private companies and public organizations located in Portugal.

2. Methodology

Data collection

Our empirical investigation into the Portuguese knowledge and innovation system uses an extended set of private companies and public organizations located in Portugal, which are evaluated by their WebPage contents. This is a rather unexplored way to trace information of innovative activities of agents. On the basis of this data set, a new combination of multivariate statistical methods is next employed to detect group performances, to compare them, and to identify gradients of capacity to dynamically innovate.

For our investigation we have considered the following actors in the innovation process:

- Governmental agencies: all entities which pertain to the sphere of governmental power, and which exercise regulatory functions in political terms, as far as innovation is concerned. Furthermore, they play an important role in the promotion, administration, financing, and evaluation of creativity and innovation processes in the country.
- Associations: this category includes all institutions with a legal status which, depending on the interests of their associates, influence creativity and innovation. Examples of the activities of such associative entities include: sectoral or regional cooperation, knowledge transfer management, support to value creation (e.g. certification), regional partnerships.

- Technological parks and science centres: in this category one can find institutions which offer technical, technological, or other type of support to organizations in the same economic or industrial sector. These entities contribute to creativity and innovation processes in numerous ways: technology transfer, partnerships, and certification.
- R&D organizations: organizations which direct their main activities to R&D, and which concentrate on broad economic and industrial applications (this category does not include private and public companies whose main activity is not R&D, though such companies may have large investments in R&D activities).
- Entrepreneurship-support entities: this category refers to institutions or organizations which aim to stimulate creative and entrepreneurship activity.
- Technological schools: these are concerned with entities which aim to provide technological and professional training and education in innovation-related areas.
- University interfaces: these include structures, units, or university associations, operating in a particular university, and which aim to act as an interface between the university and private and public companies (e.g. Technology Transfer Offices).
- Companies: these are public and private organizations involved in innovation and/or with investments in innovation activity.
- Other: these are other entities with a role in creativity and innovation, and which have not been included in any of the previous categories.

Data on Portugal have been collected by means of a careful observation and broad inspection of 820 Internet sites of Portuguese institutions, classified into the aforementioned groups of actors. They all used the word 'innovation' – or related terms – on their sites. The sample was gathered during the year 2006. Finally, after a screening, the cleaned database comprised 623 institutions, classified into the above nine groups, and characterized by ten characteristic variables defined hereafter. The selection of these variables was based on our prior theoretical framework which suggests that the considered variables will likely determine innovation patterns – or, to be more specific – the firms' capacity to dynamically innovate. The ten variables under consideration are: Promoting knowledge (PK); Studying processes (SP); Managing (Mg); Promoting R&D (PRD); Knowledge transfer (KT); Support to entrepreneurship (SE); New product development (NPD); Promoting partnership and cooperation (PPC); Application of external technologies (AET); and Orientation (Or). This database was then investigated in depth using the methodology presented below.

Methods and interpretation rules

The information used in our analysis was organized in an IxJ binary data matrix obtained from several innovation characteristics, in which the I rows correspond to the above-mentioned 623 units (18 governmental entities, 297 companies, 70 associations, 20 technological parks and centres, 58 R&D organizations, 48 entrepreneurship support entities, 12 technological schools, 80 university interfaces, and 14 other entities) and the J columns correspond to the above-mentioned 10 binary innovation characteristics scored as binary variables, viz. present or absent (1 or 0): (PK), (SP); (Mg); (PRD); (KT); (SE); (NPD); (PPC); (AET); (Or).

As a means to obtain the main innovation gradients of the entities and their relation to the observed characteristics, we apply a novel algorithm, proposed recently by Demey et al. (2008), the External Logistic Biplot (ELB).[5] This method will now briefly be explained.

The algorithm starts with a PCoA (Principal Coordinates Analysis), as a technique for ordering the units, in Euclidean space, on the latent gradients. PCoA is concerned with the problem of constructing a configuration of n points in Euclidean space in such a way that the distance between any two points of the configuration approximates, as closely as possible, the dissimilarity between units represented by these points. The objective is then to find a configuration in a lower-dimensional Euclidean (usually a two-dimensional) space whose inter-point distance matrix is as close as possible to the matrix of the dissimilarities. The dimensions of the PCoA solution can be considered as innovation factors or innovation gradients like they are in Factor Analysis for continuous data.

In PCoA, the axes have no direct meaning. Therefore, it is not possible to interpret the relationship between units and innovation attributes. For that reason, the second step of the algorithm is adjusting a logistic regression model for each variable. This is illustrated in the diagram below (see Figure 1).

Geometrically, the principal coordinate scores can be represented as points in the map, and the regression coefficients as vectors or segments, showing the directions that best predict the probability of the presence of each variable. The goodness of fit of a variable can then be measured as a combination of three indexes: the p-value of the logistic regression, in order to test the relation between the solution and each variable (using the deviance); the Nagelkerke R-squared; and the percentage of correct classifications, using the value 0.5 as the cut-off point for the expected probability. As a way to identify which gradient (latent dimension) is most related to each variable, the

[5] An exhaustive explanation of the statistical method can be consulted in: http://bioinformatics.oxfordjournals.org/content/24/24/2832.full.pdf?ijkey=2GnXYBeU3nwcM0x&keytype=ref. A computer program, based on Matlab code, for implementing the statistical method ELB is available and can be obtained from the website: http://biplot.usal.es.

cosine of the angle of the vector representing the variable and the dimension is calculated. Clearly, a variable is more related to a particular gradient when the absolute value of the cosine is higher than the cosine for the other gradients.

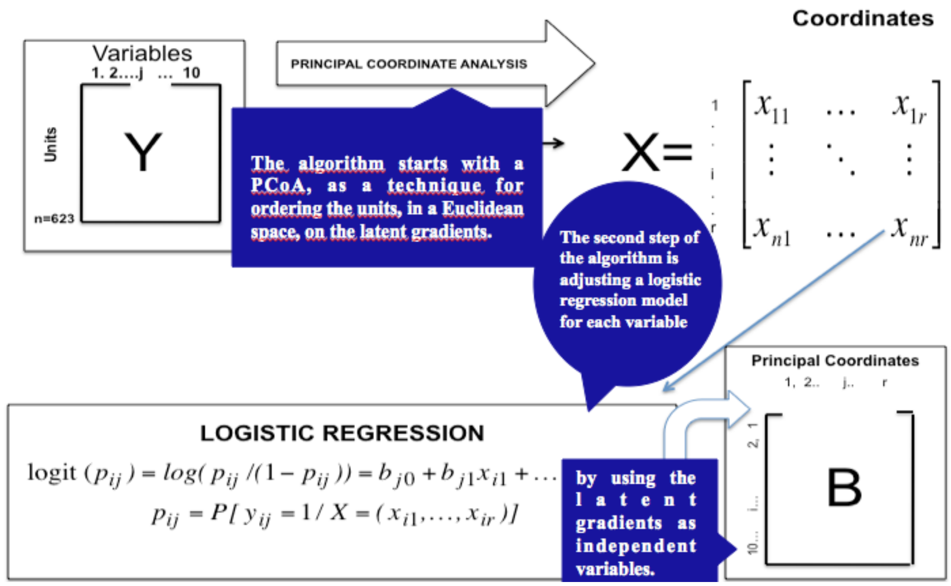

Figure 1. Steps for the External Logistic Biplot

According to the geometry of the linear biplot for binary data (see also Vicente-Villardón et al., 2006), in which the responses along the dimensions are logistic (called Logistic Biplots-LB), each variable is represented as a direction vector through the origin. For each variable, the ordination diagram can next be divided into two separate areas predicting presence or absence (following our binary logic), while the two areas can be separated by a line that is perpendicular to the characteristic vector in the Biplot, and cuts the vector at the point predicting a 0.5 probability. The characteristics associated with the configuration are those that predict the respective presences or absences adequately.

Once the coordinates of the points which represent the entities in the plane are obtained by the External Logistic Biplot, we can apply a K-Means analysis to identify the centroids of the resultant clusters. To produce an elegant solution, we may present a Voronoi diagram of the spatial relationships[6]. This approach will now be used in our application in order to represent the main force field of the Portuguese innovation system.

[6] The Voronoi sites are the four clusters centriods. Each site **s** has a Voronoi cell, consisting of all points closer to s than to any other site. The segments of the Voronoi diagram are all points in the plane that are equidistant to the two nearest sites. The Voronoi nodes are the points equidistant to three or more sites.

3. Empirical Results

A PCoA is first applied in our empirical work to the dissimilarities matrix, based on the Russel and Rao coefficients. This produced the following results (see Table 1). The inertia first principal plane (two-dimensional solutions) appears to account for 68.49 per cent of the variability. The first eigenvalue is significantly higher than the second one, meaning that, even if the two innovation gradients are considered, the first (horizontal) dimension accounts for most of the information.

Table 1. Eigenvalues, percentage of accounted variance

Eigenvalue	% of variance	Cumulative %
37.49	57.99	57.99
6.78	10.49	68.49

Table 2. Goodness-of-fit of the variables

Variable	*p-value*	R^2	*% Correct*
PK	<0.0001	0.88	93.42
SP	<0.0001	0.68	82.50
Mg	<0.0001	0.92	92.29
PRD	<0.0001	0.77	89.08
KT	<0.0001	0.90	92.67
SE	<0.0001	0.60	90.69
NPD	<0.0001	0.94	97.27
PPC	<0.0001	0.92	95.19
AET	<0.0001	0.93	95.02
Or	<0.0001	0.77	83.95

Note: The columns show, in turn, the p-value of the logistic regression; the Nagelkerke R-squared; the percentage of correct classifications, using the value 0.5 as the cut-off point for the expected probability.

In Figure 2 (ELB map) (see also Section 5), we can observe a complex representation of the main patterns of the determinants of dynamic innovation according to the ten above-mentioned variables considered to be critical: Promoting knowledge (PK); Studying process (SP); Managing (Mg); Promoting R&D (PRD); Knowledge transfer (KT); Support to entrepreneurship (SE); New product development (NPD); Promoting partnership and cooperation (PPC); Application of external technologies (AET); Orientation (Or). Each company profile has a particular location on the graph. The distance between any two company-points of the configuration approximates, as closely as possible, the dissimilarity between them.

The global goodness-of-fit as a percentage of correct classifications in this Biplot appears to be 90.43 per cent. The goodness-of-fit of indexes for each variable is shown in Table 2. All the R-squared values are higher than 0.6, and therefore all variables are closely related to the two-dimensional PCoA solution. All indexes considered in the study are therefore, relevant in the interpretation of the gradients found.

Table 3 contains the cosines of the angles of the variables (Innovation indexes) with their dimensions (latent gradient). The graph can help us to look for the most interpretable directions. An analysis of the cosines' value in the graph identifies two main directions for innovation gradients. A third column has been added to Table 3 showing which variables are most related to each direction. The first gradient is almost parallel to Dimension 1 (horizontal) and the second one to Dimension 2 (vertical). Although the variable 'Promoting knowledge' has a higher cosine with the first dimension, it has been assigned to the second gradient after inspecting the graph.

From the graph and the quality indexes, we can now conclude that the first innovation gradient is mainly given by a combination of the following variables: Promoting knowledge (PK); Managing (Mg); Promoting R&D (PRD); Knowledge transfer (KT); Promoting partnership and cooperation (PPC); Orientation (Or).

Observing the directions of the vectors relative to the first latent attribute, it can be concluded that all the above-mentioned attributes tend to show up together (as we hypothesized in the Introduction). The graphical representation corroborates the interpretation of the innovation gradients in terms of their relationship to the variables. It can also be concluded from the graph that there is a high correlation between Promoting knowledge, Studying processes, Managing, Promoting R&D, Knowledge transfer and Orientation. This is because they have small angles pointing in the same direction.

Table 3. Cosines of the angles between the index and the latent gradient

Variable	*1st gradient*	*2nd gradient*	*Associated gradient*
PK	**0.96**	0.28	1
SP	**-0.87**	0.49	2
Mg	**-0.98**	-0.20	1
PRD	**-0.94**	-0.35	1
KT	**-0.96**	-0.27	1
SE	-0.31	**-0.95**	2
NPD	-0.35	**0.94**	2
PPC	-0.75	**-0.66**	1
AET	-0.40	**0.92**	2
Or	**-0.95**	-0.31	1

At the national level, the institutions positioned on the left side of the graph have a higher capacity to dynamically innovate, because they tend to aggregate higher values of those variables (attributes) – this happens in Cluster 2. However, the institutions positioned on the right side of the figure lack most (or all) of such attributes – this happens in Cluster 4. As such, this measurement may be interpreted as a complex innovation index, defined here as the Gradient of Capacity to Dynamically Innovate (GCDI). Using this method, the scores of the variables on the first gradient can be ordered to obtain the sequence of attributes that define the degree of innovation. The most innovative institutions have the total set of characteristics, and they are then followed by those entities that have all of them, except Promoting R&D (PRD), whose score is situated to the left of the graph. The next group has all the attributes related to the gradient, except Promoting R&D and Managing (Mg), and so on.

A Voronoi diagram of the spatial relationships is next represented in Figure 2, showing 4 well-defined clusters: Cluster 1 characterized by the *presence of SP, AET, and NPD and* the *absence of SE;* Cluster 2 characterized by the *presence of PK, PPC, OR, KT, Mg and PRD, and absence of SE;* Cluster 3 characterized by the *presence of SE, PK, PPC,OR, KT, Mg and PRD and* the *absence of NPD, AET and SP*. Cluster 3 is characterized by the absence of all the indexes of innovation.

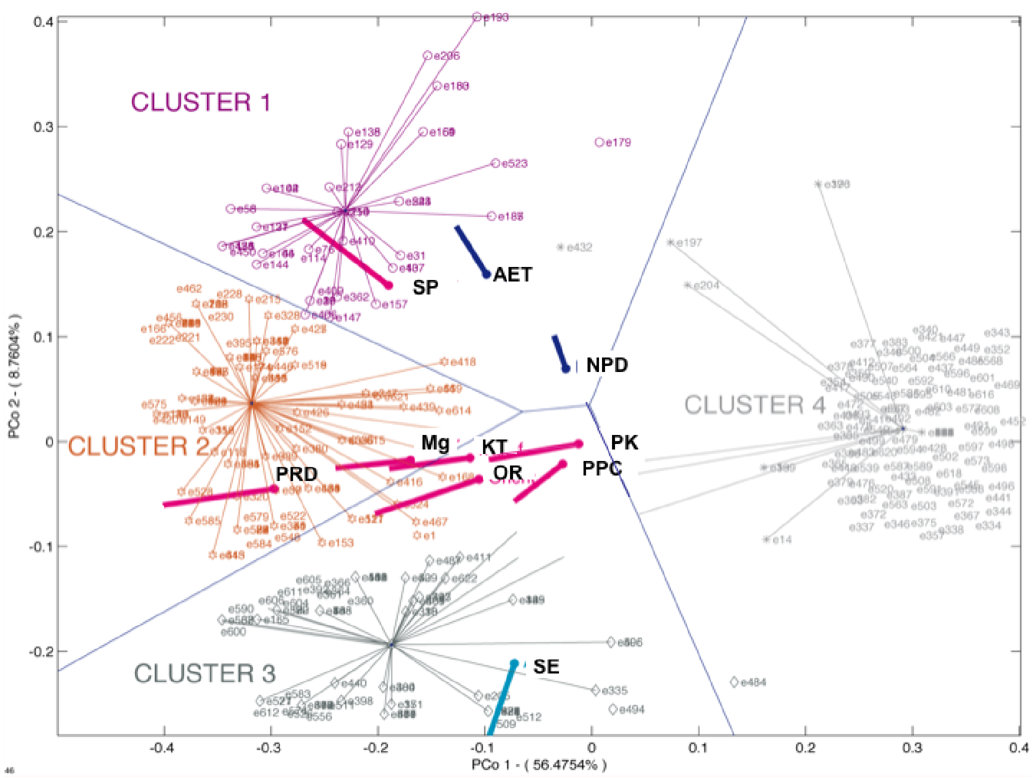

Figure 2. Logistic Biplot and Voronoi diagram representations of spatial relationships and clusters

The second innovation gradient is a combination of Studying process (SP); New product development (NPD); Application of external technologies (AET) pointing in the positive direction; and Support to entrepreneurship (SE) pointing in the opposite direction. This secondary gradient is not correlated with the first one, and summarizes an aspect of innovation independent from the main dynamic pattern. The institutions Cluster 1, situated on the top of the graph, combines the first three above-mentioned attributes, and the last is absent; while the institutions Cluster 3, situated at the bottom, has the last attribute (SE), but none of the first three above-mentioned attributes. Some profiles can already be associated with these clusters: Cluster 2, the multiple innovative profiles; Cluster 4, the non-innovative profiles; while the other two clusters suggest more focused profiles.

4. NUTS-II Distributions of Clusters

Once we have identified and represented the institution clusters on the Euclidean map containing the two innovation gradients, we can study the composition of the groups according to their geographical distribution. Table 4 shows the relevant cross-tabulation of clusters and regions, with regions defined according to the EU NUTS-II nomenclature.

Table 4. Percentage of each cluster per region (cross-tabulation between clusters and regions (NUTS-II)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Alentejo	2.20	5.50	6.80	14.70
Algarve	0.00	1.20	2.90	7.80
Centre	13.00	15.00	14.30	12.50
Lisbon	52.20	52.00	41.00	38.30
North	30.40	24.60	27.40	26.40
Islands	2.20	1.70	7.60	0.30

Table 4 indicates that in Cluster 1 more than 80 per cent of the institutions belonging to that Cluster are in the Lisbon and the North NUTS-II regions. This also occurs in Cluster 2, where more than 74 per cent of the institutions are in Lisbon and the North; in Cluster 3 more than 68 per cent and in Cluster 4 more than 64 per cent, are from Lisbon and the North. The Centre NUTS-II area is also of relative importance in all the clusters, with percentages between 13 and 15 per cent.

When analysing the distribution of clusters found in the different NUTS-II regions (see Table 5), we observe that, in the Alentejo, it is Cluster 4 that is of the greatest relevance, since it represents 63.6 per cent, i.e. most of the institutions in the Alentejo are characterized by the absence of innovation. This is also the case for the other NUTS regions, with the exception of the Islands; in all of those other regions there are high percentages of institutions lacking innovation, ranging between 42.0 and 54.5 per cent.

In the Alentejo, 36.6 per cent of the institutions certainly have innovations, but the types of innovation vary. Most have innovations belonging to Cluster 3 (22.7 per cent); the type of innovation characterizing Cluster 2 appears in 9.1 per cent of the institutions, and that representing Cluster 1 is only seen in 4.5 per cent of the Alentejo institutions.

In the Algarve, 46.5 per cent of the institutions appears to have innovations, but the type of innovation is different. Most have innovations belonging to Cluster 3 (27.3 per cent); the type of innovation characterizing Cluster 2 appears in 18.2 per cent of the institutions, but none of the Algarve institutions has the type of innovation characterizing Cluster 1.

Table 5. Percentage of institutions which belong to each cluster for each NUTS-II region (cross-tabulation between Clusters and NUTS-II regions)

	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Alentejo	4.5	9.1	22.7	63.6
Algarve	0.0	18.2	27.3	54.5
Centre	7.1	31.0	17.9	44.0
Lisbon	8.6	33.5	16.0	42.0
North	9.0	23.7	17.3	50.0
Islands	0.0	25.0	66.7	8.3

In the Centre, 56 per cent of the institutions appear to have a high degree of innovation, but the type of innovation is also different. Most have innovations belonging to Cluster 2 (31 per cent); the type of innovation characterizing Cluster 3 appears in 17.9 per cent of the institutions, and that representing Cluster 1 is only seen in 7.1 per cent of the institutions in the Centre. In Lisbon, 58 per cent of the institutions have innovations, but the type of innovation is different. Most have innovations belonging to Cluster 2 (33.5 per cent); the type of innovation characterizing Cluster 3 appears in 16 per cent of the institutions, and that representing Cluster 1 is seen in 8.6 per cent of the institutions in Lisbon. In the North, 50 per cent of the institutions have innovations, but the type of innovation is different. Most have innovations belonging to Cluster 2 (23.7 per cent); the type of innovation characterizing Cluster 3 appears in 17.3 per cent of the institutions, and that representing Cluster 1 appears in 9 per cent of the Lisbon institutions. On the Islands, only 8.3 per cent of the institutions do not feature innovations. Most have innovations belonging to Cluster 3 (66.7 per cent), followed by Cluster 2, with 25 per cent.

The data in Tables 4 and 5 may be translated into Figure 3, which is a comparative spatial analysis of the regional profiles of firms in terms of their innovative patterns in the country, confirming the historical characteristics of the Portuguese regions. For more information about them and how public support has been used, we refer to Annex 1.

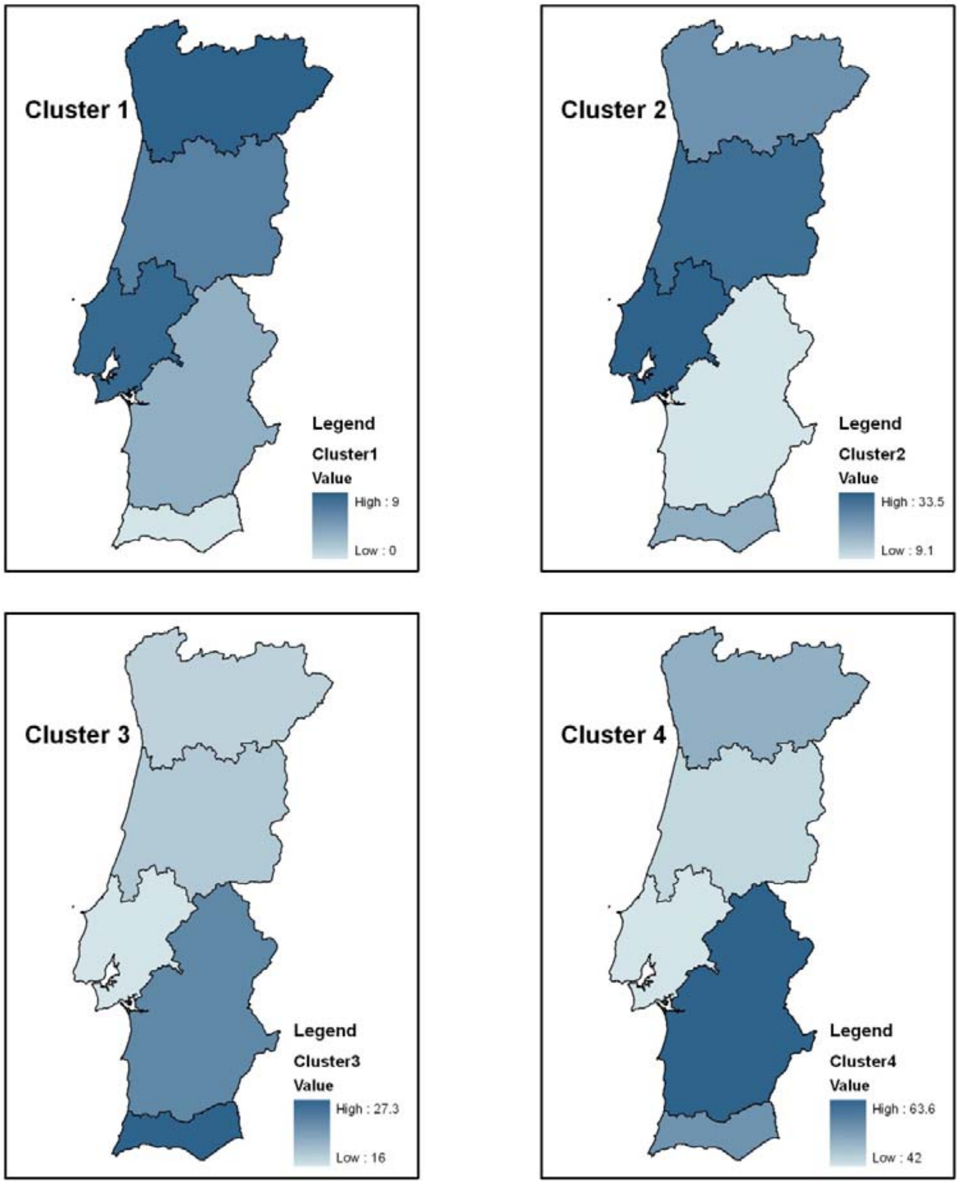

Figure 3. Comparative regional spatial analysis of the different types of innovation cluster

5. Conclusions

The motivation of the present paper was inspired by the aim to use the External Logistic Biplot method in order to detect behaviour patterns of firms with respect to innovation. Although this may be not immediately understood as having a major impact in current empirical advances related to regional innovation, it definitely does have such an impact. The advantages are related, in particular, to regional innovation systems, when they exist, or, to other more simplified forms of clustering, for, at least, two reasons.

Firstly, the method permits the measurement of patterns according to a set of dynamic variables of networking and knowledge accumulation capacity, both currently considered as the main factors of innovation and promotion of regional innovation.

Secondly, it presents an insightful way to evaluate public policy results from applied regional development instruments. The suggested method dissects the use of each attribute by each firm, individually considered (as illustrated in Figure 2) – a major advance in measuring the impacts of tailor-made public policies. Of course, its utility for such proposes is related to the intensity in which tailor-made public policy is applied. So far, when dealing with regional development, public policy has often not evolved to disaggregate support measures. However, the present financial restrictions tend to enforce a more smart use of such support systems, and this paper demonstrates that there is a way to do it.

As we can see from our sample, the resulting structure is highly complex, because the database does not suggest a static set of clustering structures. Instead, the results offer a structure of relational dimensions among companies and their attributes, in a multifaceted system of attributes and their owners.

We may emphasize here that, while the results for the Portuguese case are, of course, interesting, in this paper they play an essentially secondary role. Asymmetries have been identified, which is not new for those who know Portuguese history. But also a justification has been provided in terms of how Portuguese firms use the attributes that promote innovation across the country. These results are useful for any scholar or policy makers wishing to know how firms perform in the regions. They are statistically significant, analyse institutional behaviour by regional complexes, and are able to filter the research by groups of institutions.

Hence, the conclusions are in tune with the research question that aimed to develop an operational method able to reveal firms' regional patterns of innovation and, thereby, to facilitate a better understanding of the way firms' act towards innovation, which attributes they use in the process, and, consequently, whether or not good use of public support measures is made.

This method applied to the Portuguese case, has demonstrated that, in spite of the significant number of regional policy measures, much of the EC support has been lost in the context of inefficient attributes of innovation which characterize some regional clusters of Portuguese firms, in some cases more, in others less. Located throughout the country, many of these firms have a region-specific connotation and display, on a regional basis, irregular and very different behavioural patterns of innovation.

More specifically, and of interest for the dynamics of regional development in Portugal, we can add that the attributes ‘Promoting knowledge’, ‘Managing’, ‘Promoting R&D’, ‘Knowledge transfer’, ‘Promoting partnership & cooperation’ and ‘Orientation’, are clearly the most influential ones for regional innovation in the country. As explained, there is no homogeneous distribution of clusters among the regions. Also, by identifying the specific nature of the regional structure of innovative firms and public institutions in Portugal, many advantages and limitations in the firms’ capacity to cooperate could be identified and clearly interpreted; and, moreover, their cooperative patterns (networks) could also be closely examined. Such a goal represents a step towards novel governance structures – in the spirit of Storper and Harrison (1991), whose impressive amount of work remained inconclusive due to lack of empirical evidence.

In brief, our study is highly useful for policy makers who need versatile realistic simulations to project their policy actions. In this case, on account of the geometrical visibility[7] of the different attributes which determine the single firm’s capacity to innovate, it is easier to identify the exact set of actions to be taken in order to improve the specifically chosen profiles as targets of specific measures, actions, programs or policies.

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[7] Geometrical visibility is the term used to express the allocation of attributes in the Euclidian space.

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Annex 1: Evolution of Portuguese regional public policies[8]

In Portugal, from 1988 to 1993, the level of convergence of GDPpc increased significantly from 53 per cent to 73 per cent. It is estimated that 40% of this increase was a result of the investments made with the help of the European structural funds.

In spite of being characterized by a positive macroeconomic evolution, the situation of the Portuguese economy during the period covered by the previous Community Support Framework (1988/1999) continued to suffer from the inadequate pace of productivity convergence, caused mainly by the persistence of a specialization pattern with a predominance of products and processes with low technological intensity, defective organizational capacity and only slightly high levels of human resource qualifications.

In the first period of observation, from 1988 to 1993, the analysis of the macroeconomic indicators disaggregated for the 5 Portuguese regions indicates, only very slight alterations in the deviations of the regional Gross Added Values (GAVs) and GDPs from the national average: the Alentejo region sharply decreased its relative share of the national GAV, and the increase in the Algarve's share was minimal. The North shows a reinforcement of its situation of growth, while the Centre is a region that shows the most important convergence with the national average.

As to the GDP, the situation is not much different. This indicator reflects, even more clearly than the GAV, the deviations of the Alentejo from its development objectives, during the analysed period. The Algarve goes on presenting an unusual situation resulting from a regional GDP higher than the national average, accompanied by a GAV much lower than this average. The situation clearly results from the existence of a tourism sector, the only support of the region's economy.

Another important analysis indicator is the population density that during this observed period falls in the Centre and in Alentejo, the latter region having a growing unemployment rate. In this situation, a declining population density indicates regional out-migration.

Between 1993 and 1998, there was a rally of the Centre as well as a greater convergence (as a result of a decline in the previous values) to the average of Lisbon and Vale do Tejo. The Alentejo approaches and the Algarve deviates still more from the national average values for the GAV. The contrasting values in the values of GDP and GAV in the North and the Algarve have to be highlighted; these regions show two completely different options for growth. In this period the population indexes show a levelling-off and here the situation concerning the Central region also appears to be positive.

[8] This part is based on Noronha Vaz (2010)

The spatial distribution of investments is concentrated in the country's North Centre and littoral, and, in terms of scientific and technological infrastructures, 60 per cent of the R&D expenditures was concentrated in the Lisbon region. In addition, the industrialization pattern, especially outside the Lisbon region, is still based on labour-intensive, mainly non-skilled jobs, with a focus on textiles, shoes and furniture; In general, the investments have shown a high percentage of innovation material factors, focused as they were on an organizational behaviour oriented towards the quick profitability of investments.

Between 2000 and 2006, Portugal received a total of € 19.7 billion from the Structural EU Funds for that period, against a total of 16.3 billion received in the previous period (1994-99), which represents an increase of about 20.6 per cent. This total budget was spread over the 4 existing funds: FEDER,FSE, FEOGA(Guarantee section) and IFOP. The six Portuguese regions North, Centre, Alentejo, Algarve, Madeira, and the Azores remained eligible for funds in the Objective 1 statute, for the period 2000-06. The region of Lisbon and Vale do Tejo, which had been eligible in this statute during the previous period, lost this eligibility on 1 January 2000, because it had reached a value of GDP pc higher than 75 per cent of the Community average. However, this region was qualified for a transitory assistance until 2005 and part of it continued to receive and until 2006.

Regional disparities in Portugal have long been perceived as a vertical dichotomy between a dense and dynamic urban coast, and a desert and declining rural interior. Between 1995 and 2006, population density increased markedly in urban regions and in the intermediate regions located next to the urban regions. The Portuguese population share living in predominantly urban regions increased by 2 percentage points between 1991 and 2004. In contrast, the Portuguese population share living in predominantly rural regions decreased by 2 percentage points during the same period.

Regional disparities in GDP per capita in Portugal seem linked to the economic cycle. During the years of robust economic growth (1995-2000), the regional dispersion increased, and when the economy slowed down, regional disparities also decreased. Due to the large contribution of Lisbon to the national output, regional disparities and national growth rates are both highly sensitive to Lisbon's economic performance.

Meanwhile, Portugal displays the fourth highest level of regional disparities in terms of GDP in the OECD (the Gini index indicating disparities in the GDP of all Portuguese regions is significantly higher (0.57) than the OECD average (0.48)). The two largest urban areas in Portugal, Grande Lisboa and Grande Porto, generate alone slightly less than half (43 per cent) of national GDP. Regional disparities in GDP are in turn closely linked with the pattern of regional specialization. Not surprisingly, Portuguese urban regions devote a higher share of their total employment to service activities than rural and intermediate regions.

After the European Council decided, in spring 2005, to focus on re-launching the Lisbon Strategy, Community Strategic Guidelines for Cohesion (CSG) were adopted in 2006 and require that future cohesion policy should target resources on three priorities: improving the attractiveness of Member States, regions and cities; encouraging innovation, entrepreneurship, and the growth of the knowledge economy; and creating more and better jobs.

In response, all Member States have been preparing a National Strategic Reference Framework (NSRF), which describes how each country proposes to implement these priorities on its own territory. The European Commission approved Portugal's NSRF on 2 July 2007. Portugal will receive € 21.5 billion of EU cohesion funding over the 2007- 2013 programming period. In accordance with EU rules, at least 60 per cent of the funding available for the "Convergence" objective and 75 per cent of the "Regional Competitiveness and Employment" objective were earmarked for Lisbon-related investments (even going beyond the minimum threshold, since effective earmarked expenditures amount to 83 per cent and 78 per cent respectively). The Portuguese NSRF proposes five national strategic priorities: to improve the population's skills; to promote sustainable growth; to guarantee social cohesion; to ensure the development of the territory and the cities; and to improve governance efficiency. Five structural principles of investment are applied: concentration; selectiveness; economic viability and financial sustainability; territorial cohesion; and strategic monitoring.