

Innovation in Portugal: Dynamic patterns

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Abstract

During the last decades many studies related to innovation systems have been presented, offering to policy makers enough scientific background to choose the more adequate strategies for development. In general, the different approaches are consensual on the fact that knowledge creation, at the long run, and innovation, at a shorter term, are the drivers of change and growth for sectors and regions. However, the consensus is broken as soon as the complexity of innovation and knowledge are addressed: Innovation goes much beyond product and process development because of its interactive nature, and knowledge is not only a firm attribute but a spatial endogenous characteristic.

From this perspective, three levels of innovation analysis may be used to improve the conceptual dimension of innovation and knowledge creation: The micro, meso and the macro levels of the economic system (Vaz, M.T.N. and Nijkamp, P., (2009).

This paper integrates the above described framing context for which many unsolved problems still demand due attention. This is the case of many shared practices that form national or regional patterns of interactions among institutions; frequently, they provide the bases for the dissemination of knowledge which promote innovations further. Analyses of the dynamics of innovation are, in this case, confined to the measure level of the economic system. Its main goal is to contribute to the earlier discussion by developing a methodology able to identify different relational capacities of institutions when they are innovative, thereby finding in the networks of innovation their major characteristics. The research will be applied to an extended Portuguese set of private companies and public institutions, analysed by their WebPages contents. Besides the normal multivariate statistical methods to detect group performances by location and by use of information and communication technologies, we shall be able to detect compared institutional performances that allow perceiving the capacity of institutions to sustain innovative development.

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1. Introduction

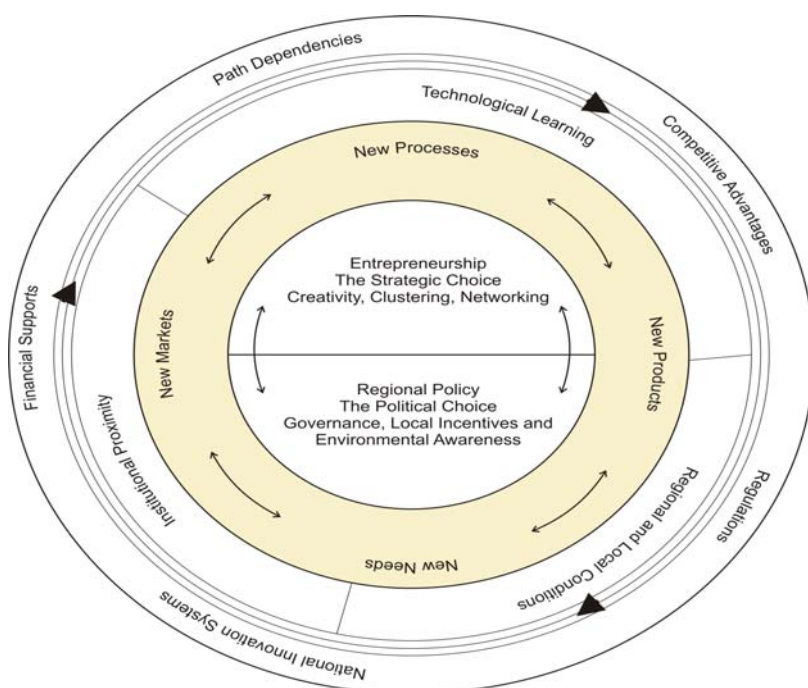
Innovation and change

Innovation has been an element of human intelligence from its earliest stages of development, although, only recently, has it been recognized as a significant driver of social and economic change. Schumpeter (1934; 1954), Freeman (1987), and Fagerberg (2003) are among the most important contributors to this view.

One of the ways to induce the process of change is to contemplate continuous production of new products or processes while, at the same time, encouraging adaptation of the society to absorb them. This represents a very accurate attempt to combine knowledge and consumption, in an interactive model for innovation, which requires a capacity of the organizations to coordinate and manage the knowledge assets (Hall, 2004 and Lundvall, 1988 and 1992).

From this perspective, three levels of innovation analysis may be used to improve the conceptual dimension of innovation and knowledge creation: The micro, meso and the macro levels of the system as pointed out in the next Figure 1 (Please, see in the Attachment file).

Figure 1
Knowledge circuit in the process of sustainable growth



Source:

Vaz, M.T.N. and Nijkamp, P., (2009) "Knowledge and innovation: the strings between global and local dimensions of sustainable growth", in *Entrepreneurship and Regional Development*.

Networks of innovation

Posner (1961), Krugmann (1979), and Fagerberg (1987; 1988) maintain that, at cross-country level analyses, the presence or lack of innovation may “affect differential growth rates”. An imitative or innovative *modus operandi* may explain different levels of development among countries or regions, the so called “technology gap” or even the “north-south” asymmetry. Thus, Schumpeter’s concern with the tendency of innovations to cluster, in spite of the closed link between innovation and economic growth, suggests that its use as an instrument of public policy, to promote fast development, may require more detailed attention. Fagerberg (2004) helps in supplying the epistemological limitations of this research field: cross-disciplinarity, undetermined causality; path dependency, pluralistic-leadership, systemic approach.

The multiple efforts to better perceive drivers of innovation took research to the resource-based view of the firms, accepting their heterogeneous character and unique choices related to strategic behavior (Knudsen, 1995; Kaleka, 2002). In this context, knowledge is recognized as a key resource for firms and other economic agents and, both codified knowledge and tacit knowledge are pertinent aspects of innovativeness. (Albino *et al.*, 1999; Nooteboom, 1999).

It is still under discussion whether the co-operation between research institutes and industrial firms enhances creativity and innovation, as argued by Antonelli and Calderini (1999) or, contrarily, that such links are of minor importance, as defended by Diederer *et al.* (2000). In any case, it seems to be of common agreement that the impact of the co-operation with research institutes is sector-related. In general, high tech firms tend to co-operate more often with research institutes than firms producing in low technology areas.

Additionally, some authors have stressed the key role of ‘good communication’ between industry and research institutes for the successful transfer of technological knowledge (Kaiser, 2002).

Another body of the literature has taken a different approach to the problem of networks. In effect, the writings on clustering have contributed to describe *how* – yet not so much to explain *why* – organizations and institutions get together to face competitive challenges (*e.g.* Porter, 1998). A few attempts, however, exist to explain why people from different entities join efforts to collaborate. Porter and Sölvell (1998), for example, explain that a cluster offers an environment for the development of a common language, social bounds, norms, and values, *i.e.* a social capital. Pounder and

John (1996) take a deeper view, and try to understand the cognitive reasons behind the existence of a cluster. They explain that in a cluster, managers and decision-makers share a wide number of values, cognitive references, perceptions, and experiences (called normative isomorphism), hence they tend to establish connections and follow the same patterns of organizational behaviour (*e.g.* competing, collaborating, and so on). Furthermore, there may also exist negative consequences of such isomorphism; since they all share a particular culture and a set of beliefs, there is a risk of strategic myopia, which reinforces imitator and non-innovative behaviours.

In spite of much literature on this issue, there is much confusion on the terms networking and clustering. According to Teigland *et al.* (2005) while the term *cluster* is widespread, no one universal definition exists, however. “We define a cluster as a spatial agglomeration of similar and related economic and knowledge creating activities”. In turn, the concept of Regional Innovation Systems (RIS) has been defined as “a network of organizations, institutions and individuals, within which, the creation, dissemination, and exploitation of new knowledge and innovation occurs” (Cook *et al.* 2004). The RIS concept has been introduced to describe how industrial and institutional structure of a given national or regional economy tends to steer technological and industrial development into certain trajectories. The link between “clusters” and “regional innovation systems” is that within these spatial systems, groups of similar and related firms (*e.g.* large and small firms, suppliers, service providers, customers, rivals, etc) comprise the core of the cluster, while academic and research organisations, policy institutions, government authorities, financial actors and various institutions for collaboration and networks make up the innovation system of which the cluster is a part (Teigland and Schenkel, 2006).

Our paper integrates the above described framing context for which many unsolved problems still demand due attention. This is the case of many shared practices that form national or regional patterns of interactions among institutions; frequently, they provide the bases for the dissemination of knowledge which promote innovations further. Analyses of the dynamics of innovation are, in this case, confined to the measure level of the economic system.

The main goal of this paper is to contribute to the earlier discussion by developing a methodology able to identify different relational capacities of institutions when they are innovative, thereby finding in the networks of innovation their major characteristics. The research will be applied to an extended Portuguese set of private companies and

public institutions, analysed by their WebPages contents. Besides the normal multivariate statistical methods to detect group performances by location and by use of information and communication technologies, we shall be able to detect compared institutional performances that allow perceiving the capacity of institutions to sustain innovative development.

2. Material and methods

The research arrives at the right time: The Portuguese Government, in power since March 2005, has as its main flag a Technological Plan and as part of its commitment to fulfil the Lisbon strategy, renewed an Integrated Plan, the *PNACES – Plano Nacional de Acção para o Crescimento e Emprego 2005-8*. This Plan had as one of its main goals “to increase the competitiveness of Portuguese economy”, through the implementation of the Technological Plan. The main question is now: How did it succeeded? A further justification is provided by the soon announced *Strategies for Collective Efficiency* based on Clusters and Economical Valorisation of Endogenous Resources (<http://www.pofc.qren.pt/PresentationLayer/conteudo.aspx?menuid=457>).

In these circumstances, the management of knowledge transfer concerns academic and research organizations, policy institutions, financial actors, and large and small firms existing in the country and becomes crucial for innovation promotion. It is hoped that an improved understanding of how this knowledge transfer takes place will enable, the innovation actors to overcome these challenges while facilitating their ability to create and sustain a knowledge – based competitive advantage.

Actors of innovation and data base composition

Innovation agents are of various types and categories. From an initial literature review and our own experience of previous projects, the following innovation agents have been proposed in this analytical framing:

- Governmental entities: all entities pertaining to the sphere of governmental power and which exercise regulator roles 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 entities with a legal status which, depending on the interests of their associates, influence creativity and innovation. Examples of activities of such associative entities include:
 - Sector or regional cooperation
 - Knowledge transfer management
 - Support to value creation (e.g. certification)
 - Partnerships
- Technological parks and centers: in this category one can find institutions which give technical, technological or other type of support to organizations in the same economical or industrial sector. These entities contribute to creativity and innovation processes through numerous ways: technology transfer, partnerships, and certification.
- R&D organizations: organizations which direct their main activities to R&D, and which concentrate on large economical and industrial application (this category does not include private and public companies whose main activity is not R&D, though they may have large investments in R&D activities).
- Entrepreneurship support entities: it refers to structures 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: it includes 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.
- Companies: public and private organizations involved in innovation and/or with investments in innovation activity.
- Other: other entities with a role in creativity and innovation and which have not been included in any of the previous categories.

Data has been collected from careful observation of 820 internet sites of Portuguese institutions using the word innovation on a static basis worked out for the year 2006., The obtained information from such sites has been organised given place to a cleaned data base of 623 institutions, classified into nine groups and ten variables. For

theoretical reasons such variables should be considered determined for innovation dynamic patterns. These variables are the following:

- Promover – Promoting knowledge
- Estudar – Studing process
- Gerir – Managing
- I&D – Promoting R&D
- Transferência – Knowledge transfer
- Apoio ao empreendedorismo – Support to entrepreneurship
- Desenvolvimento de novos produtos – New product development
- Dinamizar parcerias/cooperação – Promoting partnership and cooperation
- , Aplicação de tecnologias externas – Aplication of external technologies

3. Methodology and practical interpretations rules.

Let X be the matrix of binary data obtained from several innovation characteristics, in which the rows correspond to 623 entries (from hear taxonomic units or just units) (*ENTIDADES GOV.*, 18 rows, *EMPRESAS*, 297 rows, *ASSOC.*, 70 rows, *CENTR. TECN.*, 20 rows, *INST. I&D*, 58 rows; *APOIO AO EMPREENDEDORISMO.*, 48 rows, *ESCOLAS TECNOLÓGICAS*, 12 rows; *INTERFACE UNIVERS.*, 80 rows; *OUTROS*, 14 rows) and the columns to 9 binary characters scored as present or absent (1 or 0), (Promover, Estudar, Gerir, I&D, Transferência de conhecimento, Apoio ao empreendedorismo, Desenvolvimento de novos produtos, Dinamizar parcerias/cooperação, Aplicação de tecnologias externas).

Two entities are similar when having similar innovation profiles.

In this paper, we use a novel algorithm that uses a combination of Principal Coordinates Analysis (PCoA), and Logistic Regression (LR), recently proposed by Demey and cols (2008), as a better way to interpret the variables associated to the classification of taxonomic units, resulting in a binary data matrix. The combination of three standard techniques allows constructing an External Logistic Biplot (ELB) that helps in the interpretation of the variables responsible for the ordination of the taxonomic units in a gradient of innovations.

The Matlab code for implementing the methods may be obtained from the web site: <http://biplot.usal.es>.



According to the geometry of a linear biplot for binary data in which the response along the dimensions is logistic (Logistic Biplots, LB), each unit is represented as a point and each variable as a direction through the origin. The projection of an unit point onto a character direction predicts the probability of presence of that character. Vicente-Villardón et al. (2006).

Measures of the quality of the representation of units, and variables (innovation index) are also calculated.

The algorithm starts with a Principal Coordinates Analysis (PCoA), as a technique of ordination of the units. PCoA is concerned with the problem of constructing a configuration of n points in a Euclidean space in such a way that the distance between any two points of the configuration approximates, as closely as possible, the dissimilarity between them.

We consider that a unit is well represented when most of its information (measured through the variability) is accounted for in the reduced dimension. As the representation is centred at the origin, the variability of each taxonomic unit is measured by its squared distance to the centre, so that the quality of representation can be measured by the ratio between the squared distance in the reduced dimension and the squared distance in the complete space.

Geometrically, it is the squared cosine of the angle between the vector in the complete space and its projection onto the representation space.

In PCoA, the axes have no direct meaning; therefore it is not possible to interpret the relationship between units and variables. According to Demey et al. logistic regressions and its graphical representation on the PCoA, (ELB), allow us to represent variables onto the PCoA map. To search for the variables associated to the ordination obtained in PCoA, we can look for the directions in the ordination diagram that better predict the probability of presence of each unit.

The regression equation predicts the probability that a character will be present in that entity. Geometrically the principal coordinates scores can be represented as points in the reduced dimension space and the regression coefficients are the vectors showing the directions that best predict the probability of presence of each character. For a complete explanation of the geometrical properties of the ELB see Vicente-Villardón et al. (2006).

Taking into account the characteristics of the data we choose the similarity coefficient of Russell and Rao ($R \& R = (a/a+b+c+d)$ Sneath and Sokal, (1973); with this coefficient two entities are more similar when they have more innovation characters in common.

4. Results

The Coordenates Principal Analyses, developed over the dissimilarities matrix and built based on Russel and Rao Coefficient has produced the following results:

The inertia absorption in the first principal plan surmounts the value of 65%reaching 72.26% y the spatial data. The first Eigenvalue is significantly higher the second one , meaning even if there are two gradients of innovation the first one is the one absorbing most of the information.

Table 1
Eigenvalues, percent of variance

Eigenvalue	% of variance	Cummulative %
52.7563	56.4754	56.4754
8.1835	8.7604	65.2358
7.5854	8.1201	73.3559

The global goodness of fit as a percentage of correct classifications in the Biplot is 1.22%, and the global goodness of fit for the considered variables is given by the following table:



Table 2
Goodness of fit of the variables

Name	p-value	R2	% Correct
Promover	<0.050	0.885	94.222
Estudar	<0.050	0.747	83.949
Gerir	<0.050	0.941	91.493
ImasD	<0.050	0.757	86.035
Transf	<0.050	0.917	92.616
Apoio	<0.050	0.694	94.864
Desenv	<0.050	0.959	97.111
Dinamiz	<0.050	0.932	95.024
Aplic	<0.050	0.929	93.579
Orient	<0.050	0.809	86.677

The following Table 3 indicates the cosines of the angles that the variables assume with the respective factorial axes, detecting the innovation gradients.

The results indicates that the first axes of innovation allowing to order the institutions is mainly given by a combination of the following variables, placed in sequence of importance: Gerir, Transf, I&D, Promover.

Table 3
Cosines of the angles

	Cos Axis 1	Cos Axis 2
Promover	-0,98399474	-0,17819749
Estudar	-0,78750115	0,61631319
Gerir	-0,99452236	-0,10452403
ImasD	-0,98877733	-0,14939676
Transf	-0,99085824	-0,13490719
Apoio	-0,32358808	-0,94619805
Desenv	-0,32893634	0,9443521
Dinamiz	-0,78559542	-0,61874053
Aplic	-0,52568954	0,8506765

The gradient associated to the second axes of innovation is specified basically on the following variables: Apoio, Desenv, Aplic. Also, there are two variables simultaneously associated with both axes: Estudar y Dinamizacón.

The following Graph 1 shows the factorial representation of the variables and the related location of each institution. Having been erased from the geometric plane all those which coordinated values were out of the scale – meaning that projection of the institution over the vector of the variable is too distanced to be relevant.

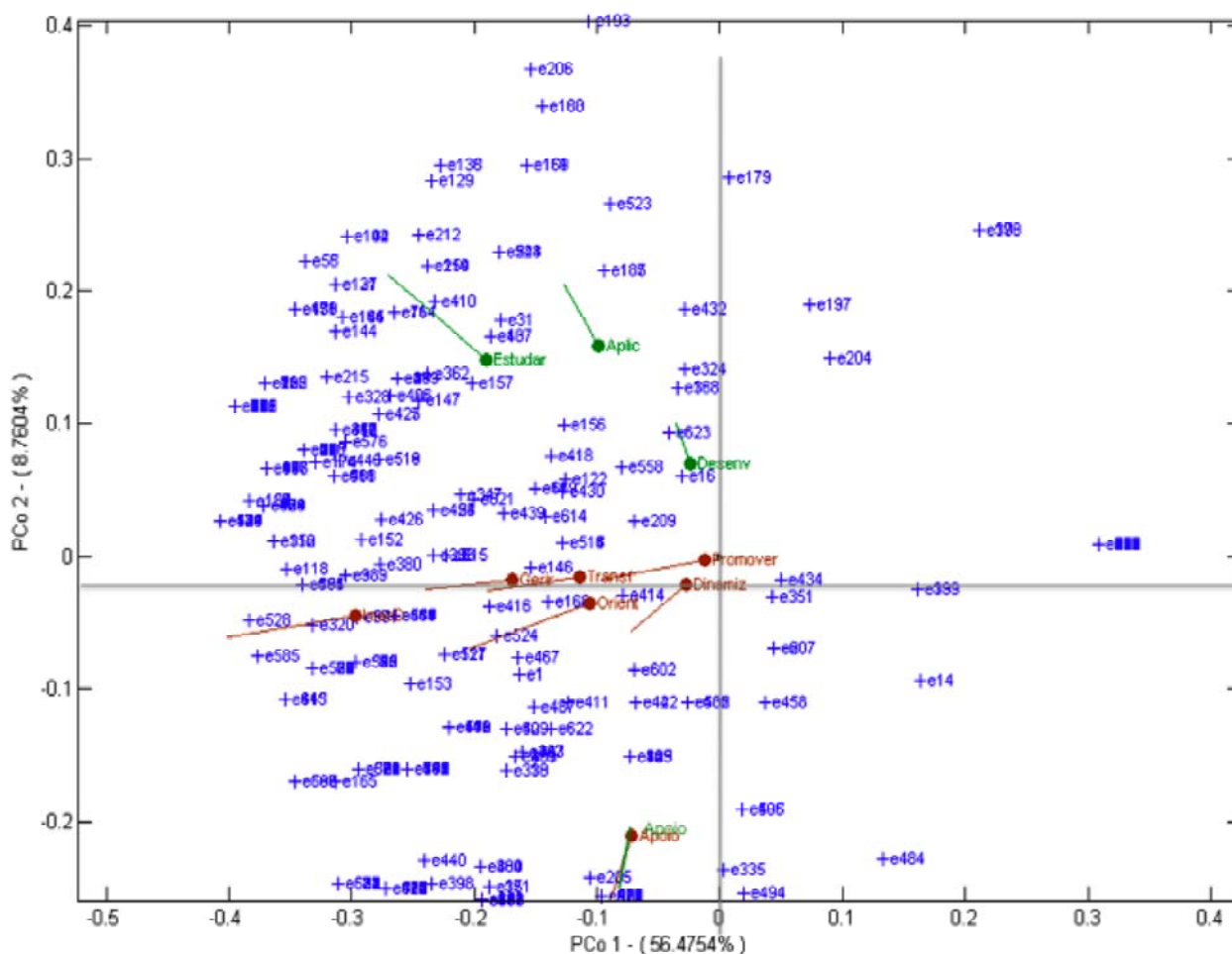
An important note for this methodology is given by the direction of the vectors, which as they approach the left side of the graph became representative of more innovative flows.

Further from the graph it can be concluded that there is a high correlation between the following variables: Promover, Dinamizar, Transf, Orient, Gerir e I&D. This is due to the fact that they are forming small angles and they covariated positively towards the same direction.

The variables with higher discriminante power are: Desenv and Apoio due to the fact that the vectors are shorter.

Because the experiment is dealing with 623 different institutions, it is impossible to visualize all of them in the first principal plan, which is why the total ranked institutions are been presented in Annex 1.

Graph 1
Gradient of capacity to dynamically innovate



5. Conclusions

From the application of the Biplot software to the institutional data bases we could demonstrate that institutions are very diversified in the way how they combine determinants for their innovation dynamic patterns.

Considering the proximity of the ten variables to axe 1, representing the gradient of capacity to dynamically innovate (more capacity to the left side) we could conclude that the determinants Gerir, Transf, I&D and Promover are those to better influence such patterns.

The interpretation of how expressive each variable is for each institution is illustrated by the graph in which single position of each form has to be evaluated regarding axes 1 and 2

It was possible to create a ranking of those institutions that have higher gradient of capacity to dynamically innovate. Globally, the first six places were taken by those forms bellowing to well known economic groups. Still, ahead in the list there are two institutions, one of research and development, and the other is a University. The first stand positions are located in Lisbon.

It will be possible to describe further single characteristics from the ranking list but the great challenge of this paper relies on its methodological approach which combines at a time Principal Coordinates Analysis (PCoA), Logistic Regression (LR), recently proposed by Demey and cols (2008) and External Logistic Biplot. The method, as demonstrated in this paper, leads to classified and identify innovation from an interrelational and therefore more dynamic point of view. Therefore, suggesting that innovation is influenced by many determinants of active functioning but, nevertheless, allowing evaluation a measure.

By detecting the relational structure of innovative firms and public institutions in Portugal, many advantages and fragilities in the firms' capacity to cooperate may be raised up; also their cooperative patterns are being identified. Such major goal represents a step further into governance structures. Seem from a meso-economic level, eventual dynamic changes of such structures can be traced for the future and help in tailor made policy making, without much additional costing. Agent partnerships have been evaluated and their added value for innovativeness judged.

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Annex 1

Ranking of Gradient of Capacity to Dynamically Innovate, by institution

120	EUROPROTEA - Sociedade Agrícola, Lda	www.europrotea.pt	EMPRESA
123	F. Lima, S.A.	www.flima.pt	EMPRESA
134	GalpEnergia, S.A.	www.galpennergia.com/	EMPRESA
140	Grupo Aitec	www.aitec.pt/	EMPRESA
143	Grupo Cised	www.cised.pt/	EMPRESA
149	Grupo Portucel/Soporcel	www.portucelsoporcel.com/	EMPRESA
420	IBET - Instituto de Biologia Experimental e Tecnologia (IBET) Oeiras	www.ibet.pt/	INST. I&D
575	IDITE - MINHO Instituto de Desenvolvimento e Inovação Tecnológica do Minho - IDITE-Minho	www.idite-minho.pt	UNIVERS. IPSFL
23	Adira - A Dias Ramos - Máquinas - Ferramentas, Lda.	www.adira.pt/	EMPRESA
29	All 2 IT - Infocomunicações, SA	www.all2it.pt/i	EMPRESA
32	Ao Sol - Energias Renováveis, Lda.	www.aosol.pt/	EMPRESA
51	BIAL - Portela & Cia, S.A.	www.bial.pt	EMPRESA
53	Biotechol - Serviços e Desenvolvimento, S.A.	http://www.cotecportugal.pt/index.php?option=com_content&task=view&id=241	EMPRESA
54	Biotempo - Biotechnology Consulting, Ltd.	www.biotempo.com	EMPRESA
56	Bluepharma - Indústria Farmacêutica, SA	www.bluepharma.pt/	EMPRESA
59	CADFORM - Design de Produto Assistido por Computador e Fabrico de Protótipos, Lda	www.cadform.pt/	EMPRESA
65	CAVEX - Sociedade de Exportação-Importação, Estudos e Planeamentos de Equipamentos Industriais	www.cavexgroup.com/cavex	EMPRESA
75	CHIRON - Sistemas de Informação, Lda.	www.chiron.pt/	EMPRESA
77	CIN - Corporação Industrial do Norte, S.A.	www.cin.pt/	EMPRESA
78	CIPAN - Companhia Industrial Produtora de Antibióticos, S.A.	www.cipan.pt/	EMPRESA
93	CTT - Correios de Portugal, AS	www.ctt.pt	EMPRESA
96	DEIMOS Engenharia, SA	www.deimos.pt/	EMPRESA
100	DURIT - Metalúrgica Portuguesa de Tungsténio, Lda.	www.durit.pt/	EMPRESA
103	ECBIO - Biotechnology Consultants	www.ecbio.com	EMPRESA
106	EDISOFT - Empresa de Serviços e Desenvolvimento de Software, SA	www.edisoft.pt/	EMPRESA
109	EID- Empresa de Investigação e Desenvolvimento de Electrónica, SA	www.eid.pt	EMPRESA
125	FAPOMED - Indústria de Confeções de Produtos Médico-Cirúrgicos, S.A.	www.fapomed.com/	EMPRESA
161	IBM Portuguesa, SA	www.ibm.com/ibm/pt/	EMPRESA
166	Innovagency	www.innovagency.com	Empresa
221	PETROGAL - Petróleos de Portugal, S. A.	www.galpennergia.com	EMPRESA
222	Philips Portuguesa, S.A.	www.philips.pt	EMPRESA
456	INESC MN Microsistemas & Nanotecnologias	www.inesc-mn.pt	INST. I&D
528	Associação CCG/ZGDV - Centro de Computação Gráfica	www.ccg.pt	UNIVERS. IPSFL
137	Gesventure (capital de risco)	www.gesventure.pt/	EMPRESA
139	GLOBALGARVE- Cooperação e Desenvolvimento, AS	www.globalgarve.pt/	EMPRESA
154	Grupo Visabeira, SGPS, SA	www.grupovisabeira.pt	EMPRESA
5	FJ - Fundação da Juventude	www.fjuventude.pt	Entidades Gov.
585	INESC Inovação - Instituto de Novas Tecnologias	www.inov.pt/	EMPRESA
90	Critical Software, S. A.	www.criticalsoftware.com/	EMPRESA
376	RECET- Associação dos Centros Tecnológicos de Portugal	www.recet.pt/	ASSOCIAÇÃO
423	ICTPOL- Instituto de Ciência e Tecnologia de Polímeros	www.ictpol.com/	INST. I&D
454	LNEC Laboratório Nacional de Engenharia Civil (LNEC)	www-ext.lnec.pt/	INST. I&D
459	ICBAS - Instituto de Ciências Biomédicas Abel Salazar	http://sigarra.up.pt/icbas/web_page.inicial	INST. I&D
580	INEB - Instituto Nacional de Engenharia Biomédica	www.ineb.up.pt	INST. I&D
70	CENTRALCER - Central de Cervejas, S. A.	www.centralcervejas.pt/	EMPRESA