Technological Clusters

Application to the Grande Porto Region

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To Marta and Matilde

About the Author

André Cardoso Rocha was born in 1978 in Porto, Portugal, where he has lived until the present day.

His academic and professional background is in electrical and computers engineering, more specifically in the field of telecommunications. He obtained his degree from the Faculty of Engineering of the University of Porto in 2000, with a final grade of 15 (out of 20). His professional life began in 1999 as an undergraduate researcher at the Institute for Biomedical Engineering.

After graduating, he spent the first two years at Portugal Telecom Inovação, as an engineer in the Customer Solutions Department, from where he left by the end of 2002. During the following year, André has carried out advanced research in the area of audio coding at INESC Porto.

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ABSTRACT

The general objective of this work is to study the conditions of the Grande Porto region (standing for "Greater Porto"), in northern Portugal, regarding the formation of clusters of firms in knowledge- and technology-intensive areas. This overall goal is accomplished by means of several elements, as follows.

Three emerging clusters are referred by the North Region Operation Programme (2007-2013 period) as having a very relevant presence in the Norte NUTS II region, in which Grande Porto is contained: ICT, Electronics, and Electrical Machines and Material; Health, Medical Devices and Pharmaceutics; and Biotechnology and Agri-Food. The high level of concentration of each of these clusters in the Grande Porto region is herein evaluated and confirmed.

In addition, several other industries (or groups of related industries) with a significant critical mass in the region, possibly forming a technological cluster or with the potential to become one, are identified.

An assessment of Grande Porto in terms of its preparedness to the knowledge economy is also performed, revealing some of its main strengths and weaknesses in this domain.

Finally, it is worth mentioning two of the main enabling tools of these tasks. On the one hand, a methodology is defined in order to measure the level of agglomeration of every industry or policy-supported cluster in the region. On the other hand, a set of face-to-face interviews with several key regional actors provides valuable inputs into the presented study.

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ACRONYMS

AEP	Associação Empresarial de Portugal [Portuguese Business Association]
ANETIE	Associação Nacional das Empresas das Tecnologias de Informação e Electrónica [National Association for Information Technologies and Electronics Firms]
ANJE	Associação Nacional de Jovens Empresários [National Young Entrepreneurs Association]
APCTP	Associação para o Parque da Ciência e Tecnologia do Porto [Porto Science and Technology Park Association]
BIC	Business and Innovation Centre
CAE	Classificação das Actividades Económicas [Portuguese Classification of Economic Activities]
CCDR-N	Comissão de Coordenação e Desenvolvimento Regional do Norte [North Regional Coordination and Development Commission]
CI	Cluster-Index
CMU	Carnegie Mellon University
DGEEP-MTSS	Direcção-Geral de Estudos, Estatística e Planeamento do Ministério do Trabalho e Solidariedade Social [Directorate-General of Studies, Statistics and Planning, Ministry of Labour and Social Solidarity]
ENSR	European Network for SME Research
EPO	European Patent Office
ERIS	European Regional Innovation Survey
ESRC	Economic and Social Research Council
EU	European Union
FDI	Foreign Direct Investment
GDP	Gross Domestic Product
GERD	Gross Expenditure on R&D

GNP	Gross National Product
GREMI	Groupe de Recherche Européen sur les Milieux Innovateurs
HEI	Higher Education Institute
HST	High-Speed-Train
ICT	Information and Communication Technology
KIS	Knowledge-Intensive Services
LSE	Large Scale Enterprise
MBA	Master of Business Administration
MIT	Massachusetts Institute of Technology
MNC	Multinational Corporation
NACE	Nomenclature des Activités Économiques dans la Communauté Européenne [General Name for Economic Activities in the European Union]
NTBF	New Technology-Based Firm
NUTS	Nomenclature of Territorial Units for Statistics
OECD	Organisation for Economic Co-operation and Development
PCTP	Parque da Ciência e Tecnologia do Porto [Porto Science and Technology Park]
PRO	Publicly-funded Research Organisation
R&D	Research and Development
SME	Small and Medium Enterprise
STP	Science and Technology Park
UT Austin	University of Texas at Austin
UK	United Kingdom
UKSPA	United Kingdom Science Park Association
USA	United States of America

The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously.

Alfred Marshall

Paradoxically, the enduring competitive advantages in a global economy lie increasingly in local things – knowledge, relationships, and motivation that distant rivals cannot match.

Michael E. Porter

Chapter 1

Introduction

Over the years, governments, firms and knowledge organisations, such as universities and research institutes, have become increasingly aware of the importance of networks, as the only means to achieve competitiveness in a more and more globalised economy.

Clusters and the geographic concentration of firms can act as crucial facilitators in this regard. By co-locating, economic actors are able to share a common culture and a mutual ground of understanding, which enable them to cooperate more easily.

In this way, firms are able to attain several types of external economies, as well. Proximity triggers the occurrence of knowledge spillovers between firms (and between firms and knowledge organisations), and makes division of labour simpler, thus promoting specialisation and the arising of supporting and related industries. Agglomeration leads to a larger and more qualified labour market, and pushes the construction of the necessary physical infrastructure, be it roads or other industry-specific investment.

No wonder, then, that governments all over the world are adopting policies to promote the development of regional clusters, networking, innovation, industry-university linkages and other related elements, especially in knowledge- and technology-intensive areas with a high potential of growth in the future.

Portugal and its Norte NUTS II region are no exceptions to this. In fact, at the same time this thesis was being written, the whole preparation process that led to the North Region Operational Programme (CCDR-N, 2007) was taking place. This document, which determines how the European structural funds for the 2007-2013 time frame will be managed and applied in the region, puts a strong emphasis on the development of clusters and networks. Therefore, these are nowadays hot issues in the political agenda and among many of the most relevant actors in the region. The general expectation is that these efforts make a decisive contribution to the upturn of the regional economy, which has suffered a steep decline between the years 1999 and 2004, as the time-

evolution of its GDP per inhabitant clearly shows.

In a nutshell, this thesis proposes to analyse the possibility of the emergence of new technological clusters, or the development of existing ones, in the Grande Porto region (standing for "Greater Porto"), which aggregates the second most important city of the country, Porto, and its surrounding municipalities.

This general objective has been broken down into four main components. Firstly, an introductory look at the social and economical key indicators of the region is essential to understand its characteristics and serves as a working base for the following parts.

Secondly, by being part of the Norte NUTS II region referred above, Grande Porto is directly affected by the regional development policies defined for the greater region. CCDR-N (2007) gives special attention to three emerging clusters in Norte, which are said to have a quite interesting critical mass in the region: ICT, Electronics, and Electrical Machines and Material; Health, Medical Devices and Pharmaceutics; and Biotechnology and Agri-Food. A thorough assessment of the presence, evolution and structure of these industries in the more limited area of Grande Porto is also included in the overall goal of this work. For this purpose, a methodology is set up based on the cluster-index measure defined by Sternberg and Litzenberger (2004) and on the availability of highly disaggregated employment data in the Table of Personnel ('Quadros de Pessoal') database, from the Directorate-General of Studies, Statistics and Planning of the Portuguese Ministry of Labour and Social Solidarity (DGEEP-MTSS).

Thirdly, a similar methodology is applied in order to try to identify other existing or potential clusters in the region, at the three-digit CAE level industries. When compared with the previous topic, this consists of a less detailed but more encompassing analysis.

Finally, the pursuance of the above-stated general objective would not be completed without evaluating the readiness of the Grande Porto region to the knowledge economy, since this will be a major determinant of its capacity to produce and nurture new technology-intensive clusters and of its overall, sustained growth in the future.

A very important source of information for these tasks is also the set of five face-to-face interviews carried out with distinguished regional actors and organisations.

The interest of this thesis can be seen from an industry, academic and political point of

view.

Firms are expected to gain an increased consciousness to the importance of forming networks, cooperating and, as much as possible, locating in the proximity of competitors, suppliers, customers and knowledge organisations, in order to achieve competitiveness in the global economy. Plus, business opportunities in Grande Porto may be identified based on the data here presented.

From an academic perspective, the proposed approach is innovative in the way it integrates several distinct views of the case study region in order to obtain a comprehensive, holistic accomplishment of the general objective. Moreover, no other previous studies of this kind having the Grande Porto region as their specific target have been identified.

The political interest is multiple, as well. On the one hand, policy-makers should be able to better understand the actual presence of the three policy-supported clusters in Grande Porto and to acknowledge the existence of other potential technological clusters that may be worth their explicit attention. On the other hand, the main strengths and, especially, weaknesses of the region, as far as its performance in the new economy is concerned, may become clearer, thus enabling regional development policy to be more adequately defined. The literature reviewed in the area of best practices in cluster development initiatives and of other established clusters and knowledge regions is also likely to contain valuable information from the political point of view.

In terms of personal motivation for this work, it is intended to be a small, modest, but hopefully valuable contribution to the economic development of the home region of the author. It represents a response to the perception that the region has been continuously loosing competitiveness, influence and brains over the past decade, with all that it means in its overall welfare of firms and individuals.

The dissertation is structured along three main chapters, besides the present introduction.

Chapter 2 reviews the existing literature in the domains of regional clusters and firm concentration. It aims to address issues such as the possible definitions of the concept of cluster, why firms tend to concentrate geographically, which methods there are to identify potential clusters, and how to evaluate regions and clusters.

The core and innovative part of this work will be concentrated in Chapter 3, in which the practical case study, the Grande Porto region, will be analysed along the lines described in the previous paragraphs.

Finally, a summary of the conclusions that can be derived from this work will be presented in Chapter 4.

Chapter 2

Regional Technological Clusters

The existing theoretical and empirical literature concerning the clusters and firm concentration subjects is addressed in this chapter. It begins by discussing some proposed definitions of cluster (section 2.1) and how these can assume several different forms and types (section 2.2). Section 2.3 lists various explanations of what leads firms and industries to concentrate in some geographically limited areas, covering some of the so-called 'new economy' topics, such as knowledge spillovers and innovation. A different view on similar subjects is described in section 2.5, which handles the factors at the base of the formation and growth of clusters.

Furthermore, the analysis of the globalisation/agglomeration duality is addressed in section 2.4, while sections 2.6 and 2.7 describe how clusters can be identified and evaluated. Section 2.8 states a number of regional policy issues, especially focusing on cluster development initiatives.

Finally, a set of case study clusters is presented in section 2.9.

2.1 Definition of Cluster

OECD (2000b) uses a rather simple definition of clusters as agglomerations of firms in related lines of business, containing a variable number of firms, with a variable proportion of small and large firms, whereas Porter (1998) provides a rather more encompassing description, by extending the set of possible participants of a cluster to "other entities important to competition", including universities and other HEIs, vocational training providers, and trade associations. Moreover, although Porter's clusters also carry a strong geographical concentration connotation, their boundaries are actually set by the relevant linkages between firms and institutions.

On the other hand, the Observatory of European SMEs (2002a) refers to a hierarchy of three concepts (also followed by Sternberg and Litzenberger, 2004), the first being the regional cluster, which is restricted to a geographical concentration of mutually

dependent firms, within the same or related industries. Regional clusters are normally considered as a spontaneous development, resulting from local spin-offs and entrepreneurial activity. The intermediate level is the regional innovation network, which implies a better organisation of cooperation projects between firms, thereby providing incentives for firms' innovation. Regional innovation systems represent the third and most advanced stage, as they upgrade the regional innovation networks with cooperation in innovation activity between firms and other knowledge creating institutions such as universities.

In a report prepared for the Directorate General for Regional Policy and Cohesion of the European Commission, Rosenfeld (2002) lists a few characteristics of clusters as he understands them. First of all, clusters rely on inter-firm systemic relationships built on e.g. common or complementary products, or access to core technologies. Secondly, their geographically-bounded aspect is herein defined in terms of distances (and durations) that employees and employers find acceptable to travel in their daily activity. Such boundaries are said to be dependent on transportation systems, traffic and cultural identity, among others. Thirdly, this author describes a cluster life cycle, progressing from an embryonic stage, into growth, maturity and decay, and clearly excludes an organisational membership from the definition of cluster. Finally, the production of externalities is also part of the list, a division being made into 'hard' externalities (e.g. lower costs of supplies, skilled labour) and 'soft' externalities (e.g. access to tacit knowledge).

A related concept which can also be found in existing literature is that of innovative milieu, a group of territorial relationships ultimately leading to a dynamic collective learning process (Keeble *et al.*, 1999). This idea was first introduced more than 20 years ago by the GREMI (Sternberg, 2000) and underlines that regional innovation intensity mainly depends on the interaction amongst local innovative actors (Koschatzky and Sternberg, 2000).

While also mentioning innovative milieux and learning regions as an increasingly important focus of ongoing research, Armstrong and Taylor (2000) describe new industrial districts as spatial concentrations of mainly SMEs (as opposed to large firm-centred clusters, which are said to be a minority in terms of industrial cluster policy

focus). New industrial districts are based on strong cultural and social links amongst their constituent economic agents, intense goods, services, information and people transactions, and a set of local supporting institutions. The Third Italy's (north-eastern and north-central Italy) luxury apparel, furniture, machine tools and ceramics successful clusters are prominent examples of new industrial districts. According to these authors, every innovative milieu is a type of industrial district, but the reverse might not be true. This means that new industrial districts are important for the generation of key ingredients for an innovative milieu, which may or may not come to develop.

2.2 Types of Clusters

Clusters differ from each other in several dimensions, such as geographic scope, horizontal and vertical scope (or breadth and depth, respectively), industrial organisation, dynamics of innovation, competitive strength and state of development (OECD, 2000b).

In their book, Armstrong and Taylor (2000) identify four types of industrial districts, which are also (more or less closely) referred by Dunning (2000):

- the 'Marshallian industrial district', e.g. Third Italy's clusters;
- the 'hub-and-spoke district', based on a constellation of SMEs gravitating around one or more large companies, e.g. the Boeing complex around Seattle;
- the 'satellite industrial platform district', formed by branch plants of multinational enterprises, with low internal linkages;
- the 'state-anchored industrial district', centred on a major public or non-profit institution, e.g. military establishments around São José dos Campos, Brazil.

Dunning, however, expands this list by adding two more types of spatial clusters:

- an upgrade to the Marshallian district, in which the R&D laboratory and the exchange of tacit knowledge amongst cluster actors play an essential role;
- Science Parks, as the most common examples of clusters aimed at promoting "all forms of asset-augmenting activities", normally located in major metropolitan areas or university towns (please refer to section 2.2.1 for further information).

Van den Berg *et al.* (2005) divide clusters into 'growth' and 'spearhead' clusters. The latter regard activities specifically targeted by policies, whereas the former refer to activities that grow in the local economy without specific political intervention. Many of the European cities they have analysed have (politically) selected similar spearhead clusters, as shown in Table 2.1.

City	**Spearhead sectors/clusters**
Amsterdam	ICT/new media, life sciences
Dortmund	MEMS, ICT, logistics
Eindhoven	Medical technology, automotive, ICT, mechatronics
Helsinki	Materials and microsystems, gene technology and molecular biology, medical technology, logistics, ICT/media
Manchester	ICT, cultural/creative industries, biotechnology and health, nanotechnology, finance/business services
Munich	ICT, biotechnology, media, environmental technologies, new materials
Münster	Biotechnology, nanotechnology, ICT
Rotterdam	ICT, audio-visual media, health, medical technology, transport and logistics
Zaragoza	ICT, logistics, business services

Table 2.1 – Spearhead sectors / clusters in several European cities (van den Berg *et al.*, 2005)

The Observatory of European SMEs (2002a) distinguishes between four different interpretations of regional clustering. It starts with research on regional production systems from the 1970s, centred on tight interaction between firms and on historical, regional-specific socio-cultural factors, of which industrial districts are an example.

Secondly, the so-called 'Californian School', for which the agglomeration of firms was caused by the need of firms to reduce transaction costs, as well as to form and take part of specialised local labour markets, as a result of great vertical disintegration of production chains.

Then, the report moves on to the 'Nordic School' of the learning economy, emphasising

innovation, a complex and interactive learning process, as the root of the competitiveness of firms. Learning is mainly considered as a localised process, since some important types of knowledge are of a 'sticky', non-codifiable, tacit nature (this issue is further developed in section 2.3.1).

Finally, the fourth interpretation regards Porter's concept of industrial cluster, according to which clustered firms acquire competitive advantage due to a better access to skilled labour, suppliers and specialised information, and by the motivation caused by local rivalry and demanding customers.

2.2.1 Science and Technology Parks

The UKSPA defines Science Parks as property-based initiatives having links with research organisations and/or HEIs, pushing the creation of knowledge-based businesses, and having a management entity "actively engaged in the transfer of technology and business skills to the organisations on site" (Westhead and Batstone, 1998; Siegel *et al.*, 2003). There are several other terms to interchangeably describe this kind of developments, such as 'Research Park', 'Technology Park', 'Business Park' or 'Innovation Centre' (Löfsten and Lindelöf, 2002).

A significant number of Science Park objectives has been identified, of which one could emphasise the strengthening of academic-industrial linkages, the promotion of the creation of NTBFs and university spin-off firms, the creation of inter-firm synergies, and the growth of the regional economy (Westhead and Batstone, 1998). Park managers claim that the barriers which frequently prevent NTBFs from successful commercialisation can be overcome by providing them with e.g. shared resources, business services and induced cooperation with other on-Park firms (Westhead, 1997). It is also expected that young, newly built, flexible entrepreneurial areas with an energetic workforce tend to attract significant levels of technology-based employment (Westhead and Batstone, 1998).

Moreover, Westhead and Batstone (1998) describe how Science Park managers should do much more than simply selecting tenants and collecting rents. Among their many possible tasks, they should consider, for instance, the promotion of technology transfer and links between the local HEI and Park tenants, and the provision of jointly used services and of business, financial and marketing skills.

Löfsten and Lindelöf (2002) have run a survey across 10 Swedish Science Parks, involving a total of 273 NTBFs (134 on-Park, 139 off-Park firms) responses, in order to identify elements of added-value provided by Science Parks to NTBFs. They conclude that off-Park firms have significantly lower employment and sales growth than those on-Park, and that the latter are more likely to have university linkages than the former. On-Park companies seem to be mostly interested in the university's equipment, R&D and (highly qualified) personnel. On the other hand, no statistically significant differences have been found with respect to profitability and R&D outputs. This last conclusion is also confirmed by the results of a related survey presented by Westhead (1997).

Westhead and Batstone (1998) analyse the factors which had influenced the location decision of on- and off-Park firms in the UK, based on interviews with 71 Park-based firms and 71 off-Park comparable companies. Several location factors have been significantly more often referred by on-Park firms, such as the existence of on-site management and sharing of common services (47.8% and 6.3% of on- and off-Park firms, respectively). Also, topics related to HEI linkages: 'access to facilities of HEI/centre of research' (43.5% against 0%); 'prestige of being linked to the HEI/centre of research' (37.0% compared to 0%); 'scope for attracting graduate HEI staff' (28.3%, 6.3%); 'key founder worked at local HEI/centre of research', which may be a proxy for university spin-offs (17.4%, as opposed to 2.1%). Finally, networking factors, namely 'friendly atmosphere among tenants on site' (21.7%, 8.3%) and 'proximity to firms in similar industrial sectors/using same technology' (15.2%, 6.3%).

2.3 Reasons for Firms to Cluster

The question of why firms (and particularly technology-based firms) tend to cluster is probably one of the most debated within regional economics and related fields of study.

In this regard, Alfred Marshall's seminal work (Marshall, 1920) represented the first effort to explain "the concentration of specialized industries in particular localities". It is appropriate to transcribe some of his most relevant passages at this point:

> "When an industry has thus chosen a locality for itself, it is likely to stay there long: so great are the advantages which people following the same skilled trade

> get from their neighbourhood to one another. The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously. Good work is rightly appreciated, inventions and improvements in machinery, in processes and the general organization of the business have their merits promptly discussed: if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas. And presently subsidiary trades grow up in the neighbourhood, supplying it with implements and materials, organizing its traffic, and in many ways conducing to the economy of its material.
>
> Again, the economic use of expensive machinery can sometimes be attained in a very high degree in a district in which there is a large aggregate production of the same kind, even though no individual capital employed in the trade be very large. For subsidiary industries devoting themselves each to one small branch of the process of production, and working it for a great many of their neighbours, are able to keep in constant use machinery of the most highly specialized character, and to make it pay its expenses, though its original cost may have been high, and its rate of depreciation very rapid.
>
> […]
>
> Employers are apt to resort to any place where they are likely to find a good choice of workers with the special skill which they require; while men seeking employment naturally go to places where there are many employers who need such skill as theirs and where therefore it is likely to find a good market."

Several factors are thus mentioned by the author:

- the diffusion of tacit knowledge – "The mysteries of the trade become no mysteries; but are as it were in the air, and children learn many of them unconsciously";
- the innovation milieu concept – "if one man starts a new idea, it is taken up by others and combined with suggestions of their own; and thus it becomes the source of further new ideas";
- the arising of supporting and correlated industries – "subsidiary trades grow up in

the neighbourhood, supplying it with implements and materials, organizing its traffic, and in many ways conducing to the economy of its material";

- the division of labour, specialisation and leveraging of equipment due to a large market – "industries devoting themselves each to one small branch of the process of production, and working it for a great many of their neighbours, are able to keep in constant use machinery of the most highly specialized character";
- the large pool of skilled labour – "Employers are apt to resort to any place where they are likely to find a good choice of workers with the special skill which they require"; and
- the attractiveness of the region for skilled workers – "men seeking employment naturally go to places where there are many employers who need such skill as theirs and where therefore it is likely to find a good market".

Such reasons are generically known as external economies:

> "Looking more closely at the economies arising from an increase in the scale of production of any kind of goods, we found that they fell into two classes – those dependent on the general development of the industry, and those dependent on the resources of the individual houses of business engaged in it and the efficiency of their management; that is, into external and internal economies.
>
> […]
>
> The general argument of the present Book shows that an increase in the aggregate volume of production of anything will generally increase the size, and therefore the internal economies possessed by such a representative firm; that it will always increase the external economies to which the firm has access; and thus will enable it to manufacture at a less proportionate cost of labour and sacrifice than before."

It will be shown throughout this chapter that these 'Marshallian' economies are still very much alive and central in modern clustering theory. Quoting Armstrong and Taylor (2000), "almost all of the current thinking [on industrial agglomerations] has looked for its inspiration to the work of Marshall (1890) [1st edition] on 19th century industrial districts".

These authors identify two kinds of sources of external economies: localisation

economies and agglomeration economies. The former are originated by the geographical concentration of plants in the same industry, which can occur due to several factors: the existence of transfer economies between plants with input-output ties; the possibility of individual plants to specialise more than if firms were dispersed and thereby attain increased efficiency in production; the enhancement of the exchange of information and knowledge between clustered firms; the reduction of risks for workers and employers. The second type of external economies is agglomeration economies, denoting the geographical association of a large number of firms, not necessarily belonging to the same industry. They are mainly due to the joint use of common facilities, such as: transportation facilities; market access; large, diversified labour markets; governmental, legal and commercial services; cultural activities.

The chapter will move on by individually addressing each of the main factors related to the firm clustering phenomenon.

2.3.1 Knowledge Spillovers

Knowledge spillovers are widely believed to be one of the main factors leading to firm agglomeration, the basic principles being that firms need to find external sources of knowledge and that proximity facilitates the exchange of knowledge among firms. The same applies to the linkages between firms and HEIs or research institutes, when the cluster also includes the latter (as it frequently does). As firstly described by Marshall, skills are passed from person to person and over time become common knowledge within the cluster, turning it into a repository of industry-specific skills and capabilities (OECD, 2000b; Rutten and Boekema, 2004).

It is appropriate to distinguish, at this point, between codified and tacit knowledge. Codified knowledge pertains to information which is formally documented and accessible over a large distance and at low costs, through ICTs and other media. On the contrary, tacit knowledge is carried only by the people who master it, and its transfer requires repeated personal, face-to-face contacts (van den Berg *et al.*, 2005; Frenken and van Oort, 2004). It refers to a vast sub-group of knowledge of which individuals are not aware when acting, and which they unconsciously acquire through a process of trials, errors and adjustments. This knowledge can be put into written documents, albeit not including its full capital (Poma and Sacchetti, 2004). While information is globally

mobile, tacit knowledge is significantly spatially rooted (Observatory of European SMEs, 2002a).

Naturally, the proximity of firms in clusters is particularly important for tacit knowledge transfer. Geographical concentration of firms is therefore in part generated by the need of people dedicated to innovation and management to exchange uncodifiable knowledge, based on understanding and trust (Isaksen, 2004).

By means of an ordered logit model, Arundel and Geuna (2001) have evaluated how the importance of proximity for the flow of knowledge from PROs to firms varies with several factors. They have concluded that proximity effects are likely to fall with an increase in R&D expenditures (as a measure for firm size), but rise with the quality and availability of outputs from national PROs. A different perspective is taken by Audretsch and Feldman (1996), who state that knowledge externalities are more likely to occur in industries where new economic knowledge, captured by the levels of industry R&D, university R&D and skilled labour, is more important.

There are several forms by which knowledge spills over from one firm, HEI or PRO to another existing or new firm. The most obvious one is the mobility of highly skilled workers taking along their expert knowledge. Then, when it comes to HEI or PRO linkages, firms usually resort to several methods, depending on the type of knowledge they wish to acquire: reading publications or attending conferences, for codified knowledge; informal personal contacts, joint research or hiring of trained scientists and engineers, for tacit knowledge (Arundel and Geuna, 2001).

The ENSR (European Network for SME Research) Enterprise Survey 2003 collected data from entrepreneurs and managers of firms with less than 250 employees from 19 European countries, regarding the theme of cooperation among SMEs (Observatory of European SMEs, 2003). ‘Access to know-how and technology’ was referred by 28% of the SMEs has having been one of the reasons to cooperate with other SMEs.

Spin-offs represent another important source of knowledge spillovers. They can depart from existing firms, HEIs and research institutes, inheriting part of the competencies of their parent organisations, and frequently locating in the same geographical area of their predecessors (Armstrong and Taylor, 2000; Frenken and van Oort, 2004).

A related concept is that of regional collective learning, broadly concerning the capacity

of a region's firms to adopt an innovative behaviour and the formation of common knowledge and procedures among a group of geographically clustered firms (Keeble *et al.*, 1999). Those collective learning processes mainly operate by means of tacit functions, such as skilled labour moving within the regional labour market, technical and organisational interchange between customers and suppliers, the existence of relationships of trust and reciprocity, imitation, informal 'cafeteria' effects and other casual information flows, and specialised services provision.

Two significant forms of knowledge creation among firms are described by Lorenzen and Maskell (2004): incremental and experimental knowledge creation. The first one takes place through vertical and horizontal spillovers. Clients and producers interact in order to solve problems that each firm alone could not work out by itself, thus 'pushing' and 'pulling' knowledge along the value chain. Knowledge spillovers also occur horizontally, as competing companies constantly monitor the activity of each other or informally trade in-breadth (as opposed to in-depth) information. The second form of knowledge creation, here named experimental, concerns firms with complementary capabilities that frequently form temporary relations enabling targeted experimentation leading to the creation of new solutions for specific demands or to the redefinition of crucial characteristics of their products.

2.3.2 Innovation

For a long time now, innovation has been assimilated by researchers, economists, firms, universities and governments as a central and vital element in the creation of competitive advantage. Innovations are heavily based on already available knowledge and on ideas and contributions from the society as a whole. In this sense, the innovation performance of a firm is greatly dependent on its access to external knowledge and linkages to the corresponding external knowledge holders (Observatory of European SMEs, 2002b).

A High Level Group was mandated in March 2004 by the European Commission with the objective of contributing to the mid-term review of the Lisbon strategy for the EU. The report then produced refers that creative interaction between universities and industry is intimately related to their close physical location. The concept of 'ideopolis' is presented as a city lying in the centre of a dynamic, high-growth, knowledge-based

region built on the above-mentioned interactions, providing several supporting factors such as sophisticated communications, transport infrastructure and venture capital, and standing as attractive environments for knowledge workers. The Group points out the stimulation of networking, and specifically of clusters and ideopolises, as being crucial to the creation of "the right climate for entrepreneurs" (High Level Group, 2004).

Porter (1990) also explains the important role of geographic concentration in constant improvement and innovation, by establishing a tight link between innovation and firm rivalry: companies located close to one another tend to be much more dynamic competitors and therefore innovation seekers, as they are permanently under strong peer pressure and comparison. In addition, HEIs nearby have a better understanding of the industry's needs and take appropriate measures, much like suppliers in regularly cooperating with the industry's R&D.

Another reason why clusters push innovation further is the fact that sophisticated customers are usually part of the cluster. This enables in-cluster firms to have a better view on the market than their isolated competitors, understanding earlier the evolution of e.g. technology, products, services and marketing concepts, and being able to delay large commitments until it becomes clear that a given innovation will effectively succeed (Porter, 1998).

Having a facilitated access to obtaining their inputs, clustered firms can implement innovations more promptly and perform experiments at lower costs.

Sternberg (1999) analyses the importance of geographic proximity in the establishment of innovative linkages between manufacturing SMEs, research institutions, customers and suppliers of three German regions – Baden, Saxony and the so-called research triangle Hanover-Brunswick-Göttingen – coming to several conclusions. Firstly, he derives that innovative firms are more abundant than non-innovative firms among those maintaining linkages with other cooperation partners. Then, firms tend to prefer intra- to interregional linkages when dealing with research institutions and competitors, even though the opposite is also true when it comes to cooperating with customers and suppliers. Small firms are more frequently part of intraregional knowledge networks than large firms, reflecting a greater need to establish linkages in order to get over their disadvantages in the innovation process and access to global resources (Sternberg,

2000). More specifically, very small firms with less than 10 employees benefit from intraregional innovation linkages in a special manner, showing a considerably better performance regarding employment and turnover growth and innovation output than the remaining firms (Koschatzky and Sternberg, 2000).

The propensity of innovative activity to concentrate geographically is also industry-dependent. As previously referred, it is in new economy industries, as well as in industries relying on a highly skilled workforce, that knowledge spillovers are more likely to take place (Audretsch and Feldman, 1996; Koschatzky and Sternberg, 2000).

The concentration of SMEs around one or more large companies may also be partly explained by the establishment of innovative partnerships with those few nuclear firms. Sternberg and Tamásy (1999), for instance, write that approximately one-third of the R&D-intensive SMEs surveyed in the region of Munich, Germany, have rated the relevance of their innovative linkages with a locally headquartered MNC, Siemens, as 'significant' or 'very significant' for their business. Plus, these SMEs exhibit considerably stronger growth, larger size and higher shares of turnover than their counterparts with no contacts with Siemens.

2.3.3 Labour Market

Agglomeration economies arising from the geographical concentration of economic activity are partly caused by the formation of well-organised labour markets and large pools of skilled workers (Armstrong and Taylor, 2000).

The Observatory of European SMEs (2003) refers that 'Access to labour' was referred by 18% of the SMEs interviewed in the ESNR Enterprise Survey 2003 as having been one of the reasons for cooperating with other SMEs. The same organisation includes the creation of a specialised labour market, along with the creation of specialised suppliers and service firms, in the second of a six step model of cluster development (Observatory of European SMEs, 2002a).

The value of the local labour market of the cluster and the interest that potentially in-moving firms have in it is augmented by the recognition of the existence of knowledge spillovers. More specifically, firms perceive that they can attain significant benefits from the movement of scientific and management experts within the cluster. In fact, it is

even difficult to dissociate the knowledge spillovers and labour market issues, given that in a certain way the former can be considered part of the latter. By means of an interesting survey involving 300 SMEs, Keeble and Nachum (2002) examine the concentration of management and engineering consultancy firms in central London, as well as their growth in decentralised locations of East Anglia and South West England, to conclude, among other topics, that their clustering is related to local labour market processes that enhance the knowledge base and competitiveness, particularly the local skilled labour flows providing consultancy SMEs with new expertise and know-how.

Big cities and their surrounding areas quite often provide both good residential environment and easy access to sophisticated urban life styles, and thereby tend to attract R&D investment and skilled labour. Plus, this magnet effect is further enforced as the locality builds up a reputation as an R&D centre (Armstrong and Taylor, 2000).

With its increased bargain power, a cluster of firms can have a much greater influence on the creation of factors, in general, and on the formation of skilled people by HEIs and research organisations, in particular, than an individual company. When a group of rivals exists, there are various potential employers for those coming out of universities, and several users of specialised facilities, programmes and knowledge (Porter, 1990).

A case study is reported by Isaksen (2004): the software consultancy cluster in the Oslo region, Norway. The large, specialised labour market in this area is appointed as one of the cluster-building factors, by making it less difficult to contract and dismiss employees. Consulting firms hire from competitors, universities and from other industries, especially from those in which they have already entered or are trying to.

2.3.4 Division of Labour

Increased inter-firm specialisation and division of labour, leading to potential economies of scale and scope, represent an important generator of competitive advantage in clusters. This may be of great interest especially to small firms, as it enables their exploitation of certain benefits of both small and large scale (OECD, 2000b; Isaksen, 2004). Networks of firms may thus enable lower costs in the services provided, better quality or higher flexibility (Arndt and Sternberg, 2000).

Sternberg and Litzenberger (2004) have identified, both in manufacturing and in

service, the ten most concentrated industries in Germany. They have concluded that highly specialised industries tend to agglomerate more, contrarily to, for instance, daily demands supply industries, such as bakeries. Moreover, manufacturing and services small industries usually concentrate more than bigger industries.

The importance of the critical mass of the cluster is stressed by van den Berg *et al.* (2005). Critical mass provides a market large enough to support the activities in the cluster, forces neighbour competitors to operate efficiently, enables the sharing of resources and equipment, among other benefits. Plus, the cluster can get into a self-reinforcing development, as its scale entails division of labour and specialisation, which leads to a large, specialised job market, higher sophistication of the cluster product, and increase in demand. This, in turn, stimulates firms to expand, new firms to be created and attracts outside firms to the cluster, thus further increasing the economies of scale.

One of the most frequently mentioned examples of well-developed division of work is the case of the industrial districts in the 'Third Italy' (north-eastern and north-central regions of Italy), composed of many small, highly concentrated, mainly traditional manufacturing companies, which have managed to specialise and become world leaders in industries such as luxury apparel, furniture and ceramics (Armstrong and Taylor, 2000; Observatory of European SMEs, 2002a).

2.3.5 Market Access

Demand-side factors can also have a highly relevant role in the geographical concentration of firms. By locating in a region which is part of a large market (or has easy access to one, by means of good transportation infrastructure), firms gain a competitive advantage over their competitors located in other regions lacking these characteristics (Gray and Dunning, 2000).

In his widely known 'diamond' model, Porter (1990) roots competitive advantage of a nation in a given industry in four broad attributes: factor conditions, demand conditions, correlated and supporting industries, and firm strategy, structure and rivalry. Demand conditions relate to the nature of the internal market for the products or services of an industry. Although internal demand also increases static efficiency by enabling greater economies of scale, its main influence is dynamic. Depending on its composition, size and growth pattern, and the mechanisms by which internal preference is transmitted to

other markets abroad, the internal market can be determinant for firms to gain competitive advantage.

Most regional clusters are dominated by SMEs, or at least by a mix of both SMEs and LSEs. This can be explained by intense vertical disintegration providing local market opportunities for small, specialised subcontractors (Observatory of European SMEs, 2002a).

Following their comprehensive survey of management and engineering consultancy SMEs, either concentrated in central London or dispersed in East Anglia and South West England, Keeble and Nachum (2002) report that 32.3% of the clustered firms surveyed had decided to locate in central London due to 'proximity to clients', whereas only 7.9% of the decentralised firms gave the same answer. Similarly, 62.5% of the clustered firms mentioned 'proximity or accessibility to clients' as being an important characteristic of their location in contributing to the competitive performance of the firm, against only 32.2% among the non-clustered companies. It is also worth mentioning that, in this particular question, 'image or prestige of location as a way of signalling quality and credibility' (which can also be seen as a part of the market access issue) was referred by 68.3% of the central London firms, compared to 27.6% of the East Anglia and South West establishments. These results are strong empirical evidence of the importance of market access in the processes of firms' concentration.

Other relevant examples are provided by Isaksen (2004), Aslesen (2004), and Armstrong and Taylor (2000), regarding the agglomeration of software consultancy firms in Oslo, of knowledge intensive business services in the largest Norwegian cities, and of American assembly plants in the border region of Mexico, respectively.

In addition to the activities directly related to the cluster, the large concentrations of population also attract market-oriented activities such as service trades.

2.3.6 Rivalry

By concentrating geographically, competitors are able to closely monitor the products, processes, prices and innovations of each other, especially in knowledge-based industries heavily reliant on the 'local buzz'. Rivalry, observation, comparison and imitation are important elements in the early development of clusters (Isaksen, 2004).

Local peer pressure can be highly motivating, as firms and their executives strive to attain good image and reputation, and to outperform one another (Porter, 1998).

Firm strategy, structure and rivalry are one of the four vertices of Porter's 'diamond' model for competitive advantage (Porter, 1990). He writes that, although it can be argued that internal competition leads to effort duplication and prevents firms from gaining economies of scale, thus recommending policies to promote the formation of one or two 'national champions', his empirical examination of the most successful industries in ten countries points in the opposite direction. Internal rivalry is said to carry several benefits: stimulating new rivals, creating and attracting factors, etc.

2.3.7 Firm Entry

New firms entry processes are also one of the factors leading to geographical concentration. Porter (1998) provides a number of reasons for that. By working within a cluster, individuals have a clearer perception of products and services gaps which might represent good business opportunities. Plus, barriers to entry are lower than in most other locations, as the necessary assets, skills and staff are frequently already available.

Spin-offs tend to locate near their parent companies or research institutions (Porter, 1990). In their survey concerning the factors which had influenced the location decision of both on- and off-Science Park firms in the UK, Westhead and Batstone (1998) find that for 17.4% of the owner-managers of firms located on Science Parks, as well as for 20.8% of those settled off-Park, the fact that the key founder had worked previously in the locality had been one of the three most important location decision factors. These results are corroborated by Keeble *et al.* (1999), who report data derived from an interview survey conducted within a group of 50 technology-based SMEs in the Cambridge region, UK. According to this study, 88% of the firms had been set up as independent start-ups or spin-offs from existing firms or institutions. For 81% of these the founder had been immediately previously employed within the Cambridge region.

Moreover, the existence of 'incubator' type organisations can also promote the formation of new firms in a given area. This kind of institutions provides resources that support the foundation of new, small companies (Löfsten and Lindelöf, 2002).

2.3.8 Supporting Services

A cluster typically contains firms operating in different stages in the production chain, service units (e.g., financial institutions), government organisations, semi-public agencies, etc. (van den Berg *et al.*, 2001). Cluster Navigators (2001) divide the stakeholders of clusters into four broad groups: core businesses, support businesses, soft support infrastructure and hard support infrastructure. The second group, support businesses, covers the activities that directly or indirectly support the core businesses of the cluster, including suppliers of specialised machinery or raw materials and service firms such as venture capital, lawyers, design and marketing. Soft support infrastructure encompasses, for instance, local schools and universities, trade and professional associations, and economic development agencies. The definition of support services herein addressed lies in-between these two categories, gathering together the service firms part of the support businesses group and the upper-mentioned soft support infrastructure organisations, excluding knowledge institutions. The availability of supporting services helps to attract new investment and new firms into the cluster.

Plus, it has been referred previously that correlated and supporting industries are one of the four determinants of the 'diamond' model for competitive advantage (Porter, 1990).

The Observatory of European SMEs (2002a) shows a comparative survey of 34 regional clusters in 17 European countries. Regarding the activities in the value chain of the main firms of each cluster which are primarily carried out within its boundaries, 'performing of supporting services' was reported in 28 of the surveyed clusters (82%). Moreover, approximately a quarter of the clusters had experienced an increasing internalisation of supporting services over the previous 10 years (i.e., supporting services increasingly provided by players inside the cluster). Relevant and unquestionable empirical evidence of the role of supporting services is also provided by Westhead and Batstone (1998), Keeble *et al.* (1999), and Armstrong and Taylor (2000), in particular concerning access to common services, advice from business support agencies and consultancy firms, and accountancy or marketing services.

High-tech SMEs pose specific financing characteristics that make venture capital and business angels more adequate than credit finance, since the provider of capital fully takes part in both opportunities and risks, and thereby better assesses the concrete

projects (Observatory of European SMEs, 2002b). Hence, the presence of the venture capital industry and associated services within a cluster constitutes one more reason why firms tend to establish inside it. Balasubramanyam and Balasubramanyam (2000) thus point out the availability of venture capital as one of the main factors promoting clusters. However, in her study of the German pharmaceutical biotechnology sector, Wolter (2004) concludes that this factor had not been as influential as initially thought.

2.3.9 Physical Infrastructure

High quality supporting physical infrastructure can also act as a magnet for firms, entrepreneurs and investment. Roads, ports, high-speed railways, international airports and communication links are examples of such physical infrastructure.

By clustering, firms also manage to have a greater influence on the creation of production factors. The existence of a group of firms and industries jointly making use of a common infrastructure, provides strong incentive for governmental bodies to invest in the creation of relevant factors (Porter, 1990), e.g. a new or improved logistic centre.

Coughlin *et al.* (1991) have run a conditional logit model of the location decision of FDI in manufacturing in the USA, concluding that the transportation infrastructure of a state (highways miles, railway miles and number of public airports) has a positive, statistically significant impact on FDI.

Singapore seems to be a paradigmatic case in this respect. The strategy of the government of Singapore has been to promote the development of clusters for industry, business services, finance, logistics and distribution, and ICTs. One of the core ideas of this strategy is to exploit the advantageous geographical location of the country, by strongly investing in e.g. air and sea transportation infrastructures, advanced communication networks, industrial estates and business and science parks (Yue, 2000).

In addition, firms and their employees are also interested in having good public utilities, housing supply, commercial areas, high quality hospitals and schools, safety, cultural facilities and events, city parks, natural surroundings, etc. These factors are crucial to attract and retain labour, especially talented, skilled knowledge workers, who tend to be greatly influenced by this element (Rosenfeld, 2002; van den Berg *et al.*, 2005).

2.4 Globalisation and Agglomeration

Globalisation is nowadays one of the most important trends in the world economy, as international business activity of all kinds has increased drastically over the last few decades, led by a set of policy, economic and technological variables. During this time, world trade, for instance, has grown considerably more than world output, and less than FDI flows (OECD, 2000b).

Opener and more global markets, along with faster transportation and communication, could represent a sign of a smaller role of location in competition. When things can be accessed remotely by everyone in an efficient manner, they no longer constitute a source of competitive advantage.

However, the opposite appears to be the case instead, as lasting and strong competitive advantages are more than ever based on the concentration of highly specialised knowledge institutions, competitors, related businesses and sophisticated customers. Globalisation and regionalisation (in the sense of firm agglomeration) are then two sides of the same coin (Porter, 1998; Sternberg, 2000; Audretsch, 2000).

Following a survey of 100 technology-intensive companies in the Cambridge and Oxford regions, UK, Keeble *et al.* (1998) find that firms achieving high levels of internationalisation also exhibit higher levels of local networking than their nationally-oriented counterparts. Among the internationalist firms, 23.5% have rated research cooperation with other local firms as being important or extremely important for their operation, 20.6% regarding links with firms in the same line of business, and 40.3% when it came to universities, against only 11.8%, 2.9% and 21.7%, respectively, within their nationalist counterparts.

Porter (1998) adds that a set of metropolitan areas, each specialising in a group of clusters, seems to be a more productive industrial organisation than an economic geography based on one or two big, diversified urban centres.

While contributing to the globalisation process, MNCs also conduce to the geographical agglomeration of firms, as their location decisions are intensifying the concentration of economic activities in a wide range of industries, such as electronics design, biotechnology research and financial services. Several examples can be referred in this

regard. New York, London and Tokyo are consolidating their positions as major financial and managerial centres. Biotechnology development is carried out by European pharmaceutical MNCs in USA biotechnology clusters. Asian semiconductor companies have their chips designed in Silicon Valley (OECD, 2000b).

The software cluster in Bangalore, India, is another example of the developments caused by globalisation, having massively attracted MNCs into the cluster, both as producers and consumers of software. The software industry in India has also greatly benefited from the return to the home country of a large number of skilled professionals who had emigrated to the USA during the 1960s and 1970s, many of them now dividing their time between India and the USA. Moreover, FDI has played a relevant role in the formation of this cluster, as well (Balasubramanyam and Balasubramanyam, 2000).

The Observatory of European SMEs (2002a) presents and analyses some interesting statistical data, which point to a mixed scenario of regionalisation and globalisation trends. While globalisation is more and more present in many clusters, in which MNCs show growing importance, and which have their firms increasingly sourcing raw materials and major components internationally, several activities have progressively become internalised by the clusters, such as supporting services and applied R&D.

The relevance of the globalisation / localisation duality is particularly true for SMEs, which would otherwise be at disadvantage in relation to innovation activities and access to global resources, as already explained throughout sections 2.3.1 and 2.3.2 (Sternberg, 2000).

OECD (2000a) lists some of the strategies adopted by SMEs in order to enhance their ability to create, access and trade new knowledge in global markets, which is considered a key issue of their competitiveness. The list includes the so-called ‘innovation strategy’, the ‘information technology strategy’, the ‘niche strategy’, the ‘foreign direct investment strategy’, the ‘network strategy’ and the ‘cluster strategy’. Among these, the latter strategy is of especial interest for the present section of this work, as it consists of the close location of competing SMEs in order to internalise knowledge spillovers. This strategy may be particularly applicable in young industries, or when strategic knowledge is essentially tacit.

The same report further makes use of the distinction between knowledge (herein

considered inherently tacit) and information (in the sense of 'codified knowledge', as defined in section 2.3.1) to explain the apparent paradox of the increasing importance of geography in a globalised world. Despite the fact that the marginal cost of transmitting information has been dramatically reduced, the marginal cost of transmitting knowledge continues to rise with distance.

2.5 Formation and Growth of Clusters

The central elements for the establishment and successful growth of a cluster are, of course, somehow related to the reasons which lead firms to cluster in the first place. For instance, if the availability of skilled labour may represent an important determinant for a great number of firms to agglomerate (section 2.3.3), then the existence of high quality universities can be considered as a key element to the development of the cluster. In a way, one could think of the present chapter as providing the point of view of the cluster itself, whereas section 2.3 concerns the perspective of the firms.

Van den Berg *et al.* (2001) specify three main factors for cluster development: general conditions, cluster specific conditions, and organising capacity. General conditions refer to e.g. the economic and spatial structure, quality of life or cultural aspects. Cluster specific conditions relate to the quality and dimension of the actors of the cluster (i.e., the 'critical mass' of the cluster). Organising capacity regards the ability of the region to mobilise all actors related to the cluster, in order to come up with new ideas and design policy aimed at promoting the sustainable development of the cluster.

Rosenfeld (2002) too refers a set of three main elements to which the economic success of clusters can be attributed: concepts, connections, and competencies. Innovation, imitation, competition and entrepreneurship are part of the concepts element. Connections accelerate the transmission of ideas, innovations and information within the regional economy. In this regard, the ability to network extensively and form networks selectively is the most relevant operating principle of competitive clusters. The last element, the competencies of the cluster, is also the most important: the presence of industry leaders and of a specialised workforce, the ability to bring in talented people, the existence of advanced tacit knowledge.

The formation of clusters can be linked to several possible roots, which are identified by

Porter (1998):

- Historical circumstances, as in the case of the Dutch transportation cluster, which resulted, among other factors, from the central location of the country within Europe, and the skills acquired during their long maritime history.
- Sophisticated, stringent local demand. An example of this would be Israel's cluster in advanced agricultural technologies, triggered by the strong desire for self-sufficiency in food, together with a context of hard growing conditions.
- The existence of supplier or related industries. In the USA, San Diego's regional cluster in golf equipment was derived from the aerospace cluster of the south of California, which created suppliers for advanced materials also applicable to the golf equipment industry.
- The presence of one or two innovative firms stimulating the growth of many others. The growth of the telecommunications cluster in the Washington, D.C., metropolitan area is closely related to the role of MCI and America Online as hubs for new businesses.
- A chance occurrence may create some competitive advantage that boosts cluster development. It is unlikely, however, that the success of a given cluster is referable exclusively to chance.

Bresnahan *et al.* (2001) sustain that the determinants of the initial phase of the formation of a cluster can be substantially different from those relevant for a more mature period. Agglomeration economies and the so-called 'social increasing returns' do take place after the initial phase has been overcome. However, at an initial stage of the cluster, 'old economy' elements such as firm building and managing skills, the availability of skilled labour and wide market access (as opposed to 'new economy' factors such as entrepreneurship, economies of scale at the level of the region or industry and external effects) seem to be crucial for the cluster to take off.

The growth of seven high-technology regions, all exhibiting far above-average dynamic growth, is analysed by Sternberg (1996), who presents a qualitative evaluation of a set of factors with respect to the genesis and growth of each of the selected case studies, herein reproduced in Table 2.2. The factors are ranked as belonging to the two most

important, other important factors, or less important or not relevant factors.

A different view of this data, showing the number of occurrences of each qualitative evaluation per factor, is provided in Table 2.3. Concerning the initial formation of the clusters, federal R&D expenditure with implicit regional impact appears to be the most important factor, followed by the research and educational infrastructure, and decentralisation processes in large agglomerations. Regarding the growth of the analysed high-tech regions, the research and educational infrastructure, along with the private demand for technology-intensive new products, are the most relevant determinants. It is worth mentioning that federal R&D-expenditure, amenities, and the availability of venture capital are also key elements for the growth of the clusters, all having been referred as important factors for four regions each.

This study thus corroborates the analysis of Bresnahan *et al.* (2001) regarding the hypothesis of the determinants of the genesis of the clusters being considerably different from those promoting their growth. OECD (2000b) moves along similar lines.

Keeble *et al.* (1999) emphasise the importance of the establishment of collective learning processes and networks, and of 'institutional thickness' in the evolution of the regional cluster of Cambridge, UK. The argument is that, when in the presence of favourable environmental, socio-economic and institutional conditions, as well as sufficient historical evolution, regional agglomerations of firms can build up a capability for technological learning, innovation and creation of new products and companies. The study also shows that the degree of 'institutional thickness' was initially limited, but that new collective initiatives, venture capital funds and intervention by development agencies have thickened the institutional framework.

Clusters can, at some point in time, get into a declining process. Reasons for this can be both internal and external to the cluster: technological discontinuities, shifts in demand, overconsolidation and other restraints to competition, group thinking, insufficient amount and quality of infrastructure (Porter, 1998; Gray and Dunning, 2000).

Factors	Silicon Valley		Greater Boston		Research Triangle		Western Crescent		Cambridgeshire		Munich		Kyushu [1]
	Genesis	Growth	Genesis	Growth	Genesis	Growth	Genesis	Growth	Genesis	Growth	Genesis	Growth	Genesis
Research and educational infrastructure	●	●●	●●	●●	●	●●	○	○	●●	●●	○	●	○
Innovation Centres, Science Parks	○	○	○	○	●●	●	○	○	●	●●	○	○	○
Government policies (with explicit regional goals)	○	○	○	○	○	○	○	○	○	○	○	○	●●
Federal R&D-expenditure (with implicit regional impact)	●●	●	●●	●	●	○	●●	●	○	●	●●	●●	○
Technology policy of the region (with explicit regional goals)	○	○	○	○	●	●	○	○	○	○	●	●	●
Private demand for technology-intensive new products	○	●●	○	●●	○	○	○	●	○	○	○	●●	○
Public demand for technology-intensive new products (especially military demand)	●●	●	●	●	○	○	●	●●	○	○	●	●	○
Amenities (environment, culture, living conditions, etc.)	●	●	○	○	○	○	●	●	●●	●	○	●	○
Availability of LSEs and their attitude toward small and young technology-oriented firms, also intraregional production networks	○	●	●	○	○	○	○	○	○	●	●●	●	●
Location of major inventions	○	●	●	○	○	○	○	○	○	○	○	○	○
Availability of venture capital	○	●	○	●	○	○	○	●	○	○	○	●	○
Role of key persons	●	●	○	○	●●	○	○	○	○	○	●	●	○
Decentralisation processes in large agglomerations	○	○	○	○	●	●●	●●	●●	○	●	○	○	●●

●● – the two most important factors ● – important factor ○ – less important or not relevant

Table 2.2 – Qualitative evaluation of the determinants of the formation and growth of a set of high-tech regions (Sternberg, 1996)

[1] Cluster growth determinants for Kyushu were missing in the data source (Sternberg, 1996).

Factors	Genesis			Growth		
	Two Most Important	Other Important	Irrelevant	Two Most Important	Other Important	Irrelevant
Research and educational infrastructure	2	2	3	4	1	1
Innovation Centres, Science Parks	1	1	5	1	1	4
Government policies (with explicit regional goals)	1	0	6	0	0	6
Federal R&D-expenditure (with implicit regional impact)	4	1	2	1	4	1
Technology policy of the region (with explicit regional goals)	0	3	4	0	2	4
Private demand for technology-intensive new products	0	0	7	3	1	2
Public demand for technology-intensive new products (especially military demand)	1	3	3	1	3	2
Amenities (environment, culture, living conditions, etc.)	1	2	4	0	4	2
Availability of LSEs and their attitude toward small and young technology-oriented firms, also intraregional production networks	1	2	4	0	3	3
Location of major inventions	0	1	6	0	1	5
Availability of venture capital	0	0	7	0	4	2
Role of key persons	1	2	4	0	2	4
Decentralisation processes in large agglomerations	2	1	4	2	1	3

Table 2.3 – Statistical view of Table 2.2: number of occurrences of each qualitative evaluation, per factor.

2.6 Identification of Clusters

Rosenfeld (2002) indicates the identification of existing clusters as the first action for understanding regional economies. In fact, clusters help governments better understand how a given regional economy works, and this represents one of the strongest incentives for focusing on their promotion. Only after analysing the regional production and innovation systems, and finding market imperfections, can policy makers decide which actions have higher probabilities of resulting in the greatest impacts.

At a lower level, the identification of the relationships within the cluster is mentioned, as well. The sector-based supply chains are usually available from government

agencies, but these do not describe the actual supplier and institutional linkages. Plus, the flows of tacit knowledge are the most difficult to map and, so, some sample questions that could be posted to individuals and firms within the region are provided:

- "List […] important suppliers of information or advice (e.g. HEIs, competitors, customers […]), and number of contacts in the previous year";
- "List […] organisations that have recently received your help, in the form of e.g. advice, shared information, production, or loan";
- "List […] leaders and/or innovators in the same industry as yours";
- "List […] businesses or professional associations to which you belong and number of events attended in the previous 6 months";
- "List […] providers of education of training in the previous year […]".

Sternberg and Litzenberger (2004), on the other hand, write that there is no consensual method for identifying clusters, either concerning the variables to measure or the geographical characterisation of the cluster. Nevertheless, there are generally two different approaches to this subject, top-down and bottom-up (which are also referred by Cluster Navigators, 2001).

Their focus is completely set on the first approach, which begins by calculating the spatial concentration of an industry, based on the assumption that a minimum degree of spatial concentration is a prerequisite for the formation of clusters. The coefficient of localisation introduced by Hoover (1936), which is similar to the Gini coefficient and evaluates the degree of specialisation of a region in a given industry as a deviation of the distribution of the total industrial employment, is pointed out as the most common method to measure concentration.

Kim (1995) details how to compute Hoover's coefficient of localisation. The coefficient is based on the location quotient, defined for the USA as

$$L_{ij} = \frac{E_{ij}}{E_{i\,us}} \Big/ \frac{E_j}{E_{us}} \qquad \text{Eq. 2.1}$$

L_{ij} being the location quotient in industry i for region j, E_{ij} the employment with the same determinants, E_j the total employment in region j, $E_{i\,us}$ the employment in industry

i, and E_{us} the total employment in the USA. An above-unity location quotient indicates that, relative to other regions, region j exhibits a higher percentage of industry i compared with its proportion of total industry employment.

Then, the localisation curve for industry i can be delineated by carrying out the following tasks: calculate L_{ij} for all regions and sort them in descending order, compute the cumulative percentage of employment in industry i over the regions (Y-axis of the chart), and compute the cumulative percentage of employment in total manufacturing over the regions (X-axis of the chart).

The coefficient of localisation is equal to the area between the localisation curve and the 45 degree line, divided by the triangular area (0.5). Hence, the closer the coefficient is to zero (i.e., localisation curve close to the 45 degree line), the more dispersed the industry is. On the contrary, if the coefficient equals one, the industry is entirely concentrated in one region.

Sternberg and Litzenberger (2004) proceed in their task of identifying German regions with industrial clusters by selecting the ten most concentrated industries in both manufacturing and services (the industries with less than 97 firms are excluded, in order to eliminate the possibility of higher concentration values caused by a lower number of firms compared to the number of regions).

They then argue that a more precise measurement must be used to identify regions as industrial clusters. Several reasons for this are provided. First, the location quotient, for instance, measures only the industrial specialisation of a region, and not the industrial concentration. The geographical proximity, which is measured with the industrial density of a region compared to the whole country, must be considered as well. On the other hand, a high industrial density value alone is not enough to identify a region as a cluster, either. Thereby, one must include the industrial stock of the region in the equation (the industrial stock is similar to the location quotient, but uses the number of inhabitants, instead of total employment, as the variable of reference). Finally, the number of firms must also be taken into account.

Based on these grounds, Sternberg and Litzenberger propose the use of the cluster-index (CI) to identify regions as industrial clusters. The CI is formed by the relative industrial density (ID), the relative industrial stock (IS), and the relative size of the establishment

(SB). For industry j and region i, it is thus proportional to the number of employed people (e_{ij}) and to the number of firms (b_{ij}), as well as to the reciprocal of the area (a_i) and of the population of the region (i_i).

$$CI_{ij} = ID_{ij} \times IS_{ij} \times \frac{1}{SB_{ij}} = \frac{\frac{e_{ij}}{\sum_{k=1}^{n} e_{kj}}}{\frac{i_i}{\sum_{k=1}^{n} i_k}} \times \frac{\frac{b_{ij}}{\sum_{k=1}^{n} b_{kj}}}{\frac{a_i}{\sum_{k=1}^{n} a_k}} \qquad \text{Eq. 2.2}$$

Its flexibility, simplicity of calculation, and the availability of the data needed constitute the advantages of the CI. It can range from zero to infinite, but it must be greater than one (the average value), at a minimum, in order to identify a cluster. In their study, Sternberg and Litzenberger have set the threshold value of the CI to 4.00, i.e., the CI had to be greater than 4.00 for the planning region to be identified as at least a potential cluster. They recognise, however, that the value is somewhat arbitrary.

With this threshold, they have identified 115 clusters in the ten chosen manufacturing sector industries, and 87 clusters in the ten services industries. The motor vehicles manufacturing is presented as a case study: 14 regions were identified as potential clusters of this industry; among these, Bremen and Stuttgart, which are both important production sites of DaimlerChrysler AG and thus host a great amount of component suppliers, achieved the highest value of the CI (52.00 and 46.50, respectively).

Keeble and Nachum (2002) elaborate on the cluster boundaries subject. It is possible that a cluster covers only part of a local government region, or that it crosses multiple regions. Cluster boundaries are nowadays pushed by commercial factors, and not by political decisions. The cluster area must be sufficiently large to gain critical mass, but also small enough to enable a community feeling. Some issues to consider are how the region is viewed by customers, the physical distance between the clusters' stakeholders (a drive of one hour may be the limit), and the type of industry of the cluster.

2.7 Evaluation of Clusters and Regions

A set of performance measurements, which can be used to evaluate clusters, compare them with equivalent clusters in other regions and identify their weaknesses, is proposed

by Rosenfeld (2002). Some of the measurements included in this benchmarking guide are presented in Table 2.4.

Factor	**Typical Performance Measurements**
R&D capacity	R&D expenditures from government and private sources that involve cluster members, products, or processes.
Workforce skills and availability	Nr of enrolments in relevant programmes. Graduates hired by cluster.
Capital availability	Value of venture capital, value of loans made in cluster. Participation of bankers in cluster activities.
Specialised services	Nr of specialised consultants in cluster. Services that employ specialists from cluster. Value of local outsourced services.
Entrepreneurial climate	Nr of new start-ups generated by cluster. Nr of firms attracted to cluster.
Innovation and imitation	Patents and copyrights. Value of investments in new technologies. New product lines started.
Presence of market leaders and innovators	Nr of headquarter operations. Value of exports of cluster products. Value of sales outside of region.
External connections	Study or benchmarking tours, travel to trade shows. Alliances that include external members.
Shared vision and leadership	Collective strategic plan or vision statement. Acceptance of cluster name or brand.

Table 2.4 – Performance measurements to evaluate clusters (Rosenfeld, 2002)

On a different approach, one could also resource to Porter's 'diamond' of determinants of competitive advantage (Porter, 1990) to evaluate a cluster or region. The four vertices of the 'diamond' are factor conditions, demand conditions, correlated and supporting industries, and firms strategy, structure and rivalry.

Porter groups the factors into several broad categories: human resources, physical resources (land, water, minerals, raw materials, etc.), knowledge resources (universities, research organisations), capital, and infrastructure. The factors can be classified along

two different criteria: basic or advanced, and general or specialised.

Demand conditions refer to the characteristics of the internal, or local, demand. Three issues, in particular, must be considered: composition, size and growth pattern, and how internal preferences are transmitted to foreign markets.

The competitive advantage of an industry in a given country or region is also dependent on the international competitiveness of correlated and supporting industries. The most important benefit in this respect seems to be the innovation and improvement process, as the joint R&D between firms and suppliers leads to faster and more efficient results.

The fourth and final pillar of Porter' theory is firms strategy, structure and rivalry, i.e., how firms are created, organised and managed, and how strong internal rivalry is. Issues such as leadership training and orientation, group versus hierarchical style, relationship with customers, coordination capacity, tendency and capacity to compete globally, and willingness to travel must be considered.

Similarly, Gray and Dunning (2000) propose an assessment model which is quite similar to Porter's diamond, except that it introduces five broad categories.

In their evaluation of several European cities with respect to the knowledge economy, van den Berg *et al.* (2005) set up a research framework consisting of what they have called foundations and core activities of a knowledge city. The former (foundations) have to do with sets of activities which are assumed to be required for a city to become and remain successful in the knowledge economy, and whether they do exist in the cities analysed, hence concentrating on the structure, whereas the latter (core activities) relate to whether organisations in functionally connected areas do actually interact, thus focusing on the process. For each core activity a foundation or set of foundations can be pointed out as being the most relevant. Seven foundations are identified by the authors.

First, the knowledge base, referring to the quality, quantity and variety of universities, HEIs and R&D activities.

Second, the economic base: cities with an economy dominated by services rather manufacturing, as well as cities with a diversified economy, typically have a more favourable starting position in the knowledge economy.

Then, the authors hold that the quality of life is a crucial factor to attracting and

retaining skilled labour. An attractively build environment, good housing, city parks, natural surroundings, cultural facilities, are examples of important issues in this respect.

Accessibility is the fourth foundation of this list. Urban regions must have good and fast access to international airports and high-speed-railways, appropriate regional transportation infrastructure, and high-quality electronic communication means.

Fifth, cities must be sufficiently diversified in order to continually pull in knowledge workers, firms and visitors.

Urban scale is referred in the sixth place, in the sense that knowledge activities are more frequently carried out in medium-large and large cities, due to the existence of more scale economies, large markets for specialised services and skills.

The final foundation is social equity. The reduction of poverty and inequality, which increases urban safety, is seen as a precondition for sustainable urban growth.

Moving on to the core activities of a knowledge city, four major topics are identified, starting with the attraction and retention of knowledge workers, both undergraduate students and graduates. Three foundations are said to be the most significant in this regard: economic base, quality of life and social equity. Several questions can be formulated in order to evaluate a city in this matter, such as: what the size of the relevant labour market is; why do students come to the city; how many they are; where do they come from; where do they work after graduating and why; whether there are any policies to attract and keep students and higher-educated people in the city; what is the proportion of skilled people in the overall labour; and what makes the city popular or unpopular with knowledge workers.

The second core activity concerns the creation of new knowledge, for which the most important foundation is the knowledge base. In this respect, it would be appropriate to ask what the cities' strong points in academic research are, how many universities, HEIs and R&D institutions exist, how good and diversified they are, what the evolution of these items over the last ten years has been, and whether there are any policies to promote certain types of research.

'Applying new knowledge and making new combinations' is listed as the third activity. At this point, it would be relevant to know e.g. how universities and R&D institutions

interact, whether local industry is involved in the preparation of education and research programmes, how many incubators and venture capital funds are contained in the region, the rate of new firm creation, whether there are MNCs in the region and how do they interact with the remaining local agents. The knowledge and economic bases lie at the ground of this core activity.

Finally, knowledge cities must be evaluated as far as the development of new growth clusters is concerned, as well. All the upper-mentioned foundations are important for this activity. The quality of life, for instance, is crucial in cluster development in order to attract and retain knowledge workers. The size and development level of the cluster are also taken into account, i.e., whether the cluster possesses critical mass, what is the quality of the actors of the cluster (e.g. international competitiveness, technological sophistication), whether there are any engines within the cluster (such as MNCs). Other questions to consider are whether there are any new growth clusters arising in the region, why did they arise in the region and what their relevant region is.

The case of Munich as the leading high-technology region in Germany has been studied by Sternberg and Tamásy (1999). Firstly, they use the share of scientists in manufacturing among all employees in manufacturing as a proxy for the technology intensity of the German regions. Secondly, the authors list the top five regions across a set of R&D intensity indicators, such as firms in technology-intensive industries, federal research funding, patent applications, and scientific and academic employment. Then, a qualitative evaluation of several determinants of the formation of nine (European, American and Japanese) high-technology regions is displayed (much like the one presented in Table 2.2). Finally, Munich is compared with three other German regions, concerning the value attributed by their research-intensive SMEs to the links with the local business environment, comprising issues like transport infrastructure, structure of clients and suppliers, consultation offer, labour and venture capital.

A set of growth clusters in European cities has been examined by van den Berg *et al.* (2001). They have used a framework of analysis built on three components: general conditions, cluster specific conditions, and organising capacity (please refer to section 2.5 for further detail on this). For each region, the study began by analysing how some key actors in the chosen sector were linked up with other firms, knowledge institutes

and governments, based on evidence such as formal cooperative structures, and joint facilities or projects. In addition, they conducted interviews with key individuals in the clusters, which turned out to be an indispensable and valuable source of information, especially in terms of identifying other linkages within the cluster.

Keeble *et al.* (1999) analyse the region of Cambridge, UK, based on the results of a 1996 interview survey conducted by the ESRC Centre for Business Research. Several very appropriate groups of questions are used in order to target issues such as the formation of new firms in the region, local inter-firm networking, the advantages of the Cambridge region for firm development, the sources of recruitment of managers and researchers, the importance and comprehensiveness of innovation networks, and 'institutional thickness'. Some examples follow:

- 'Was your firm set up by another firm, as a spin-off from an existing firm/institution or as a new independent start-up?'
- 'How important are local links with: suppliers or subcontractors / firms providing services / customers / research collaborators / firms in your line of business?'
- 'Have you received help or advice from any local agencies (government-sponsored or otherwise) over the last five years?'
- 'In which of the following areas [accountancy, banking, venture capital, legal services, management consultants, etc.] have you used external firms or services during the last five years? For those ticked, to what extent have you used firms from the Cambridge region as opposed to firms located elsewhere? […]'

2.8 Regional Policy and Cluster Development Initiatives

OECD (2000b) distinguishes three levels of government involvement when it comes to cluster development initiatives: local and regional governments, national governments, and supranational governmental institutions.

The first level has steered the majority of the initiatives that took place in large developed countries, in recent years. Governments at this level are usually better informed regarding local conditions and specificities, thus being able to react more

promptly to local circumstances than national governments.

The second level, national governments, tends to play a leading role in cluster initiatives in smaller developed countries, as well as in many developing nations. This is particularly true in countries where the capacity for local and regional authorities to interact with private entities is missing, or where decisions are normally taken centrally.

Supranational governmental institutions can support cross-border cluster initiatives, which are a rather recent type of programs. Some efforts carried out by the European Union represent the clearest examples of this type of initiatives.

Ideally, cluster development initiatives should be driven by a level of government that corresponds to its geographic ambit. Otherwise, governments might be incapable of properly focusing on the needs of the clusters, when their geographic scope is larger than the clusters', or they may lack the integrated view that the cluster demands, in the converse situation. In addition, the government at that level must be empowered over relevant programmes and expenditures, in order to maximise the return on the cluster initiative investments. When either no such government exists or it is too weak, locally based agents of a higher-level government may be necessary.

This report also provides a comprehensive set of policy guidelines on clusters and networks. Starting by the latter, the advices are to broadly spread out the networking concept to firms, with networks preferably targeting well-defined, market-driven goals, to provide some (rather modest, gradually decreasing) financial support for start-up activities and network brokerage, to account for (at least) 3-4 years of commitment, which are necessary for a substantive network initiative, and to establish network broker teams in order to enforce effectiveness and motivation.

With respect to policy toward clusters, the list is far more extensive.

Once again, the fact that cluster development initiatives should be handled by a level of government matching the geographic scope of the cluster is herein mentioned. Nevertheless, the leading role in those initiatives should preferably be assigned to the private sector, whereas the public sector should only play a catalytic role, by easing partnerships between the various types of actors of the cluster.

An initial focus on low risk and short-term activities is advisable, in order to generate

small but evident and motivating benefits right from the start, with higher risk, longer-term enterprises being increasingly introduced at later stages. Moreover, there should be a continuous assessment of each activity's progress, in order to identify necessary corrections, or even terminate it, in case of unsatisfactory results.

The activities should target a set of priority clusters and address real market failures, such as under-provision of public goods or co-ordination failures. This group of priority clusters should include existing or emerging clusters, for which a number of specific guidelines is applicable: facilitate the accommodation of new and small firms, by reducing the risk for investments in industrial real estate; encourage cooperation, by means of e.g. suppliers associations and mutual credit guarantee associations; permit specialisation and local adaptation in university-industry linkages; assure the provision of specialised infrastructure, communications and transport.

Different approaches can be used to select the priority clusters. A particular example mentioned in the report consisted of the identification of 24 target industries (4 digit SIC level) based on a set of criteria which included items such as industry growth rate, multiplier effect, job creation and income potential, availability of local resources, environmental concerns, and synergy with local actors. Less detailed targets have been defined in other cases, either by specifying broader sectors, or by disregarding the adequateness of the selected clusters to the local environment or economy.

Inward investment may also represent a relevant stimulus to a cluster, especially if focused on its weakest points (e.g. failures in the chain of local suppliers), and can be sought by all levels of government by spreading out information about the cluster and the advantages of its localisation.

The statistical data usually collected country-wide should be complemented by local or regional information about the geographic agglomeration of related groups of companies, for data organised according to industry classification standards tend to neglect linkages between firms in different (but related) industries.

An eight-step approach to the cluster development process is proposed by Cluster Navigators (2001). They begin by emphasising that this is a dynamic, organic process, which must be led from the inside of the cluster, rather than a strategic plan brought up by external consultants and with little involvement from the actors of the cluster.

The first step, which consists of identifying (both developing and more developed) local clusters and setting the priorities of those to focus on at the start, has already been described in more detail in section 2.6.

The second step is to carry out an initial review of the priority clusters selected in the previous phase, aiming at identifying each cluster's size, type and position in the local economy. A set of interviews with the core stakeholders of the cluster should be carried out, in order to better detail its opportunities, constraints and degree of networking, to evaluate possible leaders, and to present them (especially the sceptics) the clustering process. Due to its importance and to the knowledge and contacts it provides, this key step should be led directly by a development agency and not just delegated in some external entity.

The process moves on by establishing the leadership group. There must be a facilitator playing a leading role in this task, who is responsible for identifying a group of (usually 6 to 8) senior stakeholders, in such a way that the cluster is broadly represented, and for getting their attention and involvement in the initiative.

The fourth step is about building on the current position of the cluster to agree on a broad, high-level vision for its future, such as "To double the cluster's scale of activity within five years".

Having defined the vision for the cluster, the stakeholders must work on the broad steps to reach it. An appropriate way of doing this is by means of a workshop process, in which each stakeholder with a particular interest in any of the specified issues can come forward for the following phase.

These stepping stones must then be translated into an agenda of immediate, short-term activities, which requires defining the content of each action, the expected results, resources needed, and the stakeholder with skills, knowledge and passion to drive it.

The seventh thing to do is to institutionalise the cluster initiative, usually by creating a new, dedicated organisation, covering a more limited geographic area, but a wider range of sectors, than existing professional and trade organisations.

Finally, the strategic agenda of the programme can be upgraded, as soon as the leadership group is solidified, and some benefits have become visible to the participants

of the cluster. Longer-term, higher risk actions can now be performed, such as comparative studies with international clusters, identification of capacity gaps, development of an identity and brand for the cluster, and broadening of the number of people involved in the activities.

Porter (1998), on the other hand, emphasises the role of national and regional governments at the microeconomic level, which actually defines productivity and competitiveness, despite of the importance of having a solid macroeconomic policy. Some examples of the kind of factors that governments must provide are a highly-qualified workforce, good physical infrastructure and clear rules of competition. Plus, they must push the creation and upgrade of clusters. Cluster policy aims at nurturing the development of all clusters, with no political selection whatsoever of which ones are more desirable, as opposed to industrial policy, which tends to favour and support certain industries with subsidies and protectionism. An important note is that cluster development initiatives must strive for competitive advantage, specialisation and sources of differentiation, rather than simply copying the example of other successful clusters.

A review of best practices in cluster development initiatives is presented by Stewart and Luger (2003). They list five overall “must haves” in any attempt to develop a successful cluster, which are to recruit highly committed leadership, plan and ensure the necessary resources for the whole process, select the appropriate geographical boundaries of the cluster, find ways to sustain the positive dynamics between phases, and involve all relevant actors from the earliest stages.

As soon as the overall strategy is defined and the relevant regional stakeholders are committed to it, its successful implementation will depend on four main factors. Firstly, it is necessary to organise service delivery to the cluster’s firms. Cross-agency teams and one-stop shops are some of the best practices in this domain. Secondly, investments must be targeted to the clusters, for instance in R&D and innovation, technology, infrastructure and marketing of the cluster. The support and promotion of technology transfer and entrepreneurship are also included in the investments topic. In the third place comes the networking element, which can be encouraged by means of e.g. the establishment of cluster organisations and the facilitation of external linkages. Fourthly,

workforce development strategies must be in place in order to ensure that the cluster's members have access to adequately skilled human resources. This can be done, for example, by establishing cluster skills centres.

As a final note, two general, frequently mentioned ideas seem to come up from the literature herein reviewed. First, the fact that the role of governments is not as important as frequently thought. Governments can influence and provide support to cluster development initiatives, but ultimately it is the market and the members of the clusters that determine their success. Second, the basic principle that policies should not attempt to create entirely new clusters, instead of fostering existing or emerging ones.

2.9 Established Clusters

The final topic of the review of literature chapter consists of a brief analysis of five established technological clusters with relatively different characteristics. For each, this section tries to provide answers for several relevant questions, such as how and when the cluster had arisen, what factors, actors or events had contributed to its appearance, how had it evolved throughout time, and what are its main industries. However, not all issues could be covered for every cluster.

The case study regions are Cambridge (UK), Munich (Germany), Helsinki (Finland), Bangalore (India) and Ireland.

2.9.1 Cambridge

The Cambridge region ranked first in the growth of UK's high-technology industry employment in the 1980s, with an increase of 300 technology-based firms (75%) between 1984 and 1995, despite the recession of the early 1990s. Since the 1970s the region has arisen as an important location of small technology-based companies, some of them having attained remarkably rapid expansion, especially in the sectors of telecommunications, computer services and R&D services (Keeble *et al.*, 1998). Other relevant industrial sectors of the region are chemical, and electrical, electronic and instrument engineering (Athreye, 2004).

Keeble *et al.* (1999) refer the core role played by the University of Cambridge, widely acknowledged for its research and scientific activity, and the importance of collective learning processes and networking, as well as 'institutional thickness', in the

development of the Cambridge cluster. Based on a 1996 interview survey involving 50 technology intensive SMEs, they show that, during the 1990s, active entrepreneurship and spin-off processes took place in the region, which implied the diffusion within the cluster of tacit technological and managerial knowledge, inter-firm networking, and skilled labour hiring from the local pool. Moreover, they also express the high relevance of global and national innovation networks, research collaboration and market processes, that add to the region indispensable knowledge from the outside, and conclude that the institutional framework of the Cambridge region seems to be thickening over the years, due to new collective initiatives, venture capital and active intervention by development and innovation agencies. At last, the authors find that the three most important factors for firm development are the attractiveness of living environment, the credibility of a Cambridge address, and the availability of research staff.

A qualitative evaluation of the determinants of the initial formation and subsequent growth of the Cambridgeshire high-tech region is also presented by Sternberg (1996). As shown in Table 2.2, the two most important factors that triggered the formation of the cluster were the research and education infrastructure (and related availability of skilled labour), and the amenities of the region. Sternberg thus corroborates Keeble *et al.* (1999) as far as the importance of the University of Cambridge and of the region's quality of life is concerned. With respect to the existence of innovation centres and Science Parks factor, even though it is mentioned as also being an important determinant of the genesis of the high-tech region, its main role has been played in the later growth of the cluster, standing as one of the two most important factors in this regard, again along with the research and education infrastructure. Other important determinants of the growth of the Cambridge cluster have been public R&D expenditure (with implicit regional impact), amenities, the presence of LSEs and their relationship with small technology-oriented start-ups, and decentralisation processes in large agglomerations.

Bresnahan *et al.* (2001) and Athreye (2004), on the other hand, consider the case of the Cambridge cluster only as a 'partial' success story, as the growth rates of the cluster have been relatively low, when compared to other case studies in emerging countries and to Silicon Valley. Two possible explanations for this are mentioned. Firstly, the fact

that the products of the Cambridge cluster are rather similar to those of Silicon Valley, the latter having benefited from its leader advantage. On the contrary, the emerging countries' clusters embraced complementary products and services, thus avoiding direct competition with Silicon Valley. Secondly, Cambridge suffered from insufficient market access, due to a small domestic market and to the lack of mechanisms for the establishment of strong connections to major markets (e.g. returning emigrants).

2.9.2 Munich

Sternberg and Tamásy (1999) define two groups of determinants of the formation of the Munich high-tech region. On the one hand, those related to the regional economy as a whole, such as the 1948 move of the Siemens headquarters from Berlin to Munich and the well-disposed industrial environment. On the other hand, the determinants that have to do with the region's favourable characteristics to the core industry of microelectronics: the importance of Siemens, as a buyer and supplier of the region's microelectronic firms; the high potential demand of the region for the products of the industry, due to the high concentration of federal, state and local authorities, and insurance and banking firms; the availability of skilled labour, which results from Munich's universities and HEIs (approximately 90000 students and 10000 academic and artistic employees), as well as from the attractiveness of the region to skilled workers and scientists. Nonetheless, the same authors also state that these factors are not as important as the technology policies of the federal and state government, Munich being the planning region with the highest concentration of state-funded research institutions. Similarly, Sternberg (1996) makes a reference to this latter topic (see Table 2.2), by considering 'federal R&D expenditure (with implicit regional impact)' as one of the two most important determinants of the genesis of this high-tech region (along with the 'availability of large enterprises and their attitude toward small and young technology-oriented firms' factor).

Back to Sternberg and Tamásy (1999), it is worth mentioning some interesting indicators they present about Munich. First of all, the percentage of scientists in manufacturing among all employees in manufacturing, Munich standing out as one of the two single regions above 7.9%. Secondly, Munich taking the first place, among all German regions, in six out of nine R&D indicators. Thirdly, when compared with

Western Germany, the region exhibits a strong specialisation in a broad basis, based on its higher sectorial employment shares.

Van den Berg *et al.* (2005) thoroughly examine the performance of Munich in the knowledge economy, using the research framework already described in section 2.7, which consisted of seven knowledge foundations and four core activities, in which the region is scored from one to five. Starting with the knowledge foundations:

- 'Knowledge Base' (score: 5). Munich's very strong position in this foundation is mainly imputable to two factors: the high educational level of the population (18.5% of Munich's employees holding a university or applied sciences degree) and the large number of (reputed) knowledge institutions of the region (two large universities, one polytechnic, several academies, numerous public and semi-public research institutes, totalising over 80000 higher education students, and over 50000 researchers, approximately 60% in private companies).
- 'Economic Base' (score: 5). The region of Munich is presently characterised by a highly diversified and knowledge intensive economic base, with a very modern industry and hosting numerous key LSEs (e.g. Siemens and BMW). Sectors with strong growth potential, such as ICT, biotechnology and life sciences, represent a considerable share of the regional economy.
- 'Quality of Life' (score: 5). The city of Munich and its surroundings offer countless cultural and leisure activities, thereby attracting many highly-skilled workers.
- 'Accessibility' (score: 5). A relatively new airport (second largest in Germany), the connection to the high-speed railway system, and an efficient public transport system give Munich a high score in this point, as well.
- 'Urban Diversity' (score: 3). Culturally, Munich does not stand as a particularly diverse city. Still, 23% of Munich's population holds a non-German citizenship.
- 'Urban Scale' (score: 4). With a population of almost 2.5 million (approximately 1.2 million in the city) and a large economic base, the region of Munich has sufficient scale to support economic specialisations, and all the amenities and infrastructures needed for its development.

- 'Social Equity' (score: 5). The unemployment rate is low (5.0% in 2002) when compared to other German cities. Some social difficulties and poverty do exist, but with no clear spatial concentration.

The region is then evaluated along the four knowledge core activities:

- 'Attracting and Retaining Knowledge Workers' (score: 4). Munich provides a high quality of life and a wide range of high-skills-demanding jobs, thus standing as an attractive city for knowledge workers. Munich's HEIs host over 80000 students, but there are severe problems when it comes to housing them, which in turn restrain the attraction potential of the region. The universities of the city lack international orientation, for the number of foreign students is still too low, as well as the number of multinational research projects in which they participate.
- 'Creating Knowledge' (score: 5). Both the region's knowledge institutes and its companies create very large amounts of new knowledge, when measured by the level of patent registrations: 3000 patents in the year 2000, of which around three quarters were registered by companies.
- 'Applying Knowledge / Making New Combinations' (score: 5). A remarkable range of policies aimed at promoting entrepreneurship, commercialising knowledge and creating networks of innovation is carried out by both the Bavaria state government and the city of Munich.
- 'Developing New Growth Clusters' (score: 5). Bavaria's state government carries out heavy investments directed at developing new growth clusters, with a special focus on the ICT, media and biotechnology spearhead clusters.

2.9.3 Helsinki

Headed by Nokia, a global leader in the mobile communications industry, Helsinki hosts one of the major agglomerations of telecommunication and other related activities, especially ICT, in Europe. For instance, the number of ICT industries' employees in Helsinki rose from 40000 to 70000 in the 1993-2001 period (van den Berg *et al.*, 2001; van den Berg *et al.*, 2005).

The decisive turn towards the knowledge economy in Finland and, in particular, the formation of the telecom / ICT Helsinki cluster seems to have occurred in the early

1990s, with the collapse of the country's most relevant trade partner at that time, the Soviet Union, and the economic crisis that followed (van den Berg *et al.*, 2005).

Van den Berg *et al.* (2001) describe Finland as a very advanced country regarding the production and utilisation of telecom services, taking into account its very high penetration rates of new communication devices, low prices, and successful telecom industry. This can be related, they say, to Finland's relatively early liberalisation of the telecom market: the monopoly in the sector ended in the early 1980s, and long-distance connections competition was introduced in 1985. Moreover, the telecom equipment producers soon had strong incentives to innovate, pushed by their highly demanding clients, the telephone operators.

In the Helsinki region, there are two main locations where agglomeration of activities exists. First, Arabianranta / Art and Design City, which provides mixed functions of living, working, studying and recreation, and whose goal is to become one of the major European art and design sites. Secondly, the Otaniemi Technology Park, in Espoo, where the Helsinki University of Technology and a number of research institutes are located, along with approximately 200 firms (in the year 2001).

Van den Berg *et al.* (2005) also assess the knowledge foundations and core activities of Helsinki. Regarding the former, a brief summary of their analysis follows:

- 'Knowledge Base' (score: 5). The region accounts for over 50% of the country's R&D spending, with a great involvement of private firms in this respect. The educational level is high, as 40% of the population in the 25-64-year-old range has at least 13 years of education. Education is cheap, thereby enabling more people to study at a HEI. Approximately one half of Finland's academics reside in Helsinki. Furthermore, the region has eight of the 20 universities of the country, which correspond to around 60000 students, plus over 16000 students in polytechnic schools.
- 'Economic Base' (score: 4). 80% of the active population in the Helsinki region work in the service sector. Nokia has a very relevant role in the national and regional economy, having been the main responsible for the growth of the ICT sector in Finland, and carrying out a number of activities with universities. As a negative point, Helsinki may have become too dependent on the telecom / ICT

cluster and hence possibly vulnerable to these industries' crises.

- 'Quality of Life' (score: 4). The United Nations quality of life survey places Finland in the sixth position. This fact confirms Helsinki's very high quality of life, which derives straight from the metropolitan amenities it provides, while having the countryside also nearby. These advantages are partly counterbalanced by the climate factor, though. In general, the population is satisfied or very satisfied with e.g. public transport, safety, schools and health services.
- 'Accessibility' (score: 4). In spite of its location in the periphery of Europe, Helsinki's air accessibility is quite good, with a well connected international airport. Regional accessibility in also relatively good, but some transport connections can be improved, such as those linking the main campuses of universities / polytechnics and 'knowledge districts' of the region.
- 'Urban Diversity' (score: 3). The Helsinki region lacks economic diversity, by depending too much on the telecom cluster and on Nokia. Cultural diversity, however, is increasing, with special attention being given to establishments such as the Arabianranta cultural cluster and the University of Art and Design.
- 'Urban Scale' (score: 3). With a population of 1.2 million, the Helsinki region lacks scale when compared with many other European regions.
- 'Social Equity' (score: 4). Until the severe economic recession that struck Helsinki in the early 1990s, there were minor divisions in socioeconomic level among its population, and a welfare model that allowed for good income redistribution was in place. Then, massive unemployment began to cause new social problems. In addition, there has been a great growth of immigration. These social problems seem to have been decreasing in the last few years, though, and by 2002 unemployment had already fallen to 6.2%.

The region is then evaluated along the four knowledge core activities:

- 'Attracting and Retaining Knowledge Workers' (score: 4). The Helsinki region acts as a strong magnet for Finnish knowledge workers, the main reasons for moving in being the human resources, the high quality of local education, the broad knowledge and economic base, the presence of HEIs (such as Helsinki

University of Technology) and of Nokia, the sufficiently attractive climate, and the diversity of cultural amenities. Science and engineering workers appear to have high status and good career perspectives. As a downside, the supply of accommodation is deficient and the region still lacks an international location climate (some important steps are being executed in this respect).

- 'Creating Knowledge' (score: 5). The authors present interesting national statistical data from OECD. First, the investment in knowledge (including R&D, software and higher education) as a percentage of GDP, in the year 2000, in which Finland ranks third with 6.2%. Second, the yearly number of European patent applications per million inhabitants, Finland having grown from 83.1 in 1991, to 264.6 in 1999, thus ranking second behind Switzerland. Being the most important knowledge economy region of Finland, these figures are likely to be even higher in Helsinki. In addition, several institutions play an important role in the knowledge productions of the region, such as the University of Helsinki, the Helsinki University of Technology and the Helsinki Polytechnic Stadia.
- 'Applying Knowledge / Making New Combinations' (score: 5). A number of national organisations exist, that promote the conversion of knowledge into business: the Science and Technology Policy Council (STPC) stimulates cooperation between HEIs, and knowledge-intensive firms and public organisations; Tekes, Sitra and the Academy of Finland provide important R&D funding and push partnerships between relevant actors. The Helsinki Club is formed by a set of major regional players and its purpose is to foster technology development, innovation and cooperation. Regarding support and advice to SMEs, there are specific centres offering a wide range of advisory and development services. It is considered that the entrepreneurship of the region could be better: there is a small number of start-ups, partly due to the Finnish attitude towards bankruptcy which still has a negative connotation.
- 'Developing New Growth Clusters' (score: 4). The Culminatum organisation aims to develop Helsinki as a world-class innovation centre. Its strategy is to execute regional cluster programmes, as part of the Centres of Expertise programme, to establish Science Parks, and to enhance the knowledge potential

and regional innovation milieu. The Centres of Expertise programme is a national initiative with the goal of developing new growth clusters. In Helsinki, firms can make use of Culminatum's services through six Centres of Expertise: active materials and microsystems; gene technology and molecular biology; medical and welfare technologies; logistics; software; digital media, content production and learning service.

2.9.4 Bangalore

Bangalore, in India, is nowadays a renowned international cluster of the software industry, in which many MNCs have set up their local subsidiaries. Approximately 25% of the Indian software industry, which took off during the second part of the 1980s, is located in Bangalore. Balasubramanyam and Balasubramanyam (2000) point out several factors that have contributed to its formation and evolution over the years.

Firslyt, the existence and excellence of HEIs – the Indian Institute of Science, leader researcher in engineering and physical sciences, and the Bangalore University, hosting fourteen engineering colleges which train software and computer engineers – and research institutes located in the city, and consequent availability of high-technology skilled labour.

Government support is also cited as a major determinant of the growth of the cluster, through the establishment of the Software Technology Park, provision of duty-free imports of hardware, elimination of income taxes, installation of satellite equipment, and exemption from export red tape processes.

Thirdly, Bangalore offers a healthy climate, excellent schools, recreation facilities and other amenities, which usually pull in high-technology workers and firms.

Fourthly, the so-called 'Marshallian' externalities played an extremely relevant role in the formation of the cluster, boosted by the nature of the software industry and by the socioeconomic and historical characteristics of Bangalore.

Fifthly, globalisation brought in increases of cross-border workforce movements, asset-augmenting FDI, and knowledge-based production of goods and services.

Finally, a huge contribution to the formation of the software industry in India, in general, and especially of the Bangalore cluster, is related to the return to the homeland

of a great number of engineers who had emigrated (mainly) to the USA during the brain drain of the 1960s and the 1970s, and had become highly skilled professionals, thus triggering the establishment of commercial linkages in the software industry between India and USA.

Some further insight concerning the Indian software industry is provided by Arora *et al.* (2004). This study encompasses the country, as a whole, noting that "the Indian software industry is not concentrated exclusively in Bangalore, although Bangalore is certainly a very prominent location". Nevertheless, it is likely to represent a fairly close picture of the Bangalore cluster.

Three types of business models are identified: technology-driven, product-oriented firms; service-oriented firms; MNCs. The first model basically covers firms offering service-intensive products (i.e., niche products requiring services such as installation, training and maintenance), rather than mass-market products associated to large marketing and sales effort. Service-oriented firms typically provide customised development services, turnkey projects, and professional services (e.g. support, installation and maintenance). MNCs have started by entering the country to access the Indian market, but later moved on to use India as an export platform. As referred in the beginning of the chapter, some US MNCs have established software development centres in the country, running rather advanced development activities.

The determinants of India's software industry success are discussed much along the same lines as Bresnahan *et al.* (2001), by separating its initial formation and later growth phases. The genesis stage is clearly linked to the country's large ICT-skilled workforce in conjunction with the growing international demand for such skills. The excess of labour supply also caused Indian labour costs to be considerably lower than, for instance, in the US. Later on, some types of agglomeration economies have positively influenced the development of the industry, particularly the 'imitation effects': the early success of a few leading companies has provided potential entrepreneurs with role models, increased self-confidence, access to capital, and lower social stigma with respect to failure. Finally, the authors also refer the return to the country of former US-emigrants as a major source of skills and valuable links with the US market, as well as the favourable government policies.

2.9.5 Ireland

Ireland, and more specifically the capital region of Dublin, is also a case of rapid growth in the software industry. The analysis of Arora *et al.* (2004) to the Irish example is, with some relatively minor differences, similar to the one drawn for India (section 2.9.4). Therefore, a quicker analysis is herein carried out.

In 2000, software revenues in Ireland added up to more than $9.3 billion, which can be compared to India's $8.3 billion in the same year. During the 1990s, software industry employment has grown at a rate of 19%, against the overall employment growth rate of 6.3%. Contrary to the Indian case, Ireland's software exports' main destination is the European Union, accounting for 68.6% of total exports, in 1997.

The product-oriented business model in Ireland has arisen earlier than in India, with the result of Irish firms of this type existing in a greater number, size and importance. As for service-oriented companies, the most frequent activities are customised development services, turnkey projects, and professional services. Additionally, internet services, multimedia services (e.g. outsourced video and computer-based training), and localisation services (such as translated text) are also usual among Irish service-oriented firms. The number of MNCs in Ireland is also considerably greater than in India, and these companies account for the majority of the software exports of the country.

Once again, the initial formation of the Irish software cluster is attributed to the prompt availability of a large pool of ICT-skilled people, by the time that the international market called for it. In fact, well before this, in the 1960s / early 1970s, Ireland doubled its share in GNP for education, up to 6.3% in 1973-4. In 1998, the percentage of computing-related graduates was substantially high: 10.3%, against 4.8% in the US and 12% in Germany.

With respect to the subsequent growth of the software industry in Ireland, the authors carried out a survey, involving 41 firms which were asked to evaluate the importance of a number of factors in locating in Ireland. The access to skills, and to commercial and physical infrastructures have been considered as Ireland's most important advantages by both domestic and foreign-owned businesses. On the other hand, customers, competitors and partners seem to be rather unimportant. Hence, there is scarce evidence of vertical or horizontal spillovers, or small firms networking.

Foreign links and high-skills brought in by former emigrants have also played a very important role in the case of Ireland. During the 1990s, more than 53% of the immigrants that entered the country were Irish returning emigrants.

The impact of MNCs in the development of the software industry of Ireland has been twofold, not only by generating human capital spillovers, but also as a source of revenues (and reputation) for domestic Irish companies, many of which have started as subcontractors for the local subsidiaries of MNCs.

Chapter 3

The Grande Porto Region

The previous chapter has provided an insight into the theory behind many relevant topics regarding the firm clustering and agglomeration subject, from the definition and classification of clusters, to the evaluation of regions, and it demonstrated several methods which can be used to identify clusters, as well as how the apparently opposite globalisation and regionalisation trends are actually two sides of the same coin. Some examples of established clusters have also been presented, with particular emphasis on the factors that have played a decisive role in their formation.

Chapter 3 is now dedicated to applying some of that knowledge to a specific case study: the Grande Porto area, in the northern region of Portugal. Section 3.1 begins by presenting the targeted region and its social and economic key indicators. Section 3.2 analyses the existing economic base, in Grande Porto, in the three policy-supported clusters: ICT, Electronics, and Electrical Machines and Material; Health, Medical Devices and Pharmaceutics; Biotechnology and Agri-Food (CCDR-N, 2007). An attempt to identify other existing clusters in the region is performed in section 3.3, while section 3.4 evaluates the region's readiness for the knowledge economy, making use of the assessment framework defined by van den Berg *et al.* (2005). Finally, section 3.5 brings together a few final ideas expressed by relevant regional actors during a set of interviews carried out during this work.

3.1 Characterisation

Grande Porto is a NUTS III region, having the Norte region as NUTS II and continental Portugal as NUTS I (Figure 3.1). The name of the region is the Portuguese equivalent for "Greater Porto", as it is formed by Porto (Portugal's second most important city, following the capital, Lisboa), along with its suburban ring of eight other municipalities: Espinho, Gondomar, Maia, Matosinhos, Póvoa de Varzim, Valongo, Vila do Conde and Vila Nova de Gaia. Altogether, the region occupies an area of nearly 815 km^2.

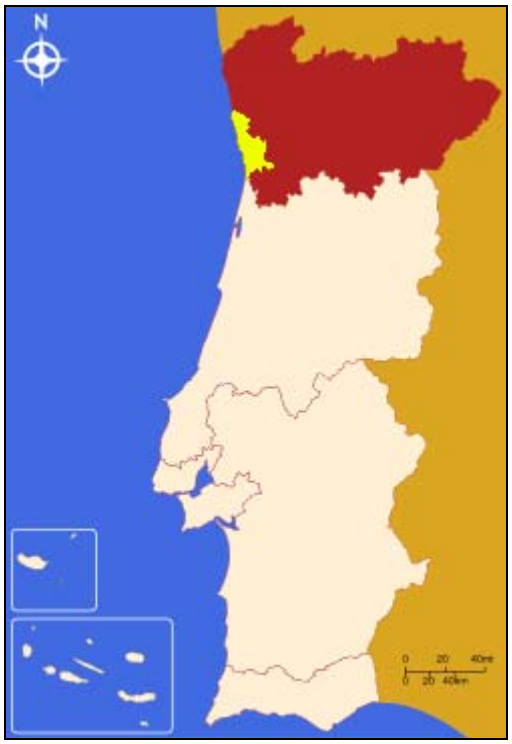


Figure 3.1 – Map representation of Norte (in dark red) and Grande Porto (in yellow) (source: wikipedia.org and post-processing)

As a general rule (some justified exceptions do exist), the statistical data of Grande Porto is here compared with three other regions: Portugal as a whole (i.e., the country overall), the Norte NUTS II region (in which Grande Porto is included), and the Grande Lisboa NUTS III region (the counterpart of Grande Porto for the Lisboa area, included in the Lisboa NUTS II region).

This is, in fact, the case of Figure 3.2, which presents the estimated values for the population and population density of these four distinct regions, for the year of 2005. Grande Porto accounts for approximately 1.3 million inhabitants, within 3.7 million of the whole Norte NUTS II, and 10.6 country-wide. In terms of population density, it ranks first among all Portuguese NUTS III regions, with nearly 1600 inhabitants/km^2.

Figure 3.3, on the other hand, shows a scatter chart representation of the area and population of all 28 NUTS III regions in continental Portugal. Grande Porto and Grande Lisboa clearly depart from the remaining regions by having relatively small areas (Grande Porto is, in fact, the smallest region in terms of area), along with a quite large population (ranking second and first, respectively).

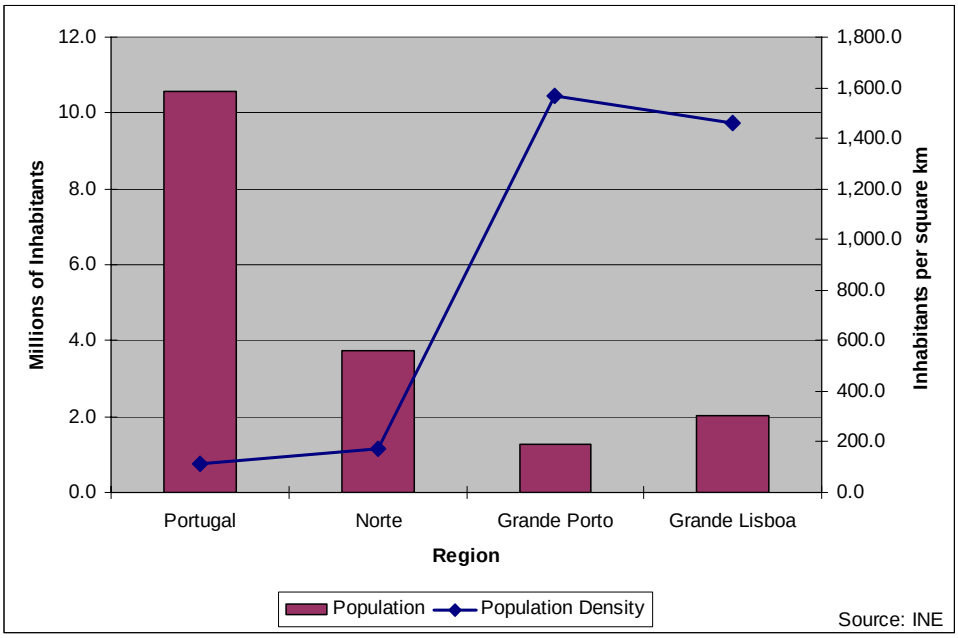


Figure 3.2 – Estimated population and population density per region, 2005

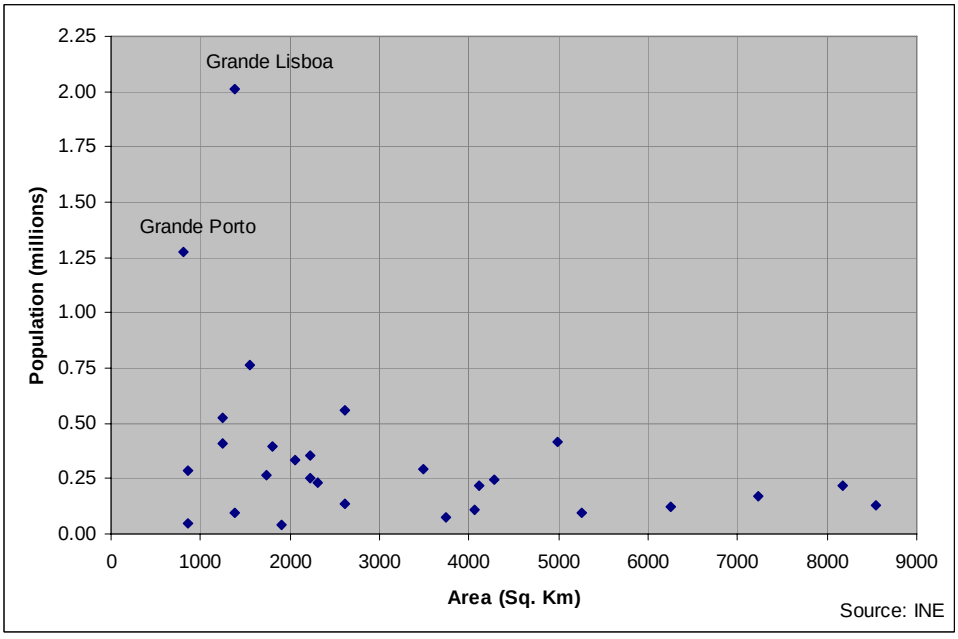


Figure 3.3 – Area and estimated population per NUTS III region, 2005

Looking at the evolution of the population of Grande Porto between the two last official censuses in 1991 and 2001 (Figure 3.4), it can be seen that the overall value has grown by 8.0%. Some ageing of the region is also noticeable, however, with a strong growth in the number of people in the older age ranges, and a reduction in the younger ones.

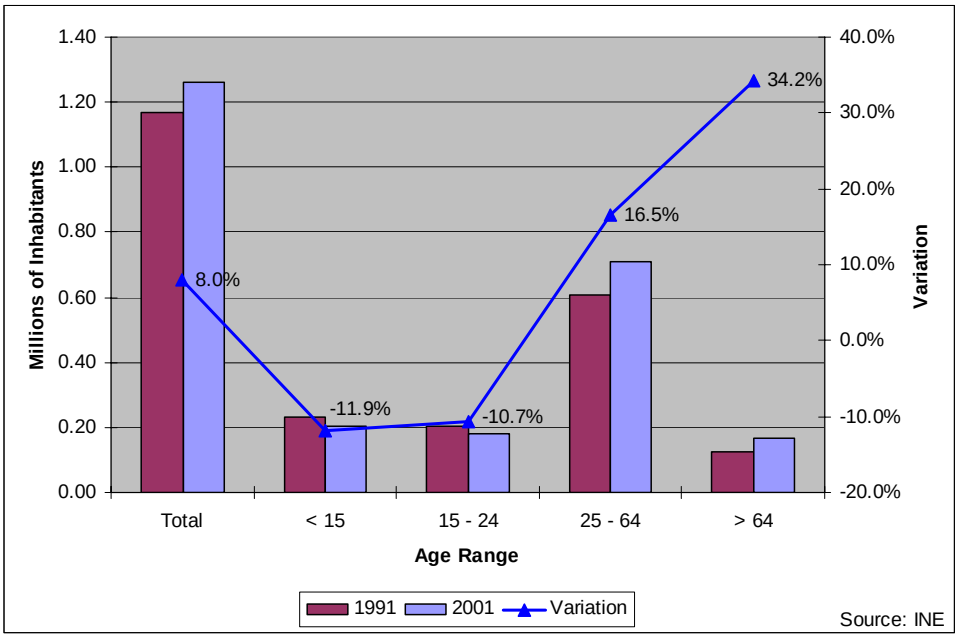


Figure 3.4 – Evolution of population of Grande Porto between the 1991 and 2001 censuses

Concerning the educational level of the population (Figure 3.5), all four regions exhibit their largest share in the basic, first cycle level (equivalent to primary school). Actually, around half the population of Portugal and Norte is either in this level, or has no education at all. Conversely, approximately 13% of the people living in Grande Porto have a university degree, against 18% in Grande Lisboa. The total number in the upper three educational levels – secondary, polytechnic and university – represents around 31% in Grande Porto and 41% in Grande Lisboa.

A complementary perspective on the lower end of the educational level of the population can be provided by the illiteracy rate. Figure 3.6 depicts a considerably positive evolution between 1991 and 2001, especially for Portugal and Norte, which show a reduction of 2.0% and 1.6%, respectively. In 2001, both Grande Porto and Grande Lisboa had an illiteracy rate of 5.3%. Overall, these values are still rather high when compared to the current trends of the developed countries.

The Norte region is responsible for more than a quarter (27.8%) of the country's GDP (136259 millions of euros, in 2004), only outperformed by Lisboa (Figure 3.7). Within these, 43% are generated in Grande Porto, by far Norte's most contributive NUTS III (Figure 3.8).

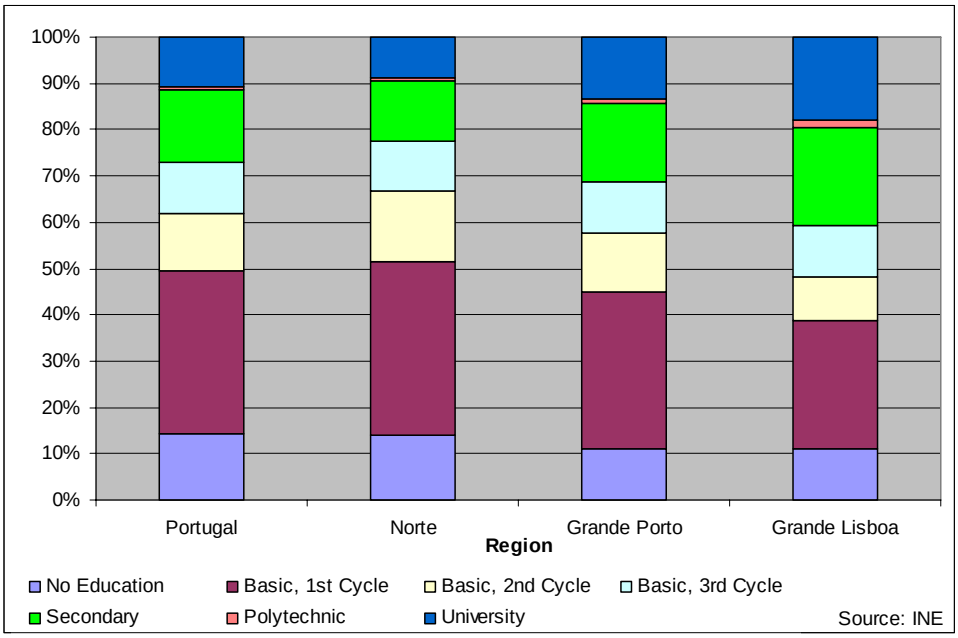


Figure 3.5 – Resident population per educational level per region, 2001

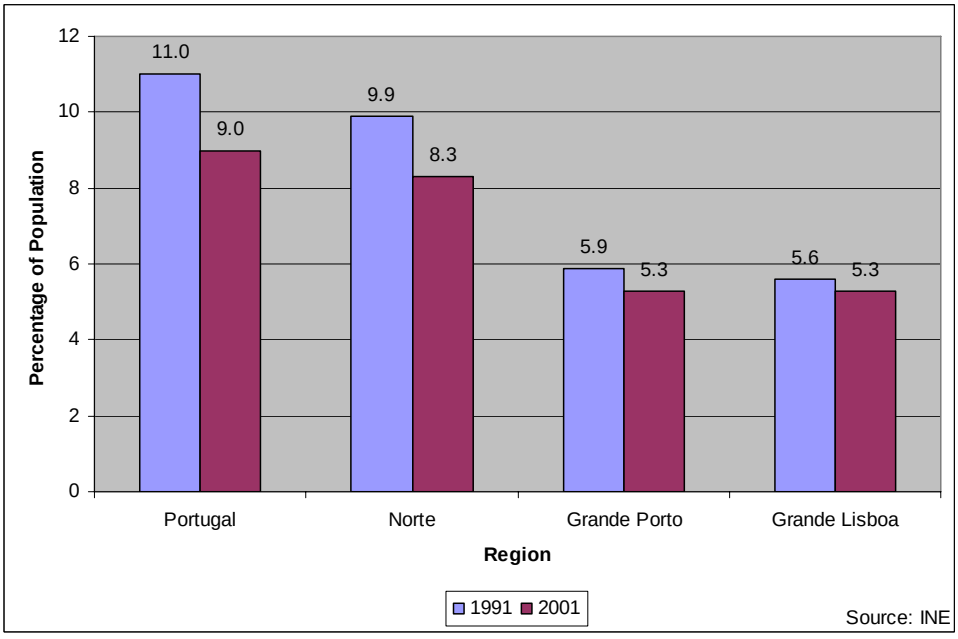


Figure 3.6 – Illiteracy rate per region, 1991 and 2001

When compared with the EU average, the development of the regional GDP of Grande Porto during the first half of the current decade has been rather negative. As shown in Figure 3.9, Purchasing Power Parities per inhabitant has diverged from around 90% of EU's average, by 2000, to less than 75%, in 2004 (100% representing the average across all 27 countries of the EU). This trend is similar to that experienced in the

comparison regions, Portugal, Norte and Grande Lisboa, but clearly in a more pronounced manner. It should also be noted how the latter of these, Grande Lisboa, exhibits purchasing power parities values well above 100%, contrary to the three remaining regions.

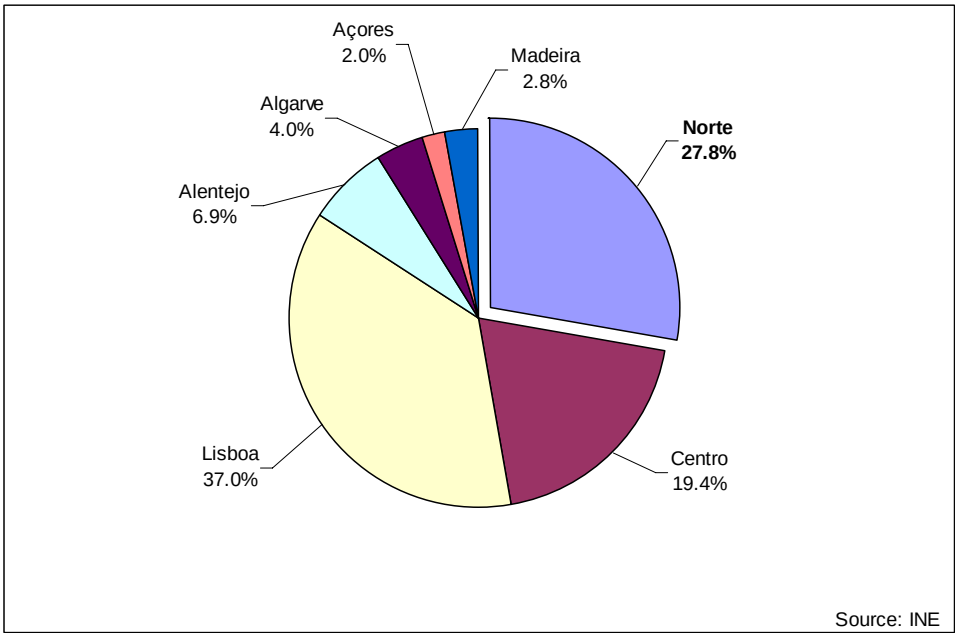


Figure 3.7 – Distribution of Portugal's GDP across its NUTS II regions, 2004

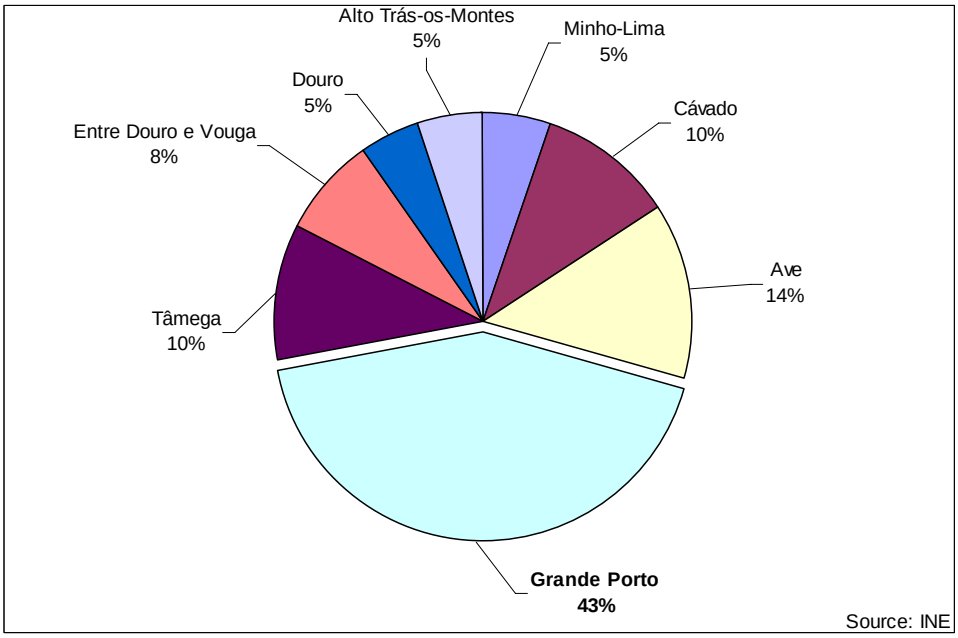


Figure 3.8 – Distribution of Norte's GDP across its NUTS III regions, 2004

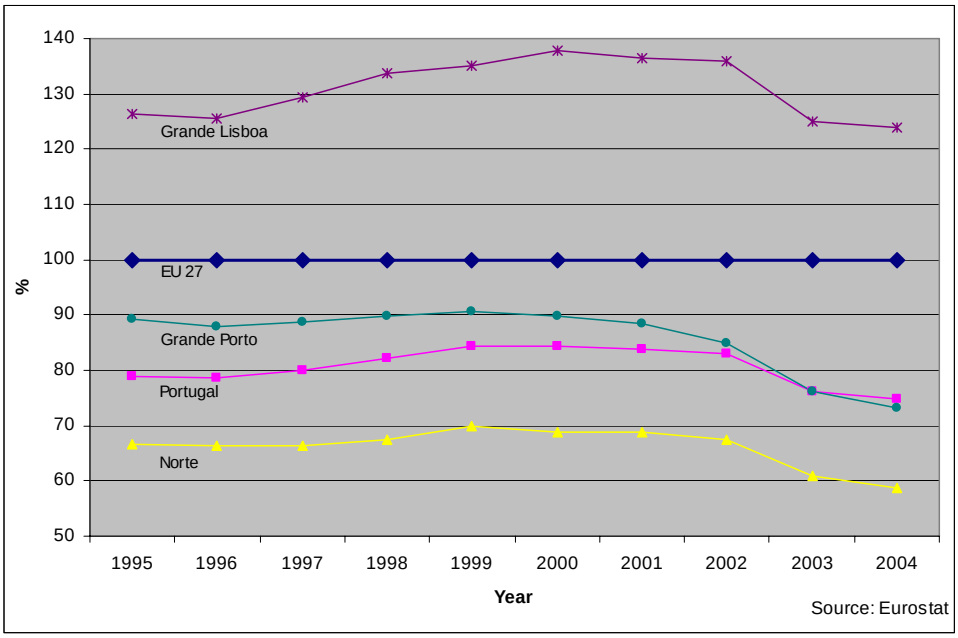


Figure 3.9 – Time-evolution of Purchasing Power Parities per inhabitant, as a percentage of the EU average, 1995-2004

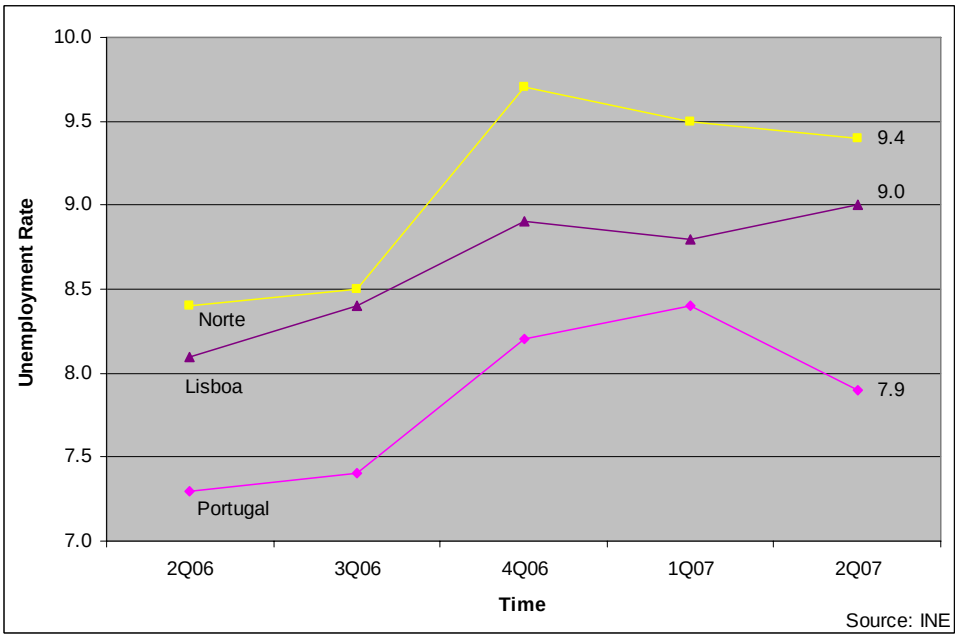


Figure 3.10 – Time evolution of unemployment rate along the five most recent quarters, 2Q06 – 2Q07

Unemployment is currently at unusually high levels, taking into account Portugal's trend over the past two decades. The value for the Norte NUTS II region (no data available at the NUTS III level) was 9.4% for the second quarter of 2007, 1.5% higher

than the average for the country, and 0.4% above the rate for the Lisboa NUTS II. When compared with the same quarter of 2006, Norte's unemployment rate rose by 1.0% (Figure 3.10). In addition, long-term unemployment accounted for about 53% of the overall value for Norte, against approximately 49% for Portugal and Lisboa (again for the most recent quarter available).

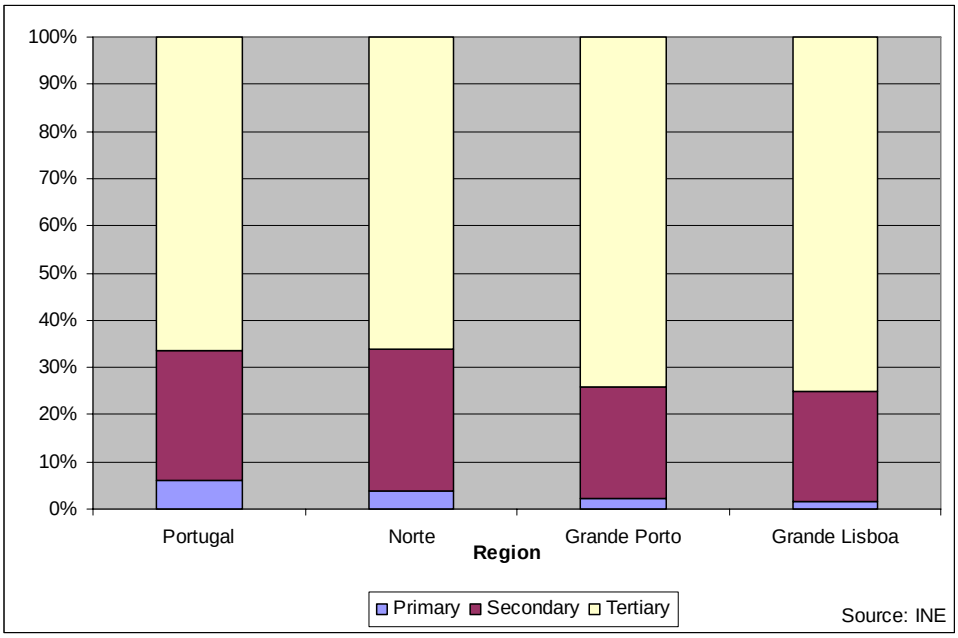


Figure 3.11 – Enterprises per economic sector per region, 2005

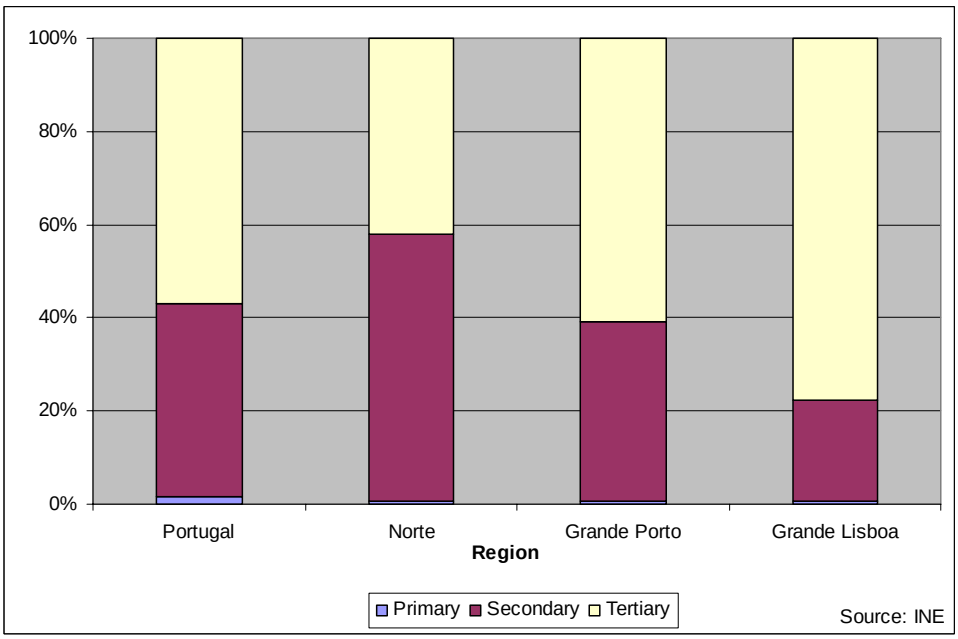


Figure 3.12 – Employment per economic sector per region, 2005

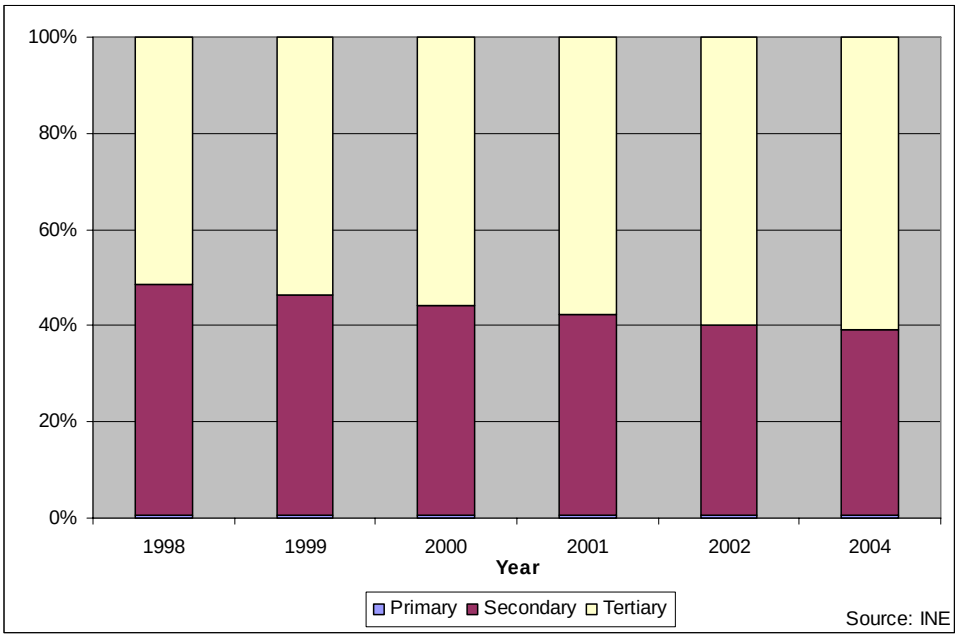


Figure 3.13 – Employment per economic sector, Grande Porto, 1998-2004 [2]

Looking at Figure 3.11 and Figure 3.12, which represent the economic structure of the regions in terms of enterprises and employment, respectively, it is possible to conclude that both Grande Porto and Grande Lisboa have a greater share of their economies in the services sector than Portugal and Norte. This is, of course, the expected result, since both those regions are essentially urban areas.

It is interesting to note that Grande Porto exhibits a significantly lower employment level in the services sector than does Grande Lisboa, even though the share is almost equal in terms of firm distribution. The reason for this is that the employment share in the secondary sector is much higher in Grande Porto, a result which is consistent with the high labour-intensiveness of the manufacture activities in the Norte NUTS II region.

The share of employment in the services sector in Grande Porto has been increasing steadily, evolving from around 50% in 1998 to slightly above 60% in 2004. The primary sector has kept a negligible level of employment during this time (Figure 3.13).

Figure 3.14 shows the distribution of employment per first-level economic activity code (CAE Rev.2.1). The sections with the highest shares are D – Manufacture (26.4%), G – Wholesale and retail trade; repair of motor vehicles, motorcycles and personal and

[2] Data for 2003 were not available.

household goods (25.7%), F – Construction (11.7%), and K – Real estate, renting and business activities (11.2%). For manufacture, the division per second-level subsection is also presented. The top activities in this regard are DB – Manufacture of textiles and textile products, DA – Manufacture of food products, beverages and tobacco, and DJ – Manufacture of basic metals and fabricated metal products.

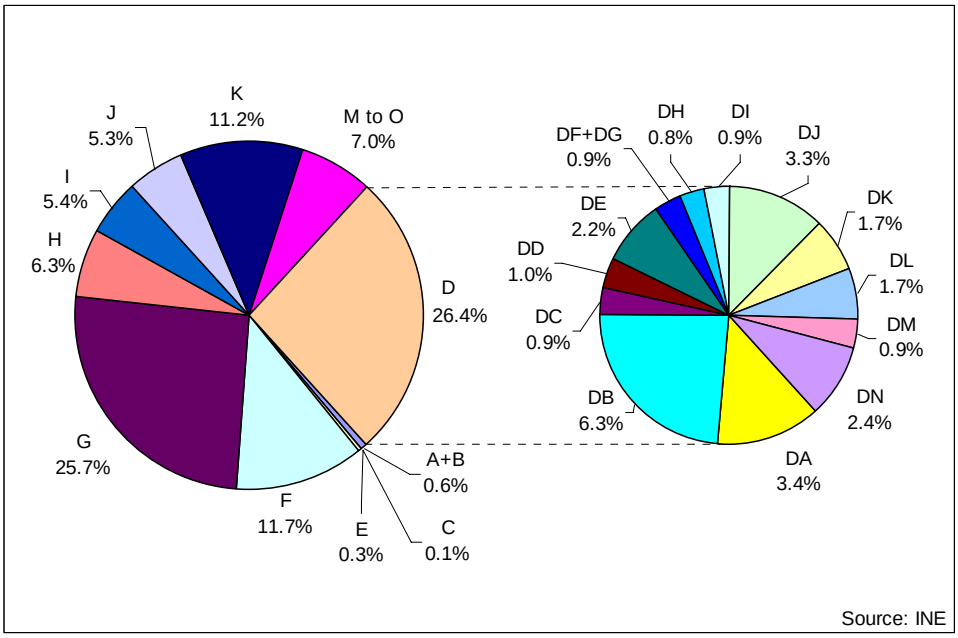


Figure 3.14 – Employment per economic activity code, Grande Porto, 2004

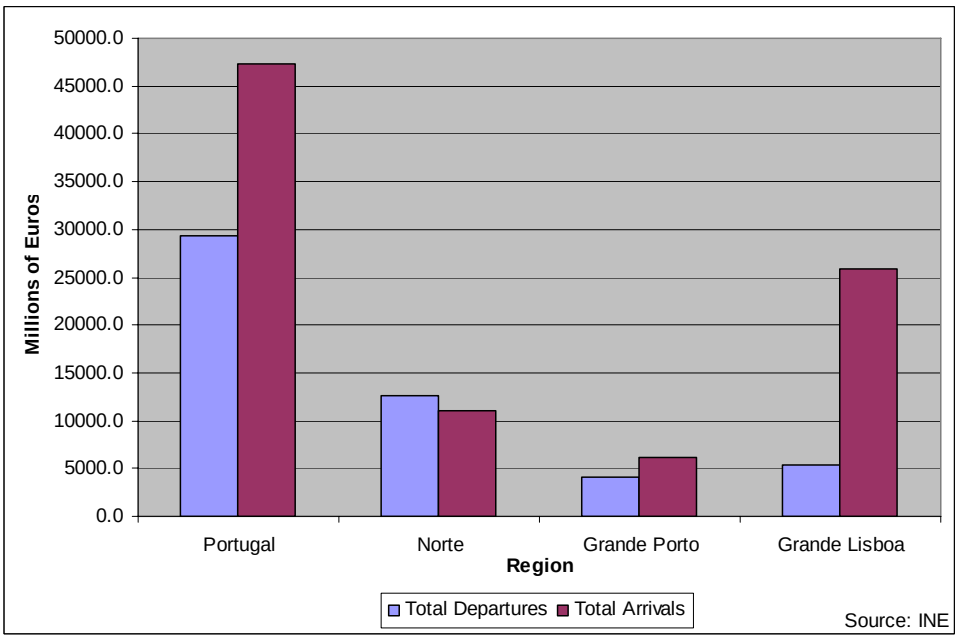


Figure 3.15 – International trade declared by region of headquarters, 2005

Figure 3.15 draws the picture in terms of international trade (declared by region of headquarters). It can be seen that both Grande Porto and Grande Lisboa have a negative balance of trade, as their arrivals exceed the departures, contrary to Norte as a whole, which shows a positive balance. Moreover, while the total departures of Grande Porto represent around 76% of those from Grande Lisboa, its total arrivals add up to only 24% of the same indicator for Grande Lisboa. This latter region accounts for more than a half of the Portuguese total arrivals (55%).

Looking into the detail for Grande Porto, Figure 3.16 shows the distribution of the total departures and arrivals for each of its nine municipalities. In terms of arrivals, the capital city of the region, Porto, accounts for the most prominent share, closely followed by Vila do Conde. The distribution of the departures can look rather surprising, at first glance, as Vila do Conde takes a very clear lead with around 36% of the overall value of Grande Porto. This result can be explained with the existence in this municipality of a large Qimonda factory (Infineon Technologies' spin-off for the computer memories business), which is, in fact, one of the largest exporters country-wide.

Dispatches to other EU countries represent nearly two-thirds of total departures from Grande Porto, whereas the remaining third has an extra-community destination.

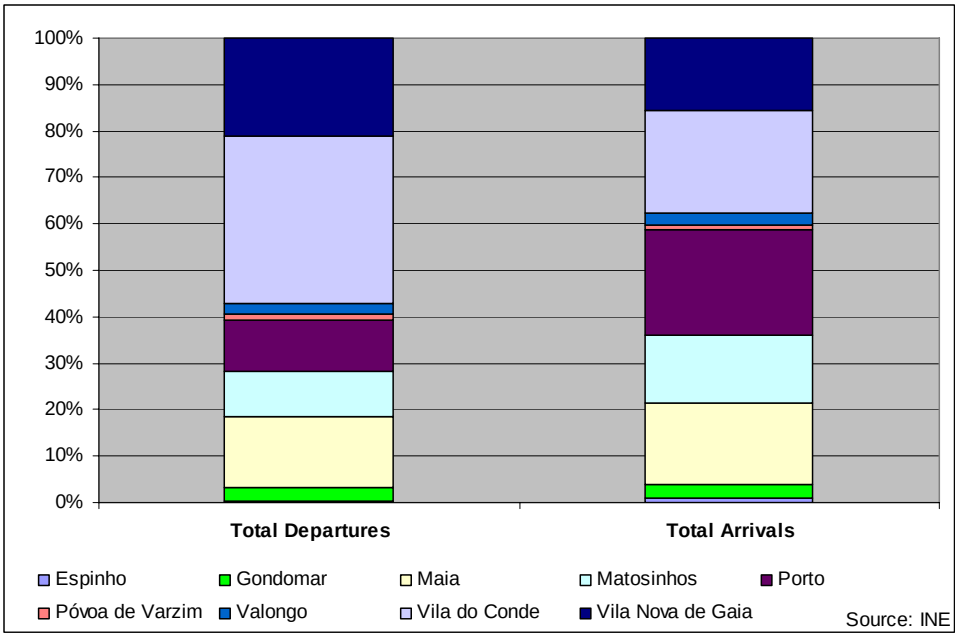


Figure 3.16 – International trade comparison between municipalities of Grande Porto, 2005

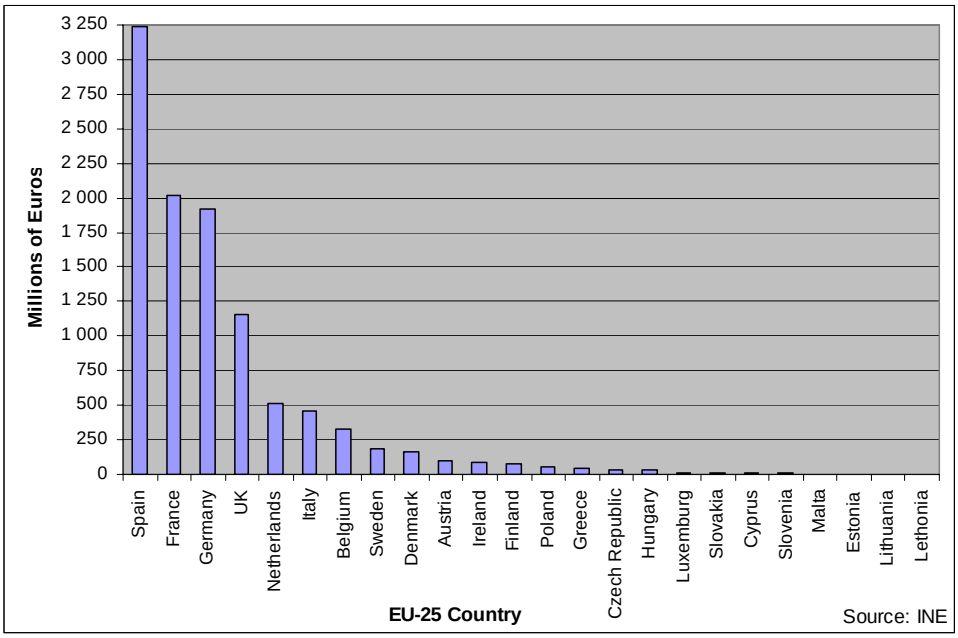


Figure 3.17 – International trade, dispatches from Norte, per EU country, 2005

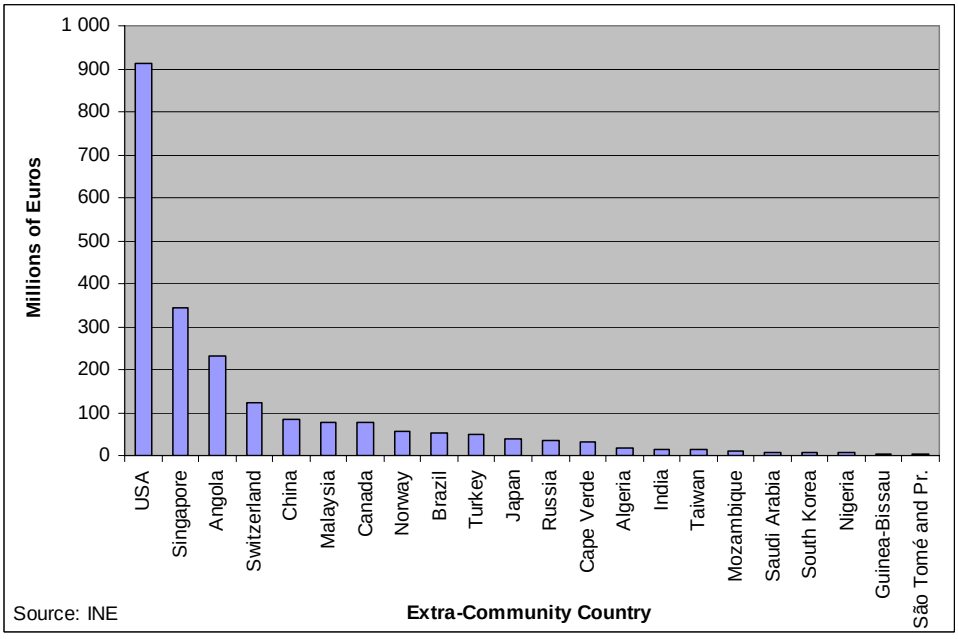


Figure 3.18 – International trade, exports from Norte, per extra-community country, 2005

Data on the distribution of departures per target country is available at the NUTS II level, only. Figure 3.17 shows the picture for EU-25 destinations, the leading countries being Spain, France, Germany, UK and Netherlands. As far as the exports from Norte are concerned, the USA stands as the main destination, accounting for almost three

times more volume than the second in the list, Singapore. The top-five rank is completed by Angola, Switzerland and China (Figure 3.18).

Grande Porto hosts a large population of higher education students, which totalled to nearly 68000 in the school year of 2005-2006. Among these, about 60% went to public HEIs, and two-thirds were enrolled in universities, as opposed to polytechnic schools (Figure 3.19). Table 3.1 shows the main HEIs of the region. The University of Porto ('Universidade do Porto') is the largest institution, in Grande Porto as well as country-wide, with more than 26000 students.

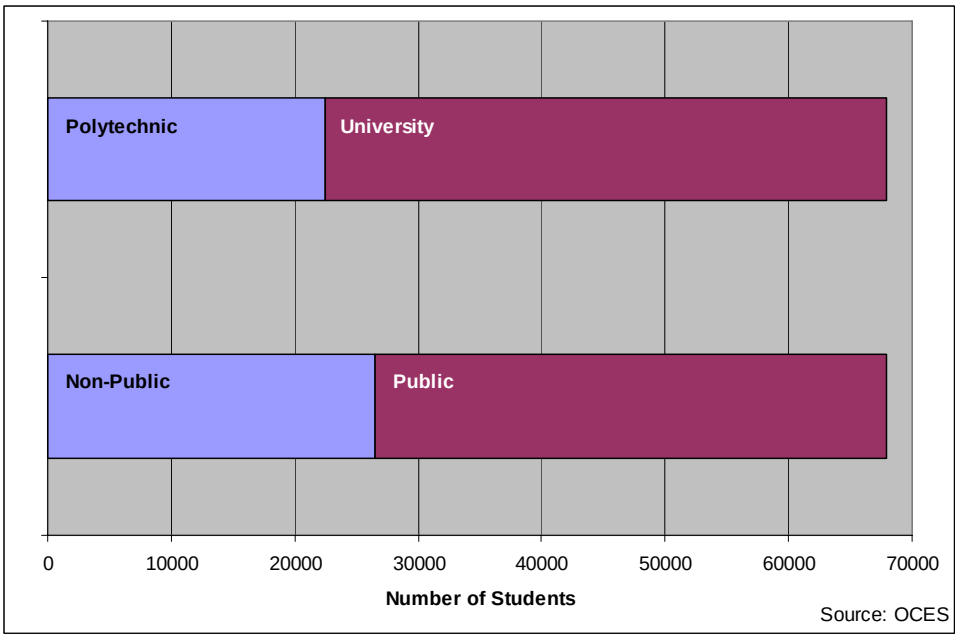


Figure 3.19 – Distribution of higher education students in Grande Porto, university vs. polytechnic and public vs. non-public, 2005-06 school year

Higher Education Institute	**Number of Students**
Universidade do Porto	26112
Instituto Politécnico do Porto	15024
Universidade Católica Portuguesa	4714
Universidade Fernando Pessoa	3987
Universidade Lusíada (Porto)	3703
Instituto Superior da Maia	3489
Universidade Portucalense Infante D. Henrique	1761
Other	9106

Table 3.1– Distribution of higher education students in Grande Porto per Institute, 2005-06 school year (source: OCES)

Regarding the distribution of these students per education areas, the three most demanded fields were, for the same school year, social sciences, business and law (32%), engineering, manufacturing and construction (23%), and health and welfare (17%) (Figure 3.20).

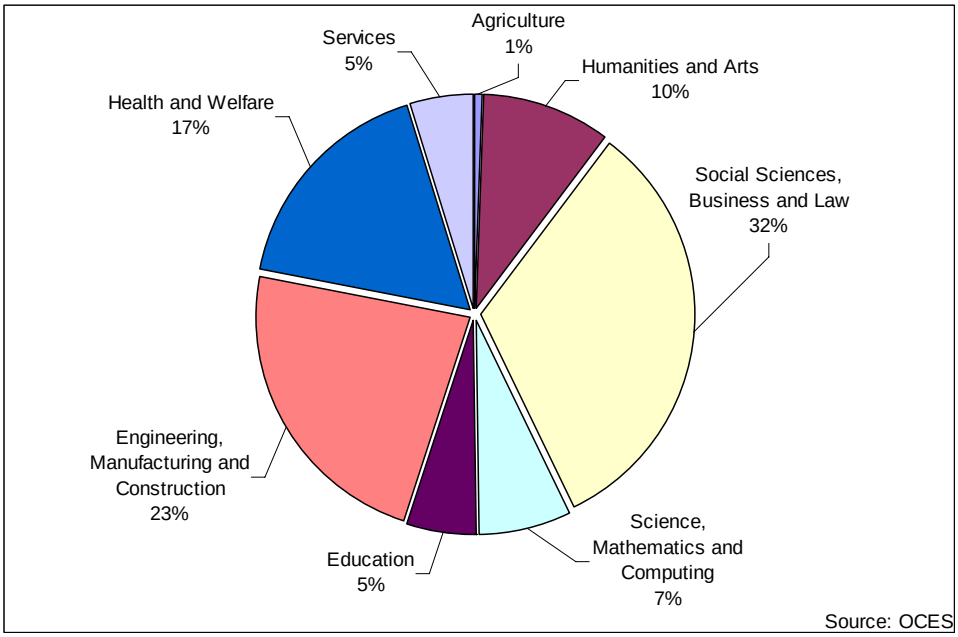


Figure 3.20 – Distribution of higher education students in Grande Porto per education area, 2005-06 school year

Figure 3.21 pertains to the indicators of R&D expenditure per region and sector of performance. All Portuguese NUTS II regions are included here in order to better emphasise the very large disparity between Lisboa and all the other regions, in this regard (no data available at NUTS III level). In fact, total R&D expenditure in Lisboa stands for more than two times the value in Norte and over three times the value in Centro, whereas in the remaining regions it is virtually residual. It is particularly striking to further detail the analysis of the distribution of Government's R&D expenditure and conclude that 79% of it is concentrated in Lisboa (Figure 3.22).

Overall, gross expenditure in R&D is applied mostly in the fields of engineering and technology, and social sciences and humanities (Figure 3.23). Norte exhibits a share of its GERD in engineering and technology which is greater than that of Lisboa and of the country as a whole.

With respect to firm innovation indicators, Figure 3.24 shows that Norte has a lower

percentage of enterprises with innovation activity (around 37%), as well as enterprises with cooperation for innovation (almost 17%), than Portugal and Lisboa. Turnover by new products constitutes about 20% of the region's overall value.

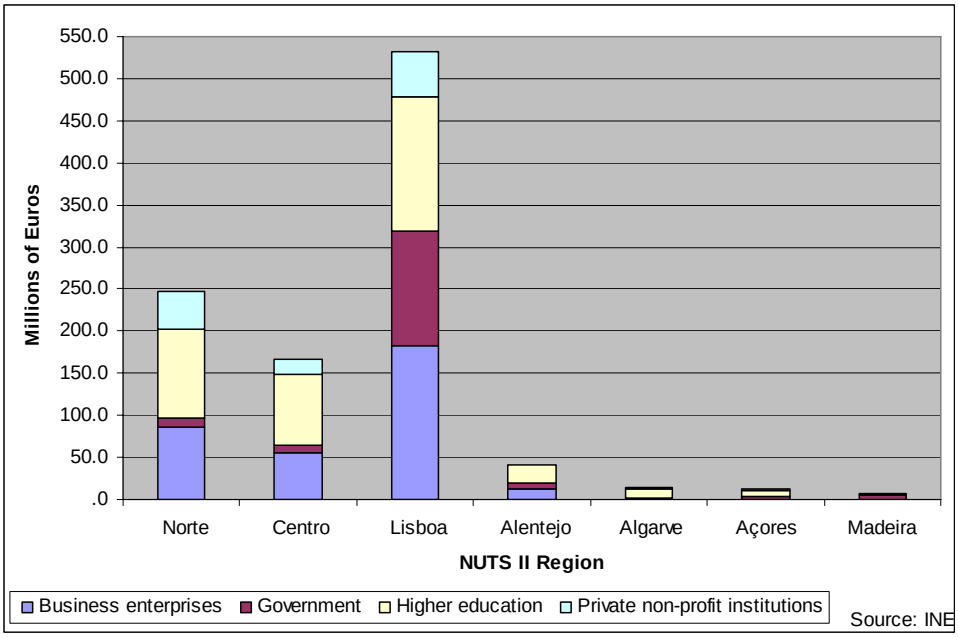


Figure 3.21 – R&D expenditure per NUTS II region and sector of performance, 2003

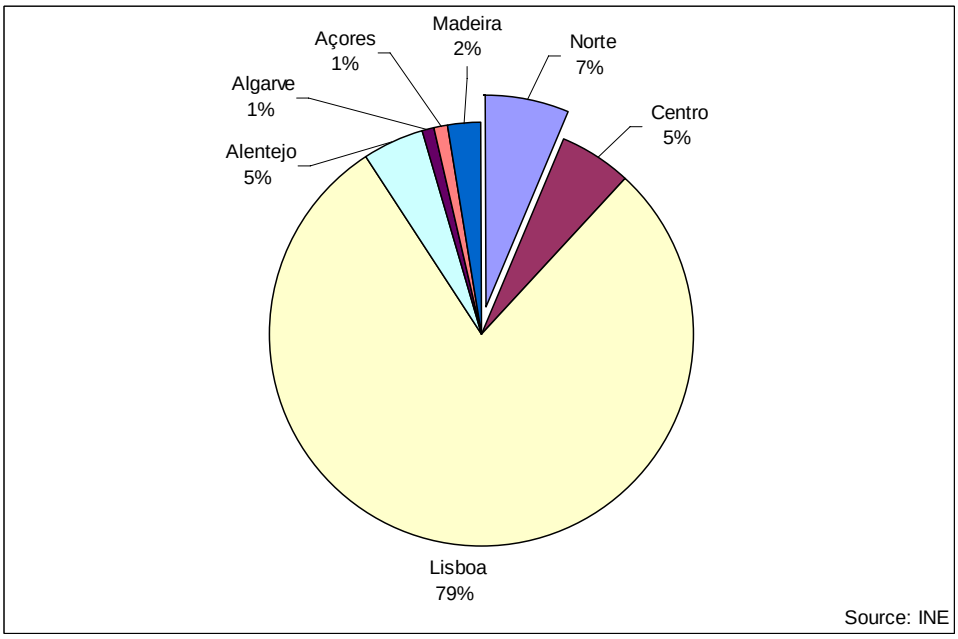


Figure 3.22 – Government R&D expenditure per NUTS II region, 2003

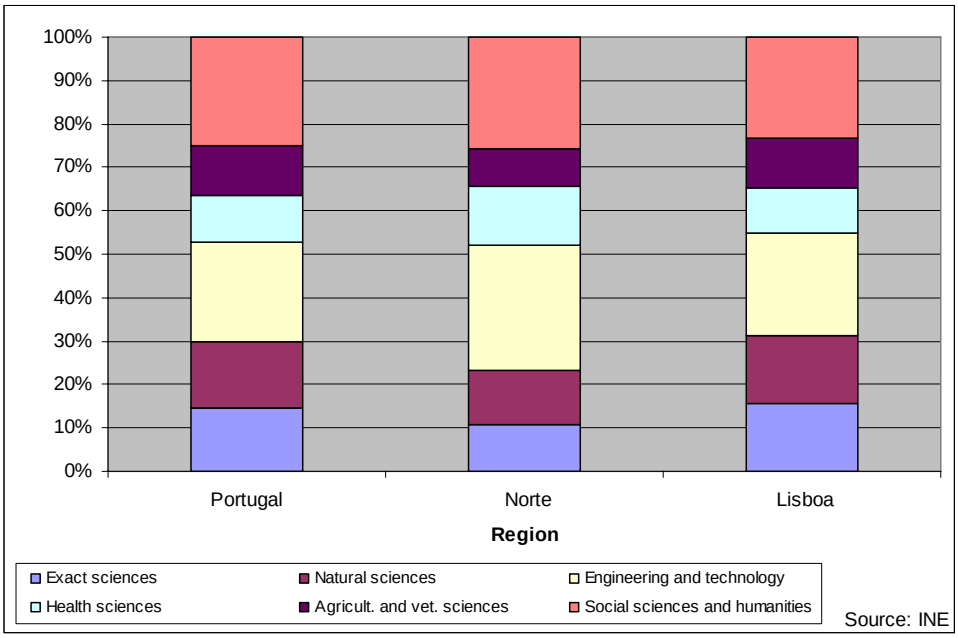


Figure 3.23 – GERD per region, and science and technology fields, 2003

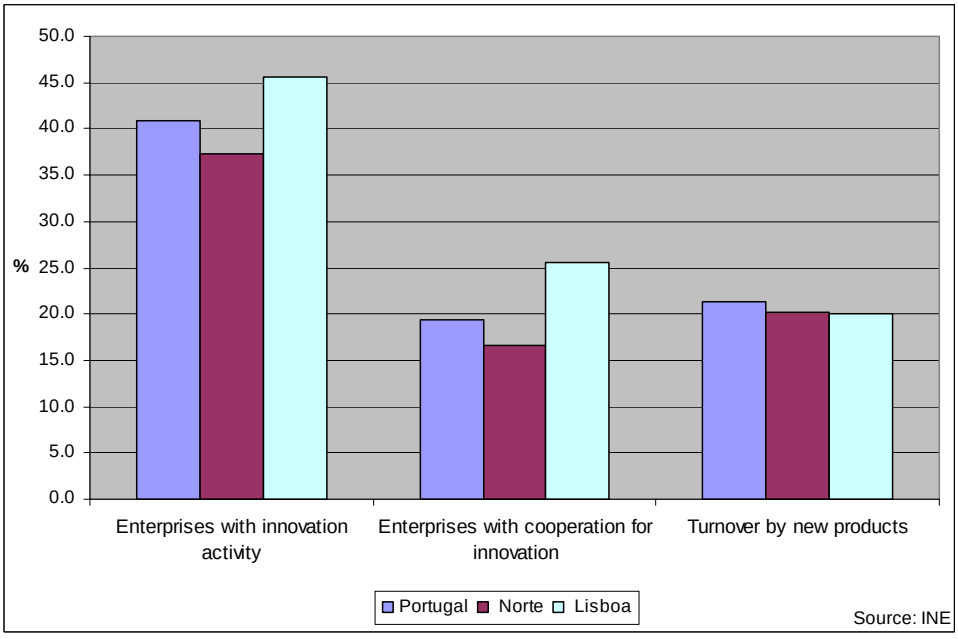


Figure 3.24 – Enterprise innovation indicators per region, 2002-2004

3.2 Policy-Supported Clusters

In light of the new 2007-2013 cycle of EU structural funds, the National Strategic Reference Framework is structured across a set of thematic, regional, territorial cooperation, and technical assistance operational programmes.

Among those, the North Region Operational Programme (CCDR-N, 2007) is of exceptional interest for the present work, as it provides a comprehensive diagnosis of the Norte NUTS II, and defines its strategic planning and how the structural funds will be managed and applied in the region. The North Regional Coordination and Development Commission (CCDR-N) is responsible for managing this Programme.

More specifically, this document points out three clusters of emergent activities in Norte[3]:

- ICT, Electronics, and Electrical Machines and Material;
- Health, Medical Devices and Pharmaceutics;
- Biotechnology and Agri-Food.

These activities are said to have a very interesting critical mass in the region, when compared to the rest of the country, especially when it comes to the capacity of producing qualified knowledge workers and of executing R&D projects. Therefore, the Operational Programme establishes that these clusters will be targeted by policies aimed at supporting their consolidation in Norte and new combinations of their activities, by means of e.g. the creation of networks of firms and R&D institutions, and of advanced training and technological centres.

Standing as the main NUTS III region of Norte in many senses (GDP, population and knowledge institutions, for instance), the more restricted area of Grande Porto (which is the actual subject of the case study herein discussed) is likely to play a dominant role in this regard, as well.

This section is intended to make an assessment of the presence of these three policy-supported clusters in Grande Porto. For that purpose, the existing economic base and level of concentration of the upper-mentioned activities is analysed in detail, with particular emphasis on the calculation and examination of the corresponding cluster-index (CI) values.

[3] For simplicity, from this point on these clusters will normally be referred to as the ICT, Health and Biotechnology clusters, respectively.

3.2.1 Methodology

Before looking at the results, it is appropriate to explain the underlying methodology which led to their obtainment.

3.2.1.1 Definition of the Clusters

The first step was to come up with a clear and concrete definition of each of the three clusters, by mapping them with the corresponding economic activity codes. The Portuguese Classification of Economic Activities, Rev.2.1 and Rev.2 (CAE Rev.2.1 and CAE Rev.2), have been used in this process, but there is a straight correspondence of these codes to the EU NACE classification, Rev.1.1 and Rev.1.

Only the Biotechnology cluster had had these constitution terms previously stated in the CCDR-N documentation (Malcata, 2006). For this reason, its definition acted as a starting point to infer the putative economy activities to be included in the remaining two clusters, serving as a model of the kind of criteria that should be used when executing that task. For example, the fact that several wholesale and retail sale activity codes had been considered to be included in the Biotechnology cluster has led to a similar reasoning when deciding to take activity GG5184 – Wholesale of computers, computer peripheral equipment and software – into account in the ICT cluster. In a more general way, the rather loose set of economic activities which had been made part of the Biotechnology cluster suggested an equivalently high flexibility level when building up the ICT and Health clusters formation.

Mendonça (2005) describes the ICT cluster in terms of its business areas and types of products. Based on his definition, this cluster has been set to include most of the DK – Manufacture of machinery and equipment n.e.c. – and DL – Manufacture of electrical and optical equipment – industries, some wholesale and retail sale codes, II642 – Telecommunications – and KK72 – Computer and related activities.

Similarly, Cunha (2005) provides a description of the Health cluster with a similar detail level, which has served as the main input for the cluster's set of economic activities herein considered. In a nutshell, the Health cluster then includes DG244 – Manufacture of pharmaceuticals, medicinal chemicals and botanical products; some DL33 – Manufacture of medical, precision and optical instruments, watches and clocks

– codes; a few wholesale and retail sale activities; NN851 – Human health activities; and OO93041 – Thermal activities.

The Biotechnology cluster includes activities pertaining to the primary, secondary and tertiary sectors, such as: AA11 – Agriculture; AA12 – Farming of animals; DA15 – Manufacture of food products and beverages; GG522 – Retail sale of food, beverages and tobacco in specialized stores; HH553 – Restaurants. This can be partly explained by the lack of a specific activity code for the biotechnology area (Malcata, 2006).

The complete list of economic activities which have been considered as part of each of the three policy-supported clusters is provided in Appendix A.

3.2.1.2 Cluster Index Calculation

The cluster-index (CI) has been selected to evaluate the level of agglomeration of the policy-supported clusters in Grande Porto. This measure is proposed by Sternberg and Litzenberger (2004) and has already been presented in section 2.6.

As shown in Eq. 2.2, its calculation requires the number of people employed and the number of firms, per industry and per region, as well as the area and population of each region. As for the first two variables, data could be found in the Table of Personnel ('Quadros de Pessoal') database, from the Directorate-General of Studies, Statistics and Planning of the Portuguese Ministry of Labour and Social Solidarity (DGEEP-MTSS, 'Direcção-Geral de Estudos, Estatística e Planeamento do Ministério do Trabalho e Solidariedade Social'). This system holds data about all the firms, and their establishments and workers, employing at least one person, from 1985 to 2005. Firms are characterised in terms of their geographical location (down to the lowest organisational level of the Portuguese territory, the 'Freguesia', thus including the NUTS III region information), CAE industry code (down to the five-digit level), number of workers, and sales size, among other issues. Establishments include all this information, as well, except for the sales size. As far as the area and population of each region are concerned, information has been collected from the Portuguese National Statistics Institute (INE).

Among the methods analysed in the review of literature, the CI appeared to be the most adequate, since it considers two different indicators of the presence of a given industry,

the employment and number of firms, and takes into account the area and population of the regions, as the level of concentration is certainly dependent on the dimension of the region.

Due to the Table of Personnel database organisation, in the present case study the CI has been computed based on the establishments data, instead of the firms data. According to this database, the NUTS III information associated to the firm relates to the location of its headquarters, but the firm can have one or more establishments in different regions. Moreover, the number of workers of a given firm, in this context linked to a single region, equals the sum of those of its establishments, which can be imputed to as many regions as the number of establishments.

All calculations have been restrained to the continental Portugal NUTS I region. For all of its NUTS III regions and for every year in the 1995-2005 period, the CI has been computed for each of the three clusters appointed in the North Region Operational Programme: ICT, Health and Biotechnology.

Section 3.2.1.1 defines these clusters and shows how each is formed by several different CAE codes. However, in order to enable the usage of the CI method in this context, each cluster had to be treated as a single industry, whose employment and number of firm establishments are equal to the sum of those of all the economic activities they include.

By fixing 1995 as the lower end of the research time window, it has been possible to make use of only two economic activity classification revisions, CAE Rev.2 and CAE Rev.2.1, which are in fact rather similar. Otherwise, it would have been necessary to employ CAE Rev.1 as well, since it is still used in the 1994 data. CAE Rev.1 has been set up in 1973 and was significantly different than its successor versions.

For simplicity, the NUTS III population values of 2005 have been used in the computation of the CI for all the years in the upper-mentioned period.

The Stata source code used for this calculation is presented in Appendix B.1.

3.2.2 Results

The results are analysed in the following sub-sections along three different perspectives: comparison between regions, evolution in the 1995-2005 period and composition of the

clusters.

3.2.2.1 Inter-regional Analysis

Figure 3.25, Figure 3.26 and Figure 3.27 present the results for the ICT, Health and Biotechnology clusters, respectively, displaying the top eight regions in terms of CI value for the most recent year for which data were available, 2005. The full set of results for the same year is provided in Table 3.3.

In all three industries, the list is headed by Grande Lisboa and Grande Porto, with CI values far above all the other regions. The difference between Grande Lisboa and Grande Porto is quite clear, as well.

The results obtained for the ICT and Health clusters are of similar magnitude. The CI values for Grande Lisboa are above 32 in both cases, whereas Grande Porto scores approximately 26 and 21, respectively. Regarding the remaining regions, it is interesting to see what appears to be the impact of the main strengths of the local universities. Baixo Vouga, Península de Setúbal and Cávado close the top five regions in the ICT graph, a possible consequence of the effect of the Universities of Aveiro (Baixo Vouga) and Minho (at Braga, Cávado), and of the New University of Lisboa (Península de Setúbal; the top position of this region is also ascribable to the proximity to Grande Lisboa). Baixo Mondego holds a respectable fourth place in the Health industry, a fact that can be related to the presence of a reputed medical school in the University of Coimbra.

The Biotechnology industry, as herein defined, shows a fairly greater dispersion. On the one hand, the top CI values are much lower than in the previous two cases, as Grande Lisboa and Grande Porto achieve CI values of around 14 and 11, respectively. On the other hand, there is a greater number of above-unity CI values among the rest of the regions (see Table 3.3).

It is worth noting the fact that some regions have a greater number of people employed but a lower CI value than others, e.g. the Península de Setúbal region in the ICT industry, or the Algarve in the Biotechnology case. Similarly, the difference between the CI values of Grande Porto and Grande Lisboa is not as stark as the departure in their employment and number of firm establishments, since the latter region pertains to a

greater geographical area and population (Table 3.2). These results seem to reinforce the need to take into account several variables when measuring the level of presence of a cluster in a region.

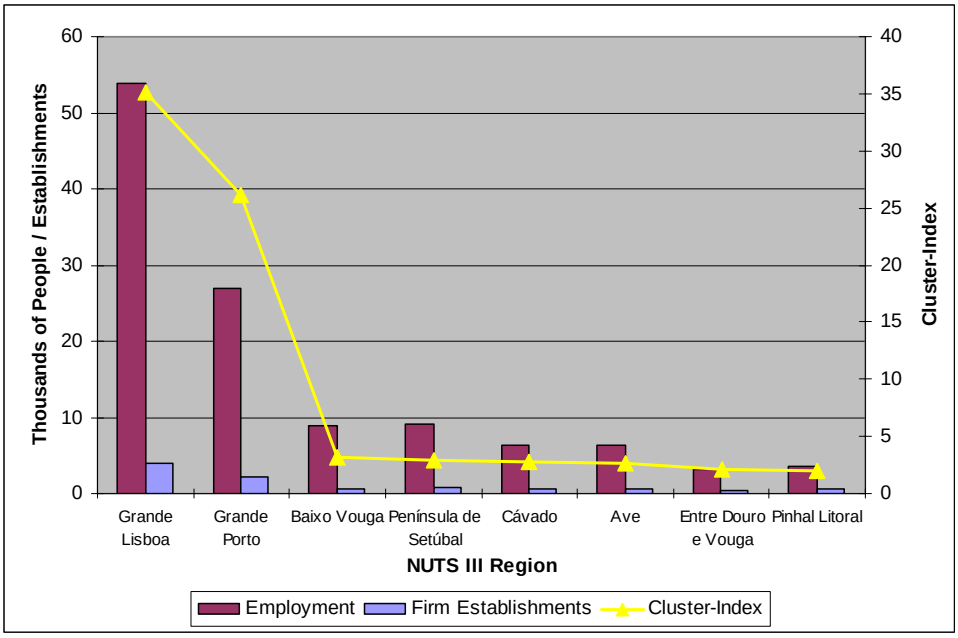


Figure 3.25 – ICT cluster: employment, number of establishments and CI values, top eight NUTS III regions, 2005

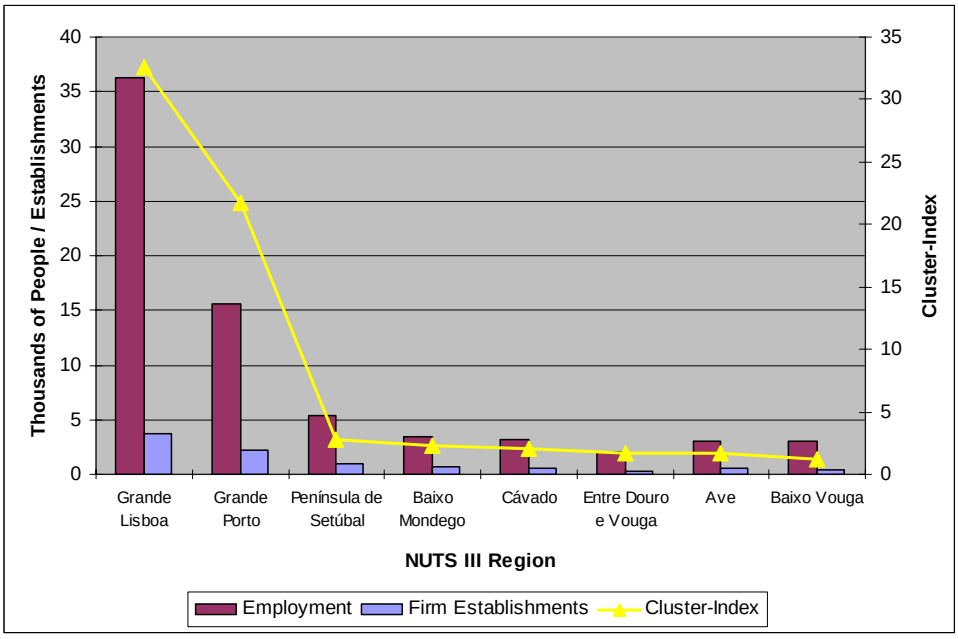


Figure 3.26 – Health cluster: employment, number of establishments and CI values, top eight NUTS III regions, 2005

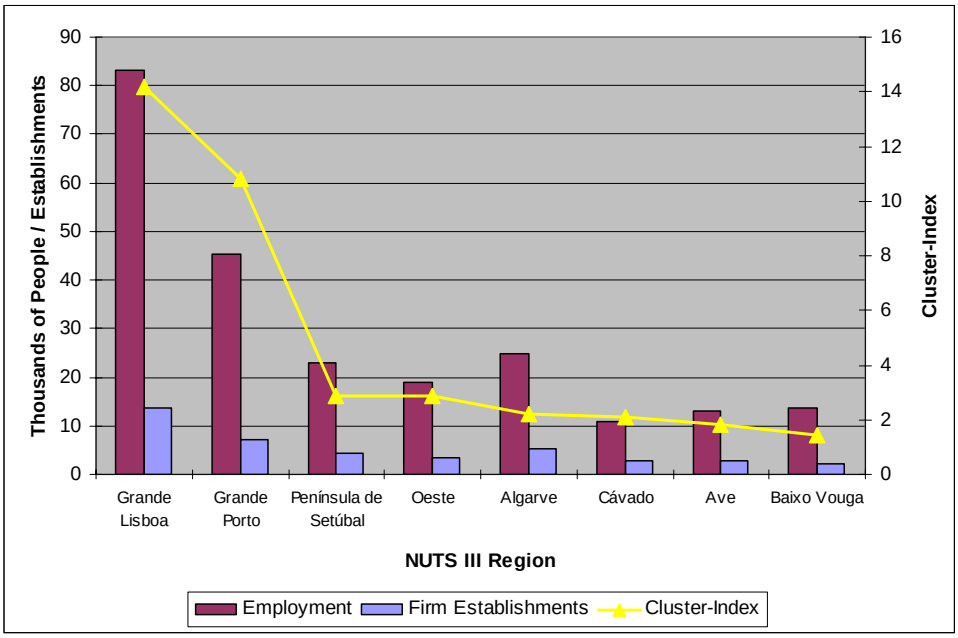


Figure 3.27 – Biotechnology cluster: employment, number of establishments and CI values, top eight NUTS III regions, 2005

	Employment	**Establishments**	**CI**
ICT	50.0%	56.0%	74.5%
Health	42.9%	58.3%	66.6%
Biotechnology	54.4%	52.6%	76.3%

Table 3.2 – Employment, number of establishments and CI in Grande Porto, per cluster, as a percentage of Grande Lisboa values, 2005

As a term of comparison, it should be said that Sternberg and Litzenberger (2004), who firstly proposed the CI method, present their own case study of the manufacture of motor vehicles industry (DM341) in Germany, for which they identify 14 German planning regions as potential clusters. The top CI value in that context is obtained for Bremen: 52.00.

				ICT			Health			Biotechnology		
NUTS II	**NUTS III**	**Area**	**Population**	**Employment**	**Establish.**	**CI**	**Employment**	**Establish.**	**CI**	**Employment**	**Establish.**	**CI**
Norte	Minho Lima	2.49%	2.50%	2109	203	0.34	1699	296	0.60	7575	2429	1.15
	Cávado	1.40%	4.04%	6391	498	2.79	3150	498	2.06	10787	2786	2.07
	Ave	1.40%	5.17%	6412	593	2.60	3002	535	1.65	12914	2659	1.85
	Grande Porto	0.92%	12.66%	26938	2269	26.16	15536	2177	21.72	45260	7108	10.82
	Tâmega	2.94%	5.55%	2650	376	0.30	2842	425	0.55	11448	4053	1.11
	Entre Douro e Vouga	0.97%	2.83%	3197	376	2.17	2079	308	1.74	7067	1398	1.40
	Douro	4.62%	2.14%	927	165	0.08	2152	206	0.33	11139	2927	1.29
	Alto Trás-os-Montes	9.18%	2.17%	547	157	0.02	953	209	0.07	4857	1263	0.12
Algarve	Algarve	5.62%	4.13%	2954	539	0.34	3217	600	0.62	24870	5248	2.19
Centro	Baixo Vouga	2.03%	3.93%	8835	585	3.22	2969	416	1.15	13536	2144	1.42
	Baixo Mondego	2.32%	3.33%	3303	463	0.98	3406	681	2.24	12031	1984	1.21
	Pinhal Litoral	1.96%	2.62%	3656	553	1.96	1706	358	0.89	8676	1739	1.15
	Pinhal Interior Norte	2.94%	1.37%	542	94	0.06	564	107	0.11	3258	826	0.26
	Dão Lafões	3.92%	2.89%	1715	254	0.19	2676	332	0.58	9200	1609	0.51
	Pinhal Interior Sul	2.14%	0.42%	67	21	0.01	85	30	0.02	1017	242	0.11
	Serra da Estrela	0.98%	0.48%	88	29	0.03	158	45	0.11	1315	275	0.30
	Beira Interior Norte	4.57%	1.11%	1813	100	0.18	460	114	0.08	3042	664	0.16
	Beira Interior Sul	4.21%	0.75%	1504	70	0.17	432	99	0.10	2843	555	0.20
	Cova da Beira	1.54%	0.91%	458	93	0.15	931	100	0.49	2273	581	0.36
	Oeste	2.50%	3.53%	2494	399	0.56	2066	395	0.69	18988	3385	2.84
	Médio Tejo	2.59%	2.29%	1386	267	0.31	1800	283	0.64	7658	1600	0.80
Lisboa	Grande Lisboa	1.55%	19.97%	53887	4055	35.11	36223	3734	32.60	83213	13502	14.19
	Península de Setúbal	1.75%	7.60%	9101	840	2.85	5439	897	2.73	22848	4296	2.87
Alentejo	Alentejo Litoral	5.91%	0.96%	295	59	0.02	537	121	0.08	4352	893	0.27
	Alto Alentejo	7.02%	1.20%	629	119	0.04	629	144	0.08	5202	1080	0.26
	Alentejo Central	8.13%	1.70%	2792	184	0.19	934	215	0.11	8059	1807	0.41
	Baixo Alentejo	9.60%	1.29%	419	95	0.02	496	147	0.04	5460	1379	0.24
	Lezíria do Tejo	4.81%	2.46%	1800	265	0.20	1462	295	0.27	14776	2091	1.02

Table 3.3 – Employment, number of establishments and CI values for the ICT, Health and Biotechnology industries, all NUTS III regions, 2005

3.2.2.2 Time-Evolution Analysis

When comparing the time-evolution of the CI of each of the three industries in Grande Porto in the 1995-2005 period (Figure 3.28), it is possible to conclude that only the Health CI presents a positive overall evolution in that period, rising from 18.8 in 1995 to 21.7 in 2005.

In terms of volatility, the ICT CI trend shows the greatest variations, especially in the years around the end of the dot-com bubble, with a steep decrease from 1998 to 2001. On the opposite end, the Biotechnology industry is the most stable in the time frame considered.

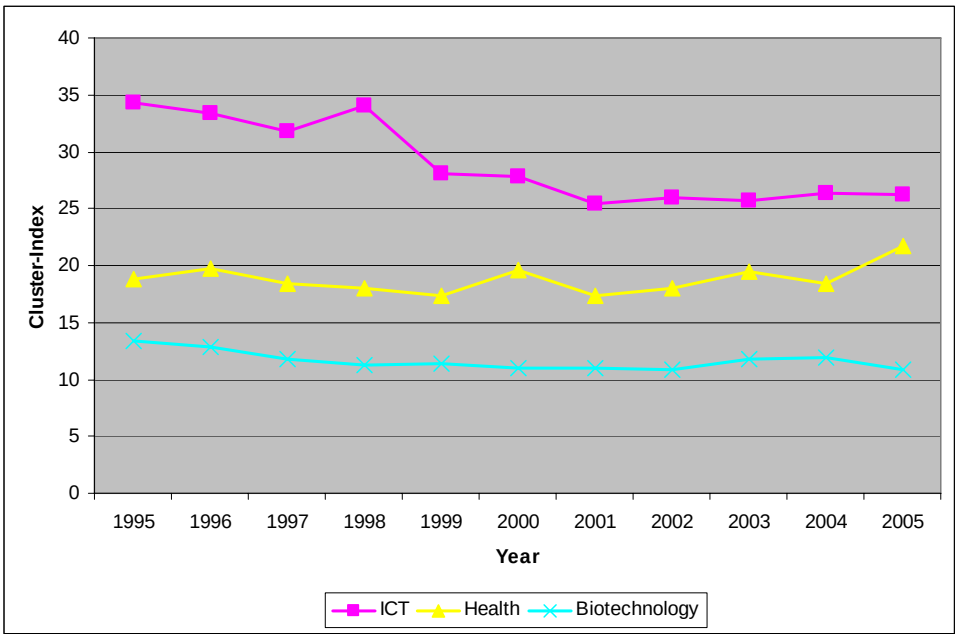


Figure 3.28 – CI evolution for the ICT, Health and Biotechnology industries in Grande Porto, 1995-2005

The same lines are depicted separately in Figure 3.29 to Figure 3.31, along with the evolution of the corresponding employment and number of firm establishments (as a percentage of the total value for the continental Portugal NUTS I region). The trends of the CI are clearly determined by the evolution of the share of employment, particularly in the ICT and Health clusters.

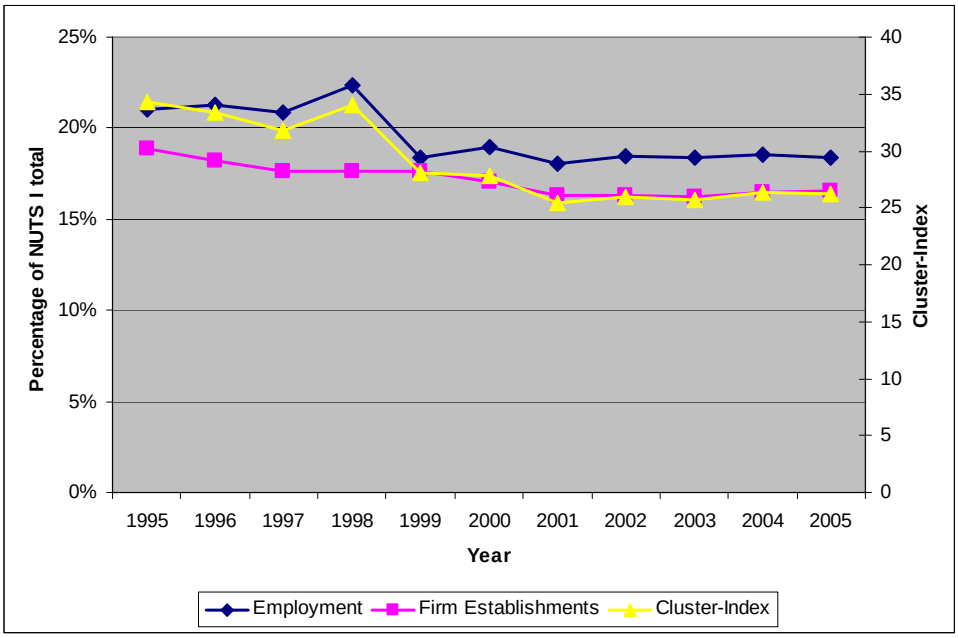


Figure 3.29 – CI versus employment and number of establishments (as a percentage of the country's total) for the ICT industry in Grande Porto, 1995-2005

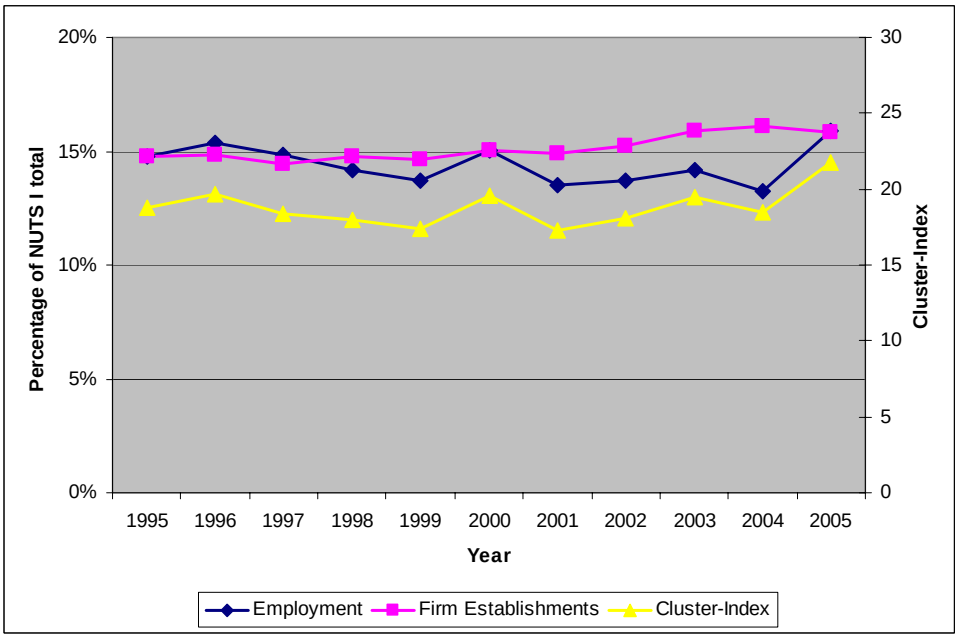


Figure 3.30 – CI versus employment and number of establishments (as a percentage of the country's total) for the Health industry in Grande Porto, 1995-2005

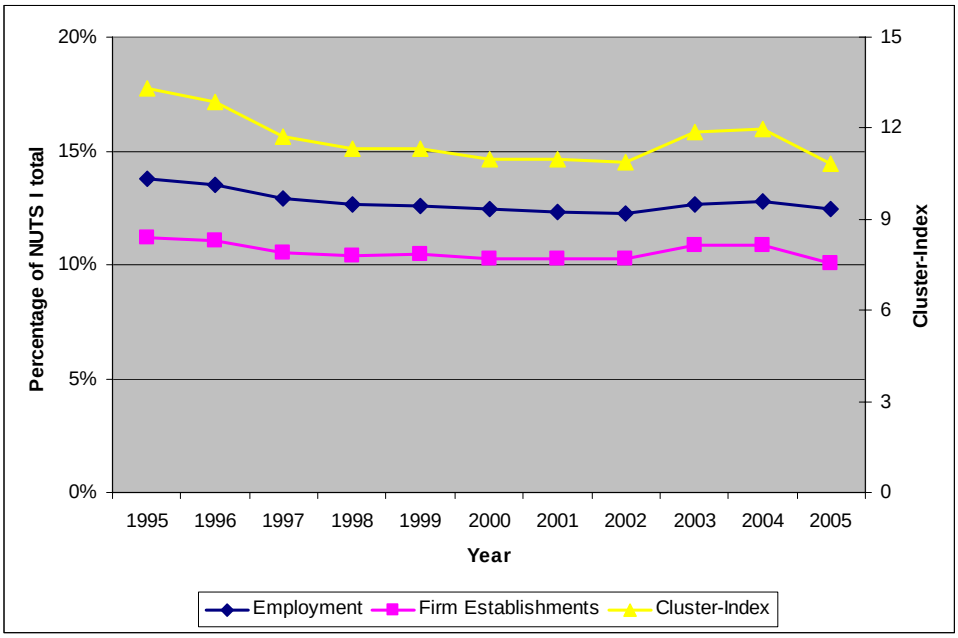


Figure 3.31 – CI versus employment and number of establishments (as a percentage of the country's total) for the Biotechnology industry in Grande Porto, 1995-2005

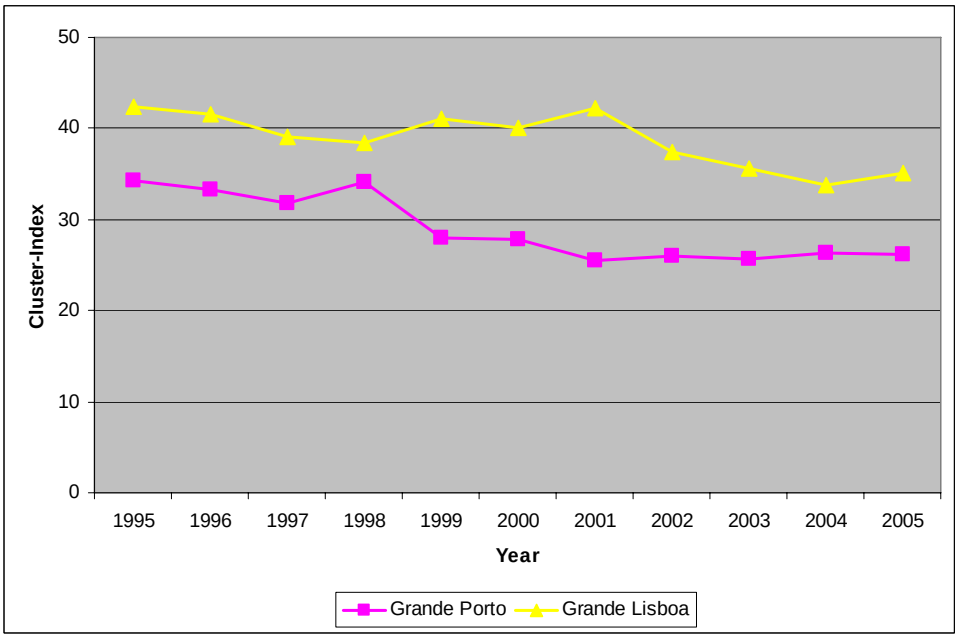


Figure 3.32 – CI evolution for the ICT industry, Grande Porto versus Grande Lisboa, 1995-2005

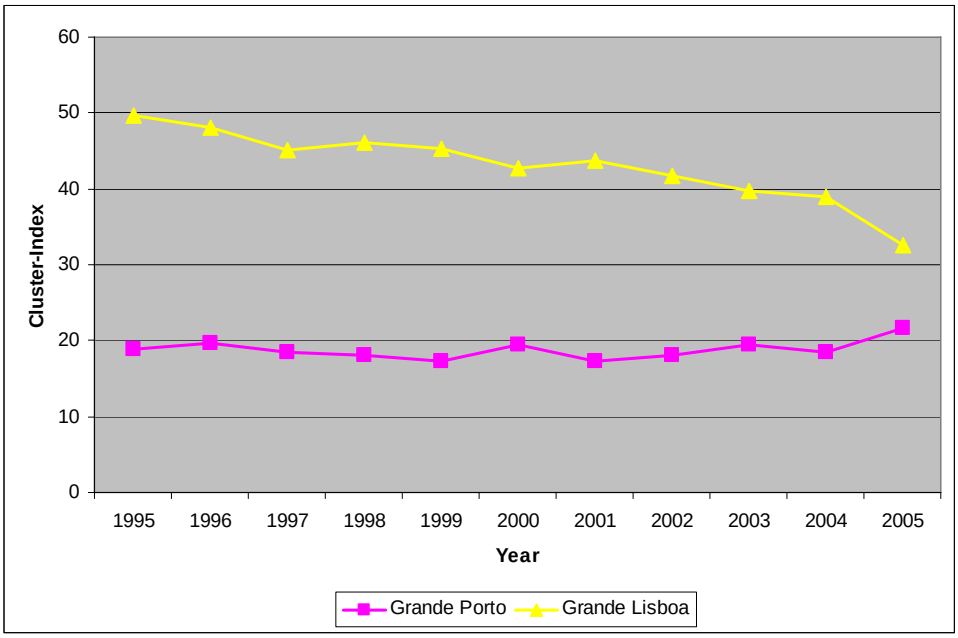


Figure 3.33 – CI evolution for the Health industry, Grande Porto versus Grande Lisboa, 1995-2005

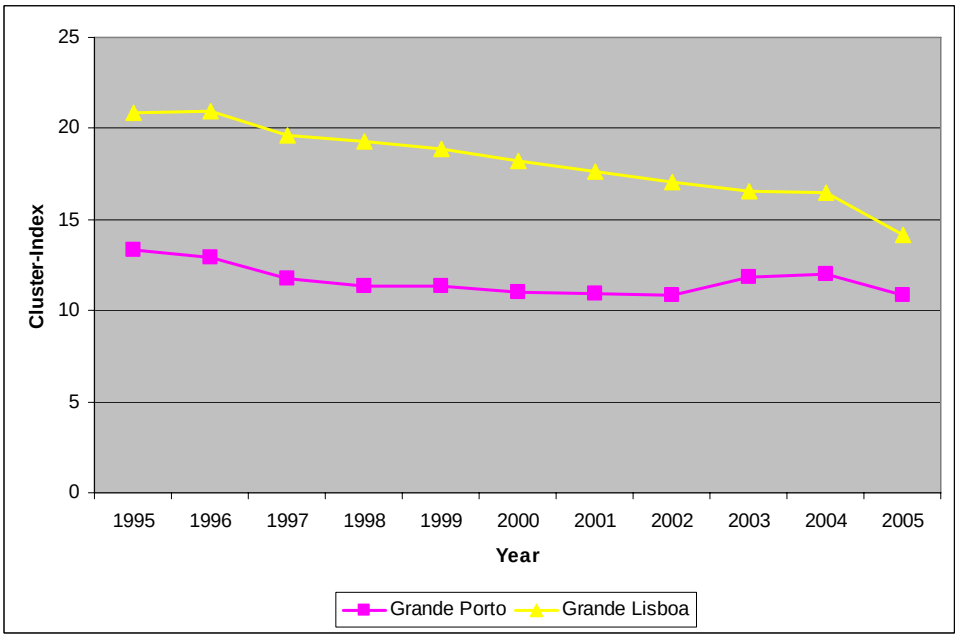


Figure 3.34 – CI evolution for the Biotechnology industry, Grande Porto versus Grande Lisboa, 1995-2005

Figure 3.32 to Figure 3.34 show yet another representation of the 1995-2005 CI trend of each industry in Grande Porto, now comparing to the Grande Lisboa case. Table 3.4 quantifies the actual overall variation values in each case. In the Health and

Biotechnology industries the evolution in Grande Lisboa is more negative than in Grande Porto. In the former industry, in particular, Grande Porto presented a positive drift of 15.4%, against a negative variation of 34.3% in Grande Lisboa.

	Grande Porto	Grande Lisboa
ICT	-23.7%	-17.1%
Health	15.4%	-34.3%
Biotechnology	-18.8%	-32.0%

Table 3.4 – CI variation per industry, Grande Porto and Grande Lisboa, 1995-2005

3.2.2.3 Structural Analysis

The three policy-supported clusters in Grande Porto have different relative positions. The Biotechnology industry accounts for the greatest numbers of establishments and workers, whereas the ICT cluster attains the highest CI with significantly less employment and establishments (Figure 3.35).

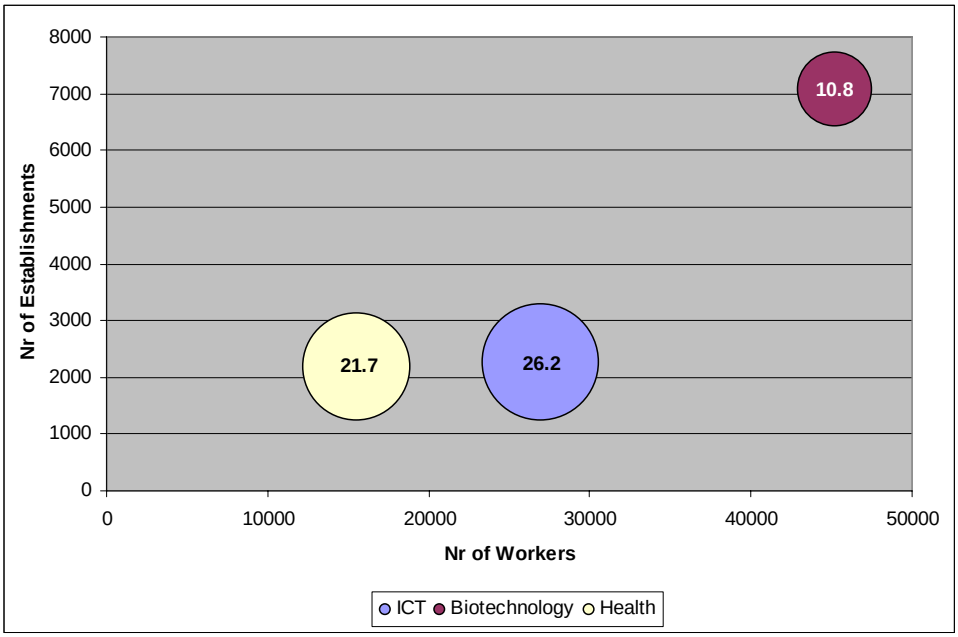
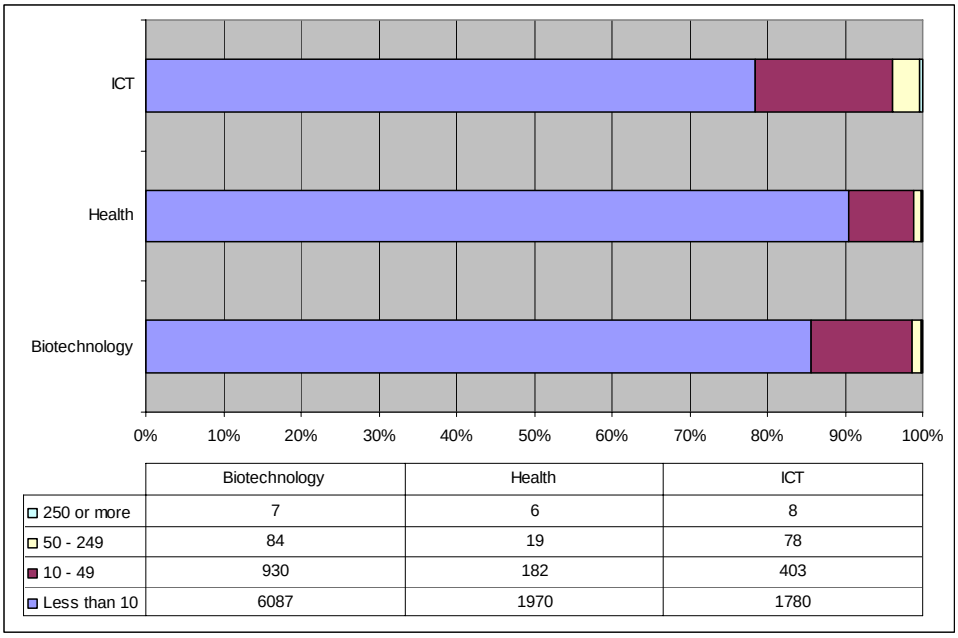


Figure 3.35 – ICT, Health and Biotechnology clusters in Grande Porto, 2005: employment, number of establishments and CI (size of the bubbles)

In terms of their distribution by size, the vast majority of the firm establishments in each industry in Grande Porto has less than 10 employees: almost 80% in the ICT industry,

over 90% in the Health case, and approximately 86% in the Biotechnology cluster (Figure 3.36). The share of ICT establishments with 10 to 249 employees is also quite significant. In all three cases, there is a very small number of large firm establishments.



	Biotechnology	Health	ICT
250 or more	7	6	8
50 - 249	84	19	78
10 - 49	930	182	403
Less than 10	6087	1970	1780

Figure 3.36 – ICT, Health and Biotechnology clusters in Grande Porto, 2005: firm establishments distribution by size

The structure of the ICT industry in Grande Porto is represented in Figure 3.37, in terms of the distribution of its employment, number of firm establishments and sales size per three-digit level economic activity code. The results have been sorted by descending sales size value.

At this point, it must be noted that the sales size information here presented pertains to the firms and not to the establishments level, since only the former was available in the Table of Personnel database. In other words, while the employment and number of establishments data actually concern to the establishments database, the sales size relates to the firms. This means that the sales of a firm which is headquartered in a given region might include the contribution of one or more establishments of that firm located in other regions.

Nonetheless, this seems to be a quite acceptable estimation, considering the superior interest of including it in this analysis. Also, around 95% of the firms in the database are single-establishment, thus further assessing the validity of these estimates.

One additional remark is that two three-digit level industries in the ICT and Health clusters did have establishments in the Grande Porto region, but no firms. Therefore, no sales values could be collected for these activities.

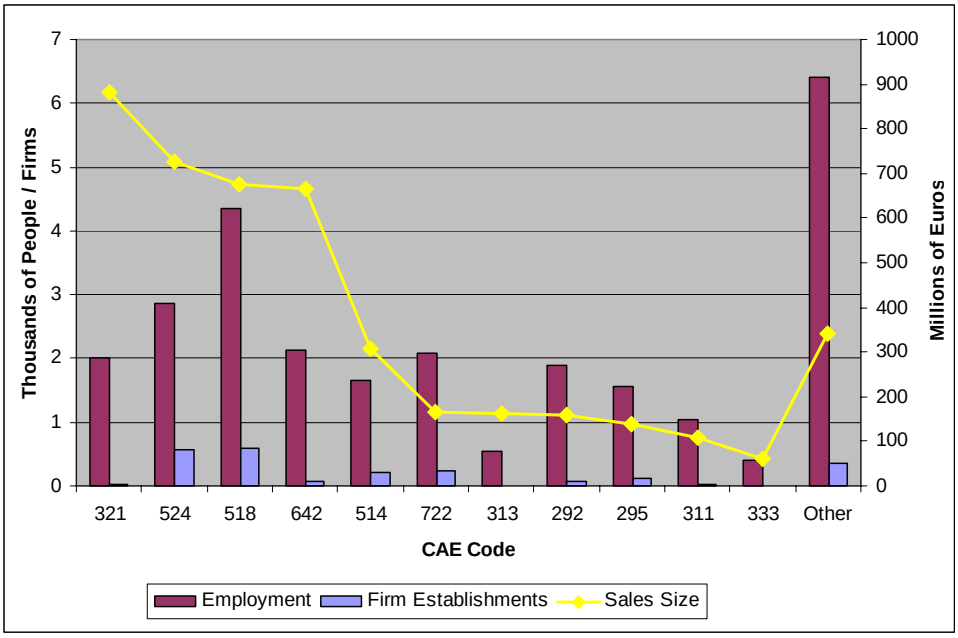


Figure 3.37 – ICT industry structure, in terms of employment, establishments and sales size per economic activity, Grande Porto, 2005

Back to the ICT cluster structural analysis, the first eleven activities (out of 27 found in the database for this industry in the Grande Porto NUTS III) account for over 90% of the total ICT sales, almost 85% of its number of company establishments, and more than three quarters of the overall industry employment.

The list is headed by activity DL321 – Manufacture of Electronic Components. Taking into account the very small number of firm establishments with this CAE code, this fact can certainly be attributed to the presence of the Qimonda factory in the municipality of Vila do Conde (previously mentioned in section 3.1, when analysing the region's international trade). This activity is likely to include a quite significant high-technology profile.

Activity GG524 – Other retail sale of new goods in specialized stores – holds the second largest sales size and number of workers. As listed in Appendix A, two five-digit level codes have been considered here: GG52451 – Retail sale of electrical household appliances, and radio, television and video goods – and GG52481 – Retail

sale of office machines and other material. Therefore, a substantial part of the high indicators exhibited by this activity may result from the typical abundance of electrical appliances shops in urban areas such as Grande Porto. Nonetheless, much of the work involved has to do with dealing with high-tech goods. The same comment goes for the fifth activity in the chart, GG514 – Wholesale of electrical household appliances, and radio and television goods.

The third largest sales size is shown by CAE GG518 – Wholesale of machinery and equipment. This includes wholesale of, for example, mining, construction and civil engineering machinery, and machine tools. This is also the activity with the largest number of workers and firm establishments. Furthermore, activities DK292 – Manufacture of other general purpose machinery – and DK295 – Manufacture of other special purpose machinery – are also part of this top sales volume list, thus providing a strong support in the Grande Porto NUTS III region for some of the business areas defined by Mendonça (2005) for the ICT, Electronics, and Electrical Machines and Material cluster in the Norte NUTS II region.

The telecommunications industry (II642) holds the fourth place, with slightly less sales than the previous activity. This result partly derives from the fact that the region hosts the headquarters of Sonaecom.

The sixth place in the list is occupied by activity KK722 – Software consultancy and supply, clearly a knowledge-intensive industry with high technological sophistication potential. Its workforce of approximately 2000 people is relatively small, but the companies in this industry are usually SMEs. In this case, the average number of employees per firm establishment is approximately nine.

Three DL industries close the list: DL313 – Manufacture of insulated wire and cable, DL311 – Manufacture of electric motors, generators and transformers, and DL333 – Industrial process control equipment. These results, in particular regarding activity DL311, are largely ascribable to the strong presence of the EFACEC group.

Similar information is depicted in Figure 3.38 for the Health industry.

Wholesale and retail sale of pharmaceutical goods (GG51460 and GG52310, respectively) account for a significant share of the Health industry's sales. They are shown in the first and third positions in the graph, even though the latter also includes

GG52320 – Retail sale of medical and orthopaedic goods. Together, these two three-digit CAE codes represent almost 80% of the overall sales of the Health industry in Grande Porto. It is also interesting to see how the first of these activities, wholesale of pharmaceutical goods, contributes with more than 60% of the overall sales, but less than 10% of the total employment and less than 4% of the total number of firm establishments.

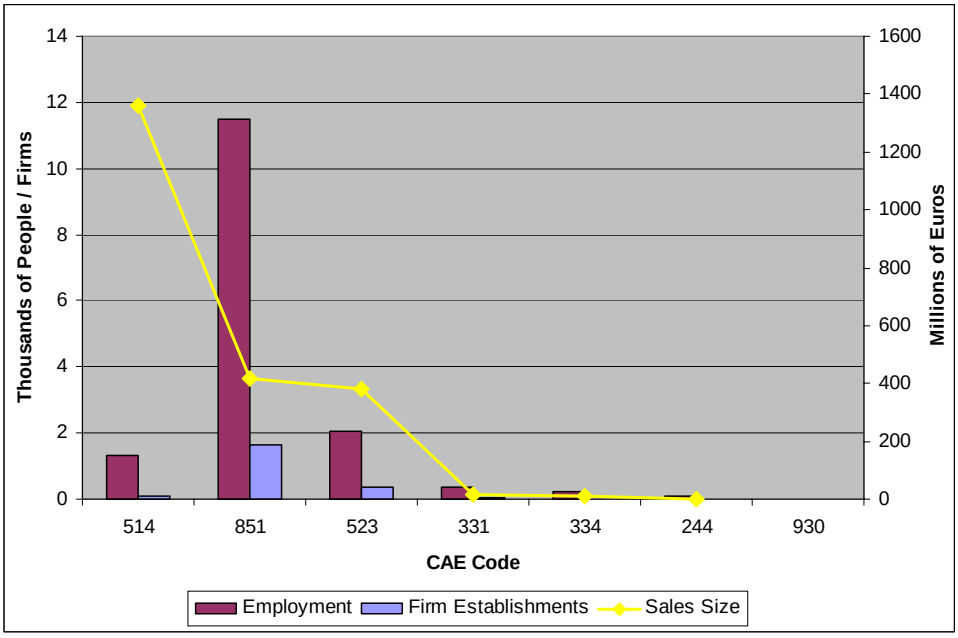


Figure 3.38 – Health industry structure, in terms of employment, establishments and sales size per economic activity, Grande Porto, 2005

As far as the employment and number of establishments are concerned, the list is distinctly headed by code NN851 – Human health activities, which is the second largest in terms of sales volume. This is not surprising, since, for example, all medical, nursing and clinical analysis services, which tend to concentrate in large urban areas, are herein included.

Some seed critical mass seems to exist in activity DL331 – Manufacture of medical and surgical equipment and orthopaedic appliances, where a quite reasonable number of firm establishments was found (57). However, its sales size is still negligible.

The remaining three industries, DL33401 – Manufacture of ophthalmic optical goods, DG244 – Manufacture of pharmaceutical products – and OO93041 – Thermal activities, exhibit insignificant values for all variables. It is worth mentioning, however, the

presence of a large Portuguese pharmaceutical company, Bial, in the neighbouring municipality of Trofa, which is part of the Ave NUTS III region, even though it is included in the Porto Metropolitan Area.

Finally, Figure 3.39 depicts the structural analysis for the Biotechnology and Agri-Food industry in the Grande Porto region, again sorted by descending sales value. The activity codes discriminated in the graph represent around 90% of the overall sales size, employment and number of establishments.

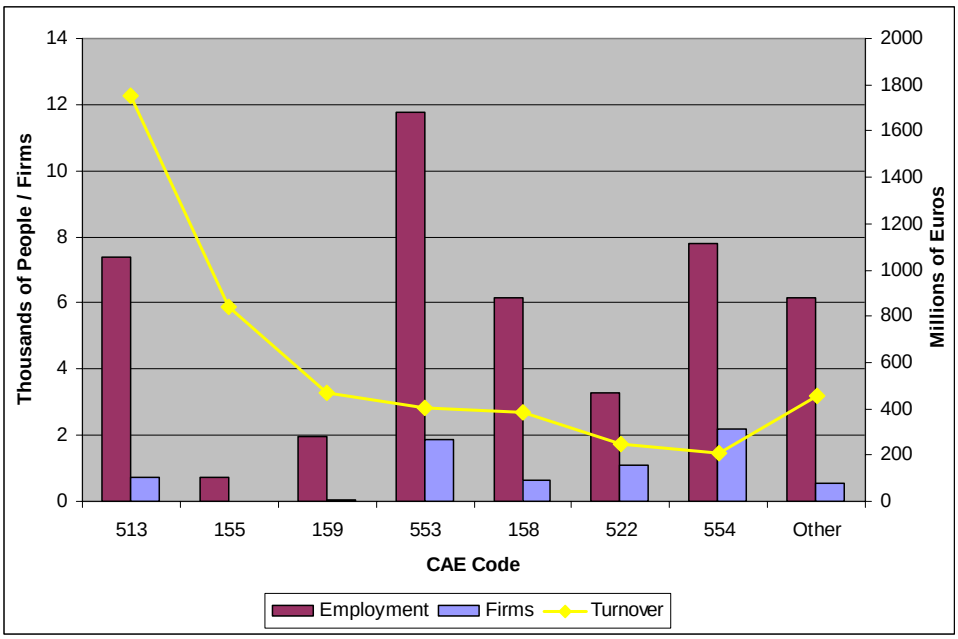


Figure 3.39 – Biotechnology industry structure, in terms of employment, establishments and sales size per economic activity, Grande Porto, 2005

In terms of sales, activity GG513 – Wholesale of food, beverages and tobacco – contributes the most, with almost 37% of the industry's overall value. The other two indicators of this activity are also quite significant: around 7400 people employed across 711 firm establishments. Its retail sale counterpart, GG522, is also part of the list, with the sixth largest sales volume.

In the DA15 area, three activities show up in this chart: DA155 – Manufacture of dairy products, DA159 – Manufacture of beverages, and DA158 – Manufacture of other food products. The first one, DA155, demonstrates a remarkable level of sales and moderate employment, but a very small number of firm establishments (17), which seems to indicate a prevalence of large companies. In addition, this industry has a high

technological sophistication potential in the biotechnology and agri-food area, reason why it is likely to have a substantial R&D expenditure. DA159 – Manufacture of beverages – too has a very relevant presence in the region, with a lower sales size than the previous activity, but a fairly higher employment level. Two main factors immediately come to mind, in this regard. Firstly, the Port Wine industry. Although the wine is mainly produced in the Douro NUTS III region, where the vineyards are located, the wine companies' cellars and management offices are located in Porto and, especially, in Vila Nova de Gaia. Secondly, the existence of a large beer factory in Matosinhos, which is also the headquarters of the Portuguese beer market leader, Unicer. As in the dairy products case, this industry can largely benefit from R&D investment and cutting-edge biotechnology.

The list is closed by HH553 – Restaurants – and HH554 – Beverage shops, which show the highest levels of employment and number of firm establishments, thus having made a great contribution to the CI values previously discussed for the Biotechnology and Agri-Food industry.

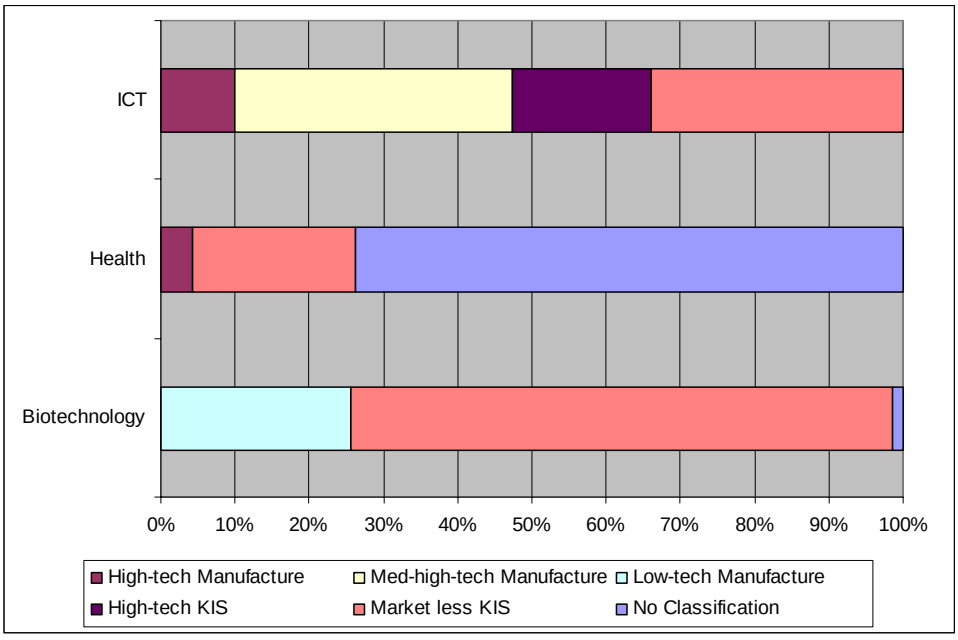


Figure 3.40 – ICT, Health and Biotechnology clusters in Grande Porto, 2005: employment distribution according to Eurostat's technological intensity classification

The Eurostat breaks down manufacture industries and knowledge-intensive services (KIS) into four and three levels of global technological intensity, respectively (Eurostat,

2005). The former are categorised as high-technology, medium-high-technology, medium-low-technology and low-technology industries, while the latter can be high-technology, market or market less KIS.

Figure 3.40 shows the corresponding decomposition of the employment in the ICT, Health and Biotechnology clusters in Grande Porto. According to this perspective, the Biotechnology cluster arises as the least technology-intensive among the three. On the opposite end, the ICT cluster has over 65% of its workforce in either high / medium-high-technology manufacture industries, or high-technology KIS. The results obtained for the Health cluster are less interesting to analyse, in the sense that almost 75% of its employment regards an activity which is not sorted out in this classification (NN851 – Human health activities – as seen above).

3.2.3 Final Remarks

As previously referred in section 2.6, Sternberg and Litzenberger (2004) set the threshold value of the CI to 4.00, for a region to be identified as a potential cluster. One could thus conclude that there are potential ICT, Health and Biotechnology clusters in the Grande Porto NUTS III region, given that the CI values obtained largely exceed this threshold.

Some care must be used when interpreting the results, though, as these high CI values are in part imputable to the encompassing definition used for each cluster, which involved the inclusion of certain activities that are normally abounding, both in employment and number of establishments, in every medium-large metropolitan region, such as Grande Porto. This is, for instance, the case of GG524 – Other retail sale of new goods in specialized stores – in the ICT cluster, NN851 – Human health activities – in the Health cluster, and HH553 – Restaurants – in the Biotechnology industry.

Nevertheless, a few notes are relevant, at this point.

Firstly, as previously referred in section 3.2.1.1, the existence of a prior definition of the Biotechnology and Agri-Food cluster, which clearly appointed the economic activities codes included in it (Malcata, 2006), obliged to the definition of the ICT and Health clusters (for which a prior definition in terms of CAE codes was not available) using a similar criteria. Otherwise, it would not have been possible to work upon clusters of

equivalent scope.

Secondly, the lack of economic activity codes more specifically dedicated to high-tech areas, or, in alternative, of R&D investment information in the Table of Personnel database, forcing the inclusion of CAE codes with a broader and more generic coverage.

Thirdly, the fact that, in a way, it does make sense to include such CAE codes, given that the existence of a cluster calls for the presence of several (or most) of the stages of the production chains, in order to enable vertical disintegration. E.g. if there is an industry of medical devices or pharmaceutical goods manufacture, there must be pharmacies to sell them and physicians to use and prescribe them.

Moreover, Sternberg and Litzenberger mention that the 4.00 threshold value is arbitrary and was selected for their own study's convenience, i.e., so that they could come up with a reasonable number of potential clusters.

3.3 Other Regional Technological Clusters

The previous section has been dedicated to a thorough examination of Grande Porto's existing economic base in the three policy-supported clusters appointed by the North Region Operational Programme (CCDR-N, 2007) to the Norte NUTS II region: ICT, Electronics, and Electrical Machines and Material; Health, Medical Devices and Pharmaceutics; Biotechnology and Agri-Food.

A different look is here taken at the clustering phenomena in the case study region. An attempt to identify other existing technological clusters in Grande Porto is performed, by computing its CI values for all three-digit level industries, for the most recent year for which data was available, 2005.

3.3.1 Methodology

The methodology followed is quite similar to that used in section 3.2.

The same two data sources have been used as an input to the CI calculation: the Table of Personnel database from the DGEEP-MTSS, for the information regarding the firms, establishments and employment, and the Portuguese National Statistics Institute (INE), for the region's area and population data.

The analysis is now restrained to the Grande Porto NUTS III region and to the most

recent year for which data was available, 2005, as a less in-depth and more in-breadth analysis is intended. Whenever appropriate, however, the results may have to be compared with those obtained for the remaining NUTS III regions.

It has already been mentioned that the industries are herein processed at a three-digit CAE level.

As before, the CI expression is provided in Eq. 2.2 in section 2.6.

The Stata source code that implements this methodology is presented in Appendix B.2.

3.3.2 Results

Table 3.5 presents the results obtained for all Grande Porto industries with CI value above 15.00.

The focus of the analysis that follows is set on those industries with both high CI values and significant levels of employment and establishments. Moreover, with some exceptions, those industries carrying a strong burden of traditional or heavy industry, as well as non-knowledge-intensive services, have been left out of the main target of this section. It is true, however, that some of these traditional industries are making a serious effort towards technological modernisation, productivity enhancement and innovation, and thus could also be considered in a study of the regions' technological clusters.

Plus, several economic activities in the table have been previously considered as part of the three policy-supported clusters of the North Region Operational Programme (CCDR-N, 2007) and thus they will not be subjected to further discussion. These activities have been marked with a footnote next to the CAE code.

CAE		Employment		Establishments		CI
		Continental Portugal	Grande Porto	Continental Portugal	Grande Porto	
DN362	Manufacture of jewellery and related articles	2626	1938	490	358	465.2
DJ283	Manufacture of steam generators, except central heating hot water boilers	84	71	6	3	364.6
II634	Activities of other transport agencies	7288	2960	859	332	135.4
DL335	Manufacture of watches and clocks	205	93	15	4	104.4
DL311 *	Manufacture of electric motors, generators and transformers	1635	1029	117	20	92.8
DG243	Manufacture of paints, varnishes and similar coatings, printing ink and mastics	4217	1652	279	62	75.1
DB181	Manufacture of leather clothes	591	150	57	18	69.1
DJ271	Manufacture of basic iron and steel and of ferro-alloys	1006	310	4	1	66.5
DM342	Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers	3389	1378	153	26	59.6
DL313	Manufacture of insulated wire and cable	2737	542	26	9	59.1
DF232	Manufacture of refined petroleum products	2139	703	34	7	58.4
LL753	Compulsory social security activities	1079	614	34	4	57.8
DJ275	Casting of metals	5989	1502	182	48	57.1
DL312	Manufacture of electricity distribution and control apparatus	2499	712	81	18	54.6
DC192	Manufacture of luggage, handbags and the like, saddlery and harness	1411	299	191	53	50.7
MM803	Higher education	6392	1502	108	26	48.8
DL321	Manufacture of electronic valves and tubes and other electronic components	7067	2010	111	22	48.6
DL315	Manufacture of lighting equipment and electric lamps	2118	390	184	56	48.3
DE212	Manufacture of articles of paper and paperboard	6954	1730	356	78	47.0
KK725	Maintenance and repair of office, accounting and computing machinery	903	256	180	34	46.2
DN366	Miscellaneous manufacturing n.e.c.	5425	1349	485	101	44.7
DK294	Manufacture of machine tools	1554	424	100	18	42.4
DL316	Manufacture of electrical equipment n.e.c.	12639	2690	153	35	42.0
DL333	Manufacture of industrial process control equipment	1085	410	70	9	41.9
KK731	Research and experimental development on natural sciences and engineering	1804	436	94	18	39.9
DL334 †	Manufacture of optical instruments and photographic equipment	1379	217	31	9	39.4
GG511	Wholesale on a fee or contract basis	14907	3135	2981	628	38.2
DD202	Manufacture of veneer sheets; manufacture of plywood, laminboard, particle board, …	2462	786	51	7	37.8
II631	Cargo handling and storage	2461	464	121	26	35.0
DK292	Manufacture of other general purpose machinery	11247	2452	688	124	33.9
DN371	Recycling of metal waste and scrap	898	217	89	14	32.8
DK297	Manufacture of domestic appliances n.e.c.	3345	567	67	15	32.7
GG514	Wholesale of household goods	53681	10453	8988	1745	32.6
BB50	Fishing, fish farming and related service activities	7753	1906	978	149	32.3

CAE		Employment		Establishments		CI
		Continental Portugal	Grande Porto	Continental Portugal	Grande Porto	
KK746	Investigation and security activities	33520	7479	455	76	32.2
DG246	Manufacture of other chemical products	2740	656	206	32	32.1
DA152 ‡	Processing and preserving of fish and fish products	4910	1063	123	21	31.9
GG518	Wholesale of machinery, equipment and supplies	24194	4965	3434	605	31.2
GG519	Other wholesale	15301	2881	2536	484	31.0
DB175	Manufacture of other textiles	15529	3517	859	135	30.7
DE222	Printing and service activities related to printing	21837	4366	2096	341	28.1
NN851	Human health activities	60944	11473	9720	1637	27.4
KK742	Architectural and engineering activities and related technical consultancy	20431	3876	3518	585	27.2
DJ274	Manufacture of basic precious and non-ferrous metals	2099	374	92	16	26.7
GG525	Retail sale of second-hand goods in stores	569	104	234	39	26.3
KK744	Advertising	10728	2067	1595	247	25.7
OO927	Other recreational activities	5376	1202	731	96	25.3
DL331	Manufacture of medical and surgical equipment and orthopaedic appliances	2232	347	311	57	24.6
KK748	Miscellaneous business activities n.e.c.	34285	6334	4494	688	24.4
DJ287	Manufacture of other fabricated metal products	18236	2965	1255	211	23.6
MM804	Adult and other education	17556	3043	2584	403	23.3
GG527	Repair of personal and household goods	2751	485	908	130	21.8
KK722	Software consultancy and supply	13943	2079	1364	229	21.6
DM343	Manufacture of parts and accessories for motor vehicles and their engines	16393	2209	227	42	21.5
DG245	Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations	3393	423	177	35	21.3
DE221	Publishing	9994	1818	900	119	20.8
GG503	Sale of motor vehicle parts and accessories	14694	2478	2924	410	20.4
II633	Activities of travel agencies and tour operators; tourist assistance activities n.e.c.	7501	1135	1305	202	20.2
GG515	Wholesale of non-agricultural intermediate products, waste and scrap	37293	6270	5843	813	20.2
JJ652	Other financial intermediation	6943	1045	459	70	19.8
KK747	Industrial cleaning	58531	10192	2277	299	19.7
KK701	Real estate activities with own property	12048	1719	3617	568	19.3
DH251	Manufacture of rubber products	5386	656	126	23	19.2
OO930	Other service activities	30468	4499	10467	1556	18.9
CB145	Other mining and quarrying n.e.c.	196	29	27	4	18.9
KK743	Technical testing and analysis	3134	501	405	55	18.7
KK702	Letting of own property	1325	227	374	47	18.6
DJ285	Treatment and coating of metals; general mechanical engineering	15660	2459	2186	298	18.5

CAE		Employment		Establishments		CI
		Continental Portugal	Grande Porto	Continental Portugal	Grande Porto	
DH252	Manufacture of plastic products	19215	2623	781	121	18.2
HH554	Bars	50342	7811	16016	2171	18.1
OO911	Activities of business, employers' and professional organizations	5272	924	800	95	18.0
HH555	Canteens and catering	15024	2198	1102	156	17.9
JJ651	Monetary intermediation	54367	8105	5020	696	17.8
DI261	Manufacture of glass and glass products	7818	1016	387	61	17.7
KK741	Legal, accounting, book-keeping and auditing activities; tax consultancy; market research and …	60826	8842	13501	1880	17.5
JJ672	Activities auxiliary to insurance and pension funding	5873	894	1693	222	17.2
EE401	Production and distribution of electricity	7778	1284	341	41	17.1
DA159	Manufacture of beverages	11888	1976	493	58	16.9
MM801	Primary education	16960	2574	1957	249	16.7
II632	Other supporting transport activities	12900	1699	468	68	16.5
KK714	Renting of personal and household goods n.e.c.	543	81	250	32	16.5
OO926	Sporting activities	8904	1346	1321	165	16.3
GG524	Other retail sale of new goods in specialized stores	146902	21670	42900	5389	16.0
DM352	Manufacture of railway and tramway locomotives and rolling stock	1709	362	23	2	15.9
KK721	Hardware consultancy	1375	169	247	37	15.9
JJ660	Insurance and pension funding, except compulsory social security	11637	1847	869	100	15.8
II642	Telecommunications	16172	2136	497	68	15.6
GG523	Retail sale of pharmaceutical and medical goods, cosmetic and toilet articles	18935	2716	4139	521	15.6
GG522	Retail sale of food, beverages and tobacco in specialized stores	23452	3277	8794	1103	15.1
GG513	Wholesale of food, beverages and tobacco	51595	7392	5822	711	15.1
DL322	Manufacture of television and radio transmitters and apparatus for line telephony and line telegraphy	982	103	30	5	15.1
KK745	Labour recruitment and provision of personnel	83196	10469	707	98	15.0

Table 3.5 – CI values for three-digit level economic activities in Grande Porto, 2005

[*] Activity previously considered as part of the ICT, Electronics, and Electrical Machines and Material cluster (either partly or as a whole).
[†] Activity previously considered as part of the Health, Medical Devices and Pharmaceutics cluster (either partly or as a whole).
[‡] Activity previously considered as part of the Biotechnology and Agri-Food cluster (either partly or as a whole).

By far, the greatest CI value has been scored by activity DN362 – Manufacture of jewellery and related articles, which presents quite significant levels of employment and number of firm establishments, both in absolute terms (1938 and 358, respectively) and when compared to the continental Portugal totals (nearly three-quarters in each case). In this perspective, there is a noteworthy probability that this activity constitutes a regional cluster.

This high degree of concentration is ascribable, at least in part, to the goldsmiths traditional industry in the municipality of Gondomar.

Although the technological potential of this industry, alone by itself, is rather doubtful, there seems to be some space for other upstream as well as downstream activities to emerge in the production chain. Upstream, for example, technology-intensive activities such as the manufacture of machines, tools or productivity-enhancing software specific for the jewellery industry might have a business opportunity.

In addition, there is an evident potential of combination with the so-called creative industries, which are widely accepted as being of unquestionable interest in every region trying to make its way in the knowledge economy. On the one hand, great benefits in the products sophistication and attractiveness can be derived from the establishment of linkages with companies in the design business. On the other hand, the fashion industry may open new markets and provide valuable partners for innovation and development of new products. This industry shows an appreciable liveliness in Grande Porto, hosting several nationally reputed fashion designers and widely publicised events, and profiting from the proximity of the traditional textile industries, mainly located in other adjacent NUTS III regions. Also, CCDR-N (2007) includes fashion within a cluster of creative industries to be supported by its Priority Line II.

Some critical mass for the formation of a logistics cluster seems to exist in Grande Porto, as leading CI values (comparing to all other NUTS III regions) have been obtained in several related activities: II634 – Activities of other transport agencies (135.4), GG511 – Wholesale on a fee or contract basis (38.2), and II631 – Cargo handling and storage (35.0). Altogether, these industries account for nearly 6600 workers and 1000 firm establishments in the region.

Moreover, several other wholesale CAE codes, some of them also included in the three

policy-supported clusters, are visible in Table 3.5, and the region is equipped with a high-quality, international airport, a fairly large sea harbour, and good road and railway accessibilities.

CCDR-N (2007) also envisions the development of the regional logistics system as a crucial factor for the economic competitiveness of Norte and, in particular, Grande Porto, and for the confirmation of the latter as a logistics node capable of extending its area of influence to the neighbouring Spanish regions of Galicia and Castilla y León.

Other European cities such as Rotterdam and Zaragoza have elected logistics as one of their spearhead clusters (van den Berg *et al.*, 2005; see Table 2.1).

Industry DG243 – Manufacture of paints, varnishes and similar coatings, printing ink and mastics – too exhibits a very high CI value (75.1; Grande Lisboa ranks second with a CI of 15.0), along with a significant employment level (1652) and a reasonable agglomeration of establishments (62), thus suggesting the existence of a cluster already established in this business sector. It encompasses highly sophisticated production processes (in particular, with a strong chemistry engineering component) and so it is likely to involve substantial R&D expenditure amounts.

The list also includes two motor vehicles industry CAE codes, namely DM342 – Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers, and DM343 – Manufacture of parts and accessories for motor vehicles and their engines. The corresponding CI values are 59.6 and 21.5, respectively. Both activities show reasonable numbers of workers and establishments. Not to mention other more common services which are also part of the list, such as the sale of motor vehicles, parts and accessories (GG503), as well as other activities with greater than one but lower than 15.0 CI values (DM341 – Manufacture of motor vehicles, with a 3.7 CI).

It is worth referring that DM343 has also a very strong presence in the neighbouring NUTS III regions of Entre Douro e Vouga and Baixo Vouga, where the overall level of employment in this activity is over 5000, distributed across 46 establishments.

Hence, a cluster in the motor vehicles industry appears to already be in place, both when analysing the Grande Porto NUTS III alone and, especially, when considering a wider geographical area. In this respect, it is also worth mentioning the existence of the Centre of Product Engineering and Development, in the municipality of Maia, a research centre

for the automobile sector which resulted from an international cooperation project with the Galicia region.

Several other activities may be grouped in what could be designated as the media and contents cluster, composed of a workforce of nearly 8400 people and more than 700 firm establishments: DE221 – Publishing, DE222 – Printing and service activities related to printing, KK744 – Advertising, and OO925 – Library, archives, museums and other cultural activities (not listed in the table; CI of 12.0).

In terms of qualified human resources, this industry is (at least partly) supported by several higher education courses in the areas of arts, design, advertising, media and other relevant domains, offered by the University of Porto, the Polytechnic Institute of Porto, and the Catholic University, apart from other smaller schools.

A final note goes to activity KK742 – Architectural and engineering activities and related technical consultancy. Although its CI in Grande Porto (27.2) is well below the value in Grande Lisboa (48.8), this activity presents rather high indicators in terms of the employment (3876) and number of firm establishments (585) in the region.

This is important as a sign of the presence of qualified workers in structural areas for economic development and, in particular, for the creation of new knowledge-intensive firms.

Plus, it draws attention to the architecture industry in Grande Porto. This is a field with a great tradition in the region, as several internationally renowned (and prized) Portuguese architects have come out of the Faculty of Architecture of the University of Porto, by many accepted as the country's leading school in this area. Furthermore, many buildings in the region are frequently used as modern architectural design case studies.

3.3.3 Summary

The results presented in section 3.3.2 are now summarised in Table 3.6.

Cluster	Economic Activities	Employment	Establish.	CI Values[4]	Eurostat Classification	Sophistication Potential	Comments
Jewellery and related articles	DN362	1938	358	465.2	Low-tech Manufacture	Medium [5]	Potential for combination with creative industries, such as design and fashion.
Logistics	II634, GG511, II631, other wholesale codes[6]	6559	986	135.4; 38.2; 35.0	Market less KIS	High	Airport, sea harbour, road and railway accessibilities.
Paints and related articles	DG243	1652	62	75.1	Med/high-tech Manufacture	High	-
Motor vehicles	DM342, DM343	3587	68	59.6; 21.5	Med/high-tech Manufacture	High	Strong presence in neighbouring NUTS III regions, as well.
Media and contents	DE221, DE222, KK744, OO925	8394	716	20.8; 28.1; 25.7; 12.0	Low-tech Manufacture / Market KIS	High	Several related higher education courses available in the region.
Architecture and engineering	KK742	3876	585	27.2	Market KIS	High	Reputed architecture school.

Table 3.6 – Potential regional technological clusters in Grande Porto

[4] Following the same order as in the Economic Activities column.
[5] When considering other upstream and downstream stages.
[6] Not accounted in the Employment, Firms and CI Values columns.

For each potential regional cluster identified, the table presents the codes of the economic activities which are part of the cluster, along with the corresponding CI values, the number of workers and firm establishments, its sophistication potential (i.e., how likely it is to allow for innovations and improvements by means of the use of knowledge and technology), the Eurostat classification in terms of technological intensity of manufacture industries (high-, medium-high-, medium-low-, or low-technology) or knowledge-intensive services (high-technology, market, or market less KIS), and other relevant comments.

Taking a comparative look, the media and contents, and the logistics clusters are the largest in terms of employment and establishments. On the opposite end, the jewellery and the paints industries employ less than 2000 people each. As far as the average firm establishment size is concerned, the motor vehicles cluster presents the highest ratio of workers per establishment, 52.8. Again, the jewellery cluster has the smallest firms, with an average of 5.4 people per establishment. Figure 3.41 provides a graphical, aggregate view of these potential clusters.

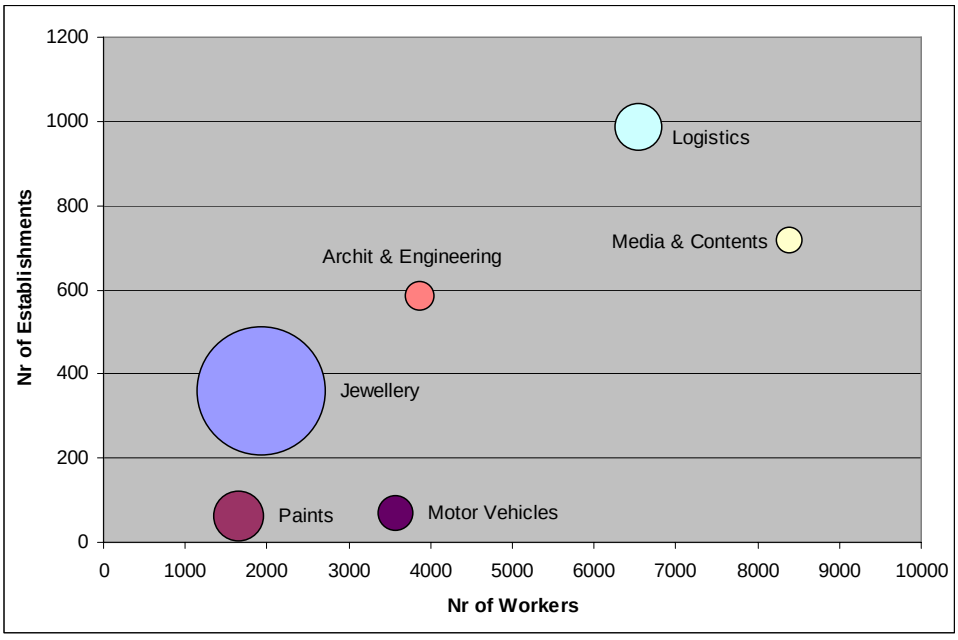


Figure 3.41 – Potential regional clusters in Grande Porto, 2005: employment, number of establishments and CI (size of the bubbles) [7]

[7] The average CI is represented whenever multiple three-digit CAE codes are included.

The jewellery and paints clusters are the ones in which Grande Porto appears to depart the most from the remaining NUTS III areas. Moreover, the region clearly stands out as a national leader in some other economic activities: II634 – Activities of other transport agencies – and GG511 – Wholesale on a fee or contract basis, in the logistics cluster, and DM342 – Manufacture of bodies (coachwork) for motor vehicles; manufacture of trailers and semi-trailers, in the motor vehicles industry.

3.4 Position in the Knowledge Economy

One essential point when assessing the viability of the establishment of technological clusters in the Grande Porto area is to evaluate its readiness to the knowledge economy, i.e., how prepared the region is to embrace and develop (both new and existing) knowledge- and technology-intensive economic activities.

For this purpose, the research framework defined by van den Berg *et al.* (2005) is herein used. As previously described in section 2.7, this framework has been applied to several European cities, such as Munich, Helsinki or Eindhoven, and consists of seven foundations, regarding the existence of organisations, infrastructure and other factors which are said to be necessary for a city to succeed in the knowledge economy, and four core activities, referring to the interaction of organisations in functionally related areas.

The foundations to be analysed are the knowledge base, economic base, quality of life, accessibility, urban diversity, urban scale and social equity. As for the core activities, the following are defined by the framework: attracting and retaining knowledge workers, creating new knowledge, applying new knowledge and making new combinations, and developing new growth clusters.

One by one, the knowledge foundations and core activities of the Grande Porto NUTS III region are discussed in sections 3.4.1 and 3.4.2.

Section 3.4.3 then summarises the results and provides a quantitative evaluation of the region in each of the previous parameters, using a one-to-five scale.

3.4.1 Knowledge Foundations

Several references to figures in section 3.1 are made throughout this section, when evaluating the knowledge foundations of the Grande Porto region.

3.4.1.1 Knowledge Base

The educational level of the population of the region is still relatively low, as shown in Figure 3.5. On the one hand, around 13% have a university degree and 31% have finished at least secondary school. On the other, approximately 45% have no education at all or have completed only primary school, and, in spite of its positive evolution, the illiteracy rate in Grande Porto (5.3%) remains too high when compared to most developed countries (Figure 3.6).

Some visible (albeit non-consensual) political effort is being carried out in order to improve the conditions of public schools, for instance by modernising and expanding their electronic infrastructure. The introduction of English classes in primary school and the emphasis placed on the importance of mathematics knowledge are also positive.

The region is well served in terms of the number and quality of its HEIs, as well as of the variety of education areas available. There is an impressive population of almost 68000 higher education students, representing approximately 60% and 18% of the overall values for Norte and Portugal, respectively. This result is not far from e.g. Helsinki, Finland, an equivalently-sized region where the number of higher education students is of around 84000 (source: van den Berg *et al.*, 2005).

Figure 3.19 depicts the division of students between universities and polytechnic institutes, and between public and non-public schools. It is relevant to mention that a considerable share of students (60%) goes to public HEIs, in which education is rather inexpensive or almost costless for less resourceful students.

The distribution of students per HEI is provided in Table 3.1. The leading role is clearly taken by the University of Porto ('Universidade do Porto'), which hosts over 38% of the overall student population. The share of foreign higher education students in the university is of 6.8%, embracing people from 58 different nationalities (Universidade do Porto, 2007). In 2006, the university was the largest producer of doctoral degrees in Portugal, 206, almost 50 more than the second placed (source: GPEARI).

This public university, which is also the largest HEI in the country, is formed by 14 faculties covering a range of education areas, from architecture and engineering, to medicine or fine arts, and distributed across three main campuses. There is also one business school offering MBA degrees and other business courses. The reputation of the

university is good and its graduates are appreciably valued by the labour market.

The Polytechnic Institute of Porto ('Instituto Politécnico do Porto') comes second in the list, with circa 15000 students. Then, there are several private universities with a few thousand students, from which the Catholic University ('Universidade Católica Portuguesa') is the most reputed.

The University of Porto has 71 research units, of which 8 are State Associate Laboratories, and 36 have been considered either 'Excellent' or 'Very Good' (Universidade do Porto, 2007). Three knowledge fields seem to be particularly strong: exact sciences, health sciences, and engineering and technology sciences.

When analysing the distribution of the higher education students of the region per education area (Figure 3.20), one possible comment is that the shares of students in the fields of social sciences, business and law, and humanities and arts appear to be too high (32% and 10%, respectively). In addition, the percentage of students in science, mathematics and computing (7%) is probably lower than desirable.

Nationwide, the absolute number of ICT graduates per year has evolved from 2502, in school year 1997-98, to 3681, in 2003-04 (source: OCES). As a percentage of the overall number of graduates per year in all education areas, however, there is almost no change (5.8% to 5.9%).

As far as R&D indicators are concerned, the picture is rather negative. As shown in Figure 3.21, R&D expenditure in the Norte NUTS II region is less than one half of that in Lisboa. The difference in the higher education and private non-profit institutions sectors is not as large. It is striking, though, to observe that only 7% of the government's R&D expenditure is applied in Norte, against 79% in Lisboa (Figure 3.22).

Furthermore, in 2003, the level of R&D personnel in Norte as a percentage of its total employment, 0.63%, was quite low comparing to the EU-25 average, 1.5% (source: Eurostat). In absolute terms, headcount amounted to around 11300 people working in R&D, of which 50% related to the higher education sector and 25% to the business enterprise sector.

Regarding the R&D expenditure for every science and technology field, it is noteworthy

that Norte spends a greater percentage of its R&D budget in engineering and technology, and health sciences, in comparison with both Lisboa and the country as a whole (Figure 3.23).

3.4.1.2 Economic Base

Typically, regional economies in which the services sector plays a prominent role are better prepared to the knowledge economy, when compared to more manufacturing-intensive regions. In Grande Porto, tertiary activities represent around 75% of the regions' enterprises, and slightly over 60% in terms of employment (Figure 3.11 and Figure 3.12). This last percentage has increased by approximately 10% in the 1998-2004 period (Figure 3.13), which is a quite significant evolution.

The economy of the region exhibits a reasonable diversity (Figure 3.14), not being excessively dependent on any particular sector and thus being less vulnerable to downturns in any particular industry. Nevertheless, some leading firms do exist and make a considerable difference. This is the case of, for instance: Sonae, one of the largest Portuguese economic groups, with companies in several business areas, from telecommunications to hypermarkets; EFACEC (also Portuguese), best known for its manufacture of electric motors and transformers, though it is also present in many other areas; or Qimonda, a MNC in the manufacture of computer memories industry, which is one of the biggest exporters in Portugal.

The region has the burden of a few traditional, labour-intensive sectors, such as the manufacture of textiles and of metal products (Figure 3.14). Sooner or later, these jobs will be replaced by positions in more value-added, knowledge-intensive activities, should the region actually embrace the knowledge economy.

Grande Porto accounted for nearly 12% of Portugal's GDP, in 2004 (Figure 3.7 and Figure 3.8). In the preceding decade, however, there was a stark negative departure from the average in the EU, in terms of Purchasing Power Parities per inhabitant (Figure 3.9).

Traditionally, the Norte region has always demonstrated a great propensity for international trade. This is visible in Figure 3.15, which shows that Norte's total departures represent nearly 43% of the country's overall value (while hosting only 35%

of its population). Grande Porto contributes with almost 33% of Norte's departures. Further detail on these topics can be found in Figure 3.15 to Figure 3.18.

3.4.1.3 Quality of Life

The capital city of the region, Porto, is usually seen as a romantic, attractive place, its historical centre having been declared UNESCO World Heritage since 1996.

Sport facilities are plentiful and the cultural agenda of the region is quite complete in terms of music concerts, art exhibitions, museums, libraries, popular activities, cinema or theatre, seemingly lacking no metropolitan amenities. The region has benefited from the fact that Porto has been one of the European Capitals of Culture in 2001. In light of this event, several public spaces and gardens were renovated, and a world-class concert hall, Casa da Música, was built in Porto, among many other initiatives.

With its singular gardens and Museum of Modern Art, the Serralves Foundation is a success story, both in terms of popular participation and of the quality of its exhibitions, workshops and other activities.

Since some years ago, the City Hall of Porto has been pursuing a policy of bringing into town international events with great visibility and capability of attracting large hordes of tourists. This is the case of the Historic Grand Prix and of the World Touring Car Championship, in the old urban circuit of Boavista, as well as of the Red Bull Air Race, over the Douro River. In addition, Porto was one the main cities hosting the European Cup of Football, which took place in Portugal in 2004.

There is a relatively large city park in Porto, and some other smaller ones across the region. Pleasant walkways can be found along a considerable part of the region's sea front. Plus, the surrounding regions also offer a lot of places where to spend enjoyable time. Several important cities can be reached within a one hour drive (see section 3.4.1.4). The same can be said regarding the countryside.

The common opinion on Portuguese public services, such as hospitals, health centres and elderly care, is not positive. The network of public child day care centres has been expanding over the years, but it is still insufficient.

It is relatively safe to work and live in Grande Porto, but this topic is more adequately targeted in section 3.4.1.7. Nevertheless, it should be herein seen as a positive point.

Mobility within the region is a negative point when it comes to quality of life, due to traffic issues, on the one hand, and to insufficient public transportation coverage in the fringe, on the other hand. The following section addresses this issue in more detail.

House prices and rents are significantly higher in the city of Porto than in the rest of the region, but quite smaller comparatively to Grande Lisboa or other European locations.

The climate of the Grande Porto region is temperate.

3.4.1.4 Accessibility

Grande Porto has a high-quality international airport, fully renovated and enlarged recently, situated at a distance of just 20 kilometres from the centre of the city of Porto, and connecting to all major national and European destinations, as well as some in other continents. Although it does not provide as many direct flights as does the Lisboa airport, it seems to be well adjusted to the region's needs. Plus, for some years now, it has got into the map of some low-cost air companies. In 2004, the airport had a capacity of 3000 passengers per hour and has served almost 3 million passengers, but there are plans to expand it until 25 million passengers per year (sources: INE; CCDR-N, 2006).

The largest sea harbour of the northwest of the Iberian Peninsula is located in the municipality of Matosinhos, not very far from the airport. The Leixões harbour ranks second in the country, in terms of loaded and unloaded goods (approximately 13.3 million tons in 2005), as well as of containers (over 230 thousand in 2005) (source: INE). The volume of passengers traffic, however, is negligible. A proposal to build a terminal for large cruises has been announced by the port administration, but it is likely to be a long-term project.

Concerning road accessibility, the Grande Porto area is well linked to basically every neighbouring region or urban centre, as well as to the major Spanish and European routes. There are motorways providing less than one hour drive access to Braga, Guimarães, Vila Real, Aveiro, or Vigo (in the Spanish region of Galicia), thus providing important connections to several knowledge centres with complementary strengths: the University of Minho, in Braga and Guimarães, the University of Trás-os-Montes e Alto-Douro, in Vila Real, and the University of Aveiro. Considering a wider ring, cities like Lisboa, Coimbra, Santiago de Compostela, or La Coruña are within a three-hour range.

Railroad accessibility can be considered relatively good along the north-south direction, since fast train links are available to e.g. Braga, Aveiro and Lisboa, but rather poor when it comes to the midland. The High-Speed-Train (HST) project, which can significantly improve the region's railroad accessibility in the upcoming years, is one of the main political flagships of the current government executive, but there is still a long path ahead. At this point, two lines appear to be relatively more stabilised: Madrid-Lisboa and Lisboa-Porto.

In terms of intra-regional mobility, the road infrastructure is equally good, but severe traffic bottlenecks do exist. Part of the problem appears to be the excessive usage of private automobile, as a result from the insufficient quality of public transportation: it is relatively efficient in Porto and its closest surroundings, but less adequate in the fringe. The tram system has been launched some years ago and has had a very positive impact on intra-regional accessibility. There are several expansion projects, some of which will start during the next year. The metro lines covers two of the three campuses of the University of Porto, but all three are very well served by buses. There is also a line going from the international airport to the centre of Porto.

The region is suited with a modern, high-speed telecommunications infrastructure. All major HEIs and research institutes, as well as many homes and companies, are linked with broadband connections.

The peripheral location of the country and, thus, of the region in the European context should be noted as a somewhat negative point.

3.4.1.5 Urban Diversity

The percentage of foreign workers is still rather low, representing only 2.9% of the overall labour force, according to the DGEEP-MTSS Table of Personnel database. Furthermore, the majority of these workers has low qualifications.

As depicted in Figure 3.42, the leading country in this regard is Brazil. As in the case of the African countries of Portuguese language, Cape Verde, Angola and Guinea-Bissau, Brazilian immigrants have a low educational level. Ukrainian people, which come in third place in the chart, typically have completed higher education, but paradoxically most are hired to do unskilled work.

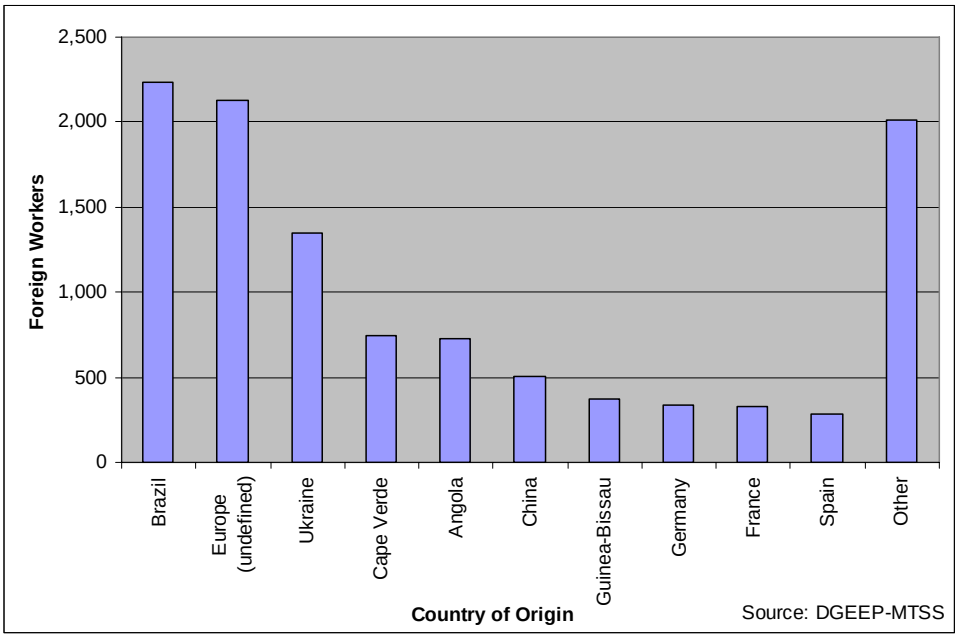


Figure 3.42 – Grande Porto foreign workers, per country of origin, 2005

It has already been mentioned (in section 3.4.1.1), however, that the share of foreign higher education students in the leading university of the region, the University of Porto, is of 6.8%, hence significantly greater than the equivalent value within the region's workforce (Universidade do Porto, 2007).

3.4.1.6 Urban Scale

The urban scale of Grande Porto is appropriate. Its medium-sized population of nearly 1.3 million inhabitants is concentrated in a relatively small area, thus yielding the highest population density among all Portuguese NUTS III regions. It is a large scale when compared with all the other Portuguese continental NUTS III regions (except for Grande Lisboa), but only a small/medium one relative to the major European areas. Nevertheless, this is an adequate scale for the region to have all common metropolitan amenities and infrastructure, which are needed for the knowledge economy to prosper.

Moreover, Grande Porto is part of the wider Norte NUTS II region, whose total population is of more than 3.7 million, mostly located within a 100 kilometre range around the city of Porto. This is a significant, appealing market, in a relatively limited area. Plus, academic and business critical mass may be achieved faster by means of cooperation, and networking with neighbouring cities is perfectly possible. It is also

worth mentioning that these opportunities are further augmented by considering the geographical and cultural proximity of the Galicia region. Altogether, Norte and Galicia represent a potential market of 6 million inhabitants (CCDR-N, 2006).

3.4.1.7 Social Equity

Social equity in Grande Porto is poor, as it is in the rest of the country.

The unemployment level is currently high, when compared to the past twenty years, especially in the Norte region: 9.4% in the second quarter of 2007, of which 53% was long-term unemployment (Figure 3.10).

Portugal's at-risk-of-poverty rate in 2005 was of 26% and 20%, before and after social transfers, respectively (source: Eurostat). In the country with the lowest rate after social transfers, Sweden, the equivalent values are of 29% and 9%, indicating a much stronger social security system. The EU-25 average values are 26% and 16%.

In general, the whole region is quite secure and so is the country. In 2007 Portugal was ranked as the ninth most peaceful country in the world by the Global Peace Index. Citizens can drive, use public transportation or walk safely almost everywhere, with a relatively low risk of being robbed or attacked. However, there are several problem neighbourhoods in the city of Porto, as well as in its surroundings, with relevant rates of drug addiction and crime, and some violence.

It has already been mentioned in section 3.4.1.5 that there is still a rather low immigration rate, and that most of the region's foreign workforce has a low educational level. This is considered to be a negative factor for social equity, since the integration of this type of immigrants in society tends to be more painful.

3.4.2 Knowledge Core Activities

In order to analyse the knowledge core activities of the Grande Porto region, it was necessary to make use of several types of data sources.

Therefore, adding up to the discussion concerning the knowledge foundations, which has taken place in the previous sections, much information has been absorbed from all kinds of reports, policy documents, websites of relevant organisations, seminars, newspapers and magazines, and, most of all, from the face-to-face interviews carried

out with a set of relevant regional actors.

3.4.2.1 Attracting and Retaining Knowledge Workers

The analysis regarding this core activity is herein divided between students and graduate knowledge workers, as they seem to be quite different.

Concerning the former, the capacity of Grande Porto is reasonably good. This is the leading NUTS III region within Norte and thus acts as a natural magnet for its higher education students. Approximately 6.8% of the students of its largest HEI, the University of Porto, are foreign citizens, and there are cooperation protocols with more than 500 foreign HEIs (Universidade do Porto, 2007). The capacity to attract students from other nationalities could be improved, should the region's HEIs be more internationally oriented, e.g. by providing English language lessons, which are still rare or inexistent. This is somewhat overcome by the fact that most professors and students are reasonably fluent English speakers, thereby easing the integration of foreign people.

Two other issues may come to have a positive impact in the capacity of the region to attract foreign students. First, the so-called Bologna Process, which aims to homogenise the various levels of higher education courses in the whole EU, thus facilitating the mobility of students between countries. Second, the national government is preparing the foreign student statute. Currently, students can only apply for Portuguese undergraduate courses in case they have completed Portuguese secondary school and gone through the normal, university-admission specific exams. This statute will define an alternative process for undergraduate courses application, so that foreign students which have missed this process are also eligible.

The university targets for a 20% annual growth in the number of foreign students.

There are nine university halls with a capacity of around 7% of the university's total number of undergraduate students, which seems to represent a rather low coverage. Furthermore, in general, this is only moderate quality, low cost housing, almost exclusively destined for less resourceful, socially-assisted students. The university relies upon the private housing and renting market in order to complement its insufficient offer. In any case, two relevant measures are being planned in order to attain some improvements in this regard. Firstly, the creation of an accommodation office within the

university, which is intended to act as a housing agent for its students. Secondly, the establishment of public-private partnerships, in which the private entity builds up student residences in land properties belonging to the university. The private builder then has to pay a rent to the university and is allowed to accommodate students at price levels previously agreed with the university.

With respect to the attraction of graduate knowledge workers, the capacity of the region is somewhat lower. The same goes for its ability to retain the students who graduate in the region. The main reason seems to be the relatively small market of skilled labour. Knowledge workers tend to find a suitable job fairly easier in the Lisboa region, and many even choose to emigrate to other more developed countries.

Immigration into Grande Porto is still quite limited in number, and is typically composed of people with a low educational level, as discussed in section 3.4.1.5. It has also been said before that the educational level of the region's population is rather low, 45% of it having no education at all or having completed only primary school. This too can be considered as a negative input into the region's capacity to pull in knowledge workers, who are normally attracted by highly qualified environments.

In terms of research, the number of high quality investigation units in the region is a positive point. In addition, the Fraunhofer Institut, one of the largest research institutes in Germany, responsible for e.g. the invention of the MP3 audio compression algorithm, has recently decided to establish a new centre in Porto, within own premises.

Overall, the quality of life in the region can be considered as a positive contributor for its attractiveness for knowledge workers. As described in section 3.4.1.3, some of its strengths are its metropolitan amenities, green and open-air spaces, safety, and climate.

The region is reasonably well known abroad, one of its main symbols being the Port Wine industry. Despite its peripheral location within Europe, the international accessibility is fairly good, especially when flying from the main European airport hubs.

As a final remark, it is noteworthy that Portugal has recently been ranked second in the Migrant Integration Policy Index (MIPEX), which assesses policies to integrate migrants across 25 EU Member States and three non-EU countries.

3.4.2.2 Creating New Knowledge

The knowledge base of the region, which is the most important foundation for this activity, is fairly good in terms of quantity, quality and diversity of HEIs and research organisations. Much having already been said on this, more detailed insight can now be provided into the knowledge creation activities of some of the region's most reputed research institutes, within two of its stronger disciplines: health sciences, and engineering and technology sciences.

In the field of health sciences, there are two State Associate Laboratories. On the one hand, the Institute of Molecular Pathology and Immunology of the University of Porto, IPATIMUP, carries out research in several types of cancer and provides diagnostics services in the fields of pathology, oncobiology and population genetics. About 120 Portuguese and foreign researchers work at the institute, half of whom hold a PhD (sources: IPATIMUP website; IPATIMUP, 2006).

On the other hand, there is the IBMC-INEB partnership, composed of the Institute for Molecular and Cell Biology (IBMC) and the Institute for Biomedical Engineering (INEB). The former conducts research in human genetics and genetic disorders, biology of infection and immunology, structural and molecular biology, basic and clinical neurobiology, and cell adaptive mechanisms. The latter, INEB, focuses on the fields of biomaterials, and biomedical signal and image. Altogether, the headcount of these institutes is of 185 researchers holding a PhD and 190 research students (sources: IBMC, INEB and MCTES websites).

Currently, a new joint research organisation, the I^3S – Institute for Investigation and Innovation in Health Sciences – is being established by IPATIMUP, IBMC and INEB. The purpose of the I^3S is to attain a significantly higher level of critical mass and to obtain operational synergies. It is still not clear what legal instrument shall be adopted in order to materialise this union. However, it is not irrelevant to note that the government has announced a reform of the State Laboratories, which encompasses the creation of consortiums between laboratories, universities and other entities.

Moving on to the field of engineering and technology sciences, two of the most active research units are the Institute for Systems and Computer Engineering of Porto, INESC Porto, and the Institute of Mechanical Engineering and Industrial Management, INEGI.

INESC Porto is more closely related to the areas of electrical engineering and computer science. It is split into five main vertical research units – power systems, telecommunications and multimedia, optoelectronics, information and communications, and manufacturing – and one horizontal innovation and technology transfer unit. There are nearly 275 people working at the institute and one-fifth of its annual budget comes from services sales (Mendonça, 2007).

INEGI has more than 100 people operating in the area of mechanical engineering and industrial management, and 50 other academics who regularly collaborate with the institute. Its three main activities are research, innovation and technology transfer, scientific and technological consultancy, and training. Financially, R&D projects with firms represent over 50% of INEGI's turnover, which is a quite significant indicator of its tight linkages with the business sector. This fact is further reinforced by the presence of more than 40 companies among the institute's shareholders (source: INEGI website).

Regarding the establishment of the new research centre from the German Fraunhofer Institut, its main focus will be the development of advanced ICT applications that are intended to create life-enhancing environments to the overall population, and news ways of accessing such technologies. The benefits to be obtained by the region are, at least, three-fold. Firstly, the Fraunhofer Institut will be a major, world-wide renowned contributor to the capacity of the region to attract and retain highly skilled researchers. Secondly, linkages are very likely to be established with other knowledge organisations from all over Germany. These linkages are covered in the agreement with the Fraunhofer Institut, in particular concerning the fields of logistics, biotechnology and nanotechnology, and the development of new products for the motor vehicles and aeronautics industry. Thirdly, the presence of the centre may trigger the formation of spin-offs and other firms in its main fields of research.

One negative aspect that is usually referred with respect to the University of Porto concerns its insufficient operation as a whole. All the 14 faculties of the university appear to be excessively independent, lacking cooperation between them. This is reflected, for instance, in the small number of inter-disciplinary courses which are jointly offered by more than one faculty. The Dean Office of the university is well aware of this and is devoting significant effort to changing procedures and behaviours.

The Ministry of Science, Technology, and Higher Education has recently launched a programme with the objective of hiring 1000 researchers holding a PhD to Portuguese scientific organisations. The HEIs and research institutes in the Grande Porto area are thus likely to also benefit from this initiative.

In addition, the national government is currently running some very important cooperation initiatives with foreign HEIs, especially American universities. The two most relevant cases are the MIT-Portugal, CMU-Portugal and UT Austin-Portugal Programmes, which are based on post-graduation courses and doctoral programs jointly provided by Portuguese HEIs and by the Massachusetts Institute of Technology, Carnegie Mellon University, and University of Texas at Austin, respectively.

The University of Porto has an active participation in some areas of these programmes. Regarding the cooperation with the MIT, the university takes part in three main fields: Engineering Design and Advanced Manufacturing, Sustainable Energy Systems, and Transportation Systems.

Within the CMU-Portugal Programme, the university is one of the partners of the doctoral dual degree programmes in Electrical and Computer Engineering and in Computer Science. It is also noteworthy that, in the case of the latter doctoral programme, the Universities of Porto, Aveiro and Minho themselves will cooperate and act together as a single Portuguese partner of the programme.

Last but not the least, the University of Porto is involved in the UT Austin-Portugal Programme, in the areas of Digital Media and Advanced Computing (the university also takes part in the UTEN project, University Technology Enterprise Network, more directed at the technology transfer issue and thus presented in the following section). The Digital Media cooperation is particularly interesting, in the sense that it promotes the combination of several quite different knowledge fields, having the participation of the Faculties of Engineering, Fine Arts, Humanities and Economics of the University of Porto, as well as of INESC Porto. In addition, it is relevant to mention the presence of some important institutions of the region, such as the Casa da Música concert hall, the Serralves Foundation, and Porto Editora (one of the country's leading book editors), among the cultural and industrial affiliates of the UT Austin-Portugal Programme.

Although the present dynamics of the region in terms of political agenda and mindset

change towards the crucial importance of knowledge, technology and innovation are very positive, the R&D key indicators of the country are still among the worst within developed economies. Adding up to the very negative R&D expenditure and personnel values already discussed in sections 3.1 and 3.4.1.1, the number of patent applications to the European Patent Office (EPO) per million inhabitants was of only 4.8 in 2002, an insignificant value when compared to the top EU-27 country, Finland, with 306.6.

3.4.2.3 Applying New Knowledge and Making New Combinations

It is not unusual to hear that research activities in Portugal have, most of the times, no visible, practical follow-up, i.e., HEIs and research institutions are reasonably good in creating new knowledge, but they lack the necessary skills and culture to transform it into valuable applications: new products, manufacture processes, etc.

The country appears to be quite behind when it comes to the level of cooperation between knowledge organisations and firms. Several causes can be pointed out for this. Firstly, academics and researchers are normally seen as people who live in their own, closed world, with no serious concern for what the companies really need. For a long time, working with the business sector has been considered only a minor importance task among the academic community. Secondly, Portuguese knowledge institutions have expanded over the years based on a growing public funding for R&D, thereby having no real need to pursue knowledge economic valuation. Thirdly, for a long time, firms have lacked the appropriate interlocutors with the academic side, as most of the companies had no skilled contact points capable of posing problems that are suitable to be tackled by HEIs or research institutes (typically, issues to be solved in the medium/long-term). Hence, the demand of firms for R&D services was also quite low.

Nowadays, technology transfer and knowledge economic valuation are definitely becoming a major concern among the main knowledge institutions of the region. Some positive indicators are, for instance, the recently established Innovation and Technology Transfer Unit, at INESC Porto, and the research, development and innovation department of the University of Porto. Alternatively, the I^3S new health sciences research institute plans to make use of the much stronger competences of other European partners in this area. In 2005, the Universities of Porto, Minho, Aveiro and the Catholic University, along with four other public and private shareholders, have

created Ciencinvest, a company whose aim is to get together the academic and business worlds, by identifying economically valuable research results, investing in seed capital, assuring the credibility of new firms, and profiting from that process. Most importantly, a mindset change seems to be taking place within academics and researchers.

Simultaneously, firms had to carry out a technological evolution and hire qualified people, in order to face the new challenges brought in by globalisation. They have now a better preparation to establish a prolific dialogue with the knowledge organisations.

There are many other entities that provide help to entrepreneurs when going into business. NET, S.A., for instance, is the local Business and Innovation Centre (BIC), whose main objectives are to promote the entrepreneurial attitude of the region, support both the creation of new innovative firms and the expansion of existing SMEs to new activities, and push technology transfer. Several services are provided by NET, such as the development of management capabilities, assistance with the preparation of business plans, access to funding, and commercial, marketing and juridical consultancy.

COTEC Portugal, on the other hand, has a country-wide scope, even though it is headquartered in Porto. Its mission is to foster the competitiveness of firms established in Portugal, via the assumption of innovation and knowledge as crucial resources. “Sustained Development of Company Innovation” and “Innovation for Growth” are two of its currently ongoing initiatives.

Similarly, AEP – the Portuguese Business Association – and ANJE – the National Young Entrepreneurs Association – are noteworthy, Porto-based entities when it comes to stimulating and supporting entrepreneurship in the country, albeit with a not as strong emphasis in technology and innovation as the previous ones. AEP, in particular, provides several types of horizontal (rather than sector-specific) services to its more than 3000 affiliates, such as training in business administration and other tailored courses (in partnership with the Portuguese Catholic University), organisation of entrepreneurial missions to foreign countries, and trade fairs.

Porto also hosts the main offices of two government institutions with a national reach: IAPMEI – the Institute for Support of SMEs and Innovation – and AICEP – the Portuguese Agency for Foreign Investment and Trade.

The former supports firms by intervening in areas such as institutional facilitation,

incentives to investment, and entrepreneurial dynamics and innovation. This includes, for example, the 'On the Spot Firm' service ('Empresa na Hora'), which enables the creation of firms in a single moment and government department.

As for the latter, it resulted from the recent merger of two other institutions from the Portuguese Ministry for the Economy and Innovation: the Portuguese Agency for Investment (API), and the Portuguese Institute for Foreign Trade (ICEP). Its goals are mainly twofold, not only to support and ease large investments and companies, and to capture FDI to Portugal, but also to provide assistance to the internationalisation of Portuguese SMEs.

The region suffers from a considerable delay regarding the topic of Science and Technology Parks. Since its official opening in 2001, Tecmaia is still the only fully operational Park in the Grande Porto region. It is located in the industrial district of the municipality of Maia, in the premises that were formerly occupied by the Texas Instruments / Samsung factory, prior to their decision to delocalise. Besides the office space itself, the Park offers a wide range of services to its tenants, e.g.: reception, canteen, communications, security and leisure spaces. In addition, the Park acts as a facilitator for other services such as juridical or intellectual property consultancies, bringing together its tenants and specialised external providers. Presently, Tecmaia hosts 42 businesses, of which 27% are in the ICT sector. The objective, however, is to grow to 200 companies and 2000 people working in the Park in 2012.

The Porto Science and Technology Park Association (APCTP) has had a rather problematic history over the last 15 years, since its establishment. This project appears to have been negatively sentenced since its beginning, the main reason for this being reasonably consensual: the decision to create three small Parks in Grande Porto and surrounding regions, rather than a single, large Park, thereby leading to the dispersion of the available resources, loss of scale economies, and several other difficulties.

Had it succeeded as initially planned, the three Parks would have been built in the municipalities of Maia (Grande Porto NUTS III), Santa Maria da Feira (Entre Douro e Vouga), and Taipas (Ave). The first one was stopped in 1997, due to the change of the location decision of a MNC which was expected to act as the anchor firm of the Park. Instead, APCTP currently holds a minority position in Tecmaia. The remaining poles of

the project, Santa Maria da Feira and Taipas, are now being handled by two private firms, Portuspark and Avepark, respectively, but none is in operation yet, albeit the latter is in a more advanced stage than the former. The City Hall of Santa Maria da Feira and the University of Aveiro have minor participations in Portuspark (the largest shareholder is Parque-Invest, a private company held by AEP), while the City Hall of Guimarães and the University of Minho are the major shareholders of Avepark.

More recently, APCTP and the University of Porto have created UPTEC, a business incubator for technology-based start-ups originated in the university. It is already operating in the Asprela campus, even though still in temporary premises.

In the preceding years, a project for another incubator for NTBFs, SOGIST, did not go as expected. Among its shareholders were the University of Porto and the Polytechnic Institute of Porto. No specific reasons for this failure could be determined.

It should be mentioned that INESC Porto also provides its own pre-incubation support to the new firms spun-off from the institute that request it.

Finally, the INSerralves project of the Serralves Foundation aims at setting up an incubator for new firms in creative industries.

One of the Priority Lines of the Operational Programme for the Norte Region, 2007-2013 (CCDR-N, 2007) targets the development of the network of Science and Technology Parks of the Norte region (among other Specific Objectives). This essential document is analysed in more detail in the following section.

The technology transfer, knowledge economic valuation and Science and Technology Parks issues are also addressed by the University Technology Enterprise Network (UTEN) project, which is part of the UT Austin-Portugal Programme. UTEN is a consortium of several Portuguese knowledge institutions (in particular their technology transfer offices and Science Parks), with the University of Texas at Austin's IC^2 Institute. The main goals of the project are, on the one hand, to develop the country's capacity of transferring knowledge into business applications, as well as its entrepreneurial skills, using a more holistic approach based on coordinating the activities across all the participating entities, and, on the other hand, to enhance the access of Portuguese technology to the US and other international markets. The Portuguese partners in the Grande Porto region are the University of Porto, including

INESC Porto, the UPTEC incubator and the university's technology transfer office, and the Higher School of Biotechnology of the Portuguese Catholic University.

In terms of the availability of capital, this is not considered to be a major issue. Although venture capital societies and business angels are not very numerous, there is no lack of money to support good projects, with a credible, sustained business plan, and appropriate market assessments. The problem is that these are not as abundant as desirable. Within the virtuous triangle of technology, capital and management skills, the latter seems to be deficient. Taking into account that there are good management and business schools in Grande Porto (e.g. the Faculty of Economics and Porto Management School, in the University of Porto, along with the Catholic University), this might indicate an insufficient involvement of the existing management-enabled human resources in the technology-based business projects of the region.

There are some differences in the way that the region's knowledge organisations handle intellectual property issues. Two different examples can be provided. On the one hand, the University of Porto owns the intellectual property of all the research carried out within its premises, and thus of the corresponding patent applications (assuming all the risk of investing money in a worthless patent). In case a given patent turns out to be profitable, e.g. by being sold to a third party or to a spin-off created by the researcher himself/herself, 65% of the earnings go to the researcher and the remainder goes to the university. On the other hand, INESC Porto does not prevent its researchers from creating new companies in order to exploit the competences, technologies or products developed by themselves while working in the Institute. It is assumed that this is part of the mission of the Institute, as a public utility institution. The start-ups originated in the Institute are considered either spin-offs or spin-outs, depending on whether INESC Porto is or is not a shareholder of the new firm, respectively. The participation of the Institute in the former may be financial or take the form of intellectual property transferring.

As far as red tape facilitating policies are concerned, they represent one of the main flagships of the current national government. Since 2006, hundreds of individual measures on all levels are being carried out (many have already finished) under the 'Simplex' umbrella programme, and have contributed to the enhancement of the

entrepreneurial environment of the country. This is the case of e.g. the availability of industrial property information in the Internet (firm brands and patents, for instance), the possibility for businesses to declare their yearly financial reports electronically, and the creation of the 'On the Spot Firm' service ('Empresa na Hora'), which has already been mentioned above.

3.4.2.4 Developing New Growth Clusters

Over the last couple of years, the formation of clusters and networks of firms, research institutes and universities has become a hot issue in the political agenda.

A crucial document in this regard is the Operational Programme for the Norte Region, 2007-2013 (CCDR-N, 2007). This document has been prepared by the Norte Regional Coordination and Development Commission (CCDR-N, a decentralised institution of the Portuguese Ministry for Environment, Spatial Planning and Regional Development) and lays the foundation for how the National Strategic Reference Framework (which sets the frame for the application of the EU economic and social cohesion policy in Portugal, in the 2007-2013 period) will actually be implemented in the Norte region.

When analysing the regional economy, the Operational Programme identifies three main clusters of emerging, technology-based activities, with the potential of having a leading role in the future economic development of the region, and in which it is said to have a significant capacity to educate highly-skilled people and carry out R&D projects:

- ICT, Electronics, and Electrical Machines and Material;
- Health, Medical Devices and Pharmaceutics;
- Biotechnology and Agri-Food.

Of all the three, the Health, Medical Devices and Pharmaceutics cluster appears to be in the most advanced stage, regarding the level of involvement and consciousness of all parties to the necessity to operate as a network, and the effort put in by CCDR-N, itself, to promote it and provide all the required institutional support.

In fact, CCDR-N has held a conference in Porto, in October 2007, to present and debate the 'Health Competitiveness and Technology Cluster' project for the Norte region. It has become clear, then, that the regional actors operating in these areas are deeply

committed to the project, be they companies, research institutes, universities, or governmental entities. High representatives (the highest ones, in most of the cases) of the Universities of Porto and Minho, the IPATIMUP, IBMC and INEB research institutes, firms and associations such as Bial (a large Portuguese pharmaceutical company, whose President is seen by many as the natural leader of the project) and the Medical Devices and Pharmaceutics Group, the AICEP agency and the national government's Technological Plan, among others, took part in the conference and expressed their strong belief in the success of the project, even though these are considered more like a formalisation of the cluster that had already been developing for the past decade or so. Moreover, it has been assumed that the project will proceed, either with or without public funding support. Several international benchmarks in this area are already being analysed, with visits being carried out to the sites themselves, in order to capture and learn the best practices.

Three main fields have been pointed out as strategic for this cluster: well-being and ageing; diseases; and e-health. The cluster also encompasses the renovation of traditional economic sectors, e.g. some firms in the textiles industry, that are now targeting the medical devices business by developing innovative products.

In the near future, the Health cluster is likely to have a main office established in Porto, which will act as a facilitator and promoter of its own development. Though the cluster is centred in the Norte region, it is important to say that its goals and scope are national, i.e., it is of everyone's interest that other valuable actors from outside the Norte region enter the network. This is the case of, for example, the Institute of Molecular Medicine, in Lisboa, and the Centre for Neuroscience and Cell Biology, in Coimbra, which were among the initial founders of the project.

The presence of these policy-supported clusters in the more restricted area of Grande Porto has been thoroughly analysed in section 3.2. The results then presented confirm the high level of concentration of all the three in the region, even though rather broad definitions of the clusters had to be used. Also, during the 1995-2005 time frame, the ICT and Biotechnology clusters became less concentrated in Grande Porto, whereas the Health cluster showed a considerable increase in the level of agglomeration (Table 3.4).

The Operational Programme is then structured across six Priority Lines, of which the

first – 'Competitiveness, Innovation and Knowledge' – is of particular interest to the present subject. Within this Line, there is one Objective specifically concerning the creation and consolidation of emerging clusters, especially the three main ones referred above, the potential combinations between them, and the creation of networks of firms connected to R&D centres and of advanced training and technological centres. All of this, taking into account the existing business and academic foundations in each area and their geographical distributions. For this purpose, this Specific Objective explicitly encompasses the promotion of technology-based entrepreneurship in those very same areas, in order to push technology transfer and knowledge economic valuation, as well as of institutions to provide assistance in those processes.

A second but also very relevant Objective of Priority Line I is the promotion of actions for collective entrepreneurial development, such as the implementation of technologies to assist the formation and operation of networks of firms.

Thirdly, there is a Specific Objective regarding the development of a network of Science and Technology Parks, which are expected to help in the interoperation between firms and knowledge institutions.

An impressive EU funding of almost 800 million euros (European Regional Development Fund) has been assigned to this Priority Line in the Operational Programme for the Norte Region.

It is worth noting, as well, that Priority Line II – 'Economic Valuation of Specific Resources' – also identifies typologies of actions aimed, on the one hand, at the development of a cluster of creative industries, such as the production of cultural contents, design, video, photography, fashion, artistic production, cinema and architecture, and, on the other hand, at the support to the organisation of large cultural events, as a means to internationalise such a cluster.

In terms of national policy, the Technological Plan is one of the government's most emblematic programmes, gathering under the same umbrella a wide range of initiatives in many different areas, with the common purpose of modernising the country and increasing its competitiveness and technologic awareness. The three axes along which it is organised – Knowledge, Technology and Innovation – are thus core issues in the current political agenda.

The Technological Plan includes some important, cluster-fostering measures. Firstly, the "Dynamisation of Regional Competitiveness Poles", an initiative which is intended to support the creation and development of regional innovation clusters, by promoting the cooperation between firms, research institutes, universities and other regional entities, and the development of innovative projects in partnership. The objective is that the regions acquire the critical mass required to their international competitiveness in one or more specific areas. The Health, Medical Devices and Pharmaceutics cluster of the Norte region, which has been discussed above, seems to fit perfectly in this measure.

Secondly, the "Creation of Thematic Networks in Science and Technology" measure, in which the cooperation agreements with the Massachusetts Institute of Technology, Carnegie Mellon University and University of Texas at Austin are included.

Thirdly, in order to mobilise firms for R&D, the "Research Laboratories and Networks with the Participation of Enterprises" measure has been idealised. The development of joint strategic projects and the creation of new laboratories for cooperative use are herein targeted.

Finallyly, it is also worth mentioning two other measures, which are related to the new growth clusters topic in a more indirect manner. These are the "Promote the Creation of New Technology-Based Firms" and the "Platform for Innovation, Exportation and Competitiveness" initiatives, which are clearly linked to the previous section (Applying New Knowledge and Making New Combinations), as well.

3.4.3 Summary and Quantitative Evaluation

The thorough discussion of the previous sections is now briefly summarised, and a quantitative evaluation of the region in each of the knowledge foundations and core activities is proposed by the author, using a one-to-five scale.

In addition, a similar exercise, i.e., to quantitatively evaluate the Grande Porto region across each of these parameters, was proposed and accepted by a set of relevant regional actors. The corresponding outcomes are herein presented.

One could thus look at the evaluation proposed by the author as a closer perspective to the one adopted by the original creators of the adopted evaluation framework, derived from a personal detailed analysis of van den Berg *et al.* (2005), whereas the evaluation

provided by the relevant regional actors represents a more empirical perspective, based on their very deep field knowledge and years of experience.

Starting with the knowledge base foundation, it has been shown that the quantity, quality and diversity of HEIs are quite good. However, the low educational level of the overall population, the poor R&D indicators and expenditure, and the excessive share of higher education students in the fields of social sciences, business and law, and humanities and arts, are rather negative points.

In terms of economic base, some problems have also been pointed out to the region, such as the high share of employment in the secondary sector (almost 40%), the persistence of some traditional, labour-intensive industries, which will have to somehow be reconverted into more knowledge-intensive activities, and the steeply decreasing GDP per capita of the region over the decade preceding 2004. On the positive side, Grande Porto has a diversified economy, which also includes several anchor LSEs, and represents a considerable share of the country's GDP (nearly 12%). Moreover, the Norte region has a historic propensity for international trade, accounting for 43% of the country's total departures.

The quality of life of the region is good, especially as far as its amenities, cultural and sports facilities, safety and climate are concerned. The main issues to tackle appear to be the quality of some public services, such as hospitals, schools and elderly care, and the intra-regional mobility.

This latter issue is also one of the few negative points regarding the accessibility of Grande Porto, the other one being the peripheral location of Portugal in the European context, when compared to the central European countries such as Germany or Switzerland. In spite of these, the region presents a very good accessibility, by air, sea, road and train. The metro system, which has been opened some years ago, has had a positive effect on intra-regional mobility, and the electronic infrastructure is modern and comprehensive.

The region presents a deficient urban diversity. The share of workers with foreign citizenship is quite small, and the majority has low qualifications. The picture in terms of foreign higher education students is fairly better.

With nearly 1.3 million inhabitants spread across an area of 815 km^2, Grande Porto

presents an appropriate urban scale, which should not be a limiting factor for its competitiveness in the knowledge economy. Additionally, it is part of a NUTS II region with over 3.7 million inhabitants, mostly concentrated in the 100 km ring around Grande Porto, and has the possibility to cooperate with other neighbours, such as the cities of Aveiro and Coimbra, and the Spanish region of Galicia.

Social equity in Portugal and in Grande Porto is quite poor. The main issues to refer in this regard are the high unemployment rate, the high at-risk-of-poverty rate (20%, after social transfers), and the existence of problem neighbourhoods in the city of Porto.

Moving on to the knowledge core activities, the capacity of the region to attract knowledge workers must be evaluated separating higher education students and graduate knowledge workers. The capacity of the region appears to be quite good regarding the former, but rather lower when it comes to the latter. Nevertheless, several aspects can be considered as positive contributors to the attractiveness of the region: the number of high quality research institutes, the establishment of a new local research centre of the German Fraunhofer Institut, the quality of life of the region, its international recognition, and the appropriateness of the country's migration policies, certified by its second place in the Migration Integration Policy Index (MIPEX).

With respect to the region's performance in creating new knowledge, various positive facts have been discussed: the existence of several high-quality research institutes in different fields, such as IPATIMUP, IBMC, INEB, INESC Porto and INEGI, the benefits that can result from the local establishment of the Fraunhofer Institut, and the government's measures to hire 1000 researchers holding doctoral degrees to the country's scientific institutions, and to set up encompassing cooperation agreements with top American universities, namely the MIT, Carnegie Mellon University, and University of Texas at Austin. Nevertheless, Portugal's R&D key indicators remain among the worst within developed countries. Moreover, it has been referred that the University of Porto still lacks a more holistic operation, instead of having each of its faculties working alone by itself.

Finally, in terms of the two last knowledge core activities, applying new knowledge and developing new growth clusters, the diagnose reveals a common overall conclusion: the region lags behind in both activities, but they are now core issues in the political

agenda, and behaviours and mindsets are definitely changing.

More specifically, knowledge institutions are either creating their own technology transfer offices or seeking for external assistance in this domain, and there are several public and entrepreneurial organisations that promote innovation and entrepreneurship by helping people going into business, such as NET, COTEC Portugal, AEP, ANJE, IAPMEI and AICEP. The region's network of Science and Technology Parks now seems to have a liver dynamic, compared to the one which had it repeatedly postponed over the years, and its development is an explicit objective of the Operational Programme for the Norte region. Access to capital by NTBFs is not seen as a serious issue, and the entrepreneurial environment of the country has been significantly improved, in recent years, by means of several bureaucracy reduction measures.

Furthermore, the development of emerging clusters and networks of firms is strongly and explicitly supported within the National Strategic Reference Framework, which sets the frame for the application of the 2007-2013 EU structural funds, as well as by the government's Technological Plan. Three clusters, in particular, are pointed out by the Norte's Operational Programme as having an interesting growth potential in the region: ICT, Electronics, and Electrical Machines and Material; Health, Medical Devices and Pharmaceutics; Biotechnology and Agri-Food.

Based on this, the results of the evaluation of the position of the Grande Porto region in the knowledge economy are then shown in Table 3.7, which also includes the scores proposed by the interviewed relevant actors of the region [8], as well as the average mark in each knowledge foundation and core activity.

As far as the knowledge foundations are concerned, the region has achieved the highest result in the accessibility foundation, with an average mark of 4.3 out of 5. This was also the only parameter in which one of the evaluators made use of the top score. Urban scale, knowledge base and quality of life are next in this ranking, attaining fairly positive scores, as well.

On the opposite end, social equity gets the lowest evaluation, 2.1. However, this seems

[8] Five interviews have taken place, but one of the interviewees has declined the request to make this evaluation.

to be more like a national problem, rather than an exclusive issue of Grande Porto.

	Interviews				Author	Average
	#1	#2	#3	#4		
Knowledge Foundations						
Knowledge Base	4	3	3.5	4	3	3.5
Economic Base	3	4	2	3	2	2.8
Quality of Life	3	4	3	3	4	3.4
Accessibility	4	5	4.5	4	4	4.3
Urban Diversity	2	4	3	3	2	2.8
Urban Scale	3	4	4	4	3	3.6
Social Equity	2	2	2	2.5	2	2.1
Knowledge Core Activities						
Attracting Knowledge Workers	3	3	3	2	3	2.8
Creating Knowledge	3	4	4	4	4	3.8
Applying Knowledge	3	3	2.5	2	3	2.7
Developing New Growth Clusters	2	3	2.5	3	4	2.9

Table 3.7 – Quantitative evaluation of the Grande Porto region across the knowledge foundations and core activities

Regarding the knowledge core activities, it seems to be quite consensual that the region is relatively good in creating knowledge (average mark of 3.8), but is still lagging behind when it comes to applying it and getting the most out of its economic value. Therefore, the 'applying knowledge and making new combinations' activity achieves the lowest score, with 2.7. In addition, 'developing new growth clusters' seems to be indirectly impacted by this deficiency, as well, as some people tend to associate both these subjects when making a judgment about the region's performance (along with the fact that, as stated above and in section 3.4.2.4, clusters are nowadays hot issues in the region's political agenda, this explains why the author provided a higher score to this activity than all the interviewed actors).

Clearly, the capacity of Grande Porto to attract and retain knowledge workers is negatively impacted by its economic base, in the sense that the lack of attractive qualified jobs leads to a significant brain drain to Grande Lisboa and to other countries.

It can be seen that all the four interviewees have expressed quite consensual evaluations of the region, except for the economic base and urban diversity foundations, in which the scores provided range from 2 to 4. With respect to the former, this discrepancy seems to have resulted from the existence of both optimistic and pessimistic views on the current status of the economy of the region, as well as more and less comparative-type analysis with other regions. As for the urban diversity, the divergent opinions may be explained by different understandings of what this foundation was about.

These results are now compared with the ones obtained by van den Berg *et al.* (2005) for two of the European regions targeted by their work, Helsinki and Munich, which, due to their high dynamics and economic prosperousness, can be considered in many senses as model regional economies and successful clusters (Figure 3.43 and Figure 3.44). These two regions are analysed in more detail in sections 2.9.3 and 2.9.2, respectively.

Grande Porto scores less than Helsinki and Munich in most of the knowledge foundations. It gets relatively close to those regions in terms of quality of life, urban diversity, accessibility and urban scale, and even surpasses Helsinki in the latter two parameters. However, when it comes to knowledge base, economic base and, especially, social equity, Grande Porto clearly underperforms.

This difference becomes somewhat sharper when comparing the results for the knowledge core activities, in which Grande Porto obtains the worst marks in all four activities, particularly in the application of knowledge topic.

Therefore, when compared to Helsinki and Munich, Grande Porto does seem to be well positioned in (at least) some of the knowledge foundations herein considered, but suffers from a considerable delay regarding issues such as entrepreneurship, R&D, innovation and networking. The currently ongoing change in the region's dynamics and attitude seems to be very positive, but actual results will only show up in the medium/long-term and only in case these efforts are continued.

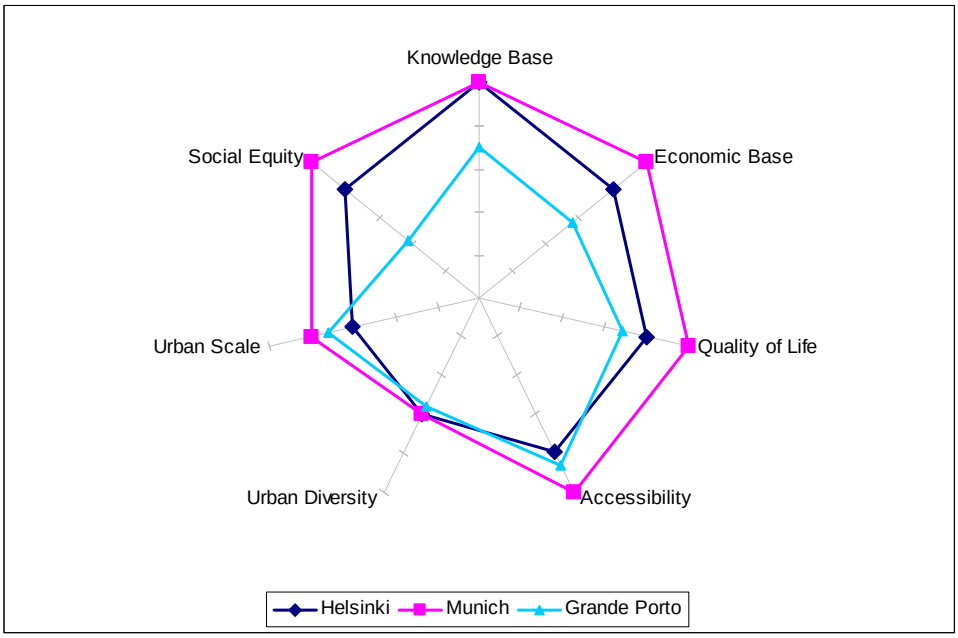


Figure 3.43 – Evaluation of the knowledge foundations: comparison of Grande Porto with Helsinki and Munich

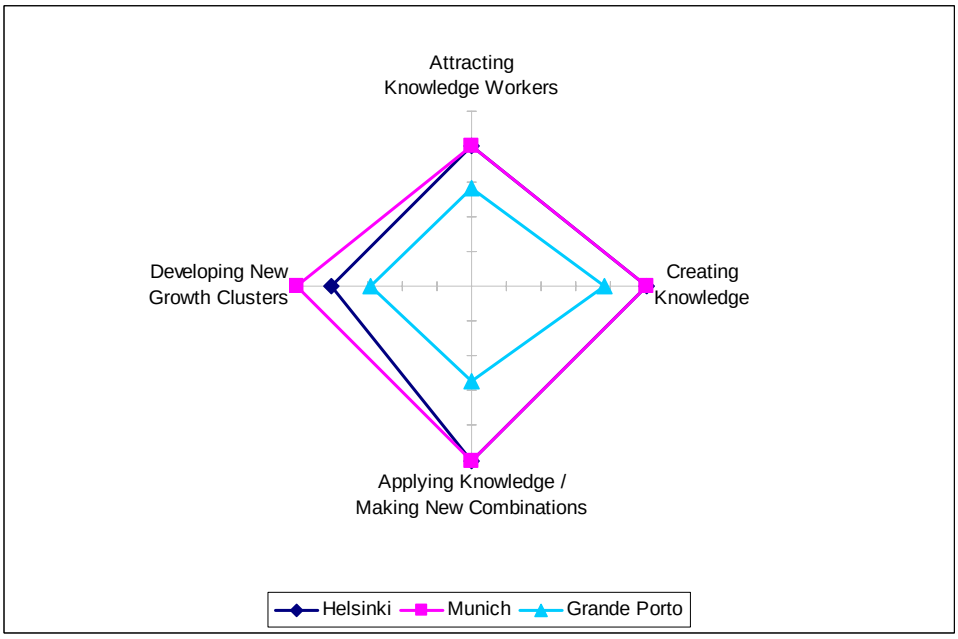


Figure 3.44 – Evaluation of the knowledge core activities: comparison of Grande Porto with Helsinki and Munich

3.5 Interviews with Regional Actors

Five face-to-face interviews have been executed with representatives from highly relevant regional institutions, thus constituting a very important source of contributions to this work. These people and organisations are:

- Professor Luís Valente de Oliveira and Dr. Pedro Capucho, Vice-President and Director of the Department of Studies (respectively) of AEP, the Portuguese Business Association.
- Dr. Paulo Santos, from the Directorate of Regional Development Services of CCDR-N, the North Regional Coordination and Development Commission.
- Professor José M. Mendonça, President of INESC Porto.
- Dr. António Tavares, General-Director of Tecmaia.
- Professor José Marques dos Santos, Dean of the University of Porto.

A telephone conversation with the Vice-President of a sixth institution has also taken place, but with trifling results.

Although many inputs from these interviews have already been implicitly applied all across sections 3.2, 3.3 and (especially) 3.4, it is also worth briefly discussing some other opinions then collected, in particular those that appeared to be common to two or more individuals.

Regionalisation, i.e., the administrative and political division of the country into regions, each electing and legitimating by means of popular vote its own regional government and parliament, has been a recurrent and non-consensual issue in Portugal's political agenda for a long time now.

When asked to express their opinions about regionalisation and how important it could be to foster the economic development of Norte, all the interviewed players seemed to be strong supporters of it, either in a more enthusiastic or less explicit way[9, 10].

The arguments presented are also somewhat consensual, the main one being the need

[9] No official positions of the institutions that were represented have been verbalised in this respect.
[10] Professor Valente de Oliveira kindly declined this request, but its position in favour of regionalisation is publicly known.

for an intermediate government in order to overcome the fact that the national government is too far from each region's reality to take the most adequate measures, and that the power of the municipalities is too fragmented and clearly lacks scale. Regional organisations such as CCDR-N do have an important role in getting over this barrier, but they lack the empowerment conferred by popular vote and independency from national government.

The case of the neighbouring Spanish autonomous region of Galicia was mentioned as an example of a region that lagged behind Norte a couple of decades ago and that has now a clearly stronger regional economy.

Likewise, the country's overly centralised type of political governance was noted by some of the interviewees as one of the main causes of the economic decline of Norte. Several other reasons for this were also mentioned, though: an excessive specialisation in some labour-intensive sectors; a lack of perception, in due time, of the globalisation trend that was taking place and how it compelled firms to take appropriate measures (such as a greater concern for their workforce's qualifications); a non-sustained growth of labour costs during the nineties, mainly caused by a reduction of interest rates and subsequent boost in demand, which further reduced the competitiveness of the regional economy.

The opinions regarding the government's Technological Plan were slightly less consonant. Most of the answers were supportive and optimistic about its positive impact in the country's economy, but one of the actors did express visible scepticism about this initiative, in his say a mere umbrella program for almost everything.

Two other matters that had already been treated in the previous sections deserve a final mention, given the strong consensus generated around them.

On the positive side, the late but quite visible change in mindsets and behaviours towards the importance of technology transfer, knowledge economic valuation, university-industry linkages and all other sub-topics concerning the application of knowledge. Apparently, this issue has definitely become part of the agenda of most of the relevant actors of the region.

On the negative side, the general and clear understanding that the Porto Science and Technology Park (PCTP) project was severely hampered right from the start by the

attempt to create three geographically distant Parks, instead of only one, larger site, dissipating the available resources and energies. The Taguspark STP in the Grande Lisboa region was referred more than once as an example of a quite successful project which started at approximately the same time as the PCTP, not having incurred in the very same mistake, however.

Chapter 4

Conclusions

The final chapter of this work is organised along four main topics: results, political implications, assumptions and future work.

As far as results are concerned, it has been seen that, after going through a comprehensive social and economic characterisation of Grande Porto, a methodology to evaluate the presence in this specific region of the three emerging clusters pointed out by CCDR-N (2007) has been defined. The first step for this was to find a quantitative measure of the level of clustering for a given industry in a specific region, for which the cluster-index (CI) proposed by Sternberg and Litzenberger (2004) has been selected. Then, it was necessary to analyse the CAE industry classification codes, one by one, in order to define the constitution of each of the three clusters, based on the textual descriptions contained in several related documents written by or to CCDR-N. This task had to be carried out in both CAE Rev.2.1 (used in the 2003-2005 period) and CAE Rev.2 (1995-2002). Thirdly, the structure of Table of Personnel database (from the DGEEP-MTSS) had to be studied, so that the Stata source code which implemented the calculation of the CI could be written. Fourthly, the corresponding results have been analysed according to three perspectives: inter-regional, time-evolution and structural analysis.

From this analysis, several conclusions are noteworthy. The level of concentration of the three clusters in the Grande Porto NUTS III region is, except for the Grande Lisboa region, much greater than in the rest of the country. Over the time period considered, it has been found that the CI of ICT and Biotechnology has decreased in Grande Porto, whereas the Health industry has become more concentrated. In general, the variation of the CI closely follows of the employment trend.

Moreover, it should be mentioned that the Biotechnology cluster is the greatest among the three, in terms of employment and number of establishments, albeit it obtained the smallest CI. Conversely, the greatest CI value in Grande Porto has been computed for

the ICT industry, which also presents a very interesting share of employment in high / medium-high-technology manufacture industries, and high-technology knowledge-intensive services. Nevertheless, the Health industry is the one which seems to be at the most advanced stage in terms of the actual formation of a regional cluster, centred in Norte but with a national scope.

A distinct component of the work has been to try to identify other potential technological clusters of Grande Porto, following a similar methodology to the one described above. In this regard, jewellery and paints have come up as the clusters in which the region seems to stand out from the rest of the country. Other industries for which sufficient critical mass to constitute clusters has been detected are logistics, motor vehicles, media and contents, and architecture and engineering.

The current status of Grande Porto in terms of its readiness to the knowledge economy has been evaluated, as well. For this purpose, a research framework defined by van den Berg *et al.* (2005), and consisting of seven knowledge foundations and four core activities, has been used. After an in-depth, qualitative analysis, each of the parameters has been scored quantitatively, both by the author and by a panel of relevant regional actors (who, in general, have selected quite consistent marks).

As far as the foundations are concerned, it has been concluded that Grande Porto achieves its best performances in the accessibility, urban scale, knowledge base and quality of life elements, whereas its main weakness is social equity. As for the core activities, the region is fairly good in creating knowledge, but rather poor when applying it.

A valuable and important part of the work has been to carry out a set of interviews with several key regional actors. Within a total of nine meeting requests, five face-to-face audiences have been granted. Altogether, around 50 e-mails have been sent and countless phone calls have taken place, in order to attain this significant rate of success.

The information collected in these sessions has implicitly (but decisively) contributed to most of the tasks described above, in particular to the assessment of the position of the region in the knowledge economy. A few other relevant topics, which were also discussed during the interviews, have been shortly presented, as well.

For all these reasons, it is considered that the general objective which this thesis had

proposed to attain, i.e. to analyse the possibility of the emergence of new technological clusters in Grande Porto, has been successfully achieved in a very positive way.

Regarding the political implications that may arise from this study, it has been shown that the three policy-supported clusters selected for the Norte region do, in fact, correspond to highly concentrated industries in Grande Porto, compared to the rest of the country. Therefore, they seem to be appropriate choices. Nevertheless, as mentioned before, other potential clusters have been identified and should be taken into account by policy-makers.

In addition, policies should concentrate on tackling the main weaknesses of the region within the knowledge economy. An improvement of its capacity of applying new knowledge is much about managing to change the mindset of knowledge workers towards entrepreneurship and the risk of failure. The promotion of new combinations between industries is also very important and a few possibilities for this have been described. Social equity must be increased at a national level, since it is not an exclusive problem of Grande Porto.

The region considerably falls behind in terms of its network of Science and Technology Parks. All relevant political, business and academic players from Grande Porto and its surrounding regions must, once and for all, join efforts in order to ensure the construction of these infrastructures, which can prove to be extremely important factors to the formation of new clusters and networks. The current uncertainty around the Portuspark project may be a reason for some concern.

Two main assumptions of this work should be mentioned. The first one respects to the definition of the geographical area of interest. It would have been equally interesting to have selected the so-called Porto Metropolitan Area (composed of Grande Porto and five more municipalities) or the Braga – Porto – Aveiro corridor as the target region of the study. However, the fact that the Grande Porto area is, itself, a NUTS III region has been determinant in this decision, since it assures a much greater availability and easier processing of statistical data. When analysing regional clusters, there are often important inter-firm relationships that transcend the imposed territorial divisions. Nevertheless, it is necessary to draw the geographical boundaries of the study.

The second constraint is the fact that, for several reasons, the three policy-supported

clusters have been defined in a rather broad manner. This may have led to the inclusion of activities which do relate in some way to the corresponding cluster, but would not necessarily be part of it.

Finally, a few topics have not been considered in this thesis and may be addressed by future follow-up work.

First of all, by carrying out more interviews with other regional actors, several improvements could be achieved. This would enable, for instance, a clearer perception of how much high-tech each potential cluster actually is, a better understanding of the existing commercial relations and innovation partnerships, and a more representative quantitative evaluation of the region within the knowledge economy. The new set of interviews should place a greater focus on actors from the business community.

An interesting exercise from the academic and political points of view would be to apply a regional economy model, such as Leontief's input-output method (Armstrong and Taylor, 2000), in order to forecast the economic impact that a growth of the policy-supported clusters or of each of the potential clusters herein identified would have in the region.

It would also be very appropriate (especially in the Portuguese case, in which this subject is progressively re-entering the political agenda) to investigate and, if possible, model the effect of regionalisation in cluster development initiatives, i.e., to assess the importance of having a regional government, legitimated and empowered by popular vote, in the success of policies aiming at the development of clusters.

Within the literature review, the most paradigmatic technological cluster of all, Silicon Valley, has not been analysed in the present work. For some reason, a very limited set of information about this cluster was found in the consulted bibliography. It would be interesting to study the characteristics, origin and evolution of Silicon Valley, much in the same manner it has been done for the five other established clusters.

Appendix A

Policy-Supported Clusters

The following tables show the economic activities which have been considered to be included in the three policy-supported clusters that are analysed in section 3.2.

The presented codes comply with CAE Rev.2.1, which has been used for the calculations regarding the 2003-2005 years. For the 1995-2002 period, CAE Rev.2 has been employed, its list of codes being exactly the same as for CAE Rev.2.1, except for the GG518** activities shown in Table 4.1 which were previously mapped into the GG516** codes.

Code	Description
DK2911	Manufacture of engines and turbines, except aircraft, vehicle and cycle engines
DK2912	Manufacture of pumps and compressors
DK2921	Manufacture of furnaces and furnace burners
DK2922	Manufacture of lifting and handling equipment
DK2923	Manufacture of non-domestic cooling and ventilation equipment
DK29241	Manufacture and repair of wrapping machinery
DK294	Manufacture of machine tools
DK2951	Manufacture of machinery for metallurgy
DK2952	Manufacture of machinery for mining, quarrying and construction
DK2953	Manufacture of machinery for food, beverage and tobacco processing
DK2954	Manufacture of machinery for textile, apparel and leather production
DK2955	Manufacture of machinery for paper and paperboard production
DK29561	Manufacture of machinery for construction materials, ceramics and glass
DK29562	Manufacture of machinery for rubber and plastic
DK29564	Manufacture of other machinery for specific use n.e.c
DK2971	Manufacture of electric domestic appliances
DL30	Manufacture of office machinery and computers
DL31	Manufacture of electrical machinery and apparatus n.e.c.
DL32	Manufacture of radio, television and communication equipment and apparatus
DL332	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment
DL333	Manufacture of industrial process control equipment
GG5114	Agents involved in the sale of machinery, industrial equipment, ships and aircraft
GG5143	Wholesale of electrical household appliances and radio and television goods
GG5181	Wholesale of machine tools
GG5182	Wholesale of mining, construction and civil engineering machinery
GG5183	Wholesale of machinery for the textile industry and of sewing and knitting machines
GG5184	Wholesale of computers, computer peripheral equipment and software
GG5185	Wholesale of other office machinery and equipment
GG5186	Wholesale of other electronic parts and equipment
GG5187	Wholesale of other machinery for use in industry, trade and navigation
GG52451	Retail sale of electrical household appliances and radio and television goods
GG52481	Retail sale of other office machinery and equipment
II642	Telecommunications
KK72	Computer and related activities

Table 4.1 – List of economic activities included in the ICT, Electronics, and Electrical Machines and Material cluster

Code	Description
DG244	Manufacture of pharmaceuticals, medicinal chemicals and botanical products
DL331	Manufacture of medical and surgical equipment and orthopaedic appliances
DL33401	Manufacture of ophthalmic equipment
GG5146	Wholesale of pharmaceutical goods
GG5231	Dispensing chemists
GG5232	Retail sale of medical and orthopaedic goods
NN851	Human health activities
OO93041	Thermal activities

Table 4.2 – List of economic activities included in the Health, Medical Devices and Pharmaceutics cluster

Code	Description
AA11	Agriculture
AA12	Farming of animals
DA15	Manufacture of food products and beverages
GG512	Wholesale of agricultural raw materials and live animals
GG513	Wholesale of food, beverages and tobacco
GG522	Retail sale of food, beverages and tobacco in specialized stores
HH553	Restaurants
HH554	Beverage stores
HH555	Canteens and catering

Table 4.3 – List of economic activities included in the Biotechnology and Agri-Food cluster

Appendix B

Stata Source Code

The main pieces of Stata source code which have been written in order to enable the use of the Table of Personnel database (from the DGEEP-MTSS) are herein presented. More specifically, this source code has been utilised for the computation of the results presented in sections 3.2 and 3.3.

B.1 Cluster-Index for the Policy-Supported Clusters

For each of the three policy-supported clusters analysed in section 3.2, ICT, Health and Biotechnology, the corresponding CI values have been computed for all NUTS III regions of continental Portugal, for the 1995-2005 period.

CalcCiClusters_Main.do

```
log using CalcCiClusters_Main, text replace
set more off
clear
set memory 500m

* generate collapsed data files for each year
do CalcCiEst05.do
do CalcCiEst04.do
do CalcCiEst03.do
do CalcCiEst02.do
do CalcCiEst01.do
do CalcCiEst00.do
do CalcCiEst99.do
do CalcCiEst98.do
do CalcCiEst97.do
do CalcCiEst96.do
do CalcCiEst95.do

* merge est.._ci files
use est05_ci
sort ano
merge ano using est04_ci est03_ci est02_ci est01_ci est00_ci est99_ci est98_ci
est97_ci est96_ci est95_ci
drop _merge*
gsort -ano n3est
list

* save
save ci_clusters_9505, replace
outsheet using ci_clusters_9505, replace

* close log
log close
```

CalcCiEmp##.do

```
* open est## data file
use /uporto/qpessoal/dados_stata/est_##

* filter out observations which do not apply
do DropNuts1Obs.do

* mark to which cluster each firm belongs, based on CAE
do IdentifyClustersCae21.do

* create variable with initial dummy value for nr of firms calculation
gen nrest = 1

* generate sum of employment and nr of firms, per cluster, per NUTS III
collapse (sum) npest_## nrest, by(ano_## n3est_## cluster)

* generate year-independent variables
rename ano_## ano
rename npest_## npest
rename n3est_## n3est

* add population and area information
do GenAreaData.do
do GenPopulationData.do

* compute CI
do CalcCiExpression.do

* save data file
save est##_ci, replace
```

DropNuts1Obs.do

```
* drop all observations from NUTS I regions other than Continental Portugal
drop if n1est != 1
```

IdentifyClustersCae21.do

```
#delimit

* generate variable containing cluster type;
gen cluster = 0;

* 1 - ITCs, electrical machines and material;
replace cluster = 1 if
caes5d==29110 |
caes5d==29120 |
caes5d==29210 |
caes5d==29221 |
caes5d==29222 |
caes5d==29230 |
caes5d==29241 |
caes3d==294 |
caes5d==29510 |
caes5d==29520 |
caes5d==29530 |
caes5d==29540 |
caes5d==29550 |
caes5d==29561 |
caes5d==29562 |
caes5d==29564 |
caes5d==29710 |
caes2d==30 |
caes2d==31 |
```

```
caes2d==32 |
caes3d==332 |
caes3d==333 |
caes5d==51140 |
caes5d==51430 |
caes5d==51610 |
caes5d==51620 |
caes5d==51630 |
caes5d==51640 |
caes5d==51650 |
caes5d==51810 |
caes5d==51820 |
caes5d==51830 |
caes5d==51840 |
caes5d==51850 |
caes5d==51860 |
caes5d==51870 |
caes5d==52451 |
caes5d==52481 |
caes3d==642 |
caes2d==72;

* 2 - Health, medical devices and pharmaceutical industry;
replace cluster = 2 if
caes3d==244 |
caes3d==331 |
caes5d==33401 |
caes5d==51460 |
caes5d==52310 |
caes5d==52320 |
caes3d==851 |
caes5d==93041;

* 3 - Biotechnology;
replace cluster = 3 if
caes3d==11 |
caes3d==12 |
caes2d==15 |
caes3d==512 |
caes3d==513 |
caes3d==522 |
caes3d==553 |
caes3d==554 |
caes3d==555;

* drop observations with CAE codes outside those clusters;
drop if cluster == 0;

* generate statistics regarding each cluster;
* nr of firms, per level-4 CAE, NUTS 3 and cluster;
table caes3d n3est cluster;

* employment, per level-4 CAE, NUTS 3 and cluster;
table caes3d n3est cluster, contents (sum npest);

* nr of micro, small, medium and large enterprises, per NUTS 3 and cluster;
do IdentifyFirmSizeClass;
table n3est class cluster;

* distribution per tech level, per NUTS 3 and cluster;
do IdentifyTechLevelCae21;
table n3est techlevel cluster;
table n3est techlevel cluster, contents (sum npest);
```

IdentifyFirmSizeClass.do

```
* generate variable to identify firm size
* micro
gen class = 1
* small
replace class = 2 if npest >= 10 & npest < 50
* medium
replace class = 3 if npest >= 50 & npest < 250
* large
replace class = 4 if npest >= 250
```

IdentifyTechLevelCae21.do

```
#delimit

* generate variable containing techlevel type;
gen techlevel = 0;

* 1 - High tech manufacture;
replace techlevel = 1 if
caes3d==244 |
caes2d==30 |
caes2d==32 |
caes2d==33 |
caes3d==353;

* 2 - Medium/high-tech manufacture;
replace techlevel = 2 if
caes3d==241 |
caes3d==242 |
caes3d==243 |
caes3d==245 |
caes3d==246 |
caes3d==247 |
caes2d==29 |
caes2d==31 |
caes2d==34 |
caes3d==352 |
caes3d==354 |
caes3d==355;

* 3 - Medium/low-tech manufacture;
replace techlevel = 3 if
caes2d==23 |
caes2d==25 |
caes2d==26 |
caes2d==27 |
caes2d==28 |
caes3d==351;

* 4 - Low-tech manufacture;
replace techlevel = 4 if
caes2d==15 |
caes2d==16 |
caes2d==17 |
caes2d==18 |
caes2d==19 |
caes2d==20 |
caes2d==21 |
caes2d==22 |
caes2d==36 |
caes2d==37;

* 5 - High-tech KIS;
```

```
replace techlevel = 5 if
caes2d==64 |
caes2d==72 |
caes2d==73;

* 6 - Market KIS;
replace techlevel = 6 if
caes2d==61 |
caes2d==62 |
caes2d==70 |
caes2d==71 |
caes2d==74;

* 7 - Market less KIS;
replace techlevel = 7 if
caes2d==50 |
caes2d==51 |
caes2d==52 |
caes2d==55 |
caes2d==60 |
caes2d==63;
```

GenAreaData.do

```
* add NUTS III area information (in km2)
gen area_n3 = npest
replace area_n3 = 2218.21 if n3est == "111"
replace area_n3 = 1245.58 if n3est == "112"
replace area_n3 = 1246.17 if n3est == "113"
replace area_n3 = 814.46 if n3est == "114"
replace area_n3 = 2619.67 if n3est == "115"
replace area_n3 = 862.23 if n3est == "116"
replace area_n3 = 4108.09 if n3est == "117"
replace area_n3 = 8171.36 if n3est == "118"
replace area_n3 = 4995.91 if n3est == "150"
replace area_n3 = 1802.26 if n3est == "161"
replace area_n3 = 2062.85 if n3est == "162"
replace area_n3 = 1743.66 if n3est == "163"
replace area_n3 = 2616.56 if n3est == "164"
replace area_n3 = 3488.99 if n3est == "165"
replace area_n3 = 1904.77 if n3est == "166"
replace area_n3 = 867.77 if n3est == "167"
replace area_n3 = 4062.59 if n3est == "168"
replace area_n3 = 3748.22 if n3est == "169"
replace area_n3 = 1374.5 if n3est == "16A"
replace area_n3 = 2220.21 if n3est == "16B"
replace area_n3 = 2306.05 if n3est == "16C"
replace area_n3 = 1375.89 if n3est == "171"
replace area_n3 = 1558.9 if n3est == "172"
replace area_n3 = 5255.78 if n3est == "181"
replace area_n3 = 6249.34 if n3est == "182"
replace area_n3 = 7228.89 if n3est == "183"
replace area_n3 = 8542.7 if n3est == "184"
replace area_n3 = 4275.06 if n3est == "185"

* add PT area information (in km2)
gen area_pt = 88966.67

* compute area percentage values
gen area_n3pc = area_n3 / area_pt
```

GenPopulationData.do

```
* add NUTS III population information (in km2)
gen pop_n3 = npest
```

```
replace pop_n3 = 252272 if n3est == "111"
replace pop_n3 = 407558 if n3est == "112"
replace pop_n3 = 521749 if n3est == "113"
replace pop_n3 = 1276575 if n3est == "114"
replace pop_n3 = 559406 if n3est == "115"
replace pop_n3 = 285464 if n3est == "116"
replace pop_n3 = 215527 if n3est == "117"
replace pop_n3 = 219240 if n3est == "118"
replace pop_n3 = 416847 if n3est == "150"
replace pop_n3 = 396704 if n3est == "161"
replace pop_n3 = 335532 if n3est == "162"
replace pop_n3 = 263848 if n3est == "163"
replace pop_n3 = 137840 if n3est == "164"
replace pop_n3 = 291019 if n3est == "165"
replace pop_n3 = 42125 if n3est == "166"
replace pop_n3 = 48548 if n3est == "167"
replace pop_n3 = 112114 if n3est == "168"
replace pop_n3 = 75282 if n3est == "169"
replace pop_n3 = 92160 if n3est == "16A"
replace pop_n3 = 356296 if n3est == "16B"
replace pop_n3 = 230980 if n3est == "16C"
replace pop_n3 = 2012925 if n3est == "171"
replace pop_n3 = 766172 if n3est == "172"
replace pop_n3 = 97179 if n3est == "181"
replace pop_n3 = 120495 if n3est == "182"
replace pop_n3 = 170896 if n3est == "183"
replace pop_n3 = 129599 if n3est == "184"
replace pop_n3 = 247802 if n3est == "185"

* add PT population information (equals the sum of the above)
gen pop_pt = 10082154

* compute population percentage values
gen pop_n3pc = pop_n3 / pop_pt
```

CalcCiExpression.do

```
* compute country employment, per cluster
egen pempptcluster=sum(npest), by(cluster)

* compute NUTS3 employment, per cluster
egen pempn3cluster=sum(npest), by(cluster n3est)

* compute country nr of firms, per cluster
egen nrempptcluster=sum(nrest), by(cluster)

* compute NUTS3 nr of firms, per cluster
egen nrempn3cluster=sum(nrest), by(cluster n3est)

* compute cluster index
gen ci = (pempn3cluster / pempptcluster) * (nrempn3cluster / nrempptcluster) /
pop_n3pc / area_n3pc
```

B.2 Cluster-Index for the Three-Digit Level CAE Industries

The source code presented in this section has been used to try to identify other existing technological clusters in Grande Porto, by calculating the CI values for all three-digit level industries in that region, for the year of 2005. The corresponding results have been thoroughly analysed in section 3.3.

CalcCiCae3d_Main.do

```
log using CalcCiCae3d_Main, text replace
set more off
clear
set memory 500m

* open est05 data file
use /uporto/qpessoal/dados_stata/est_05

* filter out observations which do not apply
do DropNuts1Obs.do

* create variable with initial dummy value for nr of firms calculation
gen nrest = 1

* generate sum of employment and nr of firms, per cluster, per NUTS III
collapse (sum) npest_05 nrest, by(n3est_05 caes3d_05)

* add population and area information
do GenAreaData.do
do GenPopulationData.do

* generate year-independent variables
rename npest_05 npest
rename n3est_05 n3est

* temporary rename of caes3d for use in CalcCIExpression
rename caes3d_05 cluster

* compute CI
do CalcCiExpression.do

* rollback renaming
rename cluster caes3d

* save data file
save ci_cae3d_05, replace
outsheet using ci_cae3d_05, replace

log close
```

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http://www.aeportugal.pt/

AICEP – Agência para o Investimento e Comércio Externo de Portugal [Portuguese Agency for Foreign Investment and Trade]
http://www.icep.pt/

CCDR-N – Comissão de Coordenação e Desenvolvimento Regional do Norte [North Regional Coordination and Development Commission]
http://www.ccdr-n.pt/

CMU-Portugal Program
http://www.cmuportugal.org/

COTEC Portugal – Associação Empresarial para a Inovação [Entrepreneurial Association for Innovation]
http://www.cotec.pt/

Eurostat
http://epp.eurostat.ec.europa.eu/

Eurostat – Regions – Nomenclature of Territorial Units for Statistics – NUTS
http://ec.europa.eu/eurostat/ramon/nuts/splash_regions.html

GEE – Gabinete de Estratégia e Estudos, Ministério da Economia e da Inovação [Strategy and Studies Cabinet, Portuguese Ministry for the Economy and Innovation]
http://www.gee.min-economia.pt/

Global Peace Index
http://www.visionofhumanity.com/

GPEARI – Gabinete de Planeamento, Estratégia, Avaliação e Relações Internacionais, Ministério da Ciência, Tecnologia e Ensino Superior [Planning, Strategy, Evaluation and International Relations Cabinet, Portuguese Ministry of Science, Technology, and Higher Education]
http://www.estatisticas.gpeari.mctes.pt/

IAPMEI – Instituto de Apoio às Pequenas e Médias Empresas e à Inovação [Institute for Support to SMEs and Innovation]
http://www.iapmei.pt/

IBMC – Instituto de Biologia Molecular e Celular [Institute for Molecular and Cell Biology]
http://www.ibmc.up.pt/

INE – Instituto Nacional de Estatística [National Statistics Institute]
http://www.ine.pt/

INEB – Instituto de Engenharia Biomédica [Institute for Biomedical Engineering]
http://www.ineb.up.pt/

INEGI – Instituto de Engenharia Mecânica e Gestão Industrial [Institute of Mechanical Engineering and Industrial Management]
http://www.inegi.up.pt/

IPATIMUP – Instituto de Patologia e Imunologia Molecular da Universidade do Porto [Institute of Molecular Pathology and Immunology of the University of Porto]
http://www.ipatimup.pt/

MCTES – Ministério da Ciência, Tecnologia e Ensino Superior [Portuguese Ministry of Science, Technology, and Higher Education]
http://www.mctes.pt/

MIPEX – Migrant Integration Policy Index
http://www.integrationindex.eu/

MIT-Portugal Program

http://www.mitportugal.org/

OCES – Observatório da Ciência e Ensino Superior [Science and Higher Education Observatory]
http://www.estatisticas.gpeari.mctes.pt/

OECD – Organisation for Economic Co-operation and Development
http://www.oecd.org/

MIT-Portugal Program
http://www.mitportugal.org/

QREN – Quadro de Referência Estratégico Nacional [National Strategic Reference Framework]
http://www.qren.pt/

Plano Tecnológico [Technological Plan]
http://www.planotecnologico.pt/

Tecmaia
http://www.tecmaia.pt/

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