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Do clusters follow the industry life cycle? An exploratory assessment of Basque clusters' evolution since the 1970s

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Abstract

Although cluster life cycle tends to co-evolve with the life cycle of its dominant industry and/or technology (Bergman, 2008; Menzel and Fornahl, 2010), empirical studies indicate that clusters do not necessarily follow the life cycles of their dominant industries: e.g. that different clusters that belong to the same industry follow different evolutionary paths due to multiple factors that go beyond those of the dominant technology or industry life cycle (Saxenian, 1994; Belussi and Sedita, 2009; Elola et al., 2012). Thus, clusters are not just a local representation of an industry; local peculiarities also matter for the evolution of a particular cluster (Menzel and Fornahl, 2010).

This paper aims at examining these questions through a comparative assessment of the competitive trajectory of six Basque industrial clusters since the 1970s. The Basque Country is an old industrial European region that successfully managed to cope with the economic crisis of the late 1970s and early 1980s renewing its industrial base by upgrading some of its mature industries and clusters and by promoting new high tech ones. Based on the experience of six Basque clusters (papermaking, maritime industries, machine tools, energy, electronics and ICTs and aeronautics), we aim at analyzing whether clusters co-evolve with their corresponding industry or deviate from it, and which are the factors that account for their evolution.

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Introduction

There is a widespread agreement to depict the economic evolution of the Basque Country from the early 1980s until 2008 as "a regional transformation success story" (OECD, 2011; Aranguren et al., 2012a; Porter et al., 2013). The Basque Country is an old industrial European region that, building on its regional base of resources and capabilities and employing innovative cluster and STI policies, successfully managed to cope with the severe economic crisis and industrial restructuring in the 1980s by renovating and upgrading some of its mature industries and by promoting new high technology ones (Trippl and Tödtling, 2008; Aranguren et al., 2012a; Birch et al., 2010 for a comparative assessment).

Based on the experience of the Basque Country, in this paper, we aim at analyzing whether the trajectory that clusters follow mirrors that of their corresponding industry or deviates from it and which are the factors that account for cluster evolution. Although it is widely recognized that cluster life cycles can differ from their dominant industry and/or technology life cycles, currently there is still little empirical research assessing how and why the life cycles of clusters differ from those of their respective dominant industries.

The empirical base of this paper draws from in-depth case studies on six industrial clusters: papermaking, maritime industries, machine tools, energy, electronics and information and communication technologies (ICTs) and aeronautics, some of them already published (Lopez et al., 2008 and 2012; Valdaliso et al., 2008 and 2010). This research is framed within a broad project that aims at studying the historical origins and evolution of the 12 clusters labeled as strategic for the Basque Government.[1] For each cluster, the research team conducted a historical (longitudinal) and qualitative in-depth case study, based on different sources of information, in order to obtain stylized facts from which more general propositions can be inferred (for a similar methodology, see Bresnahan et al., 2001; Feldman, 2001; Shin and Hassink, 2011). Based on this sample, and employing selected quantitative and qualitative data amenable to comparison, we have attempted to, first, make a comparative assessment of the evolutionary trajectory of every cluster between c. 1970 and 2008; and, secondly, to examine whether the cluster life cycle follows that of its dominant industry or deviates from it. Under this period, the Basque industry had to face up the challenges of two economic crises (the first half of the 1980s and the early 1990s), a widespread and in some sectors radical technological change, and an increasing economic openness and globalization. [2]

The paper has five parts. In the first one, we discuss the theoretical literature on cluster life cycles and present the analytical framework we have developed to classify cluster trajectories in relation to the trajectories of their corresponding industries. Then, we explain in part two the methodology and data employed. This is followed by

[1] The other six clusters are: automotive, home appliances, audiovisual, environment, port of Bilbao and transport and logistics. All of them have a cluster association that are in charge of fostering inter-firm cooperation in several fields and are one of the agents of the competitiveness policy of the Basque government. On Basque cluster policy and cluster associations, see Aranguren and Navarro (2003) and Aranguren et al. (2009) and (2012a).

[2] We stop our analysis in 2008 because it is still too early to examine the reactions of clusters and firms to the recent economic crisis.

a presentation of the six clusters studied and a stylized analysis of the competitive trajectory of every cluster from the late 1970s to 2008 in part 3. Afterwards, in part 4, we discuss how local factors have contributed either to adjust such evolution to that of the industry or to make it possible for the cluster to escape from a declining phase of an industry. Finally, we offer some conclusions and policy implications.

1. Cluster life cycles: beyond the industry life cycle

Like a product, an industry also follows cyclical development patterns. Klepper (1997) distinguishes three different stages of an industry life cycle: an embryonic stage with small output, a growing stage, and a mature stage with a decline in the number of companies and employees. This seems to indicate a deterministic industrial path. However, similarly to what has been described for cluster life cycles (Menzel and Fornahl, 2010), industries might also be able to adapt or renew themselves.

At first glance, it might seem obvious that cluster life cycles tend to co-evolve with the life cycle of its dominant industry. The cluster life cycle, then, would only be the local expression of its industry. However, both theoretical and empirical studies indicate that clusters do not necessarily follow the life cycles of their dominant industries, as, first, there are other factors that work at cluster- and regional level, and, second, different clusters that belong to the same industry life cycle follow different evolutionary paths. That is, some clusters are able to escape from the tyranny of the industry life cycle and from lock-in situations while others cannot (Bergman, 2008; Menzel and Fornahl, 2010; Martin and Sunley, 2011; Ter Wal and Boschma, 2011; Suire and Vicente, 2014). And the same goes for the regions where these clusters are located (Martin and Sunley, 2006 and 2011; Martin, 2010).

Clusters, therefore, can be viewed as complex adaptive systems (Martin and Sunley, 2011) made up of different components (companies, suppliers, institutions…), with different characteristics, that interact one each other in a systemic way (Menzel and Fornahl, 2010: 20). The population of clustered firms and other organizations is heterogeneous in terms of knowledge and capabilities (Ter Wal and Boschma, 2011) and, hence, clusters “do not develop evenly and as a whole” (Martin 2010; Menzel and Fornahl 2010: 224).

Regardless of whether the authors support the stylized life cycle model (Trippl and Todtling, 2008; Bergman, 2008; Menzel and Fornahl, 2010) or the adaptive life cycle model (Martin and Sunley, 2011), all stress that maturity and decline is one among many possible trajectories of cluster evolution. Menzel and Fornahl (2010) point to three other scenarios: adaptation (within the sustainment phase), renewal (that would lead the cluster to a new growth phase), and transformation (that would lead the cluster to a radically new phase of emergence). Martin and Sunley (2011) depict six different evolutionary trajectories: full adaptive cycle, constant mutation, stabilization, reorientation, failure and disappearance.

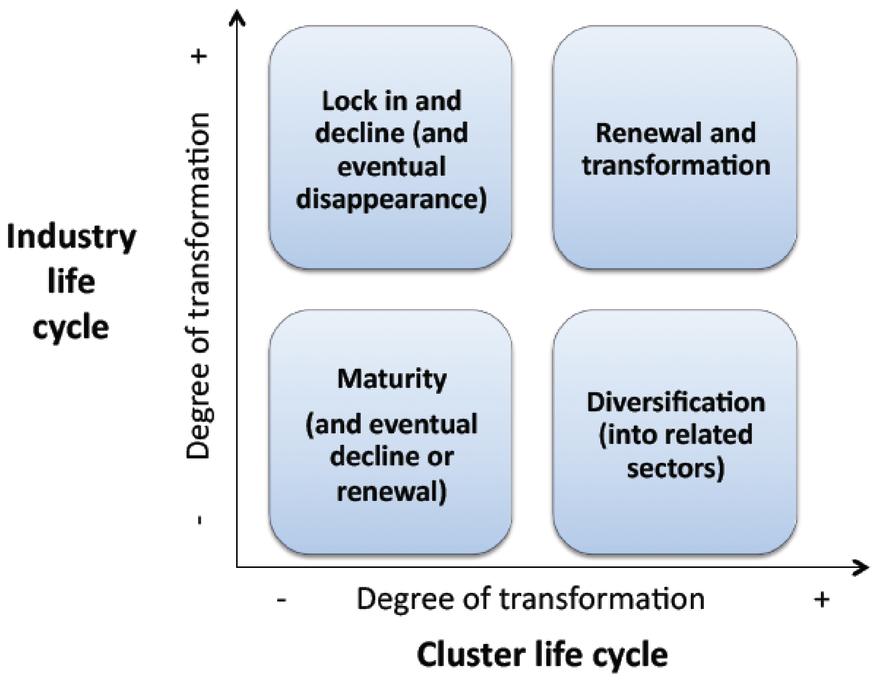
As to the driving factors of cluster evolution different than those related to the industry and technology life cycle, all authors point to the cluster knowledge base, although with different emphasis and focus: cluster knowledge diversity and heterogeneity (Menzel and Fornhal, 2010); knowledge embedded in the clustered firms' capabilities (Maskell and Malmberg, 2007); firms' capabilities and networks within the cluster and outside, including cluster absorptive capacity (Giuliani, 2005; Ter Wal and Boschma, 2011; Elola et al., 2012); structural properties of cluster knowledge networks (Suire and Vicente, 2014); and knowledge embedded in the region where the cluster is located (Bergman, 2008; Trippl and Tödtling, 2008; Martin and Sunley, 2011). Other empirical studies also suggest the role of local demand, factor conditions, entrepreneurship and the inflow of external knowledge and technology, along with historical legacy in cluster origins; and path dependent mechanisms linked to both cluster and region evolution (social capital, development of cluster specific factors, public policies) in cluster development (Van der Linde, 2003; Belussi and Sedita, 2009; Elola et al., 2012; Brenner and Mühlig, 2013). Social capital, in particular, is widely understood as conducive to the promotion of intellectual capital, collective learning and the creation and transfer of knowledge both inside and outside the firm's and cluster's borders (Nahapiet and Ghoshal, 1998; Lawson and Lorenz, 1999; Maskell, 2001; Westlund, 2006; Malecki, 2012). Cluster and business associations are regarded as institutions that promote inter firm cooperation within and between clusters, build up social capital and increase cluster absorptive capacity (Carbonara, 2002; Molina-Morales, 2002; Giuliani, 2005; Valdaliso et al., 2011). With regard to public policies, some authors have suggested the role of cluster policies and science, technology and innovation (STI) policies in facilitating cluster renewal and avoiding lock-in situations (Brenner and Schlump, 2011; Uyarra and Ramlogan, 2012).

Finally, clusters affect and are affected by their external environment and their trajectory co-evolves with that of the region where they are located. Regional knowledge bases, competences and assets shape the scope of evolutionary trajectories available for clusters and industries there, and may result in higher economic diversification or specialization (Boschma, 2004; Asheim and Gertler, 2005; Martin and Sunley, 2006; Nefke et al., 2011). Martin and Sunley (2006) suggested five possible trajectories of regional development other than that of lock-in and decline: indigenous creation, heterogeneity and diversity, transplantation (of a new industry or technology) from elsewhere, diversification into technologically related industries and upgrading of existing industries. With a particular focus on old European industrial regions, Trippl and Tödtling (2008) proposed three types of cluster-based renewal related to three distinct regional development paths: incremental change (innovation-based adjustment of mature clusters), diversification (new clusters in established industries) and radical change (new high technology clusters). These types may coexist within a given region. In fact, the research and innovation strategies for smart specialisation (RIS3) recently adopted by the European Commission (modernization or retooling, extending into related sectors and radical foundation of new industries) (Foray, 2013) are not that new, and may be seen with other names in several European regions in the last three decades (Trippl and Tödtling, 2008; Aranguren et al., 2012b; Valdaliso, 2013).

Following the above discussion, and given that our study attempts to assess cluster evolution in an old industrial region such as the Basque Country since the 1970s, facing a new phase of widespread technological change and increasing global competition, we have opted for displaying the alternative cluster evolutionary trajectories, taking into account the 'degree of transformation' in both the cluster life cycle (measured by the number of firms, employment, and production, and other qualitative indicators related to cluster knowledge) and its dominant industry life cycle (measured by the rate of technological change, the evolution of the industry and its structure) (see Figure 1). Four distinctive paths for existing clusters in old industrial regions can be identified:

- *Maturity (and eventual decline or renewal)*: clusters follow the life cycle of the dominant industry that is unable to change (although the situation might change in the future).
- *Lock-in, decline (and eventual disappearance)*: clusters are not able to adapt to the technological change undergoing in the dominant industry and consequently they become locked-in, decline and eventually disappear.
- *Renewal and transformation*: clusters are able to adapt to the evolving technological trajectory of the dominant industry by renewing and/or transforming their knowledge base, in a process that goes hand in hand with the technological evolution of the dominant industry.
- *Diversification*: clusters are able to escape from declining or mature industries by applying their knowledge base to enter into related (and more dynamic) sectors.

Figure 1. Alternative cluster evolutionary trajectories in old industrial regions



Source: authors' elaboration.

2. Data and methodology

This paper draws on in depth longitudinal studies on six Basque industrial clusters particularly representative of the industrial development of the region in the 19th and 20th centuries: papermaking, maritime industries, machine tools, energy, electronics and ICTs and aeronautics. By combining a variety of sources and quantitative and qualitative data, we set up the life cycle of every cluster and analysed its driving factors and its competitive position over time. [3]

Along with the detailed information of the in-depth case studies, we have employed quantitative data to undertake the comparative assessment. In order to do so, we had to take two methodological decisions. The first one refers to the selection of indicators for cluster performance and/or activity. As Bergman (2008: 127) indicated "at present there is no single best metric of cluster activity", which means that sometimes the use of different variables has produced different outcomes. With this caveat in mind, we describe in the next section the evolution of Basque clusters between c. 1970 and 2008 as a function of its number of firms, jobs, Gross Value Added (GVA), turnover and exports, combined with other qualitative and quantitative indicators related to different cluster variables. The sources of the variables are as follows:

- Data series of GVA, working hours and employment for the industrial sectors most representative of every cluster between 1982 and 2008 taken from EUSTAT, the Basque Institute of Statistics; [4]
- Data series of turnover, exports, employment and number of firms for every cluster, whenever it is possible, comes from the cluster associations; [5]
- Data on exports for every cluster and its share over world exports for the period 1995 to 2008 that combines information from UN Comtrade (for world exports) and *Agencia Tributaria Española* (for Basque exports). [6]

The second decision relates to the selection of activities that integrate each cluster. Even if the six clusters under study count with cluster associations, the data analysed do not only correspond to the members of the association, but to the whole cluster. That means that the clusters had to be delimited both in terms of the industries they include and the export codes that can be associated to each cluster. We started with the cluster classification of industrial sectors that has been the basis of cluster

[3] López *et al*. (2008) and (2012); Valdaliso *et al*. (2008) and (2010); and ongoing research on the energy and machine tool clusters. Preliminary results of this meta-study can be found in Elola et al. (2012) and Valdaliso et al. (2012b).

[4] Data series on GVA, working hours and employment are taken from the Basque Institute of Statistics, EUSTAT, *Industrial Statistics*, and www.eustat.es from 1982 to 2008.

[5] Data refer either to the whole cluster or to the affiliated firms. In the latter case, we know the representativeness of the cluster association over the whole cluster.

[6] Data series on exports for every cluster between 1995 and 2008 are taken from Orkestra http://tools.orkestra.deusto.es/klusterbolak/regions/. According to this source, we distinguish the following sub-clusters: aircraft and aircraft engines (aeronautics); electrical and electronic components, electronic components and assemblies, communications equipment, specially office machines, computers and peripherals (electronics and ICTs); porcelain, carbon and graphite components, electrical capacitors, electric energy, crude petroleum, hydrocarbons, oil and gas machinery, nuclear reactors, petroleum processing, transformers and turbines and turbine generators (energy); shipbuilding and repairing and marine engines (maritime industries); machine tools and accessories (machine tools); paper mills, paper industries machinery, pulp and waste paper and paper products (papermaking).

mappings in several parts of the world and was developed by Porter in his seminal 2003 paper (Porter, 2003). This classification was based on collocation of employment in the US.[7] For the exports, we used a conversion table provided by the Institute for Strategy and Competitiveness of Harvard Business School. This table matches HS6 harmonized system of export codes and cluster categories. We selected the cluster categories that best match the six clusters.[8] However, this classification did not match the standard industrial statistics available and, in order to build up a homogenous data series for the whole period, we have followed the sector aggregations made by EUSTAT. The sectors for which information is provided in the Appendix are (in brackets, their codes of the national classification of economic activities A84 according to the CNAE-93): papermaking (21/21), machine tools (39/29.401), shipbuilding and other transport equipment (such as aircrafts, but not aircrafts engines) (47-48/35.1-35.5), electricity and oil refining (52 and 23/40.1 and 23), and office and computing machines, electric and electronic parts and equipment (42-43-44/30-31-32).

The task of matching every cluster with any of these possible scenarios faces at least three important methodological problems that, so far, have not been adequately resolved by the literature.

First, how to deal with the co-evolutionary and thus systemic relationship between industry and cluster life cycles? Given that our sample of clusters is mostly comprised of 'followers' rather than 'leaders' of their respective industries (with the exception of some firms of the energy cluster), we have taken the factors related to the technology and industry life cycle (e.g., technological change, demand, industry structure) for granted (e.g., as given) and focused instead on how the clusters react to them and which are the factors at play at both cluster and regional level. Our assessment of the evolution of the life cycle of every industry is based on industry associations' reports, world outlooks for their respective sectors and secondary literature. [9]

Second, cluster (and region) knowledge base has been regarded as the main factor of cluster evolution. However, the problem of how to measure such an intangible factor – either qualitatively or quantitatively- continues to be under discussion. As mentioned above, cluster knowledge base is integrated by, at least, three different knowledge sources: those that come from the strategic and dynamic capabilities of the clustered firms, those that stem from other firms and institutions in the region, and those that come from global sources. R&D expenditures over turnover, R&D employees and human capital levels may be taken as proxies for firms' and region's capabilities. Firms' and cluster's degree of internationalization, measured by the ratio of exports over turnover, may be a proxy for both firms' capabilities and cluster openness and thus, degree of absorptive capacity. As to the cluster knowledge diversity and heterogeneity, we have adopted as proxies the following indicators: the number of industries

[7] This classification has been recently improved by Delgado et al. (2013) using a combination of employment, skills and input-output data.

[8] According to this conversion table, we have assigned several CNAE-93 4 digit codes to every cluster: 2 to the aeronautics, 11 to electronics and TICs, 19 to energy, 3 to maritime industries, 4 to machine tools and 15 to papermaking. Notice, however, that services are excluded from this classification.

[9] Reports and studies from CESA (European Shipyards) and CECIMO (European Association of the Machine Tool Industries), OECD Information Technology Outlook, World Energy Outlook, FAO Pulp and paper production capacities.

represented in the cluster, the number of public research organizations (PROs) involved, and cluster size (e.g., the number of companies and organizations). Knowledge diversity and heterogeneity at regional level can be measured by the sector distribution of GDP, with particular attention to manufacturing activities with high and medium-high technological content and knowledge intensive business activities, and the extent of related variety in exports.[10] Finally, the existence of cluster associations and other mechanisms of collaboration have been taken as a proxy for social capital and thus the existence of intra-cluster knowledge linkages and networks.

Third, assuming that clusters are complex adaptive systems made up of different components (companies, suppliers, institutions…), with different characteristics, and that clusters as a whole do not develop uniformly, the assignment of a given cluster to one of the trajectories is based on taking the trajectory of the key clustered firms as representative of that of the whole cluster.

The variety of sources employed in the six case studies, the multi-level and qualitative analysis (firm, cluster and region-based) adopted and the aforementioned methodological problems, makes our comparative assessment a descriptive and exploratory study (Yin, 2003; Eisenhardt and Graebner, 2007). However, given the need of more empirical and, in particular, longitudinal studies on cluster evolution (Boschma and Fornahl, 2011), our study can contribute to the ongoing theoretical discussion on this issue.

3. Cluster evolution and transformation in the Basque Country c. 1980-2008: what our sample of six clusters suggests

3.1. General overview of the six clusters

The origins of the six clusters under consideration can be traced back to different points in time. The clusters of maritime industries, papermaking and machine tools have a long history that goes back to the 19th century (and even farther in the first two cases) and have followed an entire life cycle of emergence, development, maturity, and decline or renewal. The energy cluster dates back to the first years of the 20th century, linked to the spread of electricity in the region and comprises not only the activities of production and distribution of energy but the manufacturing of energy equipment as well. The clusters of electronics and ICT and aeronautics correspond to younger industries that appeared in the 1940s-1950s and in the 1980s-1990s, respectively, and are still in a development phase.

On the eve of the 1970s crisis, and on the basis of their most representative industries, five out of the six clusters already had a distinctive presence in the region, accounting for 16 per cent of the industrial plants and 17 per cent of industrial employment of the Basque Country. In terms of employment, the clusters of energy, shipbuilding, machine tools and papermaking were the most important, while the younger one of electronics

[10] Following Orkestra (2013), we assume the existence of a positive relationship between the relative importance of both sectors in a region and its competitive position. According to Frenken et al. (2007) the existence of related variety reduces the risks of excessive specialization and broadens the scope of regional development trajectories.

and ICTs was quite smaller, and that of aeronautics did not exist yet. The same went for their relative importance in the Spanish industry (see Table 1).

Table 1. Plants and employment of some industrial sectors representative of the clusters studied (1978)

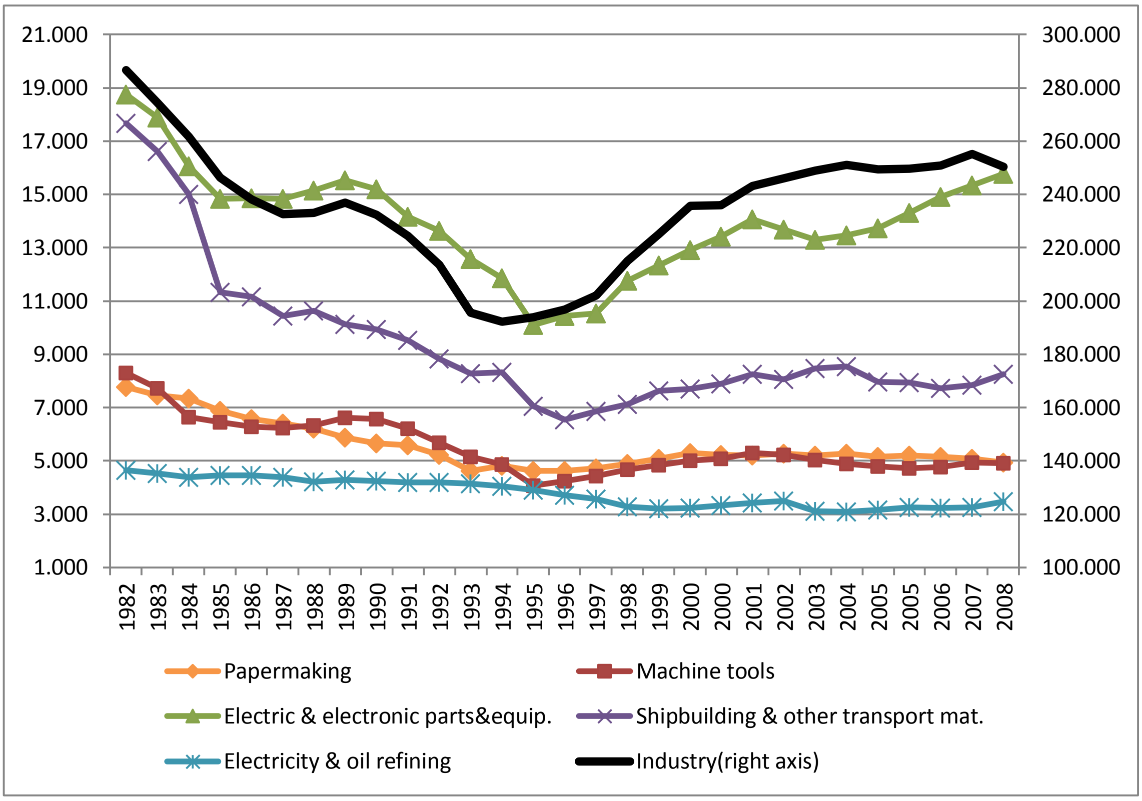
	Plants		Employment	
	No.	% Spain	No.	% Spain
Oil refining, gas and electricity (13 and 15)	5	5.10	405	2.81
Manufacturing of electrical parts and equipment (34, except home appliances 345)	254	13.49	15,537	16.97
Manufacturing of machine tools (322)	184	45.66	11,270	57.53
Manufacturing of computers, office equipment and electronic parts and equipment (33 and 35)	21	6.19	2,035	3.68
Shipbuilding (37)	76	19.44	12,634	21.60
Papermaking (471, 472 and 473)	85	9.76	7,594	13.59
Industry (total)	4,027	7.30	297,381	12.29

Source: Industrial Census of Spain, 1978. Figures refer to plants with 10 or more workers. National Classification of Economic Activities' codes of that Census are between brackets. Sectors 13, 15 and 34 would belong to the energy cluster; sectors 33 and 35 to the electronics and ICT cluster; sector 37 to the maritime industry cluster; and sectors 471 to 473 to the papermaking cluster.

From the late 1970s onwards, the Basque industry faced up a severe economic crisis that went hand in hand with an intense process of globalization and technological change. Mature industries in which the region had long specialised, such as iron and steel, metal products, shipbuilding, machinery and electrical equipment were hit hardest by the combination of a falling demand and a fiercer competition from emerging countries. To make matters worse, Basque firms had lived for decades serving a domestic market highly protected from foreign competition and were scarcely used to compete abroad. After Spain's integration into the EEC in 1986 this scenario changed radically (Navarro et al., 1994; Aranguren et al., 2012a).

In spite of this adverse situation and the negative impact of ETA terrorism, the Basque industry managed to survive, change and grow (Aranguren et al., 2012a; Porter et al., 2013). Although the share of industry over the GDP of the country had diminished with respect to that of the early 1980s (from 43% in 1980 to 28% in 2008), the Basque country still ranked among the most industrialised regions of EU in 2008 (Eurostat, 2010; Aranguren et al., 2012a). Industrial employment fell until 1994, then recovered and grew, although the levels of the early 1980s were not regained (see chart 1).

Chart 1. Employment figures of several industrial sectors of the Basque Country, 1982-2008



Source: EUSTAT. Figures from the building sector are not considered.

In 2008 the size of the six clusters studied was quite heterogeneous (see Table 2). The clusters of electronics and ICTs, maritime industries and energy comprised over 300 firms each, while those of machine tools, aeronautics and papermaking were quite smaller, with 105, 50 and 16 firms, respectively. According to employment and turnover figures, the biggest cluster was that of energy (which included not only the production and distribution of energy, but manufacturing industries such as the production of equipment goods for the electrical and wind energies), followed by electronics and ICTs; and the smallest ones were the aeronautics and papermaking.[11] As to their competitive position, the clusters of maritime industries, aeronautics and machine tool were the most export oriented (more than 60 per cent of their turnover was sold abroad in 2008). R&D data was not available for all clusters, but significant differences among those where comparison is possible are observed: from about 1% of turnover in the case of the energy cluster (but with the highest absolute figure) to close to 20% in the aeronautics cluster, being those of electronics & ICTs and machine tools in between, with a figure close to 5%.

[11] Notice, however, that firms in the Basque aeronautics cluster had facilities both in the rest of Spain and worldwide that accounted for 55 and 49 per cent of their total employment and turnover figures, respectively. In the case of the papermaking cluster, figures refer to the members of the cluster-association, whereas our own estimation, following EUSTAT figures, points to more than 40 firms and 5,000 employees (Valdaliso et al., 2008: 64-66).

Table 2. Main figures of the six Basque clusters in 2008

	Firms (No.)	Employment (No.)	Turnover (M. €)	Exports (M. €)	R&D expenses (M. €)	Exports/ Turnover (%)	R&D/ Turnover (%)
Aeronautics and aerospace (*)	50	4,035	624	n.a.	123	71.9	19.7
Electronics and ICT	330	14,600	4,136	820	137	19.8	3.3
Maritime industries	405	9,100	1,500	950	n.a.	63.3	n.a.
Papermaking (**)	16	2,078	816	281	n.a.	34.4	n.a.
Energy (#)	356	24,522	15,558	n.a.	190	33.2	1.2
Machine tools	105	5,627	925	723	46	78.2	5.0

Source: SPRI, *Observatorio de Coyuntura Industrial* (February 2009). Figures are provided by the cluster-associations and refer to facilities located in the Basque Country.

Notes: (*) SPRI figures have been corrected, including only the ones referred to the firms associated to HEGAN (the cluster association) and to the facilities located in the Basque Country, following HEGAN information. The ratio of exports over turnover is based on the total turnover and exports figures. (**) Figures are for 2007 and refer only to the firms belonging to the cluster association. # SPRI figures have been corrected including only the ones referred to the Basque Country following Europraxis (2010), from which the estimated ratio of exports over turnover has been taken.

3.2. Stylized facts about each of the clusters

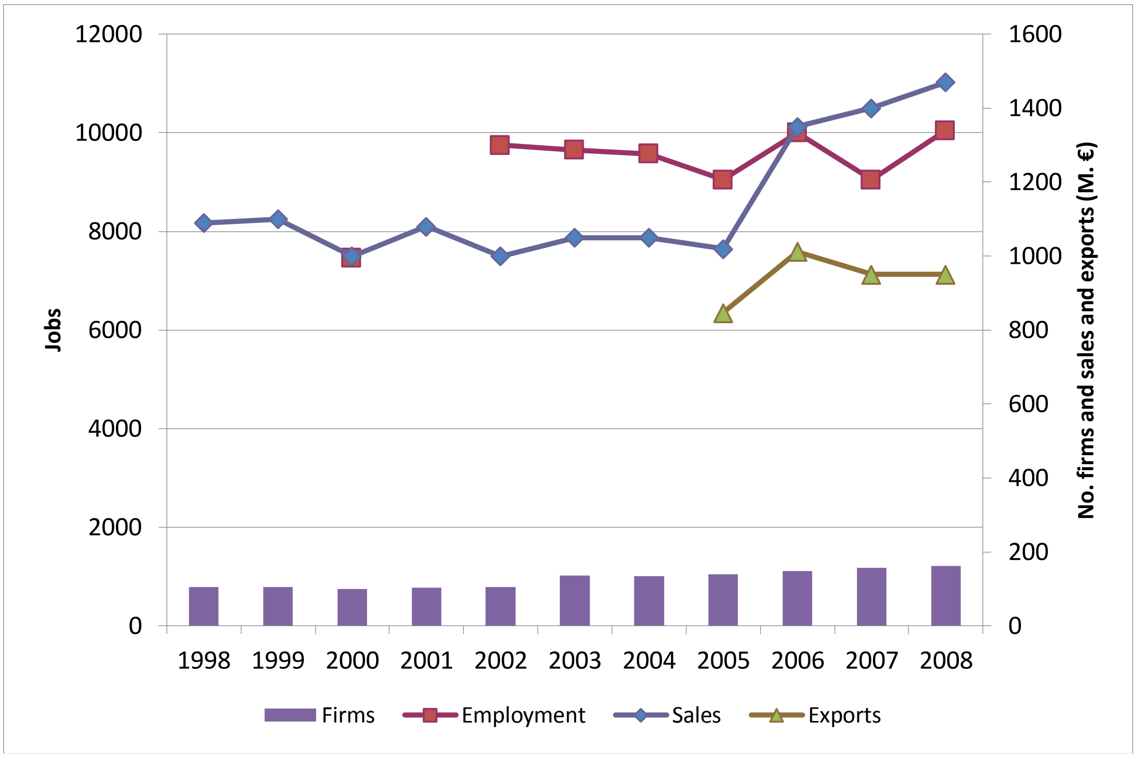
In the late 1970s, the Basque **papermaking cluster** was comprised of about 30 manufacturing firms of paper and pulp (with an average size smaller than their foreign competitors), plus circa 50 firms of paper products, and a small number of manufacturers of machines and equipment for this industry. With half of the papermaking firms created in the 19th century, and the rest before 1940, the cluster went through a maturity phase since the 1950s. As a result of the domestic and international crisis of the late 1970s, demand and prices collapsed (while labour, energy and capital costs increased), and competition became fiercer. The papermaking sector had been strongly oriented to a domestic market highly protected from abroad, but it was no longer the case after 1986: between this year and 1995 the ratio of imports over domestic consumption in Spain went from 22.5 to 42.4 per cent; the ratio of exports over production increased from 18.7 to 30.1 per cent. Besides, the internationalization process in this industry since the 1980s made paper and pulp global commodities, increased cost competition worldwide and reduced prices and brought about a process of business consolidation that resulted in the creation of larger multinational groups to benefit from economies of scale (Whiteman, 2005; Valdaliso et al., 2008).

As happened in other European countries, some of the pulp and papermaking firms of the Basque cluster, unable to compete, broke down and exited from the sector. The survivors specialized in a smaller product range, invested in new machinery and equipment and became more international. Some of them were merged into big multinational groups. Employment figures fell between 1982 and 1993, then slightly grew in the second half of the 1990s and later stabilized until 2008 (see chart 1 and Appendix). In 2007 the number of paper and pulp manufacturers had diminished to 17, and that of manufacturers of papermaking machines and equipment remained stable, around 25. Between 1995 and 2008 both sectors have managed to maintain their competitive position in terms of exports, while that of the Basque manufacturers of pulp and paper products has not changed noticeably –in the former case- or even diminished –in the latter one (see chart 6). Some of the firms established a cluster association in 1998, which represents about half of the clustered firms (Valdaliso et al., 2008)

On the eve of the international maritime crisis of the 1970s the Basque **cluster of maritime industries** was comprised of two big shipyards, highly specialised in the manufacturing of big standardized merchant vessels (tankers and bulk carriers) for the world market, along with about ten medium shipyards, more flexible and with a larger product range, and a bigger number of small shipyards and firms in auxiliary and related industries and services. Since its origins, this cluster's growth had been closely linked to the shipping and fishing sectors of the region, the most important of Spain. Since the 1960s, the cluster passed through a maturity phase, in which the big shipyards increased their export orientation. The collapse of the international shipping market after 1974 hit hardest the largest Basque shipyards specialised in the type of ships most affected by the crisis and by the increasing competition of East Asian nations. They disappeared or, after a substantial reconversion, specialised in other type of vessels (Valdaliso, 2003).

The small and medium shipyards, on the contrary, due to their wider product range and their higher flexibility, specialised in differentiated market niches, where Asian shipbuilders could not compete. This strategy of product differentiation, together with a strong commitment to innovation, helped those shipyards to survive and even grow, although with heavy cuts in employment. The employment figures of the Basque shipbuilding industry declined from 11,740 to less than 4,000 between 1982 and 1995 (see chart 1). During the 1980s and 1990s the auxiliary and related industries (marine engines, parts and equipment) underwent a period of creative destruction: many companies disappeared, while others, either incumbent ones or start-ups, promoted by former technicians from the closed shipyards and/or companies, introduced innovative products and solutions, broadened their product range and went international. Most of the survivors created in 1993 an industry association, ADIMDE, which later on, in 1997, promoted the creation of FMV, the cluster association, which represents about 80% of the firms and 90% of the cluster' sales (Valdaliso et al., 2010). Between 1998 and 2008, a period of expansion in the world shipbuilding industry (Stopford, 2009: 625), sales, exports, number of firms and employment grew, particularly from 2005 to 2008 (see chart 2). As to the competitive position of the two most important sub-clusters between 1995 and 2008, those of shipbuilding and of manufacturing of marine engines, measured by its share of world's exports, it seems to differ: the former's one has remained stable while the latter's one has increased (see chart 6).

Chart 2. Sales, exports and employment of the Basque maritime cluster, 1998-2008



Source: FMV. Number of firms associated to ADIMDE, an industry association that belongs to FMV (the rest of the FMV's associates are PROs, banks, port authorities, and government organizations).

The origins of the **machine tool cluster** in the Basque country go back to the beginning of the 20th century, due to the existence of good factor conditions (qualified labour and entrepreneurship) and a very important local demand. In the 1970s, after a phase of expansion in the 1950s and 1960s, the Basque machine tool cluster had reached a phase of maturity. It concentrated more than 50 per cent of the firms and a figure of around 60 per cent of sales and employment of the whole sector in Spain (Urdangarín and Aldabaldetrecu, 1982; and table 3). The industry faced up a severe crisis between 1976 and 1985 due to the sharp reduction of the Spanish market, significant cost increases and the appearance of new lower cost competitors –such as South Korea and Taiwan- in the segment of conventional machine tools (with low technological content). On top of that, Basque manufacturers had to cope with the introduction of numerically controlled machine tools and, more generally, microelectronics in this industry. In 1978 only 1 per cent of the machine tools produced in Spain were numerically controlled, far from the figures achieved in Germany and the United Kingdom (around 12 per cent), and even further from those of USA, France and Japan (more than 20 per cent) (Mazzoleni, 1999). As the industry association (AFM) said in 1983: "too many problems at the same time and when the firms had a narrower scope for action" (AFM, 1983). The collapse of the Spanish market forced Basque manufacturers, with a productivity 30 per cent higher than the national average, to go abroad: between 1970 and 1980 the ratio of exports over production grew from 25 to more than 60 per cent (Check S.A., 1985).

In the 1980s, the Basque firms had a low scale of production, a narrow product range, and a competitive strategy that was halfway between cost and product differentiation.

Unable to compete with lower cost/high scale manufacturers such as Taiwan and South Korea they decide to upgrade their products making higher quality goods, as manufacturers with a similar plant size were doing in Germany and Italy (Calabrese, 1993; Monitor Company, 1993). In order to obtain the increasing resources and capabilities needed to cope with technological change and internationalization, Basque firms, with the help of the regional government and the encouragement of its industry association, merged into larger groups and invested heavily in R&D resources and facilities (Aldabaldetrecu, 1992; Calabrese, 1993; Soraluze, 2012).

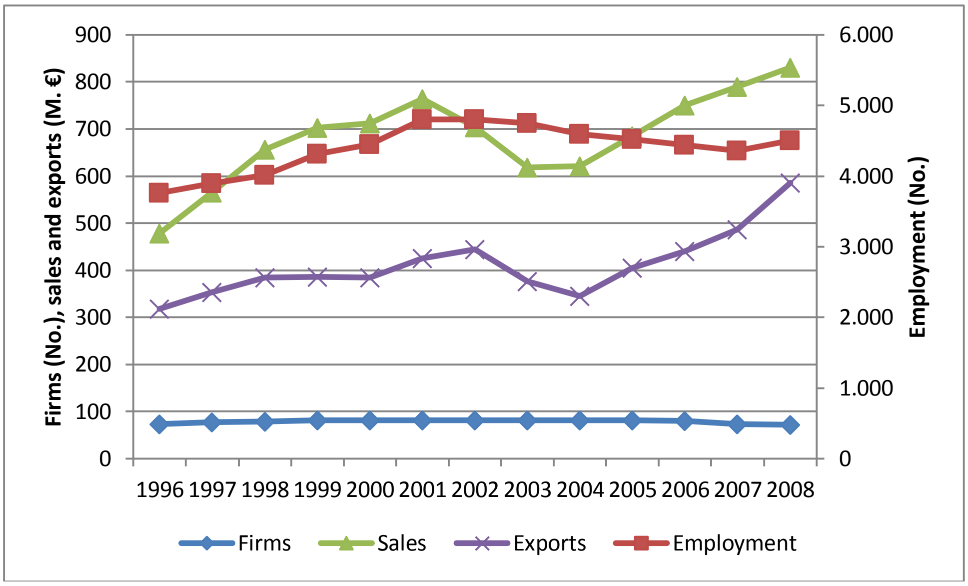
Table 3. Firms and employment of the machine tool industry in the Basque Country and Spain, 1969-2000 (selected years)

	1969		1985		2000	
	Firms	Employment	Firms	Employment	Firms	Employment
Basque Country	137	7,720	86	5,643	82	4,450
Spain	250	12,432	115	7,252	120	5,960
% of Basque Country	54.8	62.1	74.8	77.8	68.3	74.7

Source: authors' elaboration from Olascoaga (1971), Check S.A. (1985), and AFM.

In terms of firms and employment, and with regard to the figures of the early 1970s, the sector, that witnessed a new international crisis in the early 1990s, experienced a steady decline until c. 1995 although its share over the Spanish industry increased (see table 3). The number of firms continued to decline until 1995 and then remained stable, while that of employees that had decreased until 1995 tended to increase until 2002 and to slightly diminish henceforth (see charts 1 and 3). Sales and exports showed an upward trend between 1996 and 2008 (see chart 3) that followed that of the world industry (CECIMO, 2011). During this period, the cluster has gone international either by the increasing share of exports over sales (that reached 70.6% in 2008) or by the establishment of facilities abroad. Its competitive position over those years, in terms of world exports' share, remained fairly stable (see chart 6).

Chart 3. Firms, employment, sales and exports of the Basque machine tool cluster, 1996-2008



Source: AFM. Figures refer to all the firms, either associated to AFM or not. AFM affiliates account for 86% of the firms and 97% of the employment of the whole cluster.

The origins of the Basque **energy cluster** can be traced back to the beginning of the 20th century linked to the spread of hydroelectricity and to the creation of Hidroeléctrica Ibérica (today Iberdrola), a tractor firm of this cluster ever since. From the 1950s to the 1970s the cluster went through a phase of development. It remained strongly focused on hydroelectricity, although new power sources appeared such as thermoelectricity made either from coal or from nuclear power stations, and a new big firm was created in the oil refining industry (Petronor). On the eve of the oil crisis of 1974, the Basque energy cluster was comprised of two big firms in electricity and oil refining, and several small and medium firms in the sectors of electrical parts and equipment, power electronics (transmission and distribution of electricity, T&D) and engineering.

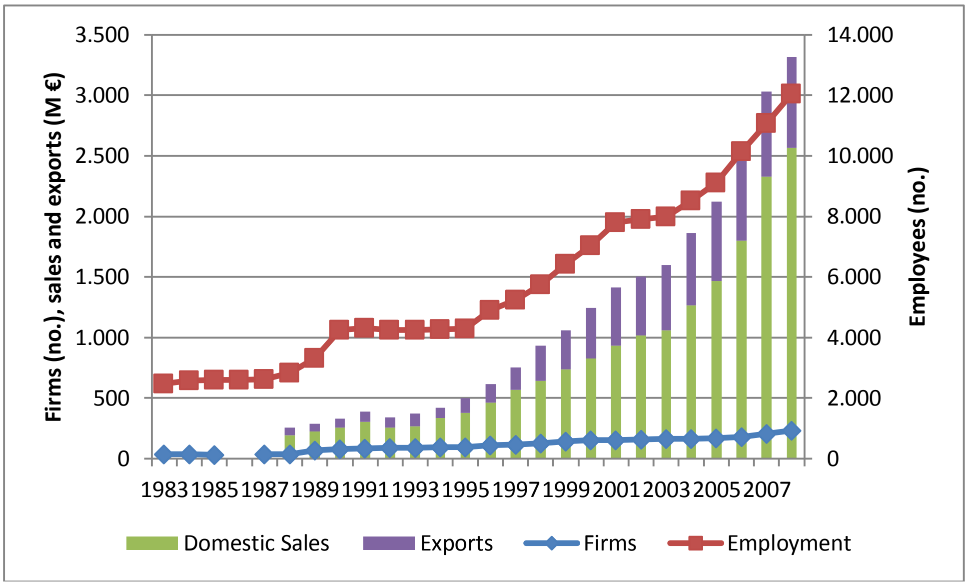
From the 1980s onwards, the Basque energy cluster has experienced a phase of renewal and reorientation, linked to the diversification of traditional energy sources (substitution of gas natural for oil) and the diffusion of renewable energies such as wind, solar and marine energies. The development of these new sectors, strongly encouraged by fixed premium systems of the national government, not only brought about new markets for incumbent firms in this cluster (electric and electronic equipment, engineering) but it has opened up new windows of opportunity for firms in related industries and clusters as well, such as aeronautics, shipyards, and marine equipment manufacturers. Iberdrola entered the wind energy business in 2001 and very soon it became a global leader in terms of wind power capacity. Another younger firm of this cluster, Gamesa (created in 1976), diversified from aeronautics into wind turbines manufacturing in the 1990s, became a key partner of Iberdrola (to which it supplied about 60% of the wind turbines installed in its wind farms) and ranked among the global top 4 turbine manufacturers from 2003 onwards. Both Iberdrola and Gamesa lead global value chains (GVCs, henceforth) in the wind energy sector into which several firms of the Basque cluster have joined. Many of them have accompanied Iberdrola and Gamesa when they go abroad (Elola et al., 2013a; Parrilli coord., 2012; Essletzbichler, 2012).

The expansion of the manufacturing activities of the energy cluster since the mid 1990s helps to explain the growth of employment in the electric and electronic equipment industries (see chart 1). In terms of jobs and turnover, the Basque energy cluster ranks today as the first one among the whole population of clusters in the Basque Country (see table 2). Apart from Iberdrola and Gamesa, it hosts a good number of global leaders and tier 1 suppliers in several niche markets such as transport and distribution of electricity (T&D), engines and equipment, solar energy, and onshore and offshore solutions. Although the role of the Basque energy cluster association (ACE) is less important than in other clusters, firms associated to ACE account for 23 per cent of the number, 62 per cent of employment and 70 per cent of turnover of the whole cluster in 2008 (Europraxis, 2010).

The origins of the **electronics cluster** in the Basque country go back to the 1940s and 1950s due to the existence of a growing local demand of power electronics (T&D) and electronic parts and equipment, together with good factor conditions (skilled labour and entrepreneurs from related sectors). The cluster had just entered an expansion phase in the 1970s when it had to cope with the technological divide brought about by the introduction of the microchip and the transition from analogue to digital electronics. The diffusion of technological change in the 1980s opened up a window of opportunity for this sector, as it spread across different sectors from industry to services. The incumbent firms of this cluster completed the transition to digital technologies, reinforced their control over the Spanish market and started or increased their export orientation. Along with these group of founders, many new small firms, either spin-offs of incumbent firms and technological centres or start-ups, were created in the 1980s and the 1990s, not only in electronics but in the expanding sector of information and communication technologies as well (López et al., 2008; Valdaliso and López, 2008; Valdaliso et al., 2011).

Technological change helps to explain the declining trend of employment in the electric and electronic parts and equipment sectors until 1995, while the ups and downs are explained by economic fluctuations (crisis until 1985 and between 1992 and 1995) (see chart 1). The number of firms affiliated to the industry association, created in 1983 (and transformed in 1996 in a cluster association, named GAIA), as well as their figures of sales and employment grew until 2008, slightly in the crisis years and more rapidly henceforth (see chart 4). Most of these new firms were born global, and maintained a strong commitment to innovation and internationalization ever since (Valdaliso, 2010; Valdaliso et al., 2011).

Chart 4. Firms, employment, domestic sales and exports of the Basque cluster of electronics and ICTs, 1983-2008

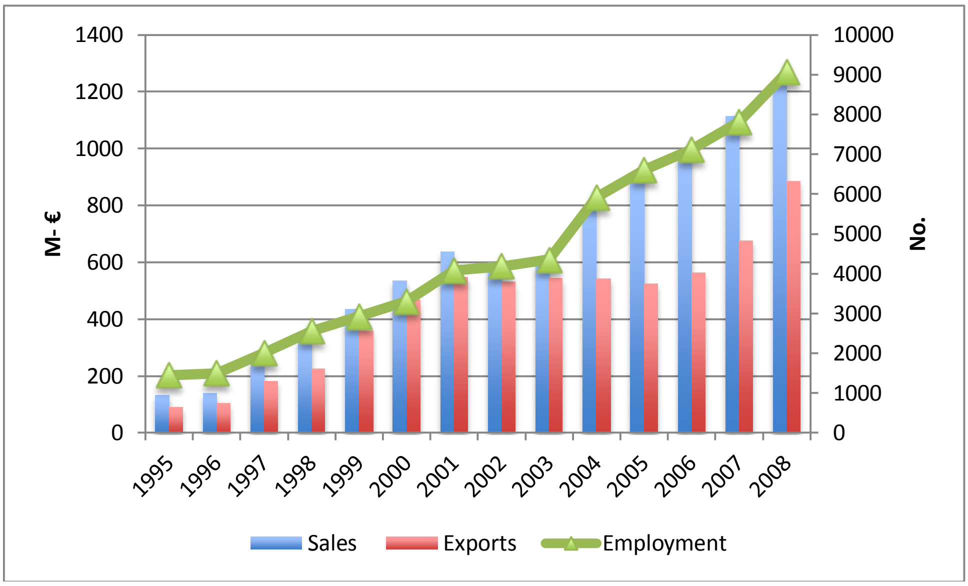


Source: AIEPV and GAIA. Figures refer to firms affiliated to the cluster association, which represents more than 75% of employment of turnover of the whole cluster.

The creation of the Basque **aeronautics cluster** took place in the late 1980s linked to the initiatives of two big firms from other industries that entered the sectors of aerospace engines (Sener-ITP) and aerospace vehicles (Gamesa, later Aernnova) as tier-1 suppliers of global leaders. Technological change in aeronautics and deregulation in air transport in the 1980s lowered entry barriers and increased modularity, paving the way to the creation of global value chains lead by airframe and engine manufacturers. Since the early 1990s, Sener-ITP and Gamesa received strong financial support from the Basque government, very interested in promoting this cluster in order to offer a new higher value-added market to the special steel manufacturers of the region, which were suffering a severe crisis by that time. A few of those incumbent steel producers and foundries, along with new firms created to manufacture parts in metallic alloys, carbon fibre and composites, joined this cluster in the 1990s, and got inserted in the global value chains (GVCs) of the aeronautics industry, first as suppliers of the Basque anchor firms (ITP and Aernnova), later on moving upwards within the GVCs and becoming 1st tier suppliers of the global leaders (Lopez et al., 2012; Elola et al., 2013b).

The main figures of the Basque aeronautics cluster (number of firms, employment, turnover) experienced a steady growth between 1995 and 2008, with the exception of the short recession that followed after the terrorist attack of September the 11th (chart 5). Its share over world exports has increased in the same period 1995-2008 (chart 6). Most of the firms that represent about 99% of turnover of the whole sector are affiliated to HEGAN, the Basque aeronautics cluster association. Another significant feature of this cluster is high degree of internationalization. Between 1997 and 2007 the number of HEGAN firms' facilities located outside the Basque Country went from 2 to 35 (HEGAN, 2007). In 2008 HEGAN firms had 32 facilities located in the rest of Spain and 13 worldwide, that accounted for 49% of turnover and 55% of employment (HEGAN, Annual Report 2008).

Chart 5. Turnover, exports and employment of the Basque aeronautics cluster, 1995-2008



Source: HEGAN. Figures refer to the firms affiliated to the cluster-association, which represents over 99 per cent of the total turnover, and refer to their overall number of facilities, regardless where they are located (see main text).

3.3. The evolution of cluster exports

Another approach to the competitive trajectory of the Basque clusters in this period can be made through the analysis of their exports, a key indicator of regional competitiveness. Based on the database constructed by Orkestra - Basque Institute of Competitiveness, we offer in chart 6 the share of world exports of every cluster between 1995, the first year for which we have export data, and 2008, the eve of the current crisis. The vertical axis shows the world exports' share of each cluster in 2008, while the horizontal axis displays the absolute variation of world exports' share between 1995 and 2008, in both cases in ‰. Therefore, the 'competitive area' would be located in the upper right side of the chart, while the 'uncompetitive area' would be situated in the lower left one. Finally, the bubble size represents the absolute export value of each cluster in 2008. Given the quite different range of sectors that integrate every cluster (with the exception of the machine tools' one), with different technological content, average wages and productivity, we have opted for representing data at sub-cluster level. [12]

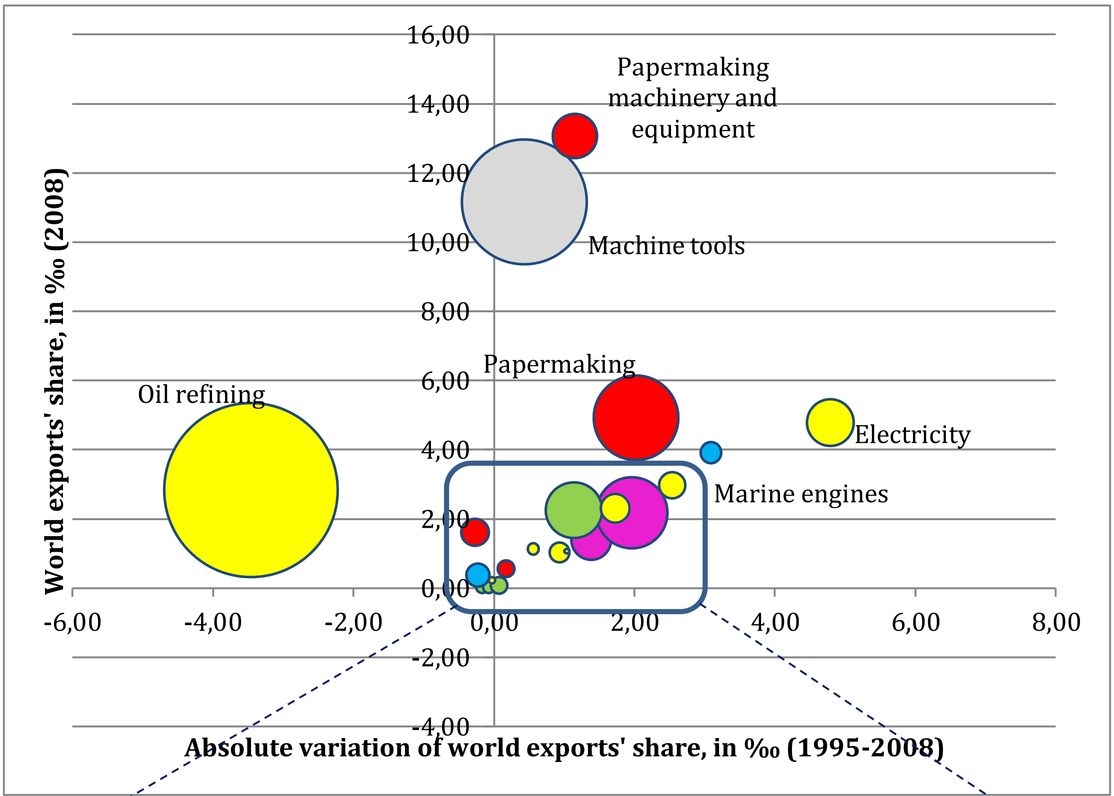
At first glance, most of the sub-clusters within the six clusters studied are located in the right side of the chart, that is, they have improved their competitive position measured by its share over world exports, between 1995 and 2008. It is worth noting that in this period, the Basque share over world exports did not change noticeably (-

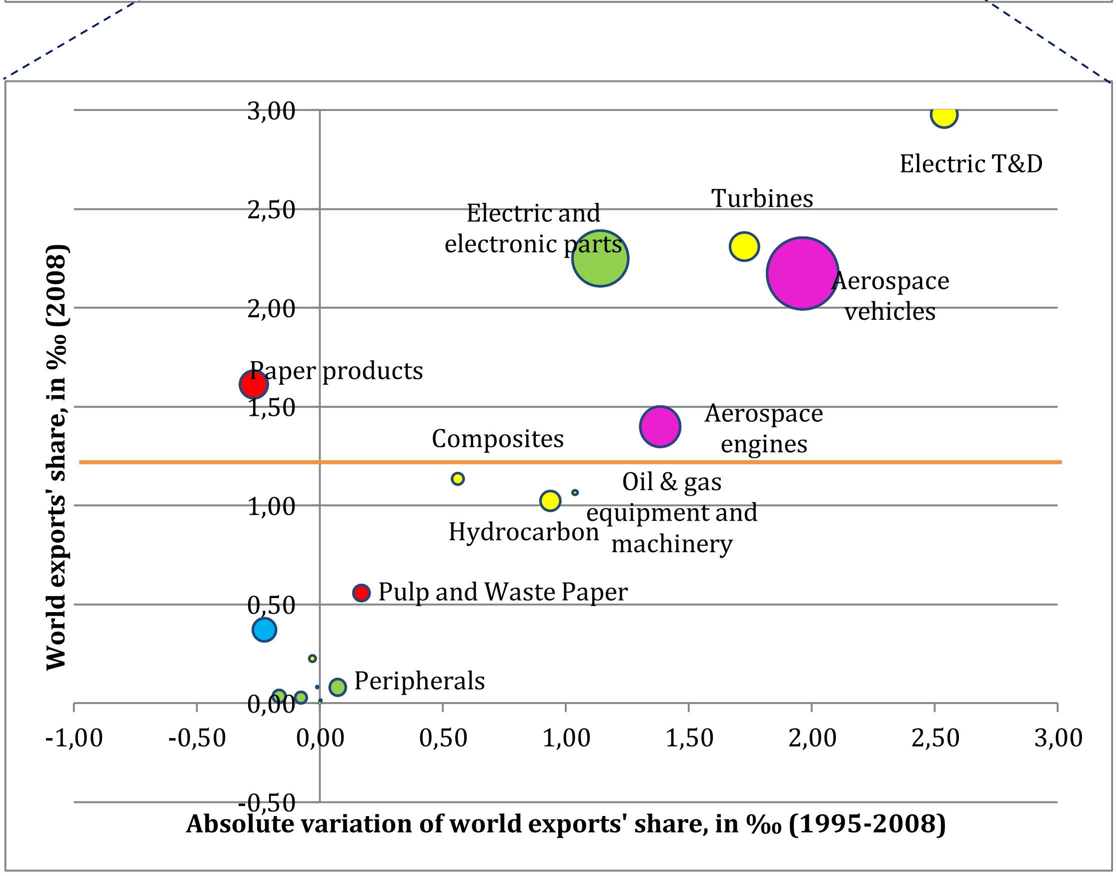
[12] "Subclusters are subgroups of industries within the cluster" (Porter, 2003: 563).

0.01‰). Moreover, most of the sub-clusters displayed have a share over world exports in 2008 higher than the average of Basque exports as a whole, which is of 1.20‰.

As to the papermaking cluster, the two most competitive subsectors are paper manufacturing and the manufacturing of equipment for this industry, while those of pulp and paper products are located very close to zero or in the medium left of the chart. With regard to maritime industries, the competitive position of the firms specialised in marine engines is much better than that of the shipyards. The machine tool cluster stands out as one of the most important Basque clusters, both by its share over world and Basque exports. Within the broader energy cluster several sector have to be distinguished. On the one hand, oil refining and production and distribution of electricity (mid-left and upper right of the chart, respectively); on the other, the manufacturing core of this cluster, integrated by medium and large manufacturers of electric T&D equipment (Arteche, Ormazabal, Ingeteam, ZIV) and wind turbines (Gamesa), all of them global leaders in niche markets. The main sub-cluster within electronics and ICT is that of electric and electronics parts, closely related to the manufacturing sub-cluster of energy. Finally, in the aeronautics cluster, both aeroplane and engine manufacturing, sectors lead by global 1st tier suppliers such as Aernnova and ITP, are in the medium-right side of the chart.

Chart 6. World exports' share of the six Basque clusters, 1995-2008





Source: Orkestra. The bubble' size represents the absolute size of each cluster's exports.

4. Discussion

Do Basque clusters follow the life cycle of their respective dominant industries? Based on our theoretical model presented in part 1 and on the empirical evidence shown in part 3, we have attempted to place every cluster in one of the four possible evolutionary trajectories. This has not been an easy task because, as we stated before, clusters are not internally homogeneous.

First, several sub-clusters that correspond to industries with different trajectories may coexist within a given cluster. Due to this reason, we have opted for splitting the energy cluster into oil refining, gas and electricity, on the one hand, and renewable energies and manufacturing of energy equipment, on the other. And the same goes for the electronics & ICTs cluster, separated into electronics and ICTs, and even for the papermaking and maritime clusters, with an increasingly diverging performance between producers of pulp and paper or ships, on the one hand, and manufacturers of equipment for their respective industries, on the other. This implies, of course, a recognition that industry and technology (life cycles) matter. Besides, there are other reasons linked to the previous trajectories of some of those respective sub-clusters, their relative importance and visibility –for instance in the creation of business associations- (and hence, political influence).[13] In addition to this, cluster knowledge diversity and heterogeneity (Menzel and Fornahl, 2010) allow to broaden the scope of evolutionary trajectories available.

Secondly, clustered firms may differ in terms of their degree of adjustment to the industry life cycle. We establish the cluster life cycles, and therefore its assignment to one of the four possible scenarios described in Figure 1, based on the development of the cluster's core of firms and organizations. However, there are some clustered firms that deviate from that cycle and may stay either in an earlier stage (and even, become locked-in and disappear) or partially escape from the industry life cycle by diversifying into new sectors. [14]

At first glance, it seems that four out of the six clusters studied have followed the life cycle of their respective dominant industries (see Figure 2). Over the period analysed in this paper, the Basque papermaking and maritime industries clusters followed the life cycle of their dominant (mature) industries and managed to maintain its competitive position becoming more cost efficient (papermaking), specialising into niche markets (shipbuilding) and innovating and going international (papermaking and marine equipment). The same goes for the sub-cluster of energy production, where the leading firms (Petronor and Iberdrola) have increased their size by a sustained strategy of internationalisation (combined sometimes with other of M&A abroad) and

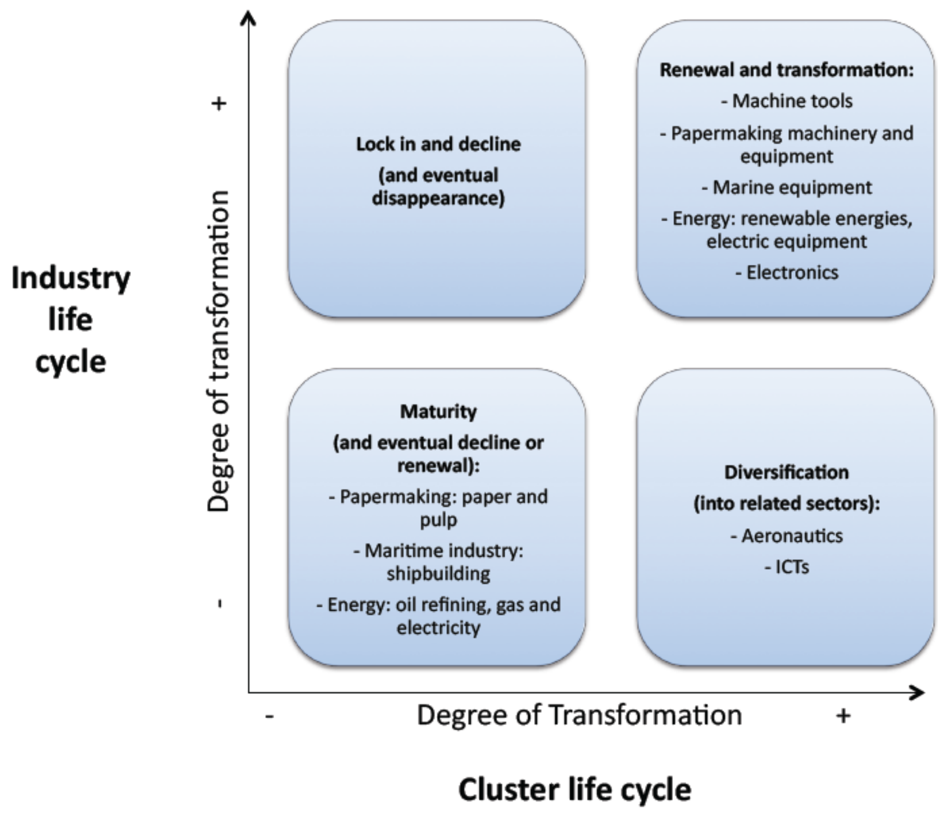
[13] For instance, the Basque electronics industry had its own business association that later on transformed into a cluster association and included ICTs firms, López et al. (2008) and Valdaliso and López (2008). In the energy cluster, the companies of the two aforementioned sub-clusters belonged to different industry associations.

[14] Some firms of the Basque cluster of maritime industries, such as Guascor, have partially diversified their product and client portfolio by moving into new and more dynamic sectors like that of renewable energies (Fernandez Bobadilla et al., 2010). The same went for Gamesa, a firm that started in the 1970s manufacturing metal products, then moved in the early 1990s to aeronautics and finally diversified into the wind energy sector (López et al., 2012; Elola et al., 2013a), and for many small suppliers of Gamesa in the Basque Country, such as Hine (Zabala and Zubiaurre, 2011). These trajectories can also be seen in other European regions, see Fornahl et al. (2012).

by entering in the new sector of renewable energies, an emerging market for manufacturing and engineering firms of this cluster too. The machine tools cluster, and the sub clusters of energy equipment (energy) and electronics (electronics & ICTs) were able to renew and transform themselves thanks to a combined strategy of innovation and internationalization developed by a core group of medium size firms (some of them strongly linked to the large energy producing firms).

There are, however, two new clusters that have appeared and developed in the Basque Country in the period under study: those of aeronautics and ICTs, linked to the new windows of opportunity brought about by technological change in those industries. The aeronautics cluster was not created from scratch; its foundations relied on the base of knowledge, resources and capabilities of incumbent firms of other related sectors (special steels, automotive, engineering) (López et al., 2012). With regard to the ICTs sub-cluster, it started in the 1980s linked to the diffusion of microelectronics, software and telecommunication technologies that speeded up in the 1990s (OECD, 2003; López et al., 2008).

Figure 2. Evolutionary trajectories of Basque clusters between c. 1978 and c. 2008



Source: authors' ellaboration.

Our findings fit well with the typology of cluster-based renewal of old industrial regions proposed by Trippl and Tödtling (2008: 207). With different degrees of innovation, the clusters of papermaking, maritime industries, machine tools and energy, would be good examples of 'innovation-based adjustment of mature clusters'; while those of aeronautics and ICT would fit, respectively, into the 'diversification' and 'radical change' types.

Which were the driving local factors behind cluster evolution? Based on previous literature, we briefly discuss the impact of three factors in every cluster: cluster knowledge base, social capital and public policies.

As mentioned in section 2, cluster knowledge base depends on the capabilities (and strategies) of the clustered firms, the cluster absorptive capacity and networks, and the region's capabilities. So far, we do not have a homogeneous quantitative indicator of the relative strength of the firms' knowledge base in every cluster, although the ratio of R&D expenditures over turnover may be a first proxy (see Table 2). Besides, in depth case studies point to a relatively stronger knowledge base in the machine tools, electronics & ICT, energy and aeronautics clusters (large or medium firms with in house R&D units) than in the papermaking and maritime clusters (except for a few firms, particularly those that diversified into the emerging sector of renewable energies).

The business strategies of the clustered firms –insofar as they are the result of their existing resources and capabilities- may be another proxy for the cluster knowledge base and have been identified as one of the driving factors of Basque clusters evolution (Elola et al., 2012a; Valdaliso et al., 2013). The clusters of machine tools, maritime industries and electronics and ICTs are comprised of SMEs that have largely followed a combined strategy of product differentiation, innovation and internationalization; and the same goes for the sub-cluster of manufacturing of papermaking equipment and machinery. The presence of large firms is much more important in the other three clusters, but they have played a very different role. The large papermaking firms, some of them owned by MNEs, followed a strategy of price competition based on scale economies and cost efficiency. In the energy cluster, a few large firms in the oil refining, natural gas and electricity have played a tractor role for the SMEs specialised in energy equipment manufacturing that, in its turn, have followed the same strategy pointed for the SMEs of the machine tools and electronics and ICTs clusters. As to the aeronautics cluster, its origins and development are strongly linked to the efforts of two large anchor firms well positioned in the industry's GVCs. In any case, again, the type of industry (and technology) does matter as it defines the scope of business strategies available for the clustered firms. For example, the 'commoditization' of paper in the global market forced papermaking firms to follow a cost competition strategy, while in other sectors the strong market segmentation (machine tools, shipbuilding) or the fast pace of technological change (energy equipment, electronics and ICTs, aeronautics) broadened the scope of business strategies available (Elola et al., 2013; Valdaliso, 2010; Valdaliso et al., 2011 and 2012b).

Some authors have stressed that the dynamic growth of clusters depends on their absorptive capacity, which has two dimensions: the intra-cluster knowledge system (based on the firms' knowledge base, the existence of regional communities of knowledge and technicians, the strength of their universities and technological centres) and the extra-cluster knowledge system (based on the relationship of leading clustered firms with foreign sources of knowledge, cluster insertion in GVCs, foreign direct investment of MNEs) (Giuliani, 2005). With the exception of the papermaking cluster, the selected clusters benefited from a strong research and educational infrastructure in the region (technological centres, training schools and universities) closely related to their needs of qualified workers, researchers and technological solutions (Valdaliso et al., 2011 and 2012b). Besides, the Basque Country ranks relatively well among the European regions in terms of R&D and innovation indicators and educational levels (OECD, 2011; Aranguren et al., 2012a). The six clusters appear to be well connected with foreign sources of knowledge, although by means of different channels: MNEs in the papermaking cluster, internationalization processes lead by leading firms (either SMEs, as in the machine tools, maritime industries, electronics and ICTs clusters, or large enterprises, as in the energy cluster), and insertion of the large firms and SMEs of the aeronautics cluster into GVCs (Elola et al., 2013; Valdaliso et al., 2011).

Another proxy to cluster diversity is the number of industries and sectors that encompasses. According to our conversion tables mentioned in section 2, energy and electronics and ICTs were those with a larger number of sub-clusters according to exports, 10 and 6, respectively, whereas machine tools, aeronautics, maritime industries, and papermaking and were quite more specialized, with 1, 2, 3 and four, respectively.[15] Additionally, clusters larger in size comprise of many firms with a great diversity of technologies and knowledge, as our clusters of electronics and ICTs, maritime industries and energy show. In terms of knowledge diversity at regional level the Basque Country maintained over this period a relative specialization in industry – particularly in metal advanced manufacturing activities with medium-high and high technological content- and business services much higher than the average level of Spanish and European regions (NUTS2 level) (Eurostat, 2010; Aranguren et al., 2012a: 160-61, 174-75; Orkestra, 2013: 48). With regard to the related variety of regional exports, the estimation made for the year 2007 ranked Basque territories among the top 10 Spanish provinces with a higher score (Boschma et al., 2012). Although the causal relationship between these regional indicators and clusters' performance is not proved, however, it seems pretty clear that Basque clusters counted on a regional base of knowledge and capabilities that might facilitate their renewal and adaptation.

Several studies have pointed out that social capital has enhanced both knowledge creation and absorptive capacity within and between clusters, and have emphasised the key role played by cluster associations in this regard (Valdaliso et al., 2011; Valdaliso et al., 2012a; Aragón et al., 2012). However, the level of social capital, grossly measured by the representativeness and recognition of the cluster association, differs across our sample of clusters studied. It is relatively high in the machine tools, maritime industries, electronics and ICTs, and aeronautics; and relatively low in the papermaking one. As to the energy cluster, the strong business relations that exist between the large energy producing firms and the manufacturing SMEs, act as a substitute for the minor role of the cluster association.[16] Cluster associations were not

[15] So far, the number of sub-clusters attending to the analysis of exports is a more accurate proxy for diversity than the number of 4 digit CNAE-93 sectors. The 15 4 digit CNAE-93 codes of the papermaking cluster, for example, can be grouped into the four aforementioned sectors, see section 2 and notes 6 and 8.

[16] If we take the degree of representativeness of cluster associations (that is, the percentage of clustered firms that are affiliated to the cluster association), it is very high in the aeronautics, machine

only drivers of social capital formation but they promoted inter-firm collaboration in human capital formation, R&D and internationalization as well. Its role was more important in those clusters comprised exclusively of SMEs that were not large enough to face those challenges alone.

Last, but not least, public policies applied in the Basque Country since the 1980s onwards have facilitated cluster-based renewal. The regional government showed a strong commitment in the 1980s to keep and restructure the traditional industries by a retooling strategy based on the creation and development of a technological infrastructure (technology centres and parks), a policy of R&D promotion (in house and external), and a strong emphasis on human capital formation. This policy was maintained in the 1990s, but combined with others: a cluster policy aimed at promoting the creation of several cluster-based initiatives in the six (and many other) clusters studied; and the first attempts to promote diversification into other sectors that did not exist in the region, such as aeronautics, telecommunications, and creative industries. This strategy of industrial diversification (a 'de-locking' mechanism according to Martin and Sunley, 2006) continued throughout the 2000s but then with a clear stress on science-based sectors, such as bio-sciences, nano-technologies and advanced manufacturing. Regional and national energy policies and strategies have encouraged the renewal and transformation of the Basque energy cluster, driven by renewable energy technologies (Aranguren et al., 2012a; Aranguren et al., 2012b).[17]

5. Conclusions

In this paper, based on the evidence of the Basque Country, we contribute to the literature on cluster life cycles. We specifically add new insights to the research on the relationship between cluster life cycles and the trajectory of its corresponding industry, by introducing an exploratory analytical framework where we can establish four different scenarios for cluster evolution depending on the degree of transformation experienced in both clusters and industries. Our work contributes to the existing research in three different ways.

First, we conclude that both clusters and their corresponding industries do not follow a "deterministic" development path. That is, they do not follow a straightforward cycle of emergence, growth, maturity and decline, but both mature industries and clusters can transform or even reinvent themselves, renewing or transforming their knowledge base, and getting into a new growth phase.

Second, although clusters tend to co-evolve with industries, we see that clusters are not just a local representation of an industry. That is, clusters do not necessarily follow the life cycle of their dominant industry (Bergman, 2008; Menzel and Fornahl, 2010; Martin and Sunley, 2011). Some clusters are able to escape from the 'tyranny' of the industry life cycle and from lock-in situations, while others cannot. In our specific case, four out of the six clusters studied have followed the life cycle of their respective dominant industries: some followed the life cycle of their dominant (mature)

tools, electronics and ICTs, maritime industries and even energy clusters, but very low (about 50%) in the papermaking one, see data offered in part 3 of this paper.

[17] National policy on renewable energies has been suggested as the key factor for the emergence of a wind power cluster in the neighbouring Navarre (Essletzbichler, 2012).

industries and managed to maintain their competitive position, and others were able to renew and transform themselves. There are, however, two new clusters that have appeared and developed in the Basque Country in the period under study. With different degrees of innovation, the clusters of papermaking, maritime industries, machine tools and energy, would be good examples of 'innovation-based adjustment of mature clusters'; while those of aeronautics and ICTs would fit, respectively, into the 'diversification' and 'radical change' types, according to Trippl and Tödtling (2008) typology.

Related to the previous issue, and following existing literature, we show that local peculiarities also matter for the evolution of a particular cluster (Menzel and Fornahl, 2010; Martin and Sunley, 2011). In this point, we contribute by deepening our understanding of which are the local factors that mostly influence the trajectory of a cluster in relation to the trajectory of its dominant industry. Our analysis shows that at least three factor groups affect mostly these dynamics: cluster knowledge base and absorptive capacity, social capital, and public policies.

Our study has implications for policy makers, as it highlights those elements that policies should focus on in order to promote cluster competitiveness. First, social capital is an element that policies should focus, that is, policies should promote the development of inter-firm networking and collaboration and community building (Aragón et al., 2012; Malecki, 2012). Second, policies should also be oriented to increase the knowledge base and absorptive capacity of clusters, through the promotion of innovation and R&D activities (of firms and other agents of the regional innovation system) and internationalization.

Acknowledgements

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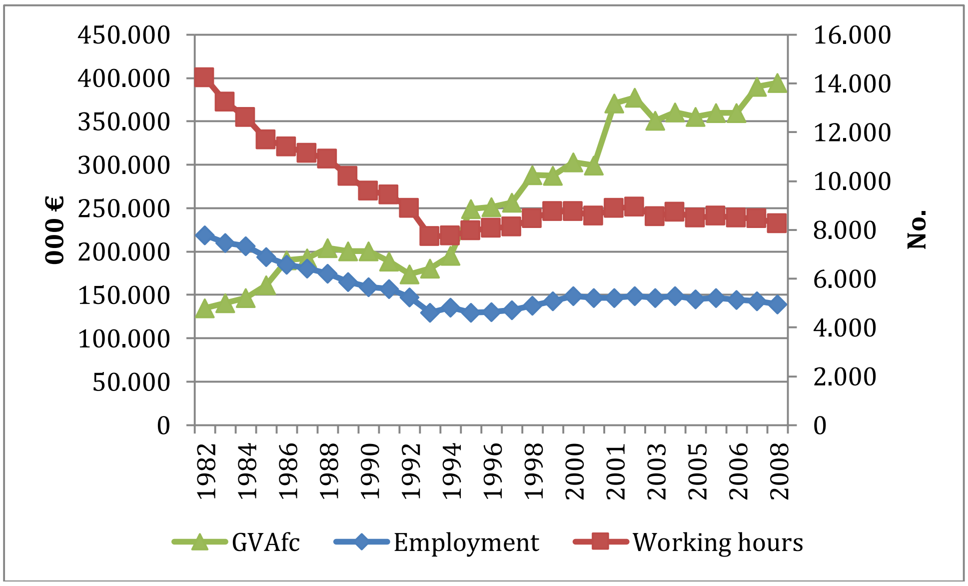
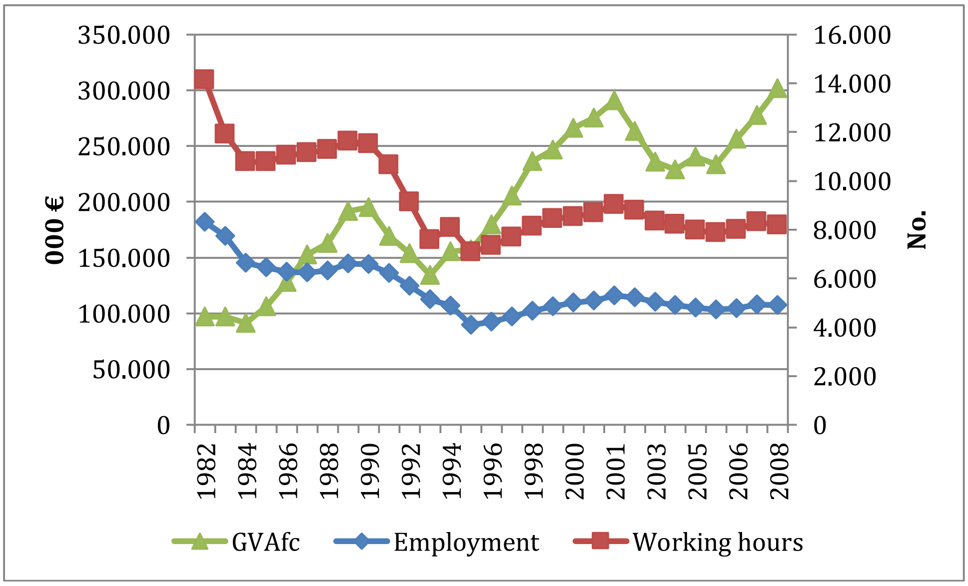
Appendix. GVA, employment and working hours in some industrial sectors representative of some of the clusters studied, 1982-2008

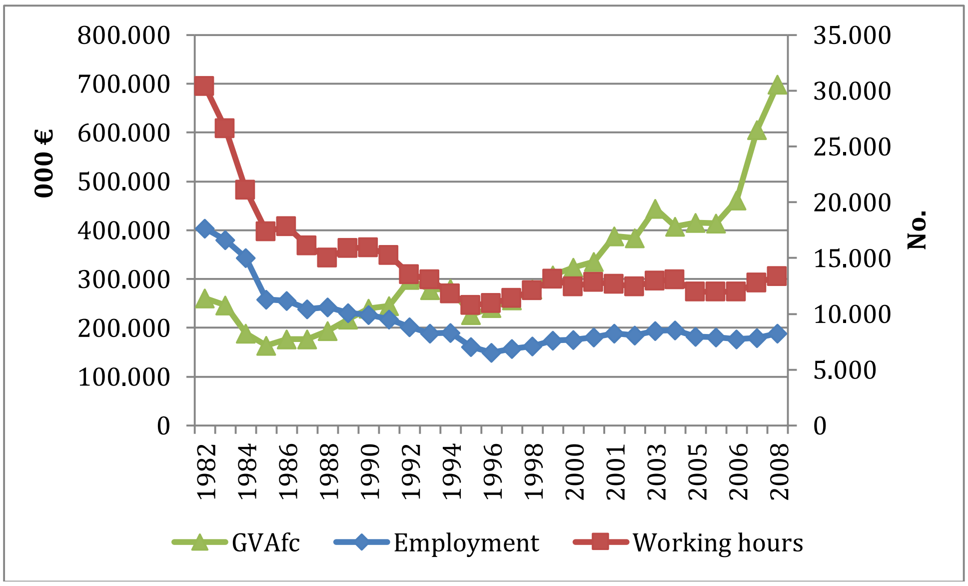
Papermaking



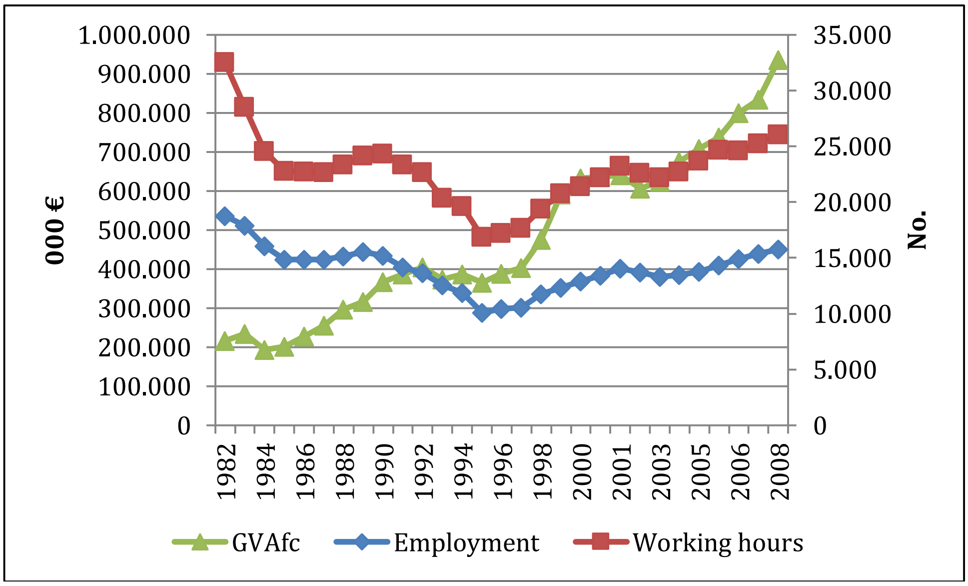
Machine tools



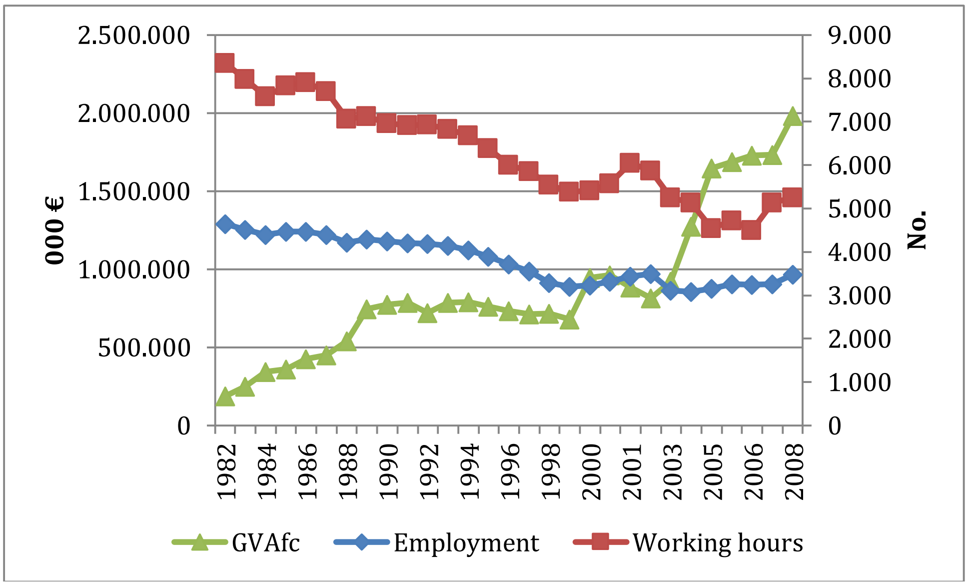
Shipbuilding and other transport material and equipment



Electric and electronics parts and equipment, office equipment and computing



Oil refining, gas and electricity



Source: EUSTAT, *Cuentas Industriales* 1982-1995; and www.eustat.es,1995-2008. GVA at factor cost, in thousand of current Euros.