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Competitiveness and Industrial Evolution: The Case of the Ceramics Industry

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Abstract

This paper analyses the contribution made by evolutionary processes to the organisation of economic activity which is designed to create and sustain a competitive advantage, and to the competitiveness of companies in a dynamic and changing environment.

The study looks at the ceramics industry sector in the Portuguese district of Aveiro, taking this as an example of change on the basis of empirical analyses of current organizational characteristics. These have resulted from centuries-long evolution and environmental adaptation and are related to the creation and sustention of a set of competitive advantages identified by top managers. They also relate to innovation, demand, knowledge, networks and co-evolution of the industry. The research concludes for the relationship between industrial evolution and competitiveness.

Keywords: competitiveness, industrial evolution, evolutionary economics, competitive advantage, industry studies.

1. Introduction

Today, globalization has become a dominant characteristic of the economy in which the agglomeration of externalities both influences the organisation of economic activity, in terms of its own capacity to produce, and sustains competitive companies and industries. Companies must understand evolution as a constant adaptation to change, based on innovation. They may understand that there are parallels between companies and species, including survival through natural selection, the creation of competitive advantage and improved performance and it is through these that only the most able survive.

The concentration of a specific industry's productive activities in a particular place makes it necessary to study the development of competitive advantages of either the

industrial companies themselves or the region in which they are located. Such advantages bring increased productivity, innovation and job opportunities as well as promote economic stability and growth. In this case, gaining an insight into the evolution of the industry will help us to understand its particular competitive features. Variations in local patterns raise specific questions of industrial evolution. These questions are related to a number of factors that represent driving forces, over a given period of time. Answering them will enable us to significantly understand the dynamics that have marked a specific industry in a special location: that is, its competitive advantage.

The ceramics industry is a promising subject for study for a number of reasons. First, ceramics are produced all around the world; however the stamp of evolution has given the industry special characteristics which include habits, culture, knowledge and location. Second, ceramics is an old industry, harking back to primitive times and referred to as one of the earliest forms of human production. It is linked to human social activities, and has developed alongside society. This fact has, together with demand for ceramic products, stimulated competition based, initially, on local features such as the abundance and quality of raw materials, manpower, sources of energy or knowledge. Craft ceramic products have evolved into industrial products, produced in contemporary high-tech plants, based on innovation, quality and design. Third, the ceramics industry of today reflects dynamic levels of competition with global, complex and highly changeable characteristics. This increases the value of any contribution by contemporary research in industrial organization and adds a historical perspective to the current debate on competitiveness.

Organizations, like species, must learn how to use their environment to survive, adapting their resources to variations and to the right speed of learning to produce and influence the competitive conditions that contribute to performance and success.

This study first examines the contribution of evolutionary economics, in an industrial evolution approach, to the ability of companies in a specific industry to obtain and sustain competitive advantages in a context of competitiveness. The second part considers global patterns in the ceramics industry and the evolution of this in the Portuguese district of Aveiro with its ancestral ceramic features, in place from the nineteenth century till today. In the third part, the precepts of evolutionary economics are applied to the companies under analysis and an attempt is made to identify some factors that may result from industrial evolution in a context of dynamic competition. Finally, some conclusions are presented, together with the implications of our study for research into empirical analyses of evolution, understood as a continuous adaptation to change in

a process that guides the industry's competitiveness.

2. Evolution, Competitiveness and Competitive Advantage

The evolution of companies is related to economic organization and industrial structure. It is centred on permanent change in such a way as to be analogous to biological evolution and natural selection. Economic systems could, thus, be interpreted as mechanisms which pursue "success" and "profits" in an adaptive way (Alchian, 1950).

Evolutionary economics has, as its fundamental hypotheses: i) companies are more based on the meeting of needs than on earning profits or profit maximization as regards their routines, decision rules and rationality; ii) the competitive environment rewards success, which is based on results. The making of profits is a factor in selecting successful and survivable companies; and iii) no industry is in balance at any given point in time (FitzRoy *et al.*, 1998).

With the aim of analyzing evolution, evolutionary economics involves research into the role of technological change and innovation related to organizational change in complex environments. It includes, in its theoretical framework, an evaluative analysis of open and complex systems (Hodgson, 2002), and sees organizations as complex adaptive systems (Arthur, 1999; Potts, 2000) and industries as systems (Malerba, 2006).

In their evolutionary theory of economic change, Nelson and Winter (1982) describe the concepts of tacit learning and routines with Schumpeterian dynamic competition. In their work they argue that companies essentially compete for improvements and innovation. In this competition, a company's search for better procedures is only based on a partial knowledge of the causal structure of its own capabilities and on the set of technological opportunities.

The relationship between innovation and the evolution of industries is central to Schumpeter's approach to economic dynamics, as it is in evolutionary and neoclassical theories (Malerba, 2006). In his work, Schumpeter (1934, 1939, 1942) offered a distinctive perspective of the competitive market process. He viewed it as an evolutionary process of growth from the equilibrium of economic capitalism to change in the pursuit of profits. It is ruled by routine activity, in which entrepreneurs play a crucial role, and innovation is introduced in the form of new or improved products, services or processes or in the form of new organizational techniques, in an unceasing flow of "creative destruction" contributing to opportunities for profit, continuous adaptation to change and evolution, moving the economy away from one temporary equilibrium to another.

Evolutionary theories posit natural selection arguments to account for stability and change. Organizations are viewed as being in a Darwinian struggle in which only the most apt survive¹⁾. According to Chiles and Choi (2002) and Alchian (1950), the natural selection used in the discourse on evolutionary economics has three fundamental components: variation, heredity and selection. Variation relates to the existing heterogeneity in a company's characteristics that makes it different. This may manifest in routines, capabilities, histories, innovation or localized search. Heredity is related to the organizational characteristics of companies which can be transmitted or imitated in an organizational population, incorporating productive and organizational knowledge, and where location has a special contribution to make. Selection is related to an environment's selection criteria, where the organizations that meet or exceed the criteria will remain and grow where those that fail to meet the criteria will wither or die. For Alchian (1950), positive profits or business volumes are market selection criteria. Thus, Alchian (1950) had a similar line of thought in relating the evolutionary Darwinian pattern with survival and business success, concluding that most economic concepts are close to biological theories of evolution, with genetic heredity, mutation and natural selection corresponding to organizational imitation, innovation and positive profits.

Foster (1997, 2000) outlines an economic auto-organization theory based on evolutionary thinking that Witt (1997) relates to the economic theory of productive resources and long term growth and development, pointing out that productive economic bases can be seen as an extension of natural auto-organization.

The studies of Nelson and Winter (1982) and Hannan and Feeman (1977) are a pioneering contribution to the forming of an intellectual and theoretical basis for the application of ecological and evolutionary concepts to organizations. However, several other authors have taken an evolutionary economics approach to studying organizations; studying the internal organization and organizational evolution of companies, industries and markets, in parallel with the ecological process that contributes to the development of a strategic pattern based on a subjacent evolutionary logic guided by evolution. Malerba (2006) demonstrates how this evolutionary pattern can constitute a generally robust framework for studying industrial dynamics.

¹⁾ In the context of evolution and change, the "most apt", are either species or companies who on better adapting and surviving in a constant and competitive environment of change, successfully survive. However, this is a relative and temporal concept; relative in terms of the variables that determine survival and temporal because features which are favourable at a given time could become adverse at another.

Like living beings, companies also live in an environment of competition. Companies don't compete for food or space, but for inputs, consumers, markets and profits that will cover the costs of their options and decisions, thus providing a path to survival. Accordingly, species and companies share a common element as, for both, competition is an important factor. This can be seen as resulting, also, from the analogy between biological, evolutionary, competition and economic competition (Hodgson, 2002; Nelson and Winter, 1982).

The evolution of a company's competencies and technical progress are factors that contribute to its ability to compete in a global, complex, and dynamic market, where evolution, impelled by systematic competitive advantage, improves, in a deterministic and sequential process, organizational performance, competitive position and business success (Day and Wensley, 1988). This gives rise to the contingent nature of companies which establish a direct relationship with the environment, with all its volatile and evolutionary features. It ensures that organizational effectiveness depends on constant adaptation, on systematic creation of competitive advantages designed to promote leadership of both current and potential market dynamics. This jointly reflects on organizational performance which orders success and induces industrial competitiveness.

A competitive advantage accentuates the difference between companies and is a vital element in enabling organizations to survive and increase their value in a competitive market. It stimulates "creative destruction", innovation, continuous improvement, entrepreneurship, and a company performance when faced with potential competitors. Competitive advantage is related to organizational performance, influencing the success level of organizations that survive in the market and could be seen as a reward for successful harmony in a complex and dynamic²⁾ environment.

A company's competitive advantage represents the value it has created, in a different way from its competitors, for its stakeholders, allowing it to compete along several dimensions as it establishes and sustains a defensible position in the market. These dimensions may result from the implementation of a strategy of self-creation of value, distinct capabilities in terms of competences, processes and superior resources (Day and Wensley, 1988) or from the access to assets, tangible or intangible, which competitors do not have (Barney, 1991), thus generating new ways of surpassing competitors (Porter and Millar, 1985).

²⁾ Complexity includes the different factors that influence business. Dynamics is related to the speed of change and uncertainty and the impact on business that leads companies to enter or exit an industry.

Location is also an important factor which contributes to creating and sustaining a competitive advantage (Porter and Stern, 2001). The development of an industry in a particular location could be a determinant for innovation and, consequently, a company's competitiveness. Thus the local environment influences the level of an industry's success, as this depends on easier and better information, local knowledge and organizational learning leading to lower transaction costs through the increase of specialization, cooperation and rivalry between companies (co-petition), through the concentration of related activities (Bianchi, 1998; Mariussen, 2001).

So, competitive advantage can be seen as resulting from a multidimensional construct. While it is true that just one relevant variable might be necessary, it is likely that this wouldn't be sufficient on its own to create competitive advantages. Such advantages will result, in most cases, from organizational resources and from the establishment of integrated, relational and dynamic relationships (Wheelwright and Hayes, 1985).

On the other hand, competitive advantage has an evolutionary character. It is relative to time and to other companies' benchmarking capabilities. A company's comparative benchmarking capabilities allow creative destruction, including innovation, to be generated and forces competitive advantage to constantly evolve, thus allowing a subsequent level of successful adaptation to the market.

In parallel with competitive advantage, competitiveness is a relative, comparative and dynamic concept which makes sense when inserted in an environmental context and when related to a given time period. The competitiveness of companies or industries can be defined as the capacity of a company or industry, which develops a sustained successful relationship with the environment, to compete in markets and sustain or obtain a dominant position. There are multiple factors involved: the characteristics and behaviours of companies, the microeconomic level, the creation of synergies generated in a sector or at an aggregate level, the environmental context, the macroeconomic level, price-setting mechanisms, the exchange or monetary regime and wage structures.

The competitive capacity of a company depends on the productivity of its workforce, capital investments, and its efficiency in using raw materials to produce goods and services which satisfy the needs of not only consumers but also other stakeholders.

Competitiveness factors are understood as factors that determine a company's competitiveness. Some factors depend on the object to which they are applied. These include, for example, internal features, the status of a company's life cycle or macroeconomic structural and conjunctural statements. They can also depend on location, governmental political decisions, levels of education and training, access to technology,

health and social security, transport and communications, infrastructures, energy, commerce and tourism, etc. All competitiveness factors suffer from the influence of time with the structural ones, in constant interaction with the environment in evolution, being in a continuous state of adaptation to change (Pereira, 2005).

In a competitive evolutionary process, the kind of behaviours selected by companies are necessarily superior and relatively efficient, with capitalist competition acting as an evolutionary process, favouring the more efficient forms and modes of industrial organization (Hodgson, 1993). In this way economic evolution promotes maximum rationalisation and efficiency.

3. Innovation and Evolution of Industry: Demand, Knowledge, Networks and Co-evolution

According to Malerba (2006), the industrial evolution is related to a process of transformation of knowledge, technologies, learning, features and competences of actors, types of products and processes, and institutions. In this process of transformation, the industry also changes its structure and the network of relationships among actors is relevant to innovation and to the performance of an industry. These dimensions contribute to innovation and to industrial evolution and throw up four challenges: demand, knowledge, networks and co-evolution.

Demand (size, growth, structure and composition) is related to consumer behaviour and affects innovation by playing an important role during the different stages of the evolution of an industry. Moreover, the process of change in knowledge and learning processes, that could differ across sectors in terms of sources, domains and applications, is at the heart of the evolution of industries. Networks, in which heterogeneous actors interact with different levels of knowledge, competences and specializations, establish several types of relationships: competitive, cooperative, informal, formal, market to non-market (Malerba, 2006). Co-evolution is an integrated process involving knowledge, technology, actors, demand, institutions, and sector-specific factors, all affecting the evolution of companies in an industry.³⁾

4. The Evolution of an Industry: The Case of Ceramics

The making of ceramics is thought to date back to around the 7th Century B.C. It was one of humankind's first economic activities, arising as a result of an agricultural surplus that

³⁾ See Malerba (2006).

allowed a transition to a productive economy, based on sedentary habits. As a result, new needs based on sedentary habits began to emerge. These included storing agricultural produce; bread ovens; houses; and spiritual and religious symbols. This, in turn, led to the production of vases, bricks, ovens, statuettes and decorative elements in argil. Ceramic production has shadowed the technical progress of human society from the Neolithic to the present day, keeping up with the development of new techniques and the establishment of new production relationships between people and the environment. It was noticeably important in a number of civilizations, e.g. the Greeks, which valued ceramics highly enough to use them as prizes for winners at the Olympic Games. Thus, the history of Ceramics is marked by a succession of eras, and associations with different cultures, habits and technologies (Pereira, 2005).

Exploration and European conquests helped spread the introduction of new ceramic techniques, as with the Portuguese voyages to the East, which began during the Middle Ages and led to the introduction in Europe of various porcelain objects from China, Japan and India. In fact, the Portuguese word *porcelana*, or a variation thereof, entered the vocabulary of several European languages, including English, French, German, Dutch and Italian (Pereira, 2005).

4.1 The Portuguese Ceramics industry: the case of the Portuguese District of Aveiro

Despite existing trading patterns, oriental porcelain only began to influence Portuguese ceramic production towards the end of the 18th century (Gomes, 1993). Ceramic production was mostly centred on potteries which were scattered around those important places in Portugal that had a tradition of ceramics, and were associated with such local features as raw materials, labour, energy sources and consumer markets (Pereira, 2005).

The new techniques and the introduction of mechanisation provoked great developments in ceramic production and industrialization in the 17th and 18th centuries. This reflected the socio-economic and technological changes in Portuguese industry, which translated into an increase in the number of industrial establishments and factory workers and the first efforts to make use of the steam-engine. In the 19th century, Portugal started porcelain production at the *Vista Alegre* factory, established in 1824, near the city of Aveiro. This production was developed in reaction to the extensive availability, resulting from the Industrial Revolution, of high-quality, lower-priced British ceramic products in Portuguese markets. This century also saw the appearance of several important ceramic factories around the country. The efforts made in the nineteenth century were continued in the 20th century with the development of the Portuguese

ceramics industry (Pereira, 2005).

At present, and despite the fact that there is ceramic activity throughout Portugal, the largest concentration and development of this industry is to be found in the coastal zone north of the Tagus River. The main specialised centres of production are located here, as a consequence of accumulated know-how and expertise together with the availability of all main production resources.

The region of Aveiro offers the ceramic business a unique set of features. These have given it an initial competitive advantage over its evolutionary history. They include geological features, with plentiful quality raw material; ample sources of energy, financial assets (capital), labour, the entrepreneurial vision of local businessmen; dynamic and competitive markets; a ceramics culture, knowledge and accumulated learning; and a propitious geographic location with good transport accessibility, by sea, river, river branches, railway and national and international roads. Together these have influenced the establishment in the district of important national and international ceramics companies, from the first industrial unit in 1775 to the present day. The development of the industry in the district, with its favourable networks, industrial culture and knowledge, has turned the region into an “industrial corridor”. This is characterized by an agglomeration of industrial companies over a relatively small but continuous geographic area, a diversified industrial arrangement and strong entrepreneurship. Here, both the metal and ceramic industries have grown into specialised businesses with the potential to form clusters, as described by Porter (1998).

Aveiro’s ceramics industry has evolved from the essentially self-sufficient businesses of the Industrial Revolution, where a company’s structure was one of total vertical integration, from the exploitation of raw materials to the marketing of products, to form interdependent patterns at a number of levels: technology, raw material and markets. In this way, companies try to respond appropriately to the functional and aesthetic requirements for products that result from the changeable, evaluative and competitive environment, dominated by increasing consumer needs and the technical complexity of industrial processes. These industrial processes reflect the structural changes in most ceramics industry subsectors and adjacent industries, in a process of disintegration that has become both more marked and more global in the present day. The companies upstream the production file are producers of added-value raw materials which supply such materials to the final producers, thus making it possible to increase productivity and quality of final products through a rationalization of resources as well as providing a boost to the renewal of industrial ceramics.

Nowadays, the ceramic corridor is home to several hundred companies and related organizations which directly employ about 33,000 workers. Together these contribute to the dynamism of the ceramics industry, helping it to be one of the largest sectors in the Portuguese economy. However, the various industrial ceramics subsectors don't share the same optimism. They are noticeable for the heterogeneity of their businesses, with some companies being economically stable and having a good market reputation in the market and others that are only able to survive with difficulty.

The ceramics industry sector offers a wide range of products and production processes, resulting from the varied uses made of the original material: argil. The ceramics industry also acts as a supplier to other industries including, for example, construction, telecommunications, power generation, space exploration, medical and food.

Over the last few decades, the ceramics industry in the Portuguese district of Aveiro has increased its importance in relation to the Portuguese ceramics industry as a whole. Aveiro district ranks third in terms of the number of companies, and first in terms of the number of employees in the sector, the number of larger businesses and business and export volumes.

The region of Aveiro has the oldest ceramic companies in Portugal, including the unique national ceramics company with more than 1000 employees. This underscores its highly adaptive approach and survival in a dynamic and evaluative environment.

Aveiro's ceramics industry is characterized by great rivalry, some cooperation and some interrelation with clients, suppliers, other companies and public and private entities, including universities, industrial and commercial associations and consultancy firms (Pereira, 2005).

The Aveiro ceramics industry has not received any special financial developmental support through national or European policies. It has relied on the same channels of financial support as other industries without any specific character or benefits to the sector or to the region. However, it has benefited from an existing network in the region that has fostered technical support, training and research in the sector. It has relationships with various trade and industry associations which provide technical support and training. These include APICER (The Association of Portuguese Ceramics Industries), CTCV (The Technological Centre for Ceramics and Glass) and AIDA (The Aveiro District Industrial Association). On the educational front, there are strong ties to the University of Aveiro which, since the 1970s, has had a department specializing in ceramics that offers a variety of degrees, masters and PhDs and carries out scientific and

technological research in the field of ceramics and materials. It also benefits from the existence of various professional technical schools in the region that train people qualified at the technical level. At the same time, it benefits from the knowledge accumulated over the centuries by local people and businesses which has resulted in the transfer of key expertise between people in the same family and between companies in the district of Aveiro.

More recently, Aveiro became part of the European network cooperation project UNIC (Urban Network for Innovation in Ceramics) along with the other main European industrial ceramics centres: Limoges (France), Delft (Netherlands), Pecs (Hungary), Stoke-on-Trent (United Kingdom), Castellon (Spain), Faenza (Italy), Cluj-Napoca (Romania) and Seville (Spain).

5. Empirical Research Results

The subject base of the current empirical study was built from a questionnaire sent, in December 2003 and May 2004, to the 115 ceramic production companies in the district of Aveiro. The questionnaire was aimed at top managers with responsibility for general company decisions. 72 questionnaires were returned with valid answers, which represent a reply rate of 63%. The companies in question are heterogeneous and belong to the four industrial ceramics subsectors: 45% producing household and ornamental ceramics; 22 % producing pavements and revetments, 32% producing structural ceramics and 1% producing sanitation ceramics. This last subsector, which was poorly represented in our sample, was only included in global analyses.

The average company, based on number of employees, is between 20 and 49, except

Table 1. Company age.

Classes [company age]	Household and Ornamental Ceramics (%)	Pavements & Revetments Ceramics (%)	Structural Ceramics (%)	Ceramics Industry(%)
1 [0–4]	0	6	4	3
2 [5–9]	21	13	4	14
3 [10–15]	16	25	4	15
4 [16–25]	41	25	18	29
5 [26–50]	16	19	57	29
6 [51–100]	3	12	13	9
7 [>100]	3	0	0	1
Total	100	100	100	100

for the subsector of pavements and revetments subsector which mostly consists of companies having between 100 and 249 employees. Thus, the companies in the sample may be classified as Small and Medium-sized Enterprises (SME).⁴⁾

As regards the age of the companies, and as shown in Table 1, 14% of the companies are less than 10 years old, 15% of the companies are between 10 and 25 years old, 39% are more than 25 years old and 10% more than 50 years old.

In addition to company size and age, other characteristics, summarised in Table 2, were also analysed for ceramics industry. These included:

- restructuring processes the company has undergone over time including, for example, location, administration, production layout, mergers and acquisitions; denoting adaptive evolution to change and variation;
- the provenance of the capital stock, if it is family-based the probability of heredity inside the company is higher. If the capital stock is not from the district of Aveiro⁵⁾ heredity is lower and the variation larger;
- the insertion of the company in a group of companies, or where the company is associated with other companies, thus benefitting from group synergies;
- the internationalization of companies, with exports being used as the simplest way of

⁴⁾ The criterion used was based on European Community legislation that sets limits on the size of enterprises. Microenterprises have fewer than 10 employees, small enterprises have fewer than 50 employees, medium-sized enterprises have fewer than 250 workers and large enterprises are companies with 250 or more employees. In other words, according to Commission Recommendation 2003/361/EC of 6 May 2003, to define an enterprise as large it is necessary to verify the cumulative number of employees and turnover, or, alternatively, the value of the annual balance sheet and the criterion of autonomy. So, the categories:

-Micro, small and medium-sized enterprises (SMEs), are enterprises which employ fewer than 250 people, which have an annual turnover not exceeding EUR 50 million, and/or an annual balance sheet total not exceeding EUR 43 million, and meet the criterion of autonomy defined as follows: if 25% or more of the capital or voting rights the enterprises are owned by another company, or group of companies the enterprises are not considered to be SME

-Small enterprises are defined as enterprises which employ fewer than 50 people, have an annual turnover and/or annual balance sheet total that does not exceed EUR 10 million and meet the criterion of autonomy defined above.

-Micro enterprises are defined as enterprises which employ fewer than 10 people, have an annual turnover and/or annual balance sheet total that does not exceed EUR 2 million and meet the criterion of autonomy.

⁵⁾ If most of the capital stock is from outside of the district, the company's management and administration processes are more likely to be different from the processes transmitted and imitated within the local organizational population.

Table 2. Company characteristics.

Variable	Ceramics industry (%)
Companies that have undergone restructuring	58
Companies with capital stock mostly from the district of Aveiro	79
Companies with family-based capital stock	46
Companies belonging to an entrepreneurial group	67
Companies with associated companies	42
Exporting Companies	68

measuring the internationalization through which the company is exposed to the selection of international markets.

Table 2 shows the percentage of companies that shows each of these characteristics.

Most of the companies under analysis have undergone restructuring which has occurred as an adaptive response to the changing environment. Most of the capital stock originates from within the district of Aveiro, meaning that management is marked by characteristics relating to local culture. There is an observable decrease in the family-based nature of the capital; however, most companies start up with family capital and management, which has been handed down through the generations. Most of the current companies belong to groups, through processes of evolving new groups, being acquired by existing groups or being set up within a group. Internationalization is another characteristic of these companies. Most of them export, except for structural ceramics, where product weight and transport logistics limit sales to regional markets.

An increase in output has been seen over the last decade thanks to increased business volumes for ceramic pavements and revetments. However, turnover of structural ceramics has decreased due to the recession in the construction industry. Total business volumes in the various ceramic market segments has decreased in the national market but increased in foreign markets, thus testifying to the positive response of Aveiro ceramics industries to the demands of international markets. An exception to this is the decrease in export sales volumes seen by Aveiro's most international ceramic subsector, household and ornamental ceramics. Top managers attribute this to a loss of international markets due to competition from aggressive global Asian companies.

Investment, which tends to negatively affect annual profits, is seen as important in creating and sustaining superior competences and resources that then generate the competitive advantages and organizational performance that leads to market success. Companies in our sample increased their investments over the period under analysis.

Table 3. General characteristics according to company age.

	Ceramics Industry (%)			Household and Ornamental Ceramics (%)			Pavements and Revetments Ceramics (%)			Structural Ceramics (%)		
	Sector (%)	Companies (%)		Sub-sector (%)	Companies (%)		Sub-sector (%)	Companies (%)		Sub-sector (%)	Companies (%)	
		Young	Mature		Young	Mature		Young	Mature		Young	Mature
Manager's Age												
<40 years old	38	67	32	37	57	32	44	100	31	35	50	33
>40 years old	62	33	68	63	43	68	56	0	69	65	50	67
Education												
Higher Education	67	50	70	63	71	56	81	33	92	65	50	67
No Higher Education	33	50	30	37	29	44	19	67	8	35	50	33
Company Size												
<50 employees	63	83	57	69	71	68	31	100	6	78	100	76
>50 employees	37	17	43	31	29	32	69	0	94	22	0	24
Capital stock												
Not Family-based	54	67	52	47	71	40	50	67	38	70	50	71
Family-based	46	33	48	53	29	60	50	33	62	30	50	29
Employment variation												
Increase	21	42	17	12	57	0	44	33	46	13	0	14
Decrease	60	25	66	66	29	76	50	33	54	61	0	67
Constant	19	33	17	22	14	24	6	33	0	26	100	19
Sales variation												
Increase	40	83	35	44	86	32	63	100	54	26	50	24
Decrease	57	17	65	56	14	68	37	0	46	74	50	76
Profits												
Positive	67	67	67	63	65	58	81	79	83	57	49	61
Negative	33	33	33	37	35	42	19	21	17	43	51	39
Exports												
Yes	68	83	65	94	100	92	94	100	92	13	0	9
No	32	17	35	6	0	8	6	0	8	87	100	91
Investments												
<250 000 €	56	83	50	75	71	76	37	100	23	48	100	43
>250 000 €	44	17	50	25	29	24	63	0	77	52	0	57

A company's age, and thus its evolutionary path, can significantly influence organizational efficiency. This is also related to the manager's age, his/her educational attainment, company size, capital stock, changes in employment, changes in business volumes, exportation and levels of investment. Table 3 shows our analysis of variables relating to company age. Young companies are those that are up to 10 years old and mature ones those over 10 years in age.

From Table 3, we can see that ceramics *mature companies* are characterised by top managers over 40 years old with higher education; company size with less than 50 employees (except for pavement and revetments ceramics); a decrease in the generation of employment and a decrease in business volumes (except for pavement and revetments ceramics). On the other hand, young companies have high export volumes; a smaller size and capital stock with no family control; top managers are under the age of 40, and have not necessarily had a higher education; lower investment levels; and increase of employment variation and business volumes (except for structural ceramics).

Table 4 presents a correlation matrix showing the relationships between the various company characteristics for the ceramics industry. We may observe that *company age* is significantly correlated, at a significance level of 5%, with size, business volume, restructuring processes, enterprise group, associated companies, and global investment; but, and with exception of the positive relation to restructuring processes, this age is negatively correlated with company size, business volume, enterprise group, associated companies and investment.^{6),7)} *Company size* is significantly negatively correlated with age and national market sales, and positively correlated with business volume, enterprise group, associated companies, internationalization, profits, investments and manager's qualifications. *Business volume*, theoretically linked to organizational success and performance (Alchian, 1950; Chiles and Choi, 2000; Day and Wenslay, 1988), is significantly negatively correlated with company age, and positively correlated with size, enterprise group, associated companies, internationalization, positive profits, investments and the manager's education. *Restructuring processes*, which may represent an adaptive response to a complex environment, is significantly positively correlated with company age, enterprise group, associated companies and manager's education, and negatively correlated with capital stock. *Profits*, as a criterion for company survival, a reward for success (FitzRoy *et al.*, 1998) and market selection (Alchian, 1950), is significantly positively correlated with the variables company size, business volume, capital stock and enterprise group.

⁶⁾ The negative relation between two variables indicates an inverse relation between them. In other words, it measures the extent to which, as one variable increases, the other variable tends to decrease, without requiring that a linear relationship exists between the two. A positive relation between two variables measures the extent to which, as one variable increases, the other variable also tends to increase, without, similarly, requiring a linear relationship between the two.

⁷⁾ So, the older companies tend to be related with restructuring processes through time, and tend to have a smaller size, low business volume and investment, and not to belong to an enterprise group or to have associated companies.

Table 4. Correlations matrix.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Company Age(1)	1	-.663(**)	-.422(**)	.301(*)	.140	-.190(“)	-.277(*)	.117	-.039	.028	.057	-.157	-.257(*)	-.128
Company Size(2)	-.663(**) 1	1	.802(**)	.109	-.079	.275(*)	.312(**)	.236(*)	-.226(**)	.027	-.148	.280(*)	.422(**)	.226(*)
Business Volume (3)	-.422(**)	.802(**) 1	1	.042	.015	.413(**)	.425(**)	.287(*)	-.182	-.116	-.089	.249(*)	.649(**)	.261(*)
Restructuring Process (4)	.301(*)	.109	.042 1	1	-.293(*)	.262(*)	.250(*)	-.071	-.032	.057	.052	-.089	-.105	.192(**)
Capital stock(5)	.140	-.079	.015	-.293(*) 1	1	-.277(*)	-.060	.104	-.103	-.008	.011	.249(*)	-.113	-.058
Enterprise Group(6)	-.190(**)	.275(*)	.413(**)	.262(*)	-.277(*) 1	1	.575(**)	.067	.004	.061	-.222	-.231(*)	.249(*)	.163
Associated companies(7)	-.277(*)	.312(**)	.425(**)	.250(*)	-.060	.575(**) 1	1	-.018	-.010	.055	-.254	.013	.239(*)	.267(*)
Internationalization(8)	.117	.236(*)	.287(*)	-.071	.104	.067	-.018 1	1	-.572(**)	.(a)	.015	.015	.218(**)	.279(*)
Sales national market (9)	-.039	-.226(**)	-.182	-.032	-.103	.004	-.010	-.572(**) 1	1	-.956(**)	-.546(**)	-.068	-.071	-.335(**)
Sales in EU(10)	.028	.027	-.116	.057	-.008	.061	.055	.(a)	-.956(**) 1	1	.258	.001	-.212	.202
Sales Rest of the World (11)	.057	-.148	-.089	.052	.011	-.222	-.254	.(a)	-.546(**)	.258 1	.176	.176	-.104	-.106
Profits(12)	-.157	.280(*)	.249(*)	-.089	.249(*)	-.231(*)	.013	.015	-.068	.001	.176 1	.079	1	-.046
Investments(13)	-.257(*)	.422(**)	.649(**)	-.105	-.113	.249(*)	.239(*)	.218(**)	-.071	-.212	-.104	.079 1	.079 1	.314(**)
Manager's studies(14)	-.128	.226(*)	.261(*)	.192(**)	-.058	.163	.267(*)	.279(*)	-.335(**)	.202	-.106	-.046	.314(**) 1	1

** p≤0.01

* p≤0.05

(a) Cannot be computed because at least one of the variables is constant.

In order to analyse the competitiveness factors affecting those companies that have survived the evolution of the industry over recent decades, in analogy with the process of natural selection, the questionnaire asked top managers of the mature companies to identify ceramic companies' sources of competitive advantage over their main potential competitors. The results are presented in Table 5. The questionnaire used a Lickert scale of 1 to 7, where 1 represents a Significant Competitive Disadvantage, and 7 represents a Significant Competitive Advantage. From a total of thirty options, the main competitive advantages identified were: quality, client relations, human resources, consumer satisfaction, image and company reputation, customer service, entrepreneurship, productivity, knowledge and organizational learning, satisfaction of human resources, relationships with suppliers, cost reduction, and innovation.

These competitive advantages are related to innovation (product and process) and the challenges referred to by Malerba (2006): demand (clients and consumers), knowledge and learning, networks (suppliers, clients), and co-evolution (as mentioned above plus technology, actors, institutions, reputation and evolution of image) and the economic evolution of maximum rationalisation and efficiency.

6. Conclusions

In this paper we analyse the contribution of evolution to the understanding of a situated organisation of economic activity and to the creation and sustaining of competitive advantages which contribute, in a continuous flow, to an adaptive response to the evolution of the global, dynamic and complex environment that, in turn, increases the competitiveness of companies.

Evolutionary economics explains how processes of adaptation to dynamic change and learning are driven by entrepreneurial creativity over time, showing how the past can be an indicator of future evolution. Many currently successful industries have their origins in actions taken long ago.

Home location is important in understanding an organizational population because it is where the core product and process development take place as well as where the organizational routines of the company reside. Thus, there are some broad local attributes that, functioning as an evolving and dynamic system, have generated the specific conditions for enhancing the competitive advantages of locally located companies.

Competition is seen as an evolutionary process in which competitive advantage is a temporal and relative component determining competitiveness. It shifts over time to

Table 5. Principal sources of competitive advantage of mature companies.

Sources of Competitive Advantage	Ceramics Industry		Household and Domestic Ceramics		Pavements and Revetments Ceramics		Structural Ceramics	
	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation	Mean	Standard deviation
Quality	5.72	1.345	5.66	1.260	5.75	1.183	5.78	1.622
Relations with Clients	5.72	1.103	5.59	1.132	5.94	.574	5.74	1.356
Human Resources	5.56	1.099	5.53	1.295	5.63	.719	5.52	1.082
Consumer satisfaction	5.47	1.087	5.41	1.103	5.75	.683	5.35	1.301
Image and company reputation	5.42	1.184	5.31	1.120	5.31	1.078	5.57	1.343
Customer service	5.39	1.120	5.41	1.214	5.50	.730	5.26	1.251
Entrepreneurship	5.32	1.320	5.06	1.294	6.06	1.237	5.09	1.240
Productivity	5.31	1.194	5.12	1.431	5.31	.873	5.57	1.037
Knowledge and Organizational Learning	5.25	1.135	5.06	1.294	5.63	.719	5.22	1.126
Satisfaction of personal /human resources	5.22	1.091	5.06	1.268	5.31	1.014	5.35	.885
Relationships with suppliers	5.21	1.186	5.06	1.134	5.06	1.063	5.48	1.344
Continuous efforts to reduce costs	5.18	1.427	5.13	1.362	5.44	1.365	5.04	1.609
Process Innovation	5.14	1.377	5.03	1.402	5.31	.946	5.13	1.632
Brand Image	5.13	1.342	5.00	1.164	5.75	1.238	4.87	1.576
Process Flexibility with rapid answer to the client	5.11	1.488	5.22	1.385	5.38	1.025	4.70	1.820
Product innovation	5.10	1.302	5.22	1.362	5.44	.727	4.65	1.465
Effectiveness of organizational structure and competencies	5.06	1.299	4.84	1.417	5.31	1.250	5.13	1.180
Technology	5.04	1.409	4.75	1.437	5.31	1.195	5.17	1.466

avoid the risk of obsolescence and adapts constantly to change in an unceasing flow of “creative destruction”. A successful competitive advantage generates imitators who develop adaptive behaviours and respond with superior product features, low prices and new ways of attracting customers. This gives rise to the constant change and the increase in global competition, compelling executives and scholars to broaden their understanding of sustainable competitive advantage. Taking into account the fact that the environment is characterized by significant uncertainty, with mechanisms that dynamically drive the unbalanced processes of change, the creative choices and actions of individual entrepreneurs have a particular value in that they contribute to forming a sort of invisible hand that moves the industry into a state of systematic order. Understanding environmental needs, as they change, can be a key to competitive advantage. The acquisition of relevant information to exploit opportunities for creating new competitive positions that others ignore is an important source for creating and sustaining competitive advantages, contributing to creative destruction and a company’s competitiveness.

The ceramics industry in the Portuguese district of Aveiro, as a historically traditional sector with several centuries of evolution and learning, together with the general specificities of ceramics as an ancestral industry, has made a valuable contribution to contemporary research into the industrial organization of evolutionary economics. The district of Aveiro evidences a set of unique features that make it a favourable context for the development of the ceramics industry. Currently these features are no longer quite so obvious, but they are still notable.

Actually, and according to our empirical study covering 63% of the total number of heterogeneous companies, the ceramics industry is composed of SME⁸⁾ with a mean of 95 employees per company, and with 32% of the companies having between 20 and 49 employees. In terms of age, the companies are characterised by their maturity, with 83% of the companies being more than 10 years old, 39% more than 25 years old and 10% more than 50 years old. This reflects, in a heterogeneous sample of companies, a long period of adaptation, heredity and market selection, corroborated by the significant restructuring processes most of the companies have undergone, an association within groups or with other companies but with continuity of local identity and most of the capital stock. The competitiveness test of international markets is also a proof of success as sales volumes in the European Union and the rest of the world have been increasing.

⁸⁾ According to Commission Recommendation 2003/361/EC of 6 May 2003.

There are differences between the young companies and the more mature ones. The mature companies are characterized by top managers over the age of 40 with higher education; lower levels of employment generation and a decrease in business volume, except for the pavement and revetment ceramics.

The principal sources of competitive advantage enumerated by the top managers of mature companies were related with market features and orientation,⁹⁾ while some advantages are related to market adaptation.¹⁰⁾ These competitive advantages are similar to the challenges, referred to by Malerba (2006), for the economic evolution of maximum rationalisation and efficiency: demand (clients and consumers), knowledge and learning, networks (suppliers, clients), innovation (product and process), and co-evolution (as mentioned above plus technology, actors, institutions, reputation and evolution of image).

Unfortunately, less cited competitive advantages included marketing, benchmarking, chance and luck, which Alchian (1950) has cited as being substantial factors in achieving success.

The industrial companies analysed here have undergone evolutionary processes over many years. Today they have arrived at a mature state in which adaptation to an ever increasingly global, competitive and uncertain environment is an everyday challenge, even more so in an industry with such traditional characteristics that have to undergo “creative destruction” in order to create and sustain competitive advantages, so they can survive successfully in the current global market by promoting maximum rationalisation and efficiency. Thus, evolution drives competitiveness.

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⁹⁾ Such as quality, relations with clients, human resources, consumer satisfaction, image and company reputation, customer service, entrepreneurship, productivity, satisfaction of human resources, relationships with suppliers, cost reduction, and innovation.

¹⁰⁾ Such as knowledge and organizational learning, entrepreneurship and initiative of the managers, and process and product innovations.

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