

The distinctive patterns of capabilities accumulation and interfirm heterogeneity: the case of the Spanish pharmaceutical industry

Pablo D'Este

SPRU-Science and Technology Policy Research
University of Sussex

Paper prepared for the “Nelson and Winter” Conference in Aalborg, Denmark June 12-15
2001 organised by DRUID

First draft for comments. Please, do not quote nor circulate.

Contact author's address: SPRU, University of Sussex, Mantell Building, Brighton, BN1
9RF, UK. Tel. + 44 1273 873625, Fax. +44 1273 685865, e-mail: prpg1@sussex.ac.uk

1. Introduction:

Interfirm heterogeneity within industries is a research area of major importance both in the strategic management literature and the industrial economics literature. The concept of strategic group of firms as key factor in analysing industrial structure and industrial dynamics (Miles and Snow, 1978; Caves and Porter, 1977; Porter, 1980) and causal ambiguity (imitation being uncertain) as the basic factor explaining mobility barriers (Lippman and Rumelt, 1982) have stressed the existence of persistent interfirm differences as common industry features. This research proposes that a deeper understanding of the origins of within industry interfirm differences is achieved by focusing on the characteristics of the firm's knowledge base from the theory of capabilities of the firm.

The purpose of this paper is to explore and expand the empirical foundations of the capabilities theory of the firm, by focusing on one main question: can we characterise firms' knowledge bases in a way that demonstrates systematic differences in firms' performance?

The Spanish pharmaceutical industry provides the setting for the study as an industry behind the technological frontier, where different commitments to technological catching-up processes by firms are possible. This is one of the value added aspects of this research insofar as most of the huge literature dealing with the pharmaceutical industry is focused at the technological frontier level, obscuring our knowledge of incremental learning processes taking place in technologically backward firms.

The structure of the present paper is as follows. Section 2 reviews the basic insights of the strategy literature on firm differences within industries. Section 3 defines the characteristics of the industry studied in this paper and lays out the questions we address. In sections 4 and 5 the methodology used to identify strategic groups according to the different degree of capabilities accumulation is developed. Sections 6, 7 and 8 discuss the questions raised. Finally, section 9 sets out our conclusions.

2. Towards an endogenous concept of mobility barrier to understand interfirm heterogeneity

The concept of mobility barrier is crucial in the economic literature dealing with the analysis of within industry interfirm heterogeneity (Caves & Porter, 1977; Hatten & Schendel, 1977; Miles and Snow, 1978; Porter, 1979, 1980; Lippman & Rumelt, 1982). A mobility barrier is a limitation on replicability or imitation, inhibiting the movement of a firm from one strategic position to another, or using another conceptual perspective, from one production function to another. However, most of the literature dealing with the analysis of interfirm heterogeneity provides no understanding of what factors are behind the firm's ability to create mobility barriers. In some cases, this is because the concept of mobility barrier and strategic choices are indistinguishable; in others because they are considered to be specific to firms and idiosyncratic –and thus exogenous to the industry structure. Both cases are discussed below.

a) The contribution of the strategic management research (SMR) in rescuing the concept of conduct is worth noting (see McGee & Thomas (1986) for a literature review on this subject; also White, (1986)). The active role of firm conduct has been reduced in most of the research belonging to the structure-conduct-performance paradigm of Industrial Organisation theory, to a mechanistic role driven by industry structure. By stressing the role of firm conduct not only in terms of its implications for performance but also its implications for firm organisation and the configuration of industrial structure, SMR has improved our understanding of industrial dynamics. One of the contributions of SMR is the concept of strategic groups and the empirical evidence showing that industries present a variety of firm strategic groups (Hunt, 1972; Porter, 1979). The concept of strategic group is based on the notion that group membership is characterised by the sharing of distinctive structural characteristics. These group defining structural characteristics contains “obvious bases for entry barriers that vary among groups” (Caves & Porter, 1977: 252). Therefore, the crucial factor profiling the strategic groups is the type of mobility barriers shared by firm members.

However, in the SMR approach strategic choices about market breadth and resources, on the one hand, and mobility barriers, on the other, are automatically connected, leaving obscure the factors explaining: (1) why certain firms are able to make some strategic choices and not others, and (2) why certain type of market scope and resource commitments involve long term, sustainable mobility barriers while others provide only transitory or no advantage. The SMR approach makes strategic choices and mobility barriers somehow indistinguishable, and building an entry barrier is synonymous with a certain type of resource commitment strategy, with the assumption that mobility barriers are perfectly known to firms.

b) The concept of causal ambiguity is crucial in the economics literature to understanding the sources of persistent interfirm heterogeneity. “Ambiguity as to what factors are responsible for superior (or inferior) performance acts as a powerful block on both imitation and factor mobility” (Lipman & Rumelt, 1982: 420). However, in their analysis uncertain imitability and uncertainty involved in the creation of a new production function are considered as irreducible uncertainties (there is no purposeful learning), and interfirm heterogeneity is modelled as being a random distribution of production function efficiencies.

However, as long as firms are able to accumulate and create knowledge, they are potentially able to reduce the causal ambiguity inherent in their current problem solving activities as well as the uncertainty regarding new processes. Therefore, an analysis of interfirm heterogeneity should relax the assumption of irreducible uncertainty in favour of a specific model of opportunity creation and exploration. On the other hand, we are interested in identifying the resources for successfully confronting causal ambiguity. Therefore, considering a random distribution of such resources is not satisfactory. Again, what is needed is a deeper understanding of the process by which firms create their own, distinctive solutions that lead to the analysis of the learning processes within the firm. The understanding of this learning and creative process is important not just to identify different learning patterns (and then a dimension through which firms may differ) but also because it is at the root of the sustainable competitive advantage: creating new questions which the

creator may be the best positioned to answer (by being a successful innovator, the firm not only may be better positioned than others to confront new challenges, but also may push the frontier by increasing the degree of uncertainty with which the competitors will be confronted if they decide to enter the new technological fields). In other words, by focusing on the capacity of the firm to create knowledge, it is possible to understand mobility barriers as a dynamic and endogenous process embedded in industry dynamics.

Following a Penrosian approach, building a long term, persistent entry barrier requires not only a resource commitment from the firm, but also a capacity to obtain distinct services from those resources. What it is lacking in both the SMR approach and in Lippman and Rumelt's approach is a deeper understanding of the distinct processes taking place within each group membership in building its specific entry barriers. Moreover, analysing these processes would provide us with a much clearer understanding of the industry structure evolution. It should be possible then to understand why: a) strategic groups within industry may change their profiles and why their number fluctuates over time, and b) group members may depart from one group and join another. To understand these two features of industry dynamics further insight into the process of building entry barriers is needed where the role of knowledge creation becomes explicit, and thereby, our understanding of the distinct services rendered in a given type of resource commitments.

The capabilities theory of the firm provides us with a conceptual framework suited to respond to the questions raised above. The capabilities theory of the firm considers:

- a) the firm as a repository of knowledge: not just an information processor reacting to external stimuli, but a locus of knowledge storage, creation and diffusion (Nelson & Winter, 1982; Fransman, 1994);
- b) knowledge incompleteness (Dosi & Egidi, 1991) as a source of uncertainty which puts learning processes in a central role of human behaviour in their attempt to shorten the competence gap in problem solving activities;
- c) problem solving activities become the unit base of knowledge creation: they drive the direction of efforts devoted to upgrading capabilities by highlighting inconsistencies between desired actions and available capabilities (Pisano, 1997; Iansiti & Clark, 1994; Dosi & Marengo, 1993).

Using this framework, it can be argued that by focusing on the key activities underlying the competitive process in an industry it is possible to have a better understanding of firm differences in degree of capabilities accumulation, formation of strategic groups, and sustained differences in performance. Following Ansoff (1965) and Chandler (1990) in defining the firm's capabilities profile, three functional areas, common to firms in all industries, can be identified in which capabilities are developed: operational area (manufacturing), research and development, and marketing. Obviously, the pertinent variables to be considered in each functional area are industry specific.

3. The case for study: the Spanish pharmaceutical industry

Most of the literature dealing with the analysis of firm's distinctive knowledge accumulation focuses on industrial contexts characterised by high technological opportunities –industries where technological innovation can yield decisive product differentiation or production cost advantages (see Klepper & Simons (1997), Cockburn et al.(2000), Holbrook et al. (2000)). However, studies about the role of learning processes in industrial contexts with low technological opportunities are less common.

We are going to focus on a particular industry case characterised by two features. First, a competition process driven by horizontal product differentiation¹ where: (i) set up costs are low, (ii) there is weak price competition after product introduction, and (iii) there is a high degree of market segmentation, with a low degree of product substitutability across market segments (both on the demand side -weak price elasticity across product varieties- and on the supply side -weak economies of scale). In this context, industrial economic theory predicts low levels of concentration in equilibrium (Shaked & Sutton, 1990; Sutton, 1991), characterised by a weak capacity of first movers to pre-empt entry.

Second, the industry is considered to be far from the technological frontier -where competition is driven by product quality differentiation. While in this case there is a potential economic premium for firms seeking to introduce product quality improvements, the risks involved are very high, particularly for (technology) latecomers. This is because latecomers confront the high entry barriers inherent in competition processes driven by escalation in product quality (where endogenous sunk costs are at work). The disadvantages derived from being a latecomer seem to outweigh any potential premium from innovation in this type of industry setting.

While this industry case may seem to be very specific, it can be argued that many industries in developing (and often in developed) countries share several of the features described above. The Spanish pharmaceutical industry fits well into these industry features due to the following characteristics:

a) until 1992 Spanish patent law (regarding the pharmaceutical industry) provided the patent holder with a process patent, while the product patent was not considered; therefore, patent rights only affected the manufacturing process.

b) two aspects of the regulatory framework have affected the conditions for price competition: (i) prices of drugs are regulated by the Ministry of Health (the price is established by considering total manufacturing costs according to the information provided by the pharmaceutical firms); (ii) a policy encouraging generic products has recently come into effect with approval of the “price of reference” decree in December 2000².

¹ Horizontal product differentiation refers to a framework of competition among differentiated products in which consumers differ in respect of their ranking of alternative varieties, while in vertical product differentiation situations, all consumers share the same rankings, where higher quality varieties are preferred over low quality varieties (other factors being equal).

² This policy is intended to complement the policy for the diffusion of generics into the market. It is based upon defining a price that is the maximum value funded by the NHS for a group of homogeneous products -a set of pharmaceutical products with identical chemical composition, among which a generic must be included.

c) the Health Authorities do not require a new product to be authorised to present therapeutic novelty (safety and, only since 1986, efficacy are sufficient).

d) the pharmaceutical industry is segmented into therapeutic areas between which linkages are weak³.

Given this set of industry features where incentives for innovation have historically been undermined by ease of imitation, and horizontal product differentiation has been encouraged by a lax regulatory framework regarding product introduction, we would expect an industry structure characterised by a low degree of concentration -large number of firms with similar market shares- and low level R&D intensity ratios together with a high level of brand proliferation. Table 1 illustrates some of these characteristics.

Table 1. Market concentration, R&D intensity and number of brands per firm

	Concentration (C4) ¹	R&D / Value Added ratio ²	Brands per firm ³
France	11	28.6	11
Germany	28	18.2	8
Italy	15	19.3	17
Spain	13	5.9	18
UK	35	32.5	9
US	26	21.1	n.a.

Sources: (1) For 4-firm concentration ratio, data are provided by Mataves (1999) for the early 90's for all countries except Spain; data for Spain are derived from IMS 1993.(2) Business R&D expenditures as a percentage of value added, for 1997, provided by OECD Science, Technology and Industry Scoreboard (1999). (3) Data provided by the European Federation of the Pharmaceutical Industry Associations (EFPIA), in Farmaindustria (1990) for 1989.

While data provided in Table 1 are consistent with theoretical predictions, there are two industry features that do not fit easily within these predictions. First, since the mid-seventies a reduced group of domestic firms has persistently occupied the leading industry positions, in terms of market share, increasing their size relative to the average size of the firm in the industry. Second, in the last 30 years some domestic firms have been able to introduce new active ingredients for which international patents (particularly in the US) have been granted, showing distinctive achievements in terms of product quality development. These trends lead us to question the extent to which the capabilities building process can impact on the firms' knowledge base and on firms' performance in industrial settings not characterised by high technological opportunities. In particular, we consider some basic questions:

³ From the demand side therapeutic areas remain highly isolated from each other as long as products in different therapeutic areas are not substitutes for one another. However, how weakly linked are therapeutic areas from the supply side is a question of discussion. Concerning research economies of scope, Sutton (1998) argues that links are tenuous because knowledge spillovers are rarely of help to develop products in different chemically related group of products (and each therapeutic area contains different chemically related groups of products). On the other side, Henderson and Cockburn (1996) argue that R&D can have a positive impact on developing new products across different research programmes.

1. Can we characterise firms' capabilities in a way that demonstrates systematic differences in firm performance in industrial settings that (i) present low technological opportunities and (ii) lie behind the technological frontier?

Furthermore, while ratios of R&D to sales are comparatively low in the case of the Spanish pharmaceutical industry, and brand proliferation seems to be a pervasive strategy, it is worth questioning the role of advertising and research in defining inter-mobility barriers. Therefore, we consider a second question:

2. Are current asset commitments in marketing and research relevant factors in building inter-mobility barriers?

We address these questions in sections 7, 8 and 9. In the next section we define the different activities along which pharmaceutical firms are believed to develop distinctive capabilities.

4. Identification of problem solving dimensions and measures of learning achievements

Pharmaceutical firms compete by seeking to discover and develop new drugs (Schwartzman, 1976), by effective promotion (Sutton, 1998), and by implementing the necessary conditions for efficient process development (Pisano, 1997).

Undoubtedly, competition at product level is the salient characteristic of the industry. The extent of resources devoted to product research for new molecules or for therapeutic improvements to existent ones positions the industry among the most intensive in R&D⁴ - DiMasi et al.(1991) present evidence showing that the average cost of new drug development for US firms during the 1970s and early 1980s increased by 2.3 times in real terms in comparison with average costs in the previous decade (1965-1975). Moreover, R&D in pharmaceuticals is an uncertain activity: the failure rates in product development are reported to be very high: in the late 1990s, of 100 molecules that entered development, only about 10 will achieve registration (Nightingale, 2000). Lastly, being successful in launching a new product is not enough: few drugs win large sales. As reported by Schwartzman (1976), not one company (among the 10 largest in the US market) required more than eight products (5 on average) to account for 50 percent of its total sales. It is not surprising then that, given the social importance of and the uncertainty involved in discovering and developing a new drug, product development has attracted most of the research interest.

However necessary they may be, resources devoted to R&D are not enough for success in the pharmaceutical industry. Sutton (1998) provides empirical evidence of the relevance of promotion activities: (1) about its effectiveness, where two products of similar therapeutic

⁴ See OECD Science, Technology and Industry Scoreboard. Benchmarking knowledge based economies, 1999. It is shown that Pharmaceuticals present values of R&D to value added higher than 20% for most developed countries, being in the same group of R&D intensive industries than Computers (and office machinery), Communication equipment and semiconductors, and Aerospace (pp.141).

attributes (similar quality) have different market penetration because of different strategies in promotion, and (2) about its role as sunk costs, where promotion expenditures have accounted for percentages to sales higher than those corresponding to R&D⁵.

Moreover, detailing (sales force) accounts for a high proportion of the firm's total promotion expenditures (around 55%, according to Sutton (1998)). If the firm has to reach different types of specialist physicians (because it is highly diversified in therapeutic fields) it not only needs a large sales force, but also a sales force with diversified expertise in multiple therapeutic fields.

Pisano (1997) contends that process development is crucial in the pharmaceutical industry. His argument is that developing capabilities in the process development of pharmaceuticals (the process of scaling up the manufacture of a new molecule) is of utmost importance to enable product development to be completed before some critical date⁶. However, this paper does not focus on the process development of new molecules basically because the industry addressed is one in which few entirely new molecules have been developed. For this reason, this research focuses on other characteristic of the manufacturing process in the pharmaceutical industry: the development of manufacturing processes for formulation. Taking this issue into account responds to: a) compliance with good manufacturing practices is not an immediate outcome (McGinty et al., 1982⁷; Schwartzman, 1976); b) the learning experience in a particular dosage form manufacturing process seems to play an important role in achieving low production costs, and also, the change to a new (new for the firm) manufacturing formulation process is not necessarily easy (Scott Morton, 1999)⁸; c)

⁵ See J.Sutton, pp 219-227. However effective marketing expenditures in increasing the willingness of customers to buy the product are, this effectiveness has a ceiling imposed by (1) the quality of the product (if product A is much better than product B, it is difficult to see that more marketing is going to render higher market share than that achieved by product A), and (2) the size of the prescribing physician population. Schwartzman (1976) raises the same observation concerning the first point: "a drug must have a valid therapeutic claim in order to become a big seller; advertising alone is insufficient for the success of a product" (pp.193). However, Schwartzman (1976) finds strong support for the beneficial effects of promotion in providing information to physicians (Schwartzman, Chapter 9).

⁶ Pisano shows that process development is an enabler of product innovation: "In helping to reduce costs and accelerate lead times, process development can play an important supporting role in product development performance. (...) In pharmaceuticals and other industries, product innovation often cannot occur without a significant degree of process innovation. (...) Without new process technologies for fermentation, penicillin would have been no more than a research material." (pp.103).

⁷ McGinty et al.(1982), concerning drug release from a tablet form, argue that the: "Drug must be released from the tablet into the gastrointestinal fluids for absorption to occur. The tableting of a medicinal substance allows for the introduction of several variables during the manufacture of the dosage form. Process and formulation variables can be adjusted to assure bioequivalence of generic dosage forms produced by different manufacturers but may also result in bioinequivalence (...) drug stability and physical tablet properties, such as color, shape, size, weight, hardness, and dissolution profile, must all be maintained within narrow limits for direct-compressed tablets. In addition to these properties, the characteristics and processing of tablets that influence disintegration and drug release include: nature of diluents, process of mixing, granule size and distribution, nature of disintegrant, nature and concentration of lubricant, age of finished tablets, presence or absence of surface active agent, compressional force in production (...). It is evident from this list that the formulation of a stable and bioavailable product requires a thorough study of the physiochemical properties of drug and tablet ensure efficacy" (pp.307).

⁸ Scott Morton (1999): "it is much cheaper to prepare an Abbreviated New Drug Application (ANDA) requiring equipment or procedures a firm already has in place. For example, a firm making its first topical

finally, the fact of focusing on a behind the technological frontier industry is another reason to explicitly consider the firms' capabilities in formulation manufacturing processes. Given that the incremental nature of product improvement is closely related to formulation development, it seems clear that the accumulation of capabilities in formulation manufacturing should be an important part of Spanish pharmaceutical firms' learning processes.

In brief, focusing on the firms' learning achievements along these three problem solving dimensions, may allow us to identify interfirm heterogeneity both in performance and in resource commitments. Below we suggest some indicators for measuring learning achievements in product development, process development and marketing activities.

4.1. Product development:

This research distinguishes three degrees of knowledge achievements concerning product development.

a) "High degree of knowledge achievements" is calculated on the basis of the economic importance of those new products introduced by the firm that contain a new active ingredient developed internally by the firm.

The drugs included in this measure are not time constrained: any drug containing an in-house developed active ingredient up to 1997 is included. The indicator is measured as the percentage of product sales in 1997 of those products containing an in-house developed active ingredient to total firm sales in 1997. In the Spanish case, all the products included in this category contain me-too molecule development. I have used the inclusion of these active ingredients in the Merck Index as a selection criteria (a benchmark for the assessment of the therapeutic importance of the own developed products). This variable – new products with own developed active ingredient- is labelled V5 in the following section.

b) "Medium degree of knowledge achievements" is calculated on the basis of the economic importance of those new products containing a new (in the Spanish market) active ingredient not developed by the firm (acquired through licence), introduced between 1990 and 1997.

So long as licensing-in implies some degree of knowledge integration effort by the firm, the introduction of these products is seen as an intermediate internal research effort at product level. This indicator is measured as the percentage of this type of product sales in 1997 to

drug has to purchase a "cream line" years before it can be used regularly, and the firm's chemists have to work with tests and FDA standards that are new and unfamiliar. A firm that already makes creams will have a lower cost of preparing the same ANDA." (pp.428).

total firm sales in 1997⁹. This variable –new products with new active ingredient not developed internally by the firm- is labelled V4 in the following section.

c) “Low degree of knowledge achievements” is calculated on the basis of the economic importance of those new products containing an existing (in the Spanish market) active ingredient introduced between 1990 and 1997. These are products that introduce a different formulation (different route of administration, pharmaceutical form, or dosage) of already existing active ingredients.

Unfortunately, we do not have enough information to distinguish different degrees of novelty across this type of product. As long as they do not involve new molecule development, we consider that the new formulations present a lower degree of knowledge achievement¹⁰.

This indicator is measured as the percentage of this type of product sales in 1997 (introduced between 1990 and 1997) to total firm sales in 1997. This variable –new products with known active ingredients- is labelled V3 in the following section.

Finally, information about sales at every product level (distinguishing by different pharmaceutical forms of the same product) is obtained from IMS data on sales. The year of introduction of the products, together with information concerning the “owner” of the active ingredient was gathered from a cross-check of four sources: Panorama Actual de Medicamento (a journal edited by the Spanish Pharmaceutical College Association), “Revista de Informacion Terapeutica del Sistema Nacional de Salud” (edited by the Health Ministry), the Merck Index and interviews conducted with members of the industry.

4.2. Process Development:

Process development is studied through the manufacturing activities performed by firms on pharmaceutical forms. Two dimensions of manufacturing capabilities are considered: on one side, the scale of the manufacturing process; on the other, the scope of the manufacturing process (across the set of pharmaceutical forms produced by the firm).

a) The scale of pharmaceutical form manufacturing capabilities, is measured as a percentage of the most important pharmaceutical form manufactured by the firm to total industry production of the same type of pharmaceutical form, weighted by the importance of the total industry pharmaceutical form production to total production of all types of pharmaceutical forms¹¹. It is assumed that each firm manufactures all the pharmaceutical

⁹ This parallels the analysis of technology catching up processes followed by new industrialised countries and developing economies through the international acquisition of technology (see Westphal et al.,1985; Hobday, 1995; Kim, 1997).

¹⁰ However, this argument should be qualified. As one interviewee put it, “if one firm achieves the launch of an oral formulation for insulin, it will have made a major innovation in the field”.

¹¹ In other words: Sales in physical units of the most important pharmaceutical form of firm “i” (the one that accounts for the highest percentage of total firm sales in physical units) divided by the total industry sales of pharmaceutical forms in physical units.

forms the firm commercialises. Manufacturing values are approached by the value of sales in physical units. This variable -scale of pharmaceutical form manufacture- is labelled V6.

b) Process diversification measures the degree of manufacture diversification across the set of pharmaceutical forms that the firm commercialises. To calculate this variable the concept of the entropia diversification index has been used. The reason for using this measure of diversification is that it allows distinction between two types of diversification: across pharmaceutical forms and within a pharmaceutical form. This index is constructed as follows:

Given that N is the total number of products, M the total number of pharmaceutical form types, P_i the share that each product represents in terms of total firm production (measured by sales in physical units), and P_j the share of each pharmaceutical form type in terms of total firm production: T.D. is total process entropia diversification, B.D. is between process entropia diversification, and W.D. ($T.D - B.D.$) is within process entropia diversification¹².

$$T.D. = \sum_{i=1}^N P_i \ln \left(\frac{1}{P_i} \right) = B.D. + W.D.$$

$$B.D. = \sum_{j=1}^M P^j \ln \left(\frac{1}{P^j} \right)$$

Between process diversification is labelled V2 in the following section.

In brief, it is argued that the higher the degree of process diversification and the higher the scale of pharmaceutical form manufacture, the higher the firm's knowledge achievements in conducting manufacturing processes.

4.3. Marketing Activities:

This variable is intended to capture the degree of homogeneity of the marketing activities across the therapeutic classes in which the firm is active. The IMS anatomical classification of therapeutic categories is taken at the four digit level. The within firm distribution of sales across therapeutic categories is taken as a proxy to measure the firm's degree of homogeneous diversification of marketing resources (expenditures) across therapeutic categories. Therefore, if firm sales remain equally distributed across therapeutic categories, this is taken as a first approximation for the fact that the firm is devoting similar amounts of marketing resources to each therapeutic category. So, the higher the degree of homogeneity in sales distribution across therapeutic categories, the more equally distributed the

¹² For a more detailed development of this diversification measure and the calculation of the within process diversification measure see Jacquemin & Berry (1979) and Palepu (1985).

marketing resources across therapeutic categories. This variable is labelled V1 in the next section: marketing dispersion.

To measure this variable an adjusted Herfindahl index is used, through which dispersion (or concentration of firm's sales across therapeutic categories is computed, controlling by the different number of therapeutic categories in which the firm is active –which means that the dispersion index was calculated for all the firms as if they were active across the same number of therapeutic categories). Controlling for the number of therapeutic categories is done for two reasons: first, to avoid the fact of a different lower bound of the herfindahl index for each firm depending on the number of therapeutic categories in which the firm is active; second, to avoid biases stemming from the fact of a firm being larger, which generally is related to participation in a higher number of therapeutic categories and then, because of the first reason, inflating the degree of diversification for the larger firms¹³.

The construction of the marketing homogeneous diversification index is as follows:

Adjusted Herfindahl Index =

$$= 1 + \frac{\text{Ln}(\sum_{i=1}^N s_i^2)}{\text{Ln}(N)}, \text{ where } s_i^2 \text{ is the share of each therapeutic category (at four digit of the}$$

anatomical classification) to total firm sales. This index is bounded between 1 and 0 (1 being complete sales concentration in one therapeutic category, and zero being a completely even distribution of sales across all therapeutic categories in which the firm is active)¹⁴.

In brief, it is considered that the higher the homogeneity in marketing dispersion across therapeutic categories, the higher the firm's knowledge achievements in marketing activities.

5. Statistical analysis for the identification of clusters

5.1. Definition of the boundaries of the case studied

The present research focuses on the Spanish pharmaceutical industry from the early 1980s to end of the 1990s. Only domestic firms were studied in order to have a better control of the learning processes origins, being sure that the capabilities estimated were effectively taking place in the firms analysed and not in the foreign parent companies. In total, 67 firms are analysed, accounting for 35% of the Spanish prescription market (using the IMS sales database), and 99% of the Spanish prescription market when only domestic firms are considered. Most of the firms included in the analysis are long time funded firms (from the

¹³ See M.Caniels (1999) for an application of the adjusted Herfindahl index in a completely different context: regional differences across EU countries.

¹⁴ In order to be coherent with the other indicators constructed above, we have worked with “1-Adjusted herfindahl index”, with the objective that the closer to 1, the higher the degree of homogeneity in marketing dispersion.

end of the 19th century to the first four decades of the 20th century). While a few of them have been recently acquired by MNCs, they have been included in the study if they have remained a commercial independent unit.

5.2. Statistical analysis

Cluster analysis is used to classify firms into different groups, according to the firms' different degrees of capabilities accumulation. Six variables are used in the cluster analysis: marketing dispersion (V1), between process diversification (V2), new products with known active ingredients (V3), new products with new active ingredients (not developed internally) (V4), new products with new active ingredients developed by the firm (V5), and scale of pharmaceutical form (V6).

Three variables were transformed using natural logarithms (V4, V5, V6), and all variables were standardised using Z-scores. The correlation matrix (using Pearson correlation coefficients) shows that variables present low levels of correlation between one other (supporting the idea of using them all in the cluster analysis). The cluster analysis is conducted using a hierarchical method in order to identify the number of clusters. Given that all the variables are metric, the similarity measure recommended is the squared Euclidean distance (Hair et al.(1998)). Also given that we are interested in identifying groups of similar, spherical shape, and given that the scatterplots among the six variables used in the cluster analysis almost never present well distinguished groups but a long cloud of observations with different degrees of density, the Ward grouping method seems the most appropriate in our case. Therefore, the Ward hierarchical clustering method and the squared Euclidean distance as a similarity measure were chosen¹⁵. A one way analysis of variance for differences between clusters for each variable allowed us to choose the five cluster solution as the one for which (according to Schaffe and Tuskey tests of multiple comparison between means) at least two clustering variables presented statistically significant differences in means between each pair of clusters.

In tables 2 and 3 the clustering variable profiles (using the raw values of the variables, not the standardised ones), and the analysis of variance (ANOVA) for differences between clusters, for the five cluster solution, are shown.

¹⁵ To select a specific cluster solution two procedures are used here, both related to the information provided by the agglomeration (or fusion) coefficients: a) the discovery of a significant jump in the value of the coefficient; and b) Mojena's (1977) criteria.

Table 2. Clustering variable profiles (raw values of each variable) for the five cluster solution

Cluster	V1. Marketing Dispersion	V2. Between Process Div	V3. Prod. With Known A.I.	V4. Prod. with new A.I. (not own devel.)	V5. Prod. with own developed A.I.	V6. Scale of Ph. Form	Cluster Size
Cluster 1	0.186	0.61	12.46	0	0	0.59	5
Cluster 2	0.36	1.13	74.48	0	0	0.04	11
Cluster 3	0.58	1.38	27.6	0	0	0.08	25
Cluster 4	0.57	1.36	34.5	22.5	0	0.29	20
Cluster 5	0.59	2.07	30.9	21.02	15.27	0.66	6

Table 3. Analysis of Variance (ANOVA) for between cluster differences for the five cluster solution

Variable	Between Cluster Sum of Squares	Degrees of Freedom	Within Cluster Sum of Squares	Degrees of Freedom	F value	Significance
V1. Marketing	34.85	4	31.14	62	17.34	0.000
V2. Between Process Div.	27.64	4	38.35	62	11.17	0.000
V3. Prod. with Known A.I.	32.61	4	33.38	62	15.13	0.000
V4. Prod. with new A.I.	64.67	4	1.32	62	758.72	0.000
V5. Own developed A.I.	64.59	4	1.4	62	715.01	0.000
V6. Scale	25.38	4	40.61	62	9.68	0.000

Finally, to assess the robustness of the cluster result, some validation techniques were applied. First, a non-hierarchical cluster analysis with non-random seeds; second, a non-hierarchical cluster analysis with random seeds; and third, replication of the Ward method for random samples. In all cases, more than 90% of the cases are grouped in the same clusters as the five cluster solutions with complete populations. Even when all these techniques are necessary (not sufficient) conditions for validating a cluster solution, all three point to supporting empirically the five cluster solution chosen. Therefore, the cluster analysis allows us to conclude that different groups of firms can be identified according to the different degree of firm capability accumulation.

6. Are there significant differences in performance between clusters?

Performance variables provide a set of ex-post market interaction indicators from which to assess the economic relevance of cluster differences. The first research question is related to the extent to which the ability of the firm to expand its knowledge base -their capacity to create difficult to imitate and to replicate assets- leads the firm to capture higher market shares (Sutton, 1998), or to obtain higher profits (Lippman & Rumelt, 1982; Dierickx & Cool, 1989). According to the theory of strategic groups, those strategic groups that possess higher group specific entry barriers, and then are relatively more insulated from rivalry,

will enjoy greater profit potential than those groups with lower group specific entry barriers (Caves and Porter, 1977; Porter, 1979)¹⁶.

Regarding the measure of performance, different indicators are analysed. As Cool & Schendel (1987) put it, the exclusive reliance on single performance indicators to draw inferences about intra-industry performance differences can be misleading: given that performance is a multi-dimensional concept, multiple performance indicators need to be employed. The variables addressing firm performance in this study are: (1) return on sales (mean for the period 1997-2000); (2) return on total assets (mean for the period 1997-2000)¹⁷; (3) growth of firm's market share for the period 1983-1997; (4) an indicator of diversification using the Herfindahl index computed on sales distribution of the firm across therapeutic categories (at 1 digit level of the anatomic classification, based on 1997 data on firm sales) weighted by the market share obtained by the firm in each therapeutic category¹⁸; (5) the mean value of the market share (at four digit therapeutic category of the anatomic classification) for the three most important (in terms of sales in 1997) firm's brands; and (6) the total market share achieved by the firm in the Spanish pharmaceutical industry (including both the prescription market and the OTC market) for the year 1997. While the first two measures of performance are aimed at capturing financial measures of performance, the other four are intended to capture firms' achievements in terms of market power and growth.

According to Table 4 firms in clusters 4 and 5 present higher levels of returns on assets and of returns on sales; however, they are only significantly higher than the values for cluster 3 (at 5% of significance) on returns on sales, and cluster 4 presents higher values than clusters 1, 2 and 3 (at 5% of significance) on returns on assets. When clusters 1, 2 and 3 are considered together (borrowing from the three cluster solution of the cluster analysis), then it is possible to observe a clearer picture, where the joint cluster (1-2-3) presents significantly lower values than those of the other two clusters.

Regarding growth, only groups 4 and 5 present sales growing at higher levels than the aggregate pharmaceutical market for the period 1983-1997. In terms of the degree of competitive diversification, three patterns seem to emerge: one defined by firms strongly focused on a small number of therapeutic categories –clusters 1 and 2-; second defined by those clusters that present an intermediate degree of competitive therapeutic diversification –clusters 2 and 4-; and finally, a cluster with a high degree of competitive therapeutic diversification –cluster 5¹⁹. Therefore, cluster 5 presents the outstanding characteristic of

¹⁶ For this higher profit potential to be effective, other elements have to be taken into account: degree of toughness in rivalry within groups (depending on firms' size distribution and number of firms), strategic distance between groups, total number of groups, and the degree of market interdependence across groups.

¹⁷ However, information on profits was not available for this period for the whole set of firms.

¹⁸ This variable is thought to capture firm's competitive therapeutic dispersion by combining two aspects: not only how high is the firm diversification across therapeutic categories, but also what is the market share that the firm reaches in each therapeutic category. The index is expressed as 1-Herfindahl Index, so the closer to 1 the higher the competitive diversification.

¹⁹ The Schaffe and Tuskey tests confirm this cluster difference at 5% of significance.

being not only highly diversified across therapeutic fields but also achieving an even distribution of market shares across the therapeutic fields in which the firms are active.

Finally, in terms of total market share in the pharmaceutical industry, again clusters 4 and 5 present values that are significantly higher than those for clusters 2 and 3 (clusters 1 and 4 are not significantly different at 5% significance level). However, if we only consider the market share achieved by the three most important brands (those with higher sales to total firm sales) in their respective therapeutic fields (at four digit level), then there are no significant differences across clusters. Therefore, even when at the aggregate level of the industry, the difference in market shares is huge, when taking into account the fact of the market being strongly segmented into therapeutic fields, some small firms have high market shares in specific (though generally also small in volume of total sales) therapeutic areas.

Table 4. Cluster differences on performance related variables

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	F (one way ANOVA)	Sig.	df
Returns on sales ¹	3.2	3.9	3.6	8.3	8.9	2.817	0.035	4 / 50
Returns on Total Assets ¹	3.0	5.32	5.0	11.1	10.4	3.702	0.01	4 / 50
Growth M.share 1983-97 ²	-10.05	-3.3	-5.5	0.3	1.2	3.269	0.018	4 / 53
1-Hf.Index weighted	0.16	0.23	0.4	0.43	0.62	4.392	0.003	4 / 62
Mshare 3 Brand (%)	4.24	7.1	6.8	9.1	12.7	1.009	0.41	4 / 62
Market share ³ (%)	0.11	0.06	0.05	0.39	2.04	16.606	0.000	4 / 62
Original Membership cases	5	11	25	20	6			

Notes:

1. Returns on sales and returns on assets are computed as profits to total firm sales and total firm assets, regardless of the importance of the pharmaceutical business to total firm sales and assets. Moreover, it was not possible to get information about profits for 8 out of the 67 firms, and a further 4 firms were excluded because of the biases introduced compared to the normal distribution within clusters; therefore, 55 firms were considered in the analysis and the firms' distribution across clusters is as follows: 4 firms in cluster 1, 9 in cluster 2, 21 in cluster 3, 16 in cluster 4, and 5 firms in cluster 5. Finally, when all firms are considered (the 55 for which profits are reported) mean profit ratio differences across clusters are significant at 0.1 significance level.

2. The market share for the whole period was not available for the whole set of 67 firms: it was not possible to get information on market share for 5 firms. Moreover, a further 4 firms were excluded, one for having been founded after 1983, and the other three for introducing biases on the within cluster normal distribution. It is worth noting that the One way Anova lead not to refuse the null hypothesis of equal means across groups when the growth period considered was 1990-1997.

3. Market share is the percentage of firm's sales to total industry sales. To conduct an Anova test, the variable was transformed into natural logarithms to achieve normal distribution characteristics, therefore the data presented in the table corresponding to the F-test, are the result of conducting Anova on the transformed variable. The mean values presented for each group are the raw values corresponding to market share percentages.

In general, then, it seems clear that firms in clusters 4 and 5, those engaged in higher efforts of capability accumulation in the three fields defined above (product development, process development and marketing activities), are those that present indicators of better performance. These results are similar to those of Bierly & Chakrabarti (1996), where, for the pharmaceutical industry, firms with a more aggressive knowledge strategy had higher financial performance.

7. Firms' differences in resource commitments

The literature on strategic groups posits that each strategic group presents a specific set of strategic variables -those which affect the height of the mobility barriers. According to this approach, Cool and Schendel (1987) propose a definition of the strategic group concept as "a set of firms competing within an industry on the basis of similar combinations of market scope and resource commitments"²⁰. Again, these two components of strategic groups are still general, and the actual determination of the variables has to be arrived at through a deep knowledge of the industry studied given that the pertinent market scope and resource commitments are industry specific. These two general components that make the concept of group strategic choices operative are defined as follows: (1) market scope commitments which includes those decisions involving the range of market segments targeted within the industry, geographic scope, and degree of corporate diversification to other industries; (2) resource commitments which are defined as the level of deployment of material and human resources to specific, key –in order to obtain and maintain a competitive advantage- activities within functional areas, such as marketing, R&D and manufacture.

Using this framework, whether firms' current strategic asset commitments vary significantly across the clustering map derived from the capabilities accumulation indicators is investigated. It is argued that, even where differences are found across clusters in the relative market and resource commitments, none of them per-se provide a source of mobility barrier; the strategic choice needs to be combined with the firm's internal capabilities to efficiently exploit those strategic commitments. Firm resource commitments in two strategic assets -marketing and R&D- are studied.

7.1. Marketing resource commitments

All the variables considered here attempt to gather information about firms' resource commitments in marketing activities. The indicators used are the following: (1) marketing expenditures to total sales (considering only sales and marketing expenditures in the pharmaceutical industry, not in any other activity in which the firm may be involved); (2) the percentage accounting for marketing sales force expenditure to total marketing

²⁰ Cool and Schendel (1987), pag.1106.

expenditures (the other two components of marketing expenditures being mailing, and advertising in medical journals); and (3) the marketing expenditure per employee.

From the data presented in Table 5 it is possible to conclude that the mean values for marketing expenditures to sales (marketing intensity), sales force to total marketing expenditures, and marketing expenditures to total employees, are not significantly different across clusters. In other words, regardless of the cluster chosen, similar marketing expenditure intensity is undertaken across clusters. This is surprising as long as, as the cluster analysis established, significant differences across clusters exist in terms of the dispersion of therapeutic categories in which the firms are involved. Therefore, regardless of the degree of diversification in marketing activities across therapeutic fields, firms devote similar efforts to marketing in terms of amount of resources relative to firm size²¹.

However, while advertising intensity is not significantly different across clusters, firms follow different strategies towards branding, and absolute resources to marketing are also very different. As Table 6 shows, clusters 2 and 3 present a higher number of brands relative to employees and to total marketing expenditure. This fact underlines that there are differences in product differentiation strategy: these two clusters are characterised not by any introduction of highly qualitative products, but present a significantly higher number of brands launched into the market relative to number of employees and total marketing expenditure. Clusters 4 and 5 present both the highest levels of marketing expenditure per brand, and the highest levels of absolute marketing expenditures.

Table 5. One Way Anova for Marketing related variables

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Anova (F)	Sig.	D. of F.
Marketing / Sales (%) ¹	10.0	11.4	18.2	15.0	9.5	1.062	0.384	4 / 56
Salesforce / Marketing Exp. (%) ²	74.1	96.3	81.4	85.4	89.5	1.470	0.224	4 / 53
Marketing / employment ³	1.4	1.3	2.6	2.5	1.8	1.168	0.336	4 / 52

Notes: (1). There are 6 firms for which no marketing expenditure data were reported in IMS (for 1998). (2) There are no data on marketing expenditures for the same 6 firms, and 3 firms which were considered outsiders were reported to have 0 salesforce expenditures. Their zero values on salesforce expenditures may be related to their presenting a low percentage of sales in the pharmaceutical industry to total sales. For this variable, LSD test of mean differences shows a significant difference (at 5% significance level) between clusters 2 and 3. (3) For this variable the Levene test of homogeneity of variance across groups does reject the null hypothesis of equal variances. A non-parametric ANOVA was carried out in this case (Kruskal-Wallis one-way analysis of variance), leading to a null hypothesis of equality of marketing relative to employment across clusters not being rejected.

In brief, firms across all clusters present similar levels of resource commitments in marketing activities relative to firm size, but very different patterns of product

²¹ This profile of marketing expenditure intensity across clusters is persistent over time. Marketing expenditures relative to sales in 1993 were not significantly different across clusters, and the values corresponding to each cluster were as follows: 10.3% (cluster 1), 18.7% (cluster 2), 18.6% (cluster 3), 17.2% (cluster 2) and 9.9% (Cluster 3).

differentiation through branding emerge, and also very different scales of marketing activities. Clusters 2 and 3 sustain a large portfolio of brands per employee, while clusters 4 and 5 present a pattern characterised by a lower number of brands to sales and a higher amount of resources devoted to marketing per brand. These results lead us to question whether marketing expenditures create entry barriers (for example, by creating brand royalty to those brands with higher associated marketing resources) or whether they play a pro-competitive role (as an instrument oriented to brand renewal).

Table 6. One Way Anova for Marketing Performance related variables

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5	Anova (F)	Sig.	D. of F.
Brand per employee ^{2 5}	0.08	0.27	0.29	0.13	0.07	5.047	0.002	4 / 56
Marketing expenditures per brand ^{4 5}	7.1	2.9	5.4	12.7	28.9	3.25	0.018	4 / 56
Marketing expenditures (million ptas) ⁶	52.5	33.4	77.4	292.3	1404.5	7.167	0.000	4 / 56

Notes: (1) According to Scaffe and Tuskey tests (at 5% significance level) clusters 4 and 5 have significantly different means from all the other groups (including each other). The variable was transformed to logarithms in order to obtain a normal distribution. (2). For the variable brand per employee two firms were excluded because of presenting values higher than the critical value at 0.01 of significance. (3) According to Scaffe and Tuskey tests (at 5% significance level) clusters 1 and 2 have significantly different means from 4 and 5. (4). There are 6 firms for which no marketing expenditure data were reported in IMS (for 1998), and 4 firms for which no information about employees was obtained. Marketing expenditure is measured in million ptas. The variable was transformed to logarithms, and the raw unit measures are expressed in the table. (5) For these variables the Levene test of homogeneity of variance across groups does reject the null hypothesis of equal variances. A non-parametric ANOVA was carried out in these two cases (Kruskal-Wallis) leading to rejection of the null hypothesis of equality of brand per employee and marketing per brand across clusters (at 1% significance level). (6) Marketing total expenditures are figures from 1999 (IMS). The Anova test is calculated on the natural logarithm transformed variable. In the table the figures in absolute terms are presented.

To analyse this question, the role of advertising to sales across 57 therapeutic categories²² was studied. The objective was to see whether there is any link between the degrees of advertising intensity across therapeutic categories, and different indicators expressing the type of product competition through branding. Three indicators were studied: the level of market concentration (through the market shares of the first product, the first two products and the first four products), the average age of the first four products in each market segment, and the dispersion of ages among the first four products (standard deviation of the first four product ages in each market segment). Therefore, if advertising to sales is hypothesised to have a pro-competitive effect, we should expect that, the higher the

²² The criteria used to select the number of therapeutic categories were those therapeutic categories at four digit level whose markets had a size over 2.000 million ptas. Below this size, markets are normally dominated by two or three pharmaceutical products and their inclusion could introduce some noise when trying to capture the dynamics of the competition process through branding. Even so, considering market segments of over 2000 million ptas possibly provides too large a market segmentation, where 57 therapeutic areas are considered.

advertising to sales ratio, the lower the level of concentration (i.e. where any single brand remains isolated from competition through the effects of advertising), and the lower the average age and the age dispersion of the most important products competing in that market segment (few old products remain in the competition). Table 9 shows that, while the correlation coefficients are not high, the sign of the correlation supports the hypothesis that advertising plays a pro-competitive rather than a barrier to entry role²³.

Table 7. Pearson correlation coefficients (n=57)

	C1	C2	C4	Average age	Age dispersion
Advertising/Sales	-0.21*	-0.234**	-0.194*	-0.341***	-0.19*
Mean values	0.33	0.51	0.71	12.3	5.8

Notes: * p < 0.1; ** p < 0.05; *** p < 0.01 (one-tailed).

7.2. R&D resource commitments:

All the variables considered here provide information about the firms' resource commitments in R&D activities. The indicators used are the following: (1) percentage of R&D employees to total employees (average for the period 1990-94), (2) average number of R&D employees for the period 1990-1994; (3) R&D expenditures to sales (where firms' sales are only related to the pharmaceutical industry) –average for the period 1990-1994.

Table 8. R&D Employment structure and R&D to sales¹

	Cluster 1- 2 and 3 together	Cluster 4	Cluster 5	One Way Anova (F)	Sig.	Degrees Freedom
R&D Employees to total Employees (%) ²	6	9	21	11.789	0.000	2 / 19
Number of R&D employees ³	7	30	119	32.266	0.000	2 / 18
R&D mean 1990-94 ³⁴	66	207	804	6.443	0.005	2 / 29
R&D to sales (%) ³	5.4	7.6	11.3	5.448	0.01	2 / 29

Notes:(1) Because of lack of information, only 3 clusters have been considered (according to the 3 cluster solution obtained above). Therefore, in the case of R&D employment, cluster 1-2-3 (originally containing 41 firms) is represented by 8 firms, cluster 4 (originally 20 firms) is represented by 9 firms, and cluster 5 (six firms) is represented by 5 firms. For R&D to sales and R&D mean, joint cluster 1-2-3 is represented by 11 firms, cluster 4 by 15, and cluster 5 by 6 firms.

(2) According to Scheffé and Tuskey tests, mean differences lie between cluster 5 and the other two clusters.

(3) According to Scheffé and Tuskey tests, mean differences lie between cluster 5 and the joint cluster (while cluster 4 is not significantly different either from the joint cluster or from cluster 5).

(4) R&D is expressed in million ptas., and is calculated as the mean R&D values for the period 1990-94. The variable was transformed to logarithms; original unit measures are expressed in the table.

Source: Author's elaboration from ESEE and Plan Pharma (Ministry of Industry).

²³ The results are similar when all therapeutic categories are considered, and when only markets over 4000 million ptas are considered (in this case the number of therapeutic areas is reduced to 33). In all three cases the signs of the correlation coefficients follow the same direction, but the correlation coefficients are not always significant at conventional levels.

In Table 8 clusters 1, 2 and 3 have been joined together to form one single cluster in order to increase the degrees of freedom in conducting Anova. This cluster grouping is justified according to the 3 cluster solution obtained in the cluster analysis. It shows that firms belonging to different clusters conduct significantly different levels of R&D to sales, conduct R&D activities on different scales, and also present significant differences in the percentage of R&D employees to total employees. In this case, it is cluster 5 that presents significantly higher values in comparison with the joint cluster, while cluster 4 remains in an intermediate position but significantly far from the mean values of cluster 3 (and not significantly different, on average, to the values presented by the joint cluster). The distance between clusters becomes more explicit when considering the absolute number of employees involved in R&D activities: while cluster 4 presents higher values than the joint cluster, it is still much further from cluster 5 than from the joint cluster. Therefore, there is evidence from Table 8 to conclude that cluster 5 is engaged in R&D activities to a greater extent than any other cluster, not only in absolute terms (total amount of R&D employees and total R&D expenditures) but also in relative terms (R&D expenditures to sales and R&D employees to total employees). Moreover, cluster 5 is the only cluster for which the proportion of R&D to sales is larger than the proportion of marketing expenditures to sales.

This distinctive role of cluster 5 in R&D activities is in line with the profile derived from the cluster analysis, where cluster 5 is characterised by having developed higher levels of capabilities in product development, being the only group of firms having been granted patents internationally for developing new active ingredients. Therefore, in this case, it seems plausible to conclude that the firm's commitments in certain type of assets (R&D activities), is related to the process of capability building in upgrading product quality and then in creating distinctive mobility barriers.

8. Interpretation of cluster profile: the relationship between capabilities accumulation, firm strategy and structure

The five cluster solution profile, presented in Table 1, together with the analysis of firms' current strategic commitments, lead to the following interpretation of capability accumulation patterns:

a) Cluster 1, with only 5 members, is characterised by a high level of pharmaceutical form scale manufacture, the lowest level of marketing dispersion, and lowest level of new products with known active ingredients. The 5 are strongly concentrated in a few therapeutic fields, and also in the manufacture of a few pharmaceutical forms. They did not introduce new highly qualitative products during the period 1990-1997, and this group showed the lowest performance level in introducing new formulation products of already existing active ingredients over this period (1990-97). This group can be viewed as the "manufacture and therapeutic specialised" group.

b) Cluster 2, with 11 members, is characterised by having the highest level of firm's sales stemming from new products with known active ingredients relative to the total number of products commercialised. These firms also present the lowest level of scale in pharmaceutical form manufacture, and an intermediate level of marketing dispersion. Moreover, they have, together with cluster 3, the largest number of brands relative to total

employees. Therefore, the high proportion of their total sales accounted for new formulations introduced over the period 1990-1997, and their being relatively specialised in therapeutic fields lead us to classify them as: “horizontal product differentiation oriented and therapeutic specialised”.

c) Cluster 3, with 25 members, is characterised by high levels of marketing dispersion, with intermediate levels of both new products with known active ingredients and between process diversification. This group presents a low scale of pharmaceutical form manufacture but a medium-high degree of diversification of pharmaceutical form manufacture embedded in products dispersed across a large variety of therapeutic fields. However, no new highly qualitative -therapeutically novel- products were introduced in the period 1990-1997. Moreover, this is the group with the highest percentage of marketing expenditures to sales, and the highest number of brands relative to total employees. Therefore, this group can be characterised as “horizontal product differentiation oriented and high marketing dispersion”.

c) Cluster 4, with 20 members, is characterised by high percentage of total sales accounted for by new products with new active ingredients licensed during the period 1990-1997, which can be a measure of the firm’s efforts in integrating new technologies and external knowledge. This group presents an intermediate scale of pharmaceutical forms manufacture, and a high level of marketing dispersion capabilities. Moreover, this group presents the second highest marketing expenditures to sales ratio (behind cluster 3) and an intermediate level of brands to total employees ratio. The fact of being involved in a comparatively very active technology acquisition process based on the licensing-in mechanism, but not having been able to introduce in-house developed active ingredients²⁴, leads this group to be characterised as the “product quality knowledge integration oriented”²⁵.

d) Cluster 5, with 6 members, is characterised by being the only group that presents positive values in new products with in-house developed active ingredients²⁶. This group also shows high levels of marketing dispersion and the highest level of between process diversification and scale of pharmaceutical forms. While this group does not differ significantly from the others in the resources devoted to marketing relative to sales, it presents the highest level of marketing resources per brand. This characteristic can be related to this group introducing products with comparatively higher degrees of therapeutic novelty, and thus, products that need a different type of marketing strategy²⁷. Cluster 5 also

²⁴ This needs to be qualified: some of these firms did introduce in-house developed me-too molecules over the period 1960-1997, but have never been granted a patent internationally, which is the basic criterion used to define the variable: “new products with own developed active ingredients”.

²⁵ As long as these firms can be viewed as (1) calculated followers of change, and (2) intending to work with technologies at the edge, while not involved in pushing the edge, they could be presented as “analyzers” according to the Miles and Snow’s (1978) strategic typology.

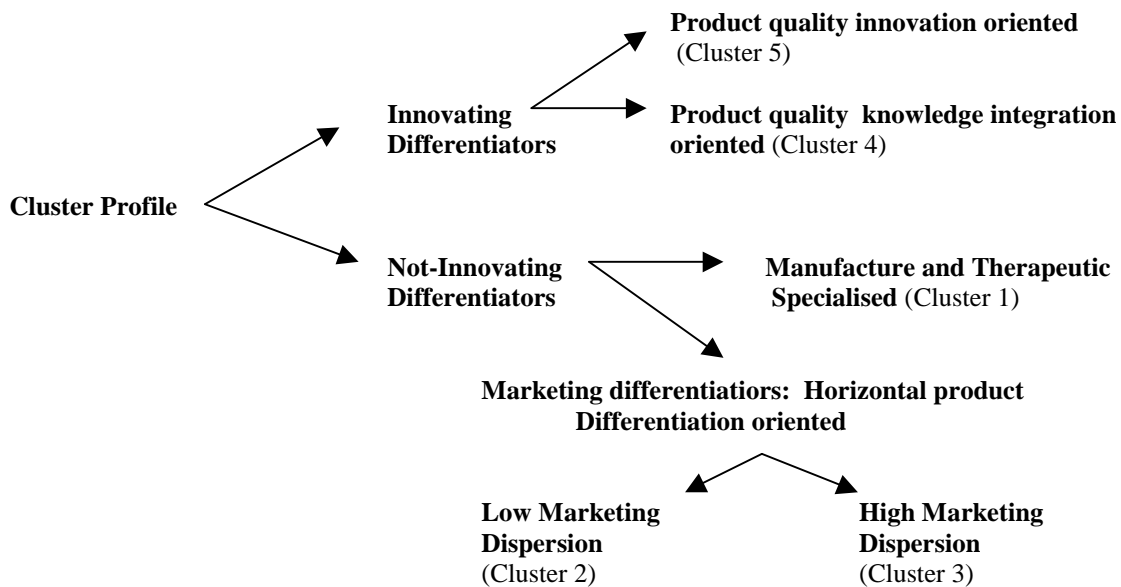
²⁶ As mentioned above, this variable includes products developed internally regardless of whether they were developed before or after 1990. Therefore, this variable is measured as the percentage of firm’s total sales in 1997 accounted for these products regardless of their year of introduction.

²⁷ Products that, while providing a therapeutic novelty, are also less known and more risky to adopt by the physicians than already existing drugs. Therefore, these products may require particularly high levels of, and different type of, marketing resources.

presents a significantly higher level in the resources devoted to R&D than clusters 1, 2 and 3, both in relative and absolute terms. Therefore, this group is defined as “product quality innovation oriented”.

This group labelling is borrowed from the arguments employed by Miller (1986) in his typology of strategic configurations, when distinguishing that Porter’s differentiation strategy can be decomposed into two types: the innovating differentiators, and the marketing differentiators. While the former are characterised as searching for the launch of highly qualitative products, charging high prices, with a strong emphasis on R&D efforts, the latter are characterised as introducing products with a low degree of novelty, emphasising advertising and promotion efforts, with a broad portfolio of brands. According to this argument, clusters 4 and 5 will belong to the innovating differentiators, while clusters 2 and 3 will belong to the marketing differentiators. Figure 1 depicts the above discussed cluster profile.

Figure 1. Five clusters profile



In brief, while the particular characteristics of the Spanish pharmaceutical industry regulatory framework (discussed in section 2) have encouraged a horizontal product differentiation competitive process, a group of firms has moved away from this strategic pattern. In particular, firms belonging to cluster 5 have managed to build technological capabilities that allow these firms to move closer to the technological frontier, a strategy characterised by a process of escalation in product quality. Therefore, concerning domestic firms, a dual structure picture of the Spanish pharmaceutical industry seems to emerge from this analysis; on the one side, a large group of small and medium firms competing only on the basis of horizontal product differentiation, where entry barriers are low and marketing plays a pro-competitive role, and profit margins are low; and on the other side, a small group of medium and large firms engaged in a process of technological capability upgrading, these firms competing not only on the basis of horizontal product differentiation

but also on the basis of vertical product differentiation where profit margins are higher and resource commitments on research activities become unavoidable.

Finally, a few comments concerning some limitations of the analysis presented above regarding the dynamics involved in the within industry structure. First, while the cluster picture of the industry structure can be seen as a snapshot, it may be argued that this snapshot captures the within configuration of the Spanish pharmaceutical industry throughout the nineties, given that the clustering variables reflect a set of firms' structural characteristics covering the period 1990-1997. This conclusion does not contradict the argument that a different industry configuration could have been found had previous decades been studied. On the contrary, we would expect that a different clustering map could be identified if the same type of analysis was conducted to study the industrial configuration during the seventies: consistent with the argument in this research, a somewhat different degree of capabilities accumulation would have produced a likely different number of clusters and a different label characterisation for each one in comparison with the clustering map obtained for the 1990s. Moreover, the very important institutional changes that have taken place in Spain regarding the pharmaceutical industry²⁸ are additional reasons to expect different industry configurations over time.

Second, this analysis does not allow identification of whether changes in cluster membership have occurred since 1990. However, there is a preliminary measure of distance between clusters that allow us to hypothesise about the most likely membership changes between clusters. Table 9 presents a distance matrix between clusters stemming from the average squared Euclidean distance obtained in the cluster analysis. According to this matrix, cluster 5 emerges as the most dissimilar, the cluster that it is farthest from the others. While cluster 3 and 4, and clusters 3 and 2 seem to be those closer to each other (and thus, those among which membership changes are more likely). Finally, a descendent level of distance between cluster 5 and the other four clusters emerges: where cluster 1 is the most distant, going down to cluster 4 which is the one closer to cluster 5.

Table 9. Distance between clusters (average squared Euclidean distance) and tightness of a cluster¹

	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Cluster 5
Cluster 1	4.459	14.737	14.537	16.711	35.259
Cluster 2		3.820	9.930	13.861	31.266
Cluster 3			4.971	9.565	24.325
Cluster 4				4.155	17.888
Cluster 5					2.976

Note:

(1) Tightness of a cluster is calculated as the average cluster distance (squared Euclidean distance) among cluster members.

²⁸ Most of these changes are related to the environmental incentives regarding the introduction of novel products; particularly, the product patent law that came into effect in 1992 and the increasing requirements concerning product novelty from the Social Security administration in order to agree on reimbursement.

9. Conclusions

Despite the fact that within industry interfirm differences and mobility barriers are an old field of research, little effort has been devoted to analyse what is the origin of interfirm sustainable differences over time. In this research it is argued that firms' accumulation of capabilities in key industry specific areas of competition may help us to understand both firms' differences in performance, and differences in resource commitments. First, it is shown that those firms with higher accumulation of capabilities are also those obtaining better performance indicators.

Second, it is shown that the clusters obtained according to their different degree of capabilities accumulation, present different current strategic asset commitments. However, it cannot be concluded that all current strategic resource commitments lead to the construction of mobility barriers. On the one hand, this is because certain types of asset commitment (i.e. marketing intensity) may have a stronger pro-competitive effect than an entry barrier effect. On the other hand, asset commitment is a potential source of the capability building process, but there is always inherent causal ambiguity between the amount of resources invested and the fruits of that investment (i.e. firms showing similar levels of marketing intensity display different marketing capabilities –measured as the dispersion of marketing activities across therapeutic fields). In other words, the differences among clusters are not necessarily well reflected by different resource commitments, but rather on the capacity to develop distinctive capabilities.

Finally, an area for future research should be noted. Regarding the fundamental factors underlying strategic group formation, a deeper understanding of firms' knowledge base and learning patterns seems necessary. In order to understand the construction of group specific entry barriers, firms' knowledge commitments (the type of problem solving activities in which the firm is involved) arise as promising candidates for within industry group characterisation (see Bierly and Chakrabarti (1996) as an example of empirical research presenting evidence on the link between firms' knowledge strategies and the strategic group structure for the US pharmaceutical industry). Therefore, it would be interesting to analyse: first, how the firm's knowledge base changes over time;²⁹ and second, the extent to which the strategic management of knowledge can be viewed as the distinctive axis along which different strategic groups may be identified.

We have shown that the capabilities theory of the firm allows us to identify interfirm heterogeneity in an industrial setting characterised by low technological opportunities. It is worth considering whether the dual structure identified for the industry case presented here could be extended to other behind the technological frontier industries.

²⁹ It is not enough with identifying the firms' different technological achievements at certain point in time, but also to analyse the factors behind these technological achievements. This objective requires to seek a description -however incomplete- of the firm's knowledge "state" (using Winter (1987) terminology).

References:

- Aldenderfer, M.S. and R.K. Blashfield (1982). *Cluster Analysis*. SAGE Publications.
- Ansoff, H.I. (1965). *Corporate Strategy*. McGraw Hill.
- Bierly, P. and A. Chakrabarti (1996). "Generic knowledge strategies in the US pharmaceutical industry", *Strategic Management Journal*, 17, pp.123-135.
- Caniels, M.C.J. (1999). *Regional Growth Differentials. The impact of locally bounded knowledge spillovers*. Faculty of Economics and Business Administration Maastricht University.
- Caves, R. and M.E. Porter (1977). "From entry barriers to mobility barriers: conjectural decisions and contrived deterrence to new competition", *Quarterly Journal of Economics*, 91, pp.241-261.
- Chandler, A.D. (1990). *Scale and Scope. The dynamics of industrial capitalism*. Harvard University Press.
- Cockburn, I., Henderson, R.M., Stern, S. (2000). "Untangling the origins of competitive advantage", *Strategic Management Journal*, Vol.21, pp.1123-1145.
- Cool, K. and D. Schendel (1987). "Strategic group formation and performance: the case of the US pharmaceutical industry, 1963-1982", *Management Science*, 33, pp.1102-1124.
- Cool, K. and D. Schendel (1989). "Performance differences among strategic group members", *Strategic Management Journal*, Vol.9, pp.207-223.
- Dierickx, I. and K. Cool (1989). "Asset stock accumulation and sustainability of competitive advantage", *Management Science*, 35 (12), pp.1504-1511.
- DiMasi, J., R.W. Hansen, H.G. Grabowski and L. Lasagne (1991). "The cost of innovation in the pharmaceutical industry", *Journal of Health Economics*, 10, pp.107-142.
- Dosi, G. and M. Egidi (1991). "Substantive and procedural uncertainty", *Journal of Evolutionary Economics*, 1, pp.145-168.
- Everitt, B.S. (1993). *Cluster Analysis*. Edward Arnold, London.
- Fransman, M. (1994). "Information, knowledge, vision and theories of the firm", *Industrial and Corporate Change*, 3, pp.713-758.
- Hair, J.F., R.E. Anderson, R.L. Tatham and W.C. Black (1998). *Multivariate Data Analysis*. Prentice Hall, New Jersey.
- Hatten, K.J. and D.E. Schendel (1977). "Heterogeneity within an industry", *Journal of Industrial Economics*, XXVI (2), pp.97-113.
- Hobday, M. (1995). *Innovation in East Asia. The challenge to Japan*. Edward Elgar.
- Holbrook, D., Cohen, W.M., Hounshell, D.A., and Klepper, S. (2000). "The nature, sources, and consequences of firm differences in the early history of the semiconductor industry", *Strategic Management Journal*, Vol.21, pp.1017-1041.
- Hunt, M.S. (1972). "Competition in the major home appliance industry 1960-1970", unpublished doctoral dissertation, Harvard University.
- Iansiti, M. and B. Clark (1994). "Integration and dynamic capability: evidence from product development in automobiles and mainframe computers", *Industrial and Corporate Change*, 3 (3), pp.557-606.
- IMS. *Medical Promotion Index*. 1998 and 1994.
- IMS. *The Pharmaceutical Market*. 1993 and 1997.
- Jacquemin, A.P. and C.H. Berry (1979). "Entropy measure of diversification and corporate growth", *Journal of Industrial Economics*, XXVII, 4, pp.359-369.

- Ministry of Health. Informacion Terapeutica del Sistema Nacional de Salud.
- Kim,L.(1997). Imitation to innovation. The dynamics of Korea's technological learning. Harvard Business School Press.
- Klepper,S.(1997). "Industry life cycles", Industrial and Corporate Change, Vol.6, n1, pp.145-181.
- Lippman,S.A. and R.P.Rumelt (1982). "Uncertain imitability: an analysis of interfirm differences in efficiency under competition", Bell Journal of Economics, 13, pp.418-438.
- McGee,J. And H.Thomas (1986). "Strategic groups: theory, research and taxonomy", Strategic Management Journal, 7 (2), pp.141-160.
- McGinity,J.W., S.A.Stavchansky and A.Martin (1982). "Bioavailability in Tablet Technology", in Lieberman,H.A. and L.Lachman (1982): Pharmaceutical Dosage Forms: Tablets. Volume 2. Ed. Marcel Dekker, Inc.
- Miles,R. and C.Snow (1978). Organizational strategy, structure and process. McGraw Hill, New York.
- Milligan,G.W. and M.C.Cooper (1985). "An examination of procedures for determining the number of clusters in a data set", Psychometrika, 45, pp.325-342.
- Mojena,R.(1977). "Hierarchical grouping methods and stopping rules –an evaluation", Computer Journal, 20, pp.359-363.
- Nelson,R.R. and S.G.Winter (1982). An evolutionary theory of economic change. Harvard University Press, Cambridge.
- Nightingale, P.(2000). "Economies of scale in experimentation: knowledge and technology in pharmaceutical R&D", Industrial and Corporate Change, 9 (2), pp.315-359.
- OECD (1999). Science, Technology and Industry Scoreboard. Benchmarking knowledge based economies. Paris, OECD.
- COF Spanish Pharmaceutical College Association.Panorama Actual del Medicamento (PAM) (issues from 1990 to 1998).
- Palepu,K.(1985). "Diversification strategy, profit performance and the entropy measure", Strategic Management Journal, 6, pp.239-255.
- Pisano,G.(1997). The development factory: unlocking the potential of process imitation. Harvard Business School Press.
- Porter,M.E.(1979). "The structure within industries and companies performance", Review of Economics and Statistics, n 61, pp.214-227.
- Porter,M.E. (1980). Competitive Strategy. Free Press, New York.
- Schwartzman,D.(1976). Innovation in the pharmaceutical industry. The Johns Hopkins University Press, London.
- Scott Morton,F.M.(1999). "Entry decisions in the generic pharmaceutical industry", Rand Journal of Economics, 30 (3), pp.421-440.
- Shaked,A., Sutton,J.(1990). "Product differentiation and industrial structure", The Journal of Industrial Economics, Vol.36, n2, pp.131-146.
- Sutton,J.(1991). Sunk costs and market structure. Price competition, advertising, and the evolution of concentration. The MIT Press, Cambridge, Ma.
- Sutton,J.(1998). Technology and market structure. Theory and History. MIT Press, Cambridge, Ma.
- Westphal,L.E., L.Kim and C.J.Dahlman (1985). "Reflections on the Republic of Korea's

acquisition of technological capability”, in N.Rosenberg and C.Frischtak (eds.), International Transfer of Technology: Concepts, Measures and Comparisons. New York.

White,R.E.(1986). “Generic business strategies, organizational context and performance: an empirical investigation”, Strategic Management Journal, 7 (3), pp.217-231.

Winter,S.G.(1987). “Knowledge and competence as strategic assets”, in D.Teece (ed.), The competitive challenge, Harper & Row, Publishers, New York.