Technological assets accumulation and organisational structure in Spanish telecommunications equipment manufacturing companies: a case study

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Abstract: The aim of this paper is to analyse the relationship between organisational structure and the accumulation of technological assets in Spanish telecommunications equipment manufacturing companies. In order to do this, the methods of asset acquisition have been analysed and a model presented which enables us to evaluate 1) the availability of technological assets (asset endowment) and 2) the degree to which they are utilised by the organisation (asset leverage). Following this, the effect of the parameters that define the organisational structure on the endowment and leverage of assets within the R&D departments has been studied. Five companies in this sector were analysed over the period 1996-2000.

Keywords: innovation; R&D; organisational structure; technological assets accumulation; asset endowment; asset leverage; telecommunications equipment manufacturers; case studies.

Reference to this paper should be made as follows: Nieto, M. and Pérez, W. (2004) 'Technological assets accumulation and organisational structure in Spanish telecommunications equipment manufacturing companies: a case study', *Int. J. Technology Management*, Vol. 27, No. 1, pp.40–56.

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1 Introduction

A company acquires its technological assets by means of two complementary routes: externally, by means of purchasing, contribution or cooperation agreements; and internally, by using existing knowledge and technology. This results in a complex process of acquisition, training and the accumulation of technological assets, which are affected by a number of factors and circumstances.

The structure of the organisation is not neutral in the face of this phenomenon, because the defined methods of operating can either facilitate or impede the acquisition and development of technology by the company and its various divisions – and therefore either facilitate or impede product innovation and productive processes.

The aim of this study is to analyse the relationship between organisational structure and the accumulation of technological assets. To do this we have analysed the methods of asset acquisition and presented a model that enables us to evaluate:

1 the availability of technological assets (*asset endowment*)

2 the degree to which they are utilised by the organisation (*asset leverage*).

Then we have analysed the evolution that the market of telecommunications equipment manufacturers has undergone, and in particular, the effect which the parameters defining organisational structure had on these two variables over the period 1996-2000.

We have taken the Research and Development (R&D) department as the unit of analysis. The methodological approach used has been the application of case studies by patterns of behaviour – the technique of comparing an empirically based pattern with a predicted one – as this allows the combination of longitudinal and transverse analysis, whilst at the same time combining the use of a number of sources of evidence and data analysis techniques [1,2].

The results obtained enable us to reach certain conclusions about vertical as well as horizontal specialisation, job formalisation, and about the relationship between the R&D department and other areas, in particular the sales and production departments. In this way, we have determined the positive and negative effect of each parameter on the accumulation of technological assets, and at the same time, we have obtained other conclusions specific to each parameter analysed.

2 Theoretical framework: the accumulation of technological assets by the organisation

There are two major complementary means of accumulating technological assets: external and internal. This means that the assets necessary for carrying out the company's business can be acquired externally, from beyond its formal limits, or internally by means of a process of development within the organisation. For example, a patent can be acquired either via some means of payment, or by developing it within the R&D department.

On occasion, the characteristics of the asset, or the circumstances surrounding its acquisition, determine the route chosen – such as would be the case if the company wanted to buy specific machinery from the manufacturer (external route), or have exclusive state-of-the-art technology at its disposal (internal route). However, a combination of various methods of acquisition will normally be required and the company will be able to exercise a certain amount of discretion in terms of the method chosen. Let us take, for example, the external purchasing of an information system, which needs to be complemented by the internal effort necessary to acquire the skills required in order to use it; or perhaps the company will decide to develop internally specific software applications to adapt the functioning of the new equipment to its own needs.

In their turn, the assets necessary to carry out business strategies can be obtained by one of the two following routes:

1 by means of purchase in the factor markets

2 by sharing assets with other organisations through cooperation agreements.

Purchasing will allow the acquisition of a very wide range of factors, such as tangible assets, financial assets or intangible assets, as well as individual skills through the hiring of staff, and even allows appropriation of the resources and expertise of other companies, via the acquisition of the company, or the acquisition of the branch of a company which contains these resources and skills [3,4].

This method of acquisition will require the payment of a fixed market price,which can be decided by various methods [5]:

- acquisition by means of the purchase of property rights to the resources, such as the purchase of tangible assets or the hiring of staff
- the purchase of a company or of a specific division or branch of the company where the required resources or skills are found
- the purchase of the service from a company which owns it.

Another route by which assets can be obtained from outside the organisation is to share them between two or more independent companies via cooperation agreements. Basically, the scarcity of resources is one of the most important motives for entering into this type of relationship [6]; in this way, alliances can prevent a duplication of activities and free up resources, thereby allowing the individual companies to focus on their core activities [7,8].

The alternative, and often necessary, complement to acquiring an asset from outside the organisation is to build it internally, through a process of accumulation [9] which brings about organisational learning. In this way, if the organisation is perceived as a combination of related resources that form a network, the links established constitute organisational patterns in the use of assets, behavioural guidelines of the organisation which contain the collective know-how – and which are created, purged, and forgotten with the passage of time.

The process and the results of organisational training and the accumulation of assets involve all levels of the organisation (corporate, business, functional), all the company' s markets (both existing and new), and all of its functions (design, operations, sales). The key to success lies in a subtle balance between external acquisitions and internal developments – a balance which must be maintained in all areas and levels of the business, in such a way as to harmonise the growth of the organisation through the integration of all its resources [10].

The level of asset accumulation in the company at a given point in time presents two basic components:

1 asset endowment

2 asset leverage (the utilisation or exploitation of assets).

Asset endowment is determined by the combined resources of the know-how and the technology available to the company at a given moment. The difference in asset endowment at two different points in time indicates the accumulation obtained in that period.

The level of *asset leverage* or utilisation refers, on the other hand, to the number of times that the company uses its asset endowment. A better leverage of resources is the best way to avoid inefficiencies and means thinking up new ways to achieve the same advantage as competitors whilst using fewer assets; through learning to do more with less [11].

In this way, the level of *asset accumulation* in a company can be defined by looking at asset endowment at a given moment and at its level of leverage. Basically, in the same way as the money supply of a country is defined by the quantity of money and the speed of circulation, the assets of a company depend as much on the endowment (quantity) as on the exploitation or leverage (speed), and this can be expressed in the following equation (i = company; t = a given moment):

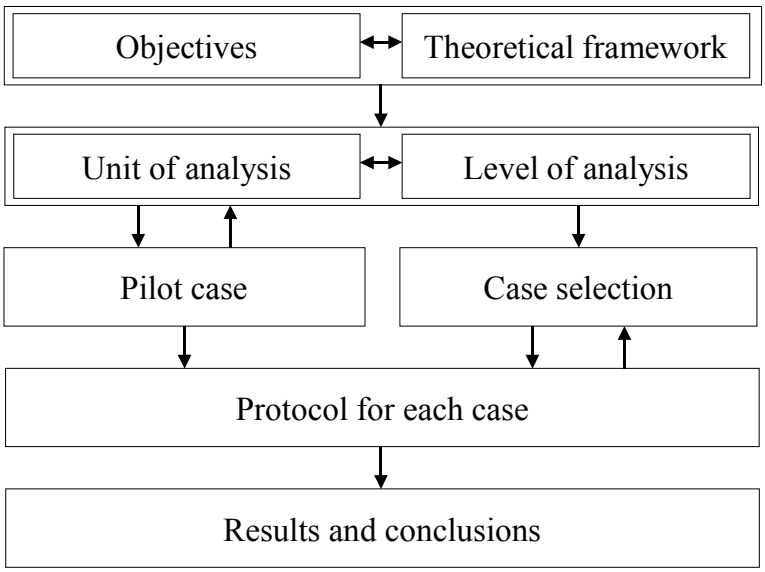
$$\begin{pmatrix} Level\ \ of\ \ asset \\ accumulation \end{pmatrix}_{it} = \begin{pmatrix} Asset \\ endowment \end{pmatrix}_{it} * \begin{pmatrix} Asset \\ leverage \end{pmatrix}_{it}$$

3 The analysis conducted

This study use an adaptation of case studies denominated by the patterns of behaviour, an ideal methodology for the development of theories explaining the organisation and its integrants' behaviour. In comparison with other alternatives, best results are obtained in the research of dynamic and complex processes that require analysis during a prolonged period of time, multiple sources of evidence, both quantitative and qualitative, and diverse analysis techniques, such as training and organisational culture [1,12].

This study deals with the analysis of the R&D departments of five telecommunications equipment manufacturers in Spain, over the period 1996-2000. A plan has been followed which sets the distinct stages and their iterations as shown in Figure 1 and of which the more relevant aspects will be discussed.

Figure 1 Stages in the case studies by patterns of behaviour



Source: Nieto and Perez [2]

3.1 The selection of case studies and the unit of analysis

Five companies have been selected from the extremely dynamic and competitive market of telecommunications equipment manufacturers in Spain in which technological progress, changing needs, and service requirements combine to impede the process of technological asset accumulation.

The criteria applied for selecting the case studies contain the homogeneity of the factors external to the company, with the aim of avoiding distortions arising from the sector environment. This has been achieved by means of the characterisation of case studies according to objective criteria, defined in accordance with Abell's dimensions [13]: technology, clients and functions.

With regard to the first dimension, all electronic technologies utilised have been considered and classified in accordance with the pilot study onwards. The definitive classification is shown in Table 1.

Table 1 Abell' s dimensions in telecommunications equipment manufacturers

	TECHNOLOGICAL
ATC	Architecture and technology of computers
DCE	Design of circuits and electronic systems
BET	Basic electronic technology including microelectronics and optoelectronics
CSP	Control of systems, processes, industrial automation
PSI	Planning and service of information technology services
RAD	Radio communications
POT	Planning and operation of telecommunications services
DTE	Data transmission engineering
ISO	Software engineering
OIT	Sound and image
ONT	Others related to information technology
OTN	Others unrelated to information technology
	CLIENTS
ADMIN	Public administration
OPERA	Telecommunications operators
SUPPL	Telecommunications suppliers
LCNTO	Large companies, not telecommunications operators
SMESC	Small- and medium-sized companies
PRIVA	Private companies
	FUNCTIONS
TENET	Construction of telecommunications networks.
CONNT	Construction of non-telecommunications networks.
NONRE	Forms of commercial exploitation of telecommunications other than network construction.
NONTE	Forms of commercial exploitation other than telecommunications

Furthermore, recent years have witnessed important changes in the telecommunications industry, which have modified the number and type of clients: firstly as a consequence of the evolution of technology which has altered the paradigm of natural monopoly existing in this industry throughout the 20th century and secondly, and as a result of this phenomenon, the appearance of new players in the market due to the process of liberalisation.

In effect, at the outset of this period, the public administration, generally the only client of equipment manufacturers, managed and commercially exploited the telecommunications services networks (telephone, telegraphic and telex) and, at the same time maintained substantial control in the regulation of these companies. For this reason, it makes sense to speak of the *administration of the telecommunications sector*. The liberalisation of the sector began with the separation of the regulatory authority on the one hand from the public operator on the other, this latter having in many cases been privatised; and has given rise to the entry of new operators who supply

telecommunications services, normally of added value, by means of the network managed by the operator [14].

The motives that led to the increase in the number of customers, also brought about an increase in the number of functions. Before the process of liberalisation, telecommunications equipment had the natural function of forming an essential part of the public network. But the advance in technology brought with it the possibility of expanding into new functions, and diversifying into other fields, such facilitating meter-reading on the arrows on large-scale networks other than telecommunications, such as electricity companies, and this induced the manufacturers to diversify their markets.

In turn, many organisations that had previously contracted telecommunications services from the public operator, now decided to create their own networks as part of their infrastructure. In addition, the liberalisation of the end product led to the appearance of a market of end users, giving rise to a new range of functions, many of which are connected with new added value services. Table 1 shows the relationship of the functions found in the companies studied.

The chosen unit of analysis is the design area of the companies (R&D departments), because their specific technological competencies are the principal factor which explains why companies are different, how they change over time, when they are capable of remaining competitive, and when they are not [15].

3.2 The pilot case study and the protocol of each case study

The protocol of each case study is the document that illustrates the way in which research was carried out and contains the tasks, instruments, procedures and general rules which have to be followed. Though this is always desirable, it becomes essential when the study incorporates numerous case studies [1,2].

The first case studied, which can be considered as a pilot study, was more open and less structured, and more in-depth in terms of the quantity of data reviewed, and it has been accompanied by an analysis stretching over a longer period of time, from 1996 to 2000. With this in mind, and due to its significance and accessibility, the general aspects to be researched in other case studies were confirmed in the protocol. The most relevant parts of this document are the sources of evidence, the procedures for data collection, and the method of data analysis.

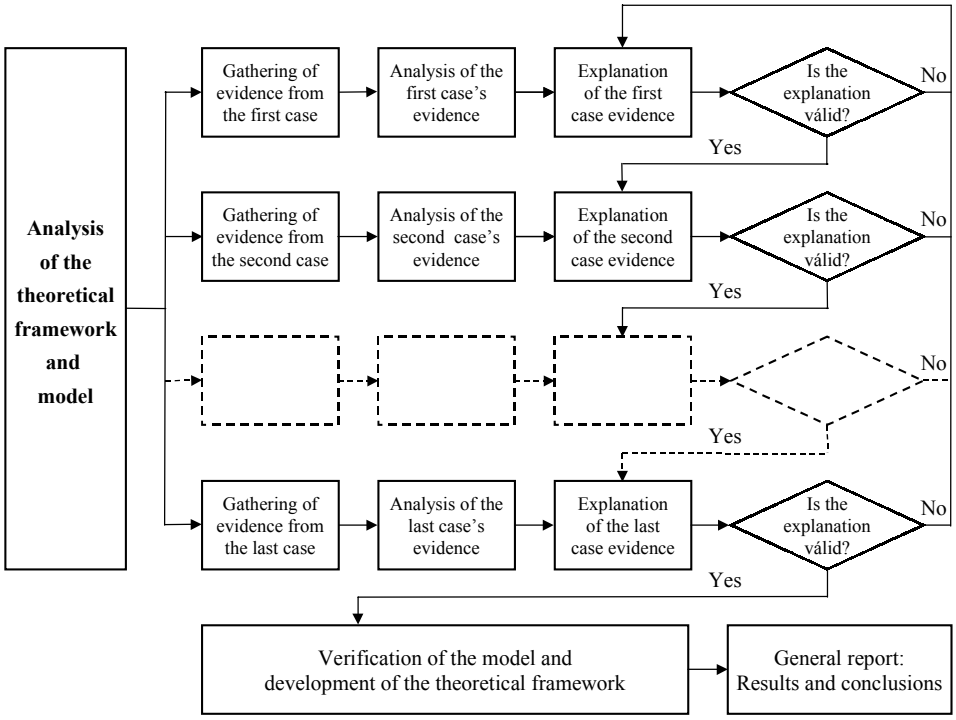
Among the sources of the data used, and the procedures followed for data collection, were the following: the various annual company reports (balance sheets, profit and loss accounts, annual reports, management reports as well as auditors' reports, if they were available); records and databases outside the company such as those of the Spanish Office of Patents and Trademarks, The National Association of the Electronics Industry (ANIEL), product catalogues published by the companies themselves and structured interviews consisting of open questions. In the pilot case study qualitative research was also carried out.

In order to analyse the evidence of each case study we have followed a strategy that develops upon the theoretical proposals which underlie the study. In this way, the theoretical framework has suggested a set of organisational parameters which can influence the accumulation of fixed assets and these formed the essence of the research.

The 'examination of patterns' has been the general method used to analyse the case study in its entirety. This consists of comparing *empirically based* patterns of behaviour with *predicted* patterns of behaviour and thereby determining the validity of lack of

validity of the latter (see Figure 2). Therefore, a set of patterns was determined to form a theoretical framework for the study.

Figure 2 The examination of patterns process



Source: Inspired by Yin [12]

A major problem in analysing the evidence found has been to establish meaningful measurements of the phenomenon of fixed asset accumulation. In other studies there has been an attempt to measure the technological capability of the company by evaluating the difference between input into the development function, in the form of resources, and output, in the form of results.

In some works the level of technological assets has been measured by looking at the results of the system using the number of patents generated by the company as a meaningful measurement [15]. But this solution presents serious drawbacks of which the ones relevant to this study are the following:

1 it is taken for granted that there are no assets which, although patentable, have not been registered

2 the importance of non-patentable elements, such as the skills and capabilities of employees, is not acknowledged – these skills and capabilities incorporate tacit and explicit knowledge which makes up a significant portion of the assets of the development area [16].

However, as well as the general disadvantages of use of the patent as a measurement of the level of accumulation of technological assets, there is an additional difficulty.

Basically, the study carried out has highlighted the fact that the companies analysed do not consider the patent as an effective mechanism for protection against the imitation of its products and processes, and this means that as a general rule, they do not tend to patent [17].

As an alternative, we have considered the products *designed* as being the fundamental results of the design function; for this reason, the level of accumulation of technological assets has been calculated with these products as a starting point by means of an aggregated measurement. Nevertheless, the products have turned out to be heterogeneous among themselves, and for that reason they cannot be directly compared.

Therefore, it was necessary to homogenise all the products before aggregating them. To do this we looked for a common denominator in each of the products using a specific variable which we shall call the *Standard Product Unit (SPU)*, i.e. an assessment of the difficulty of developing a given product according to its essential technical characteristics, such as the capacity of the flow of data transmission. In fact, the majority of the products compared were network terminals, whose function is to transmit and/or receive information, such as a telephone, a modem, an X.25 apparatus and an ISDN terminal. In this way, it was easy to establish a measurement of the difficulty of design common to all these products, with the above-mentioned characteristic as a starting point.

Once the product is developed, one might ask whether the assets necessary for its development remain in the company. Two possible situations can be distinguished with regard to this aspect: if the company continues working to perfect the product in order to adapt its specifications to new demands of the market, and thereby incorporate new functions, it can be considered that the level of the accumulation of assets is being maintained, but, if this does not happen and the company sees the work as finished, then a 30% annual rate of loss in the value of the said assets can be assumed. This difference of approach is more significant than a simple procedure of calculation, because it reveals the conviction, already highlighted by Hamel and Prahalad [11], that the more technological competencies are used, the more they develop and, in the final analysis, the more valuable they are.

An objection could be raised that technological assets measured in this way end up being counted twice, because they probably exist simultaneously in two or more products. This precision will allow the level of asset accumulation to be split into its two basic components: asset endowment and asset leverage. In this way, given that we have obtained sufficient evidence about a combination of technology which forms a part of each of the developed products and their weighting, it is possible to find an *Adjusted Standard Product Unit (ASPU)* which allows us to obtain a measurement of the level of assets once the double-counting of know-how and technology has been eliminated.

Let us suppose, for example, that the company develops an ISDN terminal (64 *standard product units*) which incorporates 30% of the technology of 'Design of Circuits and Electronic Systems' (DCE) and an X.25 apparatus (56 *standard product units*) which requires 10% of the same technology; the weighting of DCE in each product will be 19.2 and 5.6 *standard product units* respectively. It is possible to use these measurements to determine the level of the company's asset accumulation in DCE, which would be 24.8 *standard product units* (19.2 + 5.6); however, if it is considered that 5.6 *standard product units* of X.25 equipment is know-how already contained in the 19.2 of the ISDN terminal, then it must not be counted and the endowment of DCE will be 19.2 *adjusted standard product units*.

In addition to the measurements that show the level and endowment of technological assets from the measurements put forward, it is also possible to obtain a measurement of its leverage. In effect, if the *Standard Product Unit* is an evaluation of the difficulty of developing the product, and if the *Adjusted Standard Product Unit* is the same evaluation once the effect of double usage has been corrected, then the increase which goes from the *Adjusted Standard Product Unit* to the *Adjusted Standard Product Unit* is a size that measures the degree of exploitation or leverage of technological assets available.

In this way, we come up with the variable'LEVER it' as the percentage increase of the *Standard Product Unit* compared with the *Adjusted Standard Product Unit* of the company'i', in the period't', and represents the degree of leverage of technological assets:

$$LEVER\ \ it = \frac{s\tan dard\ \ \ product\ \ \ units\ \ \ it}{adjusted\ \ \ s\tan dard\ \ \ product\ \ \ units\ \ \ it} * 100$$

In the example followed, if the company has 24.8 *Standard Product Units* and 19.2 *Adjusted Standard Product Units* in DCE technology, then it will have a leverage measured in LEVER of 129% which means that this technology has been utilised in the period studied 1.29 times.

In this way, the level of asset accumulation of the company'i' in the period't' is broken into its two components, asset endowment and their asset leverage and thereby measurements indicative of each component are obtained:

$$\text{Standard Product Unit}_{it} = \text{Adjusted Standard Product Unit}_{it} * \text{LEVER}_{it}$$

4 The results obtained

Next, we present the results obtained with regard to the more notable parameters of the organisational structure. In particular, we analysed the effect of the levels of hierarchy in the R&D department, the degree of specialisation and formalisation of the position, and the relationships with the sales and production departments.

4.1 The hierarchical levels of the R&D department

The specialisation of jobs has led to important increases in productivity due mostly to the skills brought into the company by the specialised individual, the saving of time lost in changing tasks, and the development of new methods. It is worth distinguishing between horizontal and vertical specialisation; the first refers to the number of tasks defined precisely, and the second, to the degree of control that the worker has over the job which he or she performs [18]. Then, we analyse the number of hierarchical levels as the variable that reflects the degree of vertical specialisation, and the effect that it could have on the level of technological asset accumulation (horizontal specialisation is dealt with further on).

Predicted pattern

There is a relationship between the level of accumulation of technological assets and the number of hierarchical levels in the R&D Department.

Comment

Confirmation of the above pattern requires the finding of the relationship that may exist between the definition of hierarchical levels and the level of technological asset accumulation. The structure is common to practically all the case studies and consists of the head of department, project leaders and personnel assigned to each project. Those in charge of the department always contend that a greater number of levels would unnecessarily complicate the organisational structure, and that with fewer hierarchical levels it would be impossible to work.

The results obtained

All the companies have adopted the simplest structure possible; modifying it whenever it has been necessary so that it is understood that the activity is supposed to organise itself in such a way that additional levels of hierarchy are not necessary. The agreement of all the companies on this point seems to indicate that the predicted pattern is confirmed empirically in the following terms: "*An efficient accumulation of technological assets requires an organisational structure with the least possible number of hierarchical levels*".

A structure with few hierarchical levels is a factor common to all the companies studied and can therefore be taken as a prerequisite for the efficient functioning of the organisation, more than as an element which allows the maintenance of possible competitive advantages. Furthermore, in terms of vertical specialisation, it can be understood that to radically separate the execution of work from its administration and control does not have a positive effect in the area of development.

4.2 The degree of specialisation

Another element of organisation that can affect the process of fixed asset accumulation is the degree of horizontal specialisation of the members of the R&D department. The analysis of this pattern of behaviour will confirm it, and give it a more precise wording.

Predicted pattern

There is a relationship between the level of technological asset accumulation and the degree of job specialisation in the R&D department.

Comment

In order to verify the effect of the degree of job specialisation on the accumulation of technological assets, those in charge of the department were asked to carry out a subjective evaluation of this aspect on a scale of 1 to 7, in order of importance. From this, the effect of the parameter on asset endowment and asset leverage can be observed.

It is observed that the bigger the company or the larger the number of projects being carried out simultaneously, the greater the need for flexibility in the reassigning of its personnel, which means that job specialisation is an obstacle which impedes an adequate exploitation of the resources available.

The results obtained

The activities connected with the design of products related to information technology require a very high degree of specialisation for all companies, which seems more a prerequisite of function rather than a factor affecting the accumulation of technological assets.

However, once a sufficient degree of specialisation is obtained which guarantees an adequate level of efficiency, whatever decrease there is in the degree of specialisation will have positive effects on the leverage of technological assets. In effect, reduced specialisation facilitates the reassignment of personnel to different tasks, which allows and is conducive to the reutilisation of the know-how available in the development of different products.

As a consequence, the predicted pattern is confirmed empirically, and the final wording is: *"any decrease of specialisation that does not mean a decrease in the level of efficiency will lead to a better exploitation of technological assets"*.

4.3 The standardisation of activities

The standardisation of activities implies a formalisation of behaviour, which reduces the variability of work, even allowing it to be predicted and controlled. In addition, it is a way of codifying organisational know-how into a set of norms and relationships which can be easily communicated.

Predicted pattern

There exists a relationship between the level of technological asset accumulation and the degree of standardisation of activities.

Comment

Those in charge of the R&D department were asked to carry out a subjective evaluation of the degree of standardisation of activities which are carried out within their sphere of influence, and to reflect this on a scale from 1 to 7, from a lesser to a greater degree of standardisation. In general, it can be observed that almost all the activities of R&D have a high degree of standardisation. There is agreement that it is important to document processes in a systematic way, and with guidelines, as well as to carry out a series of tests in a methodical way. Basically, the process of documenting any new activity enables advances to be made in the specification and normalisation of work to be carried out and later on, also advances in the establishing of standards.

This general perception coincides with the objectives of official approval on the part of the company management (Standard ISO 9001), but in three of the cases studied, produces on occasion a certain conflict. In these cases, the organisation finds itself

obliged to set itself specific standards and norms of behaviour in order to obtain the respective approval of the relevant body. In the case of R&D this could be counter-productive, because the self-imposed standard submitted for official approval is lower than the previous standard. In short, the need for official approval can introduce a certain laxity in the way this department functions.

Results obtained

The standardisation of activities is very important for specifying the work to be done, whilst the documentation generated records an essential part of the experience accumulated which will then serve in order to formalise each basic task.

However, it has become evident that some ways of carrying out this process of standardisation, imposed by the top management of the company to obtain special official approval, has had a negative impact on the R&D department, because there occasionally appears a form of what has been called X inefficiency [19].

Consequently, we could say that the predicted pattern is confirmed with reservations. The final wording should be the following: *"If the standardisation of activities complies with certain requirements, it will positively affect the endowment of technological assets"*.

4.4 R&D/marketing relationship

The relation between departments, such as R&D and production, and R&D and the marketing department are extremely important, if the maximum level of efficiency in the development of new products is to be achieved. Gupta *et al*. [20] have detected a number of factors which make cooperation between R&D and marketing more difficult. The most important of these are the problems of communication; distrust with respect to each other's capabilities; a lack of commitment on the part of the management; cultural and personality differences; and a lack of knowledge of the market.

It was observed that other workers do not participate directly in the project team but certain meetings are held at specific moments in the execution of the project with people from the sales and production departments. Below, the importance of the participation of the sales department in the R&D project is studied. Relations with the production department will be dealt with separately.

Predicted pattern

There are areas of cooperation between the R&D department and the marketing department which have a greater impact on the level of technological asset accumulation.

Comment

Those in charge of the R&D department were asked to carry out a subjective evaluation of the various aspects of the level of cooperation between development and the sales department, such as: the search for ideas for new products or the modification of already existing products; the specification of the objectives of the new product; its program of development; the analysis of the needs and opinions of the client; competitor activity; and

other matters. They were requested to assess the real situation with regard to each of these aspects and also the situation which, from their point of view, they would consider ideal, thereby following the research methods of Gupta *et al.* [20].

The results obtained were almost entirely in line with the conclusions of the wider study by Gupta *et al.* [20]. One of the more prominent aspects is the existence of a certain amount of distrust concerning the sales area's contribution to the generation and selection of new product ideas, ("*everything they suggest should be passed through a filter of common sense to translate it into reality"*), as well as the perception of a 'tyranny' on the part of the sales department in the interpretation of client needs. In general, development personnel seem to think that they cooperate adequately, whilst believing that the sales department could do more to provide them with information, whilst at the same time their participation in specific decisions deemed as *"purely technical, for which they are not competent"* was not considered to be necessary.

Results obtained

The R&D departments in the companies where there is a greater endowment and leverage of technological assets, all make major demands on the sales department:

1 they should put much more effort into finding commercial applications for the ideas of R&D for new products and/or technologies

2 they should cooperate to a greater extent in the selection of new ideas.

Although there is greater disagreement regarding the contributions of the sales department, those mentioned seem to be the ones which affect the accumulation of technological assets to a greater degree and, what is more, the extent to which they are leveraged. In effect, if the sales department manages to find applications for the ideas of R&D, they will in reality be reutilising the knowledge available to a greater degree. Furthermore, greater cooperation in the selection of new ideas would increase the possibilities of commercial success.

Therefore, the predicted pattern is confirmed empirically, and especially with regard to the areas of cooperation mentioned previously.

4.5 R&D/production relationship

There is also a set of barriers between R&D and the production function which hinders mutual cooperation. Vasconcellos [21] cites, among others aspects: the production department's ignorance of R&D's objectives; R&D's ignorance of the capabilities and needs of production; a deficient system of communication; and a lack of trust between the teams of both areas. This following section will look deeper into the relationship between R&D and production.

Predicted pattern

There are areas of collaboration between the R&D and production departments which have a greater impact on the level of technological asset accumulation.

Comment

Those in charge of the R&D department were asked to carry out a subjective evaluation of various aspects regarding the level of cooperation with the area of production in different aspects and phases, such as prototype testing, problems in the manufacturing process, etc. They were asked about the existing level of cooperation, and also the level which they would consider to be ideal between these departments. However, outsourcing is a very common practice in this market, which seems to this qualify the relationships between these areas as a source of asset accumulation.

Results obtained

The analysis of the case studies demonstrates different types of relationships between R&D and production; we have detected neither areas of conflict, nor issues that influence the accumulation of assets. Both because of the technical characteristics of manufacture and the assembly of telecommunications equipment, and because of the custom of outsourcing, this study has not been able to confirm the extent to which the predicted pattern is complied with.

5 Conclusions

Various organisational parameters of interest exist, such as the levels of hierarchy in the department, the degree of specialisation and the standardisation of activities, as well as the relationships with the sales department.

All the companies showed themselves to be averse to hierarchical levels to the extent that there is agreement that there should be as few levels of hierarchy as possible. This agreement constitutes a prerequisite for the functioning of an efficient organisation. In its turn, the behaviour described could mean that vertical specialisation is a factor that negatively affects the process of asset accumulation in the company.

It can be observed that under certain conditions, horizontal specialisation is a restraint on the leverage of technological assets, i.e. a decrease of specialisation will mean an increase in the level of leverage.

It is also partly confirmed that the standardisation of activities favours the endowment of technological assets, even though there is a possibility that the phenomenon known as X inefficiency will appear in the process.

The relations between R&D and sales have an extensive effect on the accumulation of assets, even though not all areas of cooperation are sensitive to the same extent. In particular, what stands out are the search for commercial applications for the ideas generated by R&D and cooperation in the selection of new ideas. Furthermore, the relationship with production has not shown itself to be relevant with regard to the accumulation of assets.

Below, a summary Table is given, showing the effects of the more significant organisational parameters on the level of asset accumulation. Table 2 shows in order, the factor, the effect of the factor on the endowment of assets, the effect of the factor on asset leverage and the joint effect on asset accumulation, indicating if this is positive, negative or has not been verified (NV). Other conclusions are presented in Table 3, which have not been reflected previously.

Table 2 The organisational structure

Factor	*Asset Endowment* *Effect s. Adjusted Standard Product Unit (ASPU)*	*Asset Leverage* *Effect s. LEVER*	*Asset Accumulation* *Effect s. Standard Product Unit (SPU)*
The number of hierarchical levels	Negative	Negative	Negative
The degree of specialisation.	No effect	Negative	Negative
The standardisation of activities	Positive	No effect	Positive
The effort in the marketing department to find applications for R&D ideas.	No effect	Positive	Positive
The cooperation of the marketing department in the selection of new ideas.	Positive	No effect	Positive
The cooperation of the production department in the various activities of R&D.	NV	NV	NV

Table 3 Other conclusions about the organisation

- A structure with the lowest possible number of hierarchical levels is a prerequisite for the efficient functioning of the organisation.
- The activities involved in the development of products related to information technology require a high degree of specialisation.
- On occasions, the processes of standardisation imposed by the top management generate X- inefficiency.
- In this market, the relationship of R&D with the production function does not have an impact on the process of asset accumulation.

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