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A Balanced Scorecard framework for R&D

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Abstract

Purpose – The purpose of this paper is to produce a general Balanced Scorecard (BSC) model that is designed and delimited for managing research and development (R&D) activities.

Design/methodology/approach – A methodology based on the validity of content of an instrument of measurement, within the analytical framework of the validation of scales or constructs was employed.

Findings – The BSC model for R&D developed in this study has been subject to testing with recognised experts in management and in R&D. It has enabled a proposal to be put forward in respect of those indicators that best define the factors related to organisational effectiveness in the achievement of the strategic objectives set by companies, and to inter-relate them and group them under five broad perspectives of the BSC.

Research limitations/implications – The BSC will be validated as a construct in future research.

Practical implications – The result is the design of a scale of measurement that ranks the empirical indicators under the perspectives of the BSC; for the measurement of results, this instrument will provide unique values that group all the previous indicators in a single scale of measurement.

Originality/value – No studies dealing with the content validation of a BSC have been found in the literature on innovation.

Keywords Balanced scorecard, Research and development, Content management, Strategic management

Paper type Research paper

1. Introduction

The *Frascati Manual* (OECD, 1994, 2002) states that scientific and technological innovation can be understood as the transformation of an idea into a new or improved product, a new or improved industrial or commercial process, or a new method by which to serve society. The term "innovation" may take on different meanings in different contexts and the choice of meaning will depend on the specific objectives pursued in its measurement and analysis. The pursuit of innovation also involves a series of scientific, technological, organisational, financial and commercial activities. Research and development (R&D) is only one such activity and may be involved at various stages in the innovation process, not only as the original source of novel ideas, but also as a solution to problems as they are identified.

Both the *Frascati Manual* (OECD, 1994, 2002) and the Spanish Survey of technological innovation in firms, (Instituto Nacional de Estadística, 1999) define R&D as:

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> [...] creative work undertaken on a systematic basis in order to increase the stock of knowledge, including the knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications.

The principal objective of this study is to validate the content of a general BSC model for R&D activities. The BSC is an analytical model of strategic information for all types of organisation; it was developed by Kaplan and Norton in 1992 and since then has been the subject of many research studies in respect of its possibilities as a tool for strategic management. However, few references have been found to its development and implementation in companies which consider their R&D activities to be of strategic importance.

Our principal interest is in providing a solution for one of the problems related to the utilisation of the BSC for this type of activity – specifically, the impossibility of comparing the return or performance achieved between companies through the use of this instrument, when there is enormous heterogeneity in the use of different indicators in each perspective, and the non-existence of databases that could give us such comparative information.

Moreover, considering the problems raised in the literature on the management of R&D in respect of measuring the inputs and outputs of this type of activity, there are two reasons why it would be useful to have such a BSC. The first arises from the difficulties found in the employment of some of the indicators traditionally utilised in measuring the success obtained by companies in their R&D activities (Donnelly, 2000); the other arises from the lack of consensus in their choice of the dimensions that should be included in reports prepared for the strategic management of this type of activity, as well as from lack of alignment of the measurements of the returns from these activities with the strategy of the company; the BSC is one of the instruments for the measurement of these returns recommended in the literature on management of R&D (Bremser and Barsky, 2004; Kerssens-van Drongelen and Cook, 1997; Pearson *et al.*, 2000).

To this end, the methodology employed in this study is based on the content validity of an instrument of measurement within the general method of validation of scales or construct. We have used the scale developed by García-Valderrama and Mulero-Mendigorri (2005) for measuring the effectiveness of R&D activities and we have adapted it to the financial, customer, innovation, internal processes and learning and growth perspectives of company performance.

In our study, the starting point will be an analysis of the four dimensions of the Balanced Scorecard: financial; customers; internal processes; and learning and growth, in order to devise the framework proposed for R&D. In our case, this has been done by means of a review of the bibliography and the judgment of experts (in our case, the heads of R&D of companies with large investments in R&D), academics with expertise in R&D, and two experts in evaluation with the model of the European Foundation for Quality Management (EFQM) Quality Club. By this approach we expect to obtain a very high degree of consensus on the best way to measure each of the variables included in each dimension of our proposed BSC for R&D.

We have structured the paper in two main parts. In the first part, we analyse previous experience in developing the Balanced Scorecard for this type of activity. In the second part, we present the objectives of the study and the methodology employed in the development of the proposed BSC for R&D; in particular, we propose the

validation of content of this BSC for R&D activities, within the methodological framework of the validation of scales. Last, the results obtained and the conclusions drawn are presented.

2. The Balanced Scorecard as an instrument for measuring the performance or output from a company's R&D activities

The implementation of strategies requires integrated systems of measurement that capture changes in both financial and non-financial returns. The basis of such systems of measurement should be the alignment of the organisation's main processes (R&D, production, marketing and other traditional functional areas) with the corporate strategy; and the factors considered critical in achieving the returns should be utilised as parameters for the measurement of these returns. Traditionally, R&D activities have not formed part of corporate strategies, and this has been one of the biggest difficulties in the choice of instruments of measurement of the returns from this type of activity. Today, R&D is a key strategic topic for many if not most companies, and should therefore be aligned with the corporate strategy and associated management procedures (Pearson *et al.*, 2000).

On this point, Kerssens-van Drongelen and Bilderbeek (1999) report that, in the literature on R&D, there are relatively few references to the utility of employing measurement techniques for the returns obtained in this type of activity, and they suggest that the BSC could be employed as an integrated system of measurement of the returns from R&D. Later Neufeld *et al.* (2001) argued that the BSC offers a "most promising approach" that helps organisations to measure their performance and to achieve their objectives of excellence.

According to Kaplan and Norton (1992, p. 32) the Balanced Scorecard is:

> [...] a new framework or structure created for integrating indicators derived from the strategy, that continues to retain financial indicators of the past actions, completed with inductors of future financial actions. The inductors, which include the customers, the processes and the perspectives of learning and growth, are derived from an explicit and rigorous translation of the strategy of the organisation into tangible objectives and indicators.

The strategies and the lines of action that would enable the company to achieve its strategic vision should be translated into each of the perspectives. The company's strategies in the perspectives of learning and growth and in internal processes that are important in R&D activities will be those that, in short, help it to meet its strategic objectives related to the satisfaction of its customers and shareholders.

- Translation of company strategies in the financial perspective. The translation of strategies in the financial perspective is aligned with the improvement of the company's situation in the interests of shareholders. Strategies designed to increase market share or to increase productivity should be related to the strategic objective of improving the financial situation of the company.
- Translation of the company strategy according to the customer's perspective. In this case, the object should be to identify the segments of the market, select those market segments the company aims to satisfy, and identify proposed value to deliver to the segments selected. Customer satisfaction will lead to a higher rate of customer retention and/or the widening of the market, among other objectives. In turn, this will foreseeably generate better financial results for the company.

- Translation of the company strategy in the perspective of internal processes. It is in this perspective that we have worked most in the development of the BSC for R&D, the topic of this article. The proposed value to be offered to customers takes material form in the particular attributes and benefits that the supplier company provides, through its products and services, to create satisfaction and loyalty in its customers in the selected market segments. The proposed value is the key concept for understanding how measurements are managed within the groups of indicators of customer satisfaction, increased retention and market share.

  The satisfaction of both the shareholders and the customers are the consequence or result of the strategy of the company. The company as an organisation executes its strategy through processes that constitute its internal value chain, with special importance being attached to the initial activities of the value chain: R&D activities.

- Translation of the company strategy in the perspective of growth and learning. The company's success in the execution of its strategy will be based on the capacity of its organisation to learn, adapt and grow. This capacity also resides in the resources of the organisation allocated to R&D activities, particularly the personnel.

Each measurement is part of a chain of cause-and-effect links. There must be a balance between the measurements of results (against financial, market and customer satisfaction goals) and the motors driving those results (proposed value, internal processes, learning and growth in R&D).

In his study on measurements of scientific output Newburn (1972) stated that, while there are many studies where only one criterion is used to measure scientific output, it is generally recognised that scientific performance is multidimensional. In other words, as a general rule, after studying the indicators on the efficacy and efficiency of R&D activities proposed in the literature and applied in practice, many authors have concluded that multiple integrated measurements of output need to be utilised, owing to the complexity of the concept to be measured (Tipping *et al.*, 1995; Utunen, 2003; Werner and Souder, 1997).

Integrated measurements have the particular characteristic of combining numerous aspects of a single reality; they make it possible to utilise a series of quantitative-subjective, quantitative-objective and qualitative measurements jointly for the assessment of a single concept or reality. Often, this integration generates more information on the effectiveness of the R&D activities measured than if each measurement or indicator were taken individually (Werner and Souder, 1997).

The three types of integrated measurements most frequently utilised in the study of the efficacy of R&D activities are: the Technological Value Pyramid (Tipping *et al.*, 1995), Benchmarking (Bean *et al.*, 2000; Krause and Liu, 1993; Tipping *et al.*, 1995; Werner and Souder, 1997; Sharif, 2002) and the Balanced Scorecard (Kerssens-van Drongelen and Bilderbeek, 1999; Kerssens-van Drongelen and Cook, 1997; Li and Dalton, 2003; Neufeld *et al.*, 2001).

In this respect, Bremser and Barsky (2004) argue that companies that employ large amounts of resources in R&D can benefit from the key concepts of the BSC,

fundamentally for its basic principles, focused on the achievement of strategies. In particular, these authors identify the following advantages from its utilisation:

- the company translates its strategy into operational terms using Balanced Scorecards and strategic maps;
- the BSC aligns the organisation structure with the strategy, by "cascading" from the highest-level scorecard to strategic business units, to support departments and to external partners;
- it makes strategy everyone's job, by allowing initiatives for creating strategic awareness and for using personal scorecards with related incentives;
- it makes strategy a continual process by linking budgets to strategy, implementing a process for learning and adapting the firm's strategy; and
- it mobilises leadership for change in the strategic management system.

Deploying the corporate BSC in the functions and departments of R&D helps to achieve the integration of technological planning with the strategy of the corporation. Pearson *et al.* (2000) review the literature and report on measurements of R&D performance; they advise the joint use of traditional techniques of measurement of returns focused on the cost control of this type of activity, with strategic measurements in the long term and with financial objectives. In this process of integration, the application of a BSC is suggested.

With respect to the techniques traditionally employed for measuring the returns from R&D, Donnelly (2000) raises the question of whether techniques for monitoring the results of R&D are feasible or not, and of how these can be related to the strategies of the corporation. This author came to the conclusion that around 40 per cent of new products developed by a company do not achieve the returns desired.

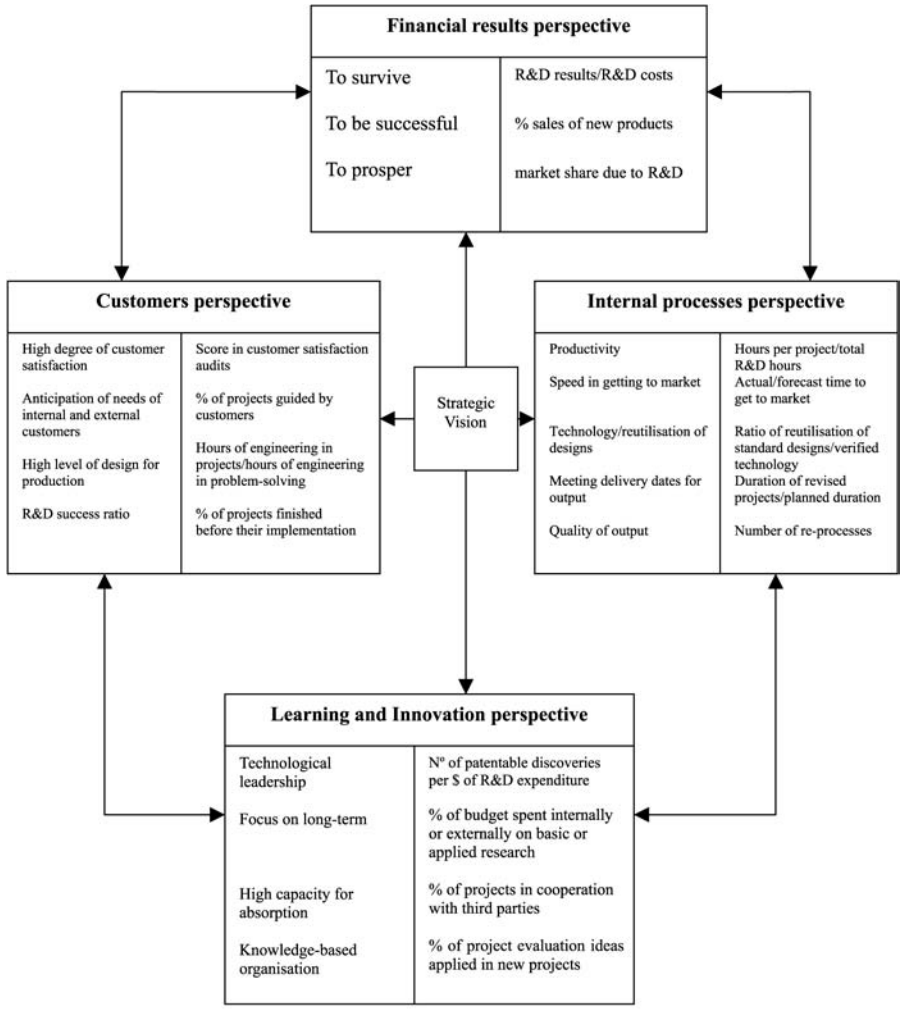
Bremser and Barsky (2004) consider that, in the implementation of strategy, the employment of non-financial measurements related directly or indirectly to the R&D plays an extremely important role, both at the level of internal processes and at the corporate level. In companies with long cycles of product design and development, the cycle of innovation is more important than the operating cycle. The process of innovation usually requires a longer period of time for value creation, in which new markets and new customers see their expectations met; R&D activities are critical in the implementation of these expectations (Bremser and Barsky, 2004).

The pioneering proposal put forward by Kerssens-van Drongelen and Cook (1997) is based on the argument that all the output measurements utilised in the literature and in practice can be placed under one or several of the following five high level parameters: cost (efficiency), quality, time, innovatory capacity and contribution to profits, and that these high level parameters can, in turn, be aligned with the four perspectives proposed by Kaplan and Norton (1992, 1993, 1996).

Quality corresponds to the perspective of the customer, cost (efficiency) and time to the perspective of the internal processes, innovatory capacity to the perspective of learning and growth, and contribution to profits to the perspective of financial results.

The model proposed by these authors is represented in Figure 1.

Neufeld *et al.* (2001) analysed eight organisations in the USA and Canada that are leaders in scientific research, with the object of identifying the attributes that define quality of management in research units or departments. Their approach was based on



Source: Adapted from Kaplan and Norton (1996)

Figure 1.
Balanced Scorecard for R&D proposed by Kerssens-van Drongelen and Cook (1997)

the BSC model of Kaplan and Norton since, according to the authors, the BSC is a point of departure for identifying the attributes of organisations with a high research output (see Table I).

Li and Dalton (2003) argue that the BSC needs to be implemented in R&D because of the scale of changes that have taken place in recent years. The rate of growth in the size and scope of R&D departments has been spectacular and rapid, to the extent that problems of visibility are being generated. Managers feel that the basic decisions that were taken relatively easily years ago have now become extraordinarily difficult. In the opinion of Li and Dalton (2003), when there is a lack of visibility from the top down, serious problems emerge from the bottom up, since at the operating level it is difficult

People	The management knows that research abilities and other skills are necessary to fulfil the mission, and therefore the company contracts, develops and retains the appropriate mix of persons The employees are highly committed to their work, have confidence in the management, and are proud of their organisation
Leadership	The current and anticipated needs of the persons engaged in the research work are critical for the organisation and its research program The employees and other persons engaged in the research work share the vision, values and goals of the management The portfolio of projects represents appropriate research work, with sufficient time and resources allocated to perform the work appropriately
Management of the research	The research projects involve significant leading-edge science, the correct persons are engaged in them, they are on course and within budget The research projects attract external financing Organisational knowledge is systematically captured and transformed into tools of work
Organisational performance and output	The organisation is widely known and respected The organisation knows the needs of everyone who depends on it

Source: Neufeld *et al.* (2001)

Table I.
Definitions of the ten attributes in the Balanced Scorecard for R&D

have a strategic vision of the company and its objectives. This has created problems in R&D activities, where measurements of productivity are passing through a crisis, as demonstrated in the study already mentioned conducted by Berger Consulting (2002) among 60 large multinational chemical companies, and in other studies.

The response to this crisis is to recognise the need for better management of R&D activities; a need exists for R&D departments to render accounts of their activities, and for their operational objectives to be focused on supporting the strategy of the company, to enable the decision-makers to identify and justify the potential rewards from these activities.

As a case study, the way this problem was solved in the company Pharmacia was by the implementation of software to keep a Balanced Scorecard for the R&D activities of the company. Li and Dalton (2003) describe the use of this tool and show the structure of the BSC applied to Pharmacia, which is presented in Figure 2.

As can be seen, the four dimensions of Kaplan and Norton have been extended to five, with "Learning and Innovation" being separated into two; at the same time, each dimension comprises four or five operating objectives, making a total of 23. According to Li and Dalton (2003), the implementation of this management tool has resulted in the following benefits for Pharmacia:

(1) The system has permitted more transparency for the managers, who have acted thinking of the long-term results.

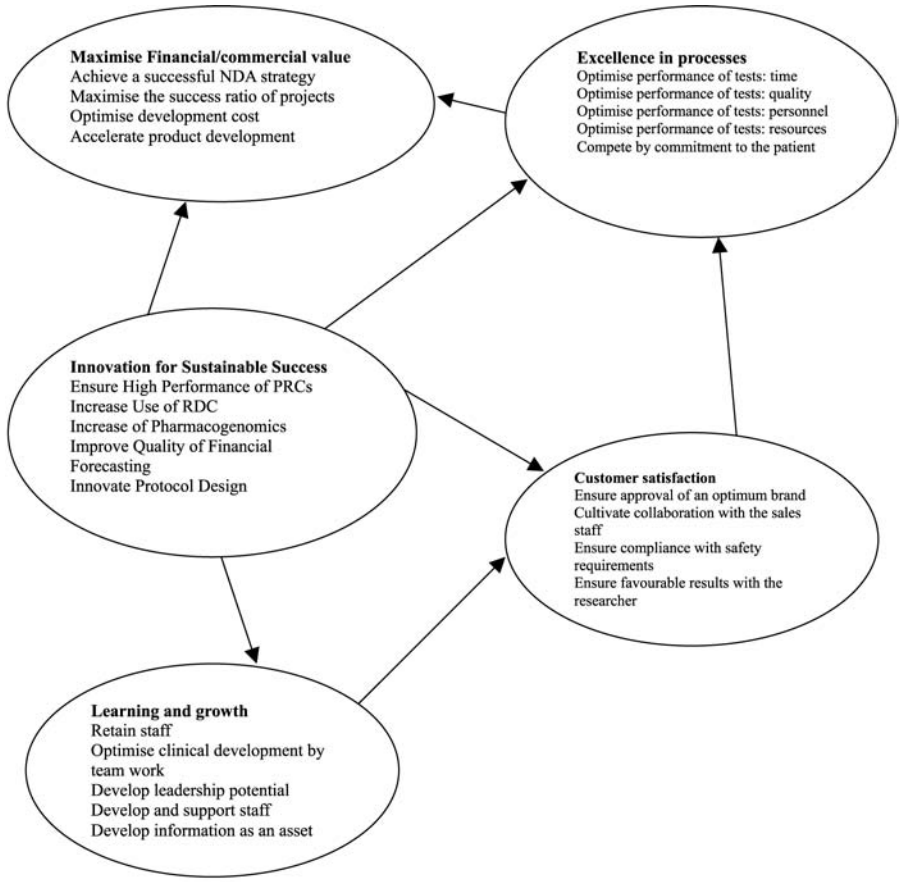


Figure 2.
Model BSC applied to the company Pharmacia

Notes: Acronyms – NDA: Non Disclosure Agreement; CRP: Corporate Research Planning; RDC: Remote Data Capture

Source: Li and Dalton (2003)

(2) This has had an impressive effect in the short-term:

- in the last two years, the company has introduced various redesigns of processes highlighted by using the BSC;
- the time cycles in the critical paths of clinical tests have been drastically reduced, by between 34 per cent and 75 per cent;
- the costs per patient have been reduced by 5 per cent;
- the number of patients recruited for clinical research has increased by 34 per cent;
- all these results have been achieved while maintaining the level of quality; and
- the BSC contributes to the global implementation of strategy and to continuous decision making.

Another of the applications analysed is that described by Bremser and Barsky (2004, p. 234). These authors present an example of specific measurements of R&D under the structure of a BSC for the company's R&D department; these are shown in Table II.

In particular, the proposal of these authors is based on relating the indicators of strategic character for the company as a whole, with the specific indicators for the R&D department.

As can be observed from the review made in this study on the measurement of the returns from R&D and its models, the literature points to the lack of definition of strategy in the planning of these activities, and the BSC is seen as the instrument that would help to achieve this definition. However, we certainly find a lack of homogeneity in the consideration of the indicators for R&D, since each company develops them in a different way, making it practically impossible to undertake any type of research that relates the advantages of the use of this technique with other parameters that could be available to the researcher.

With the object of resolving this problem, our proposal is to develop a scale or general BSC model for R&D, with the basic objective of obtaining a measurement tool that would give values that are homogeneous across several companies, and that could be adapted to the characteristics of the sector to which it may later be applied. The validation of scale would be employed to help us find performance values linked to R&D that are comparable between companies; this methodology should enable us to obtain a much more global and reliable multi-indicator (a scale or construct) than could be obtained from the analysis of individual indicators in isolation.

3. Validating the content of a Balanced Scorecard for R&D

As stated in the introduction, in our approach we propose to validate the content of a general BSC model for R&D activities. For this we design a measurement instrument, or scale, that includes all the appropriate variables, financial and non-financial, that have been proposed in the literature on the strategic management of R&D, starting from the structure of the "classic" BSC of Kaplan and Norton (1992, 1996).

To achieve this objective, we have established the following sub-objectives:

- Identification of the principal dimensions of the BSC: The dimensions are the various perspectives of the BSC. In accordance with the literature, we have considered the indicators related to each of the four perspectives, with the addition in our case of a fifth perspective termed Innovation, both in respect of the R&D department and in respect of the company as a whole.
- Delimitation of the objectives or variables measured by these indicators: The purpose of this phase of the work was to explain clearly these objectives or variables in the interviews held with the experts.
- Definition of each indicator that comprises the object of measurement (delimitation of the contents of the BSC) and design of a questionnaire (scale) in which each of these Indicators is represented by one or more items.

3.1 Methodology

In empirical research on the management of R&D, as in other disciplines, the relationships between relevant variables are examined. However, an initial problem may be encountered: how to measure these variables as accurately and reliably as

Table II.
Sample metrics at the R&D department level

Strategic objectives department	Strategic indicators at firm level	Sample metrics at the R&D level
Financial perspective	A. Return on capital employed	1. R&D value creation at innovation stages 1.4 (A, B, C)
	B. Customer profitability	2. R&D value creation in commercialisation stages 5 & 6 (A, B, C)
	C. Revenue growth rate	3. Percentage of sales from new products (D, E)
	D. Customer retention rate	
Customer perspective	E. Market share	4. Product market life cycle (D, E, F)
	F. Customer acquisition (number and quality)	5. Customer satisfaction with new products (D, E)
Internal business process	G. New product profitability for stage 5 (H)	6. Number of new products approved perspective
	H. R&D efficiency (time to market)	7. Average development cycle time stages 1.4 (H)
	I. Percentage of resources to sustain product stages 1.4 (G, H)	8. Average development cost per existing products
	J. Other metrics not related to R&D	9. Percentage of product ideas approved for stage 4 (H)
		10. Pricing and pro.t planning accuracy (G)
		11. New product acceptance rate (G)
		12. Safety incidents (H)
Learning and growth perspective	K. Employee retention	13. Number of patents awarded (M)
	L. Employee development	14. Strategic skill coverage ratio by competency category (K, M)
	M. Strategic skill coverage ratio by competency category	15. R&D competency vs. competitors (innovation level) (M)
	N. Employee survey measures	16. Employee survey measures (N, O)
	O. Innovative culture surveys	17. Employee training (hours) (K, L)

Note: The letter(s) in parentheses indicate cascading linkages to the firm-level measures
Source: Bremser and Barsky (2004, p. 235)

possible (Schwab, 1980, p. 5). Often, the conclusions obtained in research studies on the behaviour of innovative companies and its consequences are measured by the empirical observations of the researchers, and therefore errors of measurement are likely to occur. Research in this field is characterised by a scarcity of studies on the management of R&D.

The complete methodology on the validation of an instrument of measurement comprises a multiphase process, such as that depicted in Figure 3 (García-Valderrama and Mulero-Mendigorri, 2005, p. 315):

- First, a group of items (empirical indicators), chosen to measure the construct, must be identified. It is necessary first to demonstrate that the empirical indicators are logical and related to the construct, or scale. This step is referred to as the Validity of the Content (Pedhazur and Schemelkin, 1991). Two successive techniques are utilised in this phase: a review of the bibliography, and consulting the opinions of experts.
- Second, the degree of Reliability and Validity of the instrument of measurement must be established[1]. This step requires the application of a series of statistical tests that determine, first, the statistical properties of the empirical indicators (O'Leary-Kelly and Vokurka, 1998); second, within the analysis of Validity, the validity of construct must be analysed, which encompasses both convergent and discriminant validity; and third, the validity of criterion must be studied, which encompasses the concurrent validity and the predictive validity of the instrument.
- Finally, the definitive scale is applied to the company or companies being studied, by means of the questionnaire.

The methodology followed in our work is centred on the first phase of the complete process of validation of scales: the content validity (García-Valderrama and Mulero-Mendigorri, 2005).

The content validity of an instrument of measurement is defined as the sampling adequacy of the items of a test. In practice, the content validation represents a systematic examination of the content of the test, to determine if a sample is relevant to and representative of the behavioural domain that the researcher intends to measure. The following steps should be followed in the validation of content:

- definition of the universe of admissible observations;
- identification of experts with knowledge of this universe;

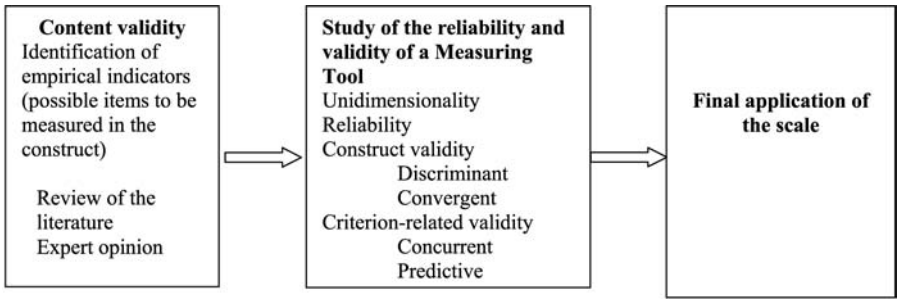


Figure 3.
Stages in the methodology for scale validation

- obtaining the considered opinion of the experts on the degree to which the content of the instrument is relevant to and representative of this universe; and
- devising a procedure for summarising the data obtained in the previous phase.

In the process of content validation, the researcher will carry out a bibliographic review with the object of determining the most significant components of the construct or scale. Once the review has been conducted, the opinions obtained from the experts are employed to corroborate or extend the battery of indicators accepted as defining the scale.

In an initial phase, the researcher will have established the specifications of the test, in accordance with which the items will be constructed. These specifications show:

- the areas of content to be covered;
- the processes that will be evaluated; and
- the relative importance of the various topics and processes.

Normally, in the validation of content, the decisions are more qualitative than quantitative; however, some indices have been proposed for summarising the opinions of the experts, including:

- the percentage of items that match or are paired with the objectives;
- the correlation between the weight given to a particular objective and the number of items that measure that objective;
- index of item-objective congruence; and
- the percentage of objectives not evaluated by any of the items.

As already stated, the methodology followed in our work is based on the first phase of the complete process of validation of scales: the validation of content, in two stages:

(1) A review was made of the bibliography, and this enabled us to determine what are the dimensions and indicators of the construct, taking the five perspectives, or dimensions of the BSC as our basis.

(2) By presenting the instrument of measurement, proposed in the first stage, to selected experts to obtain their judgment or opinion, the content of the instrument was validated.

3.1.1 First stage: Identification of the indicators of the Balanced Scorecard for R&D, by means of the bibliographic review. In our proposal for the development and content validation of the BSC for R&D, each group of items (or empirical indicators) represents one of five strategic dimensions for the companies: these dimensions cover financial results, customers, innovation, internal processes, and learning and growth. In each of the dimensions analysed, a series of indicators, or components of each dimension, with their corresponding objectives of measurement, have been considered. Using the judgment of experts, the representative items for the measurement of each objective will be selected (Table III).

As can be observed, in our proposal, we have included a new perspective that would complement the four traditional perspectives of the BSC of Kaplan and Norton. We have termed this Innovation, because the results of the financial and customer

Table III. First stage: bibliographic review in respect of dimensions, objectives and indicators of the proposed Balanced Scorecard for R&D

Dimension	Indicators (objectives)	Definition	Source
Financial results perspective	Success in the achievement of financial results due to the application of the R&D results	Measurement of the achievement of the financial objectives of the company in terms of increased profits and financial profitability	Armistead (1981); Odagiri (1983); Morbey(1988); Odagiri and Iwata (1986); Brenner and Rushton (1989); Morbey and Reithner (1990); Curtis and Ellis (1998); OECE y Eurostat (1997, 2005); Lee *et al.* (1996); Abdel-kader and Dugdale (1998); Patterson (1998); Cañibano *et al.* (1999); Wakelin (2001); Del monte and Papagni (2003)
Customers perspective	Marketing and commercial success due to the application of the results of R&D	Measurement of the achievement of the objectives of the company in terms of sales revenue, market share and customer satisfaction, due to the application of the results of R&D	Armistead (1981); Odagiri (1983); Morbey(1988); Odagiri and Iwata (1986); Brenner and Rushton (1989); Morbey and Reithner (1990); Curtis and Ellis (1998); OECD y Eurostat (1997, 2005); Lee *et al.* (1996); Abdel-kader and Dugdale (1998); Patterson (1998); Cañibano *et al.* (1999); Wakelin (2001); Del monte and Papagni (2003)
Innovation	Degree of innovation achieved: New materials New components or intermediate products New design or presentation New functions for existing product New machinery New working methods Both aspects	The company manages to offer innovative products, in comparison with its competitors', in accordance with its R&D objectives The company manages to innovate in production processes and achieve good results in reducing costs and improving the quality of its products	Ministerio de industria y energia (1991, 1994); Di Benedetto (1999); Sherman *et al.* (2000); Chryssochoidis and Wong (2000); Gemser and Leenders (2001) Saraph *et al.* (1989); Sakakibara *et al.* (1993); Flynn *et al.* (1994); Ward *et al.* (1994); Small and Yasin (1997); Patterson (1998)

(*continued*)

Table III.

Dimension	Indicators (objectives)	Definition	Source
	Degree of match between the resources deployed and R&D results achieved	Rate of growth of the number of patents obtained	Ministerio de industria y energia (1991, 1994); Lee *et al.* (1996); Urraca (1998); OECD y Eurostat (1997, 2005); Ernst (2001); Holger (2001); Hagedoorn and Cloodt (2003)
	Utilisation of technology purchased	Measure of degree to which successful use is made of technology purchased outside the firm	Falguni and Rubenstein (1989); Ministerio de industria y energia (1991, 1994); Veugelers (1997); Demirag (1998); Veugelers and Cassiman (1999); Lee *et al.* (1996)
	Utilisation of technology developed	Measure of degree to which successful use is made of technology developed in R&D departments	Ministerio de industria y energia(1991, 1994); Veugelers (1997); Demirag (1998); Veugelers and Cassiman (1999); Lee *et al.* (1996)
Internal processes perspective	Match between company strategy and its R&D objectives and planned activities	Measurement of the degree of match or consistency between, on the one hand, the R&D objectives set and the R&D activities, and on the other, the current reality of the company and its business situation	Lee *et al.* (1996); Iansiti (1997); Stojilkovic (1998); Tracey *et al.* (1999); Molleman and Timmerman (2003)
	Degree of influence of external regulation on R&D	Degree of influence of external regulation on the planning of R&D objectives and activities	Morrison and Siegel (1996); Dowdell and Press (2004); García-Valderrama and Mulero-Mendigorri (2005)
	Match between the R&D budget and the objectives set	Measurement of success in setting realistic R&D budgets in accordance with specific objectives set for the department	Lee *et al.* (1996); Halliday *et al.* (1997); Demirag (1998); Heidenberger *et al.* (2003)

(*continued*)

Table III.

Dimension	Indicators (objectives)	Definition	Source
	The existence in the company of Manuals of procedures for R&D activities	Set routines for formalized activities in the R&D department	Lee *et al.* (1996); Stojilkovic (1998); Tracey *et al.* (1999); Presley, and Liles (2000); Heidenberger *et al.* (2003)
	Fluidity of information flow between departments of the company	Degree of communication between the R&D department and the other departments of the company	Gupta *et al.* (1987); Roos and Roos (1997); Young (1997); Iansiti (1997); Kahn and Mcdonough (1997); Omta and Van Engelen (1998); Cañibano *et al.* (1999); Hoyt and Gerloff (2000)
	Coordination between R&D, production and marketing	Measurement of the degree of coordination between the activities undertaken in the R&D department and those undertaken in the departments of marketing and production	Coombs and Gómez-Mejía (1991); Lee *et al.* (1996); Young (1997); Kahn and Mcdonough (1997); Di Benedetto (1999); Maltz *et al.* (2001); Leenders and Wierenga (2002)
	Difficulties in achieving the objectives set in the R&D plans and budgets	Problems facing the company in reaching the objectives set in the plans and budgets for R&D activities	Young (1997); Demirag (1998)
	Degree of success in keeping costs to budget	Measurement of the problems faced by the company in implementing new activities proposed by the R&D department, which may not agree with those set in the annual plan	Lee *et al.* (1996); Young (1997)
	General quality of work undertaken in R&D activities	Measurement of the degree to which quality parameters in R&D activities are achieved. Compliance with quality standards on cost levels in the R&D department, parameters on research results, time, etc	Lee *et al.* (1996); Abdel-Kader Dugdalet (1998); Brennan (2001)

(*continued*)

Table III.

Dimension	Indicators (objectives)	Definition	Source
	Effort in R&D	The company allocates funds to cover activities related to R&D by reference to the average of previous years The company allocates investments in R&D as a per cent of the total income, with reference to the average per cent of previous years	Lee *et al.* (1996); The Conference Board (1997); OECD: Frascati Manual (1994, 2002); Veugelers (1997); OECD y Eurostat (1997, 2005); Souitaris, V. (2002)
	Alliances with partners in R&D	Degree of involvement of the firm's various partners in determining its R&D objectives and activities	EIRMA (1995, 1997); EFQM (2003); Hirst and Mann (2004); García-Valderrama and Mulero-Mendigorri (2005)
	Usefulness of the Infrastructures utilized in R&D	Cost-benefit ratio of these investments	Lee *et al.* (1996); Galende and Suárez (1998)
Learning and growth perspective	Relative increase in the R&D personnel	Increase of the number of persons in the R&D department, compared with the increase in the number and size of projects	Lee *et al.* (1996); Halliday *et al.* (1997); Souitaris, V. (2002); Hall (1987)
	Training of the R&D personnel	Measurement of the level of training of the R&D personnel, according to the number of qualified engineers, graduates, etc., as a percentage of the total employed	The Conference Board (1997); Souitaris, V. (2002) West and Iansati (2003)
	Aptitude of the R&D personnel for this type of work	Skills, abilities and experience possessed by the R&D personnel	Gómez-Mejía and Balkin (1989); Halls (1992); Muhlemeyer, P. (1992); Schoenecker *et al.* (1995); Myers (1996); Brooking and Motta (1996); Lee *et al.* (1996); The Conference Board (1997); Haanes and Lowendahl (1997); Randle (1997)
	Aptitude of the R&D personnel for this type of work	Motivation of the R&D personnel	

(*continued*)

Dimension	Indicators (objectives)	Definition	Source
	Adaptability of the R&D personnel to the technological changes adopted by the company and utilized in R&D	Conflicts among the R&D personnel faced with the utilisation of new research technologies	Lee *et al.* (1996); Tracey *et al.* (1999)
	Labour relations climate among the R&D personnel and between them and their supervisors	Measurement of the health of the human relationships among members of the R&D department, and between them and their supervisors	Dunegan *et al.* (1992); Roos and Roos (1997); Young (1997); The Conference Board (1997); Demirag (1998); Hoyt and Gerloff (2000)
	Degree of involvement and participation of R&D personnel I + D	Measurement of the involvement of persons engaged in R&D activities in formulating the policies, strategies and plans of the company	European Foundation Quality Management (EFQM) (2003)
	Identification of competences in R&D and training	Measurement of the degree to which the capacities of R&D personnel are identified, and policies of training in the capacities required	European Foundation Quality Management (EFQM) (2003)
	Evaluation of the performance of R&D personnel	Measurement of the degree to which Performance Evaluation of R&D personnel is implemented, and its utilisation for continuous improvement	European Foundation Quality Management (EFQM) (2003)

Table III.

perspectives must be completed with the intermediate outputs that would be obtained from the performance of this activity; in some cases, innovation need not originate with the company's own R&D department.

3.1.1.1 *Dimension of financial results: increased financial profitability and profits.* The Financial Results dimension would bear a close relationship to the final results of the R&D activity; such results should, if positive, be reflected in the increase of the profits figures, or in an improvement of the company's financial profitability. It is, however, very difficult to prove that the good financial results achieved by the more innovative companies are certainly or even probably the consequence of an effective policy for R&D, and that this policy has generated the outputs and successes expected from the R&D activity. Nevertheless, we have included in our scale two indicators related to the financial results that the company obtains from applying the results of these activities, both from the perspective of customers and from the perspective of innovation (Armistead, 1981; Odagiri, 1983; Morbey, 1988; Odagiri and Iwata, 1986; Brenner and Rushton, 1989; Morbey and Reithner, 1990; Curtis and Ellis, 1998; OECD y Eurostat, 1997, 2005; Lee *et al.*, 1996; Abdel-kader and Dugdale, 1998; Patterson, 1998; Wakelin, 2001; Del monte and Papagni, 2003).

3.1.1.2 *Dimension of customers: Improved positioning against competitors; increased customer satisfaction; increased market share.* No doubts exist on these aspects: with relation to the potential marketing benefits deriving from R&D activities, both the literature analysed and the experts consulted point to increased revenue from increased sales, to the increase of market shares, and to greater customer satisfaction, as the best indicators, from the perspective of customers (OECD y Eurostat, 1997, 2005; Lee *et al.*, 1996; Abdel-Kader and Dugdalet, 1998; Cañibano *et al.*, 1999).

3.1.1.3 *Dimension of innovation.* The reason for the inclusion of this extra perspective is the need to separate clearly the commercial and financial results of the company from the value it adds to its customers and shareholders in terms of innovation. It is important in this respect to bear in mind that R&D activities only constitute one part of the process of company innovation, and that with the inclusion of this new perspective, companies would be able to determine the efficiency of all their innovation activity, and to relate this to the resources and capacities of the persons most directly involved in this activity, to the foreseeable consequences for its processes, and to the degree of innovation really achieved.

- *Innovation in products and process.* Equally, an important factor that almost all companies evaluate as the direct result of the effort made in R&D is the number of new products launched from R&D work (Di Benedetto, 1999; Sherman *et al.*, 2000; Chryssochoidis and Wong, 2000; Gemser and Leenders, 2001), as well as innovation in processes (Saraph *et al.*, 1989; Sakakibara *et al.*, 1993; Flynn *et al.*, 1994; Ward *et al.*, 1994; Small and Yasin, 1997), and the quality achieved in the performance of their R&D activities (Brennan, 2001). This last factor of quality should be reflected sooner or later in the results achieved by the company, whether in terms of the profits figures or in terms of the improved efficiency in the general management of the company (Hirons *et al.*, 1998). In any case, these outputs should, in our judgment, not only form part of the four original perspectives of the BSC but should be measured under an additional dimension that we have termed Innovation, on the same lines as the proposals of Li and Dalton (2003) and Kerssens-van Drongelen and Bilderbeek (1999).

- *Match between resources and results.* In the light of the difficulty in determining this match, the outputs of R&D processes have traditionally been measured by the number of patents or utility models obtained, and even by the number and quality of papers published or presented at congresses; in effect, output is measured by the apparent increase of specialised knowledge acquired by the company from undertaking its R&D activities (Ministerio de industria y energia, 1991, 1994; Patel and Pavitt, 1995; Lee *et al.*, 1996; Coombs *et al.*, 1996; Urraca, 1998; OECD y Eurostat, 1997, 2005; Holger, 2001). The utility for the company of new technologies, both those acquired externally and those developed internally by the Company itself, has also been considered as an output of R&D (Ministerio de industria y energia, 1991, 1994; Demirag, 1998). These parameters clearly represent intermediate results achieved by these companies that can be expected to materialise in increases in the commercial and financial results of the company (García-Valderrama and Mulero-Mendigorri, 2005).

3.1.1.4 *Dimension of internal processes:*

- *Effort in R&D.* With relation to the Internal Processes Dimension of R&D activities, in the literature, the "expenditure on R&D" is the variable most frequently used as an indicator of input to measure the efforts that a company devotes to R&D activities that could eventually generate outputs (Lee *et al.*, 1996; Hagedoorn and Cloodt, 2003). This variable can provide information on the capacity for innovation possessed by a company that wishes to improve its performance, since current expenditures on R&D are usually the consequence of previous expenditure on R&D that produced successful results (Branch, 1974).
- *Manuals of procedures.* On the other hand, various studies have demonstrated that the planning of these activities, at both the operating and strategic levels, together with management consensus on the form in which these processes should be reflected in the company's budgets, are crucial for the success of R&D activities (Lee *et al.*, 1996; Stojilkovic, 1998; Tracey *et al.*, 1999; Presley and Liles, 2000; Heidenberger *et al.*, 2003). The clarification of objectives, the existence of a manual of procedures, and a clear statement of the results expected to be achieved, constitute the first steps in adequately evaluating the process of implementation of the R&D plan.
- *Coordination in activities, and match between objectives and budget:* However, information or views on whether or not the plan is well-designed, and whether or not the budgets are well-produced cannot be analysed exclusively or in isolation; it is also necessary to measure to what extent the personnel of the company is working towards the plan, and what are the barriers to implementation, together with the factors that will facilitate the implementation of these plans. The degree of match between the R&D objectives and the R&D budget (Lee *et al.*, 1996; Demirag, 1998), and the degree of mutual understanding and communication between the Production, Marketing and R&D departments, including the effort that the company must make to expand and diversify these activities (Lee *et al.*, 1996; Young, 1997), should be included when assessing the process of implementation of the R&D plan. Other factors considered decisive for successful investments in R&D are the existence of an internal organisation that can truly mobilise these resources, and that is capable of coordinating all the

resources and driving the generation of other new resources (Gassman and Von Zedtwitz, 1999; Christensen, 2002). This would include adequate systems of planning and control, and of information, within the company, which would enable the need for and results from R&D expenditure to be properly evaluated (Cohen, 1995; Lee *et al.*, 1996; Roos and Roos, 1997; Young, 1997; Haanes and Lowendahl, 1997; The Conference Board, 1997; Stojilkovic, 1998; Demirag, 1998; Cañibano *et al.*, 1999; Tracey *et al.*, 1999).

- *Quality, alliances with partners in R&D, and degree of influence of external regulation on R&D.* Finally, the company must know if it is responding to the quality needs of its customers, and determine the degree of involvement of customers in the design of its products, which could give rise to changes in the manufacturing processes for those products (Hirst and Mann, 2004). The results of the company can also be conditioned by external regulations that affect certain sectors of activity, and to which the company must also respond (Morrison and Siegel, 1996; Dowdell and Press, 2004; García-Valderrama and Mulero-Mendigorri, 2005). This last factor may be considered a true restriction on obtaining results from R&D: both the company's final results in terms of increased sales or profits, and in general terms of the rate of innovation.

3.1.1.5 *Dimension of learning and growth:*

- *Personnel hostility to new technology.* Measuring results in respect of the training and development of human resources, or developing the knowledge culture of the company, may be as important as, or even more important than the measurement of the financial or technological results, for evaluating the effectiveness of R&D activities. In this respect, in studies conducted by Clark *et al.* (1987) and by Clark and Fujimoto (1991), these authors reach the conclusion that the productivity of R&D activities tends to be conditioned not only by the volume of expenditure on R&D, but also by the company's capacity for coordinating its human resources, as one example, or for resolving technical problems, as another.
- *Personnel aptitudes/attitudes, training and experience and degree of involvement and participation of R&D personnel.* There are many studies in the literature demonstrating the influence of the human resources on the effectiveness of R&D activities (Halls, 1992; Myers, 1996; Brooking and Motta, 1996; The Conference Board, 1997; Halliday *et al.*, 1997; Haanes and Lowendahl, 1997). Specifically, such studies coincide in noting the positive influence on the effectiveness of the company's R&D of the knowledge, abilities and skills of the personnel employed in the R&D department; positive indicators of these factors are having a relatively high percentage of total employees working in the R&D department, and presenting high degrees of aptitude, professionalism and training in these persons (Schoenecker *et al.*, 1995; Lee *et al.*, 1996; Souitaris, 2002). In the study of West and Iansiti (2003), an analysis is made of the importance of the R&D personnel's experience, and of the experimentation undertaken to create and acquire knowledge, derived from their activities, and the subsequent effect on the generation of innovation in the company.
- *Performance evaluation applied to R&D personnel and identification of competences and training needs in R&D.* Another important factor analysed in the literature with respect to the attitude of the R&D personnel is their

motivation to be creative and innovate (Hoyt and Gerloff, 2000); numerous studies have been centred specifically on the systems of incentives utilized to motivate the R&D personnel towards the generation of innovations. On this aspect, studies such as those of Balkin and Gómez-Mejía (1984), Gómez-Mejía and Balkin (1985, 1989), and Muhlemeyer (1992) demonstrate the need for different systems of incentives for the R&D personnel, the preferences of scientists in this respect, and the positive repercussion of effective incentive systems on the development of projects (Coombs and Gómez-Mejía, 1991) and on the performance of the company (Molleman and Timmerman, 2003).

- *Labour relations climate.* The climate in the close human relationships that are formed in these departments is also considered to be a factor that encourages the creation of value from R&D activities, and improves the internal processes taking place in this activity (Lee *et al.*, 1996; Roos and Roos, 1997; Young, 1997; The Conference Board, 1997; Demirag, 1998; Tracey *et al.*, 1999; Cañibano *et al.*, 1999; Di Benedetto, 1999; Hoyt and Gerloff, 2000; Maltz *et al.*, 2001; Leenders and Wierenga, 2002).

In Figure 4, the dimensions and elements of the BSC for R&D proposed in this study are represented. In this case, the financial results dimension would be defined as:

- the financial results due specifically to the application of the results of R&D activity;
- the customers dimension would be represented by the specific marketing results due to the application of R&D results;
- the innovation perspective would include the intermediate results derived from the R&D activities, specifically the degree of innovation in products and processes, together with the increase in the number of patents and utility models;
- the internal processes dimension would be formed by the development of improved internal processes in the company as a consequence of R&D; and
- the learning and growth dimension would give information on the training, experience and motivation of the personnel, particularly those employed in R&D.

These indicators have been identified from the review of the bibliography and will be considered in the development of the items of the questionnaire subject to validation, included in Table IV. Figure 4 presents the overall structure of the BSC proposed for R&D.

In addition, to enable the proposed model to be visualised, we have employed the strategic map of Kaplan (2001) (Figure 5). The strategic map is a diagram that depicts how the organisation creates value by connecting the strategic objectives with those of each perspective of the BSC. In Figure 5, we present the strategic map proposed for R&D; with all the information contained on a single page, it is possible to visualise the cause-effect relationships described in the BSC.

3.1.2 Second stage: opinion and judgment of experts. The second phase of the process of content validation of the scale consisted of consulting recognised experts belonging to two companies active in sectors that make substantial investments in R&D; the specific sectors in which these companies operate are aeronautics and defence, respectively. These two companies operate in two of the most innovatory

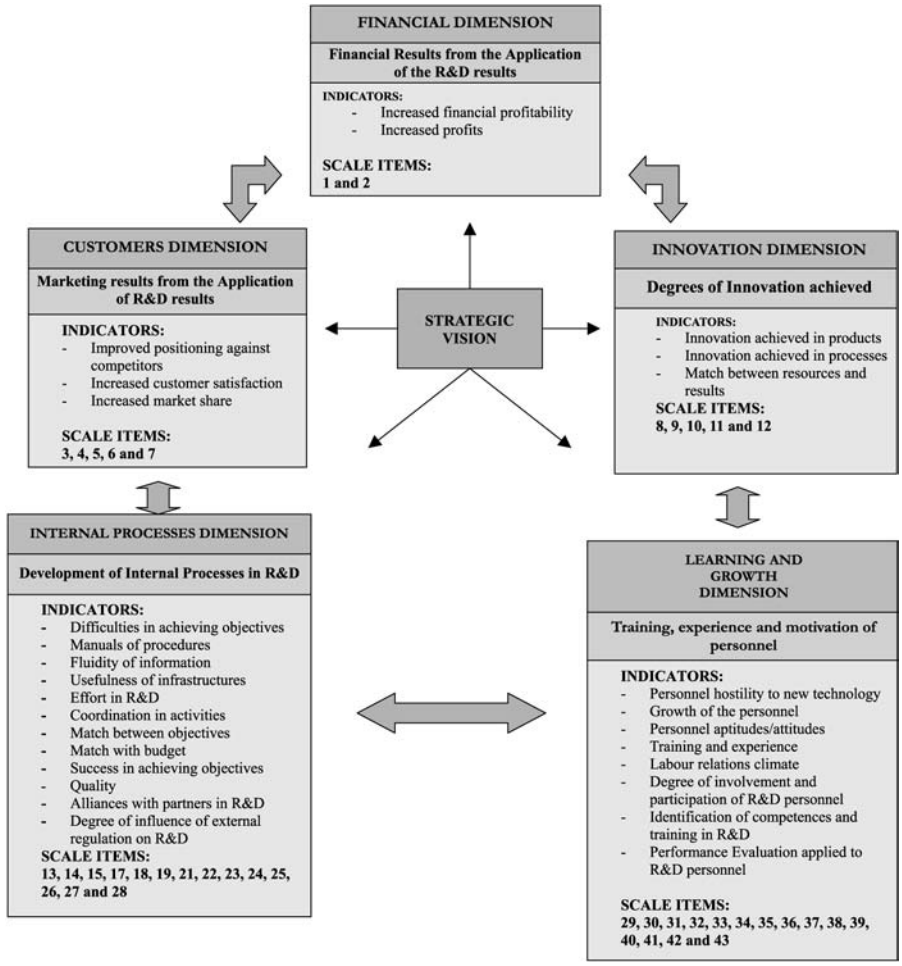


Figure 4.
Dimensions and indicators of the proposed BSC for R&D

sectors of Spanish industry, according to the Spanish National Institute of Statistics (Instituto Nacional de Estadística, 1999). The persons interviewed hold senior positions of responsibility in the two companies; in one company we interviewed the Controller, and in the other, the Director of the division.

In addition, as a check on the results obtained from these interviews, we have consulted the opinion of two of the leading Spanish researchers on the management of R&D, applying the same methodology for this second pair of experts. Some other research studies have also involved academic experts in the process of content validation, as in the cases of Saraph *et al.* (1989) and Small and Yasin (1997).

Finally, we have tested the partial results with two experts in evaluation with EFQM, belonging to the Quality Club. This last phase of consultation allowed us to incorporate new items based on the criteria and subcriteria followed in the EFQM model (Table III). The decision to interview experts in the EFQM model arose from a

Table IV.
Second stage: presentation to the experts of the items of the questionnaire and the objectives of measurement (indicators)

Questionnaire items	Indicators (objectives)
1. Estimate the increase of profits of your company in the last three years derived from the application of the results of R&D?	A. Effort in R&D
2. Estimate the increase in the rate of financial profitability of your company in the last three years, derived from the application of the results of R&D	B. Usefulness of the R&D infrastructures
3. What is the per cent increase in annual expenditure on R&D in the three last years, compared with the average of previous years?	C. Increase in the number of R&D personnel
4. What is the rate of increase in R&D expenditure as a per cent of total revenue in the last three years, compared with the average of previous years?	D. Level of training/preparation of the R&D personnel
5. What do you estimate is the cost-benefit ratio for the infrastructures utilised in R&D processes and activities?	E. Aptitude and attitude of the R&D personnel
6. How does the rate of increase in numbers of R&D personnel compare with the increase in the number and size of R&D projects?	F. Match between the R&D objectives and planned activities, and the current reality of the company and its business situation
7. What percentage of total R&D personnel have degree-level educational qualifications? What percentage of total R&D personnel have intermediate-level educational qualifications?	G. Match between the R&D budget and the objectives set
8. How do you rate the level of ability of the R&D personnel, in general?	H. Degree of conflict between the R&D personnel faced with the implementation of new technologies
9. How do you rate the level of experience of the R&D personnel, in general?	I. Attitude of the production personnel faced with technology transfer as a result of R&D activities
10. How do you rate the effectiveness of the process of planning the R&D objectives and activities of your company?	J. Fluidity of information exchange in the R&D department, and between the department and the rest of the company
11. How satisfactory do you consider the selection and design of R&D processes?	K. Labour relations climate among the R&D personnel and between them and their supervisors
12. How do you rate the match between the R&D objectives and the financial resources needed to achieve them?	L. Degree of coordination between activities performed in R&D and those in marketing and production
13. How do you rate the capacity of the R&D personnel to adapt to the technological changes adopted by the company?	M. Degree of degree of success in keeping costs to budget
14. How well prepared are they for the implementation of new production and information technologies?	N. Degree of difficulty in achieving the objectives set in the R&D plans and budgets

(*continued*)

Table IV.

Questionnaire items	Indicators (objectives)
15. How well are the R&D objectives and activities communicated to the R&D personnel, and to the personnel of the rest of the company?	O. Degree of match between the resources deployed and R&D results achieved
16. How do you rate the personal relationships between the R&D personnel?	P. The existence in the company of Manuals of procedures for R&D activities
17. How do you rate the personal relationships between the R&D personnel and their managers?	Q. Degree of innovation achieved in products and processes
18. How do you rate the coordination between the activities undertaken in the R&D department and those undertaken in the marketing and production departments?	R. Success in meeting quality standards in R&D activities
19. How difficult is it for the R&D department to keep within its budgets?	S. Measurement of the success in earning profits due to the application of R&D results
20. How difficult is it for the R&D department to reach the objectives set in its plans and budgets?	T. Use of technology purchased
21. What is the percentage increase/decrease in the number of patents obtained each year by your company, over the last three years?	U. Use of technology developed
	V. Measurement of the success in achieving marketing objectives due to the application of R&D results
22. How do you rate the results of innovation in processes originating from R&D activities?	W. Alliances with Partners in R&D
23. How do you rate the results of innovation in products originating from R&D activities?	Y. Degree of influence of external regulation on R&D
24. Does the company have manuals of procedures for R&D activities?	Z. Degree of involvement and participation of R&D personnel
25. To what extent have sales revenues been increased due to the application of R&D results?	AA. Identification of competences in R&D and training
26. To what extent have market shares been increased due to the application of R&D results?	AB. Evaluation of the performance of R&D personnel
27. To what extent has customer satisfaction increased due to the application of R&D results?	
28. To what extent has your company improved its global positioning against its competitors, due to the application of R&D results?	
29. How do you rate the perception your customers have of the products and services sold by your company?	
30. To what extent have parameters been established for measuring quality in R&D activities? To what extent are such quality parameters achieved?	

(*continued*)

Questionnaire items	Indicators (objectives)
31. Indicate the degree of influence of external regulation on the R&D objectives and activities of your firm	
32. Indicate the degree of involvement of the various Stakeholders of your firm in its R&D objectives and activities	
33. Indicate if the company has in place a system of incentives for R&D personnel	
34. Would you say that the technology purchased by your firm for use in R&D activities is bringing about positive results?	
35. Would you say that the technology developed by your firm for use in R&D activities is bringing about positive results?	
36. Indicate the degree of involvement of the persons employed in the R&D departments in developing the policies, strategies and plans of the company	
37. To what extent does your organisation provide opportunities to the employees of R&D so that their innovatory behaviour is stimulated?	
38. Indicate the degree to which your company employs innovatory organisational methods to improve the way people work. For example, restructuring the logistic chain, or working in flexible teams	
39. Estimate the development of the capacities of the R&D personnel through teamwork	
40. Estimate the degree of identification, classification and suitability of the knowledge and competences of the R&D personnel, to the needs of the organisation	
41. How do you consider that training and personal development plans for the R&D personnel are prepared and utilised? What contribution do these plans make to ensuring that the R&D personnel are fitted for the current and future capacities necessary for performing R&D activities?	
42. Estimate the degree to which the performance of the R&D personnel is evaluated. How much help does your organisation give them to improve their performance?	
43. Indicate the degree to which personnel surveys, or any other information sought from the employees, are utilised, to improve the HR policies, strategies and plans related to R&D	

Table IV.

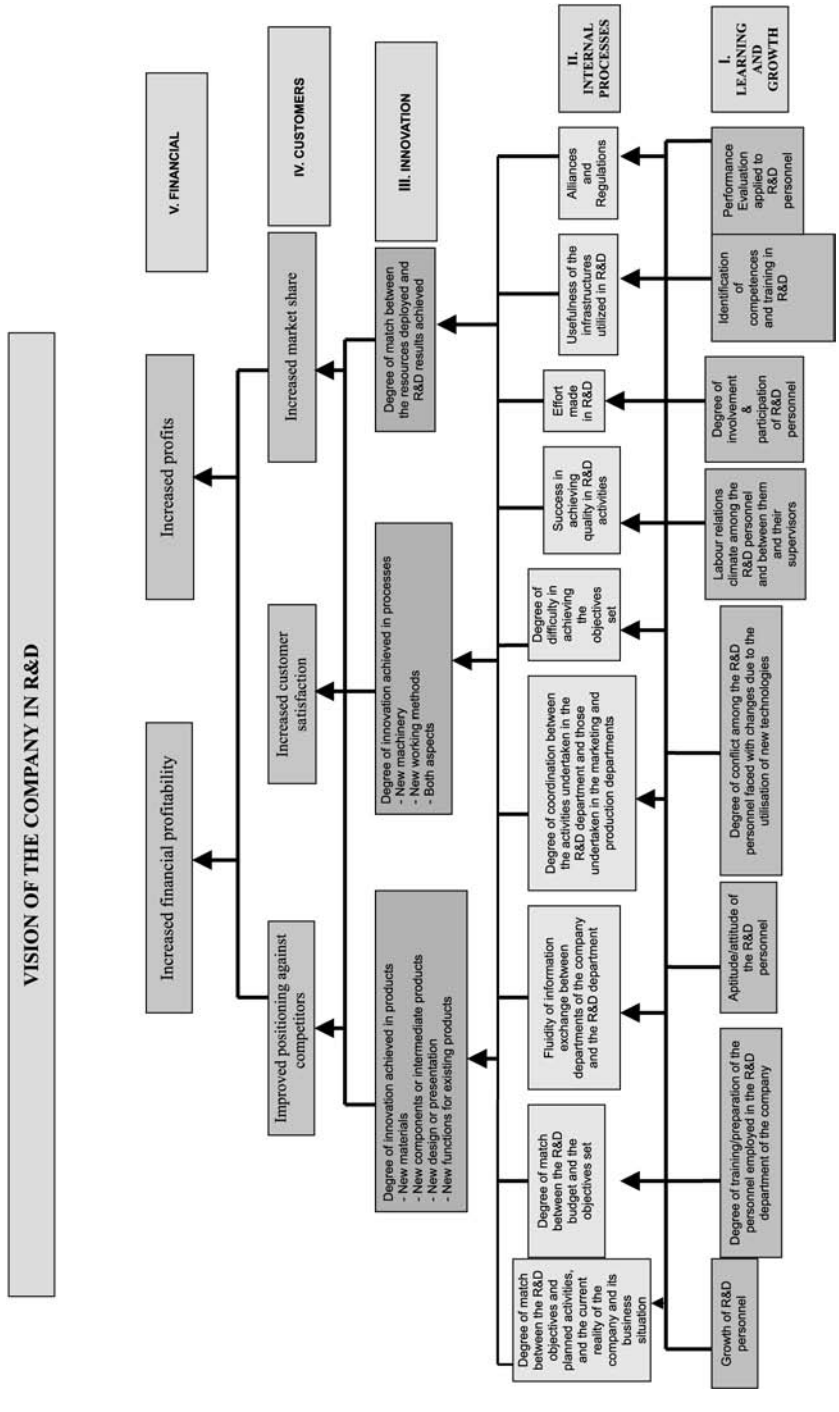


Figure 5.
Strategy map for R&D

self-evaluation carried out using this model in our University. Points of convergence were detected between the BSC model proposed in this paper and some of the criteria and sub-criteria considered in the EFQM model; this stimulated us to incorporate several items which were giving us problems in measuring, particularly in respect of the learning and growth perspective.

In this first interview, an explanation was given of the objective of the work, the form in which each of the items of the scale had been constructed – based on the bibliographic review, and on the way that we believed the questionnaire devised could help us to measure those aspects – and the areas of the company that should be involved in the future validation of the construct, the R&D department. In addition, it was explained to them that the objective of the interviews was, fundamentally, to obtain their expert opinions on three aspects: whether the various topics listed should or should not be included in the construct; the suitability of the formulation of the various questions; and the degree of agreement between the items presented and the factors or parameters that they were intended to measure. For this, in the first interview the experts were presented in Table III, and the measurement objectives sought by means of this study were explained to them. Then they were presented with the questionnaire devised previously in accordance with the bibliography analysed, with the object of obtaining their opinions on the suitability of the formulation of the different items or questions.

Subsequently, in a second interview, after the establishment of these specifications, the validation study itself was performed by presenting to the experts a double-entry table with the items in the columns and the objectives of each item in the rows, following the procedure described below (García-Valderrama and Mulero-Mendigorri, 2005, p. 320):

- *List of objectives:* In the process carried out, it was assumed that all the objectives have the same weight. On this occasion, the experts were asked to assign values to the various different objectives (+1 if the expert was in agreement with the match between the item and the objective, 0 if in disagreement, and – 1 if the expert was not sure).
- *Pairing of items-objectives:* We offered the experts a list of objectives and we presented them with each item in a separate row; the expert was asked to compare each item with the list and to record the result on a response sheet, indicating at the side of each item the number of the corresponding objective. Afterwards, the mean for each item for each expert was calculated, and the global summary represented the degree of pairing or matching between item and objective.
- *Aspects of the items examined:* We presented the experts with clear descriptions of the characteristics of the items and of the domain that they had to consider, for example, level of complexity, mode of response, or format and presentation.
- *Results:* The index of item-objective congruence calculated was that described by Hambleton and Rovinelli (1986):

$$I_{IK=}\frac{N}{2N-2}(\mu_{IK-}\mu_I)$$

where:

N = number of objectives,

μ_{Ik} = mean of the experts' score for the item i and the objective k,

μ_I = mean of the experts' score for the item i in all the objectives.

The index of item-objective congruence described by Hambleton and Rovinelli (1986) is utilised to assess the degree to which an item has validity. The formula is based in the assumption that, in the ideal case, an item would be matched with only one objective of the set.

The highest possible value of congruence of the item is 1, and this can only be reached when the item is matched to only one objective, by all the experts. Therefore, a very important step in this phase of content validation is the formulation of a questionnaire in which each of the simple elements that comprise the object of measurement gets represented by one or several items (Tables IV and V). The highest indices of congruence, with values equal to 1, represent the complete matching of the item to an objective by all the experts, and it is those that form part of the scale.

4. Results

Table III presents the dimensions and objectives of measurement, in accordance with the studies consulted in the literature. The first column gives the type of item and the dimensions of the construct to which it corresponds. This table was employed in the initial interviews with the experts. The objective sought in this case was the presentation of the initial proposal for the dimensions of the scale, and for their objectives of measurement. In this interview the objectives of each item, included in the second column of Table IV, were again designed and defined; this table also lists the 43 items of the questionnaire utilised for the validation of the scale.

Table V shows the final results for the indices of congruence of each item with its objectives. These scores rate the overall opinion of the experts with respect to each item i in terms of its intended measurement objectives, together with the mean score for each item i in all the objectives.

On the basis of the results obtained, those items that obtain an index of congruence equal to 1 are considered to be correctly paired with their corresponding objective of measurement in the questionnaire, and for this reason they have been included in the scale. Those items whose index was either 0 or -1 are eliminated from the scale.

The results of the phase of content validation of the scale will be employed in the subsequent phases of validation, to be the subject of a later study, in which the hypothetical relationships between the items of each of the dimensions of the BSC will be empirically demonstrated.

As can be observed in Table V, with respect to the learning and growth perspective of R&D, three items were initially considered:

(1) the increase in number of personnel in R&D in comparison with the increase in the number and size of new projects;

(2) personnel training; and

(3) aptitude, to which another item related to aptitude, the degree of experience, has been added.

Table V.
Results of second stage: pairing of items-objectives of the proposed Balanced Scorecard for R&D

Dimension	Indicators (objectives1)	Questionnaire items
Financial results perspective	Success in the achievement of financial results due to the application of the R&D results	1. Estimate the increase of profits of your company in the last 3 years derived from the application of the results of R&D 2. Estimate the increase in the rate of financial profitability of your company in the last three years, derived from the application of the results of R&D
Customers perspective	Measurement of success in the achievement of marketing objectives due to the application of the results of R&D	3. To what extent have sales revenues been increased due to the application of R&D results? 4. To what extent have market shares been increased due to the application of R&D results? 5. To what extent has customer satisfaction increased due to the application of R&D results? 6. To what extent has your company improved its global positioning against its competitors, due to the application of R&D results? 7. How do you rate the perception your customers have of the products and services sold by your company?
Innovation perspective	Degree of innovation achieved in products New materials New components or intermediate products New design or presentation New functions for existing product	8. How do you rate the results of innovation in products originating from R&D activities?
	Degree of innovation achieved in processes New machinery New working methods Both aspects	9. How would you assess the results of innovation in processes originating from R&D activities?
	Degree of match between the resources deployed and R&D results achieved	10. What is the percentage increase/decrease in the number of patents obtained each year by your company, over the last three years?
	Use of technology purchased	11. Would you say that the technology purchased by your firm for use in R&D activities is bringing about positive results?

(*continued*)

Table V.

Dimension	Indicators (objectives1)	Questionnaire items
	Use of technology developed	12. Would you say that the technology developed by your firm for use in R&D activities is bringing about positive results?
Internal processes perspective	Degree of match between the R&D objectives and planned activities, and the current reality of the company and its business situation	13. How do you rate the effectiveness of the process of planning the R&D objectives and activities of your company? 14. How satisfactory do you consider the selection and design of R&D processes?
	Degree of match between the R&D budget and the objectives set	15. How do you rate the match between the R&D objectives and the financial resources needed to achieve them?
	The existence in the company of Manuals of procedures for R&D activities	16. Does the company have manuals of procedures for R&D activities? $I_{IK=} = 0$
	Fluidity of information exchange between departments of the company and the R&D department	17. How well are the R&D objectives and activities communicated to the R&D personnel, and to the personnel of the rest of the company?
	Degree of coordination between the activities undertaken in the R&D department and those undertaken in the marketing and production departments	18. How do you rate the coordination between the activities undertaken in the R&D department and those undertaken in the marketing and production departments?
	Degree of difficulty in achieving the objectives set	19. How do you rate the problems faced by the R&D department in reaching the objectives set in the plans and budgets of the department?
	Degree of degree of success in keeping costs to budget	20. How difficult is it for the R&D department to keep within its budgets? $I_{IK=} = 0$
	Success in achieving quality in R&D activities	21. To what extent have parameters been established for measuring quality in R&D activities? To what extent are such quality parameters achieved?
	Effort in R&D	22. What is the per cent increase in annual expenditure on R&D in the three last years, compared with the average of previous years? 23. What is the rate of increase in R&D expenditure as a per cent of total revenue in the three last year, compared with the average of previous years?

(*continued*)

Dimension	Indicators (objectives1)	Questionnaire items
	Usefulness of the infrastructures utilised in R&D	24. What do you estimate is the cost-benefit ratio for the infrastructures utilised in R&D processes and activities?
	Alliances with partners in R&D	25. Estimate to what extent your company identifies opportunities for establishing alliances in R&D with other organisations
		26. To what extent are the key competences of the partners in R&D exploited in mutual development?
		27. Estimate to what extent an innovative and creative philosophy in R&D is generated and supported by means of such alliances
	Degree of influence of external regulation on the planning of R&D objectives and activities	28. Indicate the degree of influence of external regulation on the R&D objectives and activities of your firm
Learning and growth perspective	Relative increase of R&D personnel	29. How does the rate of increase in numbers of R&D personnel compare with the increase in the number and size of R&D projects?
	Degree of training/preparation of the personnel employed in the R&D department of the company	30. Number of persons with degree-level qualifications as a percentage of the total R&D personnel. Number with intermediate qualifications, as a percentage of the total
	Aptitude/attitude of the R&D personnel	31. How do you rate the level of ability of the R&D personnel, in general?
		32. How do you rate the level of experience of the R&D personnel, in general?
	Degree of conflict among the R&D personnel faced with changes due to the utilisation of new technologies	33. How do you rate the capacity of the R&D personnel to adapt to the technological changes adopted by the company?
	Labour relations climate among the R&D personnel and between them and their supervisors	34. How do you rate the personal relationships between the R&D personnel?
		35. How do you rate the personal relationships between the R&D personnel and their managers?
	Degree of involvement and participation of R&D personnel	36. Indicate the degree of involvement of the persons employed in the R&D departments in developing the policies, strategies and plans of the company

(*continued*)

Table V.

Table V.

Dimension	Indicators (objectives1)	Questionnaire items
	Identification of competences in R&D and training	37. To what extent does your organisation provide opportunities to the employees of R&D so that their innovatory behaviour is stimulated? 38. Indicate the degree to which your company employs innovatory organisational methods to improve the way people work. For example, restructuring the logistic chain, or working in flexible teams 39. Estimate the development of the capacities of the R&D personnel through teamwork 40. Estimate the degree of identification, classification and suitability of the knowledge and competences of the R&D personnel, to the needs of the organisation 41. How well do you consider that training and personal development plans for the R&D personnel are prepared and utilised? What contribution do these plans make to ensuring that the R&D personnel are equipped with the current and future capacities necessary for performing R&D activities?
	Evaluation of the performance of the R&D personnel	42. Estimate the degree to which the performance of the R&D personnel is evaluated. How much help does your organisation give them to improve their performance? 43. Indicate the degree to which personnel surveys, or any other information sought from the employees, are utilised, to improve the HR policies, strategies and plans related to R&D

Note: This table presents the results of the pairing by the experts of the items of the scale of measurement with the intended objectives of measurement, taking the highest value of the indicator I_{ik} of congruence for each objective and for each item. (1= total congruence, 0= lack of congruence, and hence elimination from the final scale)

In addition, also under the learning and growth perspective, other indicators included are:

- the degree of conflict among the R&D personnel faced with changes due to the utilisation of new technologies;
- the attitude of the production personnel faced with production technology transfer as a result of R&D; and
- the labour relations climate among the R&D personnel and between them and their supervisors (which in this case would be measured by items 34 and 35).

Last, items 36 and 37 were added to the scale; these measure the degree of involvement and participation of the R&D personnel in the development of the policies, strategies and plans of the company. Also added are items 38, 39, 40 and 41, which are concerned with the extent to which the company identifies the capacities of its R&D personnel, and with the training policy in this respect. Then items 42 and 43 are added, which would enable us to measure the degree of implementation of measurements of the performance of the R&D personnel, and their utilisation for continuous improvement.

In the dimension of internal processes, the effort devoted by the company to R&D would be represented in the scale by items 22 and 23 of the questionnaire. The usefulness or value of the R&D infrastructures would be represented by the cost-benefit ratio assessed by the company in respect of the employment of its R&D infrastructures. Other objectives included within this dimension are: the degree to which the R&D objectives and planned activities are appropriate given the current reality of the company, its situation and business environment, which would be measured by items 13 and 14; another factor initially considered important is the existence of manuals of procedures for R&D activities, although this item was later eliminated from the scale after the experts' review; the degree of coordination between the activities undertaken in the R&D department and those in the departments of marketing and production; the degree of difficulty in achieving the R&D objectives set; lastly, the fluidity of information exchange between the R&D department and the rest of the company would also form part of this perspective. In respect of companies' valuation of the degree to which they take advantage of the opportunities and competences arising from R&D alliances formed with partners, this information is collected in items 25, 26 and 27. The influence of external regulation on the planning of R&D activity is represented by item 28.

In respect of the innovation perspective, we have included elements related with the degree of innovation achieved, considering specific product and process innovations separately; and, last, the degree to which the R&D results achieved match the resources deployed, measured by the number of patents and the utility models obtained by the company. In this case, items 8 and 9 serve to obtain the information on innovation in products, and item 10 for information on patents and utility models. Also included are two other items, 11 and 12, corresponding to the company's success in employing the technologies purchased and/or developed in-house, respectively.

With respect to the customers perspective, the indicators included indicate the marketing success from the application of the R&D results, which would be measured through the following items: increases of sales revenue, if any, due to the application of the results of R&D; similar increases, if any, in market share, customer satisfaction, the improvement in the global positioning of the company with respect to its competitors

and, last, by changes in the customers' perceptions of the products and services marketed by the company.

With relation to the perspective of financial results, two items have been included: item 1 concerns the increase in profits; and item 2, the increase in the profitability of the company, both derived from the results of R&D.

5. Final considerations

Our objective has been to study the content validity of a proposed instrument of measurement for the R&D activities of a company, taking as our basis the perspectives of the Balanced Scorecard or integral management chart, developed by Kaplan and Norton (1992). For this, we have reviewed those previous studies that have dealt directly or indirectly with the problems of measuring this activity. Due to the wide differences of view on the choice of the correct indicators found in the literature, and to the lack of consensus on the most appropriate methodology for measuring the concept of R&D, we have framed our proposal within the methodology for the validation of scales. In this context, we have utilised the results of previous studies undertaken by our research group in the framework of the content validation of an instrument of measurement for a company's returns from its R&D activities. The validation of this instrument of measurement would allow us to obtain qualitative information, a most important consideration when large databases are not available; also, this methodology enables us to evaluate, in the most appropriate way, the inter-related factors under the perspectives of the Balanced Scorecard in companies with significant activity in R&D. In addition to the possibility of studying these factors through the methodology employed for the validation of the indicators, it is possible to derive one single value as the score for each company studied, a value which would combine the data obtained on all the dimensions that define the BSC; this single value would then be available for use as one more variable in future studies on the associations between several scales or variables.

This form of measurement, therefore, permits the evaluation of intangible concepts, necessarily composed of more than one indicator, that provide information on both quantitative and qualitative aspects of R&D; in our case, on aspects that could bear a certain relationship not only to economic and financial resources, but also with variables of human resources, personnel attitudes, behaviour and aptitudes in the organisation, in respect of the performance of R&D activities.

All the variables evaluated simultaneously would help to understand more clearly the reality of each company, together with the factors that could have influence on future success in undertaking R&D activities.

The BSC model for R&D developed in this study has been subject to testing with recognised experts in management and in R&D; however, in a future study, already in progress, the reliability and the validity of both the construct and the criterion of the scale will be studied in depth. Regardless of future possibilities, this first phase of content validity has enabled us to put forward a proposal in respect of those indicators that best define the factors related to organisational effectiveness in the achievement of the strategic objectives set by companies, and to inter-relate them and group them under five broad perspectives of the BSC.

Among the drawbacks of this methodology is the difficulty of producing the scale and of finding the most representative sample of companies, and the high cost of

devising and distributing the instrument. It is also essential to secure a very high rate of response, since this will condition the reliability of the results. Last, one should include among the disadvantages the impossibility, in some cases, of observing contingent factors that could vary between companies, of the sort that could be studied better by the case study method.

Note

1. The second and third phases of the complete methodology of scale validation will be the subject of a future article.

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