A Meta-analysis of Innovation and Organizational Size

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Abstract

Findings regarding the direction and intensity of the relation between size and innovation in the literature are contradictory. In the journal *Organization Studies* in 1992, Damanpour proposed a meta-analytical study in an attempt to clarify the diversity of existing conclusions. The present article is a replica and an extension of that study using the same methodology. Our aim is to (1) bring the pool of accumulated knowledge up to date, examining the time span 1970–2001, and (2) review in greater depth the effects of alternative ways of measuring organizational size. The sample used was made up of 87 correlations drawn from 53 empirical studies published in the most important journals on business administration. The analysis enabled us to confirm the existence of a significant and positive correlation between size and innovation. It also provided evidence showing that the contradictory results obtained in previous studies are due to divergences in the methods used to operationalize one, or more, of the variables to be analysed. The main contribution made by our work stems from the fact that the empirical analysis performs a more thorough breakdown of the definitions of the size variable used in the literature. This may well be a first step toward justifying the differences in the results of the primary studies that analyse the relation under examination.

Keywords: innovation, meta-analysis, moderating variables, size

Introduction

This work is a replica and an extension of the meta-analytical study of the relation between size and innovation conducted by Damanpour (1992). The added value of our study lies not only in the intensified effort to search for papers and the expanded time span reviewed, but also in the empirical analysis, which breaks down the definitions of the size variable used in the literature in a more thorough fashion.

The importance of knowing the effects of size has given rise to a large number of studies aimed at determining the influence of organizational dimension on diverse aspects of interest to researchers. Some clear exponents of this type of research are, among others, those that study the relation between size and performance (Szymanski et al. 1993; Audretsch and Acs 1991; Gooding and Wagner 1985; Moch and Morse 1977), with the portfolio of commercial assets (Smallbone et al. 1999; Gaskill et al. 1993; Kanter

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1989), with the structure and processes of the organization (Damanpour 1996; Mintzberg 1979; Blau 1970; Pugh et al. 1969), and with innovation (Damanpour 1992; Audretsch and Acs 1991; Hitt et al. 1990; Moch and Morse 1977).

The literature offers contradictory findings about the direction and the intensity of the relation between size and innovation. On the one hand, there are studies that point to the existence of a positive relation and suggest that organizational size is the best predictor of innovation (Sullivan and Kang 1999; Damanpour 1992; Dewar and Dutton 1986; Ettlie et al. 1984; Kimberly and Evanisko 1981; Moch and Morse 1977; Aiken and Hage 1971). On the other hand, however, other researchers defend the existence of a negative relation (Wade 1996; Aldrich and Auster 1986; Hage 1980). Lastly, still other work claims that no relation exists between the core variables (Aiken et al. 1980). The variety of studies conducted on the matter have given rise to a single common conclusion, which is that the most *consistent* result found in the organizational innovation literature is that its research results have been *inconsistent* (Wolfe 1994).

Certain previous works, based on the meta-analytical technique, have pointed out the fact that these contradictory results may be somehow conditioned by differences or errors in measuring the key variables. More specifically, Camisón (2001) concluded that the effect of size on performance is affected to a considerable extent by the way the organizational dimension is measured. Likewise, the multidimensional character of innovation is considered in studies such as those by Damanpour (1992) and Subramanian and Nilakanta (1996) as one of the possible reasons explaining the contrasting empirical results obtained as regards the relation between innovation and size.

The main aim of this article is to sum up the state of the art of the research carried out so far into the effects of size on innovation. More specifically, our interest focuses on determining what the accumulated knowledge about the direction and the intensity of the relation between size and innovation is, as well as the potential moderating effect exerted on these variables by methods of measurement. This review is conducted by means of both a classical narrative procedure and by employing a meta-analytical quantitative methodology. For the purposes of the latter, from among the different meta-analytical approaches available (Bangert-Drowns 1986), we have chosen to use *psychometric meta-analysis* as developed by Hunter and Schmidt (1990) and Hunter et al. (1982). As our starting point, we took the meta-analytical methodology used previously by Damanpour (1992) with the aim of reinforcing and completing his study, and we extended the time span to be analysed up to the present day. We also continued our intensive search for papers published within the period studied by this author. In our opinion, there is more to be gained by making use of and comparing the thoughts of different authors on a single matter over a period of time. It also helps to prevent the meta-analysis from becoming something singular and isolated.

In an age characterized by the exponential growth of scientific production, the so-called 'research reviews' are an indispensable link between past and future scientific work and provide a starting point for new research.

Traditionally, research reviews have been characterized by their lack of a systematic set of guidelines to be followed in decision-making throughout the research process, as well as an absence of quantitative referents in evaluating the results. For this reason, they are also called 'narrative' or 'qualitative reviews'. After studying the most significant research conducted in a particular subject, the reviewer offers his or her own personal view on the state of the art (Cooper and Hedges 1994; Rosenthal 1991; Hunter and Schmidt 1990; Sánchez-Meca and Ato 1989; Cooper 1989; Gómez 1987; Farley and Lehmann 1986; Hedges and Olkin 1985; Hunter et al. 1982; Glass et al. 1981).

On the other hand, the past two decades have been witness to the appearance of *meta-analysis* as a new methodology aimed at providing research reviews with the rigour, objectivity, and systematization required to obtain a fertile pool of scientific knowledge. One of the aspects that clearly differentiates meta-analysis from the narrative reviews is its quantitative character. In the same way that empirical research requires the use of statistical techniques to analyse its data, meta-analysis also applies statistical procedures that are specifically designed to integrate the results of a set of empirical studies. Unlike primary studies, in a meta-analysis the data consist of the findings from previous empirical studies which are transformed into a common metrics that allows them to be integrated and compared quantitatively. Use of this method to review the literature is becoming increasingly accepted within the fields of business administration and marketing to deal with numerous problems, such as the relation between size and performance (Camisón 2001; Szymanski et al. 1993; Gooding and Wagner 1985), the determining and moderating variables of innovation (Damanpour 1991), the factors affecting financial performance (Capon et al. 1990), success factors in internationalization (Gemünden 1991), or the knowledge acquired about generic competitive strategies (Campbell-Hunt 2000), among others.

The first step toward achieving this goal is a theoretical examination involving a narrative review of the state of the art on the subject of the relation between size and innovation. The starting point for this qualitative synthesis of the literature is the analysis of the different concepts and ways of measuring both variables. It also explores the empirical results of previous primary studies. The meta-analytical methodology is then applied to quantify the magnitude of this relation. It also serves to determine the roles certain statistical artefacts and the conceptual and methodological characteristics of the primary studies play in the contradictions found in the direction and intensity of the association. Lastly, the conclusions drawn from the meta-analysis are presented, and their implications for future research work are also defined.

Concept and Dimensions of the Innovation and Size Variables

Innovation is a term that has been conceptualized in many ways and studied from several perspectives. Although there are a lot of works about organizational innovation, the literature offers no common integrating concept. One of the most comprehensive concepts of innovation is to be found in the definition formulated by Schumpeter (1934), which has been a reference point for other authors who have focused their work on more specific aspects of this term. Thus, for instance, Tushman and Nadler (1986) highlight the creation of new goods in their definition, while Damanpour and Evan (1984), Daft (1982), and Zaltman et al. (1973) focus their attention on the process of creation, development, and implementation of new ideas. This second approach is complemented by studying the degree of involvement of the different functional areas of the company in the innovation process (Song et al. 1997; Lawrence and Lorsch 1967). One common element in all definitions of innovation is that it is a new idea that is put into practice while paying special attention to its usefulness. In any case, it must be borne in mind that defining a multidimensional concept is not only a question of literary synthesis, far more important is the fact that the definition must include all the theoretical dimensions implicit in the construct.

In the literature, there is certain agreement as regards the idea that fast changes in the environment trigger off innovation processes in an organization (Ettlie et al. 1984; Pierce and Delbecq 1977; Zaltman et al. 1973). Nevertheless, other factors also come to bear on this process; thus, Kimberly and Evanisko (1981) and Meyer and Goes (1988) see the characteristics of the innovation itself and the organizational variables as being the most important explanatory factors. This second standpoint is backed up by research that questions the reasons explaining why, within the same environment, some organizations are more innovative than others, and later analyses the characteristics of the innovative companies (Kim 1980). Within this stream of research, there have been studies which see structural characteristics as being more closely related with innovation than the individual characteristics or attitudes within the organization (Hage and Aiken 1967).

Some studies claim that the relation between organization and environment is reciprocal and that both of them interact to bring about the adoption of innovations (Russell and Russell 1992; Damanpour and Gopalakrishnan 2001). Within this wider view of the matter, Anderson and King (1992) performed a joint analysis of internal and external factors of the organization as elements that fostered organizational innovation. These factors included leaders, structure, strategy, organizational culture, and the environment.

The complexity of the process of creation and diffusion of innovations clearly illustrates the multidimensional character of innovation. An extensive review of the literature enables us to identify four different dimensions of this concept: the stages of the innovation process, the level of analysis, the types of innovation, and the scope of the innovation. Table 1 summarizes the contributions that were identified and offers an outline of the types of analysis performed in the different studies.

Furthermore, the way organizational size is defined and measured constitutes an essential issue because research findings can vary according to the conceptualization and measurement of the variable. As stated by Kimberly (1976), the way size is conceptualized and how it is measured both have an

Table 1. Dimensions of Innovation

Stages of the innovation process	
Organization as a generator of innovation The organization resolves problems and makes decisions that involve developing new products and processes.	Utterback (1971) Pinchot (1985)
Organization as an adopter of innovation The organization carries out activities to further the use of an innovation. This includes two phases: *Initiation*: perception of the problem, information gathering, creation of an attitude toward innovation, and evaluation. *Implementation*: initial use of the innovation until it becomes a routine.	Zaltman et al (1973) Zmud (1982) Damanpour (1991)
Level of analysis	
Industry *Inter-industry approach*: patterns of development of innovation and magnitude between industries. *Intra-industry approach*: differences shown by organizations in the same industry as regards how the innovation is adopted.	Pavitt et al. (1989) Mansfield et al. (1981)
Organization Studies that focus on results: identify contextual, structural, and behavioural characteristics to differentiate between innovative and non-innovative organizations. Studies that focus on the process: classification of facts related with the innovation process.	Kimberly and Evanisko (1981) Dewar and Dutton (1986) Capon et al. (1992) King (1992)
Subunits The most frequently employed subunits are departments and strategic business units.	Thamhain and Wilemon (1987)
Innovation Characteristics of the innovation that do not vary with regard to one organization or to the perception industry has of it. Examples: size and cost. Secondary characteristics: these vary according to the organization or how industry perceives it. Example: relative advantage.	Downs and Mohr (1976) Henderson and Clark (1990)
Types of innovation	
Technical-administrative innovation *Technical innovation* is directly related with the productive process and is closely linked with the core activity of the organization. *Administrative innovation* is related with the coordination and control of the firm, the structure and management of the organization, the administrative processes, and human resources. It is to be found above the technical area in the hierarchy.	Knight (1967) Daft and Becker (1978) Kimberly and Evanisko (1981) Daft (1982) Damanpour and Evan (1984) Damanpour (1987, 1992, 1996)
Product-process innovation *Product innovation* new technology, which allows the development of new products or services aimed at answering a market need, and can therefore increase the firm's power. *Process innovation* new elements, equipment or methods introduced into the firm's production system to develop a product or service.	Utterback and Abernathy (1975) Zmud (1982) Ettlie et al. (1984) Van de Ven (1986) Barras (1986, 1990) Frost and Egri (1991) Damanpour (1991) Capon et al. (1992) Ettlie and Reza (1992) Daft (1992) Pisano and Wheelwright (1995) Damanpour and Gopalakrishnan (2001)

Continues

Table 1. *Continued* Dimensions of Innovation

Radical–incremental innovation	
Radical innovation gives rise to fundamental changes in the activities of an organization or industry with respect to current practices. It poses new questions, develops new technical and commercial skills, and new ways of resolving problems. *Incremental innovation* represents a lesser degree of departure from existing practices. Enhances the capacities already present in the organization.	Pelz (1983) Ettlie et al. (1984) Dewar and Dutton (1986) Ettlie and Rubenstein (1987) Adler (1989) Henderson and Clark (1990) Gopalakrishnan and Damanpour (1994) Damanpour (1996) Chandy and Tellis (1998)
Scope of the innovation	
Number of innovations adopted by firms that make up the sample of empirical studies. Studies that include the *adoption of multiple innovations* over time represent the degree of innovation of an organization better than those that take one innovation into account. Studies that include *one innovation* contribute to a better understanding of the process of adoption.	Damanpour (1991) Damanpour (1992)

effect on the relation between size and other characteristics of the organization. Later studies have verified this fact. This is the case with meta-analyses on the relation between size and performance, which state that the different measures of the size variable have a moderating effect on this relation (Camisón 2001; Szymanski et al. 1993; Gooding and Wagner 1985). In the case of the precursory meta-analytical study into the relation between size and innovation by Damanpour (1992), the size variable was already seen to show signs of its potential moderating effect in this relation.

Theoretical development of the concept of size is scarce and very different definitions exist that may or may not be referring to the same construct (Camisón 2001). Therefore, more than 25 years ago Kimberly (1976) defined the panorama as a 'theoretical wasteland' in which academic progress was scant. The achievement of a single concept of organizational size is the first step toward advance in the knowledge of this variable and its relation with others, which will also give some meaning to research projects that may have reached diverging results, although the object of study was the same. The indicators that have most commonly been used as ways of measuring the size variable quantitatively can be seen in Table 2.

The main advantage of the quantitative criterion is the relative accessibility and objectivity of the data, because this makes it simple to apply. However, it encloses several important problems. For example, we can find different results if we use direct or logarithmic transformations of the raw data. Kimberly and Evanisko (1981) advise the use of a transformed size variable because it allows us to reduce the variance in value distribution throughout the sample. In addition, when applying the transformation, a curvilinear relation is assumed to exist between the size variable and the dependent variable, and it must be proved that this curvilinearity is fulfilled before the logarithmic transformation is actually applied.

The qualitative definitions of the term 'size' attempt to minimize the problems implicit in quantitative definitions by searching for a certain

Table 2. Methods of Quantitative Measurement of the Size Variable

Measures of the size variable	Studies	Comments
Direct versus logarithmic measurement	Kimberly (1976) Kimberly and Evanisko (1981)	The logarithmic transformation allows the variance in value distribution throughout the sample to be reduced.
Physical capacity	Kaluzny et al. (1974) Kimberly and Evanisko (1981) Goes and Park (1997)	One example is the number of beds in studies about hospitals.
Number of employees	Blau and McKinley (1979) Kim (1980) Glisson and Martin (1980) Ettlie (1998) Sengupta (1998)	One of the direct measures that is most frequently used in the literature.
Measures concerning input	Baldridge and Burnham (1975) Daft and Becker (1978)	Volume of work done by an organization over a given period of time. Example: number of students enrolled.
Measures of output	Sharma and Kesner (1996) Balkin et al. (2000)	Level of success of an organization over a given period of time. Examples: sales volume and number of customer dealings.
Financial resources	Damanpour (1987) Nohria and Gulati (1996)	Wealth of the organization and net assets.

underlying theoretical foundation for quantification. The qualitative definition has problems too, specifically related to their operationalization. Qualitative criteria do not always have the advantage of accessibility and objectivity offered by quantitative methods. Another difficulty stems from the potentially high number of criteria involved. Qualitative definitions of the concept of size can allow other aspects of the organization, such as human resources management systems, ownership structure, and planning and control systems, among others, to be taken into consideration — something which is not possible with quantitative definitions.

Relation Between Size and Innovation

The relation between size and innovation, regardless of how they are measured, is a particularly difficult problem to solve and there is no solid empirical evidence on the subject. Larger organizations have more complex and diversified resources and capabilities, above all as regards the number of professionals (Damanpour and Evan 1984) and greater technical know-how, which enable them to adopt a higher number of innovations (Nord and Tucker 1987). Moreover, large organizations are better able to bear the losses brought about when innovations are not successful, and are therefore able to take on greater risks (Damanpour 1992; Hitt et al. 1990). Kimberly and Evanisko (1981) argue that increased size makes it easier to adopt innovations as such organizations have a higher volume of activity and can therefore accept the consequences that may arise from innovations. In fact, their study shows that size is the best predictor of both technical and administrative innovations.

Nevertheless, Kimberly and Evanisko (1981) do not attempt to generalize their conclusions and leave it open to question when they claim that the effects of size may vary according to the kind of innovation involved. It should not, then, be necessarily assumed that there is a positive relation between size and innovation. Although size does exert a considerable effect on the adoption of innovations, the effects of other variables, such as the organizational attributes that foster the development of some innovations while inhibiting the progress of others (Moch and Morse 1977), must not be neglected. This reasoning seems to be justified by the findings of other empirical studies that prove the existence of a negative relation between size and innovation. These results are supported by the inherent advantages of small and medium-sized enterprises (SMEs), including their flexibility, which allows them to adapt and improve more easily, and the fact that they accept and implement changes more readily (Damanpour 1996). The inherent disadvantages of greater size also inhibit innovatory behaviour, since larger organizations are characterized by a more formalized structure and there is a more bureaucratic environment within the organization. These have a negative effect on the culture that fosters innovation, resulting in a decrease in management commitment toward innovation (Hitt et al. 1990). It can therefore be argued that the greater the growth of organizations, the lower the R&D efficiency, because of loss of management control or owing to excessively bureaucratic control (Scherer and Ross 1990).

Another research perspective focuses on the distinction between innovative *input* and *output*, instead of centring on the advantages and disadvantages of large firms or SMEs as an argument to justify the relation between size and the adoption of innovations. Here we understand innovative *input* to mean the intensity of R&D, and innovative *output* is seen as the number of innovations developed by the organization. On the one hand, Scherer (1992) and Scherer and Ross (1990) claim that intensity of R&D usually increases in proportion to the size of the firm in unisectoral studies. On the other hand, Acs and Audretsch (1991) and Pavitt et al. (1987) have shown that small firms tend to have a proportionally higher number of innovations in relation to their size. This is partly because the productivity of R&D tends to decrease as the size of the firm gets bigger. We also find studies in which size and innovation are not related (Aiken et al. 1980).

The heterogeneity of the findings does not allow us to find out more about the relation between size and innovation. Thus, rather than increase the distances and add our research to one of the three possible types of result (see Table 3), we should ask ourselves what causes such divergence, bearing in mind that some authors attempt to justify it by wielding methodological rather than theoretical reasons (Subramanian and Nilakanta 1996; Damanpour 1992). More specifically, it is worthwhile studying the extent to which the method used to measure the innovation and size variables, as well as other methodological characteristics of the primary studies such as the nature of the sample, have a moderating effect on the direction and scope of the relation.

Table 3. Classification of Results Concerning the Relation Between Firm Size and Innovation

Conclusions	Arguments	Authors
Positive relation between size and innovation	Larger organizations have more complex and diversified resources and capacities (Nord and Tucker 1987). Larger organizations are able to take on greater risks that may arise from unsuccessful innovations (Hitt et al. 1990; Damanpour 1992).	Aiken and Hage (1971) Moch and Morse (1977) Kimberly and Evanisko (1981) Ettlie et al. (1984) Dewar and Dutton (1986) Damanpour (1992) Sullivan and Kang (1999)
Negative relation between size and innovation	Flexibility of SMEs, which allows them to adapt and improve more easily. They also have less difficulty in accepting and implementing changes (Damanpour 1996). Large companies are less committed to innovation because their more formalized structure and the more bureaucratic environment within the organization have a negative effect on the culture that fosters innovation (Hitt et al. 1990).	Hage (1980) Aldrich and Auster (1986) Scherer and Ross (1990) Wade (1996)
Lack of a relation between size and innovation		Jervis (1975) Aiken et al. (1980)

Meta-analysis of the Relation Between Size and Innovation

Meta-analysis Procedure

Applying meta-analytical methodology to examine the results obtained from reviewing the research into the relation between size and innovation (if it is based on the 'validity generalization' approach) can enable us to obtain an estimate of the magnitude of the average effect of a set of studies on this association. By evaluating the degree of average correlation between studies we can obtain a measure of how solid research is in each subject and of what is needed in order to gain a better understanding of it. The results that were consulted were integrated within a common metrics using the Pearson correlation coefficient, which was provided by the primary studies.

The instrument used to perform the meta-analysis was *psychometric meta-analysis* as developed by Hunter and Schmidt (1990) and Hunter et al. (1982). Unlike merely reviewing the literature in a narrative fashion, as is usually employed in studies of the state of the art of a given matter, the application of this quantitative approach to the review of the literature will enable us to evaluate the quality and the actual progress made in scientific research on the subject. It also allows underlying methodological and conceptual weaknesses to be uncovered and shows how to realign the heuristics in order to achieve more significant results.

In our research work, we have followed the general norms set out in the literature on how to perform each of the different phases: searching for the literature in order to select the primary studies, codification of the variables, analysis of the results, and the drawing of conclusions.

Selection of the Primary Studies

The following were employed in selecting the primary studies that have explored the relation between firm size and organizational innovation.

1 Relevant bibliographical databases were searched to find references to the problem we had defined. The databases used in the search were ABI Inform and INFOTRAC–General Business File International. Different keywords were employed in the search to enable us to find the different methods used in measuring the size and innovation constructs.
2 A bottom-up search beginning with papers on meta-analysis and seminal works that studied the relation we are looking at (for example, Damanpour 1992) was developed.
3 A deeper and more direct examination of the essential journals in the fields of innovation management, technology and R&D, business administration, strategic management, organizational behaviour, and industrial economics was conducted. This extensive review of the literature enabled us to cover practically all the leading journals listed in the *Journal Citation Reports* of the Institute for Scientific Information (ISI).
4 The literature search revealed 53 empirical studies published between 1970 and 2001.
5 This first selection of primary studies provided us with a great amount of literature on the relation we were examining. However, in order to perform the meta-analysis we submitted the documentary material to a drastic screening process, as each piece of work had to meet a series of requirements before it could be used. In addition to dealing with the subject under examination, the studies had to be empirical and include enough data and statistical information to be able to calculate the *effect size*. More specifically, an essential criterion in their selection was that they should include Pearson's r correlation coefficient, the t statistic, or Fisher's test, as such data are necessary for determining the effect size.

Lastly, as shown in Table 4, the selection from the literature was made up of 53 primary studies that complied with these norms and which included 87 correlation coefficients. In order to make it clearer how results were obtained with the meta-analysis employed (Hunter and Schmidt 1990), we include the statistical formulas that we were used in the Appendix.

Codification and Definition of the Variables

In this phase, we defined the characteristics of the studies that can affect the results and enable us to explain the inter-study variability. In the process of codifying the data, the following criteria were observed.

1 In work in which an analysis was performed using time-series data, only the correlations from the first period were taken into account.
2 In papers which included multiple independent samples, the correlations for each sample were taken into consideration.

Table 4. Studies Included in the Meta-analysis and Mean Correlation

Studies	
Ahuja and Katila (2001)	Hitt et al. (1997)
Ahuja (2000)	Huselid et al. (1997)
Aiken et al. (1980)	Kalleberg and Leicht (1991)
Amit and Wernerfelt (1990)	Kaluzny et al. (1974)
Atuahene-Gima and Ko (2001)	Kim (1980)
Baldridge and Burnham (1975)	Kimberly and Evanisko (1981)
Balkin et al. (2000)	Kivimäki et al. (2000)
Banbury and Mitchell (1995)	Kochhar and Parthiban (1996)
Baum et al. (2000)	Lecraw (1983)
Baysinger and Hoskisson (1989)	Li (2000)
Billings and Fried (1999)	MacPherson (1998)
Buzzell and Wiersema (1981)	McMillan et al. (2000)
Cardinal (2001)	Meyer and Goes (1988)
Chandy and Tellis (1998)	Nohria and Gulati (1996)
Chang and Hong (2000)	Park and Luo (2001)
Chowdhury and Geringer (2001)	Reimann (1975)
Damanpour (1987)	Sengupta (1998)
Dewar and Dutton (1986)	Sharma and Kesner (1996)
Ettlie (1983)	Shrader (1999)
Ettlie (1998)	Snell et al. (2000)
Ettlie et al. (1984)	Stuart (2000)
Fennell (1984)	Tsai and Ghoshal (1998)
Goes and Park (1997)	Young et al. (1981)
Greve (1999)	Zahra et al. (2000)
Hambrick and McMillan (1985)	Zmud (1982)
Hitt et al. (1991)	Zmud (1984)
Hitt et al. (1996)	

General results			
Mean correlation	0.1500	Sampling error variance	0.0061
Average sample size	155.9425	Corrected variance	0.0453
Observed variance	0.0515	75% rule	11.9642

3 Both logarithmic and the non-logarithmic measures were included.

4 If a single study included different ways of measuring the size and innovation variables, then the correlations or statistical data from the combinations between the different measures were taken into account.

5 The sample size taken into consideration is the number of firms used in the study and not the number of observations, which can be higher because there may be more than one observation for each firm, depending on the aim of the work.

6 In studies in which the analysis was performed taking different regression models into account and the correlation coefficients were not provided, we used the model in which the regression had the best fit.

Since we are dealing with multidimensional constructs, both in the case of size (Gooding and Wagner 1985; Kimberly 1976) and innovation (Damanpour 1992), the way in which they have been measured in the primary studies can give rise to different conclusions, as each of them may be referring to a different dimension. In order to observe the influence the method of measurement can exert on the relation between size and innovation (on the effect size), we thought it important to evaluate the moderating role of the

Table 5. Moderator Effects of Size: Direct and Log Transformation Measures

Measures of size	k	Total sample	Mean correlation	Observed variance	Sampling error variance	75% rule	95% confidence interval
Log trans. measures	51	8,136	0.1601	0.0618	0.0060	9.6917	0.0212
Direct measures	36	5,431	0.1349	0.0358	0.0064	17.9628	0.0262

characteristics of the measurement, which were organized according to the following criteria.

1 In the case of the size variable, we distinguish between logarithmic and non-logarithmic measures (see Table 5). Then, the different measurements identified in the primary studies were classified into 11 groups, as can be seen in Table 6. The diversity of the measurements can give us an idea of the variety of definitions provided by the primary studies. The most common was the number of employees, when is measured directly and logarithmically. Another frequent measure is that of the total assets or their logarithm, which includes accounting data on total assets or on just a part of them. Capacity is also reflected in some studies as a measure of size. In particular, this is true in studies of hospitals, where it is seen in the index of the number of beds. Other studies propose measuring size as a contextual factor, which means they include definitions associated with the company's sales, market share, and even the growth of market share. The description of the different measures of size can be seen in Table 2.

2 Of the different dimensions of innovation that appear in Table 1, in this study we have only analysed the types of innovation according to the dimensions of the construct adopted in the primary studies, as shown in

Table 6. Moderator Effects: Measures of Size

Measures of size	k	Total sample	Mean correlation	Observed variance	Sampling error variance	75% rule	95% confidence interval
No. of employees log	34	3,464	0.1785	0.0688	0.0093	13.5122	0.0324
No. of employees	10	1,294	−0.0345	0.0171	0.0078	45.3056	0.0546
Assets log	6	2,600	0.0994	0.0220	0.0023	10.1299	0.0381
Capacity log	3	623	0.4945	0.0197	0.0028	14.0404	0.0595
Total sales	5	707	0.2604	0.0466	0.0062	13.2725	0.0690
Sales log	8	1,449	0.0813	0.0722	0.0055	7.5842	0.0513
Market share	4	471	0.0423	0.0126	0.0085	67.4967	0.0905
Growth market share	6	1,792	0.1201	0.0047	0.0033	69.8487	0.0457
Total assets	5	609	0.1439	0.0031	0.0079	100	0.0781
Capacity	3	328	0.4840	0.0041	0.0054	100	0.0833
Volume (input measure)	3	230	0.4860	0.0030	0.0077	100	0.0994

Table 7. Nevertheless, in addition to the number of innovations, which is the measure that is most often employed in the sample of studies selected, other methods of measurement were also found. These include R&D intensity (defined as the ratio between investment in R&D and sales), spending on R&D, and the innovation to sales ratio, where we can expect the numerator to include the number of patents, while the denominator will contain the average sales of new products.

So far, we have dealt with the effect of the characteristics of the measurement of the two components that go to make up the size–innovation relation. However, the characteristics of the sample can also affect the correlation results provided by the meta-analysis. It therefore seemed important to distinguish between studies involving samples made up of industrial firms and those using services firms. Furthermore, since there also exists a series of studies that include both types of company, we created a third group that contained both types of firms.

Results

The Magnitude of the Effect Size

The first step to be taken in statistical meta-analysis is to calculate the *average effect size*. The results of the calculations we performed are shown in Table 4. The average effect size is seen to have a low value (0.150). We applied the

Table 7. Moderator Effects: Types of Innovation

Measures of innovation	k	Total sample	Mean correlation	Observed variance	Sampling error variance	75% rule	95% confidence interval
Technical innovation	33	3,522	0.2141	0.0772	0.0086	11.1512	0.0317
Administrative innovation	9	922	0.1430	0.0591	0.0095	16.0160	0.0635
Product innovation	13	1,707	0.1377	0.0596	0.0074	12.3907	0.0467
Process innovation	12	945	0.2210	0.0506	0.0116	22.9761	0.0610
Radical innovation	7	481	0.2969	0.0822	0.0123	14.9426	0.0821
Incremental innovation	7	375	0.3155	0.0599	0.0154	25.7454	0.0920
Intensity in R&D	14	4,177	0.0318	0.0139	0.0034	24.1978	0.0303
Spending on R&D	7	790	0.3310	0.1207	0.0071	5.8747	0.0624
Number of innovation	28	2,868	0.2611	0.0533	0.0086	16.0574	0.0343
Innovation to sales	5	1,727	0.1063	0.0070	0.0028	40.2805	0.0467

95 percent confidence interval test to check whether this interval included zero, which would indicate that the average correlation is not significant. In this case, the interval ($\bar{r} = 0.15 \pm 0.017$) does not include zero, which means that although the average correlation coefficient is small, it is significant.

Hunter and Schmidt (1990) claim that the correlation coefficients obtained from the different studies are influenced by diverse statistical artefacts and that this effect tends to reduce their values with regard to the true correlation coefficient of the population. Therefore, the second point in our meta-analysis is the correction of the different statistical artefacts that reduce the true statistical value of the population.

In order to calculate the sampling error, we have to estimate the total observed variance of the values *r* from the studies. In accordance with Hunter and Schmidt (1990), this variance consists in the true variance of the correlations of the population, S_ρ^2 plus the variance due to the sampling error, S_e^2.We then checked to see whether the observed variance is mainly due to the error variance or to the true variance of the population. If the variance caused by the sampling error does not account for 75 percent of the total observed, then we cannot accept the hypothesis of homogeneity among empirical correlations and have to look for other moderating variables that affect the correlations. This procedure has been called the '75% rule' and it is based on corrections for three artefacts (sampling error, error of measurement, and range variation). In situations in which only the sampling error is being considered, the limit can be reduced to 60 percent (Gooding and Wagner 1985). The meta-analytical tool used enables us to compare groups that employ different methods of measurement or different types of size and innovation variables. To do so, first of all the groups must be internally homogeneous, that is to say, the 75 percent rule must be satisfied, since this will mean that the set of values *r* within each category is homogeneous as regards its mean *r* and, therefore, within this subset of values *r*, there is no need to search for other moderating variables. Once intragroup homogeneity has been verified, the comparisons between the different groups can be performed and it can be seen whether there are significant differences between the mean *r* (*t*-test), thus enabling us to confirm the existence of intergroup homogeneity.

On analysing the first of the statistical artefacts, the *sampling error*, we obtained a high observed variance (0.052), while the variance due to the sampling error was 0.006. This gives us a variance percentage accounted for by the sampling error (11.96 percent) which is far from the 60 percent threshold. This percentage leads us to think there may be moderating variables that affect the relation between size and innovation, as well as the influence of other statistical artefacts that must be corrected for.

With regard to the correction of the statistical artefacts, in our case the information provided by the primary studies only allowed us to correct the sampling error, as we saw in the previous section, and to a certain extent the range. The calculations used to correct range were performed using 38 studies, which were the ones that provided the required typical deviations. However, because the difference in the percentage of observed variance accounted for by the sampling error was not seen to undergo any appreciable modification after carrying out the correction, and since we only had this information from a part of the sample, we thought it more interesting to continue the analysis taking all the selected studies into account and correcting just the sampling error. This inability to correct statistical artefacts because of a lack of information is very common in studies involving meta-analysis (Damanpour 1992; Gooding and Wagner 1985).

Analysis of the Moderating Effect of Sample and Measurement Characteristics

Both the characteristics of the sample and the criteria used in measurement of the independent and dependent variables can affect the relation between size and innovation. We therefore went on to estimate this moderating effect following the criteria explained above in the section on the definition of variables and by creating groups according to the methods of measurement shown in Tables 1 and 2.

First, let us look at the *moderating role played by the way of measuring size*. Damanpour (1992) was the first to tackle this issue by distinguishing, in a more generic manner, between logarithmic and non-logarithmic measures. We also thought it advisable to perform a second, more specific classification by splitting the logarithmic measurements into further subgroups and doing the same with the direct measurements.

Comparing the results enables us to check whether it really makes any sense to perform a generic comparison or whether, to the contrary, the results are so heterogeneous that we would have to come down to a more concrete interpretation of the results. To begin with, the more general classification provides us with information about the heterogeneity of the data within each group (see Table 5), since the percentages obtained for the 75 percent rule are very low in both cases. We have then gone down to a specific classification (see Table 6).

If we compare logarithmic measurements with the respective measurements that have not been transformed, it is seen that when size is measured as number of employees, the logarithmic measurement is higher. In the case of measures of capacity, the result is very similar and when the dimension is measured in terms of assets and sales, the correlations in the logarithmic measures are found to be higher. This variety of results enables us to conclude that there is no common pattern when logarithmic transformation is employed, since the average correlation coefficient is not always higher when this type of transformation is performed. Consequently, groupings of this kind might reduce the amount of information and give rise to distortions in the results.

By carrying out the *t*-test, the differences between the correlations of each logarithmic measurement were compared with the same measurement without its having been transformed. This test, however, only produced significant differences in one case (number of employees). Nevertheless, on submitting the different subgroups of non-logarithmic measurements to the same test (they were compared in pairs) all but two showed significant differences. Thus, distinguishing between the different measures of size that reflect its dimensions (measures of capacity, output measures, number of employees, and so on) seems to provide a greater wealth of information than the distinction between logarithmic and non-logarithmic measurements. However, because the groups are still not internally homogeneous and offer a high degree of intragroup variability (75 percent rule), the contrast between them should be performed later, when the existence of an intragroup homogeneity allowed them to be compared with other groups. It would then become clear that the classification variable really does exert a moderating effect on the relation. It can also be seen that the size of the firm is strongly related with innovation when measured by capacity or volume.

Nevertheless, we kept the classification because we wished to study the moderating effect of the different ways of measuring the dimension defined in the theoretical review (Table 2). The different measurements of the size gave rise to different average correlations, which means that the way this variable is measured has an effect on the results. If we pay closer attention to this coefficient, we will find one case (number of employees) in which it is negative. However, the 95 percent confidence interval includes zero ($\bar{r} = -0.035 \pm 0.055$), which shows that this relation is not significant. The same happens in the subgroup represented by the measure of market share ($\bar{r} = 0.042 \pm 0.091$). Furthermore, the studies included in the groups in which size is measured as market share, growth of market share, total assets, capacity, and volume go beyond the homogeneity threshold. In this case, intragroup homogeneity enables us to analyse whether the abovementioned measures are moderators of the relation between size and innovation. In these measurements the average correlations are significantly different (t-test), except between volume and physical capacity, which shows that both types of measures could be a part of the same group. It can be concluded, then, that instead of differentiating between input measures and physical capacity, as proposed in the literature (Kimberly 1976), both types of variable should be considered within the same category, since separation does not moderate the relation between innovation and size.

We will now go on to analyse the *moderating role of the way of measuring innovation* (Table 7). If we look at the subgroups created according to the different classifications of the innovation variable displayed in Table 1, we can see that the differences between the studies involving technical versus administrative innovations, innovations in products versus processes, and radical versus gradual innovations are not as high as in the previous case of the subgroups formed according to size. The population variance is not lowered in comparison with the total variance of the sample except in two groups, which coincides with Damanpour (1992) when he said that in addition to bearing in mind the differences between the subgroups of the different types of innovation, greater emphasis should also be put on the relations that exist between the types because organizational performance will be higher in firms where there is a stronger tendency to carry out an isolated kind of innovation (Damanpour and Evan 1984). This was verified with the results of the t-test.

The different ways of measuring the innovation variable include both measures that refer to innovation as output (number of innovations and innovation against sales) and measures that attempt to include the effort made by the organization before the innovation is really implemented (intensity of R&D and spending on R&D). The population variance goes down as compared to the variance of the whole sample in only two of the four subgroups. Thus, the moderating effect of the grouping is not completely confirmed by this analysis. The 75 percent rule also reveals the existence of other moderating variables, since the variance due to sampling error still accounts for a small percentage of this intra-study variability.

We were not able to research the effects of the adoption stage and the scope of the innovation because most of the studies did not provide accurate information about these characteristics.

Third, we studied the *moderating role of the characteristics of the sample* (see Table 8). The *t*-test offered significant differences in the average correlations between the group made up of manufacturing firms and that consisting of services firms. Furthermore, the population variance also decreases as compared to the overall variance, which can be seen in the result of the 75 percent rule and points to the need to go on looking for moderating variables. If we analyse the intergroup differences, the average coefficient is positive in all cases and comparatively higher in the services firms, although this last result cannot be accounted for at this point in the study because to do so we need to perform a combined analysis of the characteristics of the sample and the measurement. Nevertheless, it can be stated that the selection of one type of company or another will produce different results in studies that relate size with innovation.

Combination of Different Characteristics

By combining the effect of the characteristics of the sample and of the measurement, and looking at them together, we can check whether there is an increase in the variance accounted for by the sampling error. First, subgroups were formed by considering sets of two characteristics and then the analysis was performed combining what are assumed to be the three moderating variables, provided the data allow us to do so. It must be pointed out that when we analyse the moderating effect of the types of innovation, the comparison will be between theoretically exclusive pairs of innovations (technical and administrative, radical and gradual, and product and process innovations) in order to determine differences between them.

Table 8. Moderator Effects: Types of Organization

Types of organization	k	Total sample	Mean correlation	Observed variance	Sampling error variance	75% rule	95% confidence interval
Manufacturing	60	9,383	0.1004	0.0480	0.0063	13.1497	0.0201
Service	22	2,412	0.3662	0.0394	0.0069	17.5256	0.0347
Manufacturing and service	5	1,772	0.1186	0.0095	0.0028	29.0983	0.0460

Table 9. Combined Moderator Effects: Types of Organization and Measures of Size

	k	Total sample	Mean correlation	Observed variance	Sampling error variance	75% rule	95% confidence interval
Manufacturing organizations							
No. of employees log	25	2,590	0.1594	0.0856	0.0093	10.8140	0.0377
Number of employees	8	1,071	−0.0254	0.0139	0.0075	54.0832	0.0601
Assets log	4	1,207	−0.0142	0.0013	0.0033	100	0.0565
Total sales	5	707	0.2604	0.0466	0.0062	13.2725	0.0690
Sales log	8	1,449	0.0813	0.0722	0.0055	7.5842	0.0513
Market share	3	311	0.0830	0.0143	0.0096	67.3831	0.1109
Growth market share	6	1,792	0.1201	0.0047	0.0033	69.8487	0.0457
Service organizations							
No. of employees log	8	701	0.2611	0.0147	0.0100	68.0361	0.0694
Capacity log	3	623	0.4945	0.0197	0.0028	14.0404	0.0595
Volume	3	230	0.4860	0.0030	0.0077	100	0.0994
Total assets	3	225	0.1733	0.0068	0.0127	100	0.1276
Capacity	3	328	0.4840	0.0041	0.0054	100	0.0833
All							
No. of employees	2	223	−0.0783	0.0304	0.0089	29.3593	0.1310

From the combination of the different types of firms with the ways of measuring the size variable (see Table 9) it can be seen that the average correlations between size and innovation are positive and higher in the case of services firms. The moderating effect of the type of firm on the relation we are studying thus becomes apparent, but we must still analyse the moderating power of this variable.

If we look at the case of manufacturing firms, there are only three homogeneous groups. However, on examining services firms, intragroup homogeneity was found in all cases, except when the logarithm of physical capacity was used to measure size. As regards the homogeneous groups, the average correlations were found to be significantly different (*t*-test) in all cases except between volume (input measurement) and physical capacity. This shows that both types of measurement could be part of the same group, which corroborates the unity of both types of variable. On the other hand, all the measurements of size concerning services firms that we found to be homogeneous are moderating variables in the relation between size and innovation. It is, then, wise to differentiate between the methods used to measure size.

From the combination of the types of firms and the ways of measuring the innovation variable (see Table 10) it could be seen that, among industrial firms, the correlation coefficients show a similar trend, although different to that observed in the case of services firms.

Findings thus diverge according to the type of firm. However, in the case of industrial firms the homogeneity hypothesis is not satisfied in any of the innovation groups, which means they are not moderating variables. This finding is in agreement with the results of the meta-analysis performed by Damanpour (1992). We must, then, continue to search for other moderating variables. In services firms, the homogeneity threshold is surpassed by

Table 10. Combined Moderator Effects: Types of Organization and Types of Innovation

	k	Total sample	Mean correlation	Observed variance	Sampling error variance	75% rule	95% confidence interval
Manufacturing organizations							
Technical innovation	23	2,626	0.1351	0.0636	0.0085	13.3994	0.0377
Administrative innovation	4	376	−0.0572	0.0244	0.0107	43.8255	0.1013
Product innovation	7	884	0.0112	0.0360	0.0080	22.1603	0.0662
Process innovation	11	898	0.2158	0.0528	0.0113	21.3688	0.0627
Radical innovation	4	342	0.2010	0.0832	0.0109	13.0963	0.1023
Incremental innovation	4	236	0.2607	0.0813	0.0150	18.4337	0.1199
Service organizations							
Technical innovation	7	652	0.4944	0.0258	0.0062	23.9789	0.0583
Administrative innovation	4	373	0.3509	0.0377	0.0083	22.1046	0.0895
Product innovation	3	502	0.4170	0.0030	0.0041	100	0.0725
Radical innovation	3	139	0.5327	0.0014	0.0113	100	0.1204
Incremental innovation	3	139	0.4086	0.0099	0.0153	100	0.1400

product, radical, and gradual innovations, but the average correlations are not significantly distinct. We cannot therefore conclude that they are moderating variables and that there is no need to distinguish them.

If we analyse the combined effect of the types of innovation and the measurements of size (see Table 11), it can be observed that the only homogeneous groups are those associated with radical and gradual innovations when size is measured as a logarithm of the number of employees, although the differences are not significant. Thus, we have new confirmation that they are not moderating variables. Looking at the number of employees, technical innovations are homogeneous within groups, although their moderating effect could not be demonstrated because it was not possible to group them according to administrative innovation owing to a lack of data.

Table 11. Combined Moderator Effects: Measures of Size and Types of Innovation

	k	Total sample	Mean correlation	Observed variance	Sampling error variance	75% rule	95% confidence interval
No. of employees log							
Technical innovation	18	1,631	0.2156	0.0642	0.0101	15.1970	0.0465
Administrative innovation	7	637	0.0167	0.0226	0.0111	49.0365	0.0781
Product innovation	5	455	0.1904	0.0895	0.0103	11.5282	0.0890
Process innovation	11	695	0.2465	0.0664	0.0142	21.3656	0.0704
Radical innovation	4	207	0.5261	0.0154	0.0103	66.9780	0.0995
Incremental innovation	4	207	0.4475	0.0126	0.0126	100	0.1100
No. of employees							
Technical innovation	5	626	−0.0004	0.0106	0.0081	75.7000	0.0787
Product innovation	4	378	−0.0516	0.0185	0.0080	42.9234	0.1011
Sales log							
Technical innovation	4	670	0.2301	0.0869	0.0054	6.1997	0.0719

Lastly, combining the effects of the types of firm, the methods used to measure size, and the types of innovation confirmed the low moderating power of the types of innovation, which contrasts with the combined moderating effect of the measures of size and the types of firm.

It is worth pointing out here that, as suggested by Damanpour (1992), the size variable can also produce an effect through other organizational aspects of the sample that have not been taken into account. Furthermore, some of the subgroups only contained one correlation coefficient and have therefore not been shown in the tables, while others had only a very small number, which reduces the statistical potential of detecting moderating variables (Damanpour 1992; Hunter and Schmidt 1990).

Conclusions

Innovation theory has focused all its attention on identifying and measuring the weight of the factors determining the innovative orientation and capacity of firms. Thus, size has been a fundamental variable. However, the narrative review of the relation between the size of the firm and innovation, based on the pool of theoretical and empirical research accumulated to date, shows how diversified results are and this makes it difficult to draw general conclusions. This approach is not so much a limitation, but rather an incentive to shed light on the reasons that justify the heterogeneity seen in the findings and perhaps even to apply a mechanism that allows them to be integrated.

This has been the basic aim of this research work, which has made use of two approaches: (1) through a theoretical review of the concepts of dimension and innovation, which has shown how much they vary conceptually, and of the association between firm size and organizational innovation, which enabled us to appreciate the lack of general agreement in the literature; (2) by means of a meta-analysis used as an objective procedure capable of integrating the different results within a common metrics, of verifying in a rigorous manner how much scientific knowledge about the problem has been accumulated to date, and of identifying the conceptual and methodological reasons acting as moderating factors in this relation.

One of the first findings attained by the meta-analysis is that the size–innovation correlation is significant and positive, although the magnitude of the average size effect is quite low (15 percent). Following the recommendations made by Hunter and Schmidt (1990), we went on to examine whether the variability observed between the correlation coefficient in each study was due to the influence of statistical artefacts, whose effect may reduce its value in relation to the true population correlation coefficient. If this was the case, it was then corrected in order to calculate the true value of the statistical data. The only statistical artefact that was corrected was the sampling error, while data cleaning in the remaining cases was limited by the absence of essential statistical information. The percentage of variance accounted for by the sampling error is 11.96 percent, which therefore did not satisfy the homogeneity hypothesis. The empirical correlations obtained were not homogeneous and hence there must be other moderating variables involved in the size–innovation relation. However, it must be pointed out that the average effect of the relation between dimension and innovation is not totally independent of the methodological errors present in the research into the problem, since the influence of the sampling error is quite significant.

In spite of the fact that the size variable is obviously a multidimensional construct, the literature deals with it in a partial fashion and only makes reference to some of its dimensions. The review has allowed us to determine four such dimensions: the physical capacity of the organization, the number of employees, the volumes of input and output, and financial resources. These measures have also been dealt with as direct and logarithmic measures. Although differentiating between measures of input and of physical capacity, as proposed in the literature (Kimberly 1976), does not moderate the relation (since both indices can be interpreted as constituting part of the same category), the overall results of the meta-analysis suggest that the method used to measure size exerts a significant effect on the relation being studied.

The multidimensional nature of innovation has also been clearly shown in work such as that by Subramanian and Nilakanta (1996), Wolfe (1994), and Damanpour (1992), which put the contradictions and inconsistencies of the inter-study findings down to ignorance of this fact. The findings show that the way innovation is measured and the type of innovation considered exert little influence on the relation between size and innovation. To a certain extent this result contradicts authors such as Van de Ven and Rogers (1988) and Downs and Mohr (1976), who recommend distinguishing between the different types of innovation and consider a universal theory of innovation to be inappropriate, since each type of innovation involves different competitive consequences because they each require distinct organizational capabilities for them to be implemented. One feasible explanation for the result of the meta-analysis is that we determined the moderating effects of the types of innovation by comparing exclusive pairs of innovations (radical/gradual, technical/administrative, and product/process), which is already a partial analysis because the organizations can develop innovations of another kind, either simultaneously or in sequence. In fact, Damanpour and Evan (1984) state that organizational performance is greater in companies in which an isolated type of innovation is more frequently carried out. To overcome these inconsistencies and as suggested by Damanpour (1992), research should focus more on the relations between the types of innovation instead of on the differences between them.

The results of the meta-analysis also show that the selection of the sample has a significant effect on the size–innovation relation. Size is more positively related with innovation in services firms than in industrial firms, which contradicts the findings of the meta-analysis conducted by Damanpour (1992). This statistical evidence can highlight the difficulty involved in generalizing the empirical conclusions drawn when the sample does not include a plural representation of firms from all kinds of industry.

The moderating effect of the way size is measured and the nature of the sample is again revealed when we study the simultaneous effect of the two characteristics or even of the three methodological design features (ways of measuring the core variables and sample traits). However, the high variability of the relation between size and innovation cannot be attributed to just a statistical artefact, in this case, the sampling error. Nor can it be accounted for by the abovementioned decisions made concerning methodology. Although they often go undetected in other studies, the existence of other variables that have a moderating effect on the relation must also be recognized. Future research should, then, design a theoretical framework which includes both the variables belonging to the internal environment of the company and others related with the market in which the organization is immersed, so that further knowledge can be gained about the relation we are dealing with. Special attention must also be paid to the selection of measures as regards firm size and innovation, since Kimberly (1976) pointed out in the case of dimension that 'different aspects of size are mainly relevant for different kinds of organizational problems and are therefore linked with different dimensions of the organizational structure'. It can thus be deduced that different measures of size will be suitable for different types of organization, as is the case when using a measure of volume for chemical companies or measures of a financial nature for insurance companies.

The use of meta-analysis is especially recommended in cases where the academic community does not agree on a matter, in particular on the direction and intensity of the relationship between some core variables analysed in primary studies. Thus, this article contributes toward reflection on the importance of selecting the appropriate measurement for variables. Without this, there could be contradictory results, making it difficult to achieve proper progress in constructing theory.

Appendix

A mean correlation ($\bar{r}$) indicates an average participation–outcome effect within each subgroup. It was calculated by weighting each correlation (r_i) included in the subgroup with the size of the correlation's sample (N_i), then averaging the result:

$$\bar{r} = \frac{\sum N_i r_i}{\sum N_i}$$

Let the average sample size be denoted $\bar{N}$, and k indicates the total number of correlations

$$\bar{N} = \frac{\sum N_i}{k}$$

An observed variance statistic (S_r^2) indicating the dispersion of the k correlations within the subgroup was calculated using the formula:

$$S_r^2 = \frac{\sum N_i (r_i - \bar{r})^2}{\sum N_i}$$

The sampling error variance was estimated using the formula:

$$S_e^2 = \frac{\left(1-\bar{r}^2\right)^2}{\bar{N}-1}$$

The estimated sampling error variance is then subtracted from the observed variance to provide an unbiased estimate of the population variance:

$$S_p^2 = S_r^2 - S_e^2$$

'75% Rules' indicates what percentage of the variance observed is due to the variance of the sampling error:

75% rule = (100) $(S_e^2)/(S_r^2)$

Note

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