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Impact of Innovative Practices in Environmentally Focused Firms: Moderating Factors

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ABSTRACT: Innovation and sustainable development have been considered fundamental elements in the competitive positioning of companies. The synergies between both concepts, known as eco-innovation, must be considered when designing company policies. The aim of this paper is to analyse which moderating factors determine how innovative companies perform when implementing a sustainable proactive approach. We analysed a representative sample of Spanish companies using a quantitative method based on data collected from the PITEC database. The empirical results show that company and market size, formal innovative activity (reflected by registered numbers of patents) as well as total expenditure on technology acquisition influence the eco-innovative orientation of firms.

Key words: Eco-innovation, Environmental proactively, Environmental management, Competitiveness

INTRODUCTION

Several studies have analysed how innovation drives business competitiveness in both the short and long term (Rennings *et al.*, 2006, Bercovitz and Mitchell, 2008, Boutellier *et al.*, 2008, European Commission, 2009). Innovation generates a range of benefits associated with productivity gains, cost reductions, and access to new markets (Crespi and Pianta, 2008, Van Leeuwen and Klomp, 2006). It represents a key aspect of competitiveness (Hidalgo and Albors, 2008, Calia *et al.*, 2007) and growth (Corley *et al.*, 2002). These positive impacts validate the interest of academic literature in identifying the factors which contribute to (Mohnen *et al.*, 2006) or hinder innovation (Baldwin and Lin, 2002). Various actors have considered company size (Segarra-Blasco *et al.*, 2008), the market structure in which they operate (Geroski, 1990) and their technological intensity (Albors *et al.*, 2009) as facilitators or barriers to innovation. Moreover, sustainable development and management is a topic that has also been considered in research. Since the Bruntland report (1987), which highlighted the need for greater private, public and political environmental pressure to maintain acceptable social conditions, environmental sustainability has turned into what some authors describe as "environmental sociology" (Kalantari, 2010). This social concern is embodied in increasingly severe legislation, as well as increasing public awareness (Kuik *et al.*, 2006, Blischwitz, *et al.*, 2009). Innovation and environmental sustainability are two concepts that have a separate impact on the competitive positioning of companies (Hitchens *et al.*, 2005) and together act synergistically (Esty, 2006) generating, on one hand, new markets for environmentally benign products (Beise and Rennings, 2005) and on the other, a new field of academic study known as eco-innovation (Fussler and James, 1996, OECD, 2008 Huppes *et al.*, 2008, Jänicke, 2008). From a strategic management standpoint, sustainable business development refers to the integrated management that encompasses the entire management of the firm's value chain, from the origins of raw materials for production processes, finished products and services, to the end of the product's life (Sartorius, 2006). The intersection between business and the environment is transforming existing markets, creating new ones, and, increasingly promoting the principles of sustainability in business strategies (González-Benito, 2010).

Companies have identified the benefits of innovative behaviour (Hidalgo and Albors, 2008, Vega-Jurado *et al.*, 2008), but what is required to shift from innovative to eco-innovative behaviour? Which aspects determine that companies which create value through innovation have a proactive environmental focus? More specifically, what are the moderating factors that help innovative companies to become eco-innovative? The objective of this paper is to identify

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the aspects that determine whether a company minimises its environmental impact as a result of its innovative activity, and evolves from being innovative to eco-innovative. In this sense, data from the Panel on Technological Innovation, PITEC (2007), a database for monitoring the technological innovation activities of Spanish companies, has been analysed. This line of study will determine whether it is possible to identify moderating factors (Anderson, 1986) which influence this relationship. This paper is structured as follows. First, it reviews the context of eco-innovation. Secondly, it analyses the state-of-the-art of eco-innovation, previously used indicators for measuring eco-innovation and current innovation barriers and drivers. The methodological framework is then set out. It then goes on to describe research methodology and fieldwork results. Statistical analysis and discussion of the results follows, and finally conclusions and points for discussion close the paper. Eco-innovation is a key factor for achieving the objectives set out in the Lisbon Strategy (European Commission, 2004, European Commission, 2010). This commitment to specific eco-innovation is set out in the Action Plan for Environmental Technologies (European Commission, 2004, b), and in the Competitiveness and Innovation Framework Programme 2007-2013 (European Commission, 2006), which is complemented with other programmes that have environmental objectives such as the Structural and Cohesion Funds and the Seventh Framework Programme for Research which includes a specific allocation for environmental issues, see Table 1.

The E.U. has also promoted several think tank centres for analysing and promoting eco-innovation, such as the European Forum on Eco-innovation, and European Clusters and Regions for Eco-Innovation and Eco-Investment Network, as well as academic papers which centre on the definition and measurement of eco-innovation (Kemp and Pearson, 2009, Reid and Miedzinski, 2008). Similarly, Eurostat (the E.U.'s statistics organisation) is working on developing an Environmental Goods and Services Sector (EGSS). However, this track is closer to eco-industries than to eco-innovation. Along the same lines, the future Community Innovation Survey (CIS2010) will include a module on eco-innovation. This survey will be available in 2011. These financial efforts and institutional interest largely justify the recent interest of the academic and business community in eco-innovation. Eco-innovation studies have begun to appear alongside the abundant work on corporate innovation, although there is still a significant gap in the study of the connections and differences in the performance of innovative and eco-innovative companies. Various authors (Vega-Jurado *et al.*, 2009, Molero and García, 2008) have used the PITEC database to advance the understanding of innovation in firms as well as the relationship between different innovative strategies, but as yet there are no publications which analyse the eco-innovative behaviour of Spanish firms. This is why we have explored the environmental performance of companies in this paper.

The role of environmental management in the value-creating process is critical (Wang *et al.*, 2009, Hallstedt *et al.*, 2010) since it involves taking decisions in areas indirectly involved in environmental decision-making such as purchasing, logistics, product design, and RandD, which have a relevant impact on integrated environmental management (Noci and Verganti, 1999). Incentives for environmental innovation go beyond

Table 1. E.U. Eco-innovation framework

MAIN PROGRAMME	DETAILED INVESTMENTS
The Competitiveness and Innovation Framework Programme 2007-2013 (CIP) Entrepreneurship and Innovation sub-programme (€433 million, out of a total of €2,172 million) aimed at technological innovation.	- Financial Instruments → €228 million - Networks of national and regional actors → €10 million - Pilot projects and replicability → €195 million
European Technologies Action Plan (ETAP); Eco-innovation Action Plan	→ Dissemination of the best environmental technologies and activities across Europe and worldwide. → Establishing performance targets in conjunction with relevant stakeholders. → Setting up mechanisms to verify the validity of environmental technologies.
Seventh Framework Programme for Research (€50,500 million). Cooperation Programme (€32,365 million).	Theme Six - Environment (including Climate Change) → €1,900 million.

regulatory pressure (Brunnermeier and Cohen, 2003) and environmental benefits (Carrión-Flores and Innes, 2010). Moreover, it is becoming increasingly necessary for firms to include sustainability as a strategic factor in their management style through differentiation (González-Benito, 2010), to consider environmental factors as a pro-active aspect of the firm, and to consider which are the determinants that make companies shift towards environmental protection in what is known as "corporate environmentalism" (Banerjee, 2002, Banerjee, 2003).

Although research on environmental management is relatively new, it is actually a field of great scientific interest for large corporations as well as small and medium enterprises (McKeiver and Gadenne, 2005, Martin-Tapia *et al.*, 2009). Abbaspour et al. (2006) defined the guidelines for establishing green management systems in sports complexes, Beveridge and Guy (2005) analysed the relation between eco-preneurs and environmental innovation, and Jänicke (2008) addressed the issue of new perspectives on ecological modernisation, understood as systematic eco-innovations and their diffusion. Lucas (2009) established an integrated model based on RBV theory and strategic management concepts together with ecological economics for understanding broad-based future environmental management. Although eco-concepts are becoming crucial issues for governments, industries and firms, specific characteristics that enhance its development have not yet been studied in depth.

Eco-innovation basically considers any innovation which reduces damage to the environment (Kanerva *et al.*, 2009). A social definition is offered by Huppes et al. (2008), who define it as a change in economic activities that involves a performance improvement in both ways, namely social and economic aspects and environmental aspects. More explicitly, Kemp and Pearson (2008) define it as the production, assimilation or exploitation of a product, production process, service or method of management or business that is new to the organization (developed or adopted) and which implies a reduction of environmental hazards, pollution and other negative impacts of resource use (including energy) during their life cycle compared to the corresponding alternatives. Other authors have addressed the issue from the need to provide public actors who facilitate decision-making (Brio and Junquera, 2003, Frenken and Faber, 2008, Chappin *et al.*, 2009), thus guiding them to "modern environmental governance" (Jänicke, 2005) and trying to reach what is known as "ecological modernisation" (Janïcke, 2008), understood as systematic eco-innovation and its diffusion.

Environmental innovation has been studied from different approaches, although no common criteria have been established to achieve a new global linkage between environmental and innovation policies (Andersen, 2006).

Andersen (2008) established links between eco-innovation and knowledge-based competitiveness, and classified the following: a) add-on eco-innovations, b) integrated eco-innovations, c) alternative product eco-innovations, and d) macro organisational eco-innovations and general purpose eco-innovations, which help us to understand the dynamic behaviour of eco-innovation in industry. Eco-innovation has recently received significant academic attention (Kemp and Pearson, 2008, Arundel and Kemp, 2009, Huppes *et al.*, 2008), especially as it represents a competitive advantage which adds value for producers and consumers, while reducing environmental impact. However, so far it has been studied from an anecdotic standpoint (Pujari, 2006).

Rennings (2000) indicated that eco-innovation has a three-fold impact on technological, social and institutional areas. More specifically, Carrillo-Hermosilla et al. (2010) conclude that different variables influence the development of eco-innovation: design, users, product use and regulatory issues, and consider design as a crucial element for assessing innovation while the other dimensions affect market issues. Hellström's work (2007) follows the same lines and underscores the need for eco-innovation to be supported by social change and for institutions to develop it successfully, both in the field of incremental eco-innovations, which are more oriented to social needs, and in the field of radical innovations, which require greater technological support.

Various authors have outlined the lack of indicators, statistics and specific databases on eco-innovation at European level (Steward, 2008). Subsequently, efforts have been made (EEA, 2006, Steward, 2008) to develop eco-innovation measurement systems which take all the actors belonging to the system into account, such as green start-ups, the financial sector, and educational and knowledge institutions. Furthermore, the Agency has paid attention to the institutional set-up through innovation-friendly environmental policy styles and has also considered sector-based specificity and significance-based selectivity. It has concluded that both new digital product announcement sources and databases are the best information sources for measuring eco-innovation.

Scientific literature has identified several distinctive features of environmental innovations. One of these refers to "double externalities" (Beise and Rennings, 2005), which improves the quality of the environment and is better for society as a whole, although the cost is only borne by the innovator. However, in many cases, the fact that it is difficult for the innovator to benefit from innovation decreases motivation towards eco-innovation. Another feature of eco-innovation is its dissemination in the market without further promotion, as Schwarz and Ernst (2009) concluded after an empirical application of the agent-based model of the diffusion of water-saving innovations in Germany.

On the other hand, the effect that environmental expenditure has on innovation activities has been analysed. Jaffe and Palmer (1997) studied the North American manufacturing industry in an empirical study using panel data. They found a positive influence of environmental expenditure on future research and RandD expenditure, but not on the number of patent applications. In the same type of study, using panel data on 500 U.S. firms, Wagner (2006) concluded that environmental innovation activities are determined by total RandD intensity, since the analysis found no link between environmental management and environmental innovation. Eco-innovation can be considered as a step beyond innovation. This is the selected track of our research whose main hypothesis is H1: The more focused companies are on innovation, the more eco-innovation oriented they are.

Company size and maturity have been considered as a variable which affects eco-innovative capacity (Andersen, 2008) but this has not yet been accepted as the dominant paradigm in academic literature. Brio and Junquera (2003) analysed innovation management in small and medium enterprises (SME) and identified their inherent characteristics, such as lack of financial resources, weak organisational structure, loose management style, weak human resource endowments, environmental management status, technological approach and lower innovative resource capacities. These authors emphasise that large companies mainly develop radical sustainable innovations. This lies in opposition to the "outsiders theory" (Chandy *et al.,* 2000) which suggests a correlation between radical products and small businesses (which he calls outsiders) and that incremental innovations were usually adopted by larger firms which have been in the sector for many years.

Literature has studied companies' organisational changes and innovations, and has identified some characteristics of business typology with the kinds of innovation carried out. Various studies (Ettlie *et al.,* 1984, Ettlie, 1987) found that incremental innovations were adopted by larger-sized firms while smaller firms tended to introduce more radical innovations.

Along the same lines, Lazaric and Dennis (2005) outlined the relevance of improving management processes in order to face changes when analysing the introduction of environmental standards while Nelson and Winter (1982) looked into how establishing organisational routines became a key aspect for successful innovation and organisational evolution (Churchill, 1983).

Biondi et al. (2002) emphasised the limitation of resources (financial, time, technical expertise and knowledge), the lack of environmental culture and also the lack of information, knowledge and short–term strategic thinking when identifying barriers and constraints that SMEs face when undertaking environmental innovation. Mir and Feitelson (2007) found a lack of correlation between environmental awareness and action in all the micro enterprises empirically studied, despite government pressure and support. Moreover, Reid and Männik (2008) carried out a prospective study on eco-innovation and identified two key issues as internal barriers: access to top-level human resources, forecasting affecting technology and markets, and (from an exogenous perspective) access to top-level human resources, access to appropriate financing, and the European legal and regulatory environment. All these factors are difficult for SMEs to comply with (Biondi *et al.,* 2002, Brío y Junquera, 2003).

Finally, seminal research by Brunnermeier and Cohen (2003) identified determinants for environmental innovation in U.S. manufacturing industries and opened a new field of study which introduced a new variable: the evidence that environmental innovation is more likely to occur in internationally competitive industries. Resources and access to them (Brío and Junquera, 2003), the role of company size and aspects related to the capability to integrate knowledge as well as the availability of human resources or funds have been also outlined (Molero and García, 2008).
On the basis of these results, we hypothesised the following H2: Company size determines the sustainable innovative proactivity of the firm.

MATERIALS & METHODS

This research adopted a two-step quantitative methodology applied to a large sample of 11,686 industrial Spanish firms, so that results could be extrapolated to a larger population (Gelman and Hill, 2007). In line with Dubé and Pare (2003), well-known standardised statistical analysis methods, such as analysis of variance and regression analysis, have helped researchers confirm or reject hypotheses in quantitative research. Thus, a factorial analysis method was applied to reduce data variables. This technique allows us to obtain homogeneous correlated variable groups. Moreover, a linear regression model with previous factor analysis identification fitted with the data.

It is important to identify the characteristics of the firms under study since these characteristics affect their environmental management practices. The companies analysed were located across Spain in order to cover a broader scenario.

The data was collected in a PITEC database (Technological Innovation Panel), which consists of a statistical tool to monitor the technological innovation activities of Spanish companies. The database was built by the INE (Spanish National Statistics Institute) with the advice of academics and experts. The first data came from 2004 and has been updated yearly to include a comprehensive list of Spanish companies which are characterised by the type of innovation (classified by the Oslo Manual, 2005) that they undertake, by industry (in line with the Spanish National Activities Classification, CNAE) or by geographical location. A total of 255 variables were analysed. Affiliate level information was not available as data was taken from an anonymous macroeconomic survey.

Data from 2007 was used to analyse a total of 11,686 firms. These companies came from a range of industries. Table 2 shows the data divided into firms with and without internal investment, firms which only had external investment and companies without any investment. Data was also segmented by the number of employees, i.e. under and over 200.

It should be pointed out that all the firms with 200 employees or more (3,276 companies) invest in RandD, 65.68% of them only undertake external investment, while 34.32% only invest in internal RandD, without outsourcing their research and development. Moreover, out of the 8,410 companies analysed in this study which have less than 200 employees, it is striking that 10.8% of the sampled firms do not carry out any RandD and only 4.8% develop RandD externally.
Variables included in this study were selected according to theoretical statements. Net sales (NS) represents the total sales income in 2007, size by number of employees (SZ) represents the number of full-time employees in the company during 2007, total goods investment (INVER) represents gross investment in tangible goods in 2007.

National market (MDONAC) indicates whether the companies operate on a national scale. This is a binary variable with 1 = Yes and 0 = No. E.U. market (MDOUE) indicates whether the companies operate on a European scale. This is a binary variable with 1 = Yes and 0 = No. Number of European patents (PATEPO) and number of national patents (PATOEPM) were measured as the number of patents applied at European and Spanish level. The U.S. patent indicators were discarded because they had no significant value in the studied sample.

Technology investment (MAQUI) included expenditure on machinery, equipment and software acquisition during the year studied. The total investment in external knowledge acquisition is referred to as TECNO; Innovations to the market (MARKET) represents the total amount spent on launching innovations onto the market; and number of RandD employees (PIDCA) represents the number of full-time employees who work on R and D activities.

RESULTS & DISCUSSION

To construct the indicators, information was taken from the PITEC database (2007) and was subsequently processed. An exploratory factor analysis was

Table 2. Classification according to type of innovation and size (PITEC database, 2007)

2007	Number of firms with fewer than 200 employees	Firms with 200 employees or more	TOTAL
Firms with internal RandD investment	7,098	1,120	8,218
Firms without internal RandD investment	0	2,156	2,156
Firm with external RandD and without internal RandD investment	405	0	405
Firms without any RandD investment	907	0	907
TOTAL	**8,410**	**3,276**	**11,686**

Table 3. Summary of exploratory factor analysis results (Rotated Component Matrix[a])

	Components			
	SIZE	OPEN MARKET ORIENTATION	FORMAL INNOVATIVE ACTIVITY	TOTAL INNOVATION INVESTMENT
Net sales (NS)	.847			
Total goods investment, (INVER)	.752			
Size by number of employees (SZ)	.848			
National market (MDONAC)			.820	
E.U. market (MDOUE)			.806	
Technology investment (MAQUI)				.687
External knowledge acquisition (TECNO)				.611
Innovations to the market (MARKET)				.656
Number of RandD employees (PIDCA)				
Number of national patents (PATOEPM)		.763		
Number of European patents (PATEPO)		.796		
% of variance	20.431	20.431	23.732	16.558

[a]Rotation converged in 4 iterations. * Principal Component analysis. Varimax with Kaiser normalisation. 76.88% variance explained -KMO .659- Sig .000

performed on all eleven independent variables, using factor analysis (Varimax method) in an attempt to understand the factor structure and the corresponding measurement quality. The solution shows four factors which account for 77.64% of the variance and significance 0.000, namely size, open market orientation, formal innovative activity and total innovation investment (Table 3 shows the factor analysis results). All statistical analyses were carried out using SPSS for Windows, version 17.0. We used Barlett's test of sphericity calculated with the Kaiser-Meyer-Olkin statistic, to verify the suitability of the analysis. In line with Hair et al. (1998), it is usual to accept a solution explaining over 60% of variance in social sciences. Factor estimates as well as the assessment of the overall fit were carried out using a principal component analysis, which was suitable to summarise the original information in factors for prospective purposes (Hair *et al.*, 1998).

The results of the Varimax rotation reinforced the expected pattern except for the number of RandD employees (PIDCA), a factor that was considered, a priori, vital to the explanation of the sample, indicating that the number of employees working in R and D is not significant.

Net sales, number of employees and total investment refer to the size of the company. According to theory, larger structures involve more employees and higher sales. Moreover, the larger the company is, the greater the innovation investment (Churchill and Lewis, 1983, Becker *et al.*, 2005, Greiner, 1997). All the variables which made up the first components were positively correlated and fitted the evolutionary theory of Nelson and Winter (1982). In more specific studies, Horbach (2008) found that environmental management tools and general organisational changes also encourage environmental innovation.

National market (MDONAC) and European Union market (MDOUE) refers to market size, and thus national and transnational open market orientation becomes the second factor: open market orientation. According to theory, innovation plays a crucial role in export behaviour, and acts as a moderating factor in open market oriented firms (Bassile, 2001, Salomon and Shaver, 2005).

Formal innovative activity is reflected in the third factor, which includes national patents as well as European ones. Economic theory views patents as policy instruments aimed at fostering innovation and diffusion (Encaoua *et al.*, 2006). The empirical evidence suggests that patents provide a fairly reliable measure of innovative activity (Acs *et al.*, 2002) since innovation, growth and competitiveness are correlated (Crosby, 2007).

Technology investment (MAQUI), external knowledge acquisition, TECNO and innovations to the market (MARKET) make up the last factor, i.e. total innovation investment. This newly generated variable includes all the expenditure firms have laid out on knowledge acquisition, including machinery with internal technology, external acquisitions through licenses or cooperation /research contracts and those related to the launching of new innovative goods or services. Positive correlation is again found among the original variables. Previous studies (Horbach, 2008) show that the improvement of technological capabilities (knowledge capital) by RandD triggers environmental innovations. In this direction, Corley et al. (2002) found a positive relation between competitiveness, productivity, investment and innovation.

In linear regression studies, the hierarchical regression method (Cohen and Cohen, 1983) was used to specify a regression model (see Table 4). The issue of multicollinearity in regression analysis was solved by running factor analyses using the Varimax method and meeting the requirements of tolerance values and variance inflation factor measures (Hair *et al.*, 1998). The dependent variable of the model is the so called EFECTO 8 in the PITEC database (ENV-IMP in our research), which measures how essential it is for innovating firms to improve their environmental impact.

Table 4. Environmental innovation impact: results of regression analysis

Factors	Model 1
Size	-.029 (.006)
Open market orientation	-.086 (.000)
Formal innovative activity	-.102 (.000)
Total innovation investment	-.119 (.000)
R square	0.033
Adjusted R square	0.032
F	75.061
N	8,870

Numbers in brackets show significant values

The regression coefficients were significant in all the performance variables analysed. Negative coefficients were due to the inverse relation in the PITEC database which considers the importance of environmental impact improvement (dependent variable, ENV-IMP) as very important (1), important (2), not so important (3), not considered (4) by firms when innovating. Linear regression with previous factor analysis identification fitted with the data.

Although all the variables have an impact on environmental impact, formal innovative activity and total innovation investment have a stronger influence on the final effect. Size and open market orientation have less influence on the importance of environmental impact.

Our first proposition, H1: *The more companies are focused on innovation, the more eco-innovation is supported* considers that both formal innovative activity and total innovation investment are good indicators of the level of innovation and are relevant to the dependent variable.

Our second hypothesis, H2: *Company size determines the sustainable innovative proactivity of the firm* is fulfilled, as size appears to be a moderating factor. This is a characteristic of eco-innovative firms together with export orientation.

CONCLUSION

This study has sought to provide an insight into the identifying factors which affect the eco-orientation of innovative firms. Our main objective was to analyse what the aspects were that determine whether companies behave in a sustainable proactive way. The empirical results show that company and market size, formal innovative activity (reflected by registered numbers of patents) as well as total expenditure on technology acquisition influence the eco-innovative orientation of firms.

The factorial analysis method did not show any relationship between the number of RandD employees, PIDCA, and the eco-innovative orientation of the firm. Firms with a high number of IP registers (patents) and large investments are focused on innovation thus validating H1. On the other hand, linear regression analysis determines that the size of the company, measured by number of employees, net sales and total investment are positively related to the sustainable orientation of the firm (C1), so H2 is validated.

The factors which literature identifies as innovation drivers, such as size and market orientation, are also eco-innovation drivers. In fact, formal innovation measured by patents, and technology expenditure appear to be the main moderating factor of eco-innovation, implying environmental weaknesses and, therefore, lower environmental innovation due to the fact that innovation facilitators may also become eco-innovation drivers.

These research results have important practical applications for industrial policies aimed at promoting eco-innovation. The E.U. is funding eco-innovation projects through different programmes but is focusing efforts on small and medium enterprises which do not innovate. If these programmes are to be optimised eco-innovation processes will need to be analysed and factors that positively influence a company to become eco-innovative will need to be identified. This paper has pointed out that it would be more effective to encourage eco-innovation in innovative firms which are relatively large. The higher the level of formal innovation, expenditure and size of a company, the greater the likelihood the company will move forwards towards eco-innovation.

The limitations of this study are basically due to the database restrictions. New research lines would call for implementing more focused and detailed company surveys. Our research has benefited from the use of the PITEC database which covers various industries. However, it must be stressed that conclusions should be considered with caution since moderating factors may depend on whether we are dealing with high tech, medium or low tech industries.

Moreover, further alternative research contrasting the model through a qualitative research is needed, as is benchmarking transnational research to compare firms internationally.

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