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Eco-innovation and its economic effect on Industrial Clusters - An FsQCA Analysis

Nohora Mercado-Caruso[a,b,*], Marival Segarra-Oña[b], Ángel Peiró-Signes[b], Ivan Portnoy[a], Evaristo Navarro[c]

[a]Productivity and Innovation Department, Universidad de la Costa, Colombia
[b]Department of Business Administration and Management, Universidad Politécnica de Valencia, Spain
[c]Economic Sciences Department, Universidad de la Costa, Colombia

Abstract

Eco-innovation refers to developing goods, processes, and services that seek companies' sustainable positioning and permanence in an ever-evolving and demanding market. On the other hand, the cluster approach has proven a successful strategy for companies to accomplish eco-innovation. This paper aims to pinpoint the factors that generate economic effects on the companies of a cluster when they engage in eco-innovation activities. The study was applied to a 40-company cluster in the Colombian metalworking sector, implementing the Fuzzy-set Qualitative Comparative Analysis (FsQCA) methodology, which identifies the inherent causal relationships between factors having economic impacts on the cluster's companies. Through the FsQCA analysis, we identified those factors that have significant economic effects, to which companies must give special attention to achieve benefits and reduce operative costs while complying with environmental regulations. Moreover, the necessary and sufficient conditions analysis showed different pathways to achieving such benefits. The factors found to have economic effects are the companies' capacity, market demand, and regulatory policies. Finally, the paper shows that by focusing on the correct factors and actions, the cluster approach fosters the companies' competitiveness and leads them to successfully engage in eco-innovation. Thus, this work provides companies with a roadmap to achieve eco-innovation-related results.

Keywords: Sustainable innovation, eco-innovation, cluster, competitivity.

* Corresponding author. Tel.: +57-5-322-5498-; fax: +355-22-66-999.
E-mail address: nmercado1@cuc.edu.co

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1. Introduction

The current literature on eco-innovation shows a trend to include sustainability-related elements as a strategy to enhance the innovation of products and processes, revolutionizing the existing markets and incorporating new approaches. Eco-innovation focuses on sustainable innovation, and it allows using natural resources more efficiently [1,2]. Moreover, eco-innovation has shown to be positively related to companies' worth, leading to reducing environmental pollution, as some authors have remarked after analyzing environmental-related innovation factors. The enterprises' capacity, customer demand, provider-distributer collaboration level, and companies' performance are particularly relevant [3–5].

Few studies, however, have addressed the identification of eco-innovation drivers at the specific sector or company level. Most research focuses on nation-level eco-innovation in developed countries. Moreover, studies on cluster eco-innovation are scarce, span far-between regions and some are non-conclusive regarding their findings on the drivers for eco-innovation [6]. Therefore, this work aims to tackle this gap, following approaches similar to those outlined by Cheng & Shiu (2012) [8], Cai & Li (2018b) [10], and Daddi et al. (2012) [12].

1.1. Study contextualization

The Colombian metalworking cluster used as the case study comprises 40 institutions, including universities, R&D and technology centers, boards of trade, customers, providers, and distributors. According to Maskell & Kebir (2005) [14], the conjunction of actors and their relationships constitute the so-called *cluster's structure*. This structure promotes the gain of economic benefits for all companies within the cluster, further giving them (and the sector) a competitive advantage. The cluster's structure fosters such benefits as the spatial concentration promotes learning and eco-innovation. The advantages of joint efforts, called *collective efficiency* by Schmitz (1995) [16], rely on cooperation and the facility to reach economic agreements. These elements allow exploiting markets at a whole new scale and strengthening the capacity response after market-wise environmental changes [17].

The economic effects on clusters are mainly related to saving eco-innovative activities-related costs and the rise of profits derived from such activities. These activities may have indirect positive effects on society from which the communities obtain benefits for which they are not charged. Furthermore, the economic performance improves the resource use efficiency and product quality, as cost-saving is key to developing novel, more impacting innovations. Thus, a company's eco-innovation behavior boosts its environmental performance and (indirectly) its economic performance [10].

2. Methodology

This study assesses the influence of economic effects on industrial cluster eco-innovation through a case study. This case study analyzes a 40-enterprise cluster, from the metalworking sector located in the city of Barranquilla, on the north coast of Colombia, South America. In line with what authors report in the literature, the following factors or variables are measured and used as candidates to have economic effects on the cluster: *i)* CAPACITY, *ii)* DEMAND, *iii)* COMPETITIVE PRESSURE, *iv)* POLICIES, and *v)* COOPERATION. The dataset used for this work can be found at https://github.com/iportnoy1/Dataset-for-FsQCA-Analysis.

To analyze eco-innovation factors and their economic effects on the cluster, we implemented the measuring methodology proposed by [18], along with the FsQCA method, which is widely used in social and managerial sciences, to conduct causality analysis. The FsQCA method allows exploring the underlying causal relationships between a set of variables, where different combinations of factors can lead to the same outcome. This can help unravel causal patterns in our cluster (case study) or many other industrial settings and scenarios. The measuring instrument comprises 44 items and conducts a sensitivity test using the Cronbach's alpha coefficient (see Table 1) with values over 80%.

Considering that fuzzy sets' elements span values within the 0-1 range, for each factor, a value of 1 indicates full membership, 0 indicates full non-membership, and values in-between indicate the degree of membership to a (fuzzy) set. A screening process is carried out, where only combinations of conditions with a consistency of at least 0.8 are considered, keeping solutions with a frequency over two observations. Hence, those combinations with consistencies equal to or greater than 0.8 are labeled with "1," while otherwise, they are labeled with "0" [19]. Further, two analyses are carried out: *i)* Analysis of necessary conditions. A condition is necessary if it is present in all the causal configurations explaining a given outcome; *ii)* Analysis of sufficient conditions. A condition is sufficient if it leads to the desired outcome, but it is not present in all causal configurations explaining the outcome.

3. Results

The analysis of the necessary conditions is presented in Table 1. It can be noticed that none of the conditions turned out to be necessary to produce economic effects on the industrial cluster. Thus, their presence or absence is not a causal precedent. Also, it is noticeable that some conditions exhibit a consistency around 0.9, which makes them quasi-necessary conditions to achieve economic effects on the cluster. Such is the case of CAPACITY (with a consistency of 0.81), POLICIES (0.83), and ~CAPACITY (0.84). The tilde (~) in Table 1 indicates the absence of the factor.

Table 1. Analysis of necessary conditions.

Necessary Conditions	Analyzed Conditions	Consistency	Coverage
Presence of Condition	CAPACITY	**0.813800**	0.834982
	DEMAND	0.773212	0.722960
	COMPETITIVE PRESSURE	0.562659	0.585224
	POLICIES	**0.835109**	0.799806
	COOPERATION	0.744292	0.717009
Absence of Condition	~CAPACITY	**0.843765**	0.823473
	~DEMAND	0.712173	0.763742
	~COMPETITIVE PRESSURE	0.612617	0.590499
	~POLICIES	0.796944	0.832647
	~COOPERATION	0.714638	0.742068

The analysis of sufficient conditions to achieve economic effects on the cluster, based on eco-innovative activities, yielded the configurations displayed in Table 2. There, (●) symbolizes the presence of the factor in the configuration, while (**o**) represents its absence (or negation). Solution 1 for OUTECONOMICS (standing for economic outcomes) features a combination of causal conditions. Such conditions include ~DEMAND (i.e., the absence of the DEMAND factor) and ~POLICIES as the most significant factors exhibiting eco-innovation-related economic effects on the cluster. That solution explains roughly 64% of the cases and exhibits a consistency of 0.87. This configuration shows the highest values for both raw coverage and consistency. It is noticeable that the factor POLICIES (or its negation) is present in three out of the four configurations found. The first configuration, ~DEMAND*~POLICIES, concludes that the absence of demand and policies produces economic effects. Results imply that, although enterprises within the cluster might have low demand and unclear policies, they still can achieve a good economic performance, reducing energy, water, and supply consumption costs.

On the other hand, Solution 2 shows that, despite lacking a strong capacity, companies can achieve economic benefits if they strengthen their cooperation networks with other enterprises within the cluster, and the competitive pressure remains rather mild. Solution 3 shows that another way to reach economic benefits is through policies (either private or governmental) fostering process improvement. Such policies lead to high-quality products. These benefits can be obtained even with low cooperation and competitive pressure levels. Finally, Solution 4 shows another alternative way to attain economic benefits through high capacity and policies promoting eco-innovative strategies.

Table 2. Sufficient conditions; OUTEFFECTS.

Model 1: OUTECONOMIC				
	Solutions			
Variable	**1**	**2**	**3**	**4**
CAPACITY		o		●
COOPERATION		●	o	
COMPETITIVE PRESSURE		o	o	**o**
DEMAND	o			
POLICIES	o		●	●
RAW COVERAGE	0.639939	0.247605	0.255673	**0.26828**
UNIQUE COVERAGE	0.199697	0.024205	0	**0**
CONSISTENCY	0.872765	0.870567	0.816425	**0.847134**
OVERALL SOLUTION COVERAGE		**0.882501**		
OVERALL SOLUTION CONSISTENCY:		**0.824305**		

Among the solutions found by the FsQCA method, Solution 1 exhibited the greatest consistency and therefore is the best path to attain economic benefits. Nevertheless, the method offers other alternative paths to gain such benefits, providing enterprises within the cluster with enough flexibility to adapt to their internal and environmental conditions. These results can be a valuable input for governmental entities, chambers of commerce, competitiveness centers, universities, and enterprises within clusters. Such entities can strengthen their capacities and incorporate sophisticated processes and increase productivity and attract more funding for the cluster.

4. Conclusions

This research aims to close the gap that exists regarding the methodologies to elucidate the drivers of eco-innovation in companies belonging to industrial clusters, especially in those companies that have not yet engaged in eco-innovation. The FsQCA methodology was applied to a metalworking cluster to elucidate the causal relationships between factors believed to intervene in the economic dynamics and the potential economic effects of eco-innovation-related activities. The FsQCA explores all the possible interactions among the variables, and different combinations of causal factors can lead to the same outcome. Thus, this methodology is appropriate to elucidate the “ingredients” to achieve economic effects in the cluster. Additionally, FsQCA allows knowing asymmetric conditions that cannot be unraveled using traditional quantitative approaches such as multivariate regression.

The cluster used for the case study belongs to the Colombian metalworking sector and is located on the country's north coast. Results show that qualified staff, R&D capacity, and policies aligned with the enterprises' needs can lead to a rise in their market share and sales. Thus, before attaining a high demand from the market, companies must create the need for their products or services through innovation.

The economic benefits are achieved through substantial investments targeting process, product, and service improvements. Such benefits are conditioned by the enterprises' size and previous innovation know-how. Furthermore, the model yielded different configurations, among which the first (~DEMAND*~PLOICIES) configuration showed the highest consistency. This configuration revealed that companies can access eco-innovation-driven economic benefits even with low demand and a lack of clear policies if they enhance cooperation (even with low capacity and competitive pressure). Additionally, the method offers alternative ways to achieve such economic benefits, providing the cluster’s companies with the flexibility to adapt to their capacities and resources.

The scope of this work is limited to a metalworking cluster (located in Colombia) used as a case study. However, the methodology can be easily extrapolated to other industrial cluster settings and regions. Hence, future works should extend the methodology to other case studies to compare results and determine whether the factors found as drivers of eco-innovation-driven economic effects remain common or vary between sectors and regions.

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