# Green innovation and competitiveness: empirical evidence from Ecuadorian manufacturing



# Innovación verde y competitividad: evidencia empírica desde la manufactura ecuatoriana

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# Inovação verde e competitividade: evidências empíricas da manufatura equatoriana

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## Abstract

**Purpose** – The purpose of this study is to explore green innovation and its role in driving competitiveness in Ecuadorian manufacturing firms, focusing on structural equation modelings, which account for more than 90% of the productive units and aggregate national income. The manufacturing sector in Ecuador reports variable growth since the start of the COVID pandemic, drawing more attention from practitioners, regulators and scholars alike, due to its distinctive footprint on people, profit and planet, particularly in the context of developing economies.

**Design/methodology/approach** – A model with two second-order constructs is developed and tested in a sample of 325 managers from manufacturing firms in Ecuador, using quantitative and cross-section methods.

**Findings** – After obtaining adjusted and validated metrics, a structural equation model is presented, where the main hypothesis is confirmed, supporting the positive impact of green innovation on competitiveness.



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**Practical implications** – The research provides evidence on how manufacturing firms favoring green innovation in their long-term planning can unlock and sustain competitiveness. Policymakers could then offer incentives for firms to embed sustainable practices, with potential ripple effects along the supply chain, aggregating up competitiveness to industry and national levels.

**Originality/value** – The study aims to bridge the existing knowledge gap on the interplay of green innovation and competitiveness, claiming that the former significantly influences the latter, in an emerging market context, with incremental gains for all stakeholders, as posited by stakeholder theory.

**Keywords** Green innovation, Competitiveness, Manufacturing, Emerging markets, Structural equation modeling

**Paper type** Research paper

## Resumen

**Propósito** – El propósito de esta investigación es explorar la innovación verde y su rol en la generación de competitividad en las empresas manufactureras ecuatorianas, centrándose en las PYMES, que representan más del 90 por ciento de las unidades productivas y del ingreso nacional agregado. El sector manufacturero en Ecuador reporta un crecimiento variable desde el inicio de la pandemia de COVID, lo cual atrae la atención de profesionales, reguladores y académicos por igual, debido a su huella distintiva en la sociedad, la rentabilidad y el planeta, particularmente en el contexto de las economías en desarrollo.

**Diseño/metodología/enfoque** – Se desarrolla y estima un modelo con dos constructos de segundo orden, en una muestra de 325 gerentes de empresas manufactureras del Ecuador, utilizando métodos cuantitativos y transversales.

**Resultados** – Tras obtener métricas ajustadas y validadas, se presenta un modelo de ecuaciones estructurales, donde se confirma la hipótesis principal, sustentando el impacto positivo de la innovación verde en la competitividad.

**Implicaciones prácticas y sociales** – Aportamos evidencia empírica sobre cómo las empresas manufactureras que favorecen iniciativas ecológicamente innovadoras en su planificación a largo plazo, pueden generar y sostener competitividad. Los reguladores podrían eventualmente diseñar incentivos para que las empresas incorporen prácticas sustentables, acumulando beneficios en la cadena de suministro, e incrementando así la competitividad a nivel de la industria y de la economía en su conjunto.

**Originalidad/valor** – Nuestro estudio aspira contribuir a cerrar la brecha en la literatura en la convergencia entre la innovación verde y la competitividad, argumentando que la primera influye significativamente en la segunda, en un contexto de mercado emergente, con beneficios incrementales para todas las partes interesadas, como lo postula la teoría de *stakeholders*.

**Palabras clave** Innovación verde, Competitividad, Manufactura, Mercados Emergentes, Ecuaciones Estructurales

**Tipo de artículo** Trabajo de investigación

## Resumo

**Objetivo** – O objetivo desta pesquisa é explorar a inovação verde e seu papel na promoção da competitividade nas empresas manufatureiras equatorianas, com foco nas PMEs, que representam mais de 90% das unidades produtivas e da renda nacional. O sector manufatureiro no Equador regista um crescimento variável desde o início da pandemia da COVID, atraindo mais atenção tanto de profissionais, reguladores como acadêmicos, devido à sua pegada distinta nas pessoas, nos lucros e no planeta, particularmente no contexto das economias em desenvolvimento.

**Desenho/metodologia/abordagem** – Um modelo com dois construtos de segunda ordem é desenvolvido e testado em uma amostra de 325 gestores de empresas industriais no Equador, utilizando métodos quantitativos e transversais.

**Resultados** – Após a obtenção de métricas ajustadas e validadas, é apresentado um modelo de equações estruturais, onde é confirmada a hipótese principal, apoiando o impacto positivo da inovação verde na competitividade.

**Implicações práticas e sociais** – A nossa investigação fornece evidências sobre como as empresas industriais que favorecem iniciativas ecologicamente inovadoras no seu planeamento a longo prazo, podem aumentar e sustentar a competitividade. Os decisores políticos poderiam então oferecer incentivos às empresas para incorporar práticas sustentáveis, com potenciais efeitos em cascata ao longo da cadeia de abastecimento, agregando competitividade aos níveis industrial e nacional.

**Originalidade/valor** – O nosso estudo visa colmatar a lacuna de conhecimento existente sobre a interação entre inovação verde e competitividade, alegando que a primeira influencia significativamente a última, num contexto de mercado emergente, com ganhos incrementais para todas as partes interessadas, conforme postulado pela teoria dos *stakeholders*.

**Palavras-chave** Inovação verde, Competitividade, Manufatura, Mercados Emergentes, Equações Estruturais

**Tipo de papel** Trabalho de pesquisa

## 1. Introduction

Social responsibility is a philosophy of action that considers the organization as a social actor with multiple stakeholders, each playing a particular role (Davis *et al.*, 2006). When an organization acts with social responsibility, it has a vested interest in increasing the social and economic value it delivers, meeting the demands of its stakeholders. Responsible business arguably yields several benefits, including increased brand image and reputation, higher sales revenue and customer loyalty, enhanced productivity, lower operating costs, improved attraction and retention of employees and reduction of regulatory oversight (Panwar *et al.*, 2016; Porter and Miles, 2013; Servaes and Tamayo, 2013).

Awareness has been steadily raising on the pronounced gap between socioeconomic strata and the alarming levels of degradation and pollution worldwide. According to The World Bank (2018), 10.7% of the planet's population, i.e. 760 million people, live on $1.90 per day, up from 9.6% in 2015. Another revealing fact is that 90% of the world's poverty, is concentrated in low-income countries (The World Bank, 2018). Social inequality and youth unemployment are growing dramatically, including a widening gender pay gap, with women's salaries on average 25% lower than men in similar jobs (Business and Sustainable Development Commission, 2017). Pollution and environmental degradation lead to the anticipated death of 12.6 million people per year (UN Environment, 2017). According to the Business and Sustainable Development Commission (2017), the frequency of natural disasters due to climate change has doubled since the 1980s. Let alone the devastating effects of COVID-19, which spread is linked to impoverished health and sanitary conditions. Nearly two centuries of industrialization, along with the depletion of natural resources, with no environmental foresight, have alarmingly increased the amount of greenhouse gases and climate risk.

How firms manage social and environmental impact out of their value chain is likely to become a core driver of competitiveness. In addition, the firm typically acts as a group, leaving aside the idea of irresponsible individual actors –companies or institutions have obligations that prevent them from being seen as a source of "organized irresponsibility" (Adam *et al.*, 2000).

According to Song and Yu (2018), organizational capacities or practices must integrate green innovation, so that they can fulfill their responsibilities, such as environmental protection requirements or standards. Responsible green innovation refers to transparent and interactive processes in organizations that make it possible for firms to meet the objectives of sustainable development by integrating them into their value chain (United Nations Development Program, 2023), delivering on those collective responsibilities inherent to all commercial, institutional or civil society activities proposed by the United Nations 2030 Agenda (Schulz *et al.*, 2021; Stilgoe *et al.*, 2013; Ureña-Espaillat *et al.*, 2022).

Responsible innovation requires the ability to redirect activities in response to public and stakeholder values and changing circumstances, while green innovation proves to be crucial for environment-friendly or responsible innovation (Jia *et al.*, 2018; Maitlo *et al.*, 2022). Therefore, we need to consider how innovation systems can be shaped to be as green and responsible as possible. Pellizzoni (2004, p. 557) describes this responsiveness as "a dimension of responsibility that is encompassed but substantially neglected," that must become more receptive to societal and environmental challenges (Stilgoe *et al.*, 2013).

Our research takes a closer look at the interplay of green innovation, responsible business and competitiveness, as responsible innovation is increasingly perceived not just as an answer to environmental demands but also as a driver of sustainable growth (Kam-Sing Wong, 2012; Scholten and Blok, 2015).

Studies on the influence of green innovation on competitiveness have been recurrent in developed countries, such as the USA (Auger *et al.*, 2003; Marin and Ruiz, 2007), Europe (Banelienė and Strazdas, 2023; Battaglia *et al.*, 2014; Castaldo *et al.*, 2009; Turyakira *et al.*, 2014) and selected Asian markets (Chen, 2008; Chen *et al.*, 2006; Kam-Sing Wong, 2012; Obeng *et al.*, 2023; Zhao and Sun, 2016), yet very little research has been conducted in developing economies. For example, the findings by Kam-Sing Wong (2012) in Asia showed that green innovation is more than a branding support, demonstrating a stronger influence on competitive advantage and green new product success in the manufacturing sector. Based on this evidence, it is observed that in developing countries, largely due to resource constraints, green product innovation should be considered before green process innovation. Conversely, manufacturing multinationals tend to leverage on green innovation to improve organizational competitiveness (Obeng *et al.*, 2023). In Europe, research shows that green innovations have a positive impact on economic growth and provide a scientific basis for strategic planning at the national and business levels, encouraging a focus on the development of green innovation not only as a means of reducing the impact of climate change but also as a strategic direction for increasing competitiveness (Banelienė and Strazdas, 2023). Green innovation unlocks productivity gains translated into higher profits, improved corporate image, new market opportunities and increased competitive advantage (Chen *et al.*, 2006). The purpose of our study is to contribute to bridging the gap on the interplay of green innovation and competitiveness in manufacturing in an emerging market setting, by exploring how the former influences the latter, assessing empirical evidence gathered from Ecuador.

According to the Global Entrepreneurship Monitor (GEM), Ecuador is one of the most entrepreneurial countries in the world, across all industries (Global Entrepreneurship Monitor Ecuador, 2021). GEM defines businesses that are small, design new products or services, are in an early stage of development or generate entrepreneurship or innovations as part of the company's activity, as entrepreneurship (Zambrano and Ordeñana, 2020; Universidad Andina Simón Bolívar, 2021). Ecuadorian micro, small- and medium-sized enterprises are drivers of economic growth, job creation, innovation and the overall productive dynamism of the country (Servicio Ecuatoriano de Normalización, 2021). According to the Directory of Companies 2019 of the National Institute of Statistics and Censuses (INEC), 99.5% of companies in Ecuador are considered SMEs (Universidad Andina Simón Bolívar, 2021).

In Ecuador, as in many emerging economies, manufacturing is constantly striving to account for a larger share of gross domestic product (GDP) (Cámara de Industrias y Producción, 2021), in an attempt to leap into higher global value chains (Gereffi, 2019). Yet increased industrial output is often achieved at the expense of diminished social value and detrimental environmental impact. This pervasive trade-off is seemingly being challenged in Ecuador by the emergence of a breed of green-minded innovators in the manufacturing sector. Our expected contribution is centered on the effect of green innovation as a determinant of competitiveness in manufacturing in an emerging market context. The model, together with the focus on manufacturing and emerging markets, accounts for gaps in the literature, worth addressing to provide empirical evidence to extended theoretical claims.

Section 2 presents a critical review of relevant literature, followed by the methodology in Section 3, while the findings from our model, largely supporting our hypothesis on a positive relationship between the constructs, are discussed in Section 4, with implications for theory, practice, policy and society summarized in the concluding Section 5.

## 2. Literature review

### *2.1 Competitiveness*

From an institutional economics perspective, competitiveness refers to the success of a production system, whether local, regional or national, as part of an appropriate institutional context (Cetindamar and Kilitcioglu, 2013). Yet the construct is often portrayed under different parameters, making the meaning and scope of competitiveness a recurrent debate. Vilanova *et al.* (2009) define competitiveness as a function of the market, that is, the factors that shape competition. Battaglia *et al.* (2014) argue that firm-level competitiveness is shaped by the company's sustainability capacity, that is, its endurance, as measured by market share, profitability and returns.

Such a view centered on the firm was spotlighted in Porter's *The Competitive Advantage of Nations* (Porter, 1990; Ketels, 2006). The fundamental claim emerging from such seminal reference, is that competitiveness is a firm-level outcome. This outcome results from the productivity gains attained by retooling the primary and supporting activities of the firm's value chain. Yet such productivity is also contingent on the business environment, as argued by Porter (1990, 2004) through his diamond model, highlighting the critical choice of location in unleashing competitiveness (Alcácer and Chung, 2007). In developing economies such as Ecuador, country-specific advantages tend to carry more weight in shaping the competitiveness of firms, particularly that of emerging market multinational enterprises (Gugler, 2017). Productivity is indeed at the core of Porter's definition of competitiveness (Porter, 2004). For those efficiency gains to lead to a competitive positioning sustainable over time, the value created by the firm should, in turn, meet the demands of its various stakeholders (Collazzo and Kubelka, 2019). Such is the underlying logic of the creating shared value concept coined by Porter and Kramer (2011), namely, that firms should deliver to its diverse set of stakeholders to stay competitive – some stakeholders pursue social value while others pursue economic value.

Based on the review of multiple studies that adopted quantitative methods to demonstrate a positive relationship between corporate social responsibility (CSR) and competitiveness, Battaglia *et al.* (2014) focused on certain dimensions of competitiveness, namely, market performance and intangible assets performance. Market performance is arguably the most common indicator to measure the competitive status of an organization. The ability to generate benefits in the medium and long term becomes an important factor for the economic performance of the firm (Battaglia *et al.*, 2014; Tomšič *et al.*, 2015), measurable through indicators such as profitability on own resources, sales performance or cash flow (Morioka and de Carvalho, 2016). Battaglia *et al.* (2014) measured the profitability of the organization using four indicators:

1. sales or turnover trend;
2. demand of traditional customers;
3. demand of new customers; and
4. level of attraction of new members and partners to business (Apospori *et al.*, 2012; Carroll and Shabana, 2010; Turyakira *et al.*, 2014).

On the other hand, "the resource-based view of the firm, explicitly recognizes the importance of intangible assets, such as knowledge (human capital), corporate culture and reputation" (Battaglia *et al.*, 2014, p. 878). Therefore, resources are classified into intangible, tangible and personnel-based. Intangible resources include reputation, technology and organizational knowledge, the latter also encompassing culture, training, employees' experience, commitment and loyalty (Battaglia *et al.*, 2014; Tomšič *et al.*, 2015).

There has been a heated debate about the influence of the strategic application of social responsibility on competitiveness. Theoretically, CSR is important in the financial and competitive practice of the organization (Lee and Min, 2015). Several CSR scholars highlight the upside for the firm, such as economic benefits, as responsible business tends to reduce costs (Reverte, 2012), unlocking both social benefits – by improving the relationship with the community (Battaglia *et al.*, 2014) – and environmental benefits – for instance, by reducing emissions resulting from process optimization and rational resource management. Some argue that economic and social objectives are fully connected in the long-term (Windolph *et al.*, 2014). Smith (2005) stated that institutional and social investors have found a common basic premise for business long-term well-being that referred to the importance of having good corporate, social and administrative practices. In addition, the mistake arguably made when questioning social value practices, lies in the expectations of short-term results, ending in a misinterpretation of unnecessary spending, when in fact they should be evaluated in the long-term to capture benefits such as sustainable competitiveness (Porter and Miles, 2013). That is, companies cannot even function if they choose to isolate themselves from the social environment because their competitiveness and overall operations depend largely on the circumstances of the location in which they compete (Porter and Kramer, 2002).

In terms of market performance, the literature suggests that CSR is an influential element to improve product and service quality, since it responds to stakeholders' expectations (Windolph *et al.*, 2014). Moreover, practices that grant fair treatment to employees, along with an optimal management of resources, generate a feeling of return for the hosting community. This, in turn, improves consumers' perception and company revenues (Turyakira *et al.*, 2014). There is arguably a growing demand for green products, by both traditional and new clients, mainly fueled by economic globalization and information transparency, which have favored the emergence of socially responsible consumers. In addition, investors give increasing importance to aspects such as the environment, social impact and corporate governance practices when deciding where to invest (Humphrey *et al.*, 2015). Regarding performance steaming from intangible assets, human capital productivity may generate additional benefits by having talented employees managing those assets, unlocking sustainable competitive advantages (Antonietti and Marzucchi, 2014). The implementation of CSR-related practices is likely to have a positive effect on human talent, reducing costs associated with staff retention and absenteeism (Windolph *et al.*, 2014).

Empirical evidence exposes CSR as an exogenous variable. To validate this argument, DeMelo *et al.* (2017) analyzed the relationship between CSR and competitiveness over a period of 19 years. In a bibliometric study, 344 articles related to the subject were reviewed through the Web of Science citation networks. The first publication on this relationship dates back to 1996, but it has been from 2006 onwards that we see a considerable increase in scientific output. Results showed that the benefits of consistent responsible business increase firm competitiveness (Apospori *et al.*, 2012; Del Brío and Junquera, 2012; Lu *et al.*, 2016).

*2.2 Green innovation*

Chen *et al.* (2006) defined green innovation as physical and virtual innovation, in hardware or software, through the improvement of products and processes, considering technologies related to energy saving, pollution prevention, waste recycling, eco-friendly product design, the use of ecological packaging and the environmental management of the firm. Based on the above, there is a difference between a conventional innovation and a green innovation, being the latter driven by the need to comply with environmental regulations or meet the ecological concerns of the market (Bekk *et al.*, 2016). The study of green innovation is relatively new, and the literature has focused mainly on its definition and theoretical explanation (Hermundsdottir and Aspelund, 2021).

A conventional innovation generates value through efficiency, productivity or performance improvements. On the other hand, green innovation creates value by addressing environmental concerns of the market, industry, firm and/or consumers through products and processes (Albort-Morant *et al.*, 2017; Charmondusit *et al.*, 2016). There are two green innovation dimensions, namely, green product innovation and green process innovation. Green product innovation is about the application of innovative ideas aimed at the design, manufacture and strategic communication of new products, whose novelty and ecological design far exceed conventional products (Bhardwaj, 2016; Kam-Sing Wong, 2012). Green process innovation is related to energy saving, pollution prevention, waste recycling and nontoxicity (Chen *et al.*, 2006).

According to Boehe and Barin-Cruz (2010), attention to environmental impact allows product differentiation and improves internationalization opportunities in markets where green consumers are more active, thus improving market performance and business turnover in the long-term (Lu *et al.*, 2016). This is where the green innovation variable impacts competitiveness (Sellitto *et al.*, 2020). Innovation must create value, and for that it should unlock productivity gains, generating either higher margins, higher profits, greater value for stakeholders, higher market share, better corporate image, performance improvement in ecological terms or a combination of the above, leading to increased competitiveness (Bornschlegl *et al.*, 2016; Chen *et al.*, 2012; Tu and Wu, 2020).

Organizations are likely to invest in green innovations because they help develop opportunities for new markets and create a competitive advantage by positioning themselves as eco-friendly businesses (Chen *et al.*, 2006; Kam-Sing Wong, 2012). A successful green innovation benefits the firm by achieving greater efficiency and strengthening its eco-friendly image, ultimately contributing to higher profitability (Chen, 2008). Corporations that are pioneers in innovation, are likely to demand higher prices for green products, improve corporate image, better sell their environmental technologies or services and, eventually develop new markets to gain competitive advantage. Based on the above literature and the evidence provided, we developed our hypothesis:

*H1*. Green innovation is positively related to the competitiveness of companies in the Ecuadorian manufacturing sector.

*2.3 Research model*

Building on the literature reviewed and the hypothesis derived thereof, a research model (Figure 1) was developed, with two second-order constructs, by adapting elements of previous research, namely, competitiveness from Battaglia *et al.* (2014) and green innovation from Chen (2008), aiming to evaluate Ecuadorian managers' perceptions about the performance impact of green innovation and their judgment on how green innovation shape their firms' competitiveness.

The survey instrument assessed two competitiveness dimensions through:

(1) market performance, with four items; and
(2) intangible assets performance, with five items.

Finally, green innovation was measured through two dimensions:

(1) green product innovation, with four items; and
(2) green process innovation, with five items.

Control variables are introduced to better understand when and how green innovation might influence competitiveness. Three control variables were added:

(1) export capacity (*H2*), since it is necessary to develop competitive advantages to operate successfully in the global market (Galbreath, 2019);
(2) firm's age (*H3*); and
(3) administrative management (*H4*), as they are relevant for innovation and competitiveness (Younis *et al.*, 2020).

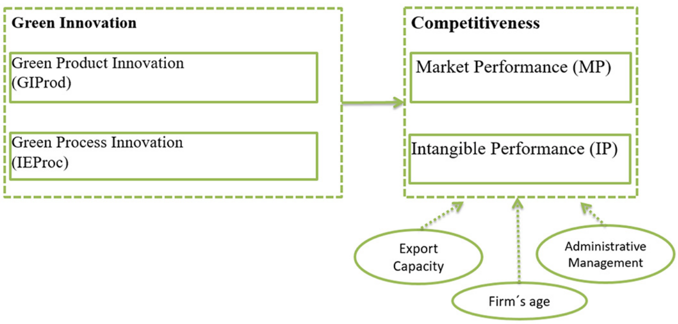
## 3. Methodology

Our research follows a quantitative paradigm, with deductive logic and causal scope. Indeed, quantitative methods were used to examine the link between green innovation and competitiveness. A pen-and-paper questionnaire was developed for data collection, and submitted to respondents who held managerial positions in manufacturing companies.

All items, except demographic information, were measured on a 5-point Likert scale, ranging from 1 for "strongly disagree," to 5 for "strongly agree," to evaluate green innovation and competitiveness dimensions over the period of five years and provide evidence on the effectiveness of their actions (Battaglia *et al.*, 2014; Kam-Sing Wong, 2012). As the items for each dimension were adapted from previous research, and modified to meet the needs of this study, a pretest, a pilot test, a confirmatory factor analysis (CFA) and Cronbach's alpha test were used to guarantee scale reliability.

### *3.1 Pretest and pilot test*

To validate the questionnaire's fit to the Ecuadorian context, with a native Spanish language, the original instrument was translated from English to Spanish, retranslated from Spanish to English by experts and then adjusted according to the needs of this research. However, as there




**Source:** Figure by authors

**Figure 1.**
Research model

were certain modifications in the writing and translation, a preliminary test was performed, to provide content validity and reliability of scales. The unknown terms for respondents were omitted, to keep simple, specific and concise questions, to reduce bias and minimize ambiguity.

In the preliminary test, five managers were invited to complete the questionnaire and interviewed by the researchers for approximately 20 min to gather their comments. Based on those comments, questions were reworded and redefined. Both the theory and the empirical evidence showed that the dimensions had an adequate model adjustment, revalidated in the confirmatory factor analysis (CFA). The refined questionnaire was tested with 30 manufacturing company managers. Respondents were asked to use a five-point scale to assess the frequency they adopt improvements in their products and processes related to green innovation in the past five years. They were also asked to evaluate competitiveness indicators in the past five years, using a five-point scale, to provide evidence on the effectiveness of green innovation actions on competitiveness variables. Results of the pilot test were satisfactory, fulfilling the first step for the application of structural equations.

*3.2 Sample*

Research conducted by Battaglia *et al.* (2014), Turyakira *et al.* (2014) and Kam-Sing Wong (2012) suggested studying manufacturing in areas other than the production of technological items and textiles, since those sectors have traditionally received more attention due to their usually higher environmental impact. Therefore, manufacturing companies (European Classification of Economic Activities code C) that most contribute to the Ecuadorian Gross Domestic Product were considered, such as those related to the production of food and beverage products (C11 and C12), chemical-pharmaceutical substances (C20 and C21) and rubber and plastic products (C22), adding up to 2119 companies. According to data sourced from the INEC of Ecuador (INEC, 2020), manufacturing makes a significant contribution to the country's GDP, with an average share of 14% over the past five years. In addition, the report states that the manufacturing industry production index has experienced a steady increase of 41.76% in the period 2015–2020, with the remarkable performance of some sectors, including food and beverage products, chemical-pharmaceutical substances and rubber and plastic products, as driving factors (Kam-Sing Wong, 2012).

The study was carried out in the city of Guayaquil, where 50.4% of the country's manufacturing companies – and all of the relevant industries mentioned above – were located. Surveys were conducted in late 2018, with prior consent from respondents, who assessed CSR initiatives and green innovation practices implemented by their firms in the past five years. A stratified sampling was applied, using the formula for finite populations. We randomly sampled 400 companies. The questionnaires were answered by a mix of e-mail, telephone and face-to-face interviews. After the data exploration process, we obtained 325 valid responses (81.25% rate). To minimize common method bias, we compared e-mail, telephone and face-to-face responses, revealing no systematic differences in the measurements.

The majority of respondents represented companies from the food and beverage industry (60% or 193/325), followed by chemical-pharmaceutical (25% or 82/325) and rubber and plastic (15% or 50/325). Participants were mostly middle-level managers (58% or 187/325), followed by senior managers (42% or 138/325). The data were, therefore, sourced from seasoned managers with full command of operations and having relevant technical expertise so as to properly assess the interplay of the variables in the model. Moreover, 45% of the firms have more than 20 years in business (147/325), followed by 17% operating between 16 and 20 years (54/325). In terms of headcount, 35% have between 10 and 45 employees (115/325), followed by 25% employing between one and nine workers (80/325) and 20% between 50 and 100 workers (65/

325). A mean difference test was performed to determine if observations from different sectors belong to the same population. No significant differences were found.

## 4. Results

Data analysis was conducted in two phases. First, a CFA with AMOS 9.0 was performed on the questionnaire data to examine model fit and assess construct validity and reliability. Finally, structural equation modeling (SEM) was used to test the hypothesis (see Appendix). Reliability was assessed using Cronbach's alpha and average variance extracted (AVE) values.

### *4.1 The measurement model*

A measurement model was developed to verify model fit and obtain the standardized loadings across dimensions and their items, and between each pair of dimensions. Before computing estimates through SEM, it is important to test whether the measurement model is acceptable, by conducting a CFA. The measurement model was estimated using the maximum likelihood method. Correlations between each pair of dimensions were in the range between 0.30 and 0.64. Factor loadings were in the range between 0.75 and 0.93, significant at $p < 0.001$. Indices such as degrees of freedom = 71, the normed chi-square statistic ($\chi^2$/df) = 2.24, the comparative fit index (CFI) = 0.974, the standardized root mean squared residual (SRMR) = 0.053 and the root mean square error of approximation (RMSEA) = 0.062, evidenced that data presented a good fit. Cronbach coefficients were in the range between 0.89 and 0.91, which were higher than the 0.7 convenience level suggested by the literature. AVE values were in the range between 0.69 and 0.73, exceeding the 0.5 acceptance limit, which indicated that the variations captured by the questionnaire items were much higher than the variation caused by the measurement error (Raykov, 2012).

Table 1 shows the summary of CFA results for the two dimensions of green innovation. Factor loadings were in the range between 0.76 and 0.93, significant at $p < 0.001$. The degrees of freedom = 26, the normed chi-square statistic ($\chi^2$/df) = 2.40, the CFI = 0.984, the SRMR = 0.047 and the RMSEA = 0.066, showed satisfactory goodness-of-fit indices. The correlation between product and process green innovation was 0.611, below 0.85, which reveals no multicollinearity (Table 4). AVE from the global model was 0.72. Cronbach's alpha values for all dimensions were greater than 0.5, and 0.924 for the entire model, reinforcing reliability.

Table 2 presents a summary of CFA results for the two dimensions of competitiveness, i.e. market performance and intangible assets performance. With maximum likelihood model estimation, the correlation between both dimensions was 0.564 (Table 4) and the factor loadings were in the range between 0.74 and 0.93, significant at $p < 0.001$. The data showed satisfactory goodness-of-fit indices (CFI = 0.979, SRMR = 0.058, RMSEA = 0.073). The $\chi^2$ statistic was 70.40 with 26 degrees of freedom ($p < 0.001$), giving a $\chi^2/df$ ratio of 2.708, below the limit of five, which indicated a good model fit. Cronbach's coefficients were 0.896 and 0.919, respectively, higher than the 0.7 limit. AVE values were 0.705 and 0.693, indicating that the variations captured by the questionnaire items were much higher than the variation caused by the measurement error (Table 3). In summary, the results of all previous tests evidenced adequate reliability and validity of the questionnaire items and dimensions.

Green innovation showed a Cronbach's alpha of 0.924, and competitiveness an alpha of 0.913. According to these results, reliability and validity are adequate. In addition, we applied the Fornell and Larcker measure of the AVE, to assess discriminant validity. To satisfy the discriminant validity requirement, the AVE square root of a latent variable must be greater than the correlations between dimensions in the model. All AVE square roots in Table 3 were

| Factor/items | | Factor Product innovation | Process innovation |
|---|---|---|---|
| *Green product innovation* | | | |
| INN41 | Ecological packaging | 0.922 | |
| INN42 | Product recycling | 0.766 | |
| INN43 | Recycled materials | 0.842 | |
| INN44 | Recyclable materials | 0.885 | |
| *Green process innovation* | | | |
| INN45 | Use of resources | | 0.792 |
| INN46 | Green production system | | 0.932 |
| INN47 | Renewable technology | | 0.813 |
| INN48 | Environmental efficiency | | 0.901 |
| INN49 | Environmental guidelines | | 0.763 |

**Note:** $N = 325$
**Source:** Table by authors

**Table 1.** Confirmatory factor loadings of green innovation questionnaire items

| Factor/items | | Factor Market performance | Intangible performance |
|---|---|---|---|
| *Market performance* | | | |
| COMP30 | Turnover | 0.856 | |
| COMP31 | Demand traditional customer | 0.913 | |
| COMP32 | Demand new customer | 0.809 | |
| COMP33 | Business attraction | 0.743 | |
| *Intangible performance* | | | |
| COMP36 | Personnel motivation | | 0.816 |
| COMP37 | Personnel productivity | | 0.760 |
| COMP38 | Reputation | | 0.930 |
| COMP39 | Stakeholders | | 0.885 |
| COMP40 | Relation with credit | | 0.794 |

**Note:** $N = 325$
**Source:** Table by authors

**Table 2.** Confirmatory factor loadings of competitiveness questionnaire items

greater than correlations between all dimensions in Table 4. Thus, discriminant validity was acceptable.

### *4.2 The structural model*

With the measurement models (CFA) of second-order constructs, the next step was to perform the evaluation of the structural model (Appendix). Table 5 reports the results and the structural path estimates. Measures indicated that goodness-of-fit of the complete model is acceptable ($\chi^2$/df = 1.54, CFI = 0.97, SRMR = 0.07, RMSEA = 0.041). In addition, all estimated paths were significant and supported the hypothesis of this study, suggesting convergent validity. The expected positive impact of green innovation on competitiveness (*H1*), as a second-order construct, was supported by their significant standardized estimates of 0.545 ($p < 0.001$). We found that the application of green product and process innovation, increase the market and intangible assets performance of manufacturing organizations, verifying the causal relationships proposed in this study.

The export capacity variable (*H2*) also presented a significant coefficient in the proposed structural model, while no statistical significance was found in the coefficients of the other control variables (*H3* and *H4*).

## 5. Discussion, implications and limitations

Our study arguably contributes new evidence on the causal relationship between green innovation and competitiveness, in the context of Ecuadorian manufacturing.

Findings on the relationship between green innovation and competitiveness (*H1*), show a positive and significant value, in line with previous studies which stated that most firms initially choose to be green to capture short-term savings, to later scale up those initiatives for strategic considerations (Albort-Morant *et al.*, 2017; Kam-Sing Wong, 2012). For this reason, companies invest in green innovation because "being greener" helps them develop new market opportunities, increase their productivity and competitive advantage (Chen *et al.*, 2006). As Ghisetti and Rennings (2014) stated, green process and product innovations could lead to a reduction in energy use and resources, increasing productivity and, by extension, profitability. Hence, both theory and empirical evidence, suggest that green

**Table 3.** Dimensions' Cronbach's $\alpha$ coefficients and AVEs

| Constructs | Cronbach's $\alpha$ | AVE | The square root of AVE |
|---|---|---|---|
| Green innovation | 0.924 | 0.720 | 0.849 |
| Product innovation | 0.913 | 0.710 | 0.843 |
| Process innovation | 0.923 | 0.732 | 0.856 |
| Competitiveness | 0.913 | 0.700 | 0.837 |
| Market performance | 0.896 | 0.705 | 0.840 |
| Intangible performance | 0.919 | 0.693 | 0.832 |

**Source:** Table by authors

**Table 4.** Correlations among dimensions

| Dimension | | Dimension | Estimate |
|---|---|---|---|
| Product innovation | ↔ | Process innovation | 0.611 |
| Market performance | ↔ | Intangible performance | 0.564 |

**Source:** Table by authors

**Table 5.** Structural path estimations

| Path from | Path to | *H* | Result | SE | *p*-value |
|---|---|---|---|---|---|
| Green innovation | Competitiveness | *H1* | Supported | 0.545 | *** |
| Export capacity | Competitiveness | *H2* | Supported | 0.137 | *** |
| Firm age | Competitiveness | *H3* | Not supported | −0.041 | |
| Administrative management | Competitiveness | *H4* | Not supported | 0.040 | |

**Note:** ***$p < 0.001$
**Source:** Table by authors

innovation helps companies achieve greater efficiency, establish and strengthen their skills, improve their image and altogether contribute to profitability. It would also allow them to evolve as an organization and ensure a more sustainable future for next generations.

Our empirical results suggest that export capacity (*H2*) could play an important role in inducing companies to embrace both the green process strategy and the innovation of organic products, since operating successfully in the global market requires the adoption of competitive advantages (Alarcón and Sánchez, 2016).

Our review of the literature suggests an incomplete understanding of how green innovation impact on competitiveness across different industries, notably so in manufacturing companies. We found that green practices contribute to improved financial results and competitiveness in international markets, as consumers increasingly screen for and reward green processes behind the products they acquire and the services they receive, even over perceived quality and price. Such evidence has been reported in multiple studies across industries in both developed and developing economies (Antonietti and Marzucchi, 2014; Battaglia *et al.*, 2014; Carrillo-Hermosilla *et al.*, 2010; Charmondusit *et al.*, 2016; Chen, 2008; Ghisetti and Rennings, 2014; Lu *et al.*, 2016; Tomšič *et al.*, 2015; Turyakira *et al.*, 2014). Thus, this research arguably contributes to narrowing the existing knowledge gap, claiming that green innovation positively and significantly impacts on manufacturing competitiveness in a developing market setting, shedding light on the relevance of stakeholder theory as grounded in the statistical analysis of our structural equation model.

Several implications are derived from our findings. From a business perspective, prioritizing the introduction of ecologically innovative initiatives should be widely considered as part of the long-term planning to gain and sustain competitiveness. Organizations should also revisit the misconception around these practices being an expense, when they are arguably an investment that ensures the continuity and sustainability of the firm. Green practices contribute to ethical and responsible organizational behavior, which does not contradict the maximization of wealth, yet for stakeholders at large. As for the public sector, regulators could provide incentives and develop policies for firms to adopt sustainable practices and green innovations likely to improve their competitiveness, and unleash a ripple effect through the supply chain, aggregating up to the industry, regional and national levels.

Additionally, our research contributes to shed light on the impact of green process and product innovations on social and environmental performance, providing evidence on the more efficient use of energy and natural resources, increasing productivity and by extension, profitability. Moreover, we have broadened the comparative assessment of our findings relative to other emerging markets, highlighting that the relative weight of the manufacturing sector in the Ecuadorian economy amplifies the impact of green innovation on firm-level competitiveness. The implications for internal and external stakeholders are described in Table 6.

Limitations to this study should be highlighted. The scope of the survey was Ecuadorian manufacturing firms, purposely so, hence results cannot be generalized to the entire Latin American context nor to developing countries as a whole. Conversely, this would open up the opportunity to extend or replicate this research in other markets.

Another relevant limitation was the nature of our quantitative approach. In the future, similar studies could be conducted, or added, so as to achieve a better understanding of the patterns and dynamics between constructs over time. Future research could consider other variables that may drive competitiveness, such as business environment, green leadership, environmental culture and environmental capacity at the firm level. Another construct that could be included is green supply chain management, relating to corporate practices geared toward optimizing the transactional and cooperative interface with suppliers and clients, as

| Stakeholder | Implications |
| --- | --- |
| Employees | • Firms with a sustainable approach are likely to attract purpose-driven skilled workers, while reinforcing human capital retention<br>• As a result of being green, firms would be set to attract and retain employees who identify themselves with the corporate purpose |
| Owners | • Green practices contribute to improved financial results and competitiveness in international markets<br>• Export capacity could play an important role in embracing green process strategy in global markets<br>• Investments in green innovation generate short-term savings and eventually unlock further (strategic) value once scaled |
| Managers | • Green innovation embedded in long-term planning generates competitive benefits<br>• Green innovation helps to develop new market opportunities, increase productivity and competitive advantage<br>• Export capacity could play an important role in embracing green process strategy in global markets<br>• Green innovation increases organizational competitiveness by reducing risks and cost structures over time |
| Customers | • Consumers increasingly screen for and reward green processes and products<br>• Consumers have been more aware of the environmental impact of human activities, so they are likely to adopt a more critical, environmentally- and socially-driven behavior<br>• Consumers are more aware of the environmental impact of human activities, which is why they adopt a more critical behavior when purchasing, choosing product upon weighing their environmental and social footprints |
| Suppliers | • By optimizing processes and resource allocation and use, suppliers with green and sustainable processes will benefit by tapping into new market opportunities<br>• To improve product innovation processes, suppliers with green practices will be favored along the supply chain |
| Investors | • Research unveiling the positive relationship between green innovation and competitiveness contributes to further encourage firms to invest in greener process and product R&D, with the expected positive impact on profitability and long-term competitiveness<br>• Businesses with a positive image and better returns than their competition are attractive to investors |
| Media | • Green practices improve the image of the firm by including sustainable processes in its products<br>• By generating activities and products beneficial to the community, favorable media coverage is likely in this type of business |
| Communities | • Green innovation fuels the evolution of the organization to ensure a more sustainable future for next generations<br>• Communities benefit from the reduction of negative externalities of manufacturing firms on both society and the environment |
| Government | • The government can offer incentives and develop policies for firms to adopt sustainability practices, eventually improving all players along the supply chain<br>• Green innovation can elevate strategic planning at the firm and national levels through policies that encourage sustainable green growth |

**Note:** R&D = Research and development
**Source:** Table by authors

**Table 6.**
Main implications of the research for the different stakeholders

CSR and green innovation are likely to deliver impact and sustainable competitiveness when carried along the (entire) supply chain. These actions involve supplier selection, aiming at a more reliable environmental performance and the development of shared improvement projects.



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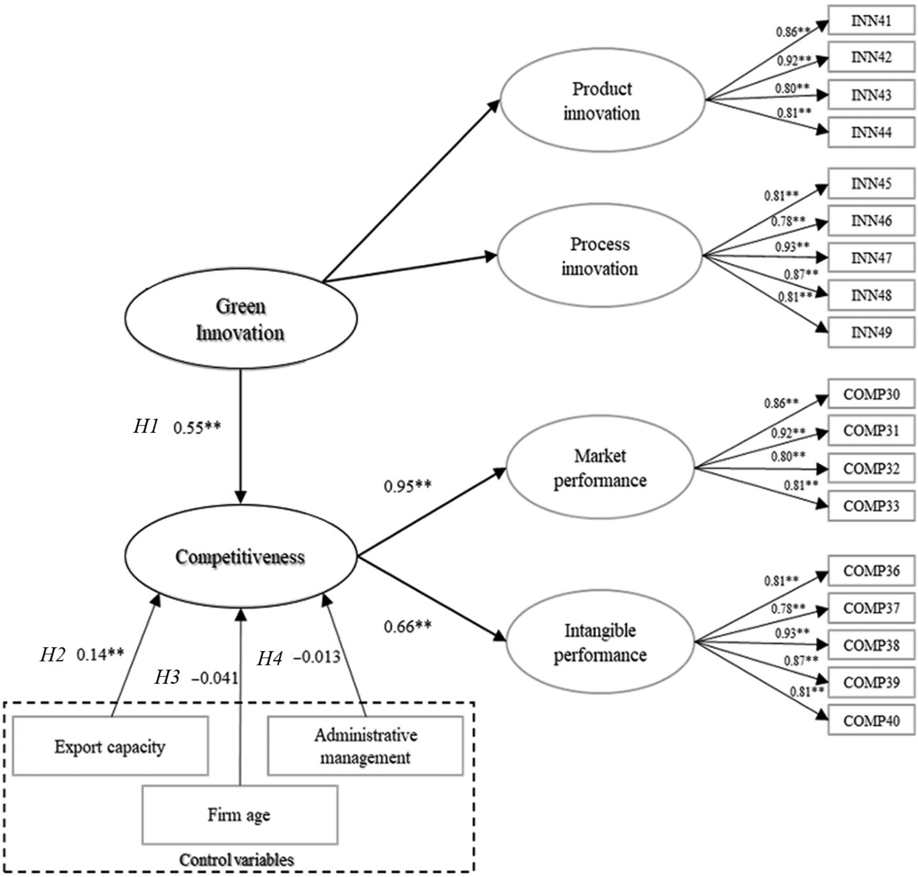
## Appendix




**Notes:** *$p < 0.05$; **$p < 0.01$
**Source:** Figure by authors

**Figure A1.**
Results of the structural model

## About the authors

Carmen Paola Padilla-Lozano PhD in Strategic Business Administration. Research Professor at ECOTEC University, Ecuador. Professional and academic experience in Ecological Innovation, Competitiveness and Social Entrepreneurship with emphasis on the Manufacturing Sector and industries with competitiveness potential like Aerospace Technology Transfer.

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