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*Research article*

# Green innovation mediates between financial innovation and business sustainability? Proof in the mexican manufacturing industry

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**Abstract:** Recent studies have shown that the lack of environmental regulations in public administrations, the inability of employees to innovate knowledge and skills, the high price of green technologies, and the lack of environmental awareness in organizations are the biggest threats to the environmental and sustainable development. In this context, manufacturing companies in emerging markets should not only focus on achieving a higher level of business sustainability in economic and financial terms, but also pay attention to financial and green innovation, because they are important ways to achieve a green transformation of businesses, to improve sustainability, and to reduce carbon dioxide emissions. This study provides data on the adoption and repercussions of these activities on the sustainability of manufacturing companies in Mexico. The proposed research model was validated by applying partial least squares structural equation modeling (PLS-SEM) on a sample of 338 companies. The results of the study showed that the business sustainability of manufacturing companies significantly improved through the application of financial and green innovation. In addition, the results of the study showed that green innovation plays the role of a mediating variable in the relationship between financial innovation and corporate sustainable development.

**Keywords:** financial innovation; green innovation; business sustainability; manufacturing industry

**JEL Codes:** G15, F36, C40

## 1. Introduction

It is recognized in the literature that the central goal of all manufacturing firms around the world is to improve their economic and financial performance (Mohd et al., 2022), which should be accompanied by business sustainability (BS) and long-term business success (Ahmed et al., 2020; Shahzad et al., 2021). Currently, this issue has received increasing attention, especially the environmental pollution caused by the manufacturing industry, which affects the global society and ecology (Yusliza et al., 2020; Sun et al., 2022a). Commonly, manufacturing firms in countries such as Mexico have ignored the negative environmental and social impacts of transforming their resources into products for the benefit of their economic profits (Najmi et al., 2019; Shahzad et al., 2021).

Similarly, the adoption of financial innovation (FI) and green innovation (GI) by manufacturing firms in emerging markets will enable them to improve their BS (Sonmez & Adiguzel, 2022), especially since FI plays a vital role in promoting GI and development as well as boosting the GI efficiency (Yuan et al., 2021). In addition, FI bottle help firms ease any financial constraints by creating more GI-enhancing loans (Huang et al., 2019a; Tariq et al., 2019; Qu et al., 2020). Moreover, FI in the literature is considered to be an important factor not only in improving BS levels (Sonmez & Adiguzel, 2023), but also in GI development (Yuan et al., 2021), mainly because FI has completely changed the way business financial transactions are conducted (Nejad, 2022). Additional examples include mobile banking, online payment systems, virtual currencies, robo-advisors, and peer-to-peer lending (Nejad, 2022).

Although some studies published in the literature have shown that FI has a positive impact on BS (Castelli, 2019; Huber, 2020; Biswas, 2020), and GI (Tariq et al., 2019; Pham, 2019; Qu et al., 2020), and that GI has a positive impact on BS (Cai & Li, 2018; Zhang et al., 2019; Ahmed et al., 2020), there are contradictory results, which indicates that there is controversy among FI, GI, and BS (Sonmez & Adiguzel, 2022). Sonmez and Adiguzel (2022, 2023) argued that due to the relatively few empirical studies on the existing impact of FI on GI and BS in the literature, the scientific, academic, and business communities must focus future research on providing reliable empirical evidence, thereby demonstrating the consistency of results among the three constructs, especially when GI is used as a mediating variable between FI and BS (Sonmez & Adiguzel, 2023).

In this sense, the aim of this study is to analyze and discuss the relationship between FI and GI in the context of BS, as well as the mediating role of GI on the relationship between FI and BS in manufacturing companies. To achieve this goal, we will conduct an empirical study on manufacturing firms in Mexico, with a sample of 338 companies. The research model is estimated using the partial least squares structural equation modeling (PLS-SEM) (Ringle et al., 2022). It is worth noting that manufacturing firms are interesting in two fundamental aspects: on the one hand, the manufacturing industry in Mexico is generally incompatible with sustainable development (Scur et al., 2019); and on the other hand, the manufacturing industry traditionally causes the highest environmental pollution (Farkavcova et al., 2018).

In particular, the Mexican manufacturing industry is responding to nationwide shifts towards eco-friendly products and production, thereby leading to the adoption of green strategies (Rodríguez-González et al., 2022). In Mexico, the manufacturing industry represents a third of all existing companies, generates a third of the total employment, and contributes to 18% of the national gross domestic product (GDP) (Statista, 2023). These data indicate that manufacturing

industry plays an essential role in advancing green production in developing economies (Le, 2022). However, as noted by Lepistö et al., despite the pivotal role of the manufacturing industry in both the economic and environmental spheres, they face many difficulties in determining the benefits of the necessary investments to obtain the ideal business sustainability performance (2023).

Moreover, the outcomes of implementing a green business strategy in developing economies depend on the extent of its implementation (Lin et al., 2021). Thus, the Mexican manufacturing industry has not yet recognized the opportunity to implement green practices through GI, GF, and BS (INEGI, 2023). In this sense, there is a notable dearth of empirical studies that addressed green actions at the strategic level and their BS performance for decision-making process in the Mexican manufacturing industry (Lopez-Torres, 2023; Maldonado-Guzán et al., 2020; Ortiz-Palafox, 2019; Rodríguez-Espíndola et al., 2022). The Mexican manufacturing industry must provide sustainability green solutions, even with limited resources, as Rodríguez-Espíndola et al. (2022) affirmed.

Furthermore, given the increasing preference of consumers and businesses for mobile and contactless payments (Bond, 2020; Mckinsey, 2020; Streeter, 2020), there is a need to develop an analysis with risk assessment methods to integrate FI, GI, and payment methods in manufacturing organizations (Nejad, 2022; Sonmez & Adiguzel, 2022, 2023), especially in the manufacturing sector of emerging economies (Yuan et al., 2021). Therefore, this study will contribute to the literature in understanding the state of knowledge, understanding and overcoming the challenges of connecting FI and GI to improve BS in manufacturing firms, and providing strong empirical evidence to address inconsistencies in the results to significantly improve on previous empirical studies published in the literature (Sonmez & Adiguzel, 2023).

## 2. Literature review

This empirical study is embedded in the Natural Resource Based View (NRBV) (Hart, 1995) and the Resource Based View (RBV) (Barney, 1991), which is essentially based on the management and efficiency of resource development to achieve a competitive advantage and to improve business performance (Mohd et al., 2022). Therefore, according to the NRBV, manufacturing companies should not pursue a high performance at the expense of environmental degradation (Hart, 1995); however, they should incorporate environmental and sustainable development elements into the design of business strategies, which obviously helps to achieve the goal of improving business performance and gaining a competitive advantage (Rehman et al., 2021).

In addition, NRBV helps manufacturing companies improve their ability to develop and optimize industrial processes, which is reflected not only in reducing the pollutant emissions and production costs (Hart, 1995), but also in improving the efficiency and the company's strategic initiative to protect the environment and sustainability (Shahzad et al., 2021). In addition, NRBV helps the manufacturing firms to examine how their available resources can improve their competitive advantage without harming the environment, which can be achieved by considering resources that are not controlled by the company, such as BS (Anderson, 2021). Therefore, NRBV supports our argument that manufacturing companies with higher levels of FI and GI are more likely to have higher levels of BS (Mohd et al., 2022).

### *2.1. Financial innovation and business sustainability*

The emergence of the FI concept in the literature in the early 1960s led to significant changes in the financial landscape of manufacturing firms and countries (Sonmez & Adiguzel, 2023). However, the importance of this concept began to attract scientific and academic interests in the late 1970s, when it gained a prominent position in financial markets (Tufano, 2003). In addition, the rapid increase in competition, technological developments, new investment and savings systems, profit maximization, and changes in consumption habits played crucial roles in the development of the financial concept (Maingi et al., 2013), especially because of fundamental increases to the BS. The purpose of FI is to reduce environmental regulatory costs and change the image of investors through new financial products, which not only reduces the financial costs, but also increases the BS (Arnold et al., 2021).

In this sense, studies published in the literature showed a positive relationship between FI and BS (Nejad, 2022), especially because FI created various opportunities for manufacturing firms in terms of development and expansion of the market by either acquiring new customers or offering new services and better satisfying customer needs (Nejad, 2022), thus increasing sales, profits, growth and BS in the long run (Scott et al., 2017). However, there are also studies that found a negative relationship between FI and BS (e.g., Gennaioli et al., 2012; Leaven et al., 2015; González et al., 2016), especially because some researchers and scholars believed that FI predatory practices harmed consumers because they were difficult to understand and could lead to lower credit standards and higher delinquency rates (Gathergod & Weber, 2017).

To provide solid empirical evidence for the relationship between FI and BS, Nejad (2016) found that the introduction of FI in manufacturing companies improved financial inclusion, especially in developing countries, by developing new financial services such as mobile banking that offered better benefits, including BS. Scott et al. (2017) found that the introduction of FI led to various customers of manufacturing firms shifting their bank deposits to new financial services, which improved the BS of the organization in the long run. Streeter (2020) concluded that the introduction of FI enabled companies to make customers feel better about paying for products or services using mobile applications, which led to a higher BS. Sardon (2020) argued that the use of information technology available in the financial system of an organization significantly improved the BS level of the organization.

In a recent study, Nejad (2022) found that 88% of consumers expected manufacturers from whom they bought products and services to provide at least the same level of personalization as Amazon and Netflix. This is why consumers prefer to pay via mobile apps, which leads to higher levels of BS for companies. Therefore, considering the information provided previously, the following research hypothesis can be proposed.

*H1: The greater the application of innovation in finance, the greater business sustainability*

### *2.2. Financial innovation and green innovation*

The literature argues that FI is a key factor to improve the environmental and socio-economic development of manufacturing enterprises and countries (Hu et al., 2021), especially when FI promotes technological innovation and the large-scale production of environmentally friendly products, thus leading to GI activities (Akram et al., 2020; Li et al., 2020). However, it is often found in the literature that GI activities are generally characterized by a high input, a high risk, and long cycles (Liu & Wang, 2023). Using credit default swaps (CDS) as a proxy service for FI, Chang et al.

(2019) studied the impact of CDS on the GI of manufacturing enterprises, and found that CDS increased the willingness of financial intermediaries to provide preferential interest rate loans for organizational innovation projects and innovation promotion, thereby improving the GI.

Similarly, there are various published studies in the literature that analyzed the impact of FI on pollutant emissions and the energy consumption of manufacturing efirms (e.g., Yue et al., 2019; Wang et al., 2020a; Acheampong et al., 2020; Anees et al., 2021); however, few published studies in the literature focused on analyzing the relationship between FI and GI (Yuan et al., 2021). Noailly and Smeets (2016) used a database of 1300 European companies between 1995 and 2009, and found that FI was an important factor that positively affected GI; alternatively, Kim and Park (2016) used a database from 30 companies between 2000 and 2013, and found that financial institutions could increase the number and preferential terms of loans to promote the GI of manufacturing firms. Tariq et al. (2019) found a mutual causal relationship between the FI and green technology (GI) in European manufacturing enterprises.

Furthermore, Pham (2019) found that FI could improve the green technology (GI) and that its positive impact was greater in countries with higher pollution levels. Huang et al. (2019b) found a positive impact between the IF and GI, while Yu et al. (2021) analyzed the impact of FI on GI in Chinese manufacturing companies and found a positive impact between the two concepts. In recent studies, Zhou and Li (2022) found a positive correlation between FI and the use of renewable energy (GI). Ronaldo and Suryanto (2022) concluded that intermittent interval training is essential to improve GI. Naeem et al. (2022) found that financial investments have a positive impact on GI in the agricultural and energy sectors. Finally, Liu and Wang (2023) analyzed the impact of FI on GI in Chinese manufacturing companies and found that FI has a significant positive impact on GI activities.

In this context, it is generally accepted in the literature that financial institutions are the key means to achieve significant improvements in GI activities, thus suggesting the need to diversify credit resources from manufacturing firms with high pollution and energy consumption to those with low pollution and high energy consumption, and low energy consumption and a respect for the environment (GI) (Sachs et al., 2019; Liu et al., 2021). Therefore, taking the information that was previously provided into account, the following research hypotheses can be proposed.

*H2: The greater the application of innovation in finance, the greater green innovation*

### *2.3. Green innovation as a moderating variable*

A large number of recently published studies indicated that environmental and sustainable development issues have received increased attention from the scientific, academic, and business communities (e.g., Sun et al., 2022a; Shahzad et al., 2022). These studies identified some of the main causes and solutions to improve the environmental quality (Mohd et al., 2022), including companies switching to renewable resources (Anwar et al., 2021), providing innovative and eco-friendly products to consumers (Ahmed et al., 2020; Shahzad et al., 2022), and introducing geographical indication initiatives in the production process (Ahmed et al., 2020). In this sense, geographical indication initiatives are considered in the literature as important activities to improve the operating performance of manufacturing companies (Jin et al., 2022; Sun et al., 2022a), especially in developing and emerging countries (Ali et al., 2021).

In this context, GIs are considered in the literature as a fundamental driver fto improve the BS level of manufacturing firms (Yousaf, 2021), especially because GI help organizations reduce environmental pollution by producing ecological products and services (Shahzad et al., 2021). In addition, Jin et al. (2022) believe that GI usually includes green product innovation and green process innovation, which leads to a significant increase in the BS (Sun et al., 2022b). However, there are differences in the results on the improvement of BS (Mohd et al., 2022). For example, Jiang et al. (2018) found that GI had a negative impact on BS based on a survey of Chinese manufacturing firms, while Stucki (2019) found that only a small number of manufacturing companies achieved significant improvements in BS, while about 81% of companies achieved negative results.

To demonstrate the relationship between GI and BS, Huang and Li (2017) found that manufacturing companies that invested in GI activities not only increased productivity by minimizing industrial waste, but also improved the BS, while Li et al. (2017) found that GI had a significant positive impact on BS through green product innovation. Saunila et al. (2018) concluded that GI reduced the production costs and pollutant emissions, thereby increasing the BS. Xie et al. (2019) found that GI practices had a significant positive impact on the competitive advantage and BS, while Fernando et al. (2019) found that manufacturing companies that adopted GI not only reduced the negative impacts on the environment and industrial waste, but also significantly improved the BS level.

Generally speaking, the use of environmentally friendly products and technologies in GI activities provides two key advantages to manufacturing companies: on the one hand, environmentally friendly products provide a commercial advantage over the main competitors; and on the other hand, it improves the economic and financial performance, which in turn increases the company returns (Albort-Morant et al., 2016). Therefore, considering the information provided in the previous paragraphs, the following research hypothesis can be proposed.

*H3: The greater the application of green innovation, the greater business sustainability*

In the literature, few published studies have analyzed GI as a mediating variable. For example, Gürlek and Tuna (2018) found that GI has a mediating effect between entrepreneurial orientation and BS, while Dulca et al. (2018) found that GI has a positive mediating effect on the relationship between entrepreneurial orientation and firm performance. Fatoki (2021) analyzed the mediating role of GI in the relationship between entrepreneurial orientation and competitive advantage, and Astuti and Datrini (2021) found that GI can be regarded as a mediating variable between environmental pressure and BS. However, analyses of GI as a mediating variable between IF and BS are relatively rare (Zhang et al., 2023); therefore, it can be found that GI can be considered as a mediating variable that has a positive impact on the relationship between FI and BS (Qiu et al., 2020; Li et al., 2023).

In this context, the literature assumes that manufacturing firms that use geographical indications for product development and the implementation of environmental practices can act as a mediating variable between FI and BS (Zhang et al., 2023). Moreover, companies that adopt GIs not only increase their FI (Chen et al., 2018a, b), but also increase their BS levels when it acts as a mediating variable (Al-Batayneh et al., 2021). In a recent study, Jahanger et al. (2022) studied how green technology (GI) affected the environmental footprint of 73 emerging economies during the period 1990–2016, and concluded that GI could act as a mediating variable between financial performance and BS through the use of natural resources. On the other hand, Wang et al. (2021) analyzed the relationship between green technology (GI) and environmental performance in 28 provinces in China during 2000–2018, and concluded that GI had a positive impact on financial performance and sustainability.

Abbasi et al. (2021) analyzed the relationship between green technology (GI) and the pollutant emissions of consumer products in Pakistani manufacturing firms, and found that GI could significantly reduce the pollutant emissions by mediating the financial and sustainable development outcomes. Similar results were obtained by Zhao et al. (2021), who used a data panel of 62 countries from 2003 to 2018 to analyze the financial institution risks and the corporate sustainable development outcomes through the mediating role of green technology (GI); they found that when green technology acted as a mediator, the financial institutions achieved better sustainable development returns. Finally, Sonmez and Adiguzel (2023) analyzed the mediating role of GI strategy in the relationship between FI and BS, and found that the BS level was much higher when GI was used as a mediating variable. Therefore, considering the information provided in the previous paragraphs, the following research hypothesis can be proposed.

*H4: Green innovation acts as a mediating variable between innovation in finance and business sustainability.*

Figure 1, which is presented below, shows the approach of the four hypotheses in the research model.

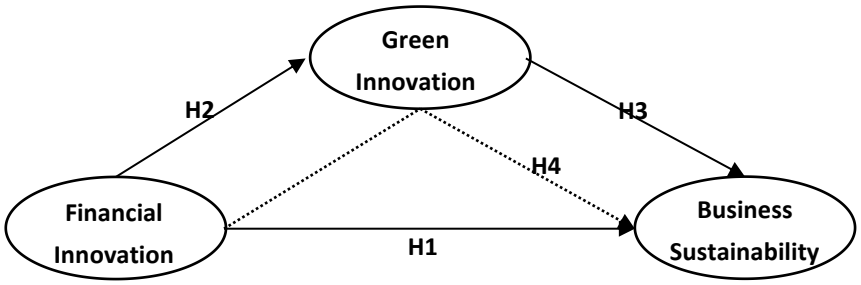


**Figure 1.** Research model.

## 3. Methodology

The National Statistical Directory of Economic Entities was used as the reference framework in this study, which covers 36,800 manufacturing companies in 2021 (INEGI, 2021). The manufacturing companies that participated in the study were selected through simple random sampling with a maximum error of ±5%, a significance level of 95%, and a sample of 280 companies. On the one hand, a "business forum" was held, with the participation of five entrepreneurs of manufacturing companies, two representatives of government agencies related to the financial support of enterprises, and three academics in the field of innovation, to whom the questionnaire was submitted for analysis and discussion.

On the other hand, the results obtained in the first phase made it possible to design an information collection survey, which was applied to a pilot sample of ten manufacturing entrepreneurs, with minor adjustments to the font, appearance, and spelling. Pilot studies are essential to ensure the validity when the survey is either self-administered or contains a self-developed scale (Hair et al., 2016). The survey used to collect the information was sent to 500 manufacturing companies in eight large states that were home to 90% of the country's manufacturing. Only 308 surveys were conducted, which made the final sample representative of the study population. In addition, the survey was conducted from February to May 2021 and was distributed to business leaders who identified the people in their organization who should answer the different

questions asked in the survey.

A comprehensive literature review was conducted to identify the most appropriate scales to measure the FI, GI, and BS. The Mbogoh (2013) scale was used to measure the FI, which uses 7 items to measure this concept. One of the recurring issues in the innovation literature is the question of how to measure GI (Zhang et al., 2019). To this end, Kemp and Pearson (2008) conducted an extensive literature review and found that GI is usually measured using 7 items. This study also adopted these 7 items to measure the GI. The scale of Ullah et al. (2021a) was used to measure the BS, who used 4 items. The use of these three scales was considered relevant, especially because these scales were tested in manufacturing firms in developing countries. All items on the scales were measured using a five-point Likert scale with a cut-off of 1 = strongly disagree and 5 = strongly agree.

In this study, the use of composite models was considered relevant, which was the key reason for using the SmartPLS 4.0 software (Ringle et al., 2022) for the partial least squares structural equation modeling (PLS-SEM) (Sarstedt et al., 2016), because the composite indicator is considered in the literature as an operational definition of an emerging construct that mediates all the effects of the model, and the components measured by the composite indicator have no error terms (Hair et al., 2021). To estimate the path model, PLS-SEM usually uses either Model A or Model B: Model A refers to the correlation weights derived from the bivariate correlations between each indicator and the construct, while Model B refers to the regression weights (Sarstedt et al., 2016). We used Model A in this study.

Table 1 shows the items of the three measurement scales used in this empirical study, which indicates that the values of the factor loadings of all the items are higher than the recommended value of 0.60 (Hair et al., 2019). Additionally, the values of Cronbach's Alpha, Dijkstra-Henseler rho, and the Composite Reliability Index (CRI) are higher than the value of 0.70, while the values of the Average Variance Index (AVE) are higher than the value of 0.50, both of which are recommended by Hair et al. (2019), which provides indications that the items are indeed measuring each of the three concepts.

Furthermore, since the data were collected using the same instrument and were applied to the same informants (company managers), there may be endogeneity and bias that could alter the responses and lead to either type I (false positive) or type II (false negative) errors. The assessment of the common method variance (CMV) was conducted according to Podsakoff et al. (2012) recommendatios. Traditionally, Harman's single factor test is the most commonly used approach by researchers when testing the possible influence of CMV in PLS-SEM analysis (Podsakoff et al., 2003), in which almost all the items of the exploratory factor analysis scale are subjected to, forcing the extraction into a single factor (Andersson & Bateman, 1997; Mossholder et al., 1998; Iverson & Maguire, 2000; Aulakh & Gencturk, 2000).

To check the adequacy of the data and the possible influence of CMV, an exploratory factor analysis (EFA) was performed using the principal component method, and the varimax rotation, Kaiser-Meyer-Olkin coefficient (KMO), and Bartlett's sphericity test were calculated. With a KMO value of 0.812 and a statistically significant Bartlett's test [$\chi 2\ (276) = 8562.47$, $p < 0.000$], the obtained results supported the use of EFA with this sample data. If there is a CMV problem, the extracted commonality factor should have a value higher than 50% of the variance (Podsakoff et al., 2003); however, the commonality factor extracted from the data was 37.25%, which is lower than the recommended value, thus indicating that CMV does not pose a threat to the

sample data of this study and does not seem to significantly affect the relationship between the variables of the research model (Podsakoff et al., 2012).

**Table 1.** Measurement model assessment.

| Indicators | Constructs | Factor Loads (p-value) |
|---|---|---|
| Financial Innovation (FI) | | |
| Cronbach's Alpha: 0.913; Dijkstra–Henseler's rho: 0.923; CRI: 0.934; AVE: 0.671 | | |
| FI1 | New financing techniques are used | 0.806 (0.000) |
| FI2 | Thanks to financial innovations, we can make technology investments by planning our budget better. | 0.718 (0.000) |
| FI3 | We can see the advantage of applying financial innovations by overcoming the economic/financial crises. | 0.764 (0.000) |
| FI4 | By following financial innovations closely, we can implement our strategies better. | 0.816 (0.000) |
| FI5 | Financial innovations give us a competitive advantage over competitors without risking our assets. | 0.839 (0.000) |
| FI6 | By applying financial innovations, organizational activities are successfully carried out. | 0.892 (0.000) |
| FI7 | Ensuring sustainability against competitors through the implementation of financial innovations is successfully managed. | 0.885 (0.000) |
| Green Innovation (GI | | |
| Cronbach's Alpha: 0.943; Dijkstra–Henseler's rho: 0.947; CRI: 0.954; AVE: 0.746 | | |
| GI1 | It mainly focuses its investment on eco-innovation activities | 0.873 (0.000) |
| GI2 | Raise awareness towards Eco-innovation | 0.877 (0.000) |
| GI3 | It has a distribution of the information of the eco-innovation | 0.894 (0.000) |
| GI4 | Has constant training in eco-innovation | 0.869 (0.000) |
| GI5 | Participate or develop research and development projects in eco-innovation | 0.869 (0.000) |
| GI6 | Consistently supports the adoption and implementation of green standards | 0.846 (0.000) |
| GI7 | Support with investments to improve the eco-innovation of its suppliers | 0.818 (0.000) |
| Business Sustainability (BS) | | |
| Cronbach's Alpha: 0.897; Dijkstra–Henseler's rho: 0.899; CRI: 0.928; AVE: 0.764 | | |
| BS1 | Business sustainability is necessary for our firm to ensure long-term growth | 0.885 (0.000) |
| BS2 | Business sustainability helps our firm to compete well in the industry | 0.887 (0.000) |
| BS3 | Sustainability increases the sales of our firm as consumers are more attracted to | 0.888 (0.000) |

| | | |
|---|---|---|
| | sustainable products. | |
| BS4 | Sustainability helps our firm to develop long-term strategies | 0.836 (0.000) |

## 4. Results

Data analysis was performed using the PLS-SEM statistical technique with the support of the SmartPLS 4 software (Ringle et al., 2022), particularly since the literature recommends the use of PLS-SEM in theories that are under development (Hair et al., 2019) in different disciplines of knowledge (Cepeda-Carrion et al., 2019; Ringle et al., 2020), and when the established objective in the study is the prediction and explanation of the concepts (Sarstedt et al., 2019). Furthermore, according to Wang et al. (2020b) and Karami and Madlener (2021), the use of PLS-SEM is recommended to measure complex research models that involve different variables. Finally, PLS-SEM is an approach frequently used in literature to measure the structural relationship between variables, generally using a confirmatory factor analysis (CFA) and regression (Ullah et al., 2022).

### *4.1. Measurement model*

The reliability of the FI, GI, and BS scales was assessed using Cronbach's Alpha and CRI, which are considered in the literature to be the two main CFA indicators to measure the reliability of the research model, as assessed through internal reliability, while AVE was adopted to measure the convergent validity of the latent structure (Ullah et al., 2022). The results obtained by applying PLS-SEM are shown in Table 2. On the one hand, the reliability of the constructs was analyzed, and it was found that, according to Wang and Yang (2021) and Abbasi et al. (2021), the recommended values of Cronbach's alpha and CRI should be between 0.60 and 0.70. In this study, the constructs used in the research model can be considered as reliable because all values of Cronbach's alpha and CRI were above the maximum recommended value of 0.70.

On the other hand, the convergent validity of the constructs was analyzed. It was found that Hair and Sarstedt (2021) suggested an acceptable AVE value of 0.70, while Ullah et al. (2021b) and Abbasi et al. (2021) considered an AVE value of 0.50 to be acceptable. In the present study, the constructs used in the research model demonstrated a convergent validity, as all the AVE values were above the recommended value of 0.50. In addition, the discriminant validity of the constructs was analyzed using two of the most commonly used indices in PLS-SEM: the Fornell-Larcker criterion and the heterotrait-monotrait ratio (HTMT) (Henseler, 2018). The Fornell-Larcker criterion specifies that the AVE value must be greater than the correlation between each pair of constructs. In the present study, the AVE values were higher than the correlations of the other constructs. Moreover, the HTMT must be less than 0.85. In the present study, all HTMT values were below the recommended value of 0.85, thus indicating the presence of a discriminant validity (Henseler, 2018).

**Table 2.** Measurement model. Reliability, validity, and discriminant validity

| **PANEL A. Reliability and Validity** | | | | |
|---|---|---|---|---|
| Variables | Cronbach's Alpha | Dijkstra-Henseler rho | CRI | AVE |

| | | | | | | |
|---|---|---|---|---|---|---|
| Financial Innovation | 0.917 | | 0.923 | | 0.934 | 0.671 |
| Green Innovation | 0.943 | | 0.947 | | 0.954 | 0.746 |
| Business Sustainability | 0.897 | | 0.899 | | 0.928 | 0.764 |
| **PANEL B. Fornell-Larcker Criterio** | | | | **Heterotrait–Monotrait ratio (HTMT)** | | |
| Variables | 1 | 2 | 3 | 1 | 2 | 3 |
| 1. Financial Innovation | **0.819** | | | | | |
| 2. Green Innovation | 0.238 | **0.864** | | 0.252 | | |
| 3. Business Sustainability | 0.280 | 0.168 | **0.874** | 0.306 | 0.179 | |

**Note: PANEL B:** Fornell-Larcker Criterion: Diagonal elements (bold) are the square root of the variance shared between the constructs and their measures (AVE). For discriminant validity, diagonal elements should be larger than off-diagonal elements.

### *4.2. Structural model*

The PLS-SEM estimation of the research model indicated that the generated data had an acceptable statistical level (Table 3). The results showed that the adjusted endogenous variable $R^2$ values (GI = 0.160; BS = 0.198) were above the recommended value of 0.10 (Hair et al., 2020), and the SRMR values were below the 0.080 value and below the recommended value of 0.10. The HI99 values (0.037–0.045), the unweighted least squares error (dULS), and the geodetic error (dG) were lower compared to those reported by Sarstedt et al. (2019) and the recommended HI99 values (0.239–0.352; 0.145–0.195). Finally, the effect size of the independent variable ($f^2$) on the independent variable $R^2$ values indicated a small change (values between 0.02–0.14) (Hair et al., 2017).

Furthermore, the estimated data confirm our argument that FI has a significant positive effect at both the BS level (0.263; p-value 0.000) and at the GI level (0.244; p-value 0.000), thus providing solid empirical evidence for hypotheses H1 and H2. These results are similar to those of Nejad (2016), Scott et al. (2017), and Streeter (2020) for hypothesis 1, Noailly and Smeets (2016), Kim and Park (2016), and Tariq et al. (2019) for hypothesis 2, thus indicating that the introduction and implementation of the new FI tool led to a significant increase in the BS and GI activities in Mexican manufacturing firms. On the other hand, the obtained results also confirm our argument that GI activities have a significant positive effect on BS (0.118; p-value 0.096), thus providing solid empirical evidence for hypothesis H3. These results are consistent with the results of Ahmed et al. (2020), Anwar et al. (2021), and Ali et al. (2021), who showed that the introduction and implementation of GI activities led to an increase in the BS level among Mexican manufacturing firms.

**Table 3.** Structural model.

| **Paths** | **Path (*t-value; p-value*)** | **95% Confidence Interval** | **$f^2$** | **Support** |
|---|---|---|---|---|
| FI → BS (H1) | 0.263 (3.217; 0.000) | [0.106 – 0.471] | 0.085 | Yes |
| FI → GI (H2) | 0.244 (3.849; 0.000) | [0.115 – 0.363] | 0.069 | Yes |
| GI → BS (H3) | 0.118 (1.657; 0.096) | [0.021 – 0.236] | 0.017 | Yes |

| **Indirect Effects** | | | | |
|---|---|---|---|---|
| FI → GI → BS (H4) | 0.206 (3.432; 0.000) | [0.085 – 0.306] | | Yes |
| **Endogenous Variable** | **Adjusted $R^2$** | **Model Fit** | **Value** | **HI99** |
| | | SRMR | 0.037 | 0.045 |
| GI | 0.160 | dULS | 0.239 | 0.352 |
| BS | 0.198 | dG | 0.145 | 0.195 |

**Note:** FI: Financial Innovation; GI: Green Innovation; BS: Business Sustainability. One-tailed t-values and p-values in parentheses; bootstrapping 95% confidence intervals (based on n=5,000 subsamples); SRMR: standardized root mean squared residual; dULS: unweighted least squares discrepancy; dG: geodesic discrepancy; HI99: bootstrap-based 99% percentiles.

Moreover, the estimated data also confirm our argument that GI can act as a mediating variable in the relationship between FI and BS (0.206; p-value 0.000), thus supporting this result with strong empirical evidence in favor of hypothesis H4. These results are similar to those of Al-Batayneh et al. (2021), Wang et al. (2021) and Jahanger et al. (2022), who showed that a large part of the positive effect of FI activities at the BS level in Mexican manufacturing firms was transmitted through the GI activities. In this context, it can be said that the introduction and implementation of GI activities by manufacturing firms not only significantly improves the BS in the organization, but also can act as a mediating variable, thus significantly improving the existing link between FI and BS in Mexican manufacturing firms.

## 5. Discussion

When estimating the data, the obtained results supported our argument that FI has a significant positive impact on the operating performance of Mexican manufacturing companies. These results are consistent with those of Streeter (2020), Sardon (2020), and Nejad (2022). The main reasons that can explain this positive effect are as follows: first, the managers of manufacturing firms experience using various information technologies in financial services, as a high percentage of customers and consumers are using mobile banking as their first choice for financial transactions after the COVID-19 pandemic; and second, manufacturing companies are increasingly facing a strong pressure to introduce and adopt new production systems in order to improve the sustainability of society as a whole.

Additionally, the obtained outcome supported our argument that FI has a important affirmative effect on GIs in Mexican manufacturing firms. These outcome are similar to those of Zhou and Li (2022), Ronaldo and Suryanto (2022), and Naem et al. (2022). The primary reasons that can explain this positive effect are as follows: first, the managers of manufacturing firms are aware of the various perks of adopting GI, especially because they can help them convert resources into products and services, and thus into monetary profits and revenues; and second, companies have the ability to improve and use resources more efficiently to produce more environmentally friendly products, which means that managers need to focus not only on financial aspects, but also on commercial activities.

Lastly, the obtained outcome supported our argument that the GI not only has a significant positive impact on BS, but also acts as a mediating variable between FI and BS. These results are consistent with those of Saunila et al. (2018), Xie et al. (2019), Fernando et al. (2019), Wang et al. (2021), Jahanger et al. (2022), and Zhang et al. (2023). On the one hand, these outcome can be

explained by the culture of manufacturing companies, which puts the customer at the center of the institution, thus leading to a high level of BS. On the other hand, manufacturing firms are able to integrate GI activities not only within the organization, but also across all companies in the supply chain, thereby reducing economic risks and improving economic performance and business value.

Additionally, these results not only established the adoption of GI, FI, and BS in manufacturing firms in Mexico, but may also have an indirect impact on manufacturing firms in the United States, Japan, and Germany, particularly because a high percentage of manufacturing firms established in Mexico, especially in the automotive industry, are of an origin from these countries, which is why green strategies and innovative organizational culture are generally designed in parent companies that are established in these countries and are applied in manufacturing firms in Mexico, as well as in other Latin American countries such as Argentina and Brazil, in which manufacturing companies in the automotive industry have a high impact on the GDP.

### *5.1. Practical implications*

The data estimated in this study have several practical implications for managers and companies, as well as for professionals in the industry and public administration, Here, we discuss the most important of these implications. On the one hand, if it is assumed that the main goal of financial institutions is to reduce financial costs and provide new financial services adapted to customer needs (Arnold et al., 2021), then the managers of manufacturing firms must adopt the digital technologies used during the COVID-19 pandemic, thereby seeking to change the profile of investors and customers by providing innovative financial services adapted to new global business models, not only to provide companies with a competitive advantage in terms of financial costs, but also to integrate sustainability into financial activities.

On the other hand, manufacturing firms must provide innovative products and services to their customers, investors, and consumers in order to remain relevant and competitive in the global market. However, this is only possible if there is a culture within the organization that encourages innovation, thereby supporting initiatives, discussions, and improvements in products and services (Ahmed et al., 2020). In this context, manufacturing firms must foster a culture where management and employees promote innovation in products, processes, and financial services through a continuous training of human resources. This helps companies develop and utilize resources in accordance with BS principles and achieve more and better competitive advantages, especially in manufacturing companies in emerging markets where most companies lack an innovative culture.

Finally, the adoption and implementation of GI activities in manufacturing firms is a relevant issue from the point of view of public administration in developing countries and emerging economies, such as Mexico, particularly because the design of public policies promotes a multiplier effect through the incorporation and use of information technologies in financial systems, as well as the generation of greener innovation activities that significantly improve the BS of organizations. In this sense, while transforming resources into products and services and then into financial gains, manufacturing firms generally almost entirely neglect the negative effects they cause to the environment and sustainability (Najmi et al., 2019), for which reason manufacturer's managers should not solely focus on the financial results of the organization, but should also strive to improve BS (Yusliza et al., 2020).

## 6. Conclusions

Several conclusions can be drawn from the data estimated in this empirical study; here, we list the most important conclusions. On the one hand, we can conclude that there is a high correlation between the concepts of FI, GI, and BS, which indicates that the research model not only has an acceptable internal consistency, but also has a holistic vision of the main health services of FI, the main activities of GI, and the basic indicators of BS, as defined in the literature. In addition, there are relatively few published studies that analyzed these three concepts simultaneously, because most of the published studies focused on the simultaneous analysis of two concepts and the development of bibliometric studies, which we believe does not make a significant empirical contribution; therefore, this study provides strong empirical evidence and new insights in favor of the links between FI, GI, and BS in the manufacturing firms of emerging economies.

On the other hand, the use of information technology in the financial services sector by clients, consumers, and manufacturing companies has exponentially increased due to the COVID-19 pandemic, from which it can be concluded that customers feel more comfortable using mobile applications for financial activities, not only because it entails lower costs, but also because it gives them a sense of control over their finances, especially because they believe that they can manage their finances using the tools available to them and that they are able to handle technology. In this sense, it can be generally concluded that the benefits of introducing and implementing innovations in the financial services (FI) and GI sectors are greater than the costs of their application in manufacturing companies, namely the BS-Organizational level.

Furthermore, this empirical study has some limitations that should be considered before interpreting the results obtained from the data estimation. Here, we list the most limitations. On the one hand, there are limitations to the sample used in the study, since only Mexican manufacturing companies with more than 10 employees were included. Therefore, the results could be different if the sample included companies with the same or fewer employees. On the other hand, another limitation could be that the estimation was carried out using data obtained through a survey of the management of manufacturing firms. The results could be very different if the opinions of the employees or stakeholders were taken into account. Finally, another limitation is that this study focused on the analysis of cross-sectional data, which actually ignored the possible transient effects of FI, GI, and BS. For this reason, it is necessary to conduct longitudinal studies to confirm the obtained results, especially in emerging countries.

## Use of AI tools declaration

The author declares they have not used Artificial Intelligence (AI) tools in the creation of this article.

## Conflict of interest

The author declares no conflicts of interest in this paper.

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