Cuadernos de Administración
ISSN: 0120-3592
ISSN: 1900-7205
Pontificia Universidad Javeriana

Maldonado Guzmán, Gonzalo; Mojica Carrillo, Elena Patricia; Pinzón Castro, Sandra Yesenia
Green supply chain management and firm performance in the automotive industry*
Cuadernos de Administración, vol. 34, 2021, January-December, pp. 1-17
Pontificia Universidad Javeriana

DOI: https://doi.org/10.11144/Javeriana.cao34.gscmf

Available in: https://www.redalyc.org/articulo.oa?id=20574633011

How to cite
Complete issue
More information about this article
Journal's webpage in redalyc.org

Scientific Information System Redalyc
Network of Scientific Journals from Latin America and the Caribbean, Spain and Portugal
Project academic non-profit, developed under the open access initiative

Green supply chain management and firm performance in the automotive industry*

Gestión de la cadena de suministro verde y rendimiento empresarial en la industria automotriz

Gestão da cadeia de fornecimento verde e desempenho de negócios na indústria automotiva

DOI: https://doi.org/10.11144/Javeriana.cao34.gscmf

Gonzalo Maldonado Guzmán [a]
Universidad Autónoma de Aguascalientes, México
gonzalo.maldonado@edu.uaa.mx
ORCID: https://orcid.org/0000-0001-8814-6415

Elena Patricia Mojica Carrillo
Universidad Autónoma de Aguascalientes, México
ORCID: https://orcid.org/0000-0003-0112-4008

Sandra Yesenia Pinzón Castro
Universidad Autónoma de Aguascalientes, México
ORCID: https://orcid.org/0000-0002-0463-1008

Received: 17 March 2021
Accepted: 29 October 2021

Abstract:

In the past few decades, an increase in articles publication that analyze and discuss environmental issues can be observed in the literature. However, because the global warming problem, various government agencies have rigorous environmental rules and policies, to such an extent that they are forcing companies particularly those that make up the automotive industry, to adopt measures to reduce the pollution generated by their supply chain, since it is one of the industries that generates most pollution globally. Thus, the objective of this study is to provide empirical evidence that helps fill the gap in the current literature, and to analyze the relationship between green supply chain management and business performance, through quantitative, explanatory research, and correlational, through the application of structural equation models. The results obtained show that green supply chain management is correlated by 47.6% with business performance, which allows to conclude that green supply chain management not only improves environmental sustainability, but also increases business performance of companies in the automotive industry.

JEL Code: M20.
Keywords: Green supply chain management, firm performance, automotive industry, structural equations.

Resumen:

En las últimas décadas se observa en la literatura un aumento en la publicación de artículos que analizan y discuten cuestiones medioambientales, sin embargo, a raíz de la problemática del calentamiento global diversos organismos gubernamentales endurecieron las reglas y políticas medioambientales, a tal grado que están obligando a las empresas, particularmente a las que integran la industria automotriz, a adoptar medidas para disminuir la contaminación de su cadena de suministro, ya que es una de las industrias que más contaminación genera a nivel global. Así, el objetivo de este estudio es aportar evidencia empírica que contribuya a llenar el vacío existente en la actual literatura, y analizar la relación existente entre la gestión de la cadena de suministro verde y el rendimiento empresarial, a través de una investigación cuantitativa, explicativa y correlacional, mediante la aplicación de modelos de ecuaciones estructurales. Los resultados obtenidos muestran que la gestión de la cadena de suministro verde está correlacionada en un 47,6% con en el rendimiento empresarial, lo cual permite concluir que la cadena de suministro verde no solamente mejora la sustentabilidad medioambiental, sino que también incrementa el rendimiento empresarial de las empresas de la industria automotriz.

Código JEL: M20.
Palabras clave: Gestión de la cadena de suministro verde, rendimiento empresarial, industria automotriz, ecuaciones estructurales.

Author notes

[a] Corresponding author. E-mail: gonzalo.maldonado@edu.uaa.mx

Resumo:

Nas últimas décadas, tem-se observado um aumento na publicação de artigos que analisam e discutem a questão ambiental na literatura, porém, em decorrência da problemática do aquecimento global, diversos órgãos governamentais têm endurecido regras e políticas ambientais, a tal ponto que estão obrigando as empresas, principalmente as que compõem a indústria automotiva, a adotar medidas de redução da poluição em sua cadeia de fornecimento, por ser uma das indústrias que mais polui globalmente. Assim, o objetivo deste estudo é fornecer evidências empíricas que ajudem a preencher a lacuna na literatura atual, e analisar a relação entre a gestão da cadeia de suprimentos verde e o desempenho de negócios, por meio de uma pesquisa quantitativa, explicativa e correlacional, através da aplicação de modelos de equações estruturais. Os resultados obtidos mostram que a gestão da cadeia de fornecimento verde está correlacionada em 47,6% com o desempenho dos negócios, o que permite concluir que a cadeia de fornecimento verde não só melhora a sustentabilidade ambiental, mas também aumenta o desempenho das empresas do setor automotivo.

Código JEL: M20.

Palavras-chave: Gestão da cadeia de fornecimento verde, desempenho dos negócios, indústria automotiva, equações estruturais.

Introduction

For a little more than two decades, the concept of supply chain management has gained the interest of researchers and academics, and importance in the context of business management (Lopes & Pires, 2020), especially in companies that make up the automotive industry, which are under increasing pressure from consumers, government authorities, NGOs, environmental groups and society, for the adoption and implementation of green practices both in production processes and in supply chain to make them greener (Yenipazarli, 2017). In addition, the planet degradation and global climate change are forcing companies to opt out of environmental activities in their supply chains, which is why the concept of green supply chain management is emerging in the literature as an activity substantial to reduce negative impacts to the environment generated by automotive industry firms (Lopes & Pires, 2020).

In this sense, in a recent study published in environmental literature Kazancoglu, Sagnak, Kayikci et al. (2020, p. 1533) state that "organizations have started to become more conscious about the environment in their supply chain operations, and the greening process has guided supply chain practices into new ways of thinking according to green standards". However, Silva, Gomes, & Sarkis (2019, p. 821) draw attention to the fact that "how organizations green practices become routinely embedded in supply chain remains underexplored in the literature". Additionally, other researchers and academics have considered that there are relatively few empirical studies published in the literature that have analyzed and discussed the green supply chain management, especially in automotive industry firms in emerging economies in Latin America (Lopes & Pires, 2020).

Furthermore, for the supply chain of manufacturing firms to have a high level of competition, it is necessary for them to identify and implement green supply chain management (Vanalle, Ganga, Godinho-Filho et al., 2017). But one might ask, what is green supply chain management? According to Beamon (1999),

> it is the extension of the traditional supply chain that includes various activities that allow minimization product environmental impacts throughout its life cycle, such as a more environmentally friendly design, the use resources reduction, materials, and the recycling and reuse of materials. (Beamon, 1999, p. 333)

Therefore, it is possible to establish that green supply chain management practices consist of the adoption and implementation of various activities and initiatives carried out by automotive industry firms, in order to comply with both environmental regulations and firms' performance improvement (Qorri, Mujkic, Gashi et al., 2018).

Similarly, there are several published studies in the scientific literature that have analyzed the influence of green supply chain management practices on firm performance, obtaining mixed and inconclusive results (Qorri et al., 2018). Some studies have obtained positive relationship among green supply chain management and firm performance, especially in automotive industry, pharmaceutical, electrical-electronic and petroleum

sectors (Zhu & Sarkis, 2004; Green, Zelbs, Meacham et al., 2012; Laari, Töyli, Solakivi et al., 2016; Younis, Sundarakani, & Vel, 2016; Vanalle et al., 2017), other studies have obtained negative relationship particularly in automotive industry, petroleum, chemical and electronic sectors (Richey, Chen, Genchev et al., 2005; Montabon, Sroufe, & Narasimhan, 2007; Large & Thomsen, 2011).

Other studies have obtained a non-significant relationship, especially in chemical, furniture, electrical-electronics, package printing industry, glass, paper & pulp, cement & ceramic, metal and industrial equipment sectors (González-Benito & González-Benito, 2005; Vachon & Klassen, 2006; De Giovanni & Vinzi, 2012; Lee, Tae-Kim, & Choi, 2012), and some others studies have obtained mixed relationship, particularly in automotive industry, electronics and industrial equipment sectors, paper products, cleaning products and lighting products (Pagell & Wu, 2009; Azevedo, Carvalho, & Cruz-Machado, 2011). Therefore, recognizing the existence of differences in the results obtained, Azevedo et al. (2011), Eltayeb, Zailani, & Ramayah (2011), Green et al. (2012), Kirchoff, Tate, & Mollenkopf (2016), Luthra, Garg, & Haleem (2016), and Vanalle et al. (2017), considered the need to carry out more studies on this typical to carry robust empirical evidence.

In this context, the effects of green supply chain management on firms' performance in automotive industry companies can be considered inconclusive, therefore the main contribution od this paper is to complementing and expanding the existing knowledge in scientific literature, and provide empirical evidence on the relationship between the two constructs in automotive industry as proposed by Vanalle et al. (2017) and Chen, Guo, Feng et al. (2021), especially in Latina America as proposed by Lopes & Pires (2020). This research paper has the following research question: *What are the effects that green supply chain management has on the firm's performance of automotive manufacturing companies in Mexico?*

Literature review

The exponential increase in environmental activities, as well as environmental policies regulation and standards are generating strong pressure on manufacturing companies, particularly those that make up the automotive industry, to implement environmental activities in supply chains management (Hao, Helo, & Shamsuzzoha, 2018; Rabbani, Foroozesh, Mousavi et al., 2019; Gharaei, Karimi, & Hoseini, 2019b). Thus, environmental activities combination with supply chain management in manufacturing companies, leads to the development of green supply chain management (Gupta Soni, & Kumar, 2019), which generates in organizations not only a higher level of competitiveness, but also a significant increase in business performance level in manufacturing firms (Dubey, Gunasekaran, Sushil et al., 2015).

In the scientific literature, supply chain management is considered an essential system for manufacturing firms, especially when it is directly related to the concept of green, since this is an emerging area that has to be analyzed and systematically discussed (Barbosa-Póvoa, Silva, & Carvalho, 2018). Likewise, the green supply chain management concept application is a relatively recent topic, and it is a fundamental element for the management success in manufacturing firms (Bubicz, Ferreira, & Carvalho, 2019). However, for manufacturing companies, especially those belonging to automotive industry, to have greater possibilities of achieving an increase in their competitive advantages, they must adopt environmental aspects both in production processes and in supply chain management (Gharaei et al., 2019c).

In this sense, green supply chain management in automotive industry manufacturing firms, have to be more aware of the various social impacts and environmental activities generated by their productive activities, and must adopt greater environmental practices in the different stages in supply chain management (Bubicz et al., 2019; Gharaei et al., 2019a). One of the main reasons established in the scientific literature for the adoption and implementation of green practices is the carbon emissions reduction (Sarkar, Guchhait, Sarkar et al., 2019), and the tightening of environmental regulations implemented by governments, which are forcing to

all members of the supply chain for the reduction of carbon emissions (Ye, Li, & Yang, 2018; Niu, Mu, Chen et al., 2019; Song, Saen, Fisher et al., 2019; Chen et al., 2021).

Likewise, according to European Union statistics data, automobiles are the ones that emit highest pollutants emission, since they generate around 12% of the total emission of carbon dioxide CO. worldwide (EU, 2020), for which various automotive companies are making innovative changes in vehicles production that lead to a significant carbon dioxide emission reduction (Niu, Yu, & Shen, 2021). An example of this is FIAT automotive company, which in 2019 the vehicles that used gasoline combustion that they manufactured substantially reduced carbon dioxide emissions by 119.2 gr. of CO./km, which is still very far from achieving the standards established by the European Union in that same year (Automobile News Europe, 2019).

In addition, environmental pollution is one of the main problems facing global society in the current century (Balasubramanian & Shukla, 2017), which is increasingly generating strong pressure on manufacturing companies in the automotive industry for the adoption and implementation of practices that protect and improve the environment (Liu, Zhu, & Seuring, 2017). For this reason, more and more manufacturing companies in the automotive industry are incorporating environmental activities throughout their green supply chain management (Singh & Kumar, 2021). However, even with the importance of green supply chain management, relatively few studies have been published in the literature that analyze the relationship of this construct with business performance (Maditati, Munim, Schramm et al., 2018; Fang & Zhang, 2018; Singh & Kumar, 2021).

Additionally, green supply chain management emphasizes that design, purchasing, production, transportation, and logistics processes should be green activities so that automotive industry firms have a greater probability of increasing their business performance level (Huang & Zhang, 2019), since the automotive industry is undoubtedly not only the industry that generates highest environmental pollution level, but also the industry with the greatest influence worldwide (Mathivathanan & Haq, 2017), since it integrates various manufacturing companies that take part in the design, development, manufacture, marketing and sale of automobiles and auto parts, which require the adoption and implementation of sustainable and environmental activities (Masoumi, Kazemi, & Abdul-Rashid, 2019).

Similarly, automotive industry is the one with the highest contribution level to the economy world and is one of the most important sectors in developing countries economy, including Mexico, since the profits that generated are equivalent to the income of the six most industrialized countries in the world (Binder & Rae, 2017), and has a high contribution to increasing the workers and society living standards (Xia, Govindan, & Zhu, 2015). Thus, considering the substantial effects of the automotive industry on economic, social, and environmental activities worldwide, it is important that they carry out an effective productive activities management that improve the environment and sustainability (Larsson, 2002). In this sense, automotive industry must adopt and implement activities both in its production processes and in supply chain management, which allow it to significantly reduce the environmental pollution level (Mathivathanan, Kannan, & Haq, 2018).

Likewise, automotive industry manufacturing firms must integrate green practices in supply chain management, considering three substantial elements within their objectives and goals organizational (Yawar & Seuring, 2017): (1) maximize economic benefits throughout the supply chain; (2) minimize negative impacts on the environment and (3) improve the well-being of firm's partners and society. Specifically, manufacturing companies must make an adequate balance between these three elements according to their essential activities, sector to which they belong, size, geographic location, capacities, culture, organizational structure and the different government policies (Closs, Speier, & Meacham, 2011; Chaabane, Ramundhin, & Paquet, 2012; S Spetic, Marquez, & Kozak, 2012; Meckenstock, Barbosa-Póvoa, & Carvalho, 2015).

In this context, compared to traditional supply chain management, green supply chain management involves activities implementation related to the significant improvement of the environment, as well as

the adoption of strategies that improve the organization and society sustainable development level (Ivascu, Mocan, Draghici et al., 2015). In addition, the importance that this concept has acquired is fundamentally due to the environment deterioration level, inefficiency in waste management and the decrease in natural resources of raw materials (Ivascu et al., 2015). Thus, according to Zhu & Sarkis (2004), green supply chain management can be considered as an environmental innovation, since green supply chain management went from being considered as purchases of green products, to the integration of environmental activities in the entire supply chain.

In this sense, green supply chain management is increasingly gaining researchers and academics attention interested in improving supply chain practices and research (Ivascu et al., 2015; Yenipazarli, 2017). Furthermore, according to Srivastava (2007), green supply chain management literature generally converges in studies that consider reverse logistics, or that analyze its interrelation with firm in a horizontal context. Therefore, the vertical interrelationships between manufacturing firms and green supply chain management, has been little explored, analyzed and discussed in business and management literature (Yenipazarli, 2017), as well as most of published studies in current literature have been oriented on theoretical analyzes, for which studies that provide empirical evidence are needed (Maditati et al., 2018; Fang & Zhang, 2018; Singh & Kumar, 2021).

One of the few empirical studies linking green supply chain management and business performance is Ouardighia, Simb, & Kim (2016), who analyzed how the phenomenon of double marginalization affects the compensation between pollutant emissions and activities related to reducing pollutants accumulation in supply chain management and retailers manufacturing firms. The authors finding that while manufacturing companies that make innovation efforts consider investment in reducing pollution levels to a greater extent, market demand and unit costs of production are the same for both manufacturing firms and retailers, which are totally independent of pollution reduction efforts, and have similar levels of green supply chain management and firms performance.

On the other hand, Luo, Chen, & Wang (2016) analyzed price policies and pollutant emissions reduction from two highly competitive manufacturing companies, finding a significant positive relationship between both constructs and green supply chain management. Finally, Zhu & He (2017) conducted a comprehensive analysis of green product design in green supply chain management and analyzed how green product development decisions are affected by factors such as the structure of the supply chain and the types of green products, finding that green products design improves the management of the green supply chain, and this in turn improves firm's performance level. Thus, considering the information presented above, it is possible to pose the following research hypothesis.

H1: Green supply chain management has a positive impact on firm's performance level in automotive industry firms.

Methodology

To respond the research hypothesis, an empirical study was conducted in manufacturing companies in the Mexican automotive industry, essentially analyzing the effects of green supply chain management on firm's performance. In a first phase of the study, qualitative research was applied in which in-depth interviews were carried out with three researchers from the innovation area and five entrepreneurs from the automotive industry. The results obtained in this phase allowed the questionnaire design, which was reviewed by four academic experts in the innovation area and ten entrepreneurs from the automotive industry, making minor adjustments to writing, appearance and spelling. Pilot studies are essential to ensure validity when questionnaires are self-administered or contain self-developed scales (Bryman, 2016; Hair, Celsi, Money et al., 2016).

Sample design and data collection

The process used in this study to obtain the reference framework consisted essentially of obtaining the automotive industry companies directory established in Mexico, for which the support of the Mexican Association of Automotive Industry (AMIA), obtaining a directory with a record of 909 automobile and auto parts producing companies as of November 30, 2018. Additionally, it should be noted that the companies associated with AMIA belong to various organizations, local, regional and national business chambers. Therefore, the empirical study did not focus on a particular group or business association.

Additionally, the survey was designed to collect information on green supply chain management activities and firm's performance, which was applied to a sample of 460 companies selected through simple random sampling, with a maximum error of ±2.5% and a reliability level of 97.5%, representing 50.6% of the total population, and the survey being applied during the months of January to March 2019. In addition, the surveys were applied through a self-administered survey to 500 logistics or supply chain management managers of the selected companies, receiving a response from 460 surveys. In addition, it should be noted that all of the managers interviewed are responsible from the implementation of green supply chain management practices in their respective companies, and have been working in the automotive industry for several years, allowing interviewees to provide valuable and interesting information.

Statistically, for the sample to be representative of the population, it must have at least 95% confidentiality and a maximum error of 5%. However, in order to reduce the sampling error to have a higher quality of the data, in this study calculate the probabilistic sample size with an error of 2.5% and a confidence level of 97.5%, and to ensure that the observable phenomenon is representative. Considering the statistical equation proposed by Murray & Larry (2005) to calculate a sample within a defined and known population, it is carried out according to the equation 1.

$$n = \frac{(p)\,(q)\,(Z^2)\,(N)}{(s^2)\,(N-1) + (p)\,(q)\,(Z^2)} = \frac{(0.5)\,(0.5)\,(2.24)^2\,(909)}{(0.025)^2\,(909-1) + (0.5)\,(0.5)\,(2.24)^2} = 626$$

The application of the above formula to calculate the sample for a finite population (p = probability of success, q = probability of not success, Z = reliability, s = error, and N = population), shows that the number of companies to be surveyed is 626 firms in the Mexican automotive industry. However, the decision was made to increase that amount to 660 companies, to have a margin of additional surveys in case any of them do not meet the required quality, that is, it is not fully completed. In addition, it is important to establish that the value of 2.24 of Z^2 that appears in the formula for the calculation of the sample, was obtained from the Table of Z under the normal curve.

Measures development

Regarding the green supply chain management measurement, an adaptation was made to the scale developed by Bag (2014), who considered that the green supply chain management can be measured through 8 items. Finally, when it comes to measuring firm performance, an adaptation was made to the scale proposed by Bansal (2005) and Chan (2005), who considered that business performance can be measured through 6 items. A five-point Likert-type scale was chosen to strike a balance between complexity for respondents and accuracy for analysis (Forza, 2016; Hair et al., 2016). Tables 1 and 2 below show the items of the green supply chain management and business performance scales used.

TABLE 1
Green supply chain management measurement

Green supply chain management scale		Total disagreement				Total agreement
GSC1	It has a well-defined program of cooperation and collaboration with its suppliers for the care of the environment throughout the supply chain.	**1**	**2**	**3**	**4**	**5**
GSC2	Has a well-defined environmental audit program for the internal management of its suppliers.	**1**	**2**	**3**	**4**	**5**
GSC3	Ask your main suppliers for an ISO 14000 certification.	**1**	**2**	**3**	**4**	**5**
GSC4	It has a program of cooperation and collaboration with its main clients and suppliers for the design of Eco-innovations of its products.	**1**	**2**	**3**	**4**	**5**
GSC5	It has a program of cooperation and collaboration with its main customers and suppliers, to have a production that doesn´t harm the environment.	**1**	**2**	**3**	**4**	**5**
GSC6	It has a program for the sale of waste and unused materials throughout the supply chain.	**1**	**2**	**3**	**4**	**5**
GSC7	It has a program of cooperation and collaboration with its suppliers for the design of products for their reuse, recycling or recovery of material components.	**1**	**2**	**3**	**4**	**5**
GSC8	It has a program of cooperation and collaboration with its suppliers to design products that avoid or reduce the use of hazardous materials.	**1**	**2**	**3**	**4**	**5**

1 = Total disagreement, 2 = Disagree, 3 = Neither disagreement nor agreement, 4 = Agreement, 5 = Total agreement.

Source: Own elaboration.

TABLE 2
Firms' performance measurement

Firms performance scale		Total disagreement				Total agreement
FPE1	One of its objectives is caring for the environment.	**1**	**2**	**3**	**4**	**5**
FPE2	It makes great efforts to promote caring for the environment.	**1**	**2**	**3**	**4**	**5**
FPE3	Has a great commitment to invest in projects that protect the environment.	**1**	**2**	**3**	**4**	**5**
FPE4	He frequently discusses within the organization the results of the performance of caring for the environment.	**1**	**2**	**3**	**4**	**5**
FPE5	They have an excellent performance in protecting the environment compared to other companies in the same industry or sector.	**1**	**2**	**3**	**4**	**5**
FPE6	They are recognized by society for their effectiveness in protecting the environment.	**1**	**2**	**3**	**4**	**5**

1 = Total disagreement, 2 = Disagree, 3 = Neither disagreement nor agreement, 4 = Agreement, 5 = Total agreement.

Source: Own elaboration.

Reliability and validity of measurement scales

The evaluation of the measurement scale's reliability and validity used in this study was carried out through Confirmatory Factor Analysis (CFA), using the maximum likelihood method with the EQS 6.2 software (Bentler, 2005; Brown, 2006; Byrne, 2006). Thus, to measure reliability, Cronbach's alpha and the Composite Reliability Index (CRI) were used (Bagozzi & Yi, 1988) (see table 3).

TABLE 3
Internal consistency and convergent validity of the theoretical model

Variable	Indicator	Factor load	Robust t-Value	Cronbach´s Alpha	CRI	EVI
Green supply chain management	GSC1	0,807***	1,000[a]	0,944	0,945	0,680
	GSC1	0,855***	21,751			
	GSC3	0,881***	22,761			
	GSC4	0,867***	22,217			
	GSC5	0,794***	19,565			
	GSC6	0,827***	20,715			
	GSC7	0,811***	20,157			
	GSC8	0,755***	18,252			
Firm performance	FPE1	0,713***	1,000[a]	0,913	0,914	0,639
	FPE2	0,725***	14,912			
	FPE3	0,820***	16,837			
	FPE4	0,871***	17,850			
	FPE5	0,841***	17,263			
	FPE6	0,815***	16,749			

S-BX^2 (df = 76) = 772,743; p < 0,000; NFI = 0,812; NNFI = 0,827; CFI = 0,847; RMSEA = 0,078

[a] = Parameters constrained to this value in the identification process.
*** = p < 0,01

Source: Own elaboration.

According to the results obtained, table 3 show all the values of the scales are greater than 0.7 for both Cronbach's alpha and CRI, which provides evidence of the reliability of the two scales used and justifies their internal reliability (Nunally & Bernstein, 1994; Hair et al., 2014). As evidence of the convergent validity, the CFA results in table 3 indicate that all the items of the related factors are significant ($p < 0.001$), the standardized factor loads sizes are greater than 0.60 (Bagozzi & Yi, 1988), and the standardized factor loads averages of each factor exceed the value of 0.70 (Hair et al., 2014). Additionally, in table 3 suggest that the measurement model has a good fit of the statistical data ($S\text{-}BX^2 = 772{,}743$; df = 76; p = 0.000; NFI = 0.812; NNFI = 0.827; CFI = 0.847; RMSEA = 0.078), and the extracted variance index (EVI) was calculated for each of the constructs, resulting in an EVI greater than 0.50 (Fornell & Larcker, 1981), in Table 3 this value is exceeded in all factors.

In addition, the theoretical model discriminant validity of green supply chain management and firm's performance was measured by means of two tests, which are presented in table 4. First, the confidence interval test is presented (Anderson & Gerbing, 1988), which establishes that with a 95% confidence interval, none of the individual elements of the latent factors of the correlation matrix has the value of 1 (0.297 – 0.393). Second, the test of the extracted variance (Fornell & Larcker, 1981), which establishes that the extracted variance of each pair of constructs (0.680 and 0.639) is less than its corresponding EVI (0.119). Thus, according to the results obtained from the application of both tests, it is possible to conclude that both tests demonstrate sufficient evidence of the existence of discriminant validity.

TABLE 4
Discriminant validity of the theoretical model

Variables	Green supply chain management	Firm performance
Green supply chain management	**0,680**	0,119
Firm performance	0,297 – 0,393	**0,639**

The diagonal represents the Extraction Variance Index (EVI), while the variance (squared correlation) is presented above the diagonal, and the correlation between the factors with a 95% interval is presented below the diagonal.

Source: Own elaboration.

Results

To answer the hypothesis set out in this study, a structural equation model was applied with the support of EQS 6.2 software (Bentler, 2005; Byrne, 2006; Brown, 2006), analyzing the theoretical model nomological validity of the green supply chain management and firm performance through the Chi-square test, by means of which the results obtained between the theoretical model and the measurement model were compared, obtaining non-significant results which allows establishing an explanation of the observed relationships between latent constructs (Anderson & Gerbing, 1988; Hatcher, 1994).

TABLE 5
Sample characteristics

Variable	Frequency	Percentage (%)
Firms age		
▪ Young Firms (≥ 10 years old)	156	33,9
▪ Mature Firms (< 10 years old)	304	66,1
Total	**460**	**100,0**
Company size		
▪ Small	139	30,2
▪ Medium	199	43,3
▪ Big	122	26,5
Total	**460**	**100,0**
Family firms		
▪ Family Firms	122	26,5
▪ Non-Family Firms	338	73,5
Total	**460**	**100,0**
Manager age		
▪ Young (18 – 35 years old)	60	13,0
▪ Adults (36 – 60 years old)	357	77,6
▪ Mature (More than 60 years old)	43	9,4
Total	**460**	**100,0**
Manager antiquity		
▪ 1-5 years	184	40,0
▪ 6-10 years	120	26,1
▪ 11-15 years	66	14,3
▪ 16-20 years	42	9,1
▪ More than 20 years	48	10,5
Total	**460**	**100,0**

Source: Own elaboration.

Table 5 shows the main characteristics of the surveyed automotive manufacturing firms, and it can be seen that a little more than 66% of the companies have been in the market for more than 10 years, most of them (43.3%) are medium-sized companies, A little more than 73% are non-family companies, which makes it possible to establish that the supply chain of vehicle assembly companies established in Mexico are non-family medium-sized companies that have some maturity in the automotive industry. Furthermore, with respect to company managers, Table 5 shows that around 78% of managers are between the ages of 36 and 60 (adults), and 13% of them are young managers of the age of 18, between 18 and 35 years old, while 40% of managers are between 1 and 5 years old, and only 26% have between 6 and 10 years of management experience.

TABLE 6
Results of the structural equation model

Hypothesis	Structural relationship	Standardized coefficient	Robust t-Value
H_1: Green supply chain management has a positive impact in firm performance.	Green S.→ F. Performance	0,476***	5,438
S-BX^2 (df = 76) = 772,969; p < 0,000; NFI = 0,812; NNFI = 0,827; CFI = 0,847; RMSEA = 0,077			

*** = p < 0,01

Source: Own elaboration.

Table 6 presents the results obtained from the structural equations model application, and the decision was made to use this important statistical technique not only because it is at the frontier of knowledge, but also

because it allows decomposing the variance and covariance of green supply chain management and business performance, based on the parameters of a system of simultaneous equations, which allows to directly analyze the direct and indirect effect between both variables (Hair et al., 2014). In this sense, in table 6 show the results obtained, $\beta = 0.476$ $p < 0.001$, indicate that green supply chain management has a positive impact in firm's performance in the automotive industry companies.

The results obtained show that the cooperation and collaboration carried out by the large vehicle assembly companies, with the companies that make up their supply chain in the development of environmental programs, recycling of materials, reuse of components and the production of eco-products that are more sustainable and environmentally friendly, as part of the activities of the green supply chain, generate not only a greater impact on the level of business performance of all companies in the supply chain of the automotive industry, but also a reduction significant in the emissions of polluting gases and CO_2, which contributes to the improvement of the global environment. In summary, it can be corroborated that green supply chain management carried out by companies that make up the automotive industry in Mexico, have a strong influence on firm's performance.

Likewise, the results obtained in this research work have different implications both for managers and for the organizations themselves. The first of the implications refers to obtaining the information, since these were obtained through the application of a survey, which allowed a general analysis of the effects of the green supply chain management at the level of firms performance in a particular industry (automotive industry), so in future studies it would be essential that both researchers and academics and industry professionals guide their studies in the analysis and discussion of these two important constructs through case studies of success or longitudinal studies, to corroborate if the results obtained are similar or not to those obtained in this research work.

A second implication derived from the results obtained is that this paper incorporates a theoretical model that directly relates the green supply chain management with firm's performance, which provides a more holistic point of view that better explains the interrelation between these two important constructs. In addition, supply chain management allows a significant reduction in environmental pollution, by integrating a system that stimulates the sustainable life cycle of products (Yenipazarli, 2017), which allows the development of a supply chain management of greener and more sustainable supply since reducing the level of waste throughout the supply chain will reduce the costs of its operation and the creation of greater value for both consumers and the main commercial partners that participate in the supply chain (Bocken, de Pauw, Bakker et al., 2016).

A third implication of the results obtained is that green supply chain management incorporates activities that allow a significant reduction in the waste of materials, so it is not surprising that in the literature of business and management sciences researchers, academics and industry professionals accept the relationship between green supply chain management and firm's performance (Qorri et al., 2018). Furthermore, there are two clear positions in the current literature on the effects of green supply chain management on firm's performance, on the one hand, who argue the existence of a negative relationship (e.g., Montabon et al., 2007; Large & Thomsen, 2011), while others consider the existence of a positive relationship (e.g. Younis et al., 2016; Vanalle et al., 2017), therefore this study provides evidence of a significant positive relationship between both constructs.

Finally, a fourth implication arising from the results obtained is that the green supply chain management is highly associated with the reduction of environmental contamination (Yenipazarli, 2017), and is essential for both the development of the economy and for the Improving the level of firms performance of manufacturing companies (Qorri et al., 2018), which is why it is necessary for researchers and academics to guide their future studies in the discussion of these two important topics to provide greater empirical evidence. Thus, this research work enriches the analysis and discussion of the business and management science literature, by providing empirical evidence that determines not only the importance of green supply chain management

for manufacturing companies in the industry automotive, but also for the development of a much greener and more sustainable supply chain and a higher level of firm's performance (Bocken et al., 2016).

Additionally, this paper has various limitations that are important to consider when interpreting and discussing the results obtained. Thus, a first limitation of this study is related to the scales of measurement of the green supply chain and firm's performance, since these two constructs were measured through various subjective indicators obtained through the application of a survey. Therefore, in future studies, the use of objective data from manufacturing companies in the automotive industry (e.g., percentage of use of renewable energy, percentage of use of treated water, percentage of recycling of raw materials, percentage of cost reduction) will be pertinent), to verify if the results obtained differ or not from those obtained in this study.

A second limitation of this study is that the relationship between the green supply chain and firm's performance, may have better results if a moderating variable of the individual characteristics of the managers of manufacturing companies is integrated (e.g., leadership, commitment, capacity directive, experience). Therefore, in future studies it would be pertinent to add some moderating variable that significantly improves the relationship between the green supply chain and firm's performance, in order to corroborate if the results obtained are similar or better to those obtained in this paper or replicate this same study in another sector or industry to corroborate the results.

A third and final limitation of this study is that only eight items were considered for measuring the green supply chain and six items for measuring the level of firms performance, which were the most frequently cited in the scientific literature, but were not considered any type or dimension of the green supply chain and firms performance, so in future studies it will be pertinent to consider other types of measurement scales or some of the dimensions most cited in the scientific literature to corroborate the results obtained, or apply this same survey in other Latin American countries and in other sectors of economic activity to verify if the results are similar.

Conclusions

The results obtained in this paper have various conclusions, among which, in the first place, theoretical model of the effects of green supply chain management on firm's performance has good consistency, as it generates a high correlation between two analyzed constructs, which allowed the acceptance of the proposed research hypothesis. Secondly, the collaboration that vehicle assembly companies have implemented with the companies that make up their supply chain in the adoption of environmental activities, allow us to conclude that these types of actions have not only significantly improved the development of a supply chain greener, but also the increase in the level of business performance of all companies that make up the automotive industry.

Third, the adoption and implementation in the supply chain of companies in the automotive industry, of those activities related to the reuse, recycling and reuse of materials and electronic components of vehicles that have concluded their life cycle, have impacted on the development of an increasingly green supply chain, which has allowed a reduction in negative impacts on the environment. In addition, the implementation of the ISO 14,000 certification program developed by vehicle assembly companies, as part of the essential requirements for companies to be able to integrate into the supply chain, has generated a green supply chain among participating companies.

Fourth, the use of recycled materials and components in the development of new products, which integrate the new vehicles produced by companies in the automotive industry, generally called eco-products, have not only generated a greener supply chain among companies that collaborate throughout the supply chain but have also significantly improved the level of business performance of the participating companies, which allows to conclude that the activities that make up the supply chain are increasingly green and sustainable,

which is It reflects both in the decrease in the emission of polluting gases and CO_2, as well as in the improvement of the level of business performance.

Finally, it is also possible to conclude that the results obtained in this research work are like those obtained by Yenipazarli (2017) and Qorri et al. (2018), which concluded that the green supply chain management generate significant positive effects on the level of firm's performance. Therefore, in general terms, it is possible to conclude that the manufacturing companies that make up the automotive industry have a good implementation of green supply chain management activities, which can generate a significant increase in the level of firm's performance, which allows organizations not only to obtain the necessary economic and financial resources to improve the activities of the green supply chain, but also to be more competitive in a highly globalized market.

Ethical considerations

The article required the ethical consideration of the Universidad Autónoma de Aguascalientes, Mexico.

Authors' contributions

The authors participated equally in the article.

Financing

This article is part of a Research Project PIEA 17-3 funded by the Universidad Autónoma de Aguascalientes, Mexico.

Interest conflicts

The authors do not have any conflict of interest associated with the development of the research and the presentation of the article.

References

Anderson, J., & Gerbing, D. (1988). Structural equation modeling in practice: A review and recommended two-step approach. *Psychological Bulletin, 13*(1), 411-423. https://www3.nd.edu/~kyuan/courses/sem/readpapers/ANDERSON.pdf

Automobile News Europe (2019). Gasoline car brand Chrysler to pay E-vehicle brand to pool CO2 emissions. Accessed October 21 at https://europe.autonews.com/automakers/gasol-inecarbrand-chrysler-pay-E-vehiclebrand-pool-co2-emmisions-paper-says

Azevedo, S., Carvalho, H., & Cruz-Machado, V. (2011). The influence of green practices on supply chain performance: A case study approach. *Transportation Review, 47*(1), 850-871. https://mpra.ub.uni-muenchen.de/42704/

Bag, S. (2014). Impact of sustainable supply chain management on organizational performance: Mediating effects of leadership. *Indian Journal of management Science, 4*(3), 10-25.

Bagozzi, R., & Yi, Y. (1988). On the evaluation of structural equation models. *Journal of the Academy of Marketing Science, 16*(1), 74-94. http://dx.doi.org/10.1007/BF02723327

Balasubramanian, S., & Shukla, V. (2017). Green supply chain management: The case of the construction sector in the United Arab Emirates (UAE). *Production Planning & Construction, 28*(14), 1116-1138. https://doi.org/10.1080/09537287.2017.1341651

Bansal, P. (2005). Evolving sustainably: A longitudinal case study of corporate sustainable development. *Strategic Management Journal, 26*(3), 197-218. http://dx.doi.org/10.1002/smj.441

Barbosa-Póvoa, A., Silva, C., & Carvalho, A. (2018). Opportunities and challenges in sustainable supply chain: An operations research perspective. *European Journal of Operation Research, 268*(2), 399-431. http://dx.doi.org/10.1016/j.ejor.2017.10.036

Beamon, B. (1999). Designing the green supply chain. *Logistics and Information Management, 22*(2), 265-289. https://doi.org/10.1108/09576059910284159

Bentler, P. (2005). *EQS 6 Structural Equations Program Manual*. California, Multivariate Software.

Binder, A., & Rae, J. (2017). *Encyclopedia Britannica*, last update 4th August. Accessed on 4 June 2017 at http://global.britannica.com/EBchecked/topic/45050/automotive-industry2013

Bocken, N., de Pauw, I., Bakker, C., & van der Grinten, B. (2016). Product design and business model strategies for a circular economy. *Journal of Industrial Production and Engineering, 33*(5), 308-320. http://dx.doi.org/10.1080/21681015.2016.1172124

Brown, T. (2006). *Confirmatory Factor Analysis for Applied Research*. New York: The Guilford Press.

Bryman, A. (2016). *Social Research Methods.* Oxford: Oxford University Press.

Bubicz, M., Ferreira, A., & Carvalho, A. (2019). Incorporating social aspects in sustainable supply chains: Trends and future directions. *Journal of Cleaner Production, 237*(1), 1-35. http://dx.doi.org/10.1016/j.jclepro.2019.06.331

Byrne, B. (2006). *Structural Equation Modeling with EQS, Basic Concepts, Applications,and Programming*. London: LEA Publishers.

Chaabane, A., Ramundhin, A., & Paquet, M. (2012). Designing supply chains with sustainability considerations. *Production Planning and Control: Management Operations, 22*(8), 727-741. https://doi.org/10.1080/09537287.2010.543554

Chan, R. (2005). Does the natural-resource-based view of the firm apply in an emerging economy? A survey of foreign invested enterprises in China. *Journal of Management Studies, 42*(3), 625-672. http://dx.doi.org/10.1111/j.1467-6486.2005.00511.x

Chen, H., Guo, W., Feng, X., Wei, W., Liu, H., Feng, Y., & Gong, W. (2021). The impact of low-carbon city pilot policy on the total factor productivity of listed enterprises in China. *Resources, Conservations & Recycling, 169*(1), 11-18. http://dx.doi.org/10.1016/j.resconrec.2021.105457

Closs, D., Speier, C., & Meacham, N. (2011). Sustainability to support end-to-end value chains: The role of supply chain management. *Journal of the Academy of Marketing Science, 39*(1), 101-116. http://dx.doi.org/10.1007/s11747-010-0207-4

De Giovanni, P., & Vinzi, V. (2012). Covariance versus component-based estimations of performance in green supply chain management. *International Journal of Production Economic, 135*(2), 907-916. http://dx.doi.org/10.1016/j.ijpe.2011.11.001

Dubey, R., Gunasekaran, A., Sushil, S., & Singh, T. (2015). Building theory of sustainable manufacturing using total interpretive structural modelling. *International Journal of Systems Science: Operations & Logistics, 2*(4), 231-247. https://doi.org/10.1080/23302674.2015.1025890

Eltayeb, T., Zailani, S., & Ramayah, T. (2011). Green supply chain initiatives among certified companies in Malaysia and environmental sustainability: Investigating the outcomes. *Resource, Conservation and Recycling*, 55(5), 495-506. http://dx.doi.org/10.1016/j.resconrec.2010.09.003

EU - European Commission (2020). Reducing CO2 emissions from passenger cars before 2020. Accessed October 18 at https://ec.europa.eu/clima/policies/transport/vehicles/cars_en.

Fang, C., & Zhang, J. (2018). Performance of green supply chain management: A systematic review and meta-analysis. *Journal of Cleaner Production, 183*(9), 1064-1081. http://dx.doi.org/10.1016/j.jclepro.2018.02.171

Fornell, C., & Larcker, D. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research, 18*(1), 39-50. http://dx.doi.org/10.2307/3151312

Forza, C. (2016). Surveys. In C. Karlsson (Ed.). *Research Methods for Operations Management.* New York, Routledge.

Gharaei, A., Hoseini, S., & Karimi, M. (2019a). Modelling and optimal lot-sizing of the replenishments in constrained, multi-product and bi-objective EPQ models with defective products: Generalized cross decomposition. *International Journal of Systems Science: Operations & Logistics, 6*(1), 1-13. https://doi.org/10.1080/23302674.2019.1574364

Gharaei, A., Karimi, M., & Hoseini, S. (2019b). Joint economic lot-sizing in multi-product multi-level integrated supply chains: Generalized benders decomposition. *International Journal of Systems Science: Operations & Logistics, 6*(1), 21-27. https://doi.org/10.1080/23302674.2019.1585595

Gharaei, A., Karimi, M., & Hoseini, S. (2019c). An integrated multi-product, multi-buyer supply chain under penalty, green, and quality control polices and a vendor managed inventory with consignment stock agreement: The outer approximation with equality relaxation and augmented penalty algorithm. *Applied Mathematical Modelling, 69*(2), 223-254. http://dx.doi.org/10.1016/j.apm.2018.11.035

González-Benito, J., & González-Benito, O. (2005). Environmental proactivity and business performance: An empirical analysis. *Omega, 33*(1), 1-15. http://dx.doi.org/10.1016/j.omega.2004.03.002

Green, K., Zelbs, P., Meacham, J., & Bhadauria, V. (2012). Green supply chain management practices: Impact on performance. *Supply Chain Management: An International Journal, 17*(3), 290-305. http://dx.doi.org/10.1108/13598541211227126

Gupta, S., Soni, U., & Kumar, G. (2019). Green supplier selection using multi-criterion decision making under fuzzy environment: A case study in automotive industry. *Computer & Industrial Engineering, 136*(3), 663-680. http://dx.doi.org/10.1016/j.cie.2019.07.038

Hair, J., Black, W., Babin, B., & Anderson, R. (2014). *Multivariate Data Analysis.* United Kingdom: Pearson Education.

Hair, J., Celsi, M., Money, A., Samouel, P., & Page, M. (2016). *Essentials of Business Research Methods.* New York: Routledge.

Hao, Y, Helo, P., & Shamsuzzoha, A. (2018). Virtual factory system design and implementation: Integrated sustainable manufacturing. *International Journal of Systems Science: Operations & Logistics, 5*(2), 116-132. https://doi.org/10.1080/23302674.2016.1242819

Hatcher, L. (1994). *A Step-by-Step Approach to Using the SAS System for Factor Analysis and Structural Equation Modeling*. North Carolina: SAS Institute Inc.

Huang, S., & Zhang, H. (2019). Green supply chain management of automotive manufacturing industry considering multiperspective indices. *IEEJ Transactions on Electrical and Electronic Engineering, 14*(12), 1787-1795. http://dx.doi.org/10.1002/tee.23005

Ivascu, L., Mocan, M., Draghici, A., Turi, A., & Rus, S. (2015). Modeling the green supply chain in the context of sustainable development. *Procedia Economics and Finance, 26*(1), 702-708. http://dx.doi.org/10.1016/S2212-5671(15)00819-9

Kazancoglu, Y., Sagnak, M., Kayikci, Y., & Mangla, S. (2020). Operational excellence in a green supply chain for environmental management: A case study. *Business Strategy and the Environment*, 29(3), 1532-1547. http://dx.doi.org/10.1002/bse.2451

Kirchoff, J., Tate, W., & Mollenkopf, D. (2016). The impact of strategic organizational orientations on green supply chain management and firm performance. *International Journal of Physical Distribution and Logistics Management, 46*(3), 269-292. http://dx.doi.org/10.1108/IJPDLM-03-2015-0055

Laari, S., Töyli, J., Solakivi, T., & Ojala, L. (2016). Firm performance and customer-driven green supply chain management. *Journal of Cleaner Production*, 112(1), 1960-1970. http://dx.doi.org/10.1016/j.jclepro.2015.06.150

Large, R., & Thomsen, C. (2011). Drivers of green supply management performance: Evidence from Germany. *Journal of Purchasing and Supply Management, 17*(3), 176-184. http://dx.doi.org/10.1016/j.pursup.2011.04.006

Larsson, A. (2002). The development and regional significance of the automotive industry: Supplier parks in Western Europe. *International Journal of Urban and Regional Responsible, 26*(7), 767-784. https://doi.org/10.1111/1468-2427.00417

Lee, S., Tae-Kim, S., & Choi, D. (2012). Green supply chain management and organizational performance. *Industrial Management & Data System, 112*(8), 1148-1180. http://dx.doi.org/10.1108/02635571211264609

Liu, Y., Zhu, Q., & Seuring, S. (2017). Linking capabilities to green operation strategies: The moderating role of corporate environmental proactivity. *International Journal of Production Economic, 187*(1), 182-195. http://dx.doi.org/10.1016/j.ijpe.2017.03.007

Lopes, L., & Pires, S. (2020). Green supply chain management in the automotive industry: A study in Brazil. *Business Strategy and the Environment, 29*(12), 2755-2769. https://ideas.repec.org/a/bla/bstrat/v29y2020i6p2755-2769.html

Luo, Z., Chen, X., & Wang, X. (2016). The role of co-operation in low carbon manufacturing. *European Journal of Operational Research, 253*(2), 392-403. http://dx.doi.org/10.1016/j.ejor.2016.02.030

Luthra, S., Garg, D., & Haleem, A. (2016). The impacts of critical success factors for implementing green supply chain management towards sustainability: An empirical investigation of Indian automobile industry. *Journal of Cleaner Production, 121*(1), 142-158. http://dx.doi.org/10.1016/j.jclepro.2016.01.095

Maditati, D., Munim, Z., Schramm, H., & Kummer, S. (2018). A review of green supply chain management: From bibliometric analysis to a conceptual framework and future research directions. *Resource Conservation and Recycling*, 1*39*(1), 150-162. http://dx.doi.org/10.1016/j.resconrec.2018.08.004

Masoumi, S., Kazemi, N., & Abdul-Rashid, S. (2019). Sustainable supply chain management in the automotive industry: A process-oriented review. *Sustainability, 11*(14), 1-30. http://dx.doi.org/10.3390/su11143945

Mathivathanan, D., & Haq, A. (2017). Comparisons of sustainable supply chain management practices in the automotive sector. *International Journal of Business Performance and Supply Chain Models, 9*(1), 18-27. https://doi.org/10.1504/IJBPSCM.2017.083884

Mathivathanan, D., Kannan, D., & Haq, A. (2018). Sustainable supply chain management practices in Indian automotive industry: A multi-stakeholder view. *Resources Conservation and Recycling, 128*(1), 284-305. http://dx.doi.org/10.1016/j.resconrec.2017.01.003

Meckenstock, J., Barbosa-Póvoa, A., & Carvalho, A. (2015). The wicked character of sustainable supply chain management: Evidence from sustainability reports. *Business Strategy and Environment, 25*(1), 449-477. https://ideas.repec.org/a/bla/bstrat/v25y2016i7p449-477.html

Montabon, F., Sroufe, R., & Narasimhan, R. (2007). An examination of corporate reporting, environmental management practices and firm performance. *Journal of Operation Management, 25*(5), 998-1014. http://dx.doi.org/10.1016/j.jom.2006.10.003

Murray, S., & Larry, S. (2009). *Statistics*. Mexico D.F.: McGraw-Hill

Niu, B., Mu, Z., Chen, L., & Lee, C. (2019). Coordinate the economic and environmental sustainability via procurement outsourcing in a co-opetitive supply chain. *Resources, Conservation & Recycling, 146*(1), 17-27. http://dx.doi.org/10.1016/j.resconrec.2019.03.007

Niu, B., Yu, X., & Shen, Z. (2021). Structure adjustment of automobile supply chain facing low-carbon emission standard. *Resource, Conservation & Recycling, 171*(1), 1-12. http://dx.doi.org/10.1016/j.resconrec.2021.105629

Nunally, J., & Bernstein, I. (1994). *Psychometric Theory*. New York: McGraw-Hill.

Ouardighia, F., Simb, J., & Kim, B. (2016). Pollution accumulation and abatement policy in a supply chain. *European Journal of Operational Research, 248*(4), 982-996. https://doi.org/10.1016/j.ejor.2015.08.009

Pagell, M., & Wu, Z. (2009). Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars. *Journal of Supply Chain Management, 45*(2), 37-56. http://dx.doi.org/10.1111/j.1745-493X.2009.03162.x

Qorri, A., Mujkic Z., Gashi, S., & Kraslawski, A. (2018). Green supply chain management practices and company performance: A meta-analysis approach. *Procedia Manufacturing, 7*(1), 317-325. https://doi.org/10.1016/j.promfg.2018.10.052

Rabbani, M., Foroozesh, N., Mousavi, S., & Farrokhi-Asl, H. (2019). Sustainable supplier selection by a new decision model based on interval-valued fuzzy sets and possibilistic statistical reference point systems under uncertainty. *International Journal of Systems Science: Operations & Logistics, 6*(2), 162-178. https://doi.org/10.1080/23302674.2017.1376232

Richey, R., Chen, H., Genchev, S., & Daurgherty, P. (2005). Developing effective reverse logistics programs. *Industrial Marketing Management, 34*(8), 830-840. http://dx.doi.org/10.1016/j.indmarman.2005.01.003

Sarkar, B., Guchhait, R., Sarkar, M., & Cárdenas-Barrón, L. (2019). How does and industry manage the optimum cash flow within a smart production system with the carbon footprint and carbon emission under logistics framework? *International Journal of Production Economics, 213*(2), 243-257. http://dx.doi.org/10.1016/j.ijpe.2019.03.012

Silva, G., Gomes, P., & Sarkis, J. (2019). The role of innovation in the implementation of green supply chain management practices. *Business Strategy and the Environment, 28*(5), 819-832. http://dx.doi.org/10.1002/bse.2283

Singh, B., & Kumar, G. (2021). Green supply chain management: Scientometric review and analysis of empirical research. *Journal of Cleaner Production, 284*(1), 1-13. https://doi.org/10.1016/j.jclepro.2020.124722

Song, M., Saen, R., Fisher, R., & Tseng, M. (2019). Technology innovation for green growth and sustainable resource management. *Resources, Conservation & Recycling, 146*(2), 141-151.

Spetic, W., Marquez, P., & Kozak, R. (2012). Critical areas and entry points for sustainability-related strategies in the sugarcane-based ethanol industry of Brazil early view. *Business Strategy and Environment, 21*(6), 370-386. http://dx.doi.org/10.1002/bse.1727

Srivastava, S. K. (2007). Green supply chain management: A state-of-the-art literature review. *International Journal of Management Reviews, 9*(1), 53-80. http://dx.doi.org/10.1111/j.1468-2370.2007.00202.x

Vachon, S., & Klassen, R. (2006). Green project partnership in the supply chain: The case of the package printing industry. *Journal of Cleaner Production*, 14(6/7), 661-671. http://dx.doi.org/10.1016/j.jclepro.2005.07.014

Vanalle, R., Ganga, G., Godinho-Filho, M., & Lucato, W. (2017). Green supply chain management: An investigation of pressures, practices, and performance within the Brazilian automotive supply chain. *Journal of Cleaner Production, 151*(1), 250-259. http://dx.doi.org/10.1016/j.jclepro.2017.03.066

Xia, X., Govindan, K., & Zhu, Q. (2015). Analyzing internal barriers for automotive parts remanufacturers in China using grey-DEMATEL approach. *Journal of Cleaner Production, 87*(7), 811-825. http://dx.doi.org/10.1016/j.jclepro.2014.09.044

Yawar, A., & Seuring, S. (2017). Management of social issues in supply chains: A literature review exploring social issues, actions and performance outcomes. *Journal of Business Ethics, 141*(3), 621-643. http://dx.doi.org/10.1007/s10551-015-2719-9

Ye, F., Li, Y., & Yang, Q. (2018). Designing coordination contract for biofuel supply chain in China. *Resources, Conservation & Recycling, 128*(1), 306-314. http://dx.doi.org/10.1016/j.resconrec.2016.11.023

Yenipazarli, A. (2017). To collaborate or not to collaborate: Prompting upstream eco-efficient innovation in a supply chain. *European Journal of Operational Research, 260*(2), 571-587. http://dx.doi.org/10.1016/j.ejor.2016.12.035

Younis, H., Sundarakani, B., & Vel, P. (2016). The impact of implementing green supply chain management practices on corporate performance. *Competitive Review, 26*(3), 216-245. http://dx.doi.org/10.1108/CR-04-2015-0024

Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operation Management, 22*(3), 265-289. http://dx.doi.org/10.1016/j.jom.2004.01.

Zhu, W., & He, Y. (2017). Green product design in supply chains under competition. *European Journal of Operational Research, 258*(1), 165-180. http://dx.doi.org/10.1016/j.ejor.2016.08.053

Notes

* Research paper

Licencia Creative Commons CC BY 4.0

Cited as: Maldonado, G., Mojica, E. P., & Pinzón, S. Y. (2021). Green supply chain management and firm performance in the automotive industry. *Cuadernos de Administración, 34*. https://doi.org/10.11144/Javeriana.cao34.gscmf