Chapter 2
Green Production Attributes and Its Impact in Company's Sustainability

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Abstract The process of selection of a supplier plays a fundamental role in the supply chain. With the emergence of the so-called green attributes this process has become more complicated. Besides, it is unknown if the attributes have an impact on the performance of the company. This chapter presents a structural equation model using four latent variables: green policy attributes, green attributes preproduction, green attributes in production processes, and green attributes postproduction to determine the dependence among them. The relationships define six hypotheses. To validate the model, a sample of 253 interviews to managers of firms located in Mexico was taken. To reduce dimensionality the partial least squares (PLS) method was used. The results indicate that there is a direct and positive impact among the variables analyzed. However, the most significant is the relationship between the green policy and the green attributes preproduction.

Keywords Supply chain · Green attributes · Structural equation model · Green supply chain · Green supplier selection

2.1 Introduction

The supply chain (SC) concept was first introduced in the early 80s. Nowadays, this concept is regarded as a strategic and competitive advantage for organizations (Wagner and Kemmerling 2014). At the beginning, a typical SC comprised activities such as planning, material control, information flow and distribution, and only considered operational and economic aspects (Ahi and Searcy 2013).

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Nevertheless, the SC concept has evolved and now is considered a social and environmental aspect (Fahimnia et al. 2015).

The social and environmental elements are integrated into the management and the operations of the SC. Especially, during the last 15 years, which has given rise to concepts such as green supply chain (GSC), sustainability, social corporate responsibility, and green supplier selection (GSS), among others. These concepts have narrowed the relationship between the SC and the suppliers. Because, the suppliers represent the first link in the SC. Therefore, the selection of a supplier is considered an operational and strategic task for the development of effective and long-term partnerships (Sarkis and Dhavale 2015), and hence, the importance of engage the providers in environmental topics of the company. Due to these considerations, the problem of green supplier's selection is more complex than the selection of a traditional supplier. However, with the identification of environmental, social, and economic criteria to be evaluated, it is sought to facilitate this task to the organizations (Sarkis and Dhavale 2015).

2.2 Green Supply Chain

The green supply chain (GSC) focuses on how the companies incorporate the suppliers, the processes and the distribution of not only the products and supply materials but also in environmental questions (Scur and Barbosa 2017). An additional purpose is to determine how operations can be carried out to generate products more green and friendly to the environment. Therefore, the collaboration of green suppliers is very important to generate interorganizational interactions among the members of the GSC, including aspects such as the fixation of joint environmental objectives, an environmental planning shared to reduce the pollution or other negative impacts and, above all, to generate products friendly to the environment (Tseng 2011).

Based on the above, then one can conceive the GSC as a system that includes the design of products, supply, and use of green materials from suppliers, green consumers, and green manufacturing processes, in addition to management that must be performed at the end of the useful life of the product (Cabral et al. 2012). Traditionally, it is considered that the green aspects have a higher cost and sacrifice of a lot of benefits. However it has been shown that GSC is able to reduce the ecological impact on the industrial activity without sacrificing quality, cost, reliability, performance, in addition to reduce the consumption of energy; complying with governmental environmental regulations, minimizing ecological damage, and generating a global economic gain (Cabral et al. 2012).

2.3 Components of a Green Supply Chain

A GSC consists of three components or fundamental elements: Suppliers that provide the raw materials to the manufacturer, green production processes, that transform the raw materials into finished products and distribution that leads the products to the final customers through distributors, warehouses, and wholesalers, among others.

2.3.1 Green Suppliers

The integration of suppliers within the GSC it is essential task, because the relationship with them begins when the management of raw materials start the manufacturing of products. This is a critical point and it is important that suppliers become actively involved in the environmental issues from the beginning of the life cycle of a product. Thus, a green supplier can be defined as the actor that supplies the raw materials to the company, complying with the quality, the quantity required, reasonable cost, environmental standards, and factors in the current manufacturing environment (Kuo and Lin 2011).

Because the green suppliers, and the material used to manufacture a product are critical for the GSC, it is convenient to involve to the suppliers in all stages of the product life cycle, from the resource extraction, manufacturing, use and reuse, to the recycling and disposal of wastes (Kannan et al. 2014), only in this way the cycle of environmental sustainability can be maintained (Fritz et al. 2017; Luthra et al. 2016).

2.3.1.1 Green Production Processes

The raw materials supplied are entered into a production process that must be respectful with the environment. Like that green practices within the SC, the productive processes have become important strategies for companies with the aim at achieving operating profit and the increase them in the market. Accordingly, it seeks to have a reduction of environmental impact and achieve greater efficiency (Lean et al. 2016).

Therefore, a process of green production can be defined as the clean production system that reduce or ultimately, eliminate polluting substances harmful for the environment. This type of system is oriented towards the improvement of productivity, reduction of energy consumption, and conservation of resources. Some authors argue that the use of products respectful with the environment can be the driving force behind the generation of added value and cost reduction to the SC. For the achievement of this purpose, the environmental elements should be taken into consideration from the stage of product design up to the final product distribution, in order to make effective use of resources and to reduce the basic environmental pollution (Hursen et al. 2015).

2.3.1.2 Green Distribution

The GSC in the distribution stage can take on different forms, because the companies are in charge of the distribution of the products, leaving to third parties this task. However, this can lead to high cost in distribution, poor management, late deliveries, and more significant environmental impacts, among others (Ameknassi et al. 2016; Zhang et al. 2015).

Nevertheless, a green distribution can be carried out with the combination of specialized distribution companies the logistics department of the organizations in order to reduce the potential pollution such as noise, air pollution, unnecessary waste material packing released to the environment during the transportation, packing and distribution process (Hursen et al. 2015).

For the above, it is understood that in the GSC cannot be neglected in any of its elements, because the synchronized function thereof, will result in the correct resources administration.

2.4 Selection of Green Suppliers

Nowadays companies expect that their suppliers to go beyond compliance, such as quality or delivery on time. The companies are looking for suppliers to commit to an efficient green design in their product with and additional environmental awareness (Tseng and Chiu 2013). Years ago, the first step for the correct selection was to identify the needs based only in the costs However, today it is impossible to see only the costs, because the consumers demand products of lower price, higher quality, longer life, environmentally friendly, shorter delivery times, and more efficient after sales service (Igarashi et al. 2013). In consequence, we can say that the selection of green suppliers is one of the growth research areas in GSC.

However, some researches try to implement several modified and multicriteria classic methods to facilitate the green suppliers selection, such as: the analytical hierarchical process (AHP), the analytical network process (ANP), the envelope analysis of data (DEA) and mathematical programming (Amindoust et al. 2012). Nevertheless, in order to make an effective evaluation and selection of green suppliers, complete and precise, environmental, social and economic features must be integrated into the fundamental evaluation processes. Here lies the importance of considering the green attributes as the main tool and most complete at the time of carrying out this process (Sarkis and Dhavale 2015).

Although today there is a great variety of green attributes, the companies have defined the circumstances and environment that surrounds them, so that they could consider individual indicators, according to specific conditions, such as the poor selection of suppliers that may bring economic, operational, and bad products problem to the company (Omurca 2013) and there is not a method that can be applied in a generalized manner.

2.5 Green Attributes for Supplier Selection

In 1996, it was the first time that the green attributes in the process of supplier selection was considered, such as: the analysis of the life cycle, the management of waste, and the management of products (Lamming and Hampson 1996). In the same year (Sarkis et al. 1996) found three more green attributes were considered by Lamming and Hampson (1996), the design for the environment, the environmental management of total quality and environmental certification ISO 14000 (Shaik and Abdul-Kader 2011). A year later, (Noci 1997) identifies four groups of green attributes to evaluate a supplier's environmental performance, green competencies, environmental efficiency, green image, and net life cycle cost (Dobos and Vörösmarty 2014). Already for 2002, (Handfield et al. 2002) identified a list of the ten most commonly used green attributes to measuring the environmental performance of suppliers, environmental emissions management, environmental products, ISO 14000 certification, among others. In 2003, Humphreys et al. (2003) does a general ranking of the environmental attributes and named attributes are quantitative, in monetary terms, and qualitative attributes focused on the image of the company (Kannan et al. 2015).

Five years later, Huang and Keskar (2007) identified 14 green attributes as part of the evaluation and selection suppliers (Dobos and Vörösmarty 2014). In 2010, it was mentioned environmental attributes, such as the control of pollution and social responsibility, and provide metrics to do this (Zhu et al. 2010). In 2013 Shen et al. (2013) identifies environmental criteria such as pollution generated in production, resource consumption, eco-design, green image, environmental management system, GSCM commitment of managers, use of environmentally friendly technology, use of environmentally friendly materials and staff training to evaluate the performance of green suppliers.

2.6 The Research Problem and Objective

Even though there are many references that indicate the companies that adopt the green production philosophy achieve operational and economic benefits, in some of them there is still a great resistance to change its practices. However, many times this reluctance on the part of managers is due to the lack of studies that demonstrate in a quantitative form, the relationship the green policy have, the attributes of preselecting green suppliers, the production process and the benefits obtained in commercial nature, including those of a financial type, which are generated when green attributes are considered from the moment they select a supplier (Di Giuli and Kostovetsky 2014).

With the purpose of contributing to the solution of the above problem, the objective of this chapter is to present a causal model that allows us to link and to determine the quantitative impact, when a set of green policy are considered during the suppliers evaluation process ant the green practices in the handling at the end of the product life.

2.7 The Hypotheses

Society, managers, and governments are deeply concerned about the environmental impact, therefore, a series of regulations on the production systems have been established (Igarashi et al. 2013). Nowadays, to reduce the pollution, the organizations are choosing to evaluate green policy attributes on their suppliers from the beginning of the production process (Çifçi and Büyüközkan 2011).

Suppliers should be concerned with complying with environmental policies of government at the local, national, and international levels, and thus meet a social responsibility imposed on them. In other words, they must present a responsible image towards the environment that can be demonstrated through environmental certification (Büyüközkan 2011). For example, Jacobs et al. (2010) mentions that the environmental certification on the ISO 14001 standard is associated with significant upticks positive in the market to the provider due to a green reputation increases unit sales and prices, in addition to that customers are willing to pay more for green products (Schoenherr et al. 2012).

On the other hand, the green attributes with a political approach, can have a major impact on the environmental attributes based on the manufacturing process of the green supplier. However, to comply with the guidelines and green policy, the providers must in turn rely on other suppliers with the same characteristics and in this way form the GSC, which starts with the green design of all and each one of the components (Maniatis 2016; Zhu and He 2017). The ability of the suppliers to improve the design of their products is important in order to reduce the environmental impact throughout the supply chain, as well as maintain sustainability and go to reinforce a green image in organizations (Çifçi and Büyüközkan 2011).

Also, it is important that, before the supplier starts his production process, they demonstrate a range of skills and green practices, such as training and education on such policies, and that such programmers are also evaluated (Winter and Lasch 2016; Teixeira et al. 2016). With the aim to contributing in this area of research, we propose the following hypothesis:

H_1: The *Green policy attributes* have a direct and positive impact on the Green a*ttributes preproduction* considered to select of a green supplier.

The environmental policies set by the provider must be focused not only for planning purposes but also must be applied in the production process (Rehman et al. 2016), as it is here where the greatest expenditure of energy in the processing of raw materials. It requires that one has the adequate technology, friendly with the environment and, above all, the technology to generate the minimum amount of waste, since many times they need to be processed again to correct the defects, which represents an extra expense of energy (Gurel et al. 2015) and there are now models of evaluation and selection of suppliers to integrate (Keshavarz Ghorabaee et al. 2016; Jain et al. 2016).

Many companies have established programs of development of suppliers to improve their environmental performance by making environmental requirements, where aspects related to the collaboration of information is also evaluated (Azadnia et al. 2015). Sometimes, cooperation is not measured only between the manufacturer and the supplier, but extends to the client, who has the duty to show its environmental certifications (Büyüközkan 2011). Therefore, it is proposed as a working hypothesis the following:

H_2: The *Green policy attributes* have a direct and positive impact on the *Green attributes in production process* considered to select a green supplier.

The presence of green skills in the supplier will make an effort to have technologies that are environmentally friendly during the production process, that is, from a green planning stage to a green implementation stage (Akman 2015). In the same way, having a green design will require that kind of technology; you may have a design and proper raw materials with an unfriendly production process (Blome et al. 2014).

However, it is also important that the provider knows the costs for having a system of green production, which should include the design, transformation, and distribution, but in addition, you must share this information with the manufacturer and with the customers (Keshavarz Ghorabaee et al. 2016; Igarashi et al. 2015). Based on the above, the following hypothesis is proposed:

H_3: The *Green attributes preproduction* have a direct and positive effect on *Green attributes in production process* considered to select a green supplier.

Suppliers, in their operating environment, competitive and environmental, understand that it is very complicated and almost impossible to produce without the establishment of clear policies that tend to generate products at low cost and with high quality (Shaik and Abdul-Kader 2011). In fact, today, instead of being a drawback costly to implement, practical green initiatives (often by law) have become a source of competitive parity (Blome et al. 2014).

Therefore, it is observed that one of the key points that can bring a competitive advantage to the organizations is to use the green policy attributes in the selection of supplier. For example, having a corporate social responsibility policy can improve the image of the company to the society in which it plays, which will be reflected in programs of processing of waste and recycling at the end of the useful life of the product (Lean et al. 2016). Finally, the fact of having an environmental certification, such as ISO 14001, will help the company to have guidelines before, during and after the manufacturing process (Zhu et al. 2012).

The companies that implement environmental practices can increase their attractiveness to investors, because today the ISO 14001 standard is associated with a significant upticks positive in the market (Jacobs et al. 2010). Therefore, it is desirable to proactively establish green policy. Based on the above, the following working hypothesis is defined:

H_4: The *Green policy attributes* have a direct and positive effect on the *Green attributes postproduction* considered to select a green supplier.

It is also necessary to incorporate the practices and competencies for evaluation and selection of green supplier, an effort should be made to see reflected in a design that is friendly to the environment, because that will bring a better corporate image (Rezaei et al. 2016). However, these practices must also include proper management of waste not only during the production process, but also at the end of the life cycle of the product through a recycling process (Dweiri et al. 2016). Thus, the attributes that are evaluated in the preproduction of the supplier, may be affecting the levels in which gets the attributes evaluated in the postproduction. This yields the following research hypothesis:

H_5: The *Green attributes preproduction* have a direct and positive effect on the *Green attributes postproduction* considered to select a green supplier.

Green production processes have as objective the continuous improvement of processes and industrial products in order to reduce or prevent all types of pollution generated in the production processes, so that these improvements can lead to reduce the cost of the raw material, increase the production efficiency and reduces the cost of environmental, safety and occupational, as well as the environmental impacts that occur at all stages of the manufacturing processes of products and the SC. Therefore, in order to reduce environmental impacts of products, companies have to ensure that the processes of production of their suppliers and their supply chain are practicing green initiatives constantly (Rostamzadeh et al. 2015). Based on the above, this working hypothesis is defined:

H_6: The *Green attributes in production processes* have a direct and positive effect on the *Green attributes postproduction* considered to select to green supplier.

In Fig. 2.1, you can see graphically the six hypotheses posed above.

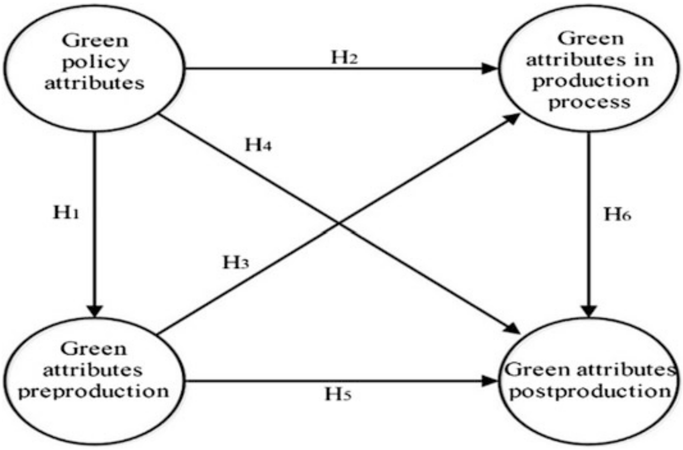

Fig. 2.1 Hypotheses

2.8 Methodology

For clarity, the proposed methodology was divided into the steps explained bravely below.

2.8.1 Stage 1: Literature Review

Information related to GSC was searched from 1996 to this date. The research focuses on the most used green attributes, and those that have recently incorporated as well as the classifications of these attributes that different authors have proposed.

The literature review was carried out on databases such as Springer, Sciencedirect, and Taylor & Francis, Emerald, among others. Some keywords such as "green supplier's selection" and "green supply chain management". Some models of GSS were obtained from the literature review and the benefits that could be obtained. This literature review represents a rational validation of the questionnaire proposed for this research. The research carried out overseas was thus adapted to the environment of the Mexican manufacturing industry.

2.8.2 Stage 2: Questionnaire Formulation

The questionnaire used as data collection instrument was composed of three sections. The first section is a brief description of the research goals and objectives and the directions to answer the survey in a better way. Demographic questions also

Table 2.1 Green attributes

Green policy attributes	Green attributes preproduction
Social responsibility (Büyüközkan and Çifçi 2012)	Green buyers (Kumar et al. 2016)
Control of environmental emissions (Lee et al. 2015)	Green competencies (Singh 2014)
Environmental certification (Tseng and Chiu 2013)	Green design (Govindan et al. 2015)
Green attributes in production processes	Green attributes postproduction
Environmental collaborations with customers (Villanueva-Ponce et al. 2015)	Management of production waste (Tseng and Chiu 2013)
Use of environmentally friendly technology (Tseng and Chiu 2013)	Recycling system (Yeh and Chuang 2011)
Environmental costs (Hashemi et al. 2015)	Green image (Caniëls et al. 2013)

included and the concern to work position of respondents, gender, and size of the company where they work, years of experience in their current position, and the industrial sector of the firm. This information lets to classify the company according to its size regarding the number of employees.

The second section of the survey included a list of 12 attributes that can be evaluated for GSS, as shown in Table 2.1. These listed attributes were previously identified through a literature review carried out at the earliest stage of the research and by considering the work of (Villanueva-Ponce et al. 2015) as the basis. Respondents had to answer this section using a Likert scale with values ranging from 1 to 5, where a value of one indicated that a given attribute was not important for the company, a value of five indicates that the same given attribute was absolutely important in supplier selection process. These items are the most important reported, because currently is possible to identify much more attributes, all them covering a special industrial sector.

2.8.3 Stage 3: Questionnaire Administration

The questionnaire was applied in the industry of Ciudad Juarez (Mexico). It was aimed at personnel of the departments involved in the selection and evaluation of green suppliers. The departments were engineering, purchase, storage, receipt quality, management, quality, finance, and among others.

Moreover, as inclusion principle, it was sought that participants had been working in their current position for at least a year and had participated no less than ten times in the *GSS* process. The questionnaire was finally administered through personal interviews from January to May 2015.

2.8.4 Stage 4: Data Capture

The data was captured using SPSS 20® statistical software because it allows the analysis of large databases and it is easy to use and understand the reports. The lines constructed in the database represent the cases of surveys answered, while columns represent the variables or attributes analyzed.

2.8.5 Stage 5: Database Debugging

The database was debugged to find missing values and to identify outliers. Missing values are the caused because respondents may be omitted one the answer or forget to answer the question, or they do not respond that item for personal decision. If a respondent does not answer a large portion of the survey, those answers provided may turn to be useless in casual models (Lynch 2003). Furthermore, the range of missing values may be flexible, although if more than 10% of answers is missing for a given case, these missing values can be problematic and the case would be discarded (Joseph 2013). In this research, due to the use of a Likert scale as a means of response, missing values were replaced by the median value of variables (Lynch 2003).

The outliers are detected using a box and whisker plots where outliers appear at the borders. Items were also standardized by considering an absolute value greater than four of values as an outlier (Kohler et al. 2015). In addition, the standard deviation was estimated for every item and values close to zero tend to indicate that a respondent has assigned the same value to all items analyzed. Thus, if a standard deviation is lower than 0.500 in a five-point Likert scale, the questionnaire or case is discarded (Leys et al. 2013).

2.8.6 Stage 6: Statistical Validation

In this chapter, we relied on several variables and model fit indexes. The Cronbach's Alpha coefficient was the first index used. It is not statistical in its use; this is the reason why it does not include a *P*-value to reject any hypothesis of reliability in the scale. However, the closest its value is to one, the greatest the reliability in the scale (George and Mallery 2003). In addition, the composite reliability index was searched to measure internal validity, that is, if latent variables are strongly correlated. Likewise, the Average Variance Extracted measured convergent validity, while *R*-squared, Adjusted *R*-squared, and *Q*-squared measured predictive validity (Kock 2014).

2.8.7 *Stage 7: Descriptive Analysis*

The descriptive analysis performed comprise two important aspects: (1) the characterization of the sample and (2) the central tendency measures, as well as the dispersion of items analyzed.

2.8.7.1 Descriptive Analysis of the Sample

Crosstabs were employed to describe the sample. They are used to determine the gender of respondents, their years of experience in their current position, and the industrial sector of the companies. This enabled us to determine the level of experience of participants and thus define reliability of data obtained.

2.8.7.2 Descriptive Analysis of Data

A descriptive analysis was carried out for all items analyzed (green attributes) in every latent variable. Median values were considered as central tendency measure values, while the interquartile range (IQR) was taken as a measure of data dispersion. The first and third interquartile ranges of information are, consequently determined (Kaiser 2011; Hair et al. 1987, 2009; Giaquinta 2009; Rosenthal and Rosnow 1991; Wold et al. 2001).

On the one hand, a high median values indicates that managers surveyed considered a given attribute as important. On the other hand, low median values indicate that the same attribute is not relevant for green supplier selection. Similarly, high IQR values indicated no consensus among respondents concerning the value of an attribute, while low IQR values demonstrated a consensus among respondents regarding the same issue (Green et al. 2014; Likert 1932).

2.8.8 *Stage 8: Generating Structural Equation Models*

In order to prove the hypotheses of Fig. 2.1, the model was evaluated using Structural Equation Modeling (SEM) due to its widely and recent use in causal relations validations and specifically in the supply chain. This technique has been used for measure the impact of JIT (Green et al. 2014), the flexibility, uncertainty, and firm performance of the SC (Merschmann and Thonemann 2011), the effect of green supply chain management on green performance and firm competitiveness (Villanueva-Ponce et al. 2015).

The SEM model can be implemented using the WarpPLS 5.0® software. Its main algorithms are based on Partial Least Squared (PLS), widely recommended for low sample size, non-normal and ordinal data (Kock 2014). The model here presented is specifically executed using a bootstrapping resampling method for a better coefficients values convergence and diminish the effect of possible outliers.

Six model fit indices are analyzed: average path coefficient (APC), the average R-squared (ARS), average adjusted R-squared (AARS), average variance inflation factor (AVIF), average full collinearity VIF (AFVIF) and Tenenhaus index, that are proposed by Kock (2014) and used by Ketkar and Vaidya (2012) in the supply chain environment. For the APC, ARS, and AARS the *P*-values are analyzed to determining the model efficiency, establishing a maximum cutoff *P*-value of 0.05, which mean that the inferences are made with 95% of confidence level, testing the null hypotheses that APC and ARS are equal to 0, versus the alternative hypotheses that APC and ARS are different to zero; while AVIF and AFVIF must be equal to or lower than 5, particularly in models where most of the variables are measured through two or more indicators. The GoF index referred to as "Tenenhaus GoF" and is a measure of a model's explanatory power (Esposito 2010), and the accepted values are small if equal to or greater than 0.1, medium if equal to or greater than 0.25, and large if equal to or greater than 0.36.

Finally, three different effects are measured in the structural equation model: (1) direct effect, that appears in Fig. 2.1 as arrows from a latent variable to another, (2) indirect effect given for paths with two or more segments, and (3) total effects, which is he sum of direct and indirect effects; with the aim to determine their significance, the *P*-values are analyzed, considering the null hypothesis $\beta i = 0$, versus the alternative hypothesis $\beta i \neq 0$.

2.9 Results

The results section is divided into several sections, according to the information that there is a question, which is discussed below.

2.9.1 Sample's Descriptive Analysis

After 4 months, we obtained from the survey a total of 270 questionnaires; only 253 were valid for the analysis. The remaining 17 were removed because of the excess of missing values. Table 2.2 shows two important aspects with respect to the sample, first we can mention that the survey was answered by more men than women, with a total participation of 182 men, representing 71.93% of the total sample and the rest were women, indicating that the positions associated with the selection of suppliers are related to this genre. In the same way, it can be seen that 73.52% specified the area where you carry out your work, being the area of logistics where there was more participation with 67 surveys, followed by the area of engineering with 63 cases.

Table 2.2 Area of the company in which it performs and gender

Area of the company in which it performs	Gender		Total
	Male	Female	
Logistic	40	27	67
Engineering	47	16	63
Manufacture	39	15	54
Materials	25	6	31
Purchasing	14	6	20
Management	12	1	13
Methods	5	0	5
Total	182	71	253

Table 2.3 Latent variable coefficients

Latent variable coefficients	Green policy attributes	Green attributes preproduction	Green attributes in production processes	Green attributes postproduction
R-squared		0.624	0.729	0.727
Adj. *R*-squared		0.622	0.727	0.724
Composite reliab.	0.874	0.916	0.903	0.854
Cronbach's alpha	0.783	0.862	0.839	0.740
Avg. var. extrac.	0.698	0.784	0.756	0.663
Full collin. VIF	3.938	3.377	4.228	3.645
Q-squared		0.623	0.729	0.727

2.9.2 Validation of Latent Variables

The index of validation of the latent variables that are integrated in the model are listed in Table 2.3. The coefficients *R*-square, *R*-square adjusted, and *Q*-squared are provided only for latent variables to be endogenous and that the values above are acceptable, as are higher at 0.02, for which the model has a predictive validity (parametric and non-parametric). The reliability composite and Cronbach's alpha coefficients are calculated for all the latent variables. Table 2.3 shows that these values are greater than 0.7. Therefore, we conclude that the latent variables have internal validity. Table 2.3 shows that all the latent variables have average of variances extracted (AVE) values greater than 0.5. This indicates that the model has an acceptable convergent validity. Finally, all the latent variables analyzed have a VIF less than 5, this values indicates that there are no problems of multicollinearity.

2.9.3 Descriptive Analysis of Items

Table 2.4 shows the descriptive analysis of the items that involve the latent variables of in the proposed model of Fig. 2.1. As it can be observed from the green attributes, the environmental certification is the attribute with a median value greater than 4. On the other hand, it is observed that the attribute of social responsibility has a mean very close to 4, which means according to perception of respondents, that these attributes are the most frequently considered for green supplier selection. The fourth column shows the interquartile range (IQR). In this case, the item with the lowest value corresponds to the item with the median a value of 4 or close to it. In this case, there is a consensus among respondents with respect to environmental certification and social responsibility, and they are the most important, from an univariate point of view since the have the lowest variability in that category.

2.9.4 Structural Equations Modeling (SEM)

The structural equations model was evaluated according to the methodology described above and the result obtained is illustrated in Fig. 2.2, where in each one of the segments that represents the relationship between two latent variables indicates the value of the parameter beta and the *P*-value of the statistical test of significance. It should also be noted that in each of the latent variables dependent indicates a value of *R*-square to measure the amount of variance that is explained by the independent variables.

Table 2.4 Descriptive analysis of items

Green attributes	Median	Percentiles		IQR
		25	75	
Social responsibility	3.910	3.099	4.682	1.582
Control of environmental emissions	3.786	2.871	4.637	1.766
Environmental certification	4.119	3.135	4.833	1.698
Environmental collaborations with customers	3.593	2.728	4.448	1.720
Use of environmentally friendly technology	3.579	2.624	4.500	1.876
Environmental costs	3.796	2.900	4.635	1.735
Green buyers	3.449	2.544	4.343	1.799
Green competencies	3.375	2.496	4.245	1.749
Green design	3.473	2.521	4.391	1.870
Management of production waste	4.083	3.231	4.782	1.551
Recycling system	3.803	2.825	4.655	1.830
Green image	3.561	2.650	4.453	1.803

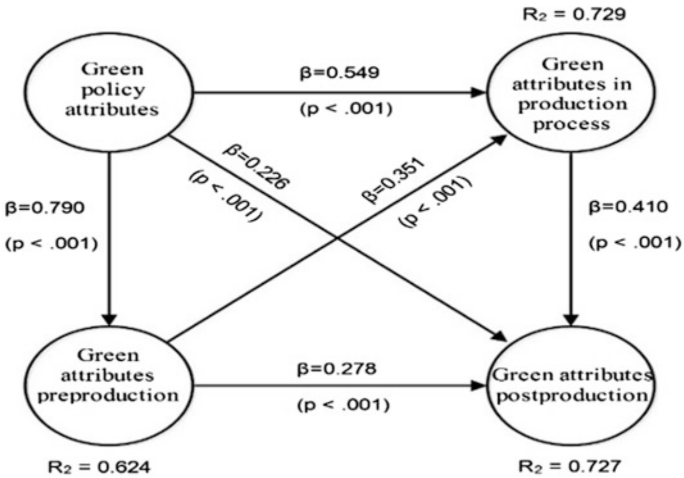

Fig. 2.2 Evaluated model

Indexes employed to measure efficiency of the model were

- Average path coefficient (APC) = 0.434 $P < 0.001$
- Average R-squared (ARS) = 0.693, $P < 0.001$
- Average adjusted R-squared (AARS) = 0.691, $P < 0.001$
- Average block VIF (AVIF) = 3.180, acceptable if <= 5, ideally ≤ 3.3
- Average full collinearity VIF (AFVIF) = 3.797, acceptable if ≤ 5, ideally ≤ 3.3
- Tenenhaus GoF (GoF) = 0.709, small ≥ 0.1, medium ≥ 0.25, large ≥ 0.36

According to the indices, APC, ARS, and AARS that have a P-value to determine its statistical significance, it is concluded that the model has sufficient predictive validity, and that the dependence between the latent variables analyzed in average is different from zero, as it is statistically significant with a confidence level of 95%. In relation to the collinearity existing between the latent variables, it is observed that the index AVIF is under 3.3 and the index AFVIF is less than 5, it is concluded that there is no problem of collinearity in the model. Finally, the index of Tenenhaus is an acceptable value; since that is higher than 0.36 and, therefore, the data fit the proposed model.

2.9.5 *Direct Effects*

The direct effects are used to test the hypotheses depicted in Fig. 2.1. The results are illustrated in Fig. 2.2. We can yield the following conclusions:

- H_1: There is enough statistical evidence to state that *Green policy attributes* have a direct and positive impact on the *Green attributes preproduction* considered to select a green supplier, In fact, when the deviation standard of the former latent variable increases one unit, the deviation standard of the latter rises 0.790 units.
- H_2: There is enough statistical evidence to state that *Green policy attributes* have a direct and positive impact on the *Green attributes in production process* prepro*duction* considered to select a green supplier, In fact, when the deviation standard of the former latent variable increases one unit, the deviation standard of the latter rises 0.549 units.
- H_3: There is enough statistical evidence to state that *Green attributes preproduction* have a direct and positive impact on the *Green attributes in production process* considered to select a green supplier, In fact, when the deviation standard of the former latent variable increases one unit, the deviation standard of the latter rises 0.351 units.
- H_4: There is enough statistical evidence to state that *Green policy attributes* have a direct and positive impact on the *Green attributes postproduction* considered to select a green supplier, In fact, when the deviation standard of the former latent variable increases one unit, the deviation standard of the latter rises 0.226 units.
- H_5: There is enough statistical evidence to state that *Green attributes preproduction* have a direct and positive impact on the *Green attributes postproduction* considered to select a green supplier, In fact, when the deviation standard of the former latent variable increases one unit, the deviation standard of the latter rises 0.278 units.
- H_6: There is enough statistical evidence to state that *Green attributes in production process* have a direct and positive impact on the *Green attributes postproduction* considered to select a green supplier, In fact, when the deviation standard of the former latent variable increases one unit, the deviation standard of the latter rises 0.410 units.

However, it is important to mention that the latent variable *Green attributes in production process* is explained in 72.9% by the variable of *Green policy attributes and Green attributes preproduction*, as R-square has a value of 0.729, of which the 27.5%, from the variable *Green attributes preproduction* while 45.4% are from the latent variable *Green policy attributes*.

Table 2.5 shows a summary of the conclusions obtained with the assumptions of Fig. 2.2.

Table 2.5 Direct effects and conclusion of hypotheses

Hypotheses	VI	*β*	VD	*P*-Values	Conclusion
H_1	GPA	0.790	GAP	$P < 0.001$	Accepted
H_2	GPA	0.549	GAPP	$P < 0.001$	Accepted
H_3	GAP	0.351	GAPP	$P < 0.001$	Accepted
H_4	GPA	0.226	GAPO	$P < 0.001$	Accepted
H_5	GAP	0.278	GAPO	$P < 0.001$	Accepted
H_6	GAPP	0.410	GAPO	$P < 0.001$	Accepted

GPA Green policy attributes, *GAP* Green attributes preproduction, *GAPP* Green attributes in production process, *GAPO* Green attributes postproduction

2.9.6 Sum of Indirect Effects

In the model evaluated in Fig. 2.2, we observe four indirect effects:

1. The latent variable, called *Green policy attributes*, has an indirect impact on the latent variable called *Green attributes in production process* given through the mediator variable *Green attributes preproduction*. The indirect effect is 0.277 ($P < 0.001$) and is statistically significant with 95% of confidence level and it can explain up to 22.9% of its variability, given that the size of the effect is 0.229.
2. The latent variable, called *Green policy attributes,* has an indirect impact on the latent variable called *Green attributes postproduction* given through the mediator variable *Green attributes in production process,* or through the mediator variable *Green attributes preproduction*. The indirect effect is of 0.444 ($P < 0.001$) and is statistically significant with a 95% of confidence level and can explain up to 34.8% of its variability, given that the size of the effect is 0.348.
3. The latent variable, called *Green policy attributes,* has an indirect impact on the latent variable called *Green attributes postproduction* given through the mediator variable *Green attributes in production process*. The indirect effect is of 0.144 ($P < 0.001$) and is statistically significant with a 95% of confidence level can explain up to 11.2% of their variability, given that the size of the effect is 0.112.
4. The latent variable, called *Green policy attributes* has an indirect impact on the latent variable called d *Green attributes postproduction* given through the mediator variable *Green attributes preproduction* and of the mediator variable *Green attributes in production process*. The indirect effect is 0.114 ($P < 0.001$), which is statistically significant with a 95% of confidence level and can explain up to 8.9% of their variability, given that the size of the effect is 0.089.

Table 2.6 illustrates the indirect effects that exist between the variables that are involved in the proposed model.

Table 2.6 Sum of indirect effects

To	From	
	Green policy attributes	Green attributes preproduction
Green attributes in production process	0.277 (*P* < 0.001) ES = 0.229	
Green attributes postproduction	0.558 (*P* < 0.001) ES = 0.437	0.144 (*P* < 0.001) ES = 0.112

Table 2.7 Total effects

To	From		
	Green policy attributes	Green attributes preproduction	Green attributes in production processes
Green attributes preproduction	0.790 (*P* < 0.001) ES = 0.624		
Green attributes in production processes	0.826 (*P* < 0.001) ES = 0.683	0.351 (*P* < 0.001) ES = 0.275	
Green attributes postproduction	0.784 (*P* < 0.001) ES = 0.614	0.422 (*P* < 0.001) ES = 0.329	0.410 (*P* < 0.001) ES = 0.334

2.9.7 Total Effects

The sum of the direct and indirect effects provides the total effects. In this case, there are three indirect effects, and Table 2.7 illustrates a summary of the same. Note that in three of the relationships between variables, the direct effect equals the total effect, and in the remaining three includes the sum of the effects-direct and indirect. It is important to mention that the direct effects of *Green attributes policy* with the variable *Green attributes postproduction* is only 0.177, but that the indirect effect through the variable *Green attributes preproduction*, or the variable Attributes of green in preproduction is 0.348.

2.10 Conclusions

From the structural equation model evaluated and the six proposed hypotheses, it can be concluded that the inclusion of the four different groups of green attributes defined in this research can be used at the time of conducting the assessment of a provider because they are significant. The underlying reason is that the attributes have a very close relationship with each other to achieve the goal of actually green supplier selection in a particular organization. In addition, it was found that the green policy attributes come to have a greater positive impact, indirectly, on the green attributes postproduction through the green attributes preproduction and production processes. With this information you can ensure that today take in consideration green attributes today is paramount in order to have a competitive advantage within the GSC as well as demonstrating a social responsibility on the part of the organization towards its customers and competitors.

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