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Eco-Innovation Practices' Adoption in the Automotive Industry

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Responses to Reviewers

Reviewer: 1

Authors are extremely thankful to the anonymous reviewer for taking the time to review our paper and make well-considered comments to improve it. We are pleased with the feedback you have provided in regards to considering that the paper has potential and for wishing us the courage and good luck for the further process. We have taken all your recommendations on board and made the necessary modifications and improvements in the revised version of our paper. We sincerely hope that our revised version satisfies your queries/concerns. We have used the track changes function to show the changes we have made in the revised paper and hence they are highlighted in red colour in the text. We have also provided pointwise answers to the raised queries below.

Query 1: Thank you for the opportunity to review this paper. While there is a lot to do in this paper and it is risky, I am recommending for the paper to continue into the revision process, since the data and methods seem largely appropriate and I think there is a niche audience that wants to know about your results. Please try hard to clarify the operationalization, definitions and language issues and make sure to provide the items used to avoid rejection in the next round. Similarly, I recommend integrating quotes from your interviews or at least some descriptive information on who you interviewed and what questions you asked to motivate your survey! Also, I think you can condense and clarify the theoretical contribution, reorganize the paper a bit and try to go deeper in the study, perhaps with one or more additional and less obvious hypotheses. I see potential in this paper and wish the authors courage and good luck for the further process. It would be great to see more papers from Latin America since our knowledge of the region is not as strong as it could be.

Response: We sincerely thank the learned reviewer for the positive comments and the constructive feedback that has been provided to improve our article. We have considered and addressed all the concerns that you summarise above as indicated in our response to your queries below.

(Me) Query 2: Originality: Does the paper contain new and significant information adequate to justify publication?: First, I enjoyed reading and reviewing this paper. It is on an interesting and trending subject at the intersection of innovation and sustainability and therefore suitable to the journal's core disciplines and mission.

The originality question is a difficult question to answer. On the one hand, analyzing the combinatory effect of the chosen constructs based on previous literature provides some value for the subfield of innovation dealing with sustainable production and for me the research gap is believable and present. On the other hand, as it stands, the hypotheses are not surprising and the added value of the study is not as high as it could be if more thought was put into it and the data explored more deeply. The article feels like it was written for the Journal of Cleaner Production and then sent to IJIS. Nonetheless, the subject is interesting and the methodology shows promise. While the paper is in an early stage of development, after reading it several times, I am inclined to accept it with major revisions.

Response: We sincerely thank the learned reviewer for considering that our paper “provides some value for the subfield of innovation dealing with sustainable production” and that the research gap that we are addressing is “believable” and current. We are also glad that you found

"the subject interesting and that the methodology shows promise". In relation to the hypotheses, they were formulated based on the gap in the knowledge that we argue and demonstrate exists in the subject field. Thus, although these may, in some instances, be considered not surprising, their testing is contributing to fill an important gap in the academic literature. We sincerely hope that the learned reviewer agrees with this. We consider that you are absolutely correct in suggesting that we can do much more with the extensive data we have collected. For this, we are currently preparing two more papers that will investigate Eco-Innovation from a different angle and that we are planning to submit to the Int. J. of Innovation Science. Finally, due to its strong emphasis on environmental sustainability, the paper may be seen/read like if it was written to the J. of Cleaner Production as the learned reviewer suggests. However, we have followed the style of other papers published in the IJIS and the Eco-Innovation topic is highly related to the IJIS, once more, we sincerely hope that you agree with this view.

Query 3: Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: Yes, overall. A number of key papers in this area are cited. However, constructs are poorly defined, e.g., eco-innovation should be defined on first use on page 1. There are also sweeping generalizations such as 'in almost all countries'. The literature review is a bit superficial right now and could be structured better. I would recommend condensing previous empirical findings in a structured literature review format as a table. The organization of the presented text is also less than idea. Some paragraphs would be better moved up front, e.g. the explanation of eco-innovation (currently on page 4). I am also not clear why you focus on internal vs. external factors (on page 4), which only became clear in the discussion – clearly much too late.

Response: We sincerely thank the learned reviewer for raising this important issue. Following your advice, we have now carried out and incorporated the conceptualization of eco-innovation on page 1 of the article, please, see end of second paragraph in Section 1 in red colour. We also improved its wording and readability. In addition, the explanations of the Internal and External Factors were eliminated. Likewise, a Table (Table 1) that summarises the empirical results of the main papers published in the literature has now been added to the article, please, see end of Section 2.

Query 4: Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?:

Overall, the paper builds on a base of previous literature in the field of eco-innovation adoption in firms. The general design seems adequate, beginning with a qualitative pilot phase (n=8 interviews) leadings into a quantitative survey-based approach. The numbers presented for the CFA and SEM analyses seem appropriate and in line with the thresholds suggested by econometricians. That being said, important information is missing in order to be able to fully evaluate the study. First, no evidence is provided for the qualitative interviews, that is no quotes and no information on the interviewees. This should be added to the methodology section or at least to the Appendix to be able to validate the study and provide stronger motivation for your research question. Second, the scale used for the survey is not included and not even sample items are presented. This is urgently needed to be able to review the study. It would also be helpful to know more about who exactly distributed the survey and who took it, e.g. only managers with innovation in their title? Second, the operationalization of constructs is very unclear to me. How is the dependent variable, "the adoption of eco-innovation practices" measured? Is this part of the survey measured on a 5-point Likert-Scale? Or is this a binary construct for which a logit or

probit analysis would make sense? I would strongly suggest clarifying the composition of the dependent variable. Concerning the independent variables, and in particular the three which are hypothesized on, it is also unclear how exactly these are measured. There is also little to no information provided about control variables - did you control for example for the firm age, manager age and gender, manager's position, etc.?

Also, if more than half of the whole ecology of firms (460 out of 909) was used as the n in the study, is this really a random sample? And if so, what was the response rate? This is a bit confusing to the reader. The response rate seems very high indeed. Please explain what you mean by a maximum error of 4% and reliability of 95%. These terms are confusing as stated. I assume you mean the maximum sampling error (MSE) at 95% confidence interval - this is probably a language issue. I would suggest better explaining the sampling procedure.

Further, what do the hypotheses really tell us? Just validating the measures is not really surprising, so I would suggest going deeper into the data to add a fourth and perhaps fifth hypotheses which more interesting questions.

A smaller question I ask myself is whether the automotive industry firms are really Mexican firms or rather international firms (also) operating factories or added value service operations in Mexico. How would this impact the generalizability of your results?

Response: Similarly as before, we sincerely thank the learned reviewer for the very detail revision of our article and providing excellent suggestions for its improvement. In regards to the specific issues raised in relation to the paper's methodology, the procedure followed in the first phase of the study in the methodology section has now been explained in more detail and clearly. The fieldwork carried out to obtain the information of manufacturing companies has also been specified in the methodology section. Please, see paragraphs/sentences in red colour in the methodology.

In regards to the measurement of the dependent variable (Adoption of Eco-Innovation Practices), it was measured through the three factors or dimensions (Independent Variables), through the use of Structural Equation Modelling. Regarding the control variables, it should be clarified that only General or Production Managers of any Mexican company in the automotive industry were considered as potential sources for data collection. In this regard, the time that the company had been operating and its capital origin were not considered. This has now been clarified in the paper, please, see paragraphs/sentences in red colour in the methodology.

The application of a "Random Sample" was considered mainly due to at the time of the gathering of the information a "Systematic Leap" was applied to avoid surveying a high percentage of companies of the same industrial parue. This was also done to ensure that the sample of 460 companies was representative of all the industrial parks where the companies of automotive industry were located.

In addition, the application of the 460 surveys was in the companies that collaborated with the research and that allowed the application of the survey, no survey was left in those companies that did not want to participate in the research (less than 5% of the companies that were visited did not want to participate in the study).

4% actually refers to the Maximum Sampling Error while 95% to the confidence interval that was considered relevant to use for the determination of the Sample, this was done in order to make the sample representative of the population under study. Finally, in the Appendix we have now included the 14 items that were used for the measurement of eco-innovation.

Query 5: Results: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: For the most part, yes. While I have conducted rudimentary SEM analyses before and am familiar with the rules of thumb, I am not an expert in this methodology and therefore tend to be on the side of the authors when it comes to the presentation of results. I like that the results are discussed in order, include the beta coefficients and significance levels, and that the results are separated from the conclusion.

Response: We thank the reviewer for this positive comment. No action required.

(Me) Query 6: Practicality and/or Research implications: Does the paper identify clearly any implications for practice and/or further research? Are these implications consistent with the findings and conclusions of the paper?: Yes and no. First, I think that the length of this section is appropriate and I like that the authors made an effort to contemplate the implications of their study. However, the theoretical contribution is not clear enough to me. I would suggest reducing the number of implications and streamlining the most important ones. Perhaps the value of the paper lies in showing which of the constructs are stronger predictors of eco-innovation adoption. For example, how much more variance in your dependent variable does the model explain with all three indicators compared to each combination or each individually?

The first limitation is correct and important - the results are based on highly subjective constructs. This is why at least a full page should be spent on the operationalization of your variables.
I would suggest adding a paragraph specifically with suggestions for future research.

Response: We thank the learned reviewer for raising this concern. We fully agree that in the final section of our article we had dedicated more space and effort to discuss the practical implications derived from our article, and hence the theoretical contribution needed to be beefed-up. We have now tried to highlight the novelty/contribution or our study and hence its theoretical implications, please, see first paragraph and two bullet points in red colour in Section 5.1. We consider that with these additions the theoretical contribution of our paper is better articulated and more emphasised. We sincerely hope you agree with this. As per your important suggestion, we have now recommended for future studies to operationalise the variables product eco-innovation, process eco-innovation and management eco-innovation by incorporating objective data from manufacturing firms (e.g. quality certificates, percentage of use of renewable energies, percentage of use of treated water, total number of units produced) to verifying if the results obtained differ from those obtained in this empirical study (please, see first paragraph in Section 5.3 in red colour.

Query 7: Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: The paper would benefit from a professional language editing service. For me this was not a basis of evaluation for the first stage, but I strongly suggest this before any potential resubmission, given a number of smaller language errors throughout the manuscript that reduce clarity and give it an unpolished feeling right now. There is a good amount of repetition in the paper and sometimes the authors do not explain abbreviations, such as QR standard in the automotive sector. One can only guess at the meaning (quality and reliability perhaps or QR

code?). Spelling errors are also present in the references, see Chair et al, 2016 ("Forecasting" not "Forecast" and "Social" and not "Sociology"). The page numbers are missing for Forza, 2016 and for Nunnally & Bernstein, 1994. Triguero et al, 2013 - is the journal name correct? I recommend double-checking this.

Response: We sincerely thank the learned reviewer for the very thorough review and pointing out some minor but very important issues that affected the quality of communication of our article. As also suggested by Reviewer 2, we have thoroughly proofread the article to ensure that it does not contain grammar or spelling errors as well as to eliminate unnecessary repetitions in our discussions. The proofreading was carried out by a native English speaker academic. We consider that this action has considerably contributed to improving the readability of our article. We hope you agree with this.

We also paid particular attention to make sure that all abbreviations were explained, including that of QR (please, see Section 2.1 in red colour). We have also checked in detail and amended the references highlighted by the reviewer and others that needed minor corrections. In particular, the Nunnally & Bernstein, 1994 reference is a book. According to Emerald guidelines, it is not necessary to include the page numbers of books. Thus, we have not included these. All the other references were amended based on the indications of the learned reviewer. If the article is accepted for publication, Emerald will cross reference the references so if there some minor errors that we were not able to pick with our detail review, these will be identified during that stage of the publication process of the article.

Reviewer: 2

Authors are extremely thankful to the reviewer for providing comments and suggestions in regards to our article. These have helped us to improve different aspects of our paper. We are very pleased with all the positive comments you have made about our article. We have reflected upon your recommendations, and in concurrence with the comments of Reviewer 1, we have incorporated them as indicated below. We have also provided pointwise answers to the raised queries below.

Query 8: Congratulations for the study. The commitment of the researchers is clearly partnered in the text. The large sample analysed is the high point of the study. Only a few minor adjustments are required. Keep investing in this area so important for the competitiveness of organizations. Well done!

Response: We thank the reviewer for this very positive comment. No action required.

Query 9: Relationship to Literature: Does the paper demonstrate an adequate understanding of the relevant literature in the field and cite an appropriate range of literature sources? Is any significant work ignored?: The references used are extremely current, which demonstrates the topicality of the subject and the authors' concern with analyzing the state of the art. Some classic authors on innovation and sustainability could better support the text, but, in my opinion, their lack did not affect the quality of the arguments presented.

Response: We thank the reviewer for this positive comment. No action required.

Query 10: Methodology: Is the paper's argument built on an appropriate base of theory, concepts, or other ideas? Has the research or equivalent intellectual work on which the paper is based been well designed? Are the methods employed appropriate?: Methodology is well

designed. the methods employed are appropriate and well done. Even so, some minor adjustments are required.

In the qualitative phase, how was the choice of experts? Their feedback is very important and should be better described.

How were they oriented? Did they have any guidance on how to analyze the questionnaire or was it done spontaneously?

Response: Thank you very much to the learned reviewer for highlighting this issues. In concurrence with the recommendations of Reviewer 1, we have now explained with more clarity and detail the methodological procedure that was followed during the first phase of the study. Please, see corresponding paragraphs/sentences in red colour in Section 3.

Query 11: Are results presented clearly and analysed appropriately? Do the conclusions adequately tie together the other elements of the paper?: The authors made an SEM, which was a good choice to demonstrate the relationships they intended. Although lean, table 3 shows the information necessary to understand the hypotheses.

The conclusion allows the reader a clear analysis of the results found in relation to the theory and methodology used.

Response: We thank the reviewer for this positive comment. No action required.

Query 12: Practicality and/or Research implications: Does the paper identify clearly any implications for practice and/or further research? Are these implications consistent with the findings and conclusions of the paper?: The authors described four practical implications for the study. All are well made and in line with the theoretical arguments presented. But, I think these implications should be restricted to the automotive industries. Extrapolating to other industries may assume that the results will be the same in any scenario, which may not happen.

Response: Thank you very much to the learned reviewer for considering that the practical implications that we establish and discuss “are well made and in line with the theoretical arguments presented”. We fully agree with the fact extrapolating the results and conclusions obtained from our study to other industries is too adventurous and not appropriate. Thus, we have eliminated these aspects and references to other industries in our discussion.

Query 12: Quality of Communication: Does the paper clearly express its case, measured against the technical language of the field and the expected knowledge of the journal's readership? Has attention been paid to the clarity of expression and readability, such as sentence structure, jargon use, acronyms, etc.: In my opinion, the language is correct, both in the structuring of the text and in relation to the use of the scientific language of this kind of approach.

Response: Thank you very much to the learned reviewer for this positive comment. As also requested by Reviewer 1, we have thoroughly proofread the article to ensure that it does not contain grammar or spelling errors. This proofreading was carried out by a native English speaker academic. We consider that this action has considerably contributed to improving the readability of our article.

Associate Editor Comment: Thank you for submitting the "Eco-Innovation Practices’ Adoption in the Automotive Industry" manuscript and congratulations on the good work. Your topic is

relevant and adds important contributions related to the innovation field. I recommended accepting your manuscript for publication, taking into account the reviewers' recommendations.

Response: We sincerely thank the AE for his/her very positive comments in regards to our article. We have now considered and actioned the comments made by the reviewers and improved our article accordingly. We hope that our actions satisfy the reviewers' concerns and hence you recommend the final acceptance of our paper.

Eco-Innovation Practices' Adoption in the Automotive Industry

Abstract

Purpose – Eco-innovation is a construct that is gaining increasing interest from academics and researchers since it is commonly considered in the literature as one of the strategies that allow manufacturing companies not only to significantly reduce the negative impacts on the environment but also the generation of pollutants. However, little is known about the adoption of eco-innovation practices in manufacturing companies, particularly in the automotive industry. Therefore, this research has as main objective to fill this gap in the literature and explore the interdependence between eco-innovation of products, processes and management.

Design/methodology/approach – The study is conducted through a research framework consisting of 3 measurement scales, 14 items and 3 hypotheses and an extensive review of the literature. A self-administered questionnaire was distributed to a sample of 460 companies in the automotive and auto parts industry in Mexico. Data were analyzed through Confirmatory Factor Analysis, Descriptive Statistics and Structural Equation Modelling.

Findings – The results obtained show that product eco-innovation, process eco-innovation and management eco-innovation are good indicators for the adoption of eco-innovation practices for companies in the automotive and auto parts industry.

Originality/value – The paper addresses a research gap in the academic literature in the eco-innovation field by providing evidence on the interdependence between eco-innovation of products, processes and management and the implementation of their practices in the automotive industry.

Keywords: *Product eco-innovation, process eco-innovation, management eco-innovation, practices of eco-innovation.*

1. Introduction

The changes that are taking place in the environment, as a consequence of global warming and the high level of pollution generated by companies (Dai & Zhang, 2017), coupled with the establishment in the literature of the three pillars of sustainability (environmental, economic and social), are increasingly forcing the international community to put pressure on organizations, particularly companies in the manufacturing industry, to not only comply with environmental regulations and protocols but also to consider the adoption of eco-innovation practices (Aboelmaged, 2018a,b). Also, companies in the manufacturing sector, including those in the automotive industry, are directly responsible for 30% of total emissions of polluting gases.

Thus, given the fact that manufacturing companies produce high levels of environmental pollution and emission of pollutants, particularly automotive manufacturers, the adoption of eco-innovation practices is emerging in the literature as a strategy that contributes to the significant reduction of negative impacts to the environment (Demirel & Kesidou, 2011; Bonzanini *et al.*, 2016). This is because eco-innovation practices do not only include the generation of eco-products, but also new processes (eco-processes) and methods of organization (eco-management) (OECD, 2009a). Therefore, eco-innovation can be conceptualized as "the development or implementation of (new) products, services, processes or management systems that can generate various environmental benefits" (Horbach *et al.*, 2012).

In this sense, eco-innovation is considered by various researchers and academics not only as one of the essential constructs of economic development (e.g. Constantini *et al.*, 2017; Arena *et al.*, 2018) but also as an essential element to reduce the levels of pollution generated by companies (Arranz *et al.*, 2019). Therefore, the development of renewable energies (Ellabban *et al.*, 2014) and the introductions of new techniques in waste management are contributing to the optimization of production processes and economic profitability in companies in the automotive industry (Marousek, 2014). Also, different studies published in the literature have provided evidence of the importance of the activities of eco-innovation in firms, especially emphasizing the role played by managers in the development of eco-innovation practices (Doran & Ryan, 2016; Liao, 2018a).

In this context, the exponential growth that demand has had to improve environmental practices in manufacturing companies, including the automotive industry, coupled with the importance that sustainable development is having in societies around the globe, is increasing the number of techniques, products and services that are friendly to the environment (Arranz *et al.*, 2019). Thus, Jové-Llopis and Segarra-Blasco (2018) considered that manufacturing companies should adopt and implement different activities that integrate sustainable development and imply the realization of important changes in their production systems and management activities. In this line, managers play an essential role in the adoption of eco-innovation practices, not only to facilitate the development of eco-innovation but also to obtain the results expected.

Likewise, the majority of manufacturing companies generally materialize their eco-innovation objectives in regards to the selection and adoption of eco-innovation activities and the degree of development in which they are found (Doran & Ryan, 2016; Liao, 2018b). In this sense, most companies have incorporated a set of objectives in the adoption of eco-innovation practices. However, this is done more as a reactive attitude to the pressure being exerted by authorities,

consumers and society in general rather than as a voluntary incorporation (Doran & Ryan, 2016; Jové-Llopis & Segarra-Blasco, 2018). This has motivated researchers and academics to orient their studies on analyzing the different practices in the adoption of eco-innovation in manufacturing companies (Horbach *et al.*, 2012; Cuevas *et al.*, 2014), including those in the automotive industry.

Several of the studies published in the current literature have focused on analyzing the effects of policies and regulations on the adoption of eco-innovation practices in manufacturing firms (Novellie *et al.*, 2016; Liao, 2018a). Similarly, other studies have centered on the analysis of eco-innovation in industrial organizations (Triguero *et al.*, 2013; Peiró-Signes & Segarra-Oña, 2018), whereas relatively few studies have focused on understanding the internal factors of firms in the decision to adopt eco-innovation practices (Arranz *et al.*, 2019). Therefore, this study emphasizes the identification of the elements that facilitate the adoption of eco-innovation practices in manufacturing firms, as recommended by Díaz-García *et al*. (2015), Bossle *et al*., 2016; Wicki and Hansen (2017), and Tang *et al*. (2018). Thus, it is evident that the chronology of the literature on the adoption of eco-innovation practices is relatively scarce and inconclusive.

Under this perspective and given that the adoption of eco-innovation practices is a global phenomenon, researchers and academics need to direct their studies to offer solid and robust empirical evidence that provides an initial overview, generalize significant inferences, and guide further and more detailed research. Thus, this study contributes to the literature of eco-innovation with the generation of new knowledge as it complements other papers published in the literature (Doran & Ryan, 2016; Da Silva *et al.*, 2017; Arranz *et al.*, 2019) and highlights the adoption of eco-innovation practices in companies in the automotive industry.

For these reasons, the overall effect of product, process and management eco-innovations may still be considered inconclusive. Therefore, to complement and expand the limited body of knowledge, this paper addresses the following research question: *What is the interdependence between eco-innovation of products, processes and management and the implementation of their practices in the automotive industry?* The rest of the paper is structured as follows: Section 2 presents the literature review and development of hypotheses; Section 3 introduces the research methodology; the analysis and interpretation of results are included in Section 4; lastly, Section 5 provides derived conclusions, limitations and future research directions.

2. Literature Review

The adoption of innovation associated with environmental sustainability activities is an issue of increasing interest to researchers and academics (Gauthier & Wooldridge, 2012), who have recognized that firms, and especially companies in the manufacturing industry, need to improve their production practices. To do this, they must consider eco-innovation as a win-win strategy that can help them achieve this goal (Cainelli *et al.*, 2012). Therefore, eco-innovation has usually been analyzed in the literature as a redefinition of innovation (Rennings, 2000), which includes the protection of the environment through the development of new products, processes and management (Dangelico & Pujari, 2010). These have become some of the main factors in the adoption of eco-innovation practices by companies (Bonzanini *et al.*, 2016).

Similarly, the degree of perception of the pressure exerted by society and business partners to reduce environmental pollution (Huang *et al.*, 2009) and environmental regulations (Green *et al.*, 1994; Horbach, 2008; Damirel & Kesidou, 2011; Weng & Lin, 2011; Chen *et al.*, 2012; Horbach *et al.*, 2012) can also boost the adoption of eco-innovation practices (Huang *et al.*, 2009; Arnold & Hockerts, 2011). Additionally, there are other factors in the current literature that are generally considered by various manufacturing companies, mainly in the automotive industry, to evaluate the costs, benefits and risks involved in the adoption of eco-innovation practices (Arnold & Hockerts, 2011), which among of them are human resources (Theyel, 2000; Arnold & Hockerts, 2011; Weng & Lin, 2011) and managers (Eiadat, 2008; Chen *et al.*, 2012).

In this context, the literature has established that not only the factors associated with the activities of suppliers (Lee & Kim, 2011), business partners (del Río-González *et al.*, 2010), and consumers (Lin *et al.*, 2013) are important for the adoption of eco-innovation practices but also that other factors related to the development of new products (Lin *et al.*, 2013), production processes (Dangelico & Pontrandolfo, 2010) and business management (Eiadat *et al.*, 2008) need to be considered. This is due to these three activities are also considered essential to the adoption of eco-innovation practices and the achievement of better organizational performance.

2.1. Product eco-innovation

Roscoe *et al*. (2016) considered that product eco-innovation is directly related to the design of eco-product, which when compared with the different alternatives existing in the market, it is distinguished from the other products as it generates a smaller amount of waste pollutants, or it works through renewable energies (Vieira de Souza *et al.*, 2018). Therefore, it is possible to establish that product eco-innovation is related to the concept of eco-design (Klewitz & Hansen, 2014), and in turn, eco-design is determined by the quality systems of ISO14006 standards (Brones & Carvalho, 2015), or by Quick Response (QR) standards for the case of firms in the automotive industry. Thus, eco-product practices are directly related to both the design and packaging of the same eco-products (Laosirihongthong *et al.*, 2013).

In this sense, product eco-innovation can be considered as a set of tools, methods and principles that allow designers to incorporate those elements that would enable them to reduce negative impacts to the environment (Jacquemin *et al.*, 2012). Likewise, product eco-innovation is generally related to eco-packaging, which commonly incorporates the environmental, economic and social aspects of sustainability, turning it into a packaging that is friendly to the environment through various features such as the optimal conservation of the eco-product, the optimization and storage capacity of the eco-product, a much lighter weight, greater ease of use and the incorporation of various raw materials that are biodegradable and/or recyclable (Jiménez-Guerrero *et al.*, 2015).

The environmental performance of product eco-innovation is closely related to the life cycle indicators of products. It can be categorized into the stages of extraction of raw materials, production of materials, production of products, use of products and completion of the life cycle of the products and their transportation (Arena *et al.*, 2013). For this reason, Klewitz and Hansen (2014) suggested that a life cycle assessment should be carried out in product eco-innovation before adopting eco-innovation practices in firms, since the life cycle of eco-products is generally standardized through ISO 14040 and 14044, which commonly quantify the environmental

impacts generated by the products in each of the stages of their life cycle (Jacquemin *et al.*, 2012; Poudelet *et al.*, 2012).

In addition, Klewitz and Hansen (2014) concluded that the management of materials and raw materials required for the production of eco-products is a practice that is closely related to the adoption of eco-friendly practices (innovation). In fact, Lindahl *et al.* (2014) considered that a combination of the adoption of a sustainability business strategy and an adequate knowledge of the characteristics of the raw materials used in the production of the product eco-innovation can not only facilitate the management of materials but also make their use more efficient.

Finally, Prieto-Sandoval *et al.* (2016) proposed that product eco-innovation is also closely related to the existence of an eco-label development program for products. Furthermore, based on the performance of environmental standards, eco-labels allow manufacturing firms, especially companies in the automotive industry, to label the eco-products to communicate the different aspects of environmental care to different consumers (Li & van't Veld, 2015). In addition, the principles on which eco-labels are generally based are subject to ISO 14020 standards (Prieto-Sandoval *et al*., 2016). Therefore, considering the information previously presented, it is possible to raise the following research hypothesis.

H1: Product eco-innovation is a good indicator of the adoption of eco-innovation practices.

2.2. Process eco-innovation

The literature of eco-innovation establishes the existence of a close relationship between process eco-innovation and the efficiency of eco-processes (eco-efficiency) (Carrillo-Hermosilla *et al.*, 2010). This is primarily when it is necessary to optimize the production systems of manufacturing firms, including companies in the automotive industry, as a result of a reduction in both the resources used in the production of eco-products and in the company's pollution indexes (Vieira de Souza *et al.*, 2018). Likewise, there are different indicators in the literature to measure the efficiency of process eco-innovation (Levidow *et al*., 2016), one of them being, for example, productivity. Productivity is the one most used indicators by researchers and academics, and it is possible to calculate it through the ratio between economic results (profit margin or quantity of eco-products produced), and the associated environmental impacts (emission of pollutants, generation of waste and the level of consumption of resources) (Arampatzis *et al.*, 2016).

Another of the indicators most widely used is the intensity of the environmental burden generated by companies. This can be calculated by means of the ratio between environmental load (emission of pollutants, generation of waste and consumption of resources), and the unit of the economic activity generated (resources generated or units produced) (OECD, 2009b). Therefore, Stanchev and Ribarova (2016) considered that the efficiency of process eco-innovation is subject to ISO 14045 standards. In addition, there are other studies published in the current eco-innovation literature that relate process eco-innovation with clean production (e.g. Klewitz & Hansem, 2014; Levidow *et al.*, 2016; Roscoe *et al.*, 2016). Therefore, manufacturing firms can achieve clean production through the use of technologies that guarantee the protection of the environment, as an integral part of production processes (Demirel & Kesidou, 2011).

Also, Triguero *et al*. (2013) concluded that the use of clean technologies, as an essential part of the adoption of eco-innovation practices, can significantly reduce the total amount of waste and environmental pollution levels of manufacturing firms, mainly those of the automotive industry. Therefore, the changes that are required in production systems and processes can be achieved through process eco-innovation, which allows companies to reduce both the negative impacts on the environment and the impacts on the different ecosystems (Carrillo-Hermosilla *et al.,* 2010).

In this sense, Triguero *et al*. (2013) considered that process eco-innovation is closely related to the use of clean technologies in production processes since process eco-innovation is generally characterized by the incorporation of components and controls that mitigate the various negative impacts that companies generate on the environment, without the need to replace the totality of the processes that had previously generated environmental problems (Carrillo-Hermosilla *et al.*, 2010). Likewise, Faulkner and Badurdeen (2014) considered that the 6 R's (reduction, recovery, rejection, recycling, remanufacturing, and redesign) can generate sustainable innovations in production processes (process eco-innovation) and material flows involved in the life cycle of eco-products.

Additionally, the adoption of eco-innovation practices requires responsible processes with the environment (eco-processes), in such a way that they support companies in the production of eco-innovation products (Triguero *et al.*, 2013), or to significantly improve existing products in the organization, with the possibility of affecting as little as possible the supply chain of eco-products (Klewitz & Hansen, 2014). Therefore, considering the previously presented information, it is possible to formulate the following hypothesis for investigation.

H2: Process eco-innovation is a good indicator of the adoption of eco-innovation practices.

2.3. Management eco-innovation

In the eco-innovation literature, it is common to find that management eco-innovation refers to the development of new management methods, which are aimed at reducing the negative impacts on the environment, as well as improving the conditions of work and welfare of employees of companies (Triguero *et al.*, 2013; Klewitz & Hansen, 2014; Roscoe *et al.*, 2016). In addition, various initiatives generated by firms can be the result of management eco-innovation (Vieira de Souza *et al.*, 2018), one of the most common being the training of employees in sustainable and environmental development (Triguero *et al.*, 2013), or the creation of a purchasing program with local suppliers to significantly reduce the emission of pollutants related to transportation and logistics of raw materials (Klewitz & Hansen, 2014).

Another of the most common initiatives in the eco-innovation literature is the implementation of an organizational structure oriented towards improving the environment (e.g. creation of departments, teams, committees and interdepartmental units) (Klewitz & Hansen, 2014). In addition, an environmental management system is also mentioned in the literature as an important practice of management eco-innovation (Vieira de Souza *et al.*, 2018). It is considered by various researchers and academics as a means to implement management actions related to the environment, as well as for the measurement, reporting and management of the resources used (materials, energy and water consumption), and generation of waste in the production process (Triguero *et al*., 2013; Klewitz & Hansen, 2014; Bossle *et al*., 2016). An environmental

management system is generally subject to the standards of ISO 14001 normative (Lozano, 2012; Campos *et al.*, 2015).

Likewise, other studies published in the current eco-innovation literature have used the classification of environmental performance, as an indicator of the ISO 14031 standard (environmental performance assessment), to classify the indicators that are related to the measurement of environmental management systems (e.g. Campos *et al.*, 2015; Nguyen & Hens, 2015). Therefore, ISO 14031 standard divides environmental performance indicators into the categories of performance management indicators (MPIs) and operational performance indicators (KPIs) (Vieira de Souza *et al.*, 2018). MPIs provide information related to the management efforts that are oriented to improve environmental performance (Campos *et al*., 2015), whereas the KPIs provide information regarding environmental performance related to the operation of the processes in the organizations (Campos *et al*., 2015). Thus, considering the information previously presented, it is possible to propose the following research hypothesis.

H3: Management eco-innovation is a good indicator of the adoption of eco-innovation practices

In summary, it is possible to establish, according to the extensive review of the literature we conducted, that there are relatively few published studies that have been focused in the analysis and discussion of eco-innovation practices in manufacturing companies. The main empirical results obtained from these studies are presented in Table 1.

Table 1. Main empirical studies and results

Authors	Methodology	Results
Doran, J., & Ryan, G. (2014)	A sample of 2,181 Irish companies was used.	The three types of eco-innovation considered (eco-innovation in products, processes and management) had a positive impact on performance.
Bonzanini et al. (2016)	A sample of 581 Brazilian companies was used.	Human resources and environmental management were the most important factors for the adoption of eco-innovation practices.
Vieira de Souza et al. (2018).	A sample of 14 Brazilian ceramic companies was used.	The eco-innovation of products, processes and management were considered as good predictors in the adoption of eco-innovation practices in companies in the ceramic industry of Brazil.
Aboelmaged, M., & Hashem, G. (2019).	A sample of 193 companies from the United Arab Emirates was used.	Sustainable orientation and collaboration were the determinants of the adoption of green innovation while human resources did not have a significant positive impact.
Arranz et al. (2019)	A sample of 5,461 Spanish companies was used.	Eco-innovation in products and management were good indicators in the adoption of eco-innovation, whereas eco-innovation in processes negatively affected the adoption of eco-innovation.

3. Methodology

To test the hypotheses formulated in this paper, an empirical study was conducted in the automotive industry of Mexico to investigate whether product eco-innovation, processes eco-innovation and management eco-innovation were good indicators of the adoption of eco-innovation practices in companies in the automotive industry. In the first phase of the study, qualitative research was conduced through in-depth interviews that were carried out with three academics from the innovation area and five entrepreneurs from the automotive industry. The three academics had several articles published on the topic of innovation while the five entrepreneurs were production managers. In the interviews, the experts were asked for their opinion regarding the 14 items that were used in this research to measure eco-innovation adoption practices.

The three academics and the five entrepreneurs of the automotive industry were invited to participate in a "Business Panel", at the facilities of the Autonomous University of Aguascalientes (Mexico), to analyze and discuss the questionnaire instrument that would be used for the collection of data in this study. The eight participants accepted the invitation, since entrepreneurs regularly have a willingness to participate in this type of studies and events at the Autonomous University of Aguascalientes. The experts worked in a 2-hour session where the moderator was the main author of this article.

After analyzing and discussing the adjustments that each of the experts considered pertinent to improve to the questionnaire, a consensus was sought among all of them to determine which of these adjustments would have to be made and the importance of the same. As a result, some minor amendments were made to the questionnaire instrument. The results obtained during the first phase allowed the design of a questionnaire instrument to collect data. The questionnaire instrument was then reviewed by four academic experts in innovation and ten entrepreneurs of the automotive industry. From such review, some minor adjustments in relation to the writing, appearance and spelling were made. Pilot studies such as the one conducted in this case are essential to ensure validity when questionnaires are self-administered or contain self-developed scales (Bryman, 2016; Hair *et al.*, 2016). An example of some of the questions included in the questionnaire instrument is presented in Appendix 1.

3.1. Sample design and data collection

The data collection process that was considered pertinent to conduct in this empirical study consisted in obtaining the most up-to-date directory of companies of the automotive industry in Mexico, for which the support of the Mexican Automotive Industry Association (MAIA) was requested. The directory consisted of 909 registered companies producing cars and auto parts as of November 30, 2018. Thus, it should be noted that the firms associated with MAIA belonged to various organizations and local, regional and national business chambers. For this reason, the study did not focus on a particular business group or association.

The questionnaire instrument was applied to a sample of 460 companies selected through a simple random sample, with a maximum error of ±4% and a level of reliability of 95%, which represented a 50.6% of the total population. The questionnaire was administrated by a private Market Research company to the General Managers and/or Production Managers of the selected companies. The questionnaire instrument was distributed during the months of January to March

2019. It should also be noted that all the managers that responded to the questionnaire were directly responsible for the adoption and implementation of eco-innovation practices in their respective companies, and they had been working in the automotive industry for several years. This allowed the respondents to provide very valuable and interesting information, due to the deep knowledge and experience they had in the automotive industry.

3.2. Development of measures

As a preliminary step to the analysis of the reliability and validity of the measurement scales used in the present study, the scales of measurement of the three variables used were determined. Thus, for the measurement of product eco-innovation, process eco-innovation and management eco-innovation, an adaptation was made to the scales proposed by Hojnik *et al.* (2014) and Segarra-Oña *et al.* (2014). In this case, product eco-innovation was measured through 4 items, process eco-innovation through 4 items while management eco-innovation was measured through 6 items. A five-point Likert-type scale was chosen to strike a balance between complexity for respondents and accuracy for analysis (Hair *et al.*, 2016).

3.3. Realiability and validity of the measurement scales

For the evaluation of the reliability and validity of the three measurement scales, a Confirmatory Factor Analysis (CFA) was carried out using the maximum likelihood method with the EQS 6.2 software (Bentler, 2005; Brown, 2006; Byrne, 2006). Thus, for the assessment of the reliability of the three scales of measurement both the Cronbach's alpha coefficient and the Composite Reliability Index (CRI) were calculated (Bagozzi & Yi, 1988). According to the results obtained, all values of the scales were greater than 0.7 for both indexes (Cronbach's alpha and CRI), which provided evidence of the reliability of the three scales used and justified their internal reliability (Nunnally & Bersntein, 1994; Hair *et al.*, 2014). Likewise, other methods of estimation were used when it was assumed that normality was present, for which the recommendations of Chou *et al*. (1991) and Hu *et al*. (1992) for the correction of the statistics of the estimation models were used. Therefore, robust statistical analyses (Satorra & Bentler, 1988) were employed to provide stronger evidence of statistical adjustments.

The adjustments that were used in the analysis of the data were the Normalized Fit Index (NFI), Non-Normalized Fit Index (NNFI), Comparative Fit Index (CFI) and the Square Root of the Error Mean of Approach (RMSEA) (Bentler & Bonnet, 1980; Byrne, 1989; Bentler, 1990; Chau, 1997; Heck, 1998; Hair *et al.*, 2014). Values of NFI, NNFI and CFI between 0.80 and 0.89 represent a reasonable adjustment (Segars & Grover, 1993), a value equal to or greater than 0.90 are evidence of a good fit (Jöreskog & Sörbom, 1986; Byrne, 1989; Papke- Shields *et al*., 2002), and RMSEA values of less than 0.080 are acceptable (Jöreskog & Sörbom, 1986, Hair *et al*., 2014). As evidence of convergent validity, the CFA results indicated that all the items of the related factors were significant ($p < 0.001$), the size of all standardized factorial loads were greater than 0.60 (Bagozzi & Yi, 1988), and the average of the standardized factorial loads of each factor surpassed the value of 0.70 (Hair *et al.*, 2014).

The results of the final application of the CFA are presented in Table 2. They suggest that the final measurement model provided a good fit of the data based on the statistical adjustments (*S-B* $X^2 = 407.629$; $df = 74$; $p = 0.000$; $NFI = 0.889$; $NNFI = 0.886$; $CFI = 0.907$; $RMSEA = 0.079$). Similarly, Table 1 showed a high internal consistency of the constructs; in each case the

Cronbach's *Alpha* exceeded the value of 0.70 recommended by Nunnally and Bernstein (1994). The composite reliability represents the variance extracted between the group of observed variables and the fundamental construct (Fornell & Larcker, 1981), for which a CRI higher than 0.60 is generally considered desirable (Bagozzi & Yi, 1988). In this study, this value was widely surpassed. The Extracted Variance Index (EVI) was calculated for each of the constructs, resulting in an EVI greater than 0.50 (Fornell & Larcker, 1981), in this investigation the 0.50 exceeded all factors.

Table 2. Internal consistency and convergent validity of the theoretical model

Variable	Indicator	Factorial Loading	Robust t-Value	Cronbach's Alpha	CRI	EVI
Product Eco-innovation	PEI1	0.664***	1.000[a]	0.874	0.875	0.638
	PEI2	0.799***	12.013			
	PEI3	0.896***	11.154			
	PEI4	0.819***	9.974			
Process Eco-innovation	PRE1	0.859***	1.000[a]	0.916	0.917	0.736
	PRE2	0.884***	31.387			
	PRE3	0.877***	26.703			
	PRE4	0.809***	19.406			
Management Eco-innovation	MEI1	0.777***	1.000[a]	0.926	0.927	0.681
	MEI2	0.759***	17.444			
	MEI3	0.864***	21.767			
	MEI4	0.888***	20.493			
	MEI5	0.884***	21.065			
	MEI6	0.768***	16.306			
$S\text{-}BX^2$ (df = 74) = 407.629; p < 0.000; NFI = 0.889; NNFI = 0.886; CFI = 0.907; RMSEA = 0.079						

[a] = Constrained parameters to such value in the identification process

*** = p < 0.01

Additionally, the discriminant validity of the theoretical model of product eco-innovation, process eco-innovation and management eco-innovation was measured by means of two tests, which are presented in Table 3. In the first place, *the confidence interval test* (Anderson & Gerbing, 1988) establishes that with a confidence interval of 95% none of the individual elements of the latent factors of the correlation matrix have the value of 1. On the other hand, *the extracted variance test* (Fornell & Larcker, 1981) establishes that the variance extracted from each pair of constructs is lower than its corresponding EVI. Therefore, according to the results obtained from the application of these tests, it is possible to conclude that both tests showed sufficient evidence of the existence of discriminant validity.

Table 3. Discriminant validity of the theoretical model

Variables	Product Eco-innovation	Process Eco-innovation	Management Eco-innovation
Product Eco-innovation	**0.638**	0.061	0.048
Process Eco-innovation	0.167 – 0.327	**0.736**	0.242
Management Eco-innovation	0.156 – 0.284	0.364 – 0.620	**0.681**

The diagonal represents the Extracted Variance Index (EVI), whereas above the diagonal the variance is presented (squared correlation). Below diagonal, the estimated correlation of factors is presented with 95% confidence interval.

4. Results

To test the hypotheses formulated in the present study, a structural equation model (SEM) was developed with the support of the EQS 6.2 software (Bentler, 2005; Byrne, 2006; Brown, 2006). The nomological validity of the theoretical model of product eco-innovation, process eco-innovation and management eco-innovation was analyzed through the Chi-square test, by means of which the results obtained between the theoretical model and the measurement model were compared. In this case, the non-significant results obtained allowed the establishment of an explanation of the relationships observed between the latent constructs (Anderson & Gerbing, 1988, Hatcher, 1994). Table 4 presents the results obtained from the application of the second order structural equation model.

Table 4. Results of the SEM

Hypothesis	Structural Relationship	Standardized Coefficient	Robust t-Value
H_1: The product eco-innovation is a good indicator of the eco-innovation practices' adoption.	Product → Eco-innovation	0.243***	11.049
H_2: The process eco-innovation is a good indicator of the eco-innovation practices' adoption.	Process → Eco-innovation	0.494***	25.843
H_3: The management eco-innovation is a good indicator of the eco-innovation practices' adoption.	Management → Eco-innovation	0.370***	19.416
$S\text{-}BX^2$ (df = 70) = 385.536; p < 0.000; NFI = 0.895; NNFI = 0.886; CFI = 0.912; RMSEA = 0.079			

*** = P < 0.01

Table 3 shows the results obtained from the application of the SEM and, with respect to **H1**, it suggests that product eco-innovation is a good indicator of the adoption of eco-innovation practices in companies in the automotive industry as $\beta = 0.243$ $p < 0.001$. Regarding **H2**, the

results obtained ($\beta = 0.494$ $p < 0.001$) indicate that process eco-innovation is also a good indicator of the adoption of eco-innovation practices in companies operating in the automotive industry. Finally, in regards to **H3**, the results ($\beta = 0.370$ $p < 0.001$) suggest that management eco-innovation is a good indicator of the adoption of eco-innovation practices in companies in the automotive industry. In summary, it can be corroborated that the three factors that integrate eco-innovation practices (eco-innovation in products, processes and management) are excellent predictors of the adoption of eco-innovation practices.

5. Discussion, conclusions, implications, limitations and future research directions

5.1 Discussion and conclusions

Several important conclusions can be drawn from the present study and its results. Firstly, the model analyzed shows a high consistency by generating a high correlation between product eco-innovation, process eco-innovation, and management eco-innovation. This enabled the acceptance of the three hypotheses under investigation. Secondly, the same model also offered a general vision in which the eco-innovation indicators most cited in the literature (eco-innovation in products, processes and management) were analyzed. Thus, this study fills a research gap, as previously established in Section 1, and expands our limited theoretical knowledge in the field of eco-innovation by:

- Providing us a better understanding of eco-innovation by exploring the still inconclusive overall interdependence of product, process and management eco-innovations and the implementation of their practices in the automotive industry. Empirical eco-innovation studies have received little attention from researchers and academics, compared to those published studies that have focused on the conceptualization, consequences and drivers of eco-innovation (Kemp, 2009), which from our point of view do not offer a substantial empirical contribution; and
- Explaining their given effects and relationships.

The discussion of eco-innovation practices is an issue that is gaining increasing attention in the academic literature. This allows us to conclude that the integration of innovation activities and sustainable development in automotive firms, and possibly in other manufacturing sectors, is a topic that is open to discussion (Díaz-García *et al.*, 2015; Bossle *et al.*, 2016). However, the adoption and implementation of eco-innovation practices, particularly in developing countries or emerging economies, such as Mexico, has not been widely explored in the literature (Vieira de Souza *et al.*, 2018; Aboelmaged & Hashem, 2019). Thus, this study also contributes by providing empirical evidence of the importance of eco-innovation practices adoption in the automotive industry of a developing nation like Mexico. The automotive sector is one of the most important industries for economic development.

The essential objective of this paper was to investigate the main factors of the adoption of eco-innovation practices in companies in the automotive industry, using a sample of 460 firms operating in Mexico. Since this study considers three essential factors in the adoption of eco-innovation practices (product eco-innovation, process eco-innovation and management eco-innovation) it differs from others that have focused on the effects of policies and regulations (Choi *et al.*, 2016; Constantini *et al.*, 2017), generally applied in the field of industrial organization (Triguero *et al.*, 2013; Bossle *et al.*, 2016), or of those studies oriented on decision-

making (Marousek *et al.*, 2015). Furthermore, some studies previously published in the literature (e.g. del Río-González, 2005, 2009; Carrillo-Hermosilla *et al*., 2010; Caiazza *et al*., 2014) have focused on the analysis of external factors that have a strong influence on the adoption of eco-innovation practices in companies. However, in this study the focus was on the analysis and understanding of the importance of internal factors. In particular, the literature has centered on analyzing the reduction of production costs, but not on the recognition of the existing needs of how eco-innovation processes facilitate the development of eco-innovation in products, and management.

Furthermore, based on the results of this study, it is possible to conclude that product eco-innovation is an important factor in the adoption of eco-innovation practices, but it is not more important than management eco-innovation, which, in this sample, has a relevant presence in firms. These results are similar to those found by Theyel (2000), Chen (2008) and Bonzanini *et al*. (2016), which argue that the adoption of environmental management practices induces companies to continue improving, as well as having a positive impact among their main commercial partners in the supply chain.

Additionally, the results obtained in this empirical study allow us to conclude that the adoption of process eco-innovation practices will condition, in a high percentage, the adoption of eco-innovation activities in companies in the automotive industry. In addition, process eco-innovation is one of the main factors that will impede or facilitate the capacity of eco-innovation of companies. These results are similar to those obtained by Arranz *et al*. (2019). Thus, in terms of eco-innovation in products, processes and management, it can be concluded that companies in the automotive industry are sufficiently developed in terms of the adoption of eco-innovation practices, which can help them to be more competitive nationally and internationally.

5.2 Research Implications

The results obtained in this paper have different implications for both managers and companies in the automotive industry. The first implication is that the data obtained through the application of a survey allowed a general analysis on how the adoption of eco-innovation practices is carried out in a specific sector, i.e. automotive industry. In this context, the impact of eco-innovation activities on companies that have implemented them suggest that such practices applied in the methods of products, processes and management are incremental. The results obtained in this study are similar to those obtained by Kiefer *et al*. (2017) and Vieira de Souza *et al*. (2018), who came to the conclusion that different types of eco-innovation activities require different levels of changes in companies and their relationship with the environment, which is why these authors argue that radical eco-innovation is more relevant to environmental improvement than incremental eco-innovation. However, Gabaldón-Estevan *et al.* (2014) found that incremental eco-innovation generates important changes in the reduction of energy and consumption of materials. This suggests that the analysis of the adoption of eco-innovation practices is still inconclusive.

The results of this study suggest that the development of different sustainable activities in the form of eco-products, eco-processes and eco-management that significantly reduce the negative impacts that companies generate on the environment should be an essential objective of any organization (Jakobsen & Clausen, 2016). Therefore, the adoption of these practices will allow

companies that make up the automotive industry not only to significantly increase the positive impacts on the environment but also to obtain more and better business performance (Cheng *et al.*, 2014; Wong & Wong, 2014).

The design of eco-innovation activities is strongly related to eco-innovation in products, processes and management but their association with organizational changes may be less significant (Kiefer *et al.*, 2017; Xavier *et al.*, 2017). Therefore, the adoption of eco-innovation practices in organizations, particularly in companies in the automotive industry, should incorporate all those elements and relationships between the external and internal factors of eco-innovation. In this respect, it is essential that companies consider the internal management of eco-innovation activities in their strategies, not only due to external pressure to improve environmental problems (Schaltegger & Wagner, 2011) but also to obtain greater level of business performance (Bonzanini *et al.*, 2016), and contribute to the transformation of a more sustainable society (Carrillo-Hermosilla *et al.*, 2010).

Finally, some studies published in the literature of organizational innovation have focused essentially on the technological aspects of manufacturing firms, leaving aside the changes in the management of the organization. Therefore, this study enriches the literature of innovation by finding enough empirical evidence which indicates that it is not only important for companies in the automotive industry to adopt technology (e.g. product eco-innovation and process eco-innovation) but also organizational innovation (e.g. management eco-innovation), additionally to other studies that have confirmed that pollution prevention and eco-innovation activities are two essential factors that generate better business performance (Chiou *et al.*, 2011; Miroshnychenko *et al.*, 2017).

5.3 Research Limitations and Future Research

This paper has various limitations that are important to consider when interpreting the results obtained and their implications. One of this limitations refer to the subjectivity of the data obtained from the survey as the studied variables were measured with different intuitive indicators. Therefore, future studies are suggested to operationalize the variables product eco-innovation, process eco-innovation and management eco-innovation by incorporating objective data from manufacturing firms (e.g. quality certificates, percentage of use of renewable energies, percentage of use of treated water, total number of units produced). This would contribute in verifying if the results obtained differ from those obtained in this empirical study.

A second limitation is that the relationship between the three types of eco-innovation may have better results if a moderate variable of some of the individual characteristics of the most important managers is considered (e.g. leadership, entrepreneurship, competitiveness). Therefore, in future studies it would be pertinent to use some variables that moderate the effects of eco-innovation and performance, with the intention of corroborating whether the results differ from those obtained in this study. Finally, a third limitation is that in this study only three types of eco-innovation were considered, so future studies can consider other types of eco-innovation (e.g. marketing, technology, systems) to broaden and advance the knowledge in this growing and important research field.

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APPENDIX 1

Please, indicate if your company… (Eco-Product Innovation)		Disagree				Agree
EPI1	It constantly improves the life cycle standards of its products and conducts studies on their life cycle.	1	2	3	4	5
EPI2	Uses or develops new energy sources with a tendency to reduce CO2 emissions.	1	2	3	4	5
EPI3	Uses the eco-label system that each country requires for its products.	1	2	3	4	5
EPI4	Uses and produces eco-innovative components and materials that are made from recycled raw materials.	1	2	3	4	5

Please, indicate if your company… (Eco-Process Innovation)		Disagree				Agree
ERI1	Treats its wastewater	1	2	3	4	5
ERI2	Uses sterilization methods for its components or technological devices	1	2	3	4	5
ERI3	Produces or uses fabric components that use tissue sanitization technologies	1	2	3	4	5
ERI4	Uses ecological or recyclable paper in your processes	1	2	3	4	5

Please, indicate if your company … (Management eco-innovation)		Disagree				Agree
EOI1	Has a management system that reuses obsolete components and equipment	1	2	3	4	5
EOI2	Has an ISO 14001 Certification or similar	1	2	3	4	5
EOI3	Has constant audits of energy and ecology savings by state and/or municipal authorities in your area.	1	2	3	4	5
EOI4	Constantly conducts seminars or training courses for staff related to Eco-innovation.	1	2	3	4	5
EOI5	Has well-defined policies that encourage and support Eco-innovation activities throughout the organization.	1	2	3	4	5
EIO6	Has a monitoring and control system for wastewater generated by the company	1	2	3	4	5