The Mediating Role of Environmental Collaborations in the Relationship Manufacturing Technologies and Green Innovation among Firms in Thai Sports Industry

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Abstract:
The study has examined the mediating role of environmental collaborations in the relationship manufacturing technologies and green innovation among firms in Thai sports industry. The response rate of the study is 47 percent. The hypotheses are aligned with the design of research questions and by using the smart PLS 3.1.2 which is also known as the second-generation multivariate data analysis, we have analyzed the reliability and validity of the instrument by the assessment of structural and measurement model. The results show the important mediating role of internal environmental collaboration between the green innovation and modern manufacturing technologies. For the examination of fundamental mechanism, the current study has addressed the need for empirical study that how the adoption of modern manufacturing technologies increases the green innovation. The results have provided the beneficial extension of modern manufacturing technologies and green innovation by ensuring that for the firms it is important to understand the fundamental relation between the adoption of modern manufacturing technologies and fostering green innovation. Firstly, the current study we have imperially examine the association between modern manufacturing technologies and green innovation at measurement level and have incorporated modern manufacturing technologies as an ancestor of green innovation. Secondly, we have also developed complete theoretical model that with the use of modern manufacturing technologies how green innovation of the firm can get benefits with important mediator that is internal environmental collaboration. Thirdly with the context of developing economy the current study will increase the literature of green innovation. Our findings will be helpful for the managers of Thai sports industry that how to deal with problems in green innovation because of implementations of modern manufacturing technologies.

I. Background

One of the outcomes of the increasing environmental pressure from stakeholders the green innovation (GI) has merged as a necessity as well key success factor or sustainable manufacturing performance and development (Aeknarajindawat & Jermsittiparsert, 2019). For the enhancement of GI, the practices, growth in technologies and polices for encouraging the private and public investments many well-known economistshave called. Now a days for making a lucrative green management patterns of the firms and competitive rules have been changed with thepopularity of environmentalism and Strict environmental regulations (Doppelt, 2017). The green innovation creativities have been increased by the manufacturing firms, and in their fundamentalbusiness strategies they also have

been integrating the GI(Jha, 2016; Namdej, Wattanapongphasuk, & Jermsittiparsert, 2019; Jermsittiparsert, Somjai, & Toopgajank, 2020; Somjai, Vasuvanich, Laosillapacharoen, & Jermsittiparsert, 2020). Whereas the research of GI is on its initial phases yet and this phenomenon is hardly understood that how green innovation can be increased.

They also questioned about general effectiveness improvement in manufacturing which have forced many firms for the investment in modern manufacturing technologies (MMT). According to the previous studies the adoption and use of the modern manufacturing technologies is linked with series of extensive benefits along with profitability, delivery, reduction in cost, increase in efficiency and manufacturing productivity, promoting the manufacturing performance ad competitive advantage of the firm, improving quality and flexibility and progress in market share(Hamdoun, Jabbour, & Othman, 2018). In recent years may researchers have oppressed that MMT manufacturing process, planning and design may consider as key sources for innovation. By using the MMT for the confirmation of appropriate product utilization we can get different opportunities like establishment of dynamic abilities for balancing the short lifecycle of products, increase in innovation performance and competitive advantage, uncertainty between different functions sharing knowledge and different management techniques, application of pollution prevention and control technologies(Hamdoun et al., 2018).Though according to the literature, the main driver for the innovation is the adoption of MMT, the benefits of its experimental evidences on GI are limited unexpectedly. For the establishment of GI practices, the managers of the firms are concerned to know about the main drivers involved. The inadequate information regarding the possible benefits of MMT on GI can creel the development of a broadly accepted framework, which in manufacturing firms will describe and classifyactivities of green innovation. So, it is very important to get a general view to explore how the

green innovation will be affected with the adoption of MMT(Aluko, 2017).

In the current study we have tried to fill research gap with concentrating on the possible antecedents of GI specially the MMT adoption. Additionally, for understanding the MMT and its association with green innovation firstly we must examine how different types of MMT are individually associated/linked with different extents of GI. The current study has extended the previous studies by examining the association between MMT planning, design and use of process and green process innovation (GPI)and green products with the development of theoretic base by giving the empirical indication for the association between green innovation and adoption of MMT with the multidimensional perspective(Sardá & Pogutz, 2018). Moreover, the prior studies highlighted that there cannot be a direct relationship between the green innovation and adoption of MMT.
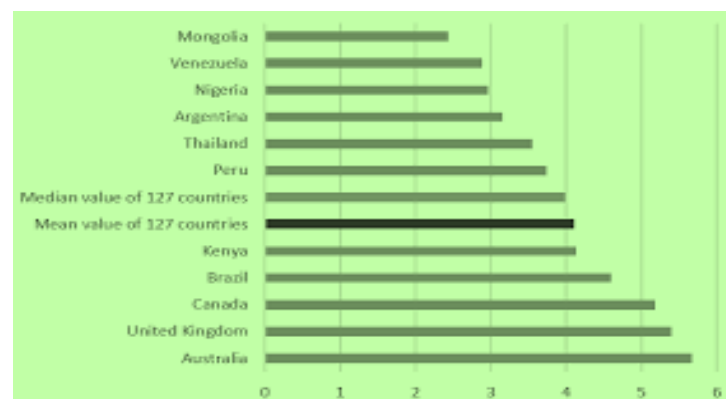

Figure 1: The stringency of environmental regulations and enforcement of 11 countries

Source Lin et al. (2019)

Which calls for examining the questions that how the green innovation is influenced with the adoption of MMT. Against the earlier background we have argued that for the GI the MMT have potential value whereas with in the firm the actual affect can be achieved only when decision makers, analyst's and experts can estimate and detect the technological knowledge. Because by nature the technical knowledge is tacit, for the achievement of green innovation and effective

knowledge integration sharing of information among different departments reflect as a main competitive competence(Lin & Chen, 2017). So, we have purposed an important organizational capability and mediator is internalenvironmental collaboration, over which the effective adoption of MMT can eventually lea toward green innovation. We have employed the mediation approach and offering the mechanism for understanding the complete benefits of underlying the relationship between the GI and MMT. The current study will contribute in the literature of GI and MMT in many ways(Wuryaningrat, Kindengan, & Sendouw, 2018).

II. Literature Review

The appropriate theoretical foundations are provided by the resource-based view (RBV) of a firm and the view to understand the association between green innovation and use of MMT. As per RBV the sustainable competitive advantage of the firm is determined by the effective capabilities and unique resource and by combining the resources in the way they are non-substitutable, inimitable, rare and valuable(Epelbaum & Martinez, 2014; Hamdoun et al., 2018). Though the important benefits of MMT are known and fundamental mechanism by which green innovation is affected is also under consideration. To fill this gap the current study has assumed that IEC mediate the effect of adopting MMT on GI. Within organization the connection of different functions like development and planning together for the environmental solutions and management, which represents the organization's fundamental competences which identify and facilitate the integration of technical knowledge to modernize the environment is known as Internal environmental collaboration(Aboelmaged, 2014). Frequently the technical knowledge is socially embedded, specialized and tacit due to which it's hard to transfer. For know-how in different departments the IEC have provided the interactive and direct access. Furthermore, commitment and trust which is derived from the IEC can increase the motivation level of employees for sharing their exclusive technological knowledge, through

which knowledge transfer efficacy integration to Green innovation increase. Therefore, the IEC may act as an important capability of organization which can enhance the probability of possible green innovation offered by MMT. So, our focus will be on IEC as mediator between the green innovation and adoption of MMT(Kyriakopoulos & Arabatzis, 2016; Sardá & Pogutz, 2018).

The range of potential development paths can be expanded significantly with huge investment in MMT. According to the literature the implementation of MMT in manufacturing firms provides many benefits. For the improved quality the literature has supported the following practices that are manufacturing performance, competitive advantages of firm, flexibility, efficiency and manufacturing productivity of the firm(Hamdoun et al., 2018). Furthermore, implementation of MMT can also be effective for the firms who are engaged in activities of high value addition like innovation. From the manual operation to mechanized technology the effected changes are marked by MMT(Bharadwaj, 2018). Within the manufacturing firm from the preliminary adoption of MMT over the programing and system design for implementing the continuous improvements, on the process innovation and green product the use of MMT has great effect on both. The adoption of MMT nurture the green product innovation in two different ways firstly by using the planning, process and design MMT helped in creation of knowledge-based sources for modern competences of manufacturing which also contribute in development of GPI. The implementation of long-term effectiveness of AMT is mainly depends on rich knowledge base of the firm. The conditions of adopting MMT are usually involved combining the new technical knowledge and transformation of general knowledge to economically valuable knowledge generating, assimilation and acquiring(Raman, 2016). Generally, the technical knowledge is intangible like understanding that or know about how to adopt the technology which is developed by others. GI is depending on the availability of knowledge, so foe the guaranteed success of GI

we must recognize the knowledge base created by the MMT. By organizing the base of knowledge MMT provides the different platforms, processes and tools to confirm the accessibility and availability of knowledge. Distribution and development of technical knowledge increase the quickness of sustainable production. For example, the development in product knowledge and quickness of technical knowledge provides the facility of recovering the end life of firm's product and its reprocessing(Cui & Wu, 2016). Additionally, over the provision of tools and technical platforms for collaborative learning and sharing the knowledge, MMT can facilitate the teamwork as mechanism of adopting the innovation. In short, the implementation of MMT have high potential to enable the teamwork by improving the assistance between the partners of supply chain and internal departments. The activities of teamwork regarding knowledge sharing and interactions related to environment like the workshops and training related to GI, product design and contribution in development of technical environment consequently increase the chances of green product development(Charter & Tischner, 2017). In a complex manufacturing system, the use of MMT will help in increasing the competence of industrial system, thus it can be an important source for the product innovation which influences the environmental advantages related to the creativity and design.

Installation of modern technology for the green production and high investments for the green equipment's may increase the productivity of the resources in that way for reduction in environmental cost have positive impact of GPI(Ma, Hou, & Xin, 2017). Additionally, with MMT companies can stimulate the actions of proactive environment like redesigning, alterations with cost saving possibility the creation of new products therefor facilitating the GPI. On the green product innovation, the adoption of MMT have positive effect by using the planning, process and design. GPI frequently integrates the modifications redesign and the new product creation, in production processes which are

mainly associated with technological changes(Dangelico, Pujari, & Pontrandolfo, 2017). MMT is that type of technology which supports organizational process and production and has become an actual way of disabling the hurdles and making that type of manufacturing process which can reduce the harmful impacts on environment. In reply to change in environmental regulations and technology, MMT can mainly increase the green product innovation over developing the competences or widely changing the process solutions in organization. MMT design is not only for the ideas and concepts, innovative products collaboration and effective communication but it has also combined the functionality(Lii & Kuo, 2016), enable the calculation, operation of dynamic product information for providing the improved quality of product features for the customers who are conscious about the environment. Whereas the MMT planning allows firms for managing their material flows and optimize the productionschedules for improving their efficiency and proper utilization of manufacturing resources(Jha, 2016). The real representation of unproductive resources is pollution. Through the MMT planning the resource productivity of the manufacturing firms and green product innovation can be increased, and environmental cost can be decreased(Sirkeck & Gupta, 2017). MMT being an important factor can increase the GPI. So, we have purposed the following hypothesis based on the above discussion.

H1: The use of process AMT has significant impact on the green product innovation

H2: The use of design AMT has significant impact on the green product innovation

H3: The use of planning AMT has significant impact on the green product innovation

Moreover, to GPI, on green process innovation the adoption of MMT too have a positive effect. By increasing the processing and information sharing capabilities of the firm, MMT mainly increases the green process innovation(Merino, Ludueña, &

Alvarez, 2018). For the successful implementation of MMT sharing and processing of effective information is very important. By using the MMT employees efficiently interact and within the organization it also allows the direct access to database of product and real time information sharing in control means. Across the practical boundaries it has leading potential to interact and communicate deeply. Which as a result improves the cross-functional teamwork/collaboration? Innovation capabilities can be improved in early phases of developing new product with the collaboration of different departments(Parida, Sjödin, & Lenka, 2015). In this way innovative performance can also be foster. Similarly, MMT adoption can be helpful for the green innovation among the various functions sharing the information regarding the quality and eco design. On the other side the information processing abilities of MMT, allow the employees on the factory floor apply for the creative solutions of problems, as a result improve the process and product. According to Kong, Feng, and Ye (2016) Whereas the know-how and processing of green information guide about the activities of green innovation. So, for the manufacturing firms it is very important for being capable of GPI they should employ the MMT. Furthermore, Green process innovation can be increased with the adoption of planning, design and process of MMT. Because of the limits in flow of information mostly manufacturing process apparently are barriers(Trianni, Cagno, & Farné, 2016). The focus of process MMT is on manufacturing characteristics, delivery and production is the requirement for creating the information linked with operational process. The application of MMT process helps in increasing the integration of information and operational process. For instance, technologies such as environmental control system is probable for improving the information based for GPI. For the improvement of green process innovation using the MMT design is also effective(Dahab, Maag, & Bagnato, 2016). The designed technologies like CAE and CA are linked with designers with manufacturers, customers and suppliers by using

language and interface of common software, which provides the customers' requirements and feed the data design directly in the production system. The environmental practices of companies can be influenced with the Involvement of suppliers and expectations of customers. So, the important driver of green process engineering is the use of common language, meanwhile for the pursual of development opportunities of green innovation it promotes the design integration and manufacturing activities(Zhang & Zhu, 2019). Lastly the MMT planning recommends its benefits in GPI. by carrying the computational and automation power collected in the synchronized decision-making, for the utilization of resources at optimal level the MMT planning like MRP II and ERP are helpful in providing the efficient plans for the environmental process for meeting the environmental regulations. Therefore, we have purposed that green process innovation can be improved by using the MMT as exemplified in the hypothesis below(Invernizzi, Locatelli, & Brookes, 2018).

H4: The use of process AMT has significant impact on the green process innovation

H5: The use of design AMT has significant impact on the green process innovation

H6: The use of planning AMT has significant impact on the green process innovation

However, to stimulate the green innovation of the firm probably uses of planning, design and process MMT, know less regarding the fundamental mechanism linked with the green innovation and adoption of MMT. From the RBV logic the internal environmental integration may identified as exceptional capability(Bromiley & Rau, 2016). Which may likely to translate MMT into enhanced green innovation performance (GIP). So, we have purposed that internal environmental integration mediate the impact of adopting MMT on process innovation and green product. An organization may adopt the different modern technologies whereas the green innovation might not be able to get benefits from

such diversification if its internal departments are reluctant for making the proactive environmental integration. According to the many researchers, Schubert and Tavassoli (2019) and Aluko (2017) the successful adoption of MMT required proper coordination and communication among the specialists of process and product. Without the application of internal collaboration of value adding functions it is improbable the successful investment in MMT. So, minimizing the conflict and for the successful dealing with strategic and technical interdependencies characteristics in the adoption of modern technology, the cooperation should be carried out by the representativesfrom different departments. With the linkage of different functional departments, mutual databases and information system. The internal environmental integration consists on the exchange of policies on sharing the technical information and for the establishment of mutual goals, the functional addition which enables the collaboration between decision makers, analysts and the experts. For the development of new skills, reduction in the potential confrontation, fostering trust, and specially the actual coordination is essential for the green innovation.

Additionally, for achieving the products, the focus of environmental collaboration is on the comprehensive means of environmental operations. The requirement of active orientation of environmental management is that firms should stop the deprivation of environment with innovative point of view for the development of products that are environment friendly and these practices are positively related with GI(Charter & Tischner, 2017). For improving the environment, the mutual willingness is required to learn about the functions of each other's, set the mutual goals and plan accordingly. With the utilization of MMT the collaboration of internal environment lead towards the systematic solution of advance product and process for environment(Bajwa, 2018). For the sharing of inter firm knowledge the internal environmental partnership is the key channel.

Within the organization by dispersing, communicating, integrating and with the learning of modern technology the internal environmental integration facilitates the activities of synchronization of product, technicalknowledge sharing and process technology progress(Enkel, Groemminger, & Heil, 2018). Furthermore, over the Informal and formal mechanism the internal environmental integration includes the combine planning meetings, related to environment and activities of knowledge sharing like seminars, workshops and meetings related to management, increase the ability of a firm to integrate environmental and technical knowledge. In this manner technologicalknowledge acquisition is in complementary support of organizational GI. On the other side the important learning capability is presented by the integration of internal environment. The learning capacity is required by the potential of MMT. Within the firms the by interaction between the different departments IEC facilitate the updates of tacit knowledge specifically related to technical interdependency among the specifications of manufacturing process and product specifications for stimulating the creation of new alternatives(Huenteler, Ossenbrink, & Schmidt, 2016). So, the IEC indicates the important mediator by which MMT contribute towards green innovation. Thirdly resource productivity and technologies can be increased by the organizations with the help of IEC for the fostering of environmental innovations. The environmental integration requires the investment of particular resources in the collaborative activities by the organization for addressing the issues related to environment. For capturing the value addition, internal environmental collaboration is useful, which arises from a cooperative interaction of various functions for promoting the innovation that decreases environmental effect. Additionally, with the cooperation of cross function the IEC also accelerates the application of process- or product-based changes and consequently lead the environmental adjustments in the process or product of focal plants. In short, the IEC might miss the relation between green innovation and

adoption of MMT(Sardá & Pogutz, 2018). Therefore, we have suggested that planning, design and process MMT have prospective advantages on the green innovation of a firm and primarily through the internal environmental collaboration these constructive effects can be achieved.

H7: IECOL mediates the relationship between product process AMT and green product innovation.

H8: IECOL mediates the relationship between product design AMT and green product innovation.

H9: IECOL mediates the relationship between planning design AMT and green product innovation.

H10: IECOL mediates the relationship between product process AMT and green process innovation.

H11: IECOL mediates the relationship between product design AMT and green process innovation.

H12: IECOL mediates the relationship between planning design AMT and green process innovation.

3.0. Methodology

We had circulated the questionnaire to total 570 SME's of sports sector of Thailand, as per the previous studies the response rate was 0.20% for the various sectors of Thai SME's, so the estimated response rate was47 percent. We had planned the questionnaire for the decision makers of the firm. So, for all the responses of respondent, we have considered the decisions of firms. For the analysis of current study, we have used the most important statistical tool that is PLS-SEM. According to the Hair, Hult, Ringle, and Sarstedt (2016) and Hair, Sarstedt, Hopkins, and Kuppelwieser (2014) the minimum requirement of sample size is 10times to the highest number of variables for the analysis. The recommended sample size for the multivariate

analysis for every variable is 15 subjects as per the study of Hair, Hult, Ringle, and Thiele (2017), therefor the suitable size for this study is 325 respondents, that will utilize the 21 independent and dependent variables. Although because of the two reasons we may accept the huge sample size there is possibility of biasness effect on small sample size. By depending on the small sample size there is possibility of sampling error because of that the affected population may not reflected.

We have employed the inferential and descriptive statistic for the analysis of collected data of the current study. For screening the data, for the analysis of collected data, profile of respondent we have used SPSS 22. We have also measured the satisfaction level of lecturer's job. We have categorized the seven-point Likert scale into five as 1.00-2.20 as very low; 2.21-3.40 as low, 3.41-4.60 as moderate, whereas 4.61-5.80 as high and 5.81–7.00 as very high (Subramanian, Gunasekaran, & Abdulrahman, 2019). The hypotheses are aligned with the design of research questions and by using the smart PLS 3.1.2 which is also known as the second-generation multivariate data analysis, we have analyzed the reliability and validity of the instrument by the assessment of structural and measurement model. The PLS-3 software allows users to detect any possible missing data; the missing value settings in the PLS-3 was used and it was discovered that there is not any item that was not responded to by the respondents.

3.1. Measure

In the current study we have used the Green innovation and internal environmental collaboration as the measures of MMT, which were adopted by many previous studies. By using a Likert scale of seven points we have measured the indicators, high values show the improved performance or high level of collaboration and technology application in green innovation of firm. According to the literature the MMT has abstracted as multidimensional construct(Sardá & Pogutz, 2018). By considering the previous studies we have measure the MMT in three

different ways: planning MMT, design MMT, and processMMT. These dimensions of MMT are controlled as three, four and five scales, and we have measured these dimensions by adopting the measurement scale from the previous studies. The environmental control system and CAM technologies are included in process MMT. Which enables the flexible and efficient manufacturing process. The technologies which assist in designing the process and products like PDM and CAM are incorporated in design MMT. The MMT planning is focused on the important resources of the firm and encompasses technologies like MRP II and ERP etc. by asking the respondents to specify the extent at which the practice or technology have utilized in their plan for managing the environment we have evaluated the constructs related to the average of industry.

4.0. Data Analysis

Smart PLS-3 is a variation of multiple regression and correlation analysis. It is used to estimate path and loading coefficient (Ahmadian & Abdolmaleki, 2018). PLS-3 is use for the estimation of average variance extraction. It is use for bootstrapping the data set. It is also use for the analysis of the data when the model is complex and whereas in this study there are four constructs which are in second order form Hair et al. (2017). It is also essential because of the items in the study are formative and 75 reflective in nature which other software analysis may not appropriately handled (Hair et al., 2016). Furthermore, PLS-3 is suitable for this study as it takes good account of measurement error. Using the PLS-3 approach to source information regarding the relationship between the variables we had carried out the analysis by forming a model which is refers as the structural model (Ahmadian & Abdolmaleki, 2018). We have used the Smart PLS for the assessment of measurement of the variables in this study and for the confirmation of relationship among variables as well as the prediction. PLS was also used to show importance-performance matrix analysis in the study.
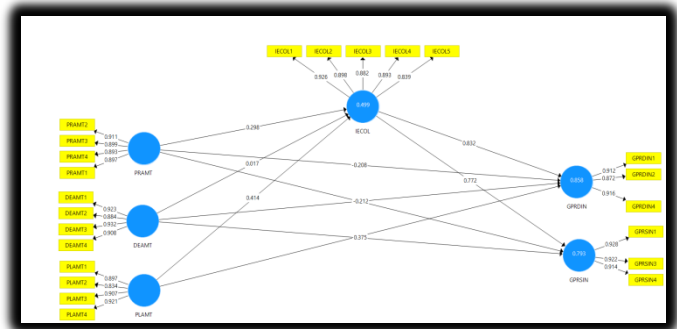

Figure 2: Measurement Model

Table 1: Outer Loading

	DEA MT	GPR DIN	GPR SIN	IEC OL	PLA MT	PRA MT
DEA MT1	0.923					
DEA MT2	0.884					
DEA MT3	0.932					
DEA MT4	0.908					
GPRD IN1		0.912				
GPRD IN2		0.872				
GPRD IN4		0.916				
GPRS IN1			0.928			
GPRS IN3			0.922			
GPRS IN4			0.914			
IECO L1				0.926		
IECO L2				0.898		
IECO L3				0.882		
IECO L4				0.893		
IECO L5				0.839		
PLAM T1					0.897	
PLAM T2					0.834	
PLAM T3					0.907	
PLAM T4					0.921	
PRAM T2						0.911
PRAM						0.899

T3						
PRAMT4						0.893
PRAMT1						0.897

Measurement model the study of Hair et al. (2014) indicates the association among the latent or unobserved and observed variables measured variables (items/indicators/ scales for each construct). In evaluating the measurement model, we have carried out the CFA to measure the construct validity (discriminate validity and convergent validity) and reliability of the items. The average variance extracted (AVE) as well as the composite reliability (CR) for the variables in the study was calculated. According to Henseler, Ringle, and Sarstedt (2015), the CR must be ≥ 0.7, AVE ≥ 0.5 while Lonial and Carter (2015) recommends a value of 0.7 for the Cronbach alpha. The convergent validity is ascertained when the outer model loadings are greater than 1.96 at 0.05 level of significance. Once the measurement model is validated and found reliable, the structural model was also assessed.

Table 2: Reliability

	Cronbach's Alpha	rho_A	CR	(AVE)
DEAMT	0.933	0.936	0.952	0.832
GPRDIN	0.883	0.884	0.927	0.810
GPRSIN	0.911	0.914	0.944	0.849
IECOL	0.933	0.934	0.949	0.789
PLAMT	0.913	0.917	0.939	0.793
PRAMT	0.922	0.922	0.945	0.810

Table 3: Validity

	DEAMT	GPRDIN	GPRSIN	IECOL	PLAMT	PRAMT
DEAMT	0.902					
GPRDIN	0.848	0.900				
GPRSIN	0.786	0.877	0.901			
IECOL	0.743	0.815	0.869	0.888		
PLAMT	0.786	0.794	0.693	0.692	0.890	
PRAMT	0.671	0.745	0.638	0.678	0.884	0.900

multicollinearity test was carried out by examining the VIF value, tolerance value as well as the condition index for the independent variables. Acceptance indicate the amount of change of independent variable not described by the additional IV in a structural model, while Variance Inflating Factor (VIF) is that level at which standard error has been inflated due to the presence of collinearity. A condition index (CI) on the other hand in formative measurement models evaluate the existence of important level of collinearity (Amaro & Duarte, 2016). An acceptance of 0.20 or smaller: VIF of 5.0 or higher and condition index of 30 or higher suggest a multicollinearity problem. Results revealed, the tolerance values go above 0.20 and all the VIF values are not more than 5, the tolerance values go above 0.20 and; the condition index are less than 30. Therefore, in the current study the multicollinearity is not a problem.
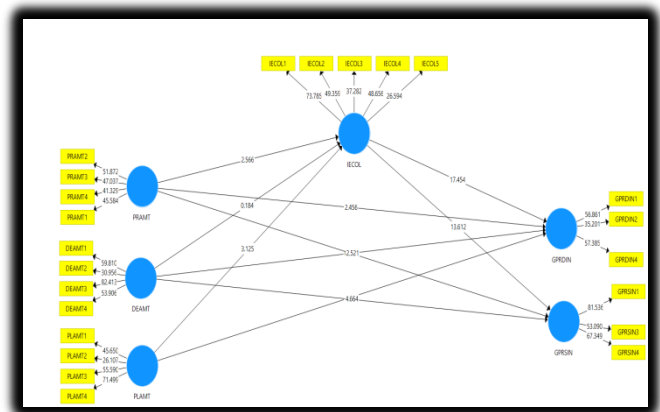

Figure 3: Structural Model

The SM according to Hair et al. (2014) deals with dependent relationships connecting the constructs in the hypothetical model. It is a useful representation of interrelationships among constructs i.e. it explains the relationship between latent variables. The relationship among the variables in the formulated hypotheses in this study as indicated in the model was tested through the structural model. The structural model comprised of the exogenous variables.

Table 4: Direct relationship

	(O)	(M)	(STD EV)	(|O/STD EV|)	P Values
DEAMT -> GPRDIN	0.040	0.048	0.080	0.503	**0.308**
DEAMT -> GPRSIN	0.375	0.380	0.080	4.664	**0.000**
IECOL -> GPRDIN	0.832	0.825	0.048	17.454	**0.000**
IECOL -> GPRSIN	0.772	0.764	0.057	13.612	**0.000**
PLAMT -> GPRDIN	0.287	0.287	0.095	3.026	**0.001**
PRAMT -> GPRDIN	-0.208	-0.210	0.085	2.456	**0.007**
PRAMT -> GPRSIN	-0.212	-0.208	0.084	2.521	**0.006**

Table 5: Mediation

	(O)	(M)	(STD EV)	|O/STD EV|)	P Values
DEAMT -> IECOL -> GPRDIN	0.014	0.023	0.078	0.185	**0.426**
PLAMT -> IECOL -> GPRDIN	0.344	0.335	0.109	3.146	**0.001**
PRAMT -> IECOL -> GPRDIN	0.248	0.243	0.095	2.606	**0.005**
DEAMT -> IECOL -> GPRSIN	0.013	0.021	0.072	0.186	**0.426**
PLAMT -> IECOL -> GPRSIN	0.319	0.311	0.107	2.978	**0.001**
PRAMT -> IECOL -> GPRSIN	0.230	0.224	0.086	2.681	**0.004**

For the significance and relevance of the SM relationship, the predictive relevance (Q2), effect sizes, and level of R2 all these collinearity issues were assessed by the structural model. Bootstrapping was used to generate the t-statistics and the standard errors as for the estimation of PLS accuracy it shows a non-parametric approach. However, which allowed the researcher for the assessment of path coefficient statistical significance. The coefficient of determination (R2) demonstrated the ability of all the exogenous or independent variables in predicting the endogenous or dependent variable. According to Hair et al. (2014), R2 is a measure of the goodness of fit against the empirically manifest items obtained with values ranging from 0 to 1.

Table 6: R-square

	R Square
GPRDIN	0.858
GPRSIN	0.793
IECOL	0.499

For the assessment of comparative analytical relevance of construct of predictor of an endogenous construct we use the measure of predictive relevance. It helps to determine the relevance of the reflective construct in a structural equation modeling (SEM) model. In this study, Q2 was calculated in SmartPLS 3 using blindfolding procedure. Crossvalidated redundancy approach was used in this study to determine the predictive relevancy of the constructs. This is because, according to Hair et al. (2014), crossvalidated redundancy approach includes the elements of structural model, path model and predicted eliminated data in its assessment.
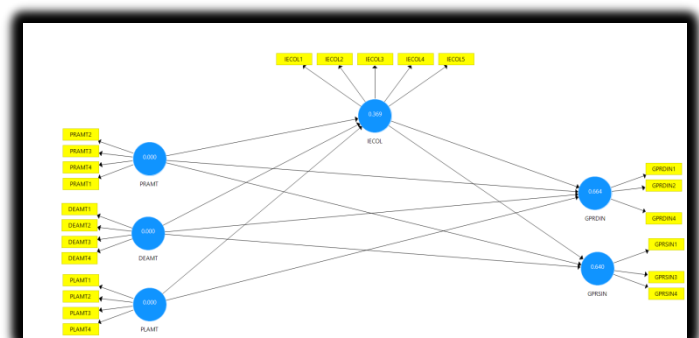

Figure 4: Q-square

Table 7: Q-square

	SSO	SSE	Q² (=1-SSE/SSO)
DEAMT	868.000	868.000	
GPRDIN	651.000	218.975	0.664
GPRSIN	651.000	234.393	0.640
IECOL	1,085.000	684.280	0.369
PLAMT	868.000	868.000	

PRAMT	868.000	868.000	

5.0. Conclusion

The results show the important mediating role of internal environmental collaboration between the green innovation and MMT. For the examination of fundamental mechanism, the current study has addressed the need for empirical study that how the adoption of MMT increase the green innovation. The results have provided the beneficial extension of MMT and GI by ensuring that for the firms it is important to understand the fundamental relation between the adoption of MMT and fostering green innovation. For the adoption of MMT and fostering the green innovation the results of current study have provided the important suggestions. Firstly, the results have suggested that firms' managers who are looking for the improving the green innovation must divert their attention towards the adoption of MMT(Bajwa, 2018). The firms can obtain the important knowledge about different technological resources with the implementation of different types of MMT, which in general will improve the process innovation and green product. So, the managers of firms must employee the MMT proactively as its very beneficial investment. Whereas the managers must strike a balance and find an ideal level of adopting MMT as its use is not free. In the Meantime, the managers who are seeking or planning to use MMT must considered the dimensions of GI carefully. Secondly the results of current study also indicate for the managers it's important to be aware with the important mediating effect of IEC as for the enhancement of green innovation the developing MMT is not enough. Through the internal environmental collaboration, the process innovation and green product both are accomplished(Dangelico, 2016). The complete understanding of crucial mediating role of IEC can make a firm to reconsider their application activities of MMT.

Additionally, the results of current study are useful particularly for the managers of sports manufacturing industry of Thailand, who want to improve their GI by adopting the different types of MMT. In Thailand the environment degradation is an important issue. For example, in GDP the increase in average annual growth is also the reason of consuming the high rate of resources and generating the pollution(Azam & Khan, 2017). So, the managers of sports manufacturing industry of Thailand need to make the serious efforts to be green. The current study has also contributed in the existing literature of green innovation. Firstly, it contributed in the literature by adding MMT as possible ancestor and test the association between the different types of MMT and particular dimensions of GI. The aim of earlier studies was on highlighting the benefits of MMT on innovation, but they have not examined the typical importance of using MMT for green innovation. The current study has also enriched the existing literature of green innovation ad increase our understanding the value of adopting MMT for increasing the green innovation, by including the planning process and design MMT and with incorporation of green process innovation and green product.

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