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Does ISO 14001 and Green Servitization Provide a Push Factor for Sustainable Performance? A Study of Manufacturing Firms

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Abstract: This study contributes to the development of a green servitization framework to achieve manufacturing firms' sustainable performance using ISO 14001 as a driving factor in their operational management system. Manufacturing firms are becoming concerned due to the associated problem of physical flow of materials and energy through the ecosystem, which can hinder resource sustainability for future generations as a result of the enormous waste and emission of carbon produced by their operations. This is possible due to a lack of implementation of ISO 14001 in the production process, leading to a waste of resources and negative environmental effects on people and the planet, which requires an urgent green solution. Therefore, the present study investigated the adoption and implementation of ISO 14001 as a catalyst of a green initiative towards achieving sustainable performance. After a review of studies in operational and environmental management, a quantitative methodology was adopted in three research design phases that included identifying dimensions for survey measurement instruments, survey validation, a pilot study, as well as data analysis to investigate the mediating effect of ISO 14001 on the relationship between green servitization and sustainable performance. The results show a significant and positive mediation effect of ISO 14001 on the interaction between green servitization and sustainable performance. In conclusion, these findings will enhance the operation and performance of the environmental management system required for the manufacturing firm and improve the practice of green service toward sustainable performance.

Keywords: servitization; green servitization; sustainable performance; manufacturing firms; operations



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1. Introduction

The adoption and implementation of ISO 14001 as a push factor has been identified as significant in driving green initiatives towards achieving sustainable performance. This is becoming a must-have due to growing concerns about massive continuous industrialization, which poses a threat to the long-term performance of manufacturing firms. This is a result of a lack of adoption and implementation of green practices in relation to the ISO 14001 standard, consequently contributing to a significantly negative environmental and sustainable performance. This led to the investigation of the possibility of successful adoption and implementation of the ISO 14001 standard as a catalyst for achieving sustainable performance. The question that arises from this is whether the use of the ISO 14001 standard in green practices serves as a push factor for sustainable performance. A review of previous literature shows that scholars have suggested some strategies as solutions to manufacturing firms' sustainability performance with no or little significance [1,2]. Examples include eco innovation [3–5] green innovation [6–8], green supply chain [9,10], and sustainable development [11,12]. However, most of these strategies have not achieved sustainable performance for the manufacturing firm. Hence, the present study examines green servitization as a paradigm shift to improve sustainability in manufacturing firms using the ISO 14001 standard as a push factor. This has given rise to determining whether the ISO 14001 standard can serve as a push factor for sustainable performance. Therefore,

servitization is defined as the act of creating value via infusing service into a product. It could also be defined as a strategy to innovate from a mere product to a more service-oriented solution by adding value to a product that can serve as an alternative or enhance the production quality for additional revenue generation [13–15]. The main idea behind this phenomenon is to generate alternative revenue through service creation for products, such as maintenance, repair, and other customer solutions that can enhance product benefits [2,16–18]. Thus, the key focus in this study is the creation of value for products in the form of services. In addition, green servitization can be defined as the process of infusing environmentally friendly service solutions into tangible products that are capable of reducing waste, emissions, and fossil fuel energy, including remediation of sites and restoration, repair and maintenance management, water conservation, and recycling of raw materials [19]. Specifically, it can be referred to as a service solution strategy that focuses on the production process and reduces excess waste and the cost of production, as well as being capable of transcending the use of tangible products to intangible ones in order to achieve sustainable performance [20–23].

Currently, negative environmental effects of energy and emissions, as well as air and water pollution from manufacturing firms, are no doubt affecting the overall sustainable performance [24,25]. As such, various governmental and non-governmental organizations are coming up with different campaigns for green production processes vis a vis sanctions to curb current and future environmental problems, while shareholders are considering investing in manufacturing firms that are conscious of green production practices to reduce global warming and other environmental problems, which will eventually increase sustainability performance [26–28]. As a result, this has led to the need for manufacturing firms to seek various alternative ways for their production processes to be environmentally friendly for profitability [29–31]. In this view, past literature has focused on servitization in the area of consumption of products and services [32,33] to promote better environmental management [15,34,35] and good financial performance [36–38]. However, the successful implementation of servitization as a strategy has not been recorded in the area of environmental performance, and it has had a huge negative impact on the overall profitability of the firm due to the difficulties in reaching a decision on what to servitize and when to servitize, among other challenges. Others include a problem of conceptualization due to a lack of appropriate empirical indices to be used by modern manufacturing firms. Therefore, a transition to a more advanced strategy of green servitization as an initiative that will enhance the sustainability of water, energy, and material usage is needed by the manufacturing firms to achieve sustainable performance according to the concept of the current study [39]. This attempts to cover the gap in the literature with regard to the role of green servitization in the manufacturing industry, especially in terms of the influence of using ISO 14001 as an alternative production process for sustainable performance using a quantitative methodology that involves adopting three research design phases, as follows: identifying dimensions for survey measurement instruments, survey validation, and a pilot study, as well as data analysis to investigate the mediation effect of the ISO 14001 standard on the relationship between green servitization and sustainable performance. The flow and organization of the study are based on five sections. The introductory section comprises detailed information on the background and problem statement to identify the research objective and question, leading to the significance of the study. The second section summarizes the prior literature to establish the concept of the study variables (servitization, green servitization, ISO 14001, and sustainable performance). This is able to provide existing indices used to measure all variables and identify the ones suitable for all the variables in the study. The third section provides an in-depth discussion on research methodology. This section elaborates on various research paradigms to select and identify the research philosophy suitable for the present study. Furthermore, the chapter provides justification for the selection of the research design, tools, procedure for data collection, and quantitative approach employed for the present study. The fourth section reports the results of the quantitative data analysis carried out in the current study. The

chapter discusses how PLS-SEM was used to analyze the study data and provides the various data analyses that were carried out. The fifth section interprets the results and provides a comprehensive discussion of the hypotheses in relation to the study objectives. A comparison of the study results is made with prior studies to validate and predict the analyses. Finally, recommendations for policy makers and industrial practitioners are provided, along with managerial and theoretical implications.

2. Review of Literature

Nowadays, there is growing attention by leading innovative organizations, such as manufacturing firms, to create new value-based production processes that are sustainable, such as green servitization, that can meet the new demand for resource sustainability, as well as ensure good public health [40–42]. This has occurred because of the negative contribution of emissions and energy by manufacturing firms, as well as air and water pollution from their production operations to the environment, which invariably affect their overall performance [43–45]. Several governmental and non-governmental organizations have been campaigning to promote green production processes [46,47] in order to avoid various types of environmental problems. In their quest to achieve sustainability performance, manufacturing firms all over the world are also being pushed to participate in waste reduction in their production processes [48–50]. Recently, environmental problems have resulted in a huge loss to firms. For example, in the cases of China and Indonesia, it amounts to USD 62.5 and USD 16 billion, respectively, which has, consequently, led to the urgent need for manufacturing firms to seek various alternative ways for their production processes that will be environmentally friendly and increase profitability [30,51,52]. Moreover, some past literature has focused on servitization in the area of consumption of products and services to bring about better environmental performance and to increase financial performance [53–55], as well as higher financial performance [36–38]. However, there has not been any study that has captured the changing nature of the implementation of a green servitization strategy in the form of indices to measure the phenomena of sustainability and how it could translate into productivity gains for the firm.

Conversely, there have been challenges associated with the competitiveness and sustainability of the service strategy to create added value for firms, which was termed “servitization of manufacturing”, mainly for the integration of service into products by manufacturers. This is because previous studies have identified that service provision allows manufacturing companies to comply with sustainability regulations [56,57]. Based on this, the campaign for green revolutions has shifted customer focus from buying products of negative environmental impact. Thus, servitization provides the means for organizations to produce environmentally sustainable products [30,58]. More importantly, there is the need for firms to shift as well as adjust their competitive races to be able to meet customer demands and compete well in the market in order not to be left behind by the changing external environment of customer demand for dematerialized products [2,59,60]. However, the problem associated with what to servitize and how to servitize remain a challenge in academic literature. This is why some scholars have extended the concept of servitization to green servitization in order to meet sustainability challenges.

Studies, such as in Refs. [19,61], have provided justification for firms to profit through integration of service design, offering, and delivery strategy using the profitability gain of green servitization in reverse logistics, as well as digital technology to bridge the servitization gap, in which their studies mentioned that most previous findings only focus on the practical usage of products and neglect the process of producing the product. However, some literature review [52] studies suggest low-carbon innovation as one way to enhance economic growth via the employment of finite resources in production without empirical evidence. Therefore, there is still a huge gap to be filled as a result of the limited literature in the area of green servitization for sustainable performance. Therefore, it is eminent to explore the profitable impact of practicing green servitization in relation to the sustainability performance in relation to process management of manufacturing firms. Conversely, there

has not been literature that has looked into the area of investigating the direct relationship between sustainability performance and firm performance, as most studies only look at the firm performance effect [36,62,63], hence neglecting the social and environmental benefits of the phenomenon. Thus, there is a need for the current research to investigate the significant positive relationship between green servitization and sustainable performance.

2.1. Variables Operationalization

2.1.1. Servitization

This is defined as the process of creating value via adding service to a product. It can also be defined as a strategy to shift from a product-centric to a more service-centric model via adding value to products that can bring about alternative or enhanced product usage solely for additional revenue generation that can provide a competitive advantage to a firm. The main idea of this phenomenon is to generate alternative revenue through service creation for products, such as maintenance, repair, and other customer solutions that can enhance product usage [2,16]. The key word here is the creation of value for products and services. However, the campaign for green revolutions has shifted customer focus from buying products of negative environmental impact. Hence, servitization becomes the means for organizations to produce dematerialized products [30]. More importantly, there is the need for manufacturing firms to shift as well as adjust their competitive thrust to be able to meet customer demands and compete well in the market in order not to be left behind by the changing external environment of customer demand for dematerialized products [2,59,60]. Hence, servitization is employed as one of the independent constructs of the current study.

Offerings

This is one dimension of servitization that involves the introduction of service solutions such as knowledge, competencies, and individual expertise, as well as flexibility [32]. As it is believed, service provision and tangible products are invariably associated with one another [17]. Thus, it needed to serve as the introduction of a new structural change that will shift a firm's core competency of using tangible materials or products into more intangible assets mainly to attain sustainable performance. Accordingly, in order for firms to meet up with sustainable performance pressure, they have to develop service solutions that are of greater internal flexibility to meet the current dynamic product market. As such, the introduction of service solutions informed by human assets into the manufacturing process will no doubt bring about better sustainable performance. In light of this, manufacturing firms are beginning to be aware of the impact and need to include service solutions in their product process as its usage will improve sustainable production and national economic development [64,65].

Using service solutions is paramount in the operations of product firms in order to attain sustainable performance. This is why the present study includes service as one of the constructs of servitization. According to Refs. [4,66], service determinants include management and technological capabilities; collaborations with universities, research institutes, and agencies; as well as access to external knowledge and information. However, resources in the present study include the use of technological know-how, intellectual capital, as well as human brainpower to provide alternative solutions in manufacturing firms' processes and practices that can bring about reductions in air pollution and climate change as well as sustainable performance.

Resources

The capability of achieving sustainable performance is regarded as a resource maximization opportunity. This is seen to be critical in a manufacturing firm's operational process as it includes both human and material, or tangible and intangible, resources, respectively. Resources were first studied as tangible assets (human and material). However, the introduction of the fourth industrial revolution perceived resources as intangible

assets and capabilities of the manufacturing firms' drive to sustainable performance. Many studies have identified the use of resources in diverse forms as one of the key driving forces in the service strategy of manufacturing firms [67,68]. Some of them see it as an intangible asset of the firm capable of providing operational solutions for manufacturing firms. They attributed these intangible solutions to digitalization [68], products innovations [67] and human initiative [69]. While other view it as the physical or tangible assists of the manufacturing firms [70,71].

According to Ref. [32], "firms moving towards a servitization strategy must engage in an internal business transformation capable of developing resources to achieve sustainable performance." However, the outcome of their study was only able to identify "what and why" resources were needed for manufacturing firms without being able to identify the process relationship of this phenomenon to the sustainable performance of the firms. All of these studies agreed with previous research that identified resources as what makes a manufacturing firm innovate [72].

In light of this, resources as a dimension for strategic input of servitization would be employed in the present study as the necessary capability for manufacturing firms to employ in their operational management process in order to achieve sustainable performance.

Activities

The growing concern towards achieving sustainable performance by manufacturing firms has required due diligence from government, society, organization stakeholders, and customers towards checking the activities of manufacturing firms. Ref. [73] explained that industrial activities is the operation of a metabolism that allows key procedures to be integrated into available resources capable of providing value added to the inventory system of core product. This value-added inventory system must enhance product usage and translate to more profitability to the firm. Activities of manufacturing firms is critical to their survival as studies identified it to be one of the reason why core product firm fails [74]. The study in Ref. [12] identified a positive relationship between manufacturing firm activity and service input to show how important this types of firm activities are vital to their operational survival. Different types of activities have been identified in studies, ranging from eco and product-innovation activities [14], customer activities [75], service activities [38], innovative activities [76,77], supply chain activities [19], outsourcing activities [32], and many others to ascertain the drive towards servitization strategy needed for manufacturing firms but many results do not translate to competitive capabilities of the firm.

Based on this, the need to infuse innovative activities that are sustainable to the development and survival of manufacturing firms has become eminent in literature and industry practice at large [78]. Thus, the present study would investigate the use of activities to measure servitization strategy of manufacturing firms.

2.1.2. Green Servitization

Green servitization is defined as the operation process that encourages environmental service solutions in place of tangible production processes for energy, emission, waste reduction, including remediation of sites and restoration, water conservation, repair and maintenance management, as well as recycling of raw materials [19]. However, the present study defines green servitization as a service solutions strategy that focuses on the production processes of a firm mainly aimed at reducing excess waste and cost of production, as well as being capable of transcending the use of tangible solutions to intangible ones in order to achieve sustainable performance. This idea must transcend from the strategic to the operational management level. Studies, such as Refs. [19,61], provided firms of making profit through integration of service design, offering as well as delivery strategy using uncovering profitability gain of green servitization in reverse logistics and as well as digital technology in recent time to breach the lacuna found in servitization. In which their studies mentioned that most previous findings focus only on product usage prac-

tices, neglecting the process in which the product has been produced. Although, ref. [52] suggested low-carbon innovation as one of the ways to uncouple economic growth via the employment of finite resources in production, there is still a lack of empirical findings. Therefore, there is still a huge gap to be filled as a result of the limited literature in the area of green servitization for sustainability performance. Hence, the present study will attempt to use green solutions or servitization as another independent variable to be used in the production process for better environmental and sustainable performance.

Green Products

In recent times, current and future generations have and will experience environmental challenges. This is due to the massive industrialization of manufacturing firms via their traditional operation processes. As such, scholars in operation management have suggested the use of green materials or equipment as a solution to curb environmental challenges [64]. Based on the situation faced by manufacturing companies, which are major players in the economy as well as contributors to environmental challenges, they have been charged by people in society to incorporate green-friendly products into their product planning process to produce green-friendly products [79]. Hence, to bring about a sustainable manufacturing industry, the introduction of zero emissions is needed during production and consumption of products. Therefore, there is a need to infuse green servitization initiatives into the planning, process, and practice of products as proposed in the present study.

Green Internal Competencies

This is one dimension of green servitization, which involves the introduction of intangible human assets such as knowledge, competencies, and individual expertise, as well as flexibility [32]. This is needed to serve as the introduction of a new structural change that will shift a firm's core competency of using tangible materials or products into more intangible assets as proposed in this study. Accordingly, in order for firms to meet sustainability pressure, they have to develop green human resources that are of greater internal flexibility to meet the current dynamic product market. As such, ref. [64] introduction of services solutions inform of human asset in to manufacturing process will no doubt bring about better sustainability performance. In light of this, manufacturing firms are beginning to be aware of the impact and need to include green human resources who are environmentally conscious about green innovative solutions in their product processes to improve sustainable production and discourage environmentally negative materials in manufacturing firms activities [65,69].

Furthermore, the use of intellectual capital is paramount in the production process of a manufacturing firm in order to achieve sustainability. This is why the present study includes resources as one of the constructs of green-servitization. According to Ref. [4], green resources determinants include: management and technological capabilities, collaborations with universities, research institute and agencies, as well as access to external knowledge and information. However, resources in the present study include the use of technological know-how, intellectual capital, as well as the human brain to provide alternative solutions in manufacturing firms' processes and practices that can bring about reductions in air pollution and climate change, as well as sustainability.

Green Maintenance

Maintenance has been identified as one of the factors that can be used to achieve sustainable firm performance for manufacturing firms. According to Ref. [58], organizations in recent times have employed maintenance culture as part of their advanced service in achieving higher performance. This is believed to bring about product availability, performance, and reliability, which, if well practiced, will bring higher sustainable performance in the long-run. However, it will only be possible if the three maintenance phases (pre-, during, and post-sales) are delivered at a reduced cost [58] before the total breakdown of a product.

However, due to the higher contribution of air pollution and climate change during maintenance, as identified by Ref. [80], the need to infuse green maintenance into the production process is necessary in order for firms to meet the needs of their esteemed customers to provide environmentally friendly service, as proposed in the present study.

Green Digital Technology

In the realization of sustainable firm performance, there are pressures by stakeholders and consumers for manufacturing firms to add value to equipment that is used for production processes. This is known as “green servitization” of the manufacturing firm [81]. This is because manufacturing firms contribute to air pollution and climate change, in which the negative effect on the public may not be able to sustain resources utilization [80]. As such, the campaign by all stakeholders for dematerialized products, as well as sustainable consumption and production, has required manufacturing firms to seek ways of providing alternatives, such as green digital technology for their equipment [30,59,65]. Previous studies have shown that the service industry often generates revenue and is able to sustain itself in the long-run more than manufacturing firms, which is largely attributed to their operation management system. Therefore, the need to explore operation management solutions that will focus on the orientation of green digital services has been raised [81]. Furthermore, the infusion of green digital technology into operations equipment will be necessary and will reduce the high impact of air and waste pollution contributed by manufacturing firms, as proposed in the present study.

2.1.3. ISO 14001

There are studies that have used several mediating and moderating effects to show the relationship between servitization and firm performance, such as digitalization [62], as well as brand reliability [34]. However, the present studies aim to investigate the moderating effect of ISO 14001 on green service and sustainable performance due to the challenges faced by firms in achieving higher productivity, quality, safety, and environmental performance with traditional production processes, which are not capable of aligning with the adoption of International Standard Organization (ISO) 14001:2015 certification. A recent study [3] investigated the ISO 14001 certification process on product life cycle, product assembly/disposition, and improvement and found that these parameters have a positive impact on the societal and economic components of firms. However, the use of environmental management systems, such as ISO 14001, as a push factor for sustainable performance is still neglected. As a result, the current research investigates the operation and performance evaluation of ISO 14001 as a push factor that directly increases the productivity level for better environmental, social, and economic performance of the firm [82].

Operation

The operation parameters are a standard set to collect related information as regards the operation performance of firms. These parameters have been used previously in Ref. [83], whose authors investigated the management and operations parameters as environmental performance indicators of firms. Their research discovered that organizations typically use the performance indicators that are legally required of them. As such, the present study shall employ the operations parameter as it is directly in line with the legal requirements of the Malaysian standard ISO 14001:2015. On 1 August 2010, this entry was published [82].

Performance Evaluation

This aspect of the parameter indicates that a firm is saddled with the responsibility to monitor, measure, analyze, and evaluate its environmental performance [82]. The study in Ref. [83] used performance evaluation to investigate firms’ management performance evaluation according to ISO requirements and found that this parameter ensures as well as demonstrates the effectiveness of the firms to clear operational and environmental

conditions. As such, this parameter shall be employed in the present study to investigate, monitor, analyze, and evaluate management and environmental performance procedures.

2.1.4. Sustainable Performance

Performance can be viewed as a firm's growth and learning that enhances internal business processes capable of providing more value to customers for higher profitability. These are categorized as financial, environmental, economics, and sustainable development and performance in recent times [84]. The concept of sustainable performance was first derived from the sustainable development goals of the Brundtland Report of the "World Commission on Environment and Development (WCED)". The commission defined sustainable development "as the development that meets the needs of the present without compromising the ability of future generations to meet their own needs." On the other hand, sustainable performance is defined as the firms' practices that combine both economic, environmental, and social activities. The concept involves a holistic approach that is designed to indicate an integration of performances in a synthetic manner [85]. This involves activities that encourage firms to focus more on long-term profitability that could simultaneously reduce environmental and societal risks other than economic activities. According to Ref. [86], countries must set standards that meet the sustainable development goals (ESG's) vision of 2030. As a result, Bursa Malaysia has developed and mandated that all publicly traded companies publish sustainability performance reporting in their annual reports [87], which must be in line with the global reporting to achieve economic, environmental, and social (EES) performance of the United Nations for nations' sustainability development [86]. In line with this, Bursa Malaysia has identified three (3) parameters (economic, environmental, and social) indicators that all firms must guide judiciously to align with their operations [87].

2.1.5. Hypotheses Development

There are prior studies that discussed the failure of servitization with performance of the firm and highlighted the importance of extending it to green servitization in the form of service solutions to improve environmental performance and meet sustainability pressure [61,88]. Moreover, there are studies that further identify that the financial gain aspect of using green practices as a solution of operation is still not understood by many manufacturing firms. Additionally, the relevance of green servitization as an integral part of green practice as opposed to just the servitization practice of the firm is increasingly gaining momentum in the literature [19] but lacks empirical evidence showing its association with sustainable performance. As such, the association or relationship of green servitization with sustainable performance is yet to be empirically proven but could be positively significant to sustainability performance [22,71,76,80,88]. As such, the following hypothesis is developed.

Hypothesis 1 (H1). *There is a positive significant production gain for manufacturing firms implementing servitization as against servitization on sustainable performance.*

Manufacturing firms in recent times have been challenged to seek alternative production processes that can address the current issue of firm financial and environmental sustainability due to the cost of pollutants, as well as waste that often occurs during production [89–91]. Based on these, there are contending arguments for the use of green servitization to be an alternative means in place of the traditional production process, mainly for resource and firm sustainability [19,61], although few studies find the direct or positive association of green servitization vis a vis sustainable performance if well implemented. However, some research did not find any relationship, which makes the study inconclusive [17,92]. Therefore, due to the contending findings and lack of study, the following hypothesis is developed.

Hypothesis 2 (H2). *There is a significant positive relationship between green servitization and sustainable performance.*

Service offerings have been the transition strategy for manufacturing firms called “servitization” in recent times. Most manufacturing firms are moving away from merely traditional product offerings to service offerings in order to achieve higher sustainable performance. As such, many manufacturing firms are making huge investments and changing their operational strategy towards service offerings [32,62]. However, achieving sustainable performance for manufacturing firms has required meeting certain environmental management systems. As such, ISO 14001 has been identified as a system that enables firms to control, analyze, and reduce negative environmental impacts that occur during the service transition process of manufacturing firms, mainly for sustainable performance. According to previous research, this offering will include competitive and differentiation advantages, customer needs, and orientation as a manufacturing firm’s service strategy [53], and the financial gain of the service offerings as a dimension of servitization was studied but with an inclusive result. The findings were based on the fact that integrated offerings are mostly complex to implement when firms are faced with environmental pressure and achieving sustainable performance.

This explains why most previous studies on the service offering dimension of service transformation on sustainable performance have been inconclusive [53,62]. Other studies mentioned that, due to the complex nature of infusing diverse service offerings, there is a need for a capability and resources that will fuel a sustainable performance culture and recommended an operational management procedure such as ISO 14001 to be a push factor for such bundles of opportunity. Thus, there is the need for a management operational system such as ISO 14001 to act as an essential element that can provide sustainable performance for a manufacturing firm. As such, Ref. [93] investigated the mediating role of competitive benefit on firm performance and used ISO 14001 as a control variable and found a positive association. Similarly, another study investigated the mediating role of ISO 14001 on environmental performance in the Malaysian automotive industry and found a positive relationship with lean manufacturing practice [94]. The result of the foregoing showed that successful adoption and implementation of ISO 14001 among manufacturing firms in Malaysia, along with various bundles of offerings, will provide a significant effect in achieving sustainable performance. Therefore, the following hypothesis has been developed:

Hypothesis 3 (H3). *There is a positive significant mediating role of ISO 14001 between servitization and sustainable performance.*

There are positions from past literature that hold that the successful adoption and implementation of the ISO 14001:2015 operational standard and evaluation standard at every level of organization is important in developing firm internal competence and capabilities for green initiatives [83]. The belief is that the regulation requirement will force firms to align their operations to the performance and evaluation process of ISO 14001, as well as the management of employees to achieve sustainable performance [82] and management of employees to achieve sustainable performance [8]. However, the positive or significant involvement of this certification towards the alignment of green practices, such as green servitization of the present study vis a vis sustainable performance, is still under research and requires further study. Based on this, the present study suggests that the ISO 14001:2015 successful certification and adoption of a firm can moderate the significant impact of green service implementation on the overall sustainable performance of the firm. Thus, the following hypothesis is developed:

Hypothesis 4 (H4). *There is a positive significant moderating role of ISO 14001 between green servitization and sustainable performance.*

Figure 1 above shows the proposed research model, which is the positive association between servitization, green servitization (independent variable), and sustainable performance (dependent variable), with the mediating effect of ISO 14001 (mediating variable). The reason for using ISO 14001 as a mediator was based on Ref. [93], whose authors mentioned that ISO 14001 serves as an influencer to the competitive benefits of manufacturing firms and can be used to achieve firm performance. Similarly, the present study employs ISO 14001 as a mediator.

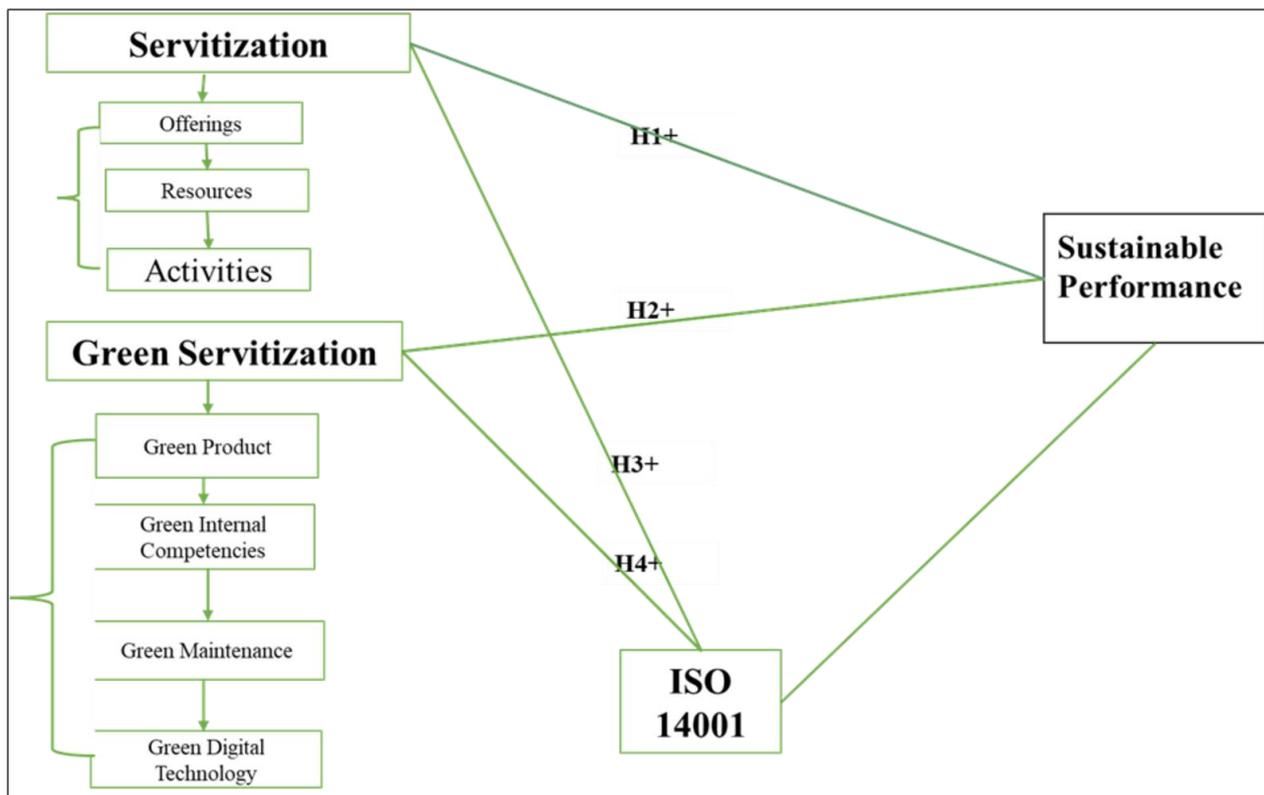


Figure 1. Proposed research model.

3. Methods

The present research employs the quantitative (deductive) approach method to validate the developed hypothesis. The research was carried out via a sample questionnaire across 201 publicly listed consumer product manufacturing firms in Malaysia, in which 3 employees, ranging from operation, sustainability, environmental, R & D, and safety managers, as the case may be, were chosen as respondents from each firm, while the dependent variable utilized available secondary data from the annual reports of these listed consumer product manufacturing firms. Respondents were reached from various online sources, such as official company email, Gmail, and LinkedIn. At first, the response rate was poor, with only about 120 completed questionnaires in the initial stage of the data collection. As such, calls were made to 55 key decision-makers of the non-responding firms to complete the questionnaire. After that, more responses were received, and a total of 243 responses were recorded, representing 40.3% of the total 603 samples. The low response rate and using online sources for data collection were due to the existence of the COVID-19 lockdown protocol as most organizations are working from home, preventing the researcher from physically collecting the data. However, this is deemed suitable for the analysis as the recommended sample size from a given population [95,96]. The analysis of the data was conducted through the use of the partial least squares (SmartPLS) version 3.3.7 due to the large amount of data [97,98]. Moreover, because it gives a thorough and systematic analysis

of the present study [99–101]. This is carried out in 3 phases, as shown in Figure 2 below, which is the research design recommended by previous studies [98,102].

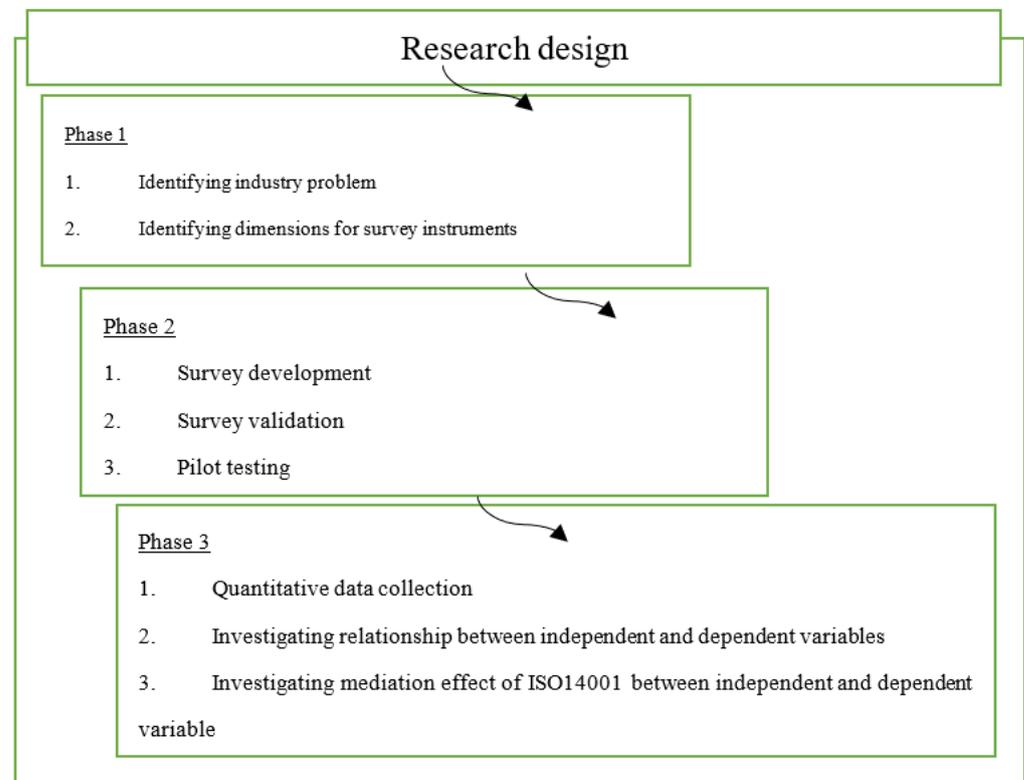


Figure 2. Research Design.

Research Process/Design

The above Figure 2 shows the research process followed in the present study. This is carried out in three (3) phases as mentioned.

The first phase involves an extensive literature review and was carried out to identify industrial problems with regard to green servitization and ISO 14001. The need to identify dimensions for survey instrument becomes eminent. The procedure recommended in Ref. [103], which stated that selecting a dimension involves specifying a domain, and, thereafter, delineating what is included and excluded in the operational definition of the variable, was employed. As such, a conceptual specification of the construct and what is and what is not included in the domain (servitization, green servitization, ISO 14001, and sustainable performance) was determined by adopting dimensions of Ref. [32] as the independent variables and the independent variables [61] because they represent all technological advancement that fosters and facilitates communication flow in operations of the firm to reduce costs and improve environmental performance and directly involve the operational definition of the present study as proposed in Ref. [103] when developing a dimension for a domain. Mainly, the constructs were developed to provide methodological solutions to most of the available research that seems generic, thus not empirically able to show the green servitization relationship with sustainable performance. This is because previous studies mostly investigated the role of green servitization on sustainable performance via networking [104], with findings confirming that new digital services offered by manufacturing firms have inherent valuable impacts on the sustainable performance but would require an external push or influencer to encourage their usage in operation management system, such ISO 14001, as a mediator. As such, the operation and performance evaluation were employed as the measurement parameters of ISO 14001 and adapted from Ref. [82] as these two parameters directly affect the productivity level and contribute to the environmental, social, and economic performance of the firm. The selection of sustainable

performance dimensions was based on the measurement standard by Bursa Malaysia for all publicly listed firms [87]. As such, the availability of secondary data was guaranteed due to the mandate given by Bursa Malaysia to all publicly listed firms to publish sustainability information in their annual report.

The second phase involves the development of a measurement instrument after identifying dimensions for survey instruments. This is completed by adapting a previous questionnaire from the studies identified in Table 1 below. The reason for this is the limited availability of a questionnaire relating to green servitization as its usage in the operational processes of manufacturing firms is the objective of the present study. Thus, the need to adapt and develop a new questionnaire, which went through a pilot study by 2 academicians who are professors from reputable Malaysian public universities, 2 policy makers from government agencies that are directly involved in environmental standard practice, measurement, and compliance, as well as 2 industrial practitioners from Malaysian publicly listed consumer product manufacturing firms, was evident [105].

Table 1. Adapted questionnaire/study measurement item.

Servitization [32,53]	
Offerings Competitive and differentiation advantage Customer need Value added Customer orientation	Resources Knowledge Expertise Capabilities and Flexibility
Activities Customer integration Further business units' integration	
Green Servitization [19,32,61]	
Green Product Cost saving Efficient Safety	Green Internal Competencies Knowledge Expertise Capabilities and Flexibility
Green Maintenance Technical Requirement Service Requirement Sales Requirement	Green Digital Technology Digital interactions with product Digital value creation to product
ISO 14001 [82,83]	
Operations Planning and control Emergency preparedness and response	Performance Evaluation Monitory and measurement Analysis and evaluation

The third phase was carried out after the face reliability and validity tests were carried out as described in phase two and started with data gathering by distributing the questionnaire using online means as it was convenient due to the COVID-19 movement control order (MCO). The questionnaire was sent to the employees of the manufacturing firms who are the environmental, operational, and sustainable managers of the firms being investigated. The collected data were then analyzed through the use of Statistical Package for Social Science (SPSS) software version 26 and partial least squares (SmartPLS) version 3.3.7 due to the large amounts of data received. In this phase, the data underwent several tests to ascertain their normality, reliability, and validity as well. Afterward, the accepted items were then tested for the significance of all variables in the study.

4. Data Analysis

4.1. Validity and Reliability

The quality of quantitative research is usually measured through validity and reliability measures [101,106–108]. They both reduce bias and increase the transparency of research. Therefore, it becomes the researcher's duty to report the reliability and validity of measurements employed. Similarly, the present research validates the questionnaire used by a panel of experts comprising two academicians, two policy makers, and two industrial practitioners. This was conducted in order to remove outright bias from the study and to obtain feedback from experts who are stakeholders in the fields of green service, ISO 14001, and sustainable performance from various Malaysian universities, companies, and government institutions to determine the validity of the items used. After feedback was received, corrections were made accordingly, and the statistical package for the social sciences (SPSS) was employed for the reliability analysis to check the internal consistency of the variables employed, as shown in Table 2.

Table 2. Reliability (Cronbach α).

No	Items	No of Items	Cronbach α
1	Servitization		
i	Offerings	3	0.931
ii	Resources	3	0.924
iii	Activities	3	0.800
2	Green-Servitization		
i	Product	3	0.890
ii	Internal Competencies	3	0.879
iii	Maintenance	3	0.942
iv	Digital Technology	3	0.938
3	ISO 14001		
i	Operations	2	0.961
ii	Performance Evaluation	2	0.961
	Total	26	0.809

Table 2 above shows the reliability results of the study, in which all Cronbach figures are all above the 0.7 recommended value [100,106,109]. This followed the recommendations by Ref. [97] that Cronbach alpha should be used as the internal consistency reliability lower bound and a recommended score of greater than (>0.70) as the acceptable score. As such, the scores recorded for the Cronbach of the current study show that the measurement model fit the items or observed variables with each other.

Measurement and Structural Analysis of Hypotheses

The present study follows the confirmatory composite analysis (CCA). These procedures were followed as they conformed to all the criteria as recommended when using a reflective item as in the presented study [100], which mentioned that CCA will require the following steps:

- (a) Confirmation of the operational definitions of the multiple items
- (b) Expert panel to reduce face validity
- (c) Refinement and purification of the items through pilot study

These procedures were all followed in the present study and are explained in the validity section. Moreover, all this must be carried out whether the items are reflective or formative measurement models, respectively. However, the present study employed a formative item as the construct to define all the items [99,110–112]. Based on this, the below Figure 3 shows the PLS algorithm model for the present study, where servitization is coded as (SV), offerings (OF), resources (RE), activities (AC), green servitization (GSV),

green product (GP), green internal competencies (GIC), green maintenance (GM), green digital technology (GDT), ISO 14001 (ISO), and sustainable performance (SP) with their respective indicators. As such, the following Table 3 was considered to determine the internal consistency of the items measured.

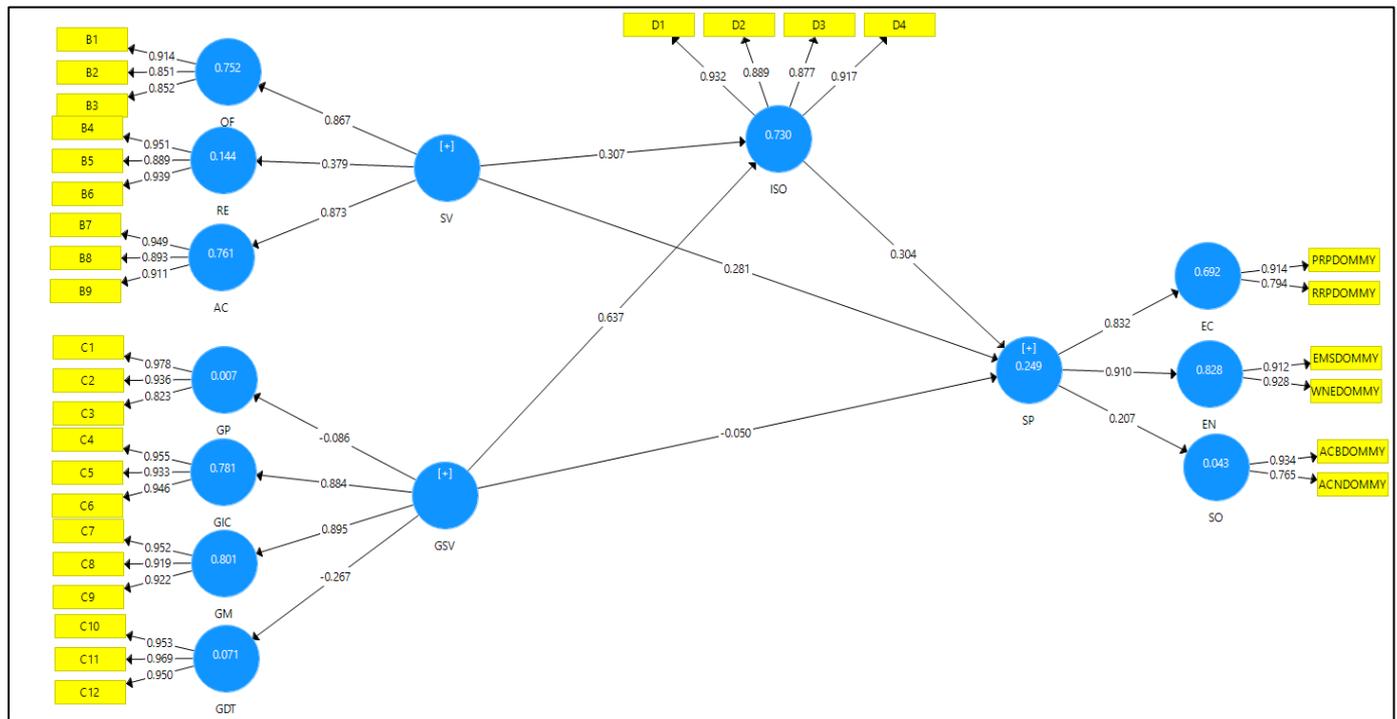


Figure 3. PLS algorithm model output.

Table 3. Construct reliability and validity.

	Cronbach's Alpha	rho_A	Composite Reliability	Average Variance Extracted (AVE)
AC	0.906	0.911	0.941	0.843
EC	0.748	0.720	0.845	0.733
EN	0.820	0.825	0.917	0.847
GDT	0.955	0.980	0.971	0.917
GIC	0.940	0.940	0.961	0.892
GM	0.923	0.923	0.951	0.867
GP	0.906	0.997	0.939	0.837
GSV	0.787	0.912	0.843	0.540
ISO	0.925	0.930	0.947	0.817
OF	0.843	0.844	0.906	0.762
RE	0.919	0.958	0.948	0.859
SO	0.652	0.807	0.841	0.728
SP	0.768	0.803	0.854	0.700
SV	0.852	0.867	0.890	0.545

For the measurement model, all the requirements were achieved, as shown in Table 3, as all Cronbach's alpha items were above 0.7, as recommended by Ref. [109]. Cronbach alpha items measure the internal consistency score for the PLS measurement model and represent the criteria for evaluating the internal consistency of items in PLS-SEM, while composite reliability and average variance extracted (AVE) are all above 0.7 and 0.5, respectively [100,102]. As such, the items are seen fit to be checked for the structural model.

Once the measurement model was fit, the next stage was to check the validity of the structural model. To validate the structural model, various statistical measures are

used, such as path coefficient (β), predictive relevance (Q^2), effect size (f^2), and coefficient of determination (R^2). The next step was to create the causal path between independent (exogenous) and dependent (endogenous) variables for establishing covariance in a direct or indirect relationship. According to Chin (2010), the structural model represents the theoretical model to evaluate the inner path model with a series of structural equations. For the evaluation of the structural model in this research, the essential criteria used were path coefficient (β), t -statistic (T), confidence interval (CI), and p -value [10,66,79]. The threshold value and description for each benchmark are shown in a stepwise test of the structural model underneath, as presented in the Results section below.

4.2. Results

The standardized value in the multiple regression analysis is similar to the path coefficient of Smart-PLS. According to [72], the bootstrapping procedure was conducted to estimate t -statistics and confidence intervals since PLS does not have any distribution assumption requirements. The path estimation or hypothetical relations were performed to observe the significant relationship in the inner path model. All the hypothetical paths in the framework were examined through the regression coefficient (β). By using the PLS bootstrap technique, the value was checked to observe the proposed hypotheses in the structural model. According to the earlier research, the path coefficient value must be at least 0.1 to account for a particular effect in the model [97]. Table 4 presents the path coefficient assessment results, where there is a significant effect of servitization (SV) on sustainable performance (SP) ($b = 0.281$, $t = 3.564$, $p > 0.01$), meaning that the first hypothesis is supported and significant.

Table 4. Structural model results.

Hypotheses	β -Value	T-Statistics	Confidence Interval (CI)		p Values	Result
			2.50%	97.50%		
SV -> SP	0.281	3.564	-0.244	0.150	0.001	Supported
GSV -> SP	-0.050	0.499	0.129	0.438	0.618	Not Supported
GSV -> ISO -> SP	0.194	2.842	0.066	0.333	0.005	Supported
SV -> ISO -> SP	0.094	2.741	0.031	0.166	0.006	Supported

Green servitization (GS) on sustainable performance ($b = 0.212$, $t = 3.057$, $p < 0.05$); management innovation practices on dynamic capabilities ($b = -0.050$, $t = 0.499$, $p < 0.618$). This means that the second hypothesis is not supported and not significant. However, the mediation effect of ISO 14001 between the relationship of servitization and sustainable performance ($b = 0.194$, $t = 1.842$, $p > 0.05$) shows that the third hypothesis is supported and significant, while ISO 14001 between green servitization and sustainable performance ($b = 0.094$, $t = 2.741$, $p < 0.06$) also shows that the hypothesis is supported and significant.

5. Discussion

The present study objective is to identify the practice of servitization and green servitization on sustainable performance through the push factor of ISO 14001.

The first objective is achieved as the structural results show a positive relationship between servitization and sustainable performance. This could be considered a novel finding because the previous study found no correlation between these variables [113–115]. Most of this study claims that manufacturing firms are often faced with too many servitization offerings and activities and ultimately end up not achieving firm sustainable performance. Nevertheless, the inclusion of adequate resources in the present study could be the defining factor required by manufacturing firms in general.

The second objective, on the other hand, as expected, is achieved but does not support the hypothesis and consistence with previous research [19,62]. The reason for the negative association of the variables measured could be the lack of implementation of a standard

operational system that is in line with the current challenges of sustainable performance practice by manufacturing firms [116]. The third objective seems supported and significant. This can be regarded as a new finding and shows the importance of ISO 14001 as a mediator or push factor for achieving sustainable performance, as suggested by many studies [74,93,94,117]. Based on this, the present study agrees that there is a need for the adoption and implementation of ISO 14001 in the operations of manufacturing firms as most studies have shown the lack of this practice in the operation process of Malaysian manufacturing firms.

The fourth objective is also achieved with the push factor of ISO 14001 between green servitization and sustainable performance. This is similar to the third objective; thus, manufacturing firms are encouraged to implement ISO 14001 in their operation management system in order to achieve higher sustainable performance.

6. Conclusions

Based on the foregoing, with the growing awareness of the degradation of the natural environment and limited available resources, the objective of the study, which is to investigate the effect of ISO 14001 on the relationship between green servitization and sustainable performance, is achieved. This is because the four measured hypotheses showed a positive and significant effect of ISO 14001 on sustainable performance. This finding could be seen as a valuable contribution to the body of literature as earlier studies only explored the effect of green servitization on sustainable performance without the push factor of ISO 14001, as carried out in the current research. Another novelty of this study is the area of linear or nonlinear effects of green servitization on sustainable performance. The present study has been able to provide new insights into this research field by demonstrating the indirect relationship between green servitization and sustainable performance. This relationship is proved to be mediated by ISO 14001 such that the operation and performance evaluation of the manufacturing firm will be sustained in the long-run when strengthened with the practice of green production processes such as green servitization.

Finally, as firms are challenged to understand how they can become sustainable, an oriented pragmatic study, such as green servitization, would no doubt provide the positive potential that is capable of advancing manufacturing operations with the necessary sustainable processes via the usage of sustainable materials that can reduce traditional material usage processes of manufacturing firms.

6.1. Managerial/Practical Implication

The present study objective is to carry out an investigation that is reliable based on the phenomena under investigation. There is no doubt that the objectives of the current study have been able to contribute to the practice of manufacturing firms' operations by showing significant relationships existing among the variables. This could serve as a practical implication to manufacturing firms for managers to employ as a tool during the production process in the area of cost reduction of production via reverse logistics of material usage and advanced green servitization. The use of ISO 14001 as a push factor in the present study for operation and performance evaluation in practice shows the need for manufacturing firms to fully adopt and implement its practice in operations as it has the capability of reducing production waste, such as water, energy, and other production materials, that represent the high-cost challenge faced by manufacturing firms when transitioning to green initiatives.

Additionally, internal competencies are a social issue among manufacturing firms and are identified in the current study as one of the determinants of green service. Previously, this dimension has not been identified to possess environmental value that will translate into profitability. However, the current study showed its importance regarding the capability and resources required by manufacturing firms for internal know-how. Conversely, increasing competition in the market, as well as narrowing product and technological differences among manufacturers, have created an opportunity for servitized strategy in manufacturing activities to generate a competitive advantage, as well as differentiation.

In light of this, the present study has shown the green-servitization-related constructs where strategic service infusion and integrated solutions could serve as alternatives for manufacturer firms' efforts in adding services to their core offering of production processes via the successful implementation of ISO 14001.

6.1.1. Policy Implication

Currently, there is already a policy or law that requires manufacturing firm operators in Malaysia to have ISO 14001 practice for environmental performance measurement [82]. However, the practice has not been fully enforced on the operators, causing noncompliance and lack of practice for both evaluation and operation performance for green production. As a contribution to academic literature, the present study has been able to demonstrate that successful implementation of ISO 14001 would provide a push factor for sustainable performance. Hence, the department of standards Malaysia with Bursa Malaysia, who are the primary government agencies to enforce this implementation, can be involved in educational programs, such as sensitization training on the importance of using ISO 14001 in the production process of manufacturing firms. Moreover, bureaucracy of certifiers or verifiers, such as the lack of experienced verifiers, duplication of effort between verifiers and certifying agencies, and many internal auditors, as reported by a previous study, must be resolved among the agencies in order to have a successful implementation of ISO 14001 in the operational practices of manufacturing firms.

Furthermore, the current research extends the existing literature on green servitization as a resource by specifically addressing its application along with ISO 14001 practice to achieve sustainable performance for manufacturing firms within consumer product industries. Earlier studies exhibit a bias towards products and digitization, tending to overlook many service innovations, such as internal competencies and maintenance, covered in the current study [60,104]. Analysis of the push factors, such as ISO 14001, that provide a transition phenomenon contributes to the achievement of sustainable performance among manufacturing firms, specifically of the underlying operation and performance evaluation, by identifying the capability that manufacturing firms must develop in order to achieve sustainable performance. Therefore, this could serve as an implication to policy makers, such as the department of Standard Malaysia and Bursa Malaysia, to focus on the activities and mechanisms identified in the current study in driving the development and practice of green policies.

6.1.2. Theoretical Implications

The current study is found to have two (2) theoretical implications for the academic body of knowledge. These are explained as follows:

Resource Based View (RBV)

The study extends the existing literature with respect to resource base view theory (RBV), specifically, addressing the importance of using green servitization and ISO 14001 as resources needed by manufacturing firms to achieve sustainable performance. Theoretically, the research was based on RBV theory, which states that a business needs different resources to begin and expand its operation. These resources could be financial, physical, human resources, technological resources, reputation, and organizational resources to contribute towards the sustainable performance of the firm [25,118,119]. As such, the operation and performance evaluation roles of ISO 14001 and green servitization form the resource capacity of the firm to control their environmental management system [120]. Thus, it becomes another expansion of RBV theory and a significant test to strengthen the theory that ISO 14001 adoption and implementation in green servitization practice form the resources needed to achieve sustainable performance of Malaysian publicly listed consumer product manufacturing firms.

Institutional Theory

The role of institutional theory in the current study focuses on expanding the literature in the area of determining the informal and formal constraints capable of driving manufacturing firms toward successful ISO 14001 adoption and implementation [116]. Previous studies have identified the informal constraints to be conventions, ethical codes, and social norms, while the formal constraints are referred to as rules, laws, and constitution [121]. All these are considered the external drivers' regulatory requirements that can force the manufacturing firms to reduce their environmental waste for higher environmental performance. As such, ISO 14001's significant impact on the adoption of green servitization for achieving sustainable performance found in the present study would require formal constraints, such as constitution, law, and rules [82,122]. In this situation, the department of Standards Malaysia (Standards Malaysia), which is the accreditation body and national standards of Malaysia, needs coercive pressure as a regulatory authority to force the manufacturing firms towards implementation of green practices, such as green servitization and ISO 14001. This is because the institutional pressures for environmental safety from external agencies, such as the Department of Standards Malaysia, would serve as the remedy for the lack of environmental regulations and practice in developing countries such as Malaysia. Therefore, the institutional obligation represents the contribution and extension of institutional theory in the academic literature.

6.1.3. Limitations and Recommendations of the Study

This study only covers publicly listed consumer product manufacturing firms. There are other types of manufacturing firms in Malaysia that require adoption and implementation of ISO 14001 practice, including energy manufacturing firms, construction manufacturing firms, automobile manufacturing firms, and many more. As a recommendation, it is suggested for future research to include other types of manufacturing firms so that it is clear to see the differences among other implementations of ISO 14001 practice in the Malaysian manufacturing industry.

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