



## Managing Product Complexity and Variety for Operational Performance through an Integrated Green Supply Chain

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### Abstract

The aim of this study is to examine the impact of product variety and product complexity on firm's operational performance when they are operating in a globally connected green supply chain. A survey utilizing a self-administered structured questionnaire was used to collect data from 161 frontend merchandisers of apparel manufacturing firms in Sri Lanka. The results indicate that the relationship between product variety and operational performance is fully mediated by green supply chain management while the relationship between product complexity and operational performance is partially mediated by green supply chain management. Thus, organisations that operate dynamic product portfolios (i.e., a variety of complex products) need green supply chain management practices to improve operational performance. This study emphasises the complementary application of the resource based view with coordination theory to explain how resources of the firm should be allocated and coordinated with regard to variety and complexity.

**Keywords:** Integrated Green Supply Chain Management, Operational Performance, Product Complexity, Product Variety

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## **Introduction**

Product variety and product complexity in manufacturing organisations have formed ample new challenges to operate within green supply chain management practices which are aimed at improving flexibility and responsiveness to customer demand in a timely and cost effective manner (Khan & Creazza, 2009; Inman & Blumenfeld, 2014; Bode & Wagner, 2015). Even though the impact of integrated supply chain management practices on operational performance has been discussed, consensus of the impact across different product portfolios is yet to be discussed.

The concept of operational performance has been recognised as a strategic dimension which has the capacity to compete with the competitors in order to gain a competitive advantage for the practicing organisation (Ho, Au, & Newton, (2002). Existing literature provides a general agreement that quality, delivery, flexibility, and cost are the main and most frequently used competitive areas in explaining operational performance (Ward, McCreery, Ritzman, & Sharma, 1998; Pagell & Krause, 2002). Increasing needs of customers in the 21<sup>st</sup> century have created a landmark for organisations to produce greater product variety and complexity while alarming the efficiency in operations (Moseley, Hvam, Herbert-Hansen, & Raben, 2017). This challenges organisations to maintain their competitiveness in offering customised products as per the requirements of customers while safeguarding the efficient operational performance (Bortolotti, Danese, & Romano, 2013). It is noticeable that some studies have been conducted to explore the impact of product variety and product complexity on operational performance (Moseley et al., 2017).

Supply chain practices are different from one firm to another. There are few studies that have investigated the factors that could influence integrated supply chain management processes (Van Donk & Van der Vaart, 2004). Fisher (1997) has claimed that the most significant factors in deciding the organisation's supply chain management process must be the product design and the nature of the demand for the organisation's products. Importantly, a new movement from supplier driven supply chain practices to demand driven supply practices could be identified after combining all the arguments developed and directions suggested by different studies and scholars (Khan & Creazza, 2009). Therefore, based on fragmented existing studies the current study aims to link the product variety and product complexity with operational performance through the mediation of integrated green supply chain management.

The concept of green supply chain management is emerging and making a tremendous impact on the organisational performance (Vachon & Klassen, 2006;

Green, Zelbst, Meacham, & Bhadauria, 2012; Zhu & Sarkis, 2004). However, few studies have been carried out to analyse the impact of product variety on integrated green supply chain management (Ellinger, Daugherty, & Keller, 2000; Flynn, Huo, & Zhao, 2010; Leuschner, Rogers, & Charvet, 2013). A comprehensive review of literature indicated that no studies have been conducted to investigate the impact of integrated green supply chain management on operational performance when firms produce a variety of products.

Supply chain is a self organising, inter organisational network which operates within its own boundaries, goals and resource limitations. Governance theory explains a setting with a plurality of actors and no formal control system that can dictate the relationships between the actors. Supply chain performance is undoubtedly relying on the extent to which members of the network with diversified knowledge are integrated (Shou, Li, Park, Kang, & Kang, 2017). Yet, the impact of supply chain integration on operational performance of firms that are having a complex and a variety of product portfolios is not empirically verified. A fair governance network is ensured by green supply chain integrations among internal customers, end customers, and suppliers (Yu, Chavez, Feng, & Wiengarten, 2014). This study investigates whether product variety and complexity results in improved operational performance through integrated supply chain management. Thus, this study is aimed at examining the impact of product variety, product complexity on operational performance in manufacturing organisations where green supply chain management practices are applied and integrated.

## **Literature Review**

### ***Operational Performance***

The concept of operational performance is frequently used in analysing the overall business capabilities in the modern business world. It can be explained as resources and manufacturing capabilities that lead to effective conversion of competitive priorities into the strategic capabilities for the succession of the company (Ho et al., 2002). It is noticeable that the concept of operational performance is multi-dimensional with four main dimensions. These four dimensions have been clearly defined in existing literature as quality, delivery, flexibility, and cost (Ward et al., 1998; Pagell & Krause, 2002). Delivery has a greater impact on deciding the next time buying behaviour of the customer (Swink, Narasimhan, & Wang, 2007). In the context of Sri Lankan apparel sector, organisations focus on speed of delivery taking the strategic location advantage along with the conducive business friendly

environment within the country to ensure smooth delivery. Quality is not only restricted to a particular component, but a combination of each and every business process starting from idea generation to completion of every aspect of satisfying the customer as the ultimate consumer (Vachon & Klassen, 2006). Quality can be identified conformance to specifications (Gilmore, 1974), conformance to requirements (Crosby, 1979), fitness for use (Juran & Godfrey, 1988) and meeting or exceeding customers' expectation (Gronroos, 1983). As per previous studies, flexibility is associated with machine, material handling, operations, automation, labour, process, routing, product, new design, delivery, volume, expansion, programme, production, and market flexibility. In addition, a contingency relationship has been suggested between manufacturing flexibility and firm performance (Sethi & Sethi, 1990). Most of apparel organisations in Sri Lanka are getting used to lean manufacturing to lower overhead cost and to secure return on investment by adopting business sustainability initiatives (Sri Lanka Export Development Board, 2017).

### ***Integrated Green Supply Chain Management***

Literature on integrated green supply chain management has been growing with interest in sustainable supply chain management for the betterment of the business and the survival of the planet (Pagell & Wu, 2009). It is also recognised that, “a unique and measurable conceptualisation of sustainability considers social, ecological, and economical dimensions” which are known as the triple bottom line (Elkington, 1998, p. 488). Further, Wuppertal Prism Model also considers the same dimensions which are explained in the triple bottom line, including its organisational aspects as well. According to the above explanation, sustainable supply chain management has multiple dimensions and it is really difficult to excel in all these dimensions at once (Pagell & Wu, 2009). It has been explained that there is a trade-off between environmental practices and operational performance. The main focus on integrated green supply chain management is to minimise the overall environmental impact by effective intra firm management of the upstream and downstream supply chain (Vachon & Klassen, 2006; Green et al., 2012). Overall, the integrated green supply chain can be explained as a combination of all linked parties to the chain including cross functional, cross company activities, suppliers, and customers. Further, existing literature explains three main dimensions of integrated green supply chain management as internal green supply chain management, green supply chain management with suppliers, and green supply chain management with customers (Green et al., 2012; Rao & Holt, 2005; Vachon & Klassen, 2006).

### ***Internal Green Supply Chain Management***

Internal green supply chain management has been identified as the environmental management practices which are carried out within the organisation (Rao & Holt, 2005, Vachon & Klassen, 2006). Aligning and communicating those activities throughout the organisation is essential for its success (Zhu & Geng, 2001). Further, the most influential factors in improving the internal green supply chain management practices are coordination among the internal departments and continuous support across all functional departments (Zhu, Sarkis, & Lai, 2008). Scholars have identified that most organisations are implementing eco-labelling products, environmental auditing of all departments, environmental management systems, environmental reports for internal evaluation, and ISO 14001 certification as tools to evaluate internal green supply chain management of the organisation (Zhu & Sarkis, 2004).

### ***Green Supply Chain Management with Customers***

Green supply chain management with customers has been identified as environmental collaboration with the focal firm and its customers with the aim of minimising the environmental impact through their transactions (Vachon & Klassen, 2006). Mainly it focuses on downstream supply chain management. Scholars have recognised multiple means of implementation through mutual collaboration by both parties to realise its aims (Zhu et al., 2010; Vachon & Klassen, 2006). Pressure from the customer-end of the green concept is also vital for the firm to practice environmental cooperation with the customers by implementing and achieving environmental goals collectively, and encouraging joint environmental planning (Vachon & Klassen, 2006). Most organisations within the apparel sector have been implementing this concept as a motivational driver and manufacturing firms have mainly focused on developing strategic environmental partnerships with their downstream customers (Zhu et al., 2010).

### ***Green Supply Chain Management with Suppliers***

Green supply chain management with suppliers has been identified as the environmental alliance between the focal firm and the firm's suppliers in executing environmental management practices (Vachon & Klassen, 2008). It is mainly focusing on the inbound or upstream segment of the organisational products and supply chain (Zhu et al., 2007, 2008, 2012). Suppliers should be included in the process of purchasing and managing material of the focal firm to achieve green supply chain management practices. In addition, firms should closely monitor their supplier's environmental practices to make sure materials and other related items

supplied by the suppliers are closely linked with the environmentally friendly processes (Rao & Holt, 2005). Further, scholars have noticed that the suppliers are recognised as the most important part in the green supply chain management since the suppliers could be in a position to support the environmental ingenuities of the firm and to provide the assistance in improving environmental performance of the supply chain (Bowen, Cousins, Lamming, & Faruk, 2001).

### ***Product Variety***

The term product variety has been explained as the breadth of products that a firm offers at a given time (Fisher, Ramdas, & Ulrich, 1999). Randall and Ulrich (2001) define it as the number of different versions of a product offered by a firm at a single point in time. Another direction has been identified by scholars linking product variety with product innovations or new product development activities by the focal firm. Additional product information would result in selection confusion (i.e., variety fatigue) for customers and lead to predicting difficulty for manufactures (Thompson, Hamilton, & Rust, 2005). Further, variation in product arrangement will lead to greater difficulties for the producers in terms of coordinating with suppliers.

Particularly, internal integration enables the transfer and recombination of knowledge, ideas and information that are dispersed across functional departments and, this is valuable for the focal firm in developing product portfolios which are robust against environmental changes (Patel & Jayaram, 2014). The focal firm can also enhance its information processing capabilities through internal integration (Wong, Boon-Itt, & Wong, 2011). Green supply chain integration has the possibility to enhance producer's knowledge and experience of the product demands, requirements, market changes, and trends (Flynn et al., 2010). It also helps manufactures to grab opportunities and develop competitive advantages. Further, concerns in scheduling production that results from product variety demands for information sharing and coordinated actions with suppliers (Randall & Ulrich, 2001).

### ***Product Complexity***

This concept is connected with “the number of parts or components needed to build the product” (Inman & Blumenfeld, 2014, p.1957). As per different directions suggested in literature, product complexity has two aspects that include structural complexity (i.e., number and variety of elements) and operational complexity (i.e., interaction between elements) (Bode & Wagner, 2015). Internal integration plays a vital role in deciding supply chain strategies and it also stimulates a higher level of

product complexity (Kotha & Orne, 1989). The reason for stimulating is that the complex products frequently consists of multiple components and are strongly connected to difficulties in product design and production (Salvador, Forza, & Rungtusanatham, 2002). The impact of high product complexity on the environment is high and manufacturers are required to coordinate and collaborate with manufacturing and purchasing departments to reduce the harmful impact of the manufacturing plant.

## **Conceptual Framework**

This section focuses on exploring the underlying relationships between study constructs in the light of the exiting literature. In this section, specific relationships between product variety, product complexity, integrated green supply chain management, and operational performance are comprehensively discussed with the endorsement of related theories and empirical studies in similar contexts.

### ***Product Variety and Operational Performance***

Manufacturing is one of the best and leading concepts for the survival of whole world. However, it is apparent that there is a lack of existing literature on product variety and operational performance. As per the new direction from Mosely et al. (2017), there is a significant relationship between operational performance and product variety. Further, the authors explain that there is a negative relationship between these two concepts. Other research findings are also the same as the above and confirm that there is a negative relationship between product variety and operational performance (Bortolotti et al., 2013; Khan, Christopher, & Burnes, 2008). Balakrishnan and Geunes (2003) have carried out a study using 261 respondents in the context of automotives to test the nature of impact of product variety on operational performance. There are not many differences in arguments and it is confirmed that there is a negative and significant relationship among these two concepts. Based on this empirical evidence, the first hypothesis can be derived as:

H<sub>1</sub>: Product variety impacts on operational performance

### ***Product Variety and Integrated Green Supply Chain Management***

It has been observed that integrated green supply chain results in operational performance of the focal firm (Shou et al., 2017; Khan et al., 2008). Khan et al. (2008) further discussed that the product design supply interface contributes to better

integration to make the supply chain management smooth. Bortolottic et al. (2013) have given a different indication that the relationship between product variety and integrated green supply chain management practices may be positive or negative due to changes in supply chain design and variation of the product. Based on these empirical findings on the impact of product variety has on integrated green supply chain management, the second hypothesis can be derived as:

H<sub>2</sub>: Product variety impacts on integrated green supply chain management

### ***Product Complexity and Operational Performance***

It has been proved that the impact of product complexity on operational performance is positive (Jacobs et al., 2007; Mosely et al., 2017). Findings of Balakrishnan and Geunes (2003) on the impact of product complexity on operational performance confirmed that there is a positive and significant relationship between these two concepts. Further, Caniato and Größler's (2015) study findings confirm that there is a positive relationship among all dimensions of operational performance and product complexity. Based on these empirical findings the following hypothesis can be derived as:

H<sub>3</sub>: Product complexity impacts on operational performance

### ***Product Complexity and Integrated Green Supply Chain Management***

Khan et al., (2008) and Mackelprang et al., (2014) have verified a positive, significant relationship between product complexity and integrated green supply chain management. Bortolottic et al. (2013) have given a different indication that the relationship between product complexity and integrated green supply chain management practices may be positive or negative due to the changes of the supply chain design and the complexity of the product. This new argument has been brought into the fashionable garment manufactures in Hong Kong. Further, the study has explained that the relationship between these two variables is significant. Alexander et al. (2017) have given the same direction indicating that product complexity has a significant and negative relationship with green supply chain management. Thus, the impact of product complexity to operational performance reports mixed results. Therefore, the following hypothesis is developed for further verification:

H<sub>4</sub>: Product complexity impacts on integrated green supply chain management practices



### ***Integrated Green Supply Chain Management and Operational Performance***

The relationship between integrated green supply chain management and operational performance is an empirically verified phenomenon (Green et al., 2012; Zhu et al., 2007; Yu et al., 2014; Zailani, Jeyaraman, Vengadasan, & Premkumar, 2012). Vochon and Klassen, (2008) surveying 365 fashion garment manufactures in Hong Kong to investigate the relationship between supply chain management integration and operational performance, also confirmed that a positive relationship exists between the two variables. By combining all these empirical and theoretical backgrounds of the integrated green supply chain management and operational performance, the current study suggests the following hypothesis for the wide-ranging analysis conducted in the apparel sector of Sri Lanka:

H<sub>5</sub>: Integrated green supply chain management impacts on operational performance

### ***Mediating Role of Integrated Green Supply Chain Management***

Integrated green supply chain management is considered as the mediating variable linked to the constructs of operational performance, product variety and product complexity. The main research gap is related to the linkages identified above which are presented in fragmented models in existing literature. However, empirical studies done in the same context are not available to the best of the knowledge of the researcher. In the present study, the concept is presented with three main dimensions that include internal green supply chain management, green supply chain management with customers, and green supply chain management with suppliers. Zhu et al. (2007, 2008, 2012) empirically verified the impact of green supply chain management on environmental, economical, and operational performance using coordination theory. Chan et al. (2012) also found that the environmental orientation results in corporate performance through the mediation mechanism of green supply chain management. Accordingly, product variety and product complexity can be connected to integrated green supply chain management with the three dimensional framework. Moreover, the relationship between integrated green supply chain management and operational performance can be connected as per the empirical study by Yu et al. (2014). However, from the perspective of coordination theory, the stakeholders in the system need to manage their activities in-line with others in the network. When manufacturing firms are operating in a globally connected supply chain that produces a variety of products with complex product designs, it requires them to be integrated with their stakeholders to achieve operational performance.

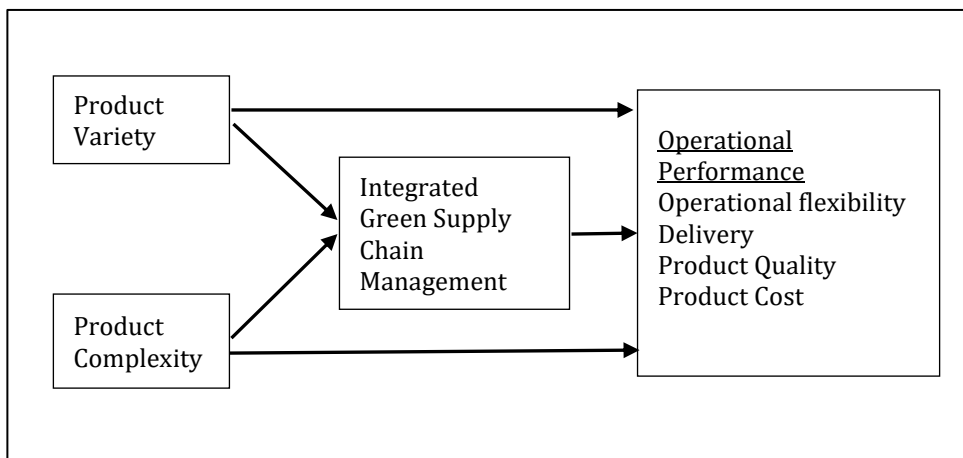
Therefore, based on empirical evidences the study proposes a mediating role of integrated green supply chain management on operational performance where there is product variety and complexity. Accordingly, the following hypotheses are proposed.

H<sub>6</sub>: The relationship between product variety and operational performance is mediated by integrated green supply chain management

H<sub>7</sub>: The relationship between product complexity and operational performance is mediated by integrated green supply chain management

Based on the hypotheses developed above, the conceptual framework of the study is presented in Figure 1.

**Figure 1: Conceptual Framework of the Study**



## Methodology

The study is positioned with objectivism based on the ontological view. As the context of the present study facilitates causal relationships (Saunders, Lewis, & Thornhill, 2009), it is in line with positivistic approach under the epistemological orientation. Accordingly, quantitative method was adopted under deductive approach to test the theoretical relationships in the research model. Considering the purpose of the study, it can be classified as an explanatory research in nature which attempts to establish a causal relationship (Bell & Bryman, 2007) between product variety, integrated green supply chain management, and operational performance. Survey

strategy was adopted in which a self-administered online questionnaire was used as the measurement instrument to collect data. The measures of each construct are reported in Appendix 1. A seven-point Likert scale was used to assess these items “1” (strongly disagree) to “7” (strongly agree)

Unit of analysis of the study is each merchandising unit that operates in apparel firms who manage different supply chains. A sample of 161 was selected using simple random sampling technique from a known sample frame of 1973 development and bulk merchandisers (company specific information was obtained through the human resource departments of each organisation) available in three leading apparel manufacturing organisations located in the Western Province, Sri Lanka. Data collection was mainly based on electronic version mail (e-mail) using Google Form since merchandising employees use e-mails and Enterprise Resource Planning systems exhaustively. Three kind reminders were sent to encourage responses. The response rate of the study is 53.6 percent.

## **Data Analysis**

The study applied Structured Equation Modeling (SEM) as it has greater accuracy over other methods (Hair, Black, Babin, & Anderson, 2014). SEM is used to test causal relationships between constructs and simultaneously measures number of variables and their interrelationships (Hoe, 2008) which fits well with the relationships of the present study. IBM AMOS (Analysis of Moment Structures) was used to perform SEM in the present study.

Testing for multivariate assumptions was conducted. The skewness and kurtosis statistics were within the +2 and -2 range and ensured that data is normally distributed (Garson, 2012). Measures indicated appropriate level unidimensionality in factor loadings ( $\lambda = 0.5$ ) and loaded into underline factors. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy and Bartlett's test of sphericity (Field, 2009) were adequate. Herman's single factor test (Podsakoff, MacKenzie, Lee, & Podsakoff, 2003) was conducted to ensure that there were no common method biases in the study. The encountered factor loading for the first factor of which Eigen value is greater than one reported 24 percent. Mean difference between early and late responses was not significant and hence reported, and non-response bias does not exist. There was a 76 percent effective response rate in the completion of the questionnaires.

### **Measurement Model**

In the measurement model purification, some of the items of the model were deleted due to lower factor loadings ( $< 0.5$ ) and to improve the model fit indices. The study has opted RMSEA and RMR as the absolute fit indices and CFI and TLI as the incremental fit indices. Accordingly, the results of the measurement model were well fit with the cut off values, CMIN/DF = 1.773, CFI = 0.972, TLI = 0.967, RMSEA = 0.069, RMR = 0.041 and the model was significant at  $p = 0.000$  ( $p < 0.001$ ). Prior to moving into path analysis, the multiple modes of validity and reliability was assessed.

### **Validity**

Content validity was ensured with a careful assessment of the scale items adopted from previous studies (Shou et al., 2017; Khan et al., 2008; Jacobs et al., 2007; Bortolotti et al., 2013). A pre-test was conducted with expert opinions of two academic scholars from two universities of Sri Lanka for face validity and a pilot test was carried for 30 respondents of merchandisers in the apparel sector. However, relying on content validity is not sufficient as it is “common sense of interpretation of scores of scale” (Malhotra & Birks, 2007, p. 358), thus construct validity was assessed. Construct validity includes convergent validity and discriminant validity (Hair et al., 2010). The results of the measurement model confirmed convergent validity with the higher factor loadings ( $> 0.5$ ) (Hair et al., 2014) and the values derived for Average Variance Extracted (AVE) were 0.5 or above as presented in Table 1. Discriminant validity was assessed by comparing the square of the correlation estimates of each construct with AVE values (Hair et al., 2014) and presented in Table 2.

**Table 1: Assessment of Validity**

<b>Variable</b>	<b>No. of Items</b>	<b>Standardised Factor Loading (Min-Max)</b>	<b>CR &gt; 0.7</b>	<b>AVE &gt; 0.5</b>
Product Variety ( <i>PCV</i> )	04	0.613 – 0.787	0.746	0.517
Product Complexity ( <i>PCX</i> )	04	0.613 – 0.787	0.746	0.517
Operational Performance ( <i>OP</i> )	16	0.501 – 0.995	0.841	0.682
Integrated Green Supply Chain Management ( <i>GSM</i> )	13	0.502 – 0.976	0.925	0.545

**Table 2: Assessment of Discriminant Validity (AVE vs SMC)**

	<i>PCX</i>	<i>PCV</i>	<i>GSM</i>	<i>OP</i>
<i>PCX</i>	<b>0.614</b>			
<i>PCV</i>	0.527	<b>0.517</b>		
<i>GSM</i>	0.278	0.249	<b>0.545</b>	
<i>OP</i>	0.094	0.162	0.145	<b>0.682</b>

## Findings and Discussion

Results of the structural model was well fit with the cut off values, CMIN/DF = 2.350, CFI = 0.936, TLI = 0.921, RMSEA = 0.069, RMR = 0.047 and the model was significant at  $p = 0.000$  ( $p < 0.001$ ). AMOS bootstrap technique (Hair et al., 2014) was used with 2000 iterations at 95 percent confidence level to test the mediation effect of integrated green supply chain management. As per the estimation results shown in AMOS, all paths among constructs were positive and significant at 1 percent significant level. Hence the model was appropriate to test the hypotheses. H<sub>1</sub> tested the direct path of product variety to operations performance and the path was not significant at 5 percent level ( $p > 0.05$ ). H<sub>2</sub> tested the impact of product variety on green supply chain management integration and proved a positive relationship and the impact between the constructs ( $\beta = 0.548$ ,  $p < 0.001$ ). H<sub>3</sub> investigated the impact of product complexity on operational performance. The results of the study reported a positive relationship and the impact of product complexity on operational performance ( $\beta = 0.373$ ,  $p < 0.001$ ). H<sub>4</sub> hypothesised that product complexity has an impact on integrated green supply chain management practices. The results of the structural model proved a negative relationship and the impact product complexity has on green supply chain management integration ( $\beta = -0.246$ ,  $p < 0.05$ ). Thus H<sub>4</sub> was accepted based on the findings. H<sub>5</sub> investigated the impact of green supply chain management integration on operational performance. It proved a positive relationship and the impact between the constructs ( $\beta = 0.905$ ,  $p < 0.001$ ) supporting the acceptance of H<sub>5</sub> of the current study.

Next, the two mediation models were tested with bootstrap method in AMOS. Based on the results of standardised path coefficients and bias corrected percentile significance levels, the hypotheses of the study were assessed and statistics are presented in Table 3.

The model has properly converged at 0.000 probability level. The fit indices for the models tested for H<sub>6</sub> and H<sub>7</sub> reported CMIN/DF = 2.423, RMSEA = 0.053, RMR-0.035, CFI = 0.915, TLI = 0.903 and CMIN/DF = 2.504 RMSEA = 0.028, RMR-0.048, CFI = 0.901, TLI = 0.913 accordingly.

### ***The Impact of Product Variety on Operational Performance***

The results indicated that product variety has a negative impact on operational performance. This is contradictory due to negative correlation between product variety and operational performance ( $\beta = -0.367, p > 0.05$ ). However, the path is not significant and hence the negative relationship between the two variables can be omitted. The negative correlation can be explained as product variety creating variations in the existing product portfolio resulting in extra work which incur costs in terms of material, labour, time, and limit the flexibility of operations. Despite the dearth of existing literature on the context, the findings of the study are consistent with few empirical studies which suggest a negative impact of product variety on operational performance such as Moseley et al. (2017), Jacobs et al. (2007), Bortolotti et al. (2013), Khan et al. (2008), and Balakrishnan and Geunes (2003).

**Table 3: Testing Mediation Effect**

		<b>Direct Effect</b>	<b>Indirect Effect</b>	<b>Total Effect</b>
H <sub>6</sub> : The relationship between product variety and operational performance is mediated by integrated green supply chain management	<i>Path</i>	<i>PCV</i> → <i>OP</i>	<i>PCV</i> → <i>GSM</i> → <i>OP</i>	0.524
	$\beta$	-0.168	0.524	
	<i>p</i>	0.117	0.021	
	<i>Decision</i>	Not Supported	Supported	
H <sub>7</sub> : The relationship between product complexity and operational performance is mediated by integrated green supply chain management	<i>Path</i>	<i>PCX</i> → <i>OP</i>	<i>PCX</i> → <i>GSM</i> → <i>EMP</i>	0.790
	$\beta$	0.226	0.564	
	<i>p</i>	0.008	0.011	
	<i>Decision</i>	Supported	Supported	

### ***The Impact of Product Variety on Integrated Green Supply Chain Management***

The resultant beta coefficient was 0.548 ( $p < 0.05$ ) and it indicates a positive relationship between the two constructs. The result indicates that product variety has a significant positive impact on integrated green supply chain management in the context of apparel manufacturing organisations. The finding of the study is consistent with the studies of Shou et al. (2017), Khan et al. (2008), Mackelprang et al. (2014), and Alexander et al. (2017). When product variety is present in the portfolio, a high level of integration in supply chain is required which is underlined with the governance theory. The results of the current study strengthen the fact that in order to continuously introduce new products, a product diversification strategy requires an integration of both internal and external complementary knowledge across different value chain activities and organisations (AlZu'Bi & Tsinopoulos, 2012).

Different styles and frequent changes in styles in apparel manufacturing will cause frequent changes in production line setups, reduce line speed, and limit number of batch sizes of specific styles. This emphasis on some valuable insights that can be considered by the industry as this will have an influence on investment plans, factory layout, machineries, and different skilled labour while aligning to the changing needs of the global clients that requires varieties in products. As argued by Moseley (2017), the appropriate level of variety which can be tolerated by the organisation should be determined with a certain level of flexibility in hand to make frequent changes to product, line set-up times, etc.

### ***The Impact of Integrated Green Supply Chain Management on Operational Performance***

The result of beta coefficient was 0.905 ( $p < 0.001$ ) and this indicates a strong positive relationship between the two constructs. The finding reveals a significant impact of integrated green supply chain management on operational performance. This is empirically consistent with the studies of Yu et al. (2014), Zailaini et al. (2012), Vochon and Klassen (2008), Green et al. (2012), and Zhu et al. (2007). Also, organisations concerned on ecological aspects in cooperation with the customer is predominantly vital to strengthen the supply chain loop (Zhu et al., 2008) providing concurrent improvement to the operational performance (Lai et al., 2010). Further, pertaining to supplier integration, liaising with suppliers for reduction of waste water, material consumption via environmental sourcing and minimising waste of resource could lead to improved overall operational performance of apparel sector organisations (Zhu & Sarkis, 2004).

### ***The Impact of Product Complexity on Operational Performance***

The result of beta coefficient was 0.373 at 0.001 level of significance which indicates a positive relationship between the two constructs. The result provides the judgment that product complexity has a significant positive impact on operational performance pertaining to apparel manufacturing organisations. It is arguable in the existing studies that in the apparel manufacturing context there is a lack of consistent patterns of the relationship between product complexity and operational performance. The finding of the current study shows an alignment with the empirical conclusion of Fan, Cheng, Li, and Lee (2016) that product complexity is positively related with operational performance. Empirical observations on similar grounds cited by Wang, Rao, and Wang (2012) revealed a positive impact of product complexity and operational performance. According to Moseley (2017), although a significant impact exists between product complexity and operational performance, the direction (positive/negative) varies from industry to industry and firm's ability to cope up with the stress of variations at the base model level without compromising the operational performance. The positive direction that emerged as the result of the current analysis indicates that product complexity is positively connected with operational performance in apparel manufacturing organisations.

### ***The Impact of Product Complexity on Integrated Green Supply Chain Management***

This study attempted to explain the relationship between product complexity and integrated green supply chain management. The result of beta coefficient was 0.246 at 0.05 percent significance level, and indicates that the relationship between the two constructs is significant. Further, the result provides the judgment that product complexity has a significant positive impact on integrated green supply chain management in the context of apparel manufacturing organisations in Sri Lanka. It was hypothesised in the current study that product complexity has an impact on the integrated green supply chain management. This is consistent with Shou et al. (2017), Khan et al. (2008), Mackelprang et al. (2014), Inman and Blumenfeld (2014), and Bode and Wagner (2015). The rationale for the positive impact can be determined as when a higher level of product complexity is present, the risk of supply chain can rise with disruptions resulting in coordination difficulties along the supply chain (Inman & Blumenfeld, 2014; Bode & Wagner, 2015). Bode and Wagner (2015) has argued that the complexity embedded in products give rise to the need of good integration along the supply chain to mitigate the transactional difficulties which is also in line with the governance theory.



***Mediation Effect of Integrated Green Supply Chain Management on the Relationship between Product Variety and Operational Performance***

The mediation effect was tested and resulted in a full mediation with a beta coefficient of 0.524. This relationship is one of the main theoretical gaps as studies linking product variety and operational performance through integrated green supply chain management were not found among existing studies. As per the findings of the study, integrated green supply chain management can be identified as a full mediator of the relationship between product variety and operational performance in the empirical context of apparel manufacturing organisations in the Western Province of Sri Lanka.

***Mediation Effect of Integrated Green Supply Chain Management to the Relationship between Product Complexity and Operational Performance***

The final relationship investigated was whether there is a mediation role of integrated green supply chain management on the relationship between product complexity and operational performance in the context of the apparel sector in Sri Lanka. Data analysis revealed that there is no mediation that exists in direct or indirect paths. Hence, in the Sri Lankan context, mediation impact of integrated green supply chain management is not validated and thereby H<sub>7</sub> was rejected. This relationship was one of the main theoretical gaps where the studies linking product complexity and operational performance through integrated green supply chain management were not found in the existing body of knowledge. As per the findings, it can be concluded that there is no mediation effect between product complexity and operational performance through integrated green supply chain management.

**Conclusion**

The current study bridged the theoretical gaps in existing literature pertaining to operational performance when the supply chain is green and integrated. This study captured the ecological aspect of supply chain integration which is emerging through environmental collaboration of upstream and downstream of the supply chain in apparel manufacturing. The first contribution of this study is that integrated green supply chain management plays a significant role to bring positive outcomes related to product variety and complexity on operational performance. Secondly, this study found that the role of the integrated green supply chain is vital for product variety than for product complexity. The third contribution is that the negative outcomes of producing a variety of products can convert into positive operational performance with the integrated green supply chain.

This study provides vital and timely insights related to the operational performance in the apparel manufacturing sector in Sri Lanka where environmental compliances are mandatory. The findings of this study help them to re-think the long-term benefits of engaging in green practices throughout the supply chain. Specifically, apparel firms that produce complex and a variety of products need to operate in an integrated green supply chain to enhance operational performance. They should have a solid integration at customer, suppliers, and internal layers of the supply chain which will bring enormous efficiency to the context. Such integration leads organisations to design, produce, and deliver products to the target customers while improving operational performance and being environmentally responsible.

However, future studies can investigate the impact of degree of product customisation, technology, and manufacturing capabilities as mediators/moderators that address the diversity of the apparel industry.

### **Declaration of Conflicting Interests**

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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**Appendix 1: Operationalisation**

Construct	Dimension	Indicator	Source
<b>Operational Performance (OP)</b>	Operational Flexibility	1. Quickly modify products and services to meet our customer's requirements	Yu et al. (2014) Flynn et al. (2010)
		2. Quickly introduce new products and services into the market	Zhu et al. (2008)
		3. Quickly respond to changes in market demand	
		4. Quickly adjust the firm's capacity to cater the customer requirement	
	Delivery	1. An outstanding on-time delivery record to our customer	Wong et al. (2011); Flynn et al. (2010)
		2. Provide reliable delivery to our customers	Gunasekaran Patel, &
		3. The lead time for fulfilling customers' orders (the time which elapses between the receipt of customer's order and the delivery of the goods) is short	Tirtiroglu (2001),
		4. Quickly adjust the delivery mode based on the customer requirement	

Contd.

<b>Construct</b>	<b>Dimension</b>	<b>Indicator</b>	<b>Source</b>
	Product Quality	<ol style="list-style-type: none"> <li>1. High-performance products that meet customer need</li> <li>2. Produce consistent quality products with low defects</li> <li>3. High reliable products that meet customer needs</li> <li>4. We implement the visual control system as a procedure or mechanism that makes the problems visible.</li> </ol>	Wong et al. (2011)
	Production Cost	<ol style="list-style-type: none"> <li>1. Produce products with low costs</li> <li>2. Produce products with low overhead costs</li> <li>3. Offer price as low or lower than our competitors</li> <li>4. Poor quality products that must be discarded (scraps) have reduced.</li> <li>5. The percentage of product that passes final inspection the first time (first-pass quality yield) has increased</li> </ol>	Wong et al. (2011)
<b>Integrated Green Supply Chain Management (GSM)</b>	Internal GSM	<ol style="list-style-type: none"> <li>1. Cross-functional cooperation for environmental improvements</li> <li>2. Environmental compliance and auditing programs</li> <li>3. Environmental management certification, e.g. ISO14000/ISO14001 certification</li> <li>4. Environmental management systems exist</li> <li>5. The internal performance evaluation system incorporates environmental factors</li> <li>6. Generate environmental reports for internal evaluation.</li> </ol>	Zhu et al. (2010)

Contd.



<b>Construct</b>	<b>Dimension</b>	<b>Indicator</b>	<b>Source</b>
	GSM with Customers	<ol style="list-style-type: none"> <li>1. Cooperation with customers for green packaging</li> <li>2. Cooperation with customers for using less energy during product transportation</li> <li>3. Working together with customers to reduce environmental impact of our Activities</li> <li>4. Searching for new ways to integrate SCM activities</li> </ol>	Vachon & Klassen (2008);  Zhu et al. (2010)
	GSM with Suppliers	<ol style="list-style-type: none"> <li>1. Providing design specification to suppliers that include environmental requirements for purchased item</li> <li>2. Cooperation with suppliers for environmental objectives</li> <li>3. Environmental audit for suppliers' internal management</li> <li>4. Suppliers are selected using environmental criteria</li> </ol>	Zhu et al. (2010)
<b>Product Complexity (PCX)</b>		<ol style="list-style-type: none"> <li>1. Integrated product design / diff dis module</li> <li>2. Many parts/materials, complex bill of material / diff liens</li> <li>3. Many steps/operations required</li> </ol>	Shou et al. (2017) Lucchetta et al. (2005) Inman & Blumenfeld, (2014)
<b>Product Variety (PCV)</b>		<ol style="list-style-type: none"> <li>1. Wider product range</li> <li>2. As a firm, we offer more innovative products</li> <li>3. Offering new products more frequently</li> </ol>	Fisher et al. (1999) Wan et al. (2012)