



Research Article

Development of Resilient-Sustainable Supplier Selection Criteria for Indirect Procurement

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ARTICLE INFO

Article History

Date Received: September 21, 2024

Date Accepted: October 21, 2024

Keywords

General Criteria; Resilient Criteria;
Sustainable Criteria; Indirect Procurement;
Resilient Sustainable Supplier

ABSTRACT

Among the groupings of sub-criteria assessed in this study, General Criteria was perceived to be the most important followed by Resilient Criteria and then by Sustainable Criteria. The ranking of importance of sub-criteria under the General Criteria is Quality > Trust > Delivery > Service > Cost > Flexibility > Financial > Technology Capability, under the Resilient Criteria is Responsiveness > Cooperation > Risk Reduction > Backup Supplier Contracting > Restorative Capacity > Surplus Inventory > Rerouting > Geographical Segregation, while under the Sustainable Criteria is Work, Safety, and Labor Health > The Rights of People > Pollution Control > Energy Efficiency > Social Management Commitment > Environmental Management System > Environmental Competencies > Green R&D and Innovation > Eco-Design Recycling > Green Design Capability. Confirmatory Factor Analysis (CFA) exposed that all of the identified main criteria and sub-criteria are essential in indirect procurement supplier selection as the generated final CFA model revealed the interrelationships of sub-criteria based on the actual survey responses from 365 supply chain professionals whereas the aforementioned model passed the various statistical validation tests such as model fitness test, internal conceptual and functional consistency and reliability test, convergent validity test and discriminant validity test.

A scorecard for evaluating and selecting resilient-sustainable supplier was generated – an approach that can be employed by any company belonging to the Electronics and Aerospace Manufacturing Industries - addressing the need for a more robust supplier selection criteria through the inclusion of sustainability and resiliency factors, an adaptive approach to the environmental and social changes brought by constant industrialization and globalization.

INTRODUCTION

A. Background of the Study

It is the ultimate goal of every company to sustain its operations from time to time – avoiding business losses in any forms. A lot of strategies and tactics are employed nowadays for a firm to survive its daily operations and one of the key areas of concerns is the continuity of supply of input materials and services through the high impact contributions of suppliers.

Suppliers play a vital role in the creation of valu-

able firm outputs through suppliers' on-time deliveries of company inputs thereby enhancing the firm's competitiveness (Sureeyatanapas et al., 2018). Past studies have revealed the direct effects of suppliers on supply chain efficiency and effectiveness and organization's profitability, cost reduction initiatives, and flexibility (Tirkolae et al., 2019). Maximizing the collaboration with suppliers fortifies innovativeness, responsiveness, and viability (Connor et al., 2020). Aside from that, suppliers immensely contribute to the quality of the company's final product and servic-





es (Su et al., 2019). Irrefutably, suppliers are indeed considered as very important partners for every company. Such expounded criticality of suppliers' roles in firms' success has initiated the necessity to screen and pick the right suppliers; provoking the interests of countless researchers to study the many facets encompassing the process of selecting suppliers.

Literatures on traditional supplier selection criteria

Cost. It includes all the costs associated with the buying of any product and/or services from a certain supplier; in other studies, this is termed as price (Surreyatanapas et al., 2018). Cost has been considered for a long time as a performance factor in the supplier selection phase (Lo et al., 2018). Vast studies have been undertaken utilizing cost to select suppliers which can provide low priced products at same quality for the evaluating firm to maximize profits (Gao et al., 2019).

Quality. It is a metric for the performance of the purchased input material and services to meet or exceed customer requirements (Ecer et al., 2020); measuring the ability of supplier to control service and product quality (Arabsheybani et al., 2018). Since companies prioritize suppliers that can provide affordable supplies at the highest quality, quality, as a selection criterion, has been proven to be interdependent with cost in the study (Chauhan et al., 2020). Quality has been the most influential criteria in selecting lean and agile suppliers in Chinese textile industries since said criterion highly promotes firm's competitive advantage especially during the post globalization era (Li et al., 2019).

Delivery. Also known as lead time, this dimension tackles about the delivery of right quantity at the right time set by the customer (Stevic et al., 2019); on-time-delivery parameter signifies the delivery reliability and commitment of the supplier. Company prefers doing business with suppliers having short delivery time (Goren, 2018); timely delivery of products and/or services is indeed crucial to any industry (Singh, 2019).

Technology Capability. It is the dimension which encourages suppliers to develop their processes and produce new and upgraded products to the customers (Gao et al., 2019); gauging the knowledge of a firm to contribute to industry's technological innovation (Zhou et al., 2018). For instance, automotive manufactures in Taiwan had given high regard to technology capability in selecting part suppliers; relating that the full control of manufacturing facilities and capabilities has direct impact to production efficiency and image of the enterprise; there should be a continuous focus on technology to guarantee good performance of parts suppliers (Jiang et al., 2018). Meanwhile, experts in an Iranian automaker firm utilized technology capability to open partnership opportunities with technology capable suppliers to increase manufacturing capacity while reducing costs at the same time (Hadian et al., 2019).

Service. It covers the efficiency of scheduling and the capability to manage changing orders, after sales responsibility of the suppliers, and the willingness and effectiveness of sharing skills to solve problems related to the purchased items; showing how supplier renders such services to achieve customer satisfaction



(Zhou et al., 2018). In Pakistan, service capability was ranked to be the top 2 sub-criteria in selecting suppliers for the management of hospital wastes (Ishtiaq et al., 2018).

Flexibility. It pertains to the capacity of the supplier to adjust to the changing demand and requirements of the customers such as but not limited to the changes in the services being rendered, volume, mix, delivery, and characteristics of the product, modification of the manufacturing processes, and product customization using the existing machines or equipment (Lopes et al., 2021) (Hadian et al., 2019). Since flexibility relies to the existing technology, flexibility criterion is highly affected by the technology capability criterion (Chauhan et al., 2020). When coupled with delivery criterion, flexibility criterion maximizes company benefits; priority to delivery and flexibility criteria can give an adequate supply of raw materials to an Iranian auto maker quickly and on time (Hadian et al., 2019).

Financial. This relates to the financial capability, position, stability, and payment conditions of the supplier (Lopes et al., 2021) (Amindoust, 2018). A financially stable supplier can always promote supply chain improvements, attaining overall company economic growth (Liao et al., 2019). Suppliers with strong financial backgrounds have high regards to innovation and generation of new ideas during the process of continuous research and development (Ahmadi et al., 2020).

Trust. In buyer-supplier relationship, trust covers the buyer's high assurance on supplier's integrity and reputation leading to the so-called continuing desire

of the buying institution to sustain business relationship and partnership with the vendor (Agarwal et al., 2020). Literatures have mentioned that trust among supply chain allies have influenced the success of most of the established ventures with suppliers (Konnys, 2019). Trust can be built by supplier's engagement to the customer's process and showing inclination to meeting the buyer's purchasing criteria which includes involvement in the development of knowledge and corrective action as early knowledge development can decrease business risk (Cole et al., 2019).

Literatures on resiliency relating to supplier selection criteria

Responsiveness. It measures the supplier's state of being reactive to various situations (visibility) (Falahpour et al., 2021) and the supplier's quickness to adapt to the changes (velocity) brought about by the market and/or customers (Sramek et al., 2018) within a suitable and an acceptable time frame to induce, maintain, and/or improve customer's competitive advantage (Sundram et al., 2018). In the emerging Industry 4.0 wherein companies are starting to utilize the fourth wave of intelligent technological innovation in manufacturing and industrial operations, Industry 4.0 ready companies have started to prioritize doing business with responsive and not cost-effective suppliers alone doing highly visible resilient performance during disruption (Hasan et al., 2020). Suppliers contribute a huge impact to the production line and efficiency of the entire eco-system; thus, it is essential for the suppliers to be more responsive as a method of enhancing and establishing standard level practices to support the focal firm (Singh et al., 2020).



Risk Reduction. The capacity of the supplier to predict different circumstances, determine risk conditions and vulnerabilities, and reduce such risks and vulnerabilities present in various and difficult situations (Fallahpour et al., 2021). Giving emphasis only on supply cost minimization can make supply chain more vulnerable and susceptible to risks, thus a risk management approach should also be taken into consideration and be integrated into the supply chain management; supply risk is greatly related to vendor's performance variability risk, thus risk reduction aspect highly affects the supplier selection decisions (Alikhani et al., 2019).

Backup Supplier Contracting. This dimension connects to the supplier's cooperation with a backup supplier as a method of mitigating supply risk (Yin et al., 2018). Even at lower probabilities of supply disruption, main suppliers would always favor to reap the benefits of establishing back up suppliers (Chakraborty et al., 2020).

Geographical Segregation. Geographical segregation or location separation is the absorptive capacity of suppliers to geographically disperse its production areas to maintain uninterrupted supply chain rather than being located in a short distance zone thereby reducing the risk of geographically-induced- supply chain disruption (Hosseini et al., 2019) (Gan et al., 2019). A practical approach to address supply disruption is by clustering suppliers based on their commonality of vulnerabilities and one of those is by partitioning suppliers according to geographical location taking into consideration the correlated disruption risks originated from natural calamities and phenom-

enon including the instabilities coming from political and economic conflicts and conditions (Zhao et al., 2018). One benefit of supplier location clustering is avoiding the negative influences of the existence of natural disasters through the acquisition of raw materials from suppliers located in different locations and regions (Hosseini et al., 2019).

Rerouting. Another adaptive capacity characterized by how suppliers evolve or make internal changes such as re-engineering to enlarge the variety of changeability that the supplier can cope up with the effects of disruptions (Bassett et al., 2021). Rerouting is very reactive to disruption – suppliers may undertake ad-hoc rerouting of current competences to guarantee that the supply chain evades shifting into the catastrophic side of any disruptive incident (Mackay et al., 2019).

Cooperation. It is a resilient enhancing feature of supplier's adaptive capacity in overcoming disruptions by way of ensuring timely communication and collaboration among the members of the supply chain (Hosseini et al., 2019). Supply chain resilience published literatures have proven that collaboration is indeed a vital aspect in building resilient supply chains; collaboration between the buyer and the supplier brings an important reduction in the probability of occurrence of disruption in the upstream portions of the supply chain aside from said mutual cooperation stops the adverse effects of disruption proliferation in the entire supply chain (Hosseini et al., 2019). In addition to that, strong collaboration with firm's suppliers yield to strengthen company resilience (Durach et al., 2020).



Restorative Capacity. Restorative capacity refers to the restoration capability of suppliers in terms of having restoration budget and technical resource restoration to repair and quickly reestablish operations after a disruptive occurrence; an ability which can be strongly manifested by suppliers by providing technical supports to the customer (Gan et al., 2019). It is still considered as the last line of defense of firm's supply chain from disruption effects with the caveat that it is highly dependent on supplier's restoration budget and ability to restore technical resources (Hossain et al., 2019).

Surplus Inventory. Surplus inventory covers all the excess inventories of a firm but when the term is employed in supplier selection, surplus inventory is the criterion of gauging supplier's investment capacity buffer and supplier's capacity to hold safety or supplementary available stocks such as strategic inventory stocks and emergency stocks useable during inventory crises (Amindoust, 2018) (Fallahpour et al., 2021). It is an indicative factor of the absorptive capacity of the supplier to continue the production operations and repair the supply chain in times of disruptions (Gan et al., 2019) while driving supply chain resiliency in meeting customer demand if a quantified surplus inventory is determined prior to disruption (Hosseini et al., 2019), aside from it promotes inventory sharing for parties facing shortages (Alikhani et al., 2021).

Literatures on sustainability relating to supplier selection criteria

Green Design Capability. This applies to the com-

petence of the supplier to formulate a product design to lessen energy and raw material usage reflecting the supplier's image in the marketplace as an environment friendly company that can produce green products (Ecer, 2020) (Memari et al., 2019). Green design or eco-design ability was determined to be one of the critical factors that should be chiefly taken into consideration in selecting suppliers; though engagement with suppliers with green practices in the manufacturing premise might be costly, such undertaking gives a lot of benefits such as good corporate image, environmental protection, resource recovery options, and cost reduction in product disposition (Dos Santos et al., 2018).

Environmental Management System. A system that comprehensively analyzes the internal and external environmental performance of a firm which can be successfully gauged through the availability of environmental certificates and green process plan as well as through the firm's compliance to environmental policies (Zhou et al., 2018). It is the core in successfully implementing green supply chain management thus Jiang et al. (2018) mentioned in their study that manufacturers in Taiwan automotive industry should give more attention to said system.

Environmental Competencies. The capacity to implement environment friendly initiatives through balancing the containment relationships between economic and environmental performance of the organization (Zhou et al., 2018). Environmental competency criterion is the most important and influential index in evaluating intended suppliers under uncertainty (Goddarzi et al., 2022).



Pollution Control. Manifests the ability of an entity to manage and control the environmental pollutants coming from the business operations (Jiang et al., 2018). The study of Jiang et al. (2018) exposed the key consideration of Taiwanese automotive manufacturers to measuring the pollution control strategy of parts suppliers, with a high regard to the urgent improvement of the pollution control aspect.

Energy Efficiency. The organization's responsible energy consumption, effectiveness, and conservation through the creation of optimized energy models (Govindan et al., 2018). Energy efficiency can cut both the environmental impact and product lifecycle costs thereby alluring competitive advantage in the era of global initiatives towards sustainable global economy (Haraldson et al., 2019).

Eco-Design Recycling. The manner of designing the process integrating the reuse of waste materials and energy (Durmic, 2019), contributing to the green practice of supply chain (Zhou et al., 2018).

Green R&D and Innovation. Pertains to the capacity of the supplier to sustain environment friendly practices through investment on green and break through projects (Li et al., 2020). Giving more attention to green innovation capability in selecting green suppliers had complimented to the findings of various studies stating that green innovations help a firm respond to established environmental regulations and create competitive advantage while pushing for green innovations among suppliers (Mohammad et al., 2020).

Work Safety & Labor Health. The dimension that

deals with the safety, health, welfare, and job security of people at work (Durmic, 2019). Published studies have shown the common concept of work safety and labor health criterion – initiates and sustains the maintenance of sound working conditions for supplier's employees (Singh, 2019). As a result, this dimension has captured the attention of many researchers focusing on socially sustainable supplier selection. For instance, Rashidi et al. (2020) figured out that work safety and labor health is the most frequent criterion used by various studies; with a frequency of occurrence of more than 7 out of 298 social criteria (extracted from published papers) used by the team of Rashi et al. in their study.

Social Management Commitment. Supplier's obligation to generate supportive activities for the development of the community within which the business operates (Bai et al., 2019). As compliance to social standards and practices has equivalent supplier's operating costs, not all suppliers can fully go along with this commitment especially if suppliers are located in developing countries (Jajja et al., 2019).

The Rights of People. This appertains to the human rights of the people composing and surrounding the business – covering the aspects promoting employees' and stockholders' concerns and related sustainable matters; including the interests of the society (Bai et al., 2019). Kannan (2018) highly suggested to evaluate suppliers based on this dimension – especially those suppliers that are located in countries where human rights are prone to abuses, locations with cheap labor and large population size. He then termed this dimension related to the rights of the people as



one of the suppliers' critical success factors – should be strictly watch out for in picking the best supplier.

Literature Synthesis

Although supplier selection has been a popular area of study in the Supply Chain field, majority of the past studies does not provide a broad perspective – focusing on one facet only like the traditional standards such as economic and basic supplier performance metrics, collectively termed as General Criteria (Amindoust, 2018). This was witnessed by the proponent of this study to be true and existing in the following industries: Semiconductor Manufacturing Services, Electronic Manufacturing Services, and Aerospace Manufacturing Industries. Such current condition has triggered the researcher, having work experiences in the abovesaid industries, to generate a more robust set of supplier selection criteria to keep abreast of the everchanging market requirements. For instance, the Philippine government has created comprehensive foundations for promoting social well-being of people and conserving natural resources, which comprises of the Corporate Social Responsibility (a vital part of a more responsible business conduct), the Philippine Clean Air Act, the Clean Water Act, the Ecological Solid Waste Management Act, among others (Lofranco, 2024). While complying to such regulations and practices, the firm should also immensely partner with compliant suppliers when it comes to corporate social initiatives and environmental directives – this situation triggers the need to include sustainability in supplier selection criteria. Additionally, supply chain disruptions, which were hugely experienced during COVID-19 pandemic, have negatively

impacted numerous firms, thus resiliency has become a vital part in choosing appropriate suppliers. Parkouhi et al. (2019) exposed in their study how resiliency becomes a main issue of current supplier selection research and thus resilient suppliers should be developed in order to eliminate problems in times of supply chain disorders.

Furthermore, most of the previous studies focused on the selection of suppliers for high costs and high valued commodities like evident product parts. Israel et al. (2020) even pointed out in their study how indirect procurement has been ignored by various scholars in the past and how indirect procurement has started to grow as a new area of investigation as proper management of indirect spend leads to sustainable competitive advantage as well as reduced and optimized company costs. This scenario has opened up opportunities to extend the said field of study to other high impact areas such as indirect procurement, as there are numerous benefits that can be obtained in the efficient and effective management of indirect procurement (Israel, 2019) – indirect procurement accounts for 80% of the total company spend and at least 50% of maverick purchases (Israel, 2019) (Jilani, 2018) and it involves the purchase of indirect materials which are not directly integrated to the final outputs but are still needed to sustain day to day operations.

Most importantly, this undertaking contributed in promulgating the concepts of the following Sustainable Development Goals (SDG) – SDG 8: Decent Work and Economic Growth (creating equal opportunity for stable and safe work while socially protecting human rights since suppliers are going to adjust their



social sustainability practices in order to adapt to the selection framework generated in this study); SDG 9: Industry, Innovation, and Infrastructure (building resilient business methods, promoting sustainable industrialization and fostering innovation for the ever-changing world as a holistic supplier selection approach was developed in this research); and SDG 12: Responsible Consumption and Production (ensuring resilient and sustainable consumption and production patterns both by the company and its partnered suppliers). Specifically, the study output is an excellent assessment and decision-making platform for any company – making sure to only engage business with suppliers who are extremely valuing innovative resiliency as well as social and environmental sustainability. Apart from these benefits, the outcome of this study could also be a reliable basis of further studies by other researchers who are aiming to delve into supplier selection and indirect procurement.

B. Research Framework

This study adopted the framework from the study of Amindoust (2018) – conceptual framework is shown in Figure 1.

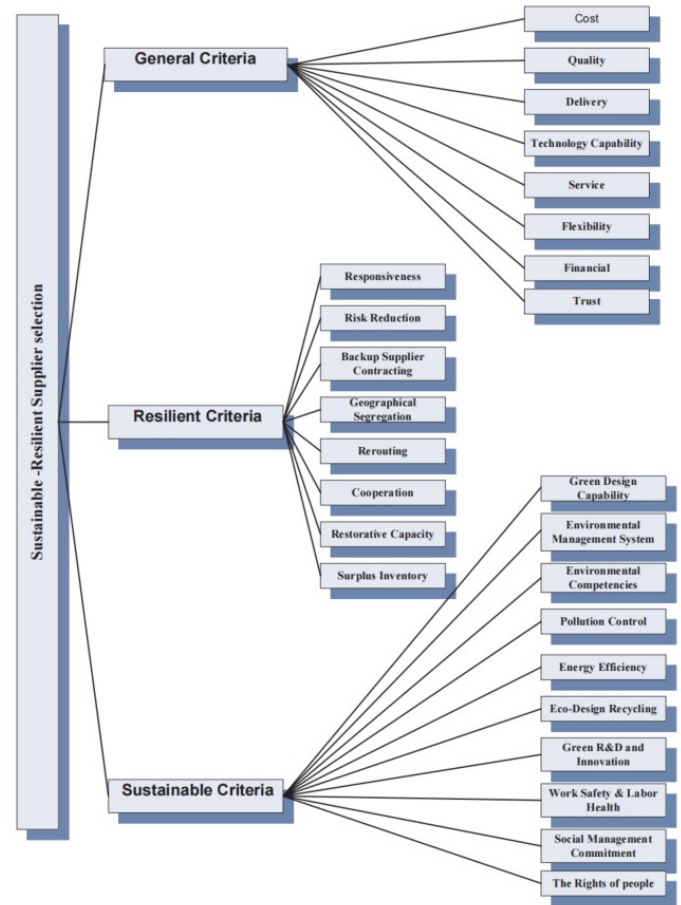


Figure 1. Conceptual Framework

Note. Adopted from A resilient-sustainable based supplier selection model using a hybrid intelligent model (p. 123), by A. Amindoust, 2018, Computers and Industrial Engineering.

While Amindoust (2018) generated a framework through review of related literatures, this study statistically produced an acceptable model based on the actual perceptions of the target population – valuing the real applicability of the study outcome to the designated end users. Unlike with the study of Amindoust (2018) which focused on the development of an intelligent model after the generation of set of criteria, this study only utilized the same variables from the said mother journal to determine which main criteria and sub-criteria are only applicable in the selection of suppliers for indirect procurement.



C. Objectives of the Study

Using the supplier selection variables published in the study of Amindoust (2018), this study aimed to identify the selection criteria which are relevant only to Indirect Procurement. Moreover, this study was designed to meet the following specific objectives:

1. determine the perception of target respondents on the importance of below identified sub-criteria, under the main variable (General Criteria), to the selection of the best supplier for any indirect procurement transaction:
 - i. Cost;
 - ii. Quality;
 - iii. Delivery;
 - iv. Technology Capability;
 - v. Service;
 - vi. Flexibility;
 - vii. Financial; and
 - viii. Trust.
2. determine the perception of target respondents on the importance of below identified sub-criteria, under the main variable (Resilient Criteria), to the selection of the best supplier for any indirect procurement transaction:
 - i. Responsiveness;
 - ii. Risk Reduction;
 - iii. Back-up Supplier Contracting;
 - iv. Geographical Segregation;
 - v. Rerouting;
 - vi. Cooperation;
 - vii. Restorative Capacity; and
 - viii. Surplus Inventory.
3. determine the perception of target respondents on the importance of below identified sub-cri-

teria, under the main variable (Sustainable Criteria), to the selection of the best supplier for any indirect procurement transaction:

- i. Green Design Capability;
 - ii. Environmental Management System;
 - iii. Environmental Competencies;
 - iv. Pollution Control;
 - v. Energy Efficiency;
 - vi. Eco-Design Recycling;
 - vii. Green R&D and Innovation;
 - viii. Work Safety & Labor Health;
 - ix. Social Management Commitment; and
 - x. The Rights of People.
4. determine if each sub-criterion, through its weight importance and fit indices, is fitted to the identified variable (main criteria) as a parameter in selecting the best supplier for any indirect procurement transaction; and
 5. generate a statistically acceptable model containing the resilient-sustainable criteria -encompassing three perspectives namely economic, resiliency, and sustainability.

D. Significance of the Study

The outcome of this study has addressed the current need of any company (belonging to Semiconductor Manufacturing Services, Electronic Manufacturing Services, and Aerospace Manufacturing Industries) for a more robust set of supplier selection criteria. With working experiences in the said industries, the researcher has witnessed how companies have given much focus on economic factors when se-



lecting indirect procurement suppliers; the emergence of much stringent social and environmental laws has triggered the necessity to also consider sustainability for compliance purposes while the occurrence of supply disruptions, like the Covid-19 pandemic, has prompted the concept of choosing resilient suppliers.

Most importantly, this undertaking contributed in promulgating the concepts of the following Sustainable Development Goals (SDG) – SDG 8: Decent Work and Economic Growth (creating equal opportunity for stable and safe work while socially protecting human rights); SDG 9: Industry, Innovation, and Infrastructure (building resilient business methods, promoting sustainable industrialization and fostering innovation for the ever-changing world); and SDG 12: Responsible Consumption and Production (ensuring resilient and sustainable consumption and production patterns). Specifically, the study output is an excellent assessment and decision-making platform for any company – making sure to only engage business with suppliers who are extremely valuing innovative resiliency as well as social and environmental sustainability.

Apart from those benefits, the outcome of this study could also be a reliable basis of further studies by other researchers.

MATERIALS AND METHODS

A. Research Design

This study utilized a descriptive research design – quantitatively collecting and understanding the perceptions of the target respondents towards the im-

portance of each identified sub-criterion in selecting supplier for any indirect procurement transaction. Research data was collected through a set of survey questionnaires published online through Google Survey Form - link for Google Survey Form was sent to the target respondents via LinkedIn and Messenger. Furthermore, actual survey printouts were distributed to the target population within the reach of the researcher. The results of the survey research were used to generate an acceptable supplier selection criteria framework for indirect procurement.

B. Locale of the Study

The researcher conducted this study in the Philippines, specifically in Luzon area. By doing so, this study captured comprehensive and general findings with high degree of reliability and relevance.

C. Respondents of the Study

The initial target population is the entire manufacturing sector of the Philippines but to address possible scalability issues two areas were involved in this research: the Electronics industry (both for Semiconductor Manufacturing Services and Electronic Manufacturing Services), which is evidently one of the well-established manufacturing industries in the country, and the Aerospace Manufacturing Industry, one of the emerging and fastest growing manufacturing businesses in the same nation.

Professionals with working experiences from the following supply chain functions of a certain company were the target respondents of this study – Com-



pliance, Continuous Improvement, Customer Service, Data Analytics and Management, Digital Technology, Engineering, Equipment Maintenance, Environment, Health & Safety, Facilities Management, Finance and Accounting, Human Resources, Inventory Management, Manufacturing & Operations, Procurement, Quality Assurance, Supply Chain Planning & Management, Warehousing & Logistics. This approach covered the opinions and judgments from the different facets of the business since this study was focused on indirect procurement, purchases needed to sustain daily business operations. Respondents were composed of the managerial and non-managerial employees to capture opinions from two different perspectives: the one who performs merely for his job and the other who performs decision making not only for himself but for the success of the entire team. Through that tactic, fair insights from the decision making and non-decision-making sides were considered in this research.

D. Sampling Design

Purposive convenience sampling was used in this study in order to select participants with specific characteristics (work experiences and affiliations) and expertise essential in constructing reliable results. Also, for the benefit of time, respondents were chosen based on how convenient they can be reached and they can provide their responses without sacrificing the quality of this study. Actual respondents were colleagues of the researcher, came from referrals, while some were reached through social media platforms after verifying that they passed the needed respondent qualifications. For online survey, respondents who were not matching with the desired qualifications were not al-

lowed to proceed to the next part of the survey; for survey conducted through issuance of print outs, respondents with irrelevant working experience were ignored in data run and analysis. Through purposive convenience sampling, 365 respondents were able to return the accomplished survey on time.

E. Research Tools and Instruments

The survey instrument for this study is tailored from the survey approach of the study conducted by Lin et al. (2018) to fit on the purpose of this research. The set forth journal employed a survey asking the importance of each selection criterion (a value of 5 means very important while a value of 1 means very unimportant). With the same method from the set forth journal, the survey instrument for this research aimed to measure the importance of sub-criterion, under each main criterion, to indirect procurement supplier selection. On the other hand, instead of using the same variables used by Lin et al. (2018), this study utilized the variables from the mother journal authored by Amindoust (2018).

There are two parts of questionnaires for the survey instrument: 1) Respondent's Profile; 2) Importance of Resilient-Sustainable Supplier Selection Sub - Criteria to Indirect Procurement. To ensure that the right respondent is selected, Part 1 gauged the experience of the respondent in supply chain – given the fact that the indirect procurement is part of a bigger concept, supply chain. In Part 2, each of the respondents was instructed to assess the importance of each sub-criterion to indirect procurement supplier selection. Selection indicators per sub-criterion were also



included in part 2 to serve as a guide of the respondent in rating each variable. Meanwhile, Likert's five-point scale (5 means very important, 1 means very unimportant) was applied to Parts 2 and 3, which is still in reference to the study of Lin et al. (2018).

F. Data Analysis and Interpretation

The respondents' overall perception on the importance of each main criterion and each sub-criterion to indirect procurement supplier selection can be determined through the respective mean values. A mean of at least 4.0 makes the variable an important part of the supplier selection model and thus needs to be considered in selecting indirect procurement suppliers whereas a mean of 3 and below means the variable can be ignored due to its unimportance in indirect procurement supplier selection.

The overall acceptability of the structure of the pre-determined supplier selection criteria for indirect procurement was tested through Confirmatory Factor Analysis (CFA) run in the IBM SPSS Amos software – assessing how the said scale adopted from the mother journal fits to the actual gathered survey data and thus be applicable to indirect procurement. In every CFA run, the generated model was statistically validated against the standards until all of the checkpoints were satisfied. Model validity was tested through the validation of the generated fitness indices against the standards set by Hu et al. (1999) and Browne (1992) such as the chi-square value (should be between 0 to 5), Root Mean Square Error of Approximation (RMSEA) (should have a maximum value of 0.08), and Normed Fit Index (NFI) value,

Incremental Fit Index (IFI) value and Tucker Lewis Index (TL) (NFI, IFI, and TL should have a range value of 0.90 to 1.0). Meanwhile, the internal consistency of each sub-criterion loaded to each main criterion as well as the overall reliability were verified through the Cronbach alpha value, should be greater than 0.7 (Shrestha, 2021). Then after, the model was screened for convergent validity, a measure of correlations or mutual relationships of variables with same concept or of same phenomenon without correlating with unrelated and dissimilar variables (Cheah et al., 2018), which can be evaluated through the Average Variance Extracted (AVE) value (should not be lower than 0.50) (Cheung et al., 2023), Standardized Factor Loading (SFL) value (should not be lower than 0.50) (Hair et al., 2017) and Composite Reliability (CR) value (should not be lower than 0.6) (Shrestha, 2021). A further checkpoint to determine the suitability of the model was by validating the occurrence of discriminant validity – distinction of criteria networks from other groups as there is no correlation or very low correlation of variables with unrelated variables (Rasoolimanesh, 2022). There is discriminant validity if the AVE of each construct is greater than the Maximum Shared Variance (MSV) (Fornell et al., 1981). On the other hand, as a common practice, for every unsuccessful CFA run, model modifications can be performed through elimination of variable, changing the loading of sub-criteria under each main criterion, or creating covariances or relationships of each variable under same main criterion (Eaton et al., 2018).

G. Ethical Consideration

This research was highly executed with all hones-



ty, objectivity, and carefulness and in accordance with the guidelines set by the De La Salle Lipa. Above all, this research project has been anchored on the following principles: voluntary participation (every participant had the freedom to join the study), informed consent (respondents were fully aware of the purpose, risks, and mechanics of the study/survey before their approval was obtained and actual survey was done. Proper consents from the concerned entities were strictly secured first prior to holding the survey), anonymity (the population had the option not to disclose their personal identity in the survey), confidentiality (details shared by the respondents were highly confidential and accomplished surveys were disposed of properly after data analysis. No Proprietary Information was collected while the survey was launched), potential for harm (all other types of harm were extremely kept at the very minimum level), and results communication (free from plagiarism and any other form of dishonesty).

RESULTS AND DISCUSSION

General Criteria was perceived to be the most important main criterion in indirect procurement supplier selection, followed by Resilient Criteria, and then Sustainable Criteria. These findings are aligned with the past studies as shown in Table 1. Meanwhile, respondents weighed up all of the enumerated sub-criteria under each main criterion cardinal parts of the selection process since all of the enumerated factors received a mean higher than 4 (i.e. 4 means important in the survey instrument).

Table 1. Ranking of Importance of the Defined Main Criteria to Indirect Procurement Supplier Selection

Table with 6 columns: Main Criteria, Mean, Std. Deviation, Interpretation, Rank, and Related Findings from Published Studies. Rows include General Criteria, Resilient Criteria, and Sustainable Criteria.

Note. Mean column presents Likert Scale (1: Very Unimportant, 2: Low Importance, 3: Neutral, 4: Important, 5: Very Important).

1. Perception on the Importance of Identified Sub-Criteria (under the General Criteria) to Indirect Procurement Supplier Selection

Table 2. Importance of each Sub-Criterion (under General Criteria) to Supplier Selection

Table with 6 columns: Sub-Criterion, Mean, Std. Deviation, Interpretation, Rank, and Related Findings from Published Studies. Rows include Cost, Quality, Delivery, Technology Capability, Service, Flexibility, Financial, and Trust.

Note. Mean column presents Likert Scale (1: Very Unimportant, 2: Low Importance, 3: Neutral, 4: Important, 5: Very Important).

Table 2 presents the perception of the target respondents on the importance of the listed sub-criteria (under the main supplier selection criteria, General Criteria) to indirect procurement together with the related findings from published studies. Quality emerged as the respondents' top consideration in selecting the best suppliers after accumulating the highest mean of 4.87. Next to Quality, Trust was distinguished to be a vital check point in supplier selection – with M = 4.81. Delivery and Service are also in the top four essential dimensions collecting a mean of 4.79 and 4.69 respectively. The respondents still considered Cost as a key metric in selecting suppliers – possessing a mean of 4.68). Statistical results also show that the





right suppliers are expected to be flexible as Flexibility factor has a mean of 4.59 and financially capable as financial aspect holds a mean of 4.54. The Technology Capability of the supplier is also a contributing factor in the selection process as sensed by the respondents through a mean of 4.40.

2. Perception on the Importance of Identified Sub-Criteria (under the Resilient Criteria) to Indirect Procurement Supplier Selection

Importance of each criterion under the Resilient Criteria is reflected in Table 3 – including significant findings from related literatures. Being the most important measure of being resilient, supplier’s responsiveness statistically obtained a mean of 4.70. Having the second highest mean (M=4.68), cooperation was deemed to be another critical supplier evaluating factor. Risk reduction capability was regarded as the third most important resilient criteria, with a mean of 4.55. Having a backup supplier was looked on as an additional checkpoint in selecting the main supplier as backup supplier contracting obtained the fourth highest mean of 4.31. Supplier’s Restorative Capacity during and after any disruptive event was viewed as a further consideration in choosing right suppliers as such competency gained an importance mean of 4.25.

Table 3. Importance of each Sub-Criterion (under Resilient Criteria) to Supplier Selection

Table with 6 columns: Sub-Criterion, Mean, Std. Deviation, Interpretation, Rank, and Related Findings from Published Studies. Rows include Responsiveness, Risk Reduction, Backup Supplier Contracting, Geographical Segregation Rerouting, Cooperation, Restorative Capacity, and Surplus Inventory.

Note. Mean column presents Likert Scale (1: Very Unimportant, 2: Low Importance, 3: Neutral, 4: Important, 5: Very Important).

A supplier with strategic excess inventory as safety and supplementary stocks has been sought as vital partner as confirmed by the survey results – Surplus Inventory acquiring an importance mean of 4.24. Rerouting criterion secured an importance mean of 4.05 – suggesting that respondents still value the significance of this disruption adaptive capacity in supplier selection. Supplier’s absorptive capacity to geographically disperse its facilities to maintain uninterrupted supply chain was also conceived by the respondents as an influential dimension in supplier selection – geographical segregation sub-criterion earned a statistical mean of 4.04.

3. Perception on the Importance of Identified Sub-Criteria (under the Sustainable Criteria) to Indirect Procurement Supplier Selection



Table 4. Importance of each Sub-Criterion (under Sustainable Criteria) to Supplier Selection

Table with 6 columns: Sub-Criterion, Mean, Std. Deviation, Interpretation, Rank, and Related Findings from Published Studies. It lists 10 sub-criteria such as Green Design Capability, Environmental Management System, etc., with their respective mean scores and ranks.

Note. Mean column presents Likert Scale (1: Very Unimportant, 2: Low Importance, 3: Neutral, 4: Important, 5: Very Important).

Table 4 summarizes the insights of the respondents with regards to the noteworthiness of each sustainable sub-criterion to indirect procurement supplier selection. Among the 10 sub-criteria under the Sustainable Criteria, Work Safety and Labor Health bagged the highest mean of 4.61- giving much emphasis on suppliers that have high regards on the safety, health, welfare, and job security of employees. A mean of 4.57 for the sub-criterion The Rights of People implies the need to select suppliers that have robust consideration on human rights of the people within and surrounding the business. As any business can potentially deteriorate the environment overtime, it is a must to do business with entities that can manage and control environmental pollutants – a same perception made by the respondents by giving Pollution Control sub-criterion a mean result of 4.38. In connection to that, organiza-

tions are also looking for suppliers that are responsible in their energy consumption – as confirmed in the Energy Efficiency factor’s mean of 4.34. Respondents also wanted to engage with suppliers that are devoted to implementing socially supportive and humane activities – producing a mean of 4.31 for the Social Management Commitment dimension. Furthermore, it is an advantage for a certain supplier in the selection process to have and exhibit an Environment Management System and Environmental Competencies; said two sub-criterion both received a mean of 4.31 respectively. Continuous innovation to sustain environment friendly practices is an edge as well for suppliers that are expanding its customers as the respondents of this study gave a mean of 4.22 to Green R&D and Innovation sub-criterion. Suppliers that are also leaning towards the practice of Eco-Design Recycling (M = 4.21) are highly appraised by the respondents to become part of the business supply chain. Supplier’s green design capability was also discerned by the respondents as a substantial basis in choosing indirect procurement suppliers as such sub-criterion accumulated a mean of 4.2.

4. Initial Model Generation and Fitness Test

Initial model is seen in Figure 2 – showing shared relationship of main criteria in indirect procurement supplier selection as represented by double headed arrows. Each main criterion was used as the latent variable while the survey results for each sub-criterion were utilized as the observed variables. Such model generated fit measures which were not within the rules of thumbs values of model fitness evaluation.

Actual statistical values are displayed in Table 5





- with a Chi-Square/df value of 5.06 (greater than the maximum acceptable value), RMSEA value of 0.11 (greater than the maximum acceptable value), NFI value of 0.81 (less than the maximum acceptable value), IFI value of 0.85 (less than the maximum acceptable value), and TLI value of 0.83 (less than the maximum acceptable value). Such results exposed that the initial model neither have a good fit nor an acceptable fit thus model modification was mandatory in order to arrive with an acceptable model.

Table 5. Results of Fitness Evaluation Test of the Initial CFA Model

Table with 5 columns: Fit Measure, Rules of Thumbs for Model Fitness Evaluation (Good Fit, Acceptable Fit), Actual Value, and Interpretation. Rows include Chi-Square/df, RMSEA, NFI, IFI, and TLI.

Note. The recommended and acceptable fit measure ranges appeared in this table are based on the guidelines of Hu et al. (1999) and Browne (1992).

5. Generation of Final Model (Statistically Acceptable Model)

Since survey results exposed that all the sub-criteria are important in the selection of suppliers for any indirect procurement transaction, no sub-criterion was removed in the process of model modification. Instead, interrelationships among sub-criteria under same main criterion was performed through covariances – double headed arrows signify such covariance as exemplified in Figure 3. Covariance exists if there is an observed relationship between any two indicators loading on the same factor entirely because of shared influence of the latent variables (Hoyle, 2023). For this case, significant covariances (p value <= 0.05) were done in the run of the final CFA model – resulting to the final model passing the model fitness evaluation as clearly presented in Table 6.

The final model has a good and acceptable fit as manifested by its Chi-Square/df value of 2.96 (within the rule of thumbs range). Furthermore, other fit measures confirmed the fitness of the final model since the RMSEA value of 0.07, NFI value of 0.91, IFI value of 0.94, and TLI value of 0.92 are all within the acceptable range. The fitness of the final model relied on the fact that there were correlations and strong reliability

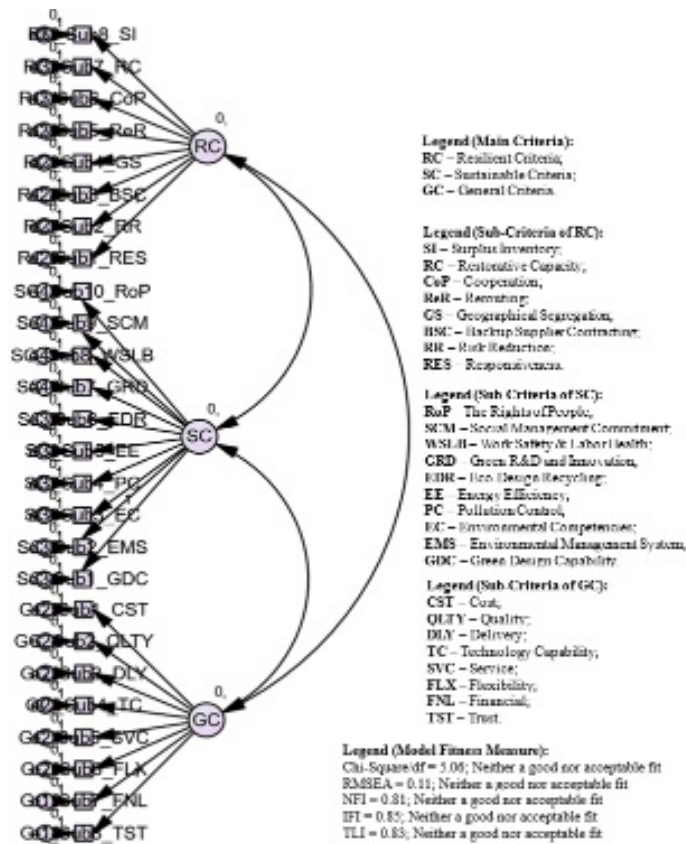


Figure 2. Initial Model of the Indirect Procurement Supplier Selection Criteria

Note. A CFA Model run through IBM SPSS Amos software correlating main criteria from one another.





within the items under each main criterion. This was confirmed through the reliability, convergent validity, and discriminant validity data unveiled in Table 7. A strong construct (i.e., groupings of sub-criteria) reliability is exhibited by the final model as evident in the Cronbach alpha values of greater than 0.70; indicating that although there are multiple sub-criteria underlying each construct, the combined measures of each construct greatly represent the main criterion to which the construct is created. Another measure of construct reliability is Composite Reliability (CR); CR value of each construct in this study is higher than 0.60, which reflects a good, shared variance among the observed variables (sub-criteria) used as indicators of each laten construct (each main criterion) (Fornell et al., 1981). The higher the CR value, the higher the level of consistency and stability of the concepts representing each construct (Othman et al., 2022). The quality of the model can also be statistically gauged through the Average Variance Extracted (AVE); AVE of each construct is at least 0.50, meaning that the model constructs explain more than half of the variance of their respective items (Othman et al., 2022). The acceptable values of AVE for the final model signifies minimal errors, on an average, in the concepts being embodied by each grouping of sub-criteria. Standardized Factor Loading (SFL) for each indicator or sub-criterion is above 0.50, a good measure of the adequacy of each sub-criterion to each main criterion. Statistical analyses also revealed that the CFA final model achieved convergent validity since AVE, SFL, and CR values are all within the acceptable statistical threshold; a model that achieves convergent validity connotes a positive correlation or linear relationships between two variables among the set of indicators measuring

the same construct (Quoquab et al., 2020).

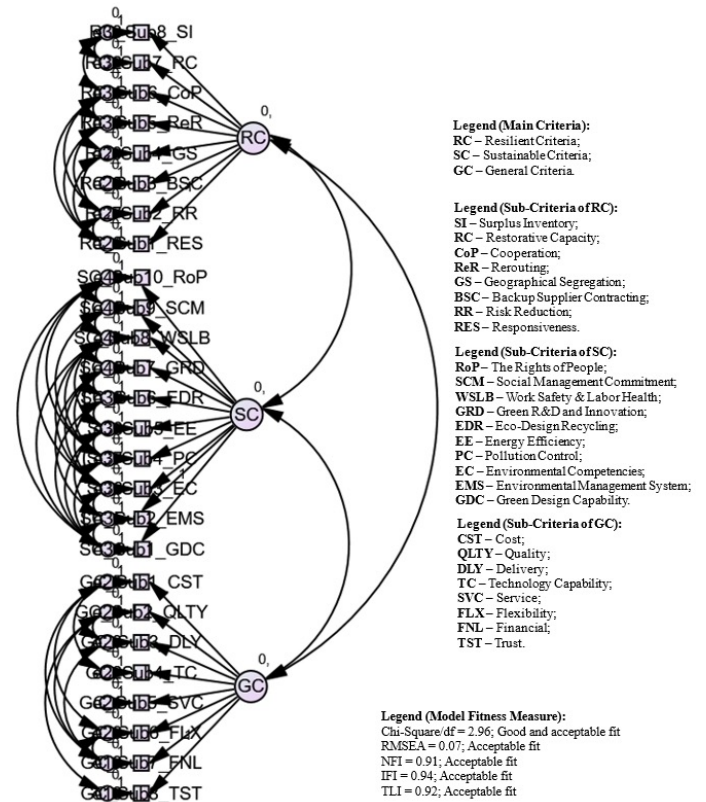


Figure 3. Final Model of the Indirect Procurement Supplier Selection Criteria

Note. A CFA Model run through IBM SPSS Amos software correlating main criteria from one another.

Table 6. Results of Fitness Evaluation Test of the Final CFA Model

Fit Measure	Rules of Thumbs for Model Fitness Evaluation		Actual Value	Interpretation
	Good Fit	Acceptable Fit		
Chi-Square/df	$0 \leq \chi^2/df \leq 2$	$2 \leq \chi^2/df \leq 3$	2.96	Good Fit Acceptable Fit
RMSEA	$0 \leq RMSEA \leq 0.05$	$0.05 \leq RMSEA \leq 0.08$	0.07	Acceptable Fit
NFI	$0.95 \leq NFI \leq 1.0$	$0.90 \leq NFI \leq 0.95$	0.91	Acceptable Fit
IFI	$0.95 \leq IFI \leq 1.0$	$0.90 \leq IFI \leq 0.95$	0.94	Acceptable Fit
TLI	$0.95 \leq TLI \leq 1.0$	$0.90 \leq TLI \leq 0.95$	0.92	Acceptable Fit

Note. The recommended and acceptable fit measure ranges appeared in this table are based on the guidelines of Hu et al. (1999) and Browne (1992).



Table 7. Reliability and Convergent Validity Data of the Final CFA Model

Variables/ Constructs	Items	Standardized Factor Loadings (SFL)	Cronbach Alpha (CA)	Composite Reliability (CR)	Average Variance Extracted (AVE)	Maximum Shared Variance (MSV)
Resilient Criteria	Surplus Inventory	0.62	0.90	0.90	0.55	0.39
	Restorative Capacity	0.78				
	Cooperation	0.58				
	Rerouting	0.88				
	Geographical Segregation	0.86				
	Backup Supplier Contracting	0.75				
	Risk Reduction	0.76				
Sustainable Criteria	Responsiveness	0.62	0.96	0.96	0.70	0.39
	The Rights of People	0.64				
	Social Management Commitment	0.71				
	Work Safety & Labor Health	0.79				
	Green R&D & Innovation	0.88				
	Eco-Design Recycling	0.90				
	Energy Efficiency	0.87				
General Criteria	Pollution Control	0.89	0.88	0.88	0.50	0.36
	Environmental Competencies	0.93				
	Environmental Management System	0.88				
	Green Design Capability	0.84				
	Cost	0.64				
	Quality	0.60				
	Delivery	0.77				
General Criteria	Technology Capability	0.62	0.88	0.88	0.50	0.36
	Service	0.78				
	Flexibility	0.77				
	Financial	0.72				
	Trust	0.74				

Note. Acceptable thresholds: SFL > 0.50 (Hair et al., 2017); CA > 0.7 (Shrestha, 2021); CR > 0.6 (Shrestha, 2021); AVE > 0.5 (Cheung et al., 2023); MSV < AVE (Hair, 2010).

In relation, this study effectuated a CFA model with converging items per construct, sharing a high proportion of variance among the sub-criteria under each construct (Hair et al., 2014). On the other hand, discriminant validity was also obtained by the final model; the Maximum Shared Variance (MSV) is less than AVE for all the constructs; an excellent specification that the model doesn't have highly identical construct in terms of conceptual or operational function (Matthes et al., 2018) ensuring that each construct can evaluate suppliers using different concepts at different perspectives.

Through CFA, covariances among the observed variables, sub-criteria, were identified through the respondents' feedback on how important each observed variable is on indirect procurement supplier selection. Such relationships are disclosed in Figure 4.

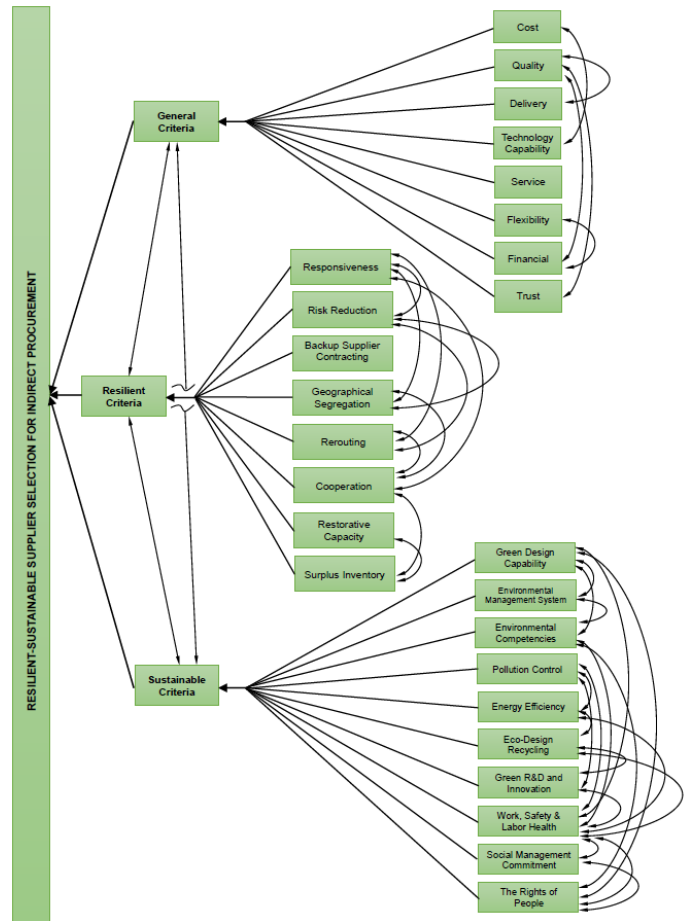


Figure 4. Acceptable Conceptual Framework for Indirect Procurement Supplier Selection

Note. A statistically acceptable conceptual framework for indirect procurement supplier selection. Double headed arrows signify covariances (observed relationship between any two indicators loading on the same construct).

CONCLUSION AND RECOMMENDATIONS

The ultimate goal of this study is to develop a resilient-sustainable supplier selection criteria for indirect procurement. Supplier selection has gained the attention of numerous researchers in the past years since suppliers play a very vital role in ensuring adequate and timely supply of materials and service to a business entity. As a result, it is necessary to select partners that can best support any indirect spend requirement and such can only be attained if the right and appropriate set of criteria is established.





Gone are the days that only traditional factors such as cost, delivery time, and other economic criteria are being considered in supplier selection as constant industrialization and globalization have brought new approach and that is the inclusion of resiliency and sustainability. Thus, this research aimed to generate supplier selection criteria for any indirect procurement transaction – covering not only the conventional or general criteria but also aspects pertaining to resiliency and sustainability. Specifically, this study was designed to verify the applicability of the adopted supplier selection criteria framework to indirect procurement through their mean importance based on the survey respondents' perceptions and then by using a Confirmatory Factor Analysis (CFA) model fitness evaluation. Eventually, this research is intended to create a final CFA model containing the criteria highly related only to indirect procurement.

Traditionally, suppliers were originally assessed using economic indicators to mostly boost the welfares of the enterprise and promote continuous innovation while achieving quality at work, products, and services. A lot of research studies have used General Criteria as the conventional method of selecting suppliers based on economic factors and supplier capability. Such conventional approach was verified in this study as still the main consideration in choosing suitable suppliers. Based on the respondent's perception, the top three determinants for said main criterion are Quality, Trust, and Delivery followed by Service, Cost, Flexibility, Financial and lastly Technology Capability. Generally, business entities have been looking for suppliers which are extremely valuing the commitment to earn and meet customer trust and sat-

isfaction through timely delivery of right and cost-effective products and services.

Undeniably, the occurrence of unfavorable market circumstances has negatively impacted the supply chain through supply disruptions leading to businesses with material stocks shortages and services discontinuation. As a result, resiliency has gained attention as a factor which can determine the adaptive capability of suppliers to disruptions aside from suppliers' ability to recoil from unwanted events. There are a lot of determinants of supplier resiliency and this study exposed that Responsiveness, Cooperation, and Risk Reduction are the top three considerations in evaluating resilient suppliers for indirect procurement. Other determinants validated to be significant in gauging supplier resiliency in indirect procurement are Backup Supplier Contracting, Restorative Capacity, Surplus Inventory, Rerouting and Geographical Segregation. Resilient partners are those that possess outstanding reactions to various situations while being significantly cooperative and has the competence to determine, mitigate and manage risks and vulnerabilities.

The concept of sustainability has also become an integral part of the supplier selection process. Part of the emerging process nowadays is to choose suppliers which are compliant to the existing social and environmental regulations. Furthermore, businesses have started to engage more with competent suppliers which are operating in a more environment friendly manner aside from being more dedicated to social responsibility principles. Such developing trends have influenced the respondents of the survey to distinguish the top three determinants of sustainability for this study –



Work Safety and Labor Health, The Rights of People, and Pollution Control. In addition, other sustainability factors which were deemed to be essential also in supplier selection are as follows: Energy Efficiency, Environmental Management System, Environmental Competencies, Social Management Commitment, Green R&D and Innovation, Eco- Design Recycling, and Green Design Capability (arranged in descending importance). Sustainable suppliers are organizations which are vastly aligned with the environmental and social responsibility while fulfilling business objectives.

Meanwhile, the final CFA model (with acceptable model fitness, strong construct reliability and internal consistency, and that achieved convergent and discriminant validity) has unveiled the interrelationships, through covariances and correlations, of one determinant from the other which validated the fitness of each sub-criterion in its respective supplier selection main criterion. Such observed correlations are excellent indication that the final generated model containing rigorous sets of supplier selection criteria has high potential of being the foundation and basis for a more robust and holistic approach in selecting suppliers for any indirect procurement transaction. Besides, the aforementioned model enables firms to consider and evaluate suppliers using three perspectives – economic, resiliency, and sustainability.

As the concepts of resiliency and sustainability have been vastly accepted and applied in the supply chain area due to their tremendous and timely benefits, suppliers should immensely take into consideration the general, resilient, and sustainable factors enumer-

ated in this research and be able to feasibly integrate such factors into their business strategy. By doing so, suppliers can catch up to such emerging trend while coping up with the continuous industrialization and globalization to stay competitive in the market scene.

In fact, in order to sustain market competitiveness nowadays, firms ought to partner with suppliers which are not only cost efficient but also have high regard to sustainability while being resilient to any kind of supply chain disruption. To do that, firms are highly encouraged to screen and select the right and appropriate suppliers through the use of the sets of criteria developed in this study. By doing so, firms can significantly rely on resilient-sustainable partners for the former's appropriate, cost-effective, and timely material and service supplies. Consequently, companies can strategically level up their performance and sustainability compliance factor as said selection approach ensures conduct of business ventures with high performing suppliers that irrefutably value best sustainable and supply chain practices. On the other hand, firms can also utilize the aforementioned criteria to monitor performance of existing suppliers, inducing improvements on supplier performance.

Meanwhile, in order for the supplier selection process to effectively serve its purpose, robust selection criteria shall be established first– considering majority of vital business and industry related insights. For a firm from the Electronics and Aerospace manufacturing industries to skip said tedious initial phase (i.e., setting up the selection criteria) and then just resort to swiftly evaluate suppliers, the researcher tremendously advocates the use of the readily available CAP-



STONE output of this research, Scorecard for Resilient – Sustainable Supplier. Said scorecard, shown in the Appendix section of this research, has achieved a high degree of statistical acceptance after being conceptually emanated from multiple perspectives obtained from aforesaid industries; while encompassing many facets of supplier capability in terms of economic-delivery, resilient, and sustainable factors. The mean weight importance of each variable from study survey results was translated to criteria weight (i.e., weight percent approach, obtaining the proportion of a certain variable to the entirety of the group of variables) reflected in the said scorecard.

Undeniably, choosing the best supplier plays a crucial role in any firm's success thus there should be a persistent launch of adaptive initiatives pertaining to supplier selection process – most importantly the process' widespread application. To continuously contribute and add meaningful substance to the body of knowledge surrounding supplier selection process, future researchers are hereby encouraged to explore on the applicability of the results of this study to other type of procurement such as direct procurement. Besides, the proponent of this study seriously proposes herewith the action to validate the applicability of the research outcome to numerous industries.

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