The Supply Chain Innovation, Supply Chain Transaction Cost, Supply Chain Risk and Supply Chain Responsiveness and the Supply Base and Its Complexity

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Abstract- **The main objective of the study is to investigate the impact of the supply chain innovation, supply chain transaction cost, supply chain risk and supply chain responsiveness as antecedents of the supply base and its complexity. The study attempted to understand the way in which transaction costs, supplier responsiveness, supplier innovation, and supply risk are affected by the supply base complexity, and the study also expressed them in liner relationships. With the supply base complexity, it became easier to understand ways for managing supply base. Therefore, the study is among the pioneering studies on the issues. So, current study has used SEM-PLS as statistical tool to answer the research questions raised in this study and research objectives envisaged in the current study. The findings of the current study have provided support to with the hypothesized results. This study will be helpful for policymakers and researchers in examining the link between supply chain innovation, supply chain transaction cost, supply chain risk and supply chain responsiveness as antecedents of the supply base and its complexity.**

Keywords: *Supply chain innovation, Supply chain transaction cost, Supply chain risk, Supply chain Supply base*

1. Background

Almost all businesses that are involved in the value-adding activities, generally buy goods and services from a number of suppliers, and this set of suppliers is known as a supply base, whereas the company which make purchases from the supply base is known to be the focal company [1]. Therefore, focal company being the central point of supply base, controls and coordinates its organizational practices. It may also involve in developing a working relationship with the suppliers, whereas, an autonomous relationship can also be appeared between the suppliers [2].

With the growing trend of orchestrating with the suppliers, and outsourcing with regard to the focal firm perspective, it has now considered as an important strategic issue in recent times [3]. Generally, the higher the tendency of a focal company to buy manufacturing inputs instead of producing them on their own, the more dependent the focal company on the supply base. Particularly, the higher the share of products and services purchased from the suppliers in comparison to total cost of the sold goods, the more important a supply base management would be for the bottom line of a company, i.e. shareholder value, return on investment, etc. [4].

This paper proposes, with the aim of initiating an important step forward to develop a supply base management theory. The literature of supply base management and buyer-supplier association have shown that the supply base management theory could not be further studied and developed, due to the insufficient set of definitions and terms which created hindrance in the development of supply base management theory. Thus, this study proposes definitions in order to explain and differentiate the concept of supply base from related set of concepts. Finally, the study proposes a supply base management theory [5].

For better facilitation of supply base management, the present study advance complexity to be a major managerial issue that needs to be addressed by the supply chain managers [6]. The term complexity is defined as how the members involved in a system are different from one another and how they interact with each other. Regardless of the supply managers who supply base complexity influence the supply risk, supplier innovation, supplier responsiveness, and transaction costs. Therefore, a focal company dealing with a set of twelve suppliers, may face different sort of issues as compared to a two-supplier company. In addition, if all the suppliers of a company belong to same

industry, using a single mode of transportation, then simpler efforts would be needed for the supply base management, as compared to the suppliers coming from various industries, and also utilizing different modes of transportation. Furthermore, the interaction among the suppliers, generate different challenges for the supply base management, than in case of disconnected suppliers. Such illustrations, although simpler ones, are based on solid theoretical base [7]. The study will demonstrate, with the lens of complexity that is in what way supply base management has implications on the business performance and efficiency of a company.
The next section includes the set of definitions developed for the supply network, supply base, supply base complexity, and supply base management. It is a prerequisite for establishing a supply base management theory.

2. Hypothesis Development

2.1. Transaction costs

Since the transaction cost economics revolves around the cost considerations that are required in the decision-making related to outsourcing [8], therefore, supply chain management has gained considerable interest by many researchers, also it has been adopted by them for research facilitation [9]. On the basis of the definition by [9] i.e. transaction cost being an economic counterpart of friction, therefore, this study views transaction cost to be a friction cost of working among the suppliers. Although, frictions primarily arise as a result of the interaction of the focal company with its supply base, for acquiring the required parts, services, and material inflows. There are various sources of frictions, such as, identifying the set of qualified suppliers, monitoring suppliers, contracting with them, and carrying out agreements are the potential friction sources. Some particular kinds of transaction costs were also offered in a study, these are: order placement, preparation, inspection, goods transportation, return of parts, correction of orders, and follow-up [10].
Hence, the central point of transaction costs lies in the association among the suppliers and a focal company. Company bears cost in establishing, maintaining, and monitoring, an exchange relationship, in addition it also protects such relationships from opportunism [11]. It signifies that there are more chances of potential friction, when there are more suppliers involved in a supply base and incur greater transaction costs. Moreover, the higher the differentiated suppliers and inter-dependencies between the suppliers, the more will be the frictional cost or the coordination cost. Such as, the degree to which the operating procedures of one supplier varies from the other one, the focal company then seems to incur higher frictional costs. The focal company have to deal with two ways of documenting. In addition, the greater the extent to which the suppliers closely interact with each other, the higher will be the cost the focal company has to incur for safeguarding from the opportunistic behaviors of the suppliers [12], similar to the case of prisoner's dilemma. Alternatively, focal company will incur less cost in case of less supply base complexity, since it requires less negotiation, less order placing, better problem tracing, and few communication channels. Thus, the study proposes the following proposition.
Several scholars explained the opportunistic behaviors of suppliers and how such behaviors diminish in case of repeated transactions [13]. For instance, a study [14] also demonstrated that how the opportunism declines in case of repeated transactions. This greatly implies to the relation among transaction costs and the level of inter-relationship. The sufficient reduction of the supply base to ensure long-term association among the suppliers involved in repeated transactions and the focal company reduces the concern about opportunism, thus minimizing the cost of protecting from the opportunistic behavior. It signifies that the focal company does not require spending maximum resources to monitor the level of inter-relationships between the suppliers. Moreover, the higher the inter-relationships between the suppliers the less will be the differentiation among them, allowing a focal company to involve with them in repeated transaction, thereby minimizing the transaction costs incur by the focal company.
Hypothesis 1: The total transaction cost is significantly related with the supply base complexity.

2.2. Supply risk

Supply risk refers to the potential event occurrence that is linked to the suppliers, leading to focal firm's inability to satisfy customer needs [15]. Hence, supply risk may involve negative occurrence of events originated from the supply base creating, hindrance in the ability of a focal firm to satisfy demands of the customers.
There may be various means of negative occurrence. For instance, disturbances in supply can occur due to strike or a fire. A study [16] exemplified Toyota's strategy for dealing with such risk. In addition, the supplier may acquire the core knowledge of technology by the focal firm as compared to other suppliers, thus making it a potential supply competitor. Furthermore, a study also discussed Thomson Consumer Electronics, as the first JVC supplier, which finally entered as a competitor into the JVC's market after gaining the JVC technologies core knowledge. Similarly, another supplier may rise prices for taking advantage of such circumstances. Additionally, if

the suppliers' technology is crucial for the company, then some risk may be associated for maintaining technological access in order to satisfy demand of the customers. In this context, the risk discussed in this section arises from the managerial decisions and structural arrangement, and the risk in previous sections arises due to the opportunism, being taken as a behavioral assumption [17].

Managing risks is a core issue, however, as a whole, the supply risk has the susceptibility to become higher at the high and low ends of the supply base complexity. As, reduction in the high supply base complexity brings the risk to the moderate level, therefore, we propose the following proposition:

The given example shows how a firm earlier attempted to minimize the supply base till the point of minimal complexity, and then came to know the risk involved to that decision, thus backing up to the moderate level of suppliers [18]. The Materials Director of Computon, an electronics manufacturing company, for the industrial and consumer application, noted how the company is striving hard for improving its procurement proficiency. Few years back, the company possessed a commodity team and 84 cable suppliers, which this commodity team assess while travelling around the globe. At last, the commodity team on the basis of highest assessment score recognized four suppliers and they were then brought closer with the aim of discussing how together they could satisfy the needs of Computon.

The company wanted to lessen the risk associated with the shortage of parts that it purchases from the suppliers. These suppliers tend to act supportively with each other. Furthermore, for ensuring supply, Computon promoted the contingency planning between the suppliers, in case of floods and fires. The Materials Director acclaimed after several months of decision; the company then realized that working among only four suppliers may involve high risk to meet the cable needs of Computon. Resultantly, it increased the number of suppliers to the level of 10-15.

With fixed number of suppliers, the lower differentiation level would lead to lower supply risk. In this way Toyota used to manage its supply base, as the company directs its suppliers to have knowledge and command on the production system of Toyota, making it easier for the firm to substitute any supplier when needed [19]. The low differentiation indicates greater susceptibility of risk reduction strategies, enabling suppliers to take position of each other, during emergencies. In a similar manner, the increase in differentiation, gradually increases the risk, thereby indicating a positive association among the supply risk and level of differentiation, having a curvilinear trend. On the other hand, the relation among these two variables turned out to be negative, in case of inter-relationships. Therefore, a higher risk is associated with the lower levels of inter-relationships, since it might be difficult for a supplier to take position for any other one. However, implementation of risk mitigation strategies can help reduce the level of risk, in case of increased interrelationships [20].

Hypothesis 2: There is a significant relationship between supply risk and supply base complexity.

2.3. Supplier responsiveness

Due to the emergence of time-based management and just-in-time purchasing strategies, enough attention has been given to the issues that how well and quickly suppliers act against time-sensitive requests, arising from the focal firm [21]. The significance of the responsiveness of supplier for satisfying customer needs has been illustrated in a study [22]. In this regard, supplier responsiveness can be taken as the level of supplier accuracy and promptness in response to the requests of the focal company, regarding new requirements (Ochkovskaya, 2018).

Therefore, supplier responsiveness seems to be related with the number of suppliers, i.e. the greater the suppliers the more the level of supply responsiveness. Predominantly, it occurs because more suppliers tend to assert more pressure, which consequently results in higher responsiveness of the suppliers. Although, studies [23] found that competitive pressure have not acted to assert any influence on the supplier responsiveness. However, [24] suggested that an open communication or association among the suppliers and focal company is what actually results in supplier responsiveness. It signifies the widespread utilization of preferred suppliers by various industries. While working along a few preferred suppliers to make synthesized purchases, the role of focal company becomes effective, as it tries to communicate with the suppliers regarding their needs and can convince them to be more responsive in satisfying the needs.

With regards to the number of suppliers, negative association is expected to exist among supplier responsiveness and supply base complexity. Moreover, the supplier responsiveness and differentiated features of complex supply base must have negative relation, in order to proclaim that higher the level of differentiation among the suppliers, the harder it becomes to maintain a close association with the focal company. In addition, the higher degree of supplier inter-relationship also increases the complexity, which the focal company is supposed to deal with, along with its suppliers. Hence, it may obstruct the ability of a focal firm to closely integrate and consequently decrease the responsiveness of suppliers [25].

The Electronix offers illustrations that how the company plays its role to reduce its suppliers and

efforts for increasing responsiveness of the supplier [26]. However, Electronix being a new entrant, having less vertical integration as compared to its competitors, the company is inclined to outsource activities that are not key competencies, indicating high dependency on suppliers. During the company's former years, it has frequently switched its suppliers. The Materials Director stated that with each supplier change, it takes at least two-year investment for the company to understand the working of Electronix supplier. However, in recent years, Electronix has went through an increased level of mutual association due to the reduction made in its supply base, which consequently resulted in supplier responsiveness [27].

Focal company focuses upon the number of suppliers as compared to the other dimensions, signifying that focal firms need to realize that focusing primarily on the number of suppliers is necessary to obtain maximum value of their efforts. Afterwards, it will make sense that which remaining dimensions can be immediately undertaken by these companies. The first preference of the focal company would be inter-relationships between the suppliers, as they can integrate with each other for sharing capability and capacity in order to respond better with the changing focal firm's requests [28], precisely, this has happened in Japan after the war. Having highly differentiated supply base indicates diversity among the suppliers, causing difficulty to work closely for satisfying the changing requests of the focal firm.

Hypothesis 3: There is a significant relationship between supply responsiveness and supply base complexity.

2.4. Supplier Innovation

Supplier innovation played a contributory role in the conflict between the automakers [29] where three to five percent annual cost reduction occurs normally. Supplier innovation intensified several projects related to product improvement that utilize the value engineering and value analysis [30]. Value engineering and vale analysis approaches are the innovative practices, which improve or maintain the subassemblies or functionality of the components and reduce manufacturing cost. A study demonstrated the way product can be improved with the supplier responsiveness [31]. VA/VE practices that involve suppliers, act to be the main source for improving the product functionality, size and cost reduction of the automotive firms in the United States [32]. A Honda executive stated that during mid1990s, the Accord's design has undergone series of improvements. With this improvement, its manufacturing cost reduced by 25 percent. In addition, majorly the innovative ideas about savings were proposed by the Honda suppliers. Finally, while investing on the innovativeness of suppliers, Honda managed to develop a bigger Accord with diverse options having insignificant change in its selling price (Tabor, 2018).

Although, it has informed that direct association exists among innovative activities and autonomy. He also indicated the existence of agitation among free-for-all independent practices and the integration pressure of such practices. The close inspection shows that greater autonomy results in disintegrated coherent activities and anarchy, having the ability to control innovative ideas. This idea has been reflected as: the independent behaviors of several agents under complex system, create random and unstructured aggregate behavior [33]. Moreover, due to a critical inter-relationship with the company agents, less significant impact is found on one agent by the other. As a whole, an inflection point must exist in the earlier mentioned relation among supplier innovation and complexity.

Hypothesis 4: There is a significant relationship between Supplier Innovation and supply base complexity.

3. Methodology

The results of quantitative research approach are found from the responses of questionnaires. The quantitative analysis is constrained to the statistics, numbers, data calculation, as well as to different forms of statistical examination. Research design for this quantitative research has been formulated that would provide help in complete examination of large sample size and opinions about the proposed hypotheses. This research study is based on analyzing the relation among the variables. For research analysis, quantitative research approach has been adopted. The method of collecting information is questionnaire survey. The use of questionnaire survey allows incorporating large sample size and a detailed analysis of the responses collected. The instrument for data collection is questionnaire survey. The survey responses are quantified. The relation among the dependent, independent and intervening variables is determined through questionnaire analysis. The questionnaire has been structured considering the research objectives, problem and hypothesis developed. The respondents were given Likert scale for answering the questions. Literature review was considered in the development of questionnaire survey [34]. The scale of the study is adopted from the study of [9]. The relative importance of the variables in influences the employee performance within the Indonesian manufacturing sector has been assessed. The information collected through questionnaires is then added to the statistical software. The software

used for analysis includes SPSS, IBM, MS Excel and Smart-PLS.

4. Results

For testing the relation among the variables, the Smart PLS Structural Equation Modeling [33] is has been used. It has been recognized as a second-generation approach. The approach is considered superior to multiple regressions due to its increased abilities. In multiple regressions, one dependent variable can be used at a time. However, PLS-SEM can use various dependent variables simultaneously. Therefore, the approach allows the incorporation of various dependent variables at a time. The approach is extensively used by the researchers of behavioral sciences, it has the ability to include unobserved (latent) variables in the model analysis. It can perform analytic modeling with the variables. The variables, which cannot be observed directly, are called latent variables. These variables are estimated by other measures as claimed by [35]. In the present research study, all the variables are latent constructs that have been measured through their indicators. The SEM approach involves the use of inner model and an outer model.

In a study conducted by it has been suggested that goodness of fit is not a suitable indicator of measuring validity of the model. According to the researcher, when goodness of fit is used with PLS path models, it does not give good estimate for model validity since the valid and invalid models cannot be differentiated [36]. A two-step mechanism has been discovered due to progress in the PLS path modeling and unsuitability of model validity. These steps are used to determine the results of PLS-SEM path. The first step is the assessment of measurement model and the second step is the assessment of structure model. The allocation of measures to the unobserved variables is identified through the measurement model. However, the structural model involves the association among the dependent and explanatory unobserved constructs. The researcher is able to determine, explain and forecast the extent of association among the latent variables. The reliability of individual content is determined in the assessment of measurement model. Moreover, the convergent and discriminant validity are required as well.

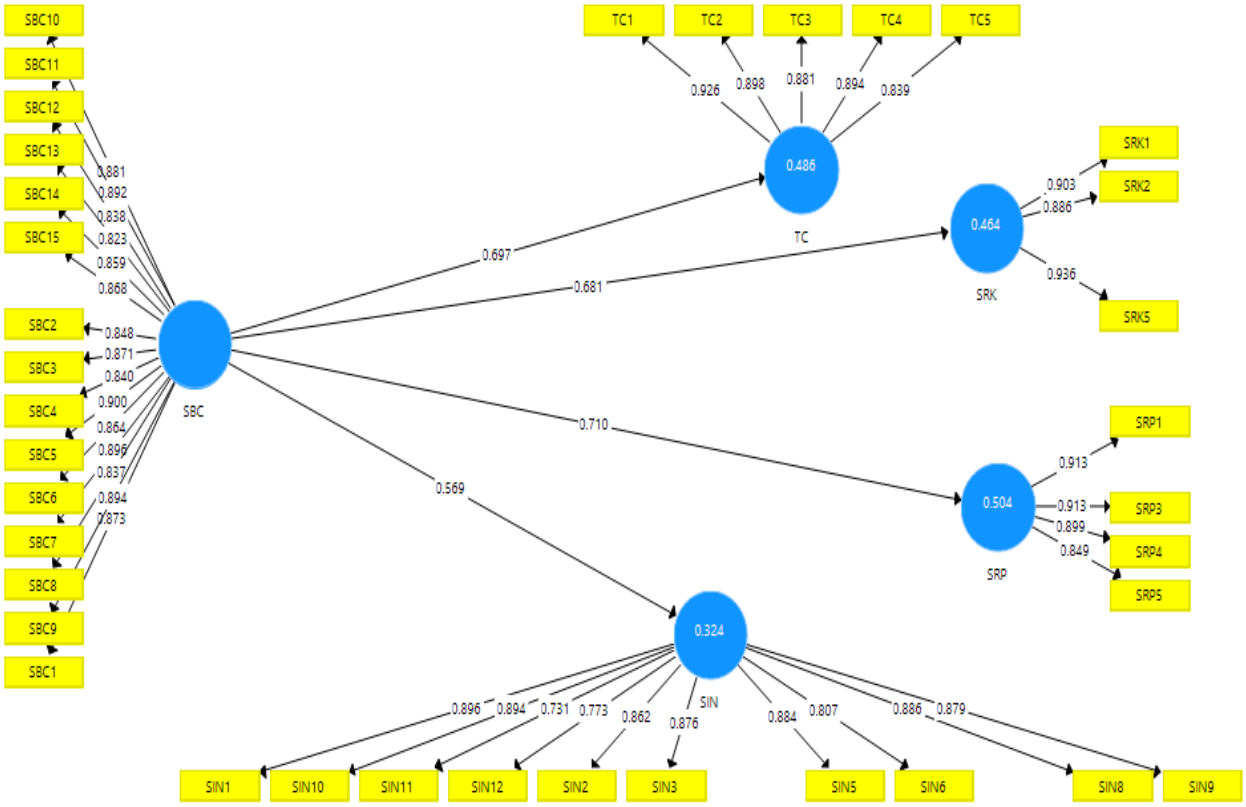

Figure 1. Measurement Model

By analyzing the outer loadings of every measure of variable, the reliability of individual item was measured. The items having the loadings value between 0.40-0.70 are not eliminated. The items having value out of this range are eliminated from the model. In this research study, 6 items were eliminated out of 46 as they had loadings below the standard value. The items are omitted because of multicollinearity. When there is high similarity among the items, they are less likely to measure a construct [37]. When most of the items become similar, the acceptable item set consists of one or

two items. It is sufficient to use one or two indicators. When the model is required to be estimated at best, each latent should have two measured indicators. When a complex model is estimated, degrees of freedom are increased. According to [38], validity of single item measures is similar to multiple item measures. The results demonstrate similar empirical and theoretical findings. Some examples of the constructs, which are measurable through indicators of single item, are provided by [37] and this clears the debate related to use of single item indicator.

Table 1. Outer Loading

	SBC	SIN	SRK	SRP	TC
SBC10	0.881				
SBC11	0.892				
SBC12	0.838				
SBC13	0.823				
SBC14	0.859				
SBC15	0.868				
SBC2	0.848				
SBC3	0.871				
SBC4	0.840				
SBC5	0.900				
SBC6	0.864				
SBC7	0.896				
SBC8	0.837				
SBC9	0.894				
SIN1		0.896			
SIN10		0.894			
SIN11		0.731			
SIN12		0.773			
SIN2		0.862			
SIN3		0.876			
SIN5		0.884			
SIN6		0.807			
SIN8		0.886			
SIN9		0.879			
SRK1			0.903		
SRK2			0.886		
SRK5			0.936		
SRP1				0.913	
SRP3				0.913	
SRP4				0.899	
SRP5				0.849	
TC1					0.926
TC2					0.898
TC3					0.881
TC4					0.894
TC5					0.839
SBC1	0.873				

The degree of correlation among the latent constructs is referred as convergent validity. By determining the AVE of each construct, convergent validity was analyzed. The suggestion of ref. [39] has been used in this research study. In order to achieve convergent validity in sufficiently, the value of AVE of each construct must be equal or greater than 0.50. High loadings are revealed when the value is greater than 0.50 as the AVE values came to be 0.567 and 0.8771 as presented in the table. This indicates that the convergent validity is established in the model. Discriminant validity is regarded as the degree to which the latent construct differ from other unobserved constructs. Using the AVE (Average Variance Extracted) in this research study, discriminant validity was measured. The value of correlation among the unobserved constructs was compared with the square value of avg. morhe discriminant validity was estimated based on the suggestion of [39]. The value of AVE to be acceptable is 0.50. The value of AVE square needs to be greater than the correlation among the unobserved constructs for sufficient discriminant validity. The table 1 presents the AVE values. The values reflect that they lie between 0.56 and 0.87, which means they are acceptable.

Table 2. Reliability

	Cronbach's Alpha	**rho_A**	**Composite Reliability**	**Average Variance Extracted [40]**
SBC	**0.976**	**0.977**	**0.978**	**0.750**
SIN	**0.957**	**0.960**	**0.963**	**0.723**
SRK	**0.894**	**0.901**	**0.934**	**0.826**
SRP	**0.916**	**0.921**	**0.941**	**0.799**
TC	**0.933**	**0.934**	**0.949**	**0.789**

Discriminant validity is a test to determine whether the concepts which are supposed to be unrelated are in fact found to be unrelated. It also determines the extent of correlation among the constructs. However, if the constructs are multidimensional and unique, then they exhibit low correlation. Resultantly, the EFA and correlation matrix can help in assessing the construct validity, in order to achieve discriminant or convergent validity of the items [5].

Table 3. Discriminant validity

	SBC	**SIN**	**SRK**	**SRP**	**TC**
SBC	0.866				
SIN	0.569	0.850			
SRK	0.681	0.536	0.909		
SRP	0.710	0.530	0.863	0.894	
TC	0.697	0.524	0.907	0.876	0.888

After the estimation of measurement model, the structural model is estimated in the next step. For the determination of structural model, bootstrapping technique was adopted. The next stage is the assessment of the structural model after ascertaining the measurement model in the present study. 5000 bootstrap samples was used in this research with 331 number of sample size. The path coefficient significance was identified and 331-sample size to assess the significance of the path coefficients was applied. It is illustrated by [41] that the structural model is based on the relationships in the hypothesized model. The path coefficient values and t-values are used in the structural model used by partial least squares (PLS).

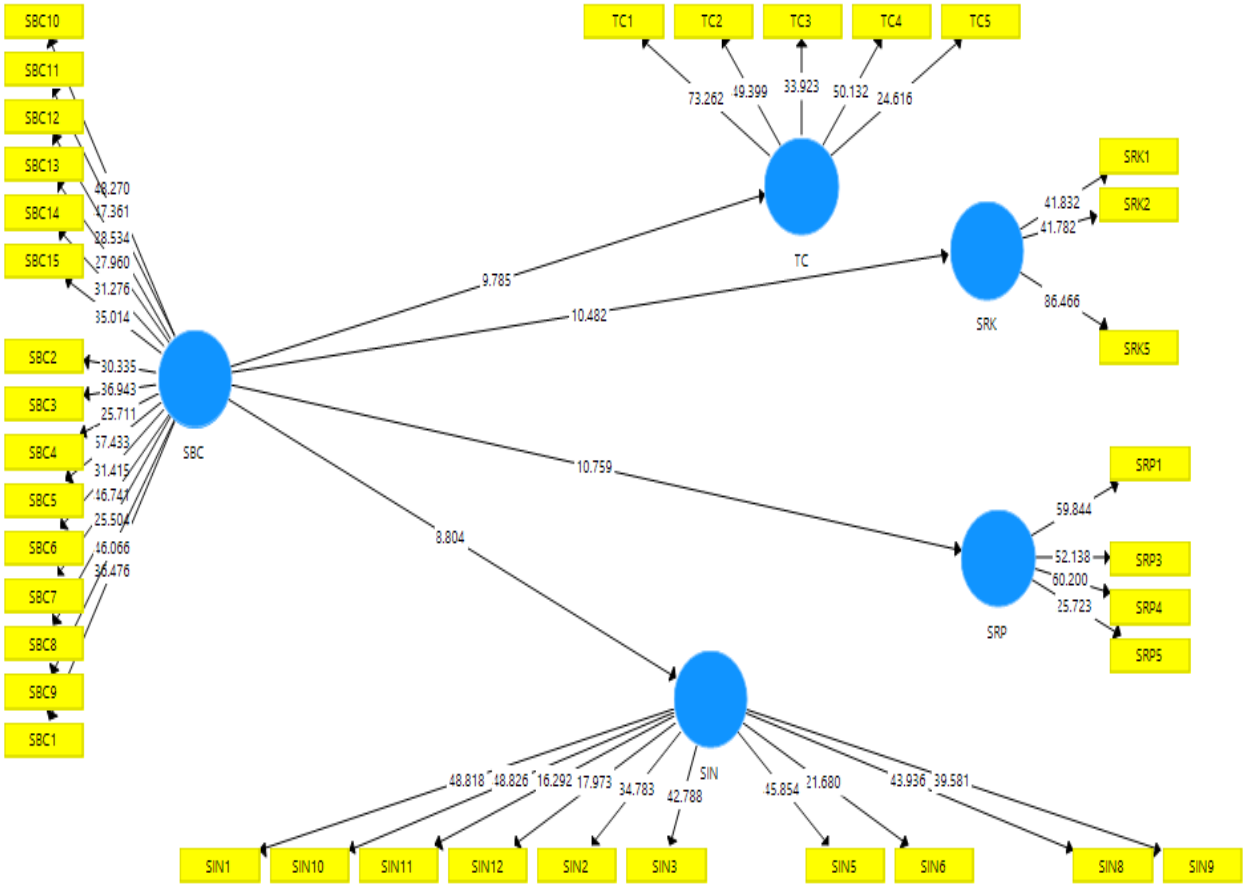

Figure 2. Measurement Model

The PLS approach is similar to Standardized Beta coefficient of regression regarding the path coefficient. The evaluation model, hypothesis assessment and correlation among the variables have been identified in this research study. PLS-SEM approach adds to Parsimonious model in the structuring of hypothesis. The models provide the least possible number of parameters for given quality of the results for the estimated model. Different layers of constructs are included in the Hierarchical component model (HCM) that is second order structure. It includes a high abstraction level. A more précised higher order component is included in HCMs, which is linked with components of lower order (one or two).

Table 4. Direct impact

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	T Statistics (|O/STDEV|)	P Values
SBC -> SIN	0.569	0.570	0.065	8.804	**0.000**
SBC -> SRK	0.681	0.683	0.065	10.482	**0.000**
SBC -> SRP	0.710	0.713	0.066	10.759	**0.000**
SBC -> TC	0.697	0.699	0.071	9.785	**0.000**

The link can be in a formative or reflective way. In PLS-SEM, several reasons exist behind the inclusion of Hierarchical component model. This supports in the reduction of relations involved in the structural model. PLS path model becomes parsimonious with the reduction of relations and easy to use. When there is high correlation among the constructs, HCMs is considered impressive. Multi-collinearity issues can result in biased results of the estimated relationships among the variables. A second-order construct can reduce the issue of multi-collinearity and resolve the issue of discriminant validity.

For determining the PLS-SEM mode, another criterion is R-squared. R2 is also known as coefficient of determination. According to [39] the variation in the independent variable caused by one or more predicting variables is referred as R2 value. The minimum acceptance value of R2 is considered to be 0.10. According to [37], the value of R2 to be 0.19 is considered weak, 0.33 as moderate and 0.67 to be substantial while using

PLS-SEM approach. The R-squared values for the endogenous latent variable shave been presented in the table.

Table 5. R-Square

	R Square
SIN	0.324
SRK	0.464
SRP	0.504
TC	0.486

5. Discussion and Conclusion

According to [42], the deeper we look into the object complexity, the more knowledge we can gain related to the object. Certainly, understanding of the system complexity acts as an initial step to grasp system behavior [43]. The study attempted to understand the way in which transaction costs, supplier responsiveness, supplier innovation, and supply risk are affected by the supply base complexity, and the study also expressed them in liner relationships. With the supply base complexity, it became easier to understand ways for managing supply base. Specifically, association that has been expressed in the proposition of this study provide an original approach, which may play a significant part for future researches and for the examination of supply base management. When individually examined, the associations expressed in the propositions seem to be straightforward. However, when collectively examined, they create complex conception. Firstly, the phenomenon that high complexity results in greater supply risk and high costs of transactions, may come out to be true. Furthermore, a manager seeks to minimize the level of complexity for enhancing supplier responsiveness. These observations, when taken collectively indicate that although transaction cost reduces and supplier responsiveness increases with the minimization of complexity, it also possesses the ability to decrease supplier innovation. The study propose that complexity of supply base can be taken as a higher construct in future studies, comprising of the following constructs, i.e. differentiation, interrelationships level, and the number of suppliers. With regards to empirical view, researchers must strive to refine and establish measures, to empirically test the propositions. Practically, the transaction costs were empirically tested, however, such measures need to be simultaneously tested along with the dependent factors namely, the innovation, responsiveness, and supply risk.

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