Author/s:
Mannaperuma, B;Singh, P;Ho, W;Kurnia, S

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Supplier's contractual embeddedness and sales performance in uncertain environments

Buddhika Mannaperuma (b.mannaperuma@unimelb.edu.au)
The University of Melbourne, Australia

Prakash J. Singh
The University of Melbourne, Australia

William Ho
The University of Melbourne, Australia

Sherah Kurnia
The University of Melbourne, Australia

Abstract

Literature offers limited knowledge on the online markets that consist of both open contractual and supply networks which are subject to environmental uncertainties. This study investigates how the environmental uncertainty dimensions and supplier's contractual embeddedness (as informed by the degree and closeness centralities) impact the supplier's sales probability in light of Complex Adaptive System theory, Social Network Analysis and the environmental uncertainty literature. Australian based Open Food Network data from 2012 to 2016 empirically validates that the supplier's contractual embeddedness generally improves its sales probability and uncertainty dimensions moderate this relationship with the help of panel logit regression model.

Keywords: Contractual embeddedness, environmental uncertainty, sales performance

Introduction

Scholars increasingly conceptualise the supply network as a complex adaptive system (CAS) where a network topology emerges over time rather than a purposeful design by a single firm (Choi et al., 2001; Park et al., 2018). CAS view further explains the coevolution between the embedded firms of the supply network and the environment (Nair et al., 2016; Park et al., 2018). Yet, how an open contractual network that resembles a CAS leads the consumers to derive the supply network from the open contractual network in each order cycle offers very limited knowledge in the literature. In a broader view, how much effort a supplier needs to put into being central in the open contractual network to increase their sales probability in the supply network while adapting the environmental uncertainties remains mostly unexplored in the literature. The current CAS

validation of the supply network coevolution does not consider the dual networks are coexisting with each other that is present in Internet-enabled supply chain platforms.

There are two types of networks that freely emerge in these online platforms that resemble a CAS. These include the open contractual network where any supplier can register and connect to each other based on their mutual understanding and the supply network as a collection of consumer designed supply chains for each order cycle using the suppliers of the open contractual network. Suppliers' contractual embeddedness (SCE), which is how they are linked with each other with open contracts, may influence their sales probability in online markets. The concept of SCE is vague because the current literature posits both linear and nonlinear effects of embeddedness on performance mostly based on subjective measures (Uzzi, 1996; Kim, 2014). Scholars popularly use perceptual measures to inform a supplier's network embeddedness and ignore the objective measures due to the network data collection difficulties (Uzzi, 1996; Kim, 2014). Nevertheless, social network analysis (SNA) matrices are now widely available to inform the SCE in different aspects such as degree, eigenvector, betweenness and closeness centralities (Borgatti and Li, 2009; Kim et al., 2011).

Also, suppliers change their contractual relationships in an online market to adapt to environmental uncertainty dimensions of dynamism, munificence and complexity over time (Gligor 2018), but this remains poorly understood in the literature. To explore these gaps, this paper investigates the impact of environmental uncertainty and SCE dimensions on the supplier's sales probability in the supply network. In doing so, this study integrates the CAS theory, Social Network Analysis (SNA) and the literature of environmental uncertainty, supply chain and performance. This paper addresses the following research question:

- How do environmental uncertainty and supplier's contractual embeddedness impact the supplier's sales probability in the supply network, over time?

The open contractual network of the Australian based open food network (OFN), the research context consists of small to medium scale farmers and food hubs who register to the OFN with their product and shipping options and connect with each other. When a consumer makes an online order and designs its food supply chain by picking the preferred suppliers from the open contractual network for each item, the chosen food suppliers stand a chance of joining the supply network. It thus enabled the analyses of the impact of environmental uncertainties and the SCE on the supplier's sales probability in the supply network in a panel data setting involving food suppliers that registered to the OFN from 2012 to 2016.

This longitudinal study makes generous contributions to the literature. It elucidates how the supply network emerges in each order cycle as a derivative of the open contractual network that resembles a CAS that received less attention in the literature. This study relies on the objective measures using the SNA matrices to provide a network understanding of the SCE than the widely used perceptual measures. The results reveal that the SCE generally improves the supplier's sales probability in the supply network context contradicting the beliefs that hold on to non-linear effects of the embeddedness on performance. This study graphically unveils the evolution of the open contractual and the supply networks from 2012 to 2016 using the SNA. This study further discloses that the environmental uncertainty dimensions have a moderating influence on the SCE and

the supplier's sales probability relationship which remain largely unexplored in the literature.

Hypotheses Development

Supplier's Contractual Embeddedness and the Sales Probability

The in-degree is the number of ties received by the supplier, and the out-degree is the number of ties initiated by the supplier (Borgatti and Li, 2009). In this study, the centrality calculations are based on the open contractual network where the value of a tie equals one for having a contract between two suppliers; otherwise, it is zero. When the supplier holds on to more ties, it can play a central role as a coordinator collecting the demand information from other suppliers and aligning the customer segments and innovative business strategies to achieve the greater supply network interests (Kim et al., 2011). The open contractual network exhibits complex multi-scale behaviour among the suppliers since a variety of food producers, restaurants and food hubs evolves and self-organises through a complex interplay of its structure and function (Choi et al., 2001; Pathak et al., 2007). Consumers prefer suppliers with high in-degree centrality who receive from many other suppliers and act as a food integrator (Kim et al., 2011). Those food hubs create vast opportunities for the consumers ordering a variety of food items ranging from meat, fish, egg, fruit, vegetables, winery, bakery and grain under one shelter and deciding the producers for each item from the available pool of suppliers that attached to the food hub. Hence, there is a high probability of consumers choosing them for their food supply chains. Accordingly, the suppliers with high out-degree centrality are the ones who promise to deliver food items to many other suppliers that act as a food allocator distributing its products across many suppliers, focusing on the economies of scale (Borgatti and Li, 2009; Kim et al. 2011). The food suppliers in the open contractual network also prefer to connect with such food producers/hubs who are readily available for the food supply to them and hence, there is a high probability of consumers picking them for the supply network.
Hypothesis 1: A supplier who holds a more significant number of contracts in the open contractual network has a high sales probability in the supply network over time.

The open contractual network consists of inter-supplier relationships that connect multiple food and beverages related industries in Australia. The consumers consider certain factors from multiple perspectives such as logistics cost, product costs, flexibility and quality in designing their food supply chains to fulfil their food requirements (Terjesen et al., 2011). The significant factors that a consumer might consider are the constraints of the open contractual network and the supplier's adaptivity to the environmental uncertainties including the past customer experiences (Pathak et al., 2007). The OFN consists of geographically concentrated clusters to satisfy the regional consumers. Hence, the closeness centrality, which indicates how close a supplier to all the other suppliers in a network, is a significant factor that determines the supplier's geographic and conceptual proximity (Borgatti and Li, 2009). The highest scores indicate more closeness. A supplier with high closeness centrality has more freedom from others' influence and higher capacity for the independent actions (Kim et al., 2011). Such suppliers get the consumers' attention in that region. Consumers might entertain less shipping and exchange fees by connecting original producers with the suppliers of high closeness to fulfil their orders. Since the high closeness suppliers hold on to shorter food

supply chains, they can optimally balance supply and demand with less inventory and lower operational costs (Borgatti and Li, 2009).
Hypothesis 2: A supplier who can quickly reach all the other suppliers in the open contractual network has a high sales probability in the supply network over time.

Environmental Uncertainties as Moderators: Dynamism, Munificence and Complexity

Dynamism refers to the level of environmental volatility or the unpredictable change within an industry that intensifies uncertainty (Gligor, 2018). The suppliers that possess more direct ties become more central and visible in the network, and they perceive a leadership role in coordinating the other suppliers due to its greater connectedness (Borgatti and Li, 2009; Kim et al., 2011). The dynamic rigour inlays unanticipated environmental fluctuations into the open contractual and supply networks which lead to the network transitions ensuring the embedded suppliers' survival. Hence, the suppliers with high in-degree centrality manage the incoming food supplies from the upstream suppliers by putting together or transforming different food items into a value-added product such as vegetable and fruit boxes, meat boxes and beverage cartons that ensure the product quality (Kim et al., 2011). Also, the suppliers with high out-degree centrality manage the demand flow by distributing consumer selected producer items focusing on the economies of scale. High degree centrality suppliers have a great impact on the operational decisions and the strategic behaviour of the other suppliers reconciling the differences in network members and aligning them with the OFN interests (Kim et al., 2011; OFN, 2018). The pressure on the high degree centrality suppliers is much higher during the dynamic events such as food surpluses and supermarket domination that prevent the regional farmers supplying beyond the restricted quotas (National Association of Retail Grocers of Australia, 2007).
Hypothesis 3: Higher dynamism leads to a stronger positive relationship between a supplier who holds a larger number of contracts in the open contractual network and its sales probability in the supply network over time.

Dynamism can bring adverse effects into the existing interrelationship structure thereby weakening the coordinated and shared supply chain strategies which may be obsolete in the face of emerging challenges. Nair and Vidal (2011) emphasise that long average path lengths between suppliers in a supply network are detrimental to its robustness against the disruptions while shorter average distances allow faster propagation of products and information. So, the closeness should enhance the responsiveness of the supply network in the event of environmental dynamics. Though the supplier's ability to remain in cliques by selectively connecting to the well-connected suppliers advances the regular supplier network operations, it is vulnerable to the environmental distractions due to the higher level of dependency on dominant suppliers (Borgatti and Li, 2009; Nair and Vidal, 2011). The consumers favour the suppliers that can quickly reach most of the other suppliers in a cluster in terms of logistics costs, but the product reliability and flexibility issues generated by the environmental disruptions may weaken customer loyalty. In adapting to dynamic situations, some ties and suppliers would disappear from the shortest paths, and new suppliers and ties enter the network and hence, the closeness centrality may decrease.
Hypothesis 4: Higher dynamism leads to a weaker positive relationship between a supplier who can quickly reach all the other suppliers in the open contractual network and its sales probability in the supply network over time.

Munificence refers to the resource abundance in the environment resulting in a higher capacity to support the sustained growth of a firm and thus focuses on an industry's sales trend (Terjesen et al., 2011). Network structure partially determines the opportunities and constraints to access valuable resources and information that would help the suppliers sustain competitive advantage (Burt, 1992). The suppliers with high degree centrality can influence their suppliers either to compete or corporate or both when developing value-added products by recognising, leveraging and deploying the market knowledge and demands (Kim et al., 2011; Bellamy et al., 2014). Since they experience high relational activity in the open contractual network that capture the potential transactional intensity or related risks, they can influence other connected suppliers' operational scope. High degree centrality suppliers are willing to absorb the opportunities generated by highly munificent environments to meet the diversified consumer requirements aligning with the anticipated actions of other connected suppliers.
Hypothesis 5: Higher munificence leads to a stronger positive relationship between a supplier who holds a larger number of contracts in the open contractual network and its sales probability in the supply network over time.

The environment interacts with the contractual relationships in ways that cause selective pressure and competition among the structural dimensions to create nonadditive effects on the supplier's survival (Gell-Mann, 1994). The OFN is more vital in munificent environments as its primary purpose is to become an alternative platform for the sustainable producers and hubs to sell their surplus produces to the consumers. Thus, the suppliers with high closeness centrality have the potential to deliver the produces promptly to consumers as they can quickly reach most of the other suppliers in the network (Borgatti and Li, 2009). The suppliers that are at a short distance from most other suppliers receive information and produces sooner than the suppliers that are far away from most others (Borgatti and Li, 2009). The other suppliers would like to join the short food supply chains to get more sales while consumers place orders assigning a pivotal role to the high closeness centrality suppliers to get the benefits of less operational and inventory costs (Lee et al., 2004).
Hypothesis 6: Higher munificence leads to a stronger positive relationship between a supplier who can quickly reach all the other suppliers in the open contractual network and its sales probability in the supply network over time.

An industry's complexity is implied by the number of firms and their composition in terms of size and perceived resources (Child, 1972). In a complex business environment, a supplier needs to satisfy the environmental expectations placed on it with the available resources, capabilities and products to remain operationally sustainable (Li et al., 2010). Having a higher number of direct contacts with other suppliers in the open contractual network enhances the supplier's ability to absorb the external knowledge in response to the increased information processing demands and open innovation. Also, suppliers that are unable to recognise and leverage the extensive information that can be accessed from other evolving suppliers are likely to face legal consequences and weak performances (Pathak et al., 2007). The new suppliers entering the open contractual network connects with high degree centrality suppliers than the isolated suppliers in a complex business environment to attract consumers. Further, consumers trust a high degree of centrality suppliers in a market spoiled by choice with a large number of physical establishments. Eventually, the OFN producers that start with fewer connections transform into high degree centrality food hubs over the years responding to the various market requirements.

Hypothesis 7: Higher complexity leads to a stronger positive relationship between a supplier who holds a larger number of contracts in the open contractual network and its sales probability in the supply network over time.

Food suppliers inescapably engage in a cycle of continuously changing inter-relationships to increase its internal fit to the supply chain and external fit to the environment (Choi et al., 2001; Park et al., 2018). It is even more critical in a CAS to find the strategic fit between the network structure and the collaboration patterns (functionality) (Li et al., 2010). Hence, the key interest of this study aligns with this interplay and the shorter food supply chains that cover a heterogeneous product range. Since the longer paths increase the operations costs and network disruptions, high closeness centrality suppliers are in relatively powerful positions in delivering a wide range of food items with shorter and flexible delivery times. Both the consumers and the embedded suppliers coevolving with the complex environment increasingly connect with the high closeness centrality suppliers that could reduce the logistics costs and improve on-time delivery.
Hypothesis 8: Higher complexity leads to a stronger positive relationship between a supplier who can quickly reach all the other suppliers in the open contractual network and its sales probability in the supply network over time.

Conceptual Model

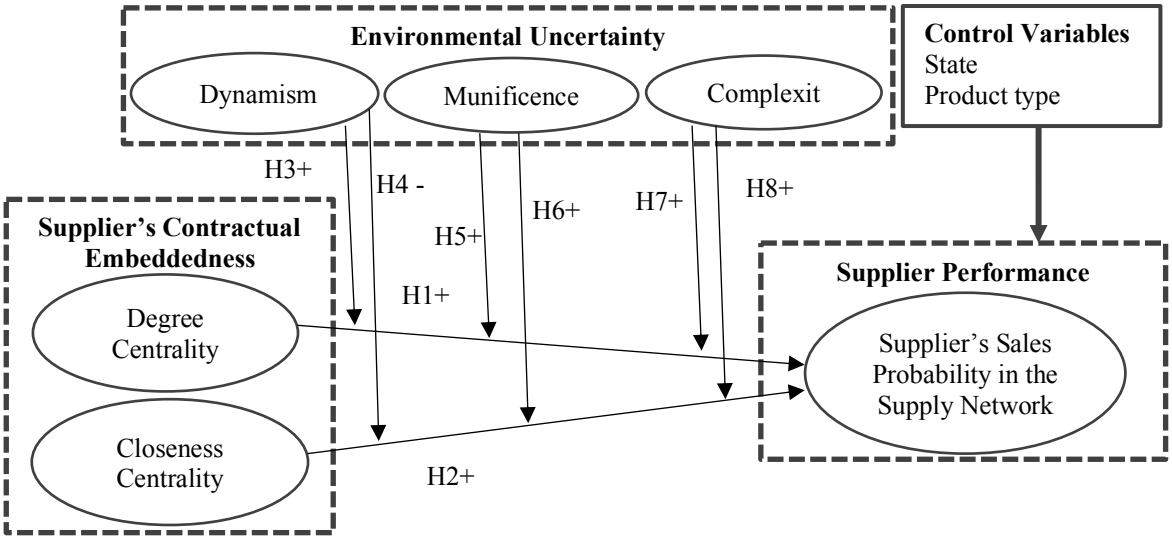

Figure 1: Conceptual model

Research Methodology

OFN dataset was used for the analysis which started in 2012 with 34 food suppliers and grew to 96, 234, 1033 and 1876 in each consecutive year up until 2016. The corresponding supply network started with 30 food suppliers and evolved by 71, 234, 395 and 503 in each successive year along with the open contractual network's evolution. The network deals with 52 main product categories. The IBISworld industry reports from 2008 to 2016 were used to measure the environmental uncertainty dimensions. SNA and panel logit regression modelling methods were used to test the proposed hypotheses.

In-degree centrality of a supplier is the number of ties received by the supplier and out-degree is the number of ties initiated by the supplier (Borgatti et al., 2002; Kim et al.,

2011). The log transformation of the sum of the in and out degree centralities of the supplier is used in this study for the degree centrality. Closeness centrality is the reciprocal of farness which is the sum of the lengths of the ties to every other supplier (Borgatti et al., 2002; Kim et al., 2011). As an alternative to taking the reciprocal after the summation, the reciprocals can be taken before. Since the data is directed, the average of both in and out closeness centralities was calculated after which the log transformation was obtained.

Munificence is measured as the five-year average growth in industry sales revenue and industry value added of the industries that the supplier is involved in (Keats and Hitt, 1988; Gligor, 2018). Measures were taken in $ millions. The basic equation followed is

$$y_t = b_0 + b_1 t + at$$

where y=natural logarithms of sales/industry value added, t=year and a=residual. Growth measure is the average of the antilog transformations of the sales and industry value added regression coefficients. Dynamism is the five-year patterns of the instability of the environment (Keats and Hitt,1988; Gligor, 2018). The measure is the average of the antilog transformations of the standard errors of each regression slopes (sales and income) measured for munificence (IBISworld, 2016; Gligor, 2018). Complexity is the breadth and variety of the industries' geographic markets that the supplier operates in (Child, 1972;). The five-year average growth of the number of physical establishments of the industries that the supplier operates in was used (Keats and Hitt, 1988; IBISworld, 2016). The basic equation followed is

$$y_t = b_0 + b_1 t + at$$

where y=natural logarithms of the number of physical establishments, t=year and a=residual (Gligor, 2018). The growth measure is the antilog transformation of the regression coefficient. The probability of sales is a binary variable. If the supplier generates sales in the supply network it is 1; otherwise, it is 0 (Lanier et al., 2010).

Descriptive Statistics

Table 1: Descriptive statistics and correlations

Variable	Mean	Standard Deviation	Minimum	Maximum	1	2	3	4	5	6
1.Degree	0.78	1.07	0.00	5.81	1.00					
2.Closeness	-2.41	0.18	-2.63	-0.85	0.48*	1.00				
3.Dynamism	1.01	0.01	1.00	1.12	0.01	0.10*	1.00			
4.Munificence	1.02	0.04	0.85	1.34	-0.09*	-0.07*	0.09*	1.00		
5.Complexity	0.99	0.03	0.74	1.36	-0.07*	-0.05*	-0.14*	0.56*	1.00	
6.Sales	0.37	0.48	0.00	1.00	0.63*	0.49*	0.02	-0.14*	-0.10*	1.00

*p<0.01

Table 1 provides descriptive statistics and the correlations between the variables.

Results

The analysis was conducted in two steps. SNA and the panel logit regression modelling procedures were used respectively. First, the SNA technique was applied using the UCINET software to visualise the network evolutions from 2012 to 2016 as shown in Figure 2 and to derive measures for our independent variables which are degree and closeness centralities. Second, the moderated panel logit regression modelling

methodology was used given the dichotomous nature of the dependent variable which is the supplier's sales probability in the supply network and it is unbalanced due to the unequal number of suppliers presented by the regional food network evolutions. The control variables; product type and the state, do not significantly vary over time and the suppliers in the OFN are a small representation of the Australian food suppliers in each category. Hence, the random effects panel logit model was used. The odd ratio was used to infer the true nature of the relationship between the explanatory variable and the dependent variable (Wiersema and Bowen, 2009).

Results are shown in Table 2. These results show the support for six out of the proposed eight hypotheses. The first model includes the effect of the control variables on the supplier's sales probability. The independent variables of centralities were added into the second model and the moderators of the environmental uncertainty variables into the third model. The fourth model includes the interaction terms, which are the product of each centrality variables with each of the mean centred environmental uncertainty variables. Since the odd ratios of the log transformations of degree and closeness centralities are greater than 1, they associate with higher sales probability supporting hypotheses 1 and 2.

In both highly dynamic and complex environments, the positive association between the supplier's degree centrality and its sales probability are very high as their odd ratios are significantly greater than 1 supporting hypotheses 3 and 7. Though the munificent environments increase the positive association between the closeness centrality and the sales probability with an odd ratio greater than 1 supporting hypotheses 4, dynamic environment diminishes that positive slope with an odd ratio less than 1, thus confirming the hypothesis 6. The relationship between the degree centrality and the sales probability is not evident in the munificent environment, thereby contradicting the hypothesis 5. This may be due to when most of the food suppliers have product surpluses, and they get motivated to directly sell the products for lower prices rather than from selling through food hubs. Therefore, consumers may reach both the individual food producers and hubs to get price advantages in munificent environments. Also, the relationship between closeness centrality and sales probability is absent in the complex environment. Consumers that are spoiled by the choices with a heterogeneous product range chase after local brands without concerning the distance in a complex environment and hence it is possible to have hypothesis 8 not being supported.

Table 2: Unbalanced panel logit regression results

Model	Model 1	Model 2	Model 3	Model 4	Hypothesis
Sales	Odd ratio	Odd ratio	Odd ratio	Odd ratio	
Constant	0.03*	$3.72x10^{10}$*	$2.13x10^{24}$*	$3.24x10^{30}$*	
State	Yes	Yes	Yes	Yes	
Product type	Yes	Yes	Yes	Yes	
Degree centrality		10.07*	14.99*	16.66*	H1: Yes
Closeness centrality		65241.54*	29794.79*	1994342*	H2: Yes
Dynamism			$3.93x10^{-5}$	$1.78x10^{-08}$***	
Munificence			$2.44x10^{-9}$*	$1.03x10^{-08}$*	
Complexity			0.02	0.23	
Degree *Dynamism				$1.12x10^{17}$**	H3: Yes
Closeness *Dynamism				$3.90x10^{-160}$*	H4: Yes
Degree * Munificence				0.01	H5: No
Closeness * Munificence				$5.41x10^{57}$**	H6: Yes

Degree * Complexity				$3.25x10^{07}$***	H7: Yes
Closeness * Complexity				$3.96x10^{32}$	H8: No
Wald chi2	21.16***	228.97*	201.57*	189.70*	

Observations = 3273, Groups = 1876, p<0.01*, p<0.05**, p<0.1***

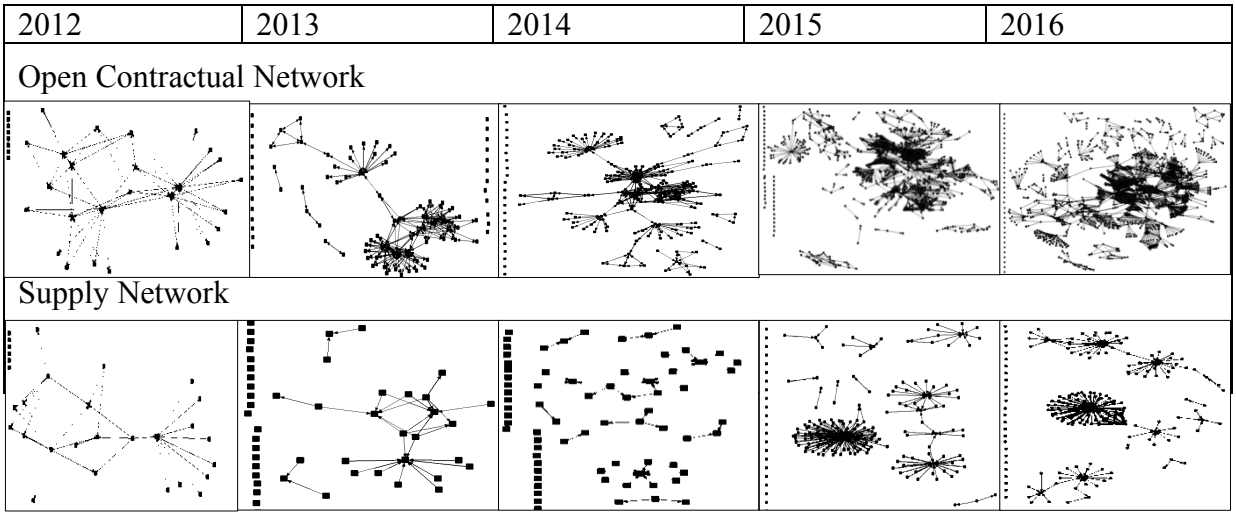

Figure 2: Network evolutions from 2012 to 2016

Discussion and Conclusion

This study primarily investigates how the open contractual network derives the supply network in each order cycle in response to the environmental uncertainties over five years by applying CAS theory. Results reveal that the SCE as informed by the SNA matrices of degree and closeness centralities generally improves the supplier's sales probability in the supply network. This contradicts the belief about the non-linear effects of the embeddedness on performance. Further, the study elucidates how freely emerging open contractual network interacts with the environmental uncertainties without any global controller to increase the embedded supplier firm's performance. This study discloses that environmental uncertainty dimensions moderate the relationship between SCE and the supplier's sales probability which is mostly unexplored in the literature. Both the dynamic and complex dimensions improve the positive association between the degree centrality and the sales probability as per the odd ratios. Munificence increases the positive association between the closeness centrality and the sales probability nexus, but dynamism lowers this positive relationship.

This study graphically unveils the simultaneous coevolution of the open contractual and the supply networks embedded in a single system over five years to adapt the environmental uncertainties. The geographically remotes network clusters that connected through the structural holes in the networks evolve into different network patterns over time. These network transitions and the changes in the SCE centralities aim at catering the local interests than the global optimum, and hence these networks exhibit the characteristics of a locally sufficient CAS. This study offers a more rigorous and scientific analysis elucidating how to foster the CAS and SNA views of the open contractual

network to develop the supply network and increase the embedded suppliers' sales probability.

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