The Interactive Effect of Task Business Environment and Supply Chain Relationship on Manufacturing Plant's Operational Sustainability: Synergies or Anatagonies?

Research Paper

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ABSTRACT

The recent global "Great Recession" showed that many manufacturing plants that appeared to be operationally sustainable were not able to withstand the forces in their task environments and supply chains. In this study, we invoke the complex adaptive system (CAS) theory to assess the interactive effects of these two constructs on operational sustainability. Here, we show that empirical data from 522 plants across 9 countries and 21 industries validates both the positive and negative synergistic or antagonistic interactions among the features of task business environment (dynamisms, munificence and complexity) and supply chain relationship (information exchange, supplier and customer leveraging and complexity).

Key words:

Task business environment; supply chain relationships; operational sustainability; CAS

INTRODUCTION

The reality for manufacturing plants is that they face extremely turbulent environmental conditions and operate within the strictures of supply chains. Many successfully operating plants pay much attention to the supply chain relationships to face the external stimuli but still fall apart during the shifting economic conditions. For instance, the entire industries in the United States such as the automobile broke down during the global "Great Recession" (2008-2010). Hence, the literature that reveals the plant's operational sustainability based on its adaptability to the supply chain (Kim et al., 2011) and the task business environment (Bourgeois, 1980; Miller, 1988; Ward et al., 1995) fails to live up to their promise and pays less attention to the interactions between these two systems.

CAS view helps to visualise the supply chain's ability to serve as a complex web of decision-making (Pathak et al., 2007) as it consists of a large number of nonadditively interacting (Holand, 2002) customers and suppliers that are organised in an interdependent and networked manner (Choi et al.,2001). Hence, the manufacturing plant tries to increase its internal fit to the supply chain by modifying the supply chain relationships through the dimensions of information exchange (Lorenzoni and Lipparini, 1999; Weigelt, 2013), customer and supplier leveraging and complexity (Kim et al., 2011). It also adapts and learns from the dimensions of the task business environment such as dynamism, munificence and complexity (Dess and Beard, 1984; Heeley et al., 2006). The plant seeks the optimal ground between these two forms of adaptation to increase the operational sustainability which is the plant's ability to prosper and survive in its operations longer and possibly characterised by the survival (business continuity) and the economic growth (financial performance) (Lanier et al., 2010; York and Miree, 2004). Thus, we invoke the CAS theory to propose these system level interactions to be nonadditive as they could be either greater or lesser than the cumulative of the distinctive effects of the supply chain relationship and the task business environmental dimensions on the operational sustainability. The powerful and weaker interactive effects turn out to be the synergies and antagonies respectively.

By shedding new light on these nonadditive interactions, this paper helps to make sense of the operational sustainability phenomenon that would otherwise be difficult to explain from the viewpoint of either the supply chain or the business environment literature, taken separately. Hence, this paper's primary purpose is to offer an answer to "How the manufacturing plant's operational sustainability is influenced by the nonadditive interactions between the dimensions of supply chain relationship and task business environment?" We analyse both the supply chain relationship and task business environmental characteristics in our empirical setting: a global manufacturing dataset from 522 plants across 9 countries and 21 industries to examine how the operational sustainability is influenced by these nonadditive interactions.

This paper has useful contributions in many ways. Existing literature explains nonlinear occurrences of events (Choi et al., 2001) and agent's nonadditive interactions (Holland., 2002) within a CAS while offering limited knowledge about the nature of the system level interaction between the CAS and its task environment. Hence, this study first extends the CAS theory by theoretically proposing that system level interactions between the dimensions of a CAS and its task environment are either synergistic or antagonistic. Second, we empirically validate those dimension level interactions that occur in the coevolution of a CAS with its environment within the context of supply chain. All the dimensions in supply chain relationship and task environment engage in at least one significant interaction. Third, we offer a new theoretical view point for the operational sustainability by integrating CAS theory with the literature of supply chain and business environment in the directions of profit maximisation and innovation. Finally, we inform managers about the shifting conditions of supply chain relationships and task business environment. Their nonadditive interactions would gauge the plant's operational sustainability including survival and revenue profile.

The remainder of this paper is split into six main sections. Section 2 presents the conceptual model, the theoretical and hypotheses development. Section 3 presents the research methods, data and operational definitions used to test the proposed hypotheses. Sections 4 and 5 discuss the research findings based on the hierarchical regression analysis and theoretical contributions and managerial implications. Section 6 provides conclusions and research limitations.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

A CAS consists of an extensive number of agents who interact in nonadditive ways within the CAS by self-organising and learning to adapt the environment (Dooley, 1997; Holland, 2002). They change their rules of interactions to improve their survival within the CAS and its environment. Hence, of key interest in this research is how the plant interacts in nonadditive ways through the supply chain relationships with its task business environment to improve the operational sustainability. The model shown in figure 1 indicates the links between the key constructs. We hypothesise these relationships for empirical validation.

Holland (2002) suggests that a CAS consists of an extensive number of agents continuously interacting with each other. These agents can be focal business, customers and suppliers in the context of the supply chain (Choi et al., 2001). They develop rules to adapt the environmental effects by anticipating the consequences of other agents' responses (Holland, 2002) and sorting out the regularities from randomness (Gell-Mann, 1994). However, they are embedded in novel surroundings as they perpetually revise their rules of relationships. The environment interacts with the supply chain relationships in ways that cause selective pressure and competition (Gell-Mann, 1994) among the relationship dimensions which create nonadditive effects on the agent's operational sustainability. Businesses inescapably engage in this cycle of interaction to increase its internal fit to the supply chain and external fit to the environment (Choi et al., 2001).

However, they are usually far from the global optimum, instead, they are preoccupied with dynamic rugged landscapes or local optima (Choi et al., 2001). The aggregate behaviour of a CAS is always at disequilibrium by the continuous revision of rules for survival. If a CAS remains at equilibrium, it will die or terminate, such as the disappearance of societies, tribes and organisms (e.g., dinosaurs and mammoths) (Gell-Mann, 1994). Though CAS theory enables defining the supply chain and explaining the adaptive and coevolving behaviour of the supply chain relationships with its environment (Choi et al., 2001), it does not offer a comprehensive knowledge of the relationship and environmental dimensions and the nature of their interactions.

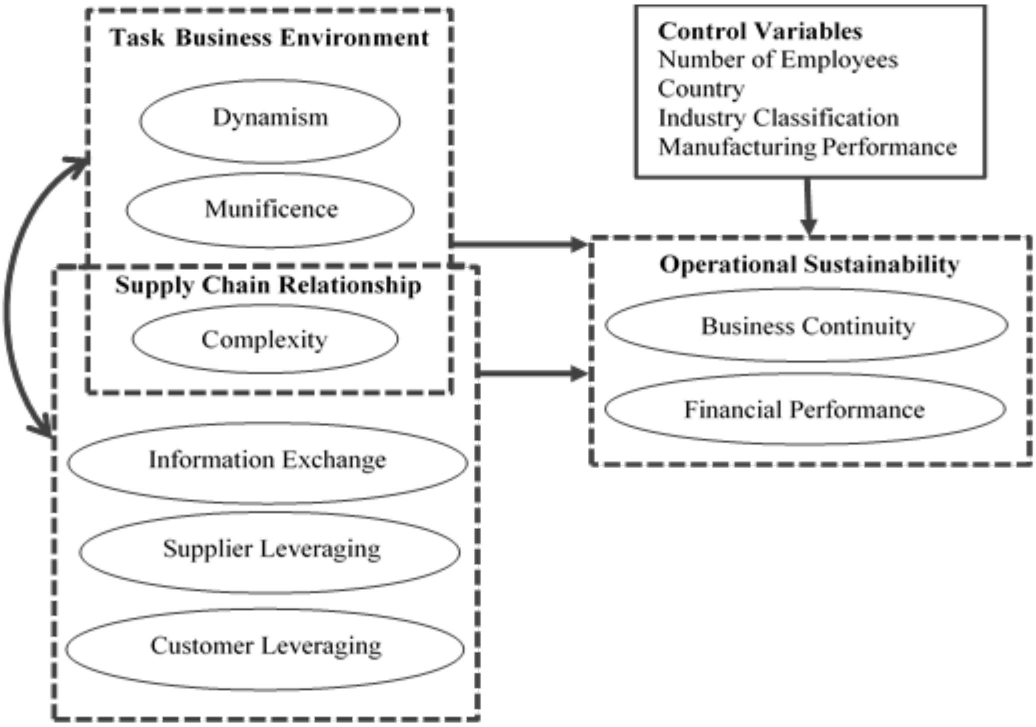

Figure 1: Conceptual model

Task business environment is a multidimensional construct, with the most commonly recognised dimensions being the munificence, dynamism, and complexity in managerial perception (Bourgeois, 1980; Dill, 1958; Miller, 1988; Swamidass and Newell, 1987). Dynamism refers to the unpredictable change within an industry that intensifies the uncertainty (Dess and Beard, 1984). Munificence is the resource generosity of the task environment which can support the sustained growth of the manufacturing plant (Heely et al., 2006). Complexity refers to the heterogeneity and range of a plant's activity (Child, 1972) and overlaps with the supply chain complexity. Although previous remarkable studies are illuminating, they obscure the fact that there are also more recent failures in businesses even with satisfying conditions of the business environment (e.g., Nokia, 2016). They fail to offer in-depth discussions on interactions of the task business environment which could enhance the operational sustainability.

Supply chain relationship continues when a firm's input into the relationship is valued and are being adequately rewarded by its exchange partner and hence, the firm becomes socially indebted to its partner by responding with a positive attitude (Griffith et al., 2006). In CAS view, the plant can modify its rules of interactions with suppliers and customers via information exchange, supplier and customer leveraging (Lanier et al., 2010; Wagner and Bode, 2014) and complexity (Choi and Krause, 2006; Pathak et al., 2007). These relationship dimensions act as the generators of shifting conditions within the supply chain. Holland's (2002) popular example of building blocks is less than a dozen rules of chess creates a miniature artificial world to find perpetual novelty in which two parties interact. We cannot specify the best strategy for the game even after repeatedly occurring certain patterns of extracting and exploitation. As such, the interaction of relationship dimensions with task environment can nonadditively change the direction of plant's operational sustainability.

Operational sustainability is the plant's ability to prosper and survive its operations longer. It depends on how profitably plant creates the strategic fit between the available resources and the plant's absorptive capacity to create an artificial demand and price (Alchian and Demsetz, 1972; Bain, 1954). Also, the plant's possession of a specific combination of resources that is valuable, rare and difficult to imitate (Barney, 1989; Rumelt, 1974; Schumpeter, 1947) directs to innovation. These two perspectives of profit maximisation and innovation can conjointly enrich the concept of operational sustainability to respond the shifting conditions in supply chain and task environment than the objectives of relative competitiveness and cost minimisation. Therefore, we posit that this construct to consist of the financial performance (sales, profitability and market share) and the business continuity (product and process innovations and developments). In this study, this construct syndicates only the plant's survival and economic growth as its antecedents such as the task business environmental dimensions deal with the environmental audits that the plant has to pass on to stay in business.

The interactions between the dynamism and supply chain relationship dimensions

Dynamism contributes to the fluctuations in innovations, customer preferences (Ward et al., 1995) and organisational decision making (Bourgeois, 1980; Heeley et al., 2006). The product-specific sales fluctuations encourage plants to learn, develop and innovate diverse product and process offerings for business survival. The managers are supposed to turn the dominant influence of dynamism to the successful resource allocation decisions (Keats and Hitt, 1988) that increase the operational sustainability.

Anchored in the premise, quality and timeliness of information exchange among the supply chain partners enhance the plant's ability to make successful decisions in dynamic conditions. It indicates what kinds of information are being exchanged, between whom and to what extent (Haythornthwaite, 1996). Hence, the plant has control over the capacity and routes of the information exchange that reduce the total logistics cost (Moberg et al., 2002). Further, CAS view (Gell-Mann, 1994) helps to make sense of the likelihood that plant exposes to certain kinds of information and the likelihood that considers data to be authoritative (Haythornthwaite, 1996). This aligns the extent and quality of information exchange (Moberg et al., 2002) in dynamic situations and applies to commercial ends (Wagner and Bode, 2014) in which ways that improve the operational sustainability. Hence,

Hypothesis 1a: The interaction between the information exchange and the dynamism improves either the business continuity or the financial performance or both.

The plant can gain competitive advantages by accessing the knowledge that resides in supply chain relationships (Tsai, 2001). Consequently, the plant's ability to exploit the knowledge and technology outputs from the suppliers leads to supplier leveraging (Ofek and Sarvary, 2001). The aim of supplier leveraging is to maximise the value of a manufacturer's supply base through substantial reductions in the true cost of materials, increased flexibility to dynamic situations and faster cycle times which can increase the market share (Herrmann and Hodgson, 2001). It increases payoffs (Lanier et al., 2010) and stimulates the pull model of innovation (Wagner and Bode, 2014) to optimise the opportunities generated by the dynamic environmental conditions that improve the plant's operational sustainability.

Hypothesis 1b: The interaction between the supplier leveraging and the dynamism improves either the business continuity or the financial performance or both.

Customer leveraging allows exploiting the customers' knowledge to reduce costs and improve the quality that maximises their satisfaction while increasing the return on sales (Ofek and Sarvary, 2001). The plant's leveraging occurs when supply chain coevolves with its task environment to create the strategic fit between knowledge exploitation and exploration (Choi et al., 2001; Holland, 2002). However, during the dynamic conditions of task environment, the customers become a destitute in their rapidly changing requirements. Hence, the customer base builds up selective pressure on the plant and creates competition (Gell-Mann, 1994) among the supplier and customer relationships by diminishing the plant's supply chain fit. Consequently, the operational sustainability is negatively associated with plant's effort in modifying supply chain relationships to satisfy the misguided customer requirements during the shifting conditions.

Hypothesis 1c: The interaction between the customer leveraging and the dynamism decreases either the business continuity or the financial performance or both.

Supply chain complexity, the core constituent of a CAS engages with the chain size, degree of interdependency and the number of tiers (Kim et al., 2011) that reflect the structural dimension (Nahapiet and Ghoshal, 1998). This overlaps with the complexity of the task business environment that focuses on the heterogeneity of plant's activities and range (Child, 1972). Choi and Krause (2006) conceptualise that although a reduction in supply chain complexity may lead to lower transaction costs and increased supplier responsiveness, sometimes, it may increase the supply risk and reduce supplier innovation. Pathak et al. (2007) posit that although the rising complexity in a supply chain creates increased demands for costs, responsiveness and flexibility, the complexity based solutions would alleviate the situation and increase the operational sustainability via new product and process developments. Complex supply chains create vast opportunities for the plant in timely responding to the dynamic conditions through its relationship reconfigurations that improve the operational sustainability.

Hypothesis 1d: The interaction between the supply chain complexity and the dynamism improves either the business continuity or financial performance or both.

The interactions between the munificence and supply chain relationship dimensions

Munificence is the resources generosity that may attenuate the resource slack. Developing resource efficiency is argued to have a stable and predictable (Shah and Ward, 2003) financial position for a plant. Likewise, maintaining a resource slack would experiment product and process innovations without compromising plant performance and consequently attenuating negative financial reactions from the market (Modi and Mishra, 2011). They also confirm that all resources such as inventory, production and marketing are critical for the business continuity and underscore the importance to managers of having a holistic view of resource configurations to maximise the financial returns.

Greater information access precedes the plant's quick responses to the munificent task environment with the growth of relational governance processes and technological systems (Williams et al., 2013). The opportunities for and occurrences of information exchange (Haythornthwaite, 1996) in the relationships endow with the details of sales trends (Heely et al., 2006) and the resource flow of critical input. The plant's strategic priorities of profit maximisation and innovation illuminate specific combinations of resources that are difficult to imitate (Rumelt, 1974). These combinations which consist of labour and capital (Alchian and Demsetz, 1972) develop different types of responses to the challenges posed by the munificence by restricting the output to create artificial demand or price (Bain, 1954) (e.g., Apple products). Thus, the information exchange optimises value and volume of the supply chain relationships by adjusting the resource flow restrictions in the task environment to increase the plant's survival.

Hypothesis 2a: The interaction between the information exchange and the munificence improves either the business continuity or the financial performance or both.

Resource-based theory views that a plant performs superior based on its possession of a specific combination of resources that is valuable, rare and difficult to imitate (Barney, 1989; Rumelt, 1974). Since the supplier leveraging induces the control over the resource flow from suppliers to customers, the plant can reconfigure the supply chain relationships in a unique fashion towards a monopolistic or oligopolistic market behaviour by leveraging the suppliers' technical knowledge and resources. For instance, the utility companies such as water, gas, electricity and even telecommunication continue to remain in a monopoly in munificent environments. As it inspires the selective pressure (Gell-Mann, 1994) on supplier relationships, the plant is likely to enjoy the pull model of innovation (Wagner & Bode, 2014) for its survival. It allows the plant to select the most appropriate from the available state of the art technologies and skilled workers generated by the munificent task environment. Hence,

Hypothesis 2b: The interaction between the supplier leveraging and the munificence improves either the business continuity or the financial performance or both.

The extent a manufacturing plant excels in product and process innovation gives it a competitive edge to sustain longer in business. The integrated perspective of product and process innovation allows the plant to align the manufacturing technologies and designs with new product developments (Ettlie and Reza, 1992). Information exchange and supplier leveraging envisage to improve the plant's operational sustainability (Wagner and Bode, 2014) in a munificent environment but not the customer leveraging (Powell, 1995). While the information exchange and supplier leveraging offer the plant numerous opportunities to benefit from munificence, the plant sorts the regularities from randomness (Gell-Mann, 1994) in customer leveraging not to get stranded among the lots of alternative technical know-how from the customers. Although the customer leveraging in a munificent environment generates an array of rugged landscapes (Choi et al., 2001), the plant may get distracted by the random events than finding more fine-grained business opportunities. Thus;

Hypothesis 2c: The interaction between the customer leveraging and the munificence decreases either the business continuity or the financial performance or both.

A complex supply chain in a munificent environment persuades the manufacturing plant to approach different industries, a variety of products and geographically diverse markets even beyond their actual capacity. The plant keeps connecting with new suppliers and customers while strengthening bonds with the existing partners for survival. These sudden supply chain reconfigurations hardly attune to the changes in the industry structure and competition (Stonebraker and Liao, 2004). The complex supply chain which concerns about the power distribution and greater effort in relationship coordination (Kim et al., 2011) would impede the chain's potential to face the challenges posed by the munificence. Higher coordination costs entailed with prompt and accurate information that is visible to all the partners (Holweg and Pil, 2008) in a complex supply chain might go beyond the plant's capacity. Bound by the rules and regulations of munificent task environment, the plant might confuse in balancing the relationship requirements and feeds from new customers and suppliers. Hence, this interaction would degrade the operational sustainability as the requisite for complexity is unnecessary.

Hypothesis 2d: The interaction between the supply chain complexity and the munificence decreases either the business continuity or the financial performance or both.

The interactions between the task business environmental complexity and supply chain relationship dimensions

The insights of task business environmental complexity (Bourgeois, 1980; Dill, 1958) are congruent with the supply chain complexity which extends to the plant's suppliers and customers (Bozarth et al., 2009) and refers to the heterogeneity and range of the plant's activities (Child, 1972). We recognise that these two concepts overlap in this study bound by their definitions. The complexity in CAS view comes in two faces such as detail and dynamic complexity in products, processes and relationships (Bozarth et al., 2009). It emerges through the relationships between the plant and embedded partners in the supply chain and created by the multiplicity of inputs and outputs (Dess and Beard, 1984). However, it confines the plant's ability to foresee the disruptions to operations (Azadegan et al., 2013).

The complex environments urge the importance of sufficient information exchange that defines the content, direction and intensity of the supply chain relationships (Haythornthwaite, 1996). It deepens the plant's understanding of adaptation to the complex task environment. The complexity based solutions disclose an array of possible supply chain reconfigurations while the accurate and timely information flow helps to recognise the optimum solution that ensures the plant's survival. This interaction that seeks the strategic fit between the information availability and its acceptance to the complex environmental conditions improves the plant's operational sustainability.

Hypothesis 3a: The interaction between the information exchange and the task business environmental complexity improves either the business continuity or the financial performance or both.

Supplier leveraging contributes to lower the opportunistic behaviour of supplier base that generates from the competitors and regulators in the complex task environment. It also inclines the supplier reliability, lead time and supply base management (Bozarth et al., 2009). Responsive supply chains which admire the innovations and unique products (Fisher, 1997) swiftly reconfigure the supplier relationships to adapt the complexity. Indeed, the plant utilises the environmental complexity by reaching different markets with product proliferation in shorter life cycles (Azadegan et al., 2013) and optimising supplier base as it slightly encourages the push model and mostly by the pull model of innovation (Wagner and Bode, 2014). Consequently, the manufacturing plant sets the relational strategies such as coopetition (Pathak et al., 2014) to leverage suppliers' power sufficiently that shape both the cooperative and competitive behaviours and capture value from the relationships (Kim and Wemmerlov, 2015).

Hypothesis 3b: The interaction between the supplier leveraging and the task business environmental complexity improves either the business continuity or the financial performance or both.

The exchange partners use the power differently depending on their role in the manufacturing supply chain. This suggests that customers tend to leverage their potential power to claim benefits from relationships while suppliers are not likely to use their power in a corresponding way (Kim and Wemmerlov, 2015). They also provide ample shreds of evidence to prove that greater the supplier's dependence, the smaller its financial gains. Although complex task environment with multiple products and shorter life cycles persuades the plant to leverage the customers, the customer base is very fragmented for products such as smartphones. Customers' dependence on multiple manufacturers in a complex environment debunks the exploited knowledge about the cost reductions, enhanced sales forecasting and delivery performance (Cousins and Menguc, 2006) without satisfying the true customer requirements. Hence,

Hypothesis 3c: The interaction between the customer leveraging and the task business environment complexity decreases either the business continuity or the financial performance or both.

RESEARCH METHODOLOGY

Data and Operational Definitions

The database used in this study is the fifth edition of Global Manufacturing Research Group (GMRG) survey that designed for the improvement of manufacturing supply chains worldwide and it includes questions related to the business performance, supply chain management, innovation and sustainability. It collected data from directors of operations/ manufacturing and the sample consists of 968 manufacturing facilities in 21 industrial classifications and 18 countries. We use data from 522 manufacturing facilities in 9 countries for the analysis after eliminating the missing values. The unit of analysis is the manufacturing plant.

Task business environment

We characterise the task business environment through dynamism, munificence and complexity. Since the task environmental complexity overlaps with the supply chain complexity, we discuss it under supply chain relationship section. Further, in complex situations, features of the task environment that represent uncertainty and predictability are known only through the managerial perception (Swamidass and Newell, 1987). Hence, the proposed conceptual model focuses on the perceptual measures. All the items that represent the task environment are measured with 7 points Likert scale from 1(not at all) to 7 (great extent).

This study uses four items to reflect the dynamism. The first two items are "most innovations come from monitoring competitors and/or using suppliers" and "constantly looking outside facility for useful ideas". They describe the fluctuations in task environmental elements such as competitors, suppliers, customers and regulatory groups (Dill, 1958) that are caused by innovation, technology and consumer preference (Ward et al., 1995). Further, the task environment as a body of accessible information (Dill, 1958) soundly reflects the volatility and turbulence in managerial decision making (Bourgeois, 1980; Child, 1972; Heeley et al., 2006). Hence, rest of the two items fairly represent the manager's perceptual measures of environmental dynamic rigour and its frequency and instability level (Dess and Beard, 1984; Wholey and Brittain, 1989). They are "operational decisions are always set to quickly match current needs" and "devote most of the time solving immediate, short-term issues".

Munificence mostly focuses on an industry's sales trend (Heely et al., 2006), and hence, this study selects items that exhibit how the plant responds to the sales stimuli. Ward et al. (1995) propose three scales of munificence, which often measured on a reverse scale of environmental hostility such as business costs, labour availability and competitive hostility. The selected items are state of the art manufacturing processes, unique manufacturing process capabilities, workforce technological skills and superior technological knowhow. The last two items comply with labour availability while first two items present as a combination of both the business cost and competitive hostility.

Supply chain relationships

Despite a great deal of interest in CAS view of supply chain (Kim et al., 2011; Surana et al., 2005) that exhibits the plant's network presence, it requires a deeper understanding of interactions that form the network and plant's access to information and resources

(Nahapiet and Ghoshal, 1998). Hence, we use information exchange, complexity, supplier and customer leveraging to reflect the dimensionality of supply chain relationships. We propose five items to measure the information exchange with supply chain partners which act as catalysts for the plant's innovation and financial performance (Bellamy et al., 2014). They are "main customers exchange proprietary information", "main customers inform each other about events affecting the other party", "main suppliers exchange proprietary information", "main suppliers inform each other about events affecting the other party" and "main customers regularly exchange information of supply and demand forecast". All the items are measured in 7 points Likert scale from 1(not at all) to 7(great extent).

Lorenzoni and Lipparini (1999) highlight that leveraging of interfirm relationships must occur with deliberate initiatives undertaken by the plant to enhance the responsiveness and foster trust and cooperation. In their paper, leveraging considered as a substitute for the formal control based on the trust in the relationships and as a source of access to the external knowledge that brings opportunities to apply new technologies, ideas, innovations and supply chain reconfigurations (Weigelt, 2013). We use six items for each construct of customer and supplier leveraging which assure the perspectives highlighted in the literature. The customer leveraging items are "obtain a tremendous amount of technical know-how from customers", "rapidly respond to technological changes in our industry by applying what we know from our customer", "as soon as we acquire new knowledge from our customer, we try to find applications for it", "our key customer's technological knowledge enriched the basic understanding of our innovation activities", "our key customer's technological knowledge reduced the uncertainty of our innovation activities" and "our key customer's technological knowledge helps us to identify new aspects of innovation activities that would otherwise have gone unnoticed". We repeat same items with 'supplier' instead of 'customer' for supplier leveraging and they are measured in 7 points Likert scale from 1(strongly disagree) to 7(strongly agree).

A supply chain's complexity which overlaps with the task environmental complexity can be measured in terms of chain size, the degree of interdependency and the number of tiers (Kim et al., 2011). We select four items related to complexity such as the number of parts in a typical end item bill of material for the plant's most important product line, the number of items listed in the bill of material for the highest value product line, the number of items that are produced within the manufacturing plant and the number of first tier suppliers. First two items represent the supply chain size while third item indicates the degree of interdependency. Last item relates to the number of tiers in a supply chain. All of them relates to the heterogeneity and range of a plant's activity (Child, 1972) that reflect the task environmental complexity. The manufacturing plant has been asked to rate one of the given seven categories which show the ranges in the respective measure.

Operational sustainability

A plant's operational sustainability is whether it is economically viable to operate continuously in the respective markets. Therefore, plant's business continuity and financial performance become the fundamental dimensions that represent the operational sustainability. First, business continuity could best characterise by the integrated approach of product and process innovation that generate future benefits or at least not worsening the current position of the plant (Bellamy et al., 2014; Wagner and Bode, 2014). We select five items such as "the first within the industry to deploy new processes", "frequently introduce processes that are radically different from existing processes in the industry", "have no difficulty in introducing processes that are radically different from existing processes in the industry", "the first within the industry to introduce new products" and "frequently introduce products that are radically different from established products in the industry". They mainly focus on continuous innovation and deployment of manufacturing processes and products (Wagner and Bode, 2014) and measured in 7 points Likert scale from 1(strongly disagree) to 7(strongly agree). Second, financial performance is represented in three items of total sales of goods and services, profitability (Lanier et al., 2010) and market share (York and Miree, 2004) and measured in 7 ranges from reduced <25% to increased 25%. A subjective financial performance which is based on respondent's opinions mostly applies with suggestive study (Powell, 1995).

Control Variables

We control for each country and industry (Swamidass and Newell, 1987) specific fixed effects on manufacturers' operational sustainability using dummy variables. Also, we control for the plant size which is a proxy for economies of scale and measure as the natural logarithmic transformation of the number of employees. The plant's manufacturing performance could signal competence and attractive long term prospects to the suppliers and customers, thus increase the innovations (Wagner and Bode, 2014) and financial performance. Hence, we control for the manufacturing performances using the latent variables of cost, quality, delivery and flexibility (Neely et al., 1995; Peng et al., 2011) to eliminate undesirable variance in the effects on the operational sustainability. We concern about three main types of manufacturing costs such as labour unit cost, raw material unit cost and total product unit cost (Neely et al., 1995). The four selected items to measure quality are rejected percentages of incoming material, during processing, at final inspection and from customers for the financial year (Peng et al., 2011). The selected three items for delivery are delivery speed, delivery reliability and response to changes in delivery due dates (Neely et al., 1995). Both cost and delivery items are measured in 7 points Likert scale from 1(far worse) to 7(far better) comparative to the major competitors. The other seven items measured in 7 points Likert scale from 1(strongly disagree) to 7(strongly agree) reflect diverse aspects of flexibility (Neely et al., 1995; Peng et al., 2011). They are a high variety of products, increasing product variety without increasing cost and sacrificing quality, the lead time to implement new or change existing processes compared to competitors, the capacity of large scale product customisation, responding quickly to customisation requirement and customising products while maintaining high volume.

Validity and Reliability

The principal components factor analysis with varimax rotation converged with Kaizer normalisation of 0.857 (p=0.000) verifies the convergent validity. The discriminant validity is ensured through an exploratory principal component factor analysis with Promax rotation that reveals exactly 8 factors. In both situations, the average factor loadings are greater than 0.70. The degree of internal consistency of a construct (Boyer et al., 1997) concerns for the reliability. We use Cronbach's coefficient of alpha to assess the reliability of scales. The threshold for acceptable reliability for existing measures is alpha values of 0.70 and 0.60 for new measures (Hair et al., 2006). We standardise all the items that measured in different scales. Table 1 indicates the mean, standard deviation, reliability and correlations between standardised variables.

Table 1: Descriptives, reliability and correlations between scale variables

	Mean	SD	Alpha	BC	FP	C	Q	DE	F	D	M	CO	IE	SL	CL
BC	0.01	0.80	0.91	1.00	0.22*	.21*	.026	.21*	.36*	.21*	.42*	.17*	.21*	.52*	.41*

FP	0.05	0.89	0.86		1.00	.26*	-.053***	.23*	.11*	.10**	.20*	.00	.18*	.10*	.14*
C	0.01	0.83	0.78			1.00	.017	.34*	.15*	.11*	.36*	-.03	.03	.11*	.17*
Q	0.00	0.87	0.78				1.00	-.25*	-.00	-.14*	-.04*	.24*	-.09**	.01	.04
DE	0.01	0.90	0.89					1.00	.28*	.16*	.35*	-.17*	.16*	.21*	.22*
F	0.00	0.80	0.89						1.00	.23*	.24*	-.02	.19*	.42*	.47*
D	0.00	0.75	0.73							1.00	.14*	.11	.17*	.20*	.26*
M	0.00	0.81	0.83								1.00	.03*	.17*	.31*	.25*
CO	0.00	0.79	0.92									1.00	.00	.07***	-.01
IE	0.01	0.77	0.89										1.00	.31*	.26*
SL	0.01	0.85	0.78											1.00	.50*
CL	0.00	0.84	0.92												1.00

SD- Standard deviation, BC- Business continuity, FP- Financial performance, C-Cost, Q-Quality, DE-Delivery, F-Flexibility, M-Munificence, D- Dynamism, CO- Complexity IE- Information exchange, SL- Supplier leveraging and CL- Customer leveraging
**P<0.01; ** P<0.05; *** P<0.10*

Endogeneity

The number of survey respondents varying from 1 to 11 persons answered the questionnaire together from a plant and collected from 18 countries in 21 industrial classifications. The survey that consists of five separate sections employee different measurement scales. Although the mentioned precautions are taken to reduce the common method bias it is still likely to occur in the results. Therefore, we performed endogeneity tests to check whether some explanatory variables are not independent of the residuals. First, we use the Hausman's test to check whether reverse causality exists (Sluis and De Giovanni, 2016) between the dependent variable, financial performance and the likely endogenous variable. The munificence and dynamism are likely endogenous variables for the financial performance in this study due to the susceptibility of the proxy measures used from the questionnaire to deliver the true interpretations. Reverse causality of the conceptual model does not exist as all the beta coefficients of likely endogenous variables of the task business environment and supply chain is not statistically significant. Second, we performed the Two-Stage Least Squares (2SLS) regression analysis using an instrumental variable procedure to check the endogeneity for the dependent variable of business continuity. In stage one, we regress munificence on the instrumental variable of competitive intensity in the industry. The results indicate that competitive intensity positively relates to munificence ($\beta=0.57$, $p=0.05$). In the second stage, we substitute the predicted estimations of the endogenous variable based on the instrumental variable to the original model equation and calculate the standardised residual. Covariance between the predicted endogenous variable and the standardised residual does not differ from 0, as such, endogeneity does not exist in the variable.

RESULTS

We use the hierarchical regression to analyse how the operational sustainability is influenced by the interaction between the task business environment and supply chain relationship. It is of particular interest that this is the most appropriate technique to analyse the effects of groups of latent variables in an incremental and controlled manner (Hair et al., 2006). Table 2 shows the results of hierarchical regressions with the business continuity and the financial performance as dependent variables. The first model that controls for the firm size, country and industry effects and manufacturing performances account for a variance of 16.6% for the business continuity and 10.9% for the financial performance. The concurrent inclusion of the task business environment and the supply chain relationship variables in the second model provide a significant improvement with an incremental variance of 17.5% for the business continuity and 3.5% for the financial performance. Since the inclusion of the interaction effects in the third model explains the variance of 1.8% and 2.5% for business continuity and financial performance respectively, it lays the foundation for hypothesis testing of nonadditive interactions. The overall effect of the model explains 47.2% and 26.2% of the variance in the business continuity and the financial performance correspondingly, which the associated F tests are significant at $p<0.01$.

Table 2: Hierarchical regression for business continuity and financial performance

Model	Business Continuity			Financial Performance			Hypothesis
Variables	Model1 Beta	Model2 Beta	Model3 Beta	Model1 Beta	Model2 Beta	Model3 Beta	
Employees	.09***	.02	.03	.05	.03	.02	
Australia	.05	.06	.05	.02	.01	.01	
Croatia	-.10	-.12***	-.10***	-.04	-.10	-.12***	
USA	-.14**	-.09***	-.10***	.17*	.18*	.17**	
Vietnam	.04	.07	.08	.16**	.16**	.15**	
Poland	-.07	-.05	-.04	.02	.08	.07	
Ireland	-.04	.02	.02	-.02	-.02	-.03	
Hungary	-.09***	-.03	-.03	.13**	.14**	.12**	
China	.14**	.10**	.08***	.13**	.12**	.11***	
Industry 1	-.04	-.01	.00	-.05	-.04	-.05	
Industry 2	-.04	-.02	-.02	.07***	.07***	.07***	
Industry 3	.01	.02	.02	-.02	-.03	-.03	
Industry 4	-.03	-.03	-.02	-.03	-.02	-.03	
Industry 5	-.00	.01	-.01	-.04	-.05	-.07***	
Industry 6	-.01	.02	.03	.00	.00	-.01	
Industry 7	-.02	.01	.02	.02	.01	-.01	
Industry 8	.02	-.01	-.01	.05	.05	.05	
Industry 9	-.02	.01	.02	-.04	-.05	-.05	
Industry 10	.04	.03	.03	-.05	-.05	-.05	
Industry 11	-.04	-.05	-.04	-.04	-.04	-.06	
Industry 12	.04	.02	.02	.03	.03	.02	
Industry 13	-.12**	-.10**	-.09***	.01	.00	-.02	
Industry 14	.04	.01	.01	-.05	-.06	-.06	
Industry 15	.01	.00	.01	-.04	-.04	-.02	
Industry 16	.07***	.04	.04	-.01	.00	-.01	
Industry 17	.03	.02	.03	-.04	-.02	-.01	
Industry 18	-.02	-.05	-.05	-.02	-.01	-.01	
Industry 19	-.00	-.01	-.00	-.02	-.02	-.02	
Industry 20	.00	.02	.02	-.12*	-.12*	-.12*	
Cost	.18*	.06***	.08**	.21*	.19*	.19*	
Quality	.10**	.06	.07***	-.04	-.05	-.04	
Delivery	.09**	.02	.02	.19*	.17*	.17*	
Flexibility	.32*	.11*	.10**	.03	-.04	.06	
Dynamism (D)		.06	.05		.08***	.06	
Munificence (M)		.20*	.18*		.05	.05	
Complexity (CO)		.08**	.08***		.19*	.17*	
Information Exchange (IE)		.05	.04		-.05	-.07	
Supplier Leveraging (SL)		.31*	.32*		.01	.03	

Customer Leveraging (CL)		.11*	.14*		-.02	-.02	
H1a: D x IE			-.02			**.09****	Yes
H1b: D x SL			**.07*****			.03	Yes
H1c: D x CL			-.01			.03	No
H1d: D x CO			.02			-.04	No
H2a: M x IE			.02			.02	No
H2b: M x SL			**.11***			.04	Yes
H2c: M x CL			**-.10****			**-.14***	Yes
H2d: M x CO			**-.06*****			.04	Yes
H3a: CO x IE			**.07*****			-.01	Yes
H3b: CO x SL			-.02			.05	No
H3c: CO x CL			.01			.01	No
R^2	.279	.453	.472	.202	.236	.262	
ΔR^2	.166	.175	.018	.109	.035	.025	
F	5.654	10.146	8.323	3.703	3.788	3.305	

**P<0.01; ** P<0.05; *** P<0.10*

The results support six hypotheses. They indicate significant positive interaction effects of dynamism with information exchange and supplier leveraging by supporting hypotheses H1a and H1b correspondingly. However, results reveal that customer leveraging and complexity are not dominant in dynamic task environments as the plant prominently focuses on accurate and timely information and flexibility in supplier base to modify the relationships that increase its strategic fit to the environment.

The munificence supports all the interactions with relationship dimensions except the information exchange. This supports H2b, H2c and H2d. The interaction between munificence and customer leveraging significantly decreases both the business continuity and financial performance while the supply chain complexity with munificence reduces only business continuity. Since, the nature of munificence pumps the information abundantly and consists of a large pool of alternatives, unnecessary complexity in the supply chain decreases the plant's profits and innovations. Also, the plant's role as a supplier in the customer relationship does not capture value by leveraging rather cooperative behaviours and customer initiation increase the profits (Kim and Wemmerlov, 2015). In contrast, the interaction between munificence and supplier leveraging significantly improves the business continuity. Leveraging the supplier base is critical than ever in a resourceful environment which accrue the savings from reduction in working inventories, losses from excess and scrap inventory and nonvalue adding tasks (Herrmann and Hodgson, 2001).

The complex task environment urges the need for modifying the products and supply chain relationships in response to the strategic information about the market fluctuations, thus it supports the H3a with a positive significant interaction effect between the complexity and information exchange. Since, the complexity is both a cause and a consequence, the plant adheres to selective strategies such as co-opetition to coevolve with respect to each relationship not as an entity (Pathak et al., 2014). Hence, the plant may rather appreciate cooperative behaviours in supply chain than making tactical decisions based on its perceptions to leverage suppliers and customers (Kim and Wemmerlov, 2015) in a complex environment.

DISCUSSION

The primary objective of this study is to understand how the operational sustainability is influenced by the interaction between the supply chain relationships and the task business environment. Our analysis confirms that the significant interactions are either synergistic or antagonistic. The results empirically confirm that a CAS behaviour is not a derivative of the individual behaviour (Holland, 2002) since the nonadditive interaction effects largely vary from the constituting features' distinctive effects on the operational sustainability.

The interaction becomes synergistic when the absolute value of the cumulative of distinctive effects is lesser than the absolute value of the interaction effect and antagonistic when the cumulative is larger than the interaction effect. The positive synergy between the dynamism and the information exchange significantly improves the financial performance. In contrast, the negative synergy between the munificence and the customer leveraging reduces the financial performance while the same interaction acts as a negative antagony on business continuity. The interaction between the munificence and the supply chain complexity also turns out to be a negative antagony by reducing the business continuity. These negative antagonies interestingly reflect how their positive discrete effects on the operational sustainability turned into negative interaction effects in a CAS. The positive antagonies such as the interactions of supplier leveraging with dynamism and munificence and the interaction between complexity and information exchange are not effective as their individual effects on business continuity. The interactions of supplier and customer leveraging with the munificence are the highest effects on the business continuity and the financial performance in turn.

Theoretical Contributions

Though existing literature mostly defines the supply chain in CAS view as a form of adaptation to the environment (Choi et al., 2001; Pathak et al., 2007; Surana et al., 2005), a gloomy conventional wisdom exists about the nature of the interaction between the supply chain and its task business environment. The CAS theory postulates the nonlinear occurrences and the agents' nonadditive interactions within the CAS but not the nature of the system level interactions between the CAS and its environment. Therefore, this research further expands the CAS theory by theoretically proposing that these system level interaction effects on the agent's operational sustainability are nonadditive. We empirically validate these interactions by justifying our theoretical model developed based on CAS theory and literature of supply chain and business environment. The results confirm the existence of the interactions between the environment and the CAS and their nonadditive effects on the operational sustainability. We elucidate both synergies and antagonies accordingly with the properties of a CAS such as the interactive agents, anticipation, building blocks, coevolution, aggregate behaviour and emergence (Holland, 2002).

The conceptual model postulates that the plant must maintain both the internal fit to the supply chain and the external fit to the task business environment simultaneously. Although researches explore the plant's adaptation to the task environmental dimensions such as dynamism, munificence and complexity (Dess and Beard, 1984; Ward et al., 1995), relatively less attention paid to the other form of adaptation that involves with the supply chain relationship dimensions. Exploring which relationship dimensions that drive the operational sustainability vigorous and unpredictable in their interactions with the task environment is similarly important. Hence, we recognise information exchange, complexity, supplier and customer leveraging as the building blocks that modify the volume and value of the supply chain relationship.

To a larger extent, the supply chain and task business environment literature evolve independently to elucidate the changing fortune of manufacturing plants. They offer limited knowledge in merging these two forms of adaptation and how these elements interact in nonadditive ways to increase the plant's operational sustainability. In this study, we recognise one positive and one negative synergy and three positive and two negative antagonies between the supply chain relationships and the task business environment that significantly impact the operational sustainability. This is quite a significant finding since, the management expects additive improvements in operational sustainability by focusing on each dimension individually but the reality is that they interact with each other at the interface to produce either synergistic or antagonistic effects.

This research incorporates CAS findings with previous literature in innovation and profit maximisation perspectives of operational sustainability that is characterised by the business continuity and financial performance. We propose and validate new measures to represent the dimensions of task business environment, supply chain relationships and business continuity in the conceptual model. A new theoretical view of the operational sustainability has been amassed the business continuity and the financial performance to address the timely business needs that largely absent in this body of literature. For supply chain managers, this CAS perspective offers a new perceptual model from which to view the business world that integrates the objectives of profit maximisation and innovation.

Managerial Implications

This research pioneers in informing how the nonadditive interactions between the supply chain relationship and the task business environmental dimensions stimulate the operational sustainability. The model development and empirical testing presented in this study provide an important guidance to the managers who are eventful in upholding the plant's internal fit to the supply chain by adapting the task business environment. Managers who foster the CAS view of the supply chain can develop their plants by optimising the different aspects of the challenging task business environment. Table 3 provides managerial recommendations with industrial case examples.

In fact, these interactions are becoming increasingly important as plants struggle to find ways to increase their operational sustainability with rising competition from both the internal and external parties. At the macro level, these negative effects can be hindered or positive effects can be advanced by making the strategic fit between the environmental availability and supply chain manageability. The rationale behind this is that the manufacturing plant should decide at which level the mutual benefits to be considered with supply chain partners by optimising the nonadditive interactions to promote the plant's own interests. Further, the conceptual model reinforces the CAS view of supply chain relationships in its task environment to offer a new theoretical view of the operational sustainability by employing the profit maximisation and innovation perspectives.

In conclusion, these interactions are effective strategic means of transferring the resources, knowledge and technology across the supply chain relationships that ensure the plant's operational sustainability. Through the lens of CAS, the proposed supply chain relationship dimensions and their coevolution with the task business environmental properties provide an ideal platform for the managers to develop more effective business models by facilitating the supply chain partner enabled vision for the operational sustainability. It will result in competitive advantage for the plants to stay operationally sustainable in their target markets and to approach new markets. Having a proper awareness of the interaction effects can avoid unexpected disruptions to the supplier and customer relationships and mitigate the negative impact on the operational sustainability.

Table 3: Recommendations for supply chain managers

Hypothesis	Managerial recommendations
H1a Positive Synergy	Dynamism =.08, Information Exchange = not significant, **Dynamism * Information Exchange** = .09, |.09|>|.08| Hence, it is a positive synergy. For instance, during the dynamic "Great Recession" in 2009, Toyota misinterpreted the accelerator malfunctions to human error in US market. They decided not to recall the cars with problem parts and continue the manufacturing with the same parts and it ended up with paying $1.2 billion and withdrawing eight models from the consumer recommendation label. Hence, managers must ensure the strategic fit between the available information and the market requirements to respond the dynamics in a timely manner. Further, they should encourage the customers and suppliers to inform each other about events affecting the other party including supply and demand.
H1b Positive Antagony	Dynamism = not significant, Supplier Leveraging= .31, **Dynamism * Supplier Leveraging** = .07, |.07|< |.31| Hence, it is a positive antagony. Managers must increase supplier leveraging to obtain the technological knowhow from suppliers and find applications to identify new aspects and reduce the uncertainty of innovations. For instance, Apple who remains the world's number one supply chain since 2010 grows in revenue even during the recession. Apple is best at its inventory handling with unrivalled 5 days' turnover by handling entire operation with one assembly plant in China and one central warehouse in US. Its upstream supply chain strategy accounts for around 200 suppliers for 97% of the supplies while around 600 suppliers for the rest. Apple leverages its diversified supply network for pricing, volume and strategic raw material during the dynamic economic conditions through its long term relationships and new entrances that allow competition. This helps Apple to increase the business continuity that entirely driven by design and innovation.
H2b Positive Antagony	Munificence = .20, Supplier Leveraging =.31 **Munificence * Supplier Leveraging** =.11, |.11|<|.2+.31| Hence, it is a positive antagony. Supplier leveraging helps to stay abreast with new technology tapping into external suppliers' capabilities to compensate the plant's weaknesses (Weigelt, 2013) in forms of resources, technical skills and manufacturing technologies. Although resources are readily available in munificent task environments, it is how the plant recognises, transforms and delivers resources profitably. Honda works with the strategic suppliers from an early stage of product developments with open book arrangements to continuously improve the quality, delivery and costing. It outsources nearly 75% while suppliers provide 90% of the costing details. The plant optimises the available resources and supplier diversity to fulfil the regional demand with direct contacts of around 600 suppliers in North America.
H2c Negative Anatagony and Synergy	For business continuity; Munificence= .2, Customer Leveraging = .11, **Munificence * Customer Leveraging** = -.10, |-.10| < |.2+.11| hence, it is a negative antagony and for financial performance; Munificence= not significant, Customer Leveraging = not significant, **Munificence * Customer Leveraging** = -.14 hence, it is a negative synergy. Merely possessing the customer knowledge and technology (Weigelt, 2013) does not increase the operational sustainability, rather the plant must ensure the return business and profits by focusing only on opportunities that enhance the reliability of boundary spanning processes. Yahoo, the leading business that owned 21% in online advertising by 2005 reorganised its structure to leverage the operations with key customer segments and create relatively unimportant unique customer experience in a munificent environment. Its desire to be an online portal instead of a search player failed to translate its customer base into revenue that led to near bankruptcy putting behind Google, Facebook and Microsoft.
H2d Negative Antagony	Munificence = .2, Complexity = .08, **Munificence * Complexity** = -.06, |-.06|<|.28| Hence, it is a negative antagony. Complexity based supply chain solutions can become a silent killer of manufacturing plants in munificent task environments by creating excess inventories and non-value adding activities. Compaq, the world's largest PC supplier during 1990s won an enormous credibility and a technological lead unmatched by its competitors supported by its munificent task environment including skilled employees and astute marketers. However, Compaq's acquisitions of Tandem Computers and Digital Equipment Company led a great deal of increased supply chain complexity with excess inventory and unnecessary price competitions. It wiped out a successful PC selling business from the market by 2002.

H3a Positive Antagony	Complexity=.08, Information Exchange = not significant, **Complexity * Information Exchange** = .07, |.07|<|.08| Hence, it is a positive antagony. Complex task environment urges the frequent and accurate information exchange in supply chain relationships. For instance, Zara operates more than 7000 outlets sensing both demand and supply through online platforms to enhance capacity, cost, availability and lead time far better than competitors. It follows a flat hierarchy in information exchange using newest technologies such as personal digital assistants to capture real time consumer data while centralised manufacturing with 11 plants and one warehouse dedicated to supplying. The fastest fashion chain continues to grow in profits with improved information exchange to deal with inherent complexity in supply chain and task environment.

CONCLUSION

Our primary objective of onset of conducting this study was to expand the CAS theory by exploring the nature of the interaction effects between the supply chain and the task business environment on the manufacturing plants' operational sustainability. We further dig into the dimension level interactions characterising the task business environment by dynamism, munificence and complexity and supply chain relationship by information exchange, complexity, supplier and customer leveraging. Our findings confirm to the aggregate behaviour of CAS which in forms of interactions that cannot be deducted to the manufacturing plant's behaviour on the operational sustainability. The significant synergistic and antagonistic interactions provide evidence for the nonadditive behaviour of supply chain relationships. Further, the interactions of supplier leveraging in both dynamic and munificent task environments and information exchange in the complex task environment contribute to positive antagonies of operational sustainability. The supply chain complexity and customer leveraging in munificent task environments contribute to negative antagonies of business continuity while information exchange in dynamic environment claims for a positive synergy.

Our work supplements with the CAS view of supply chain literature and provides clarity into the interaction effects of a CAS with its task environment and how the participants' operational sustainability is influenced by them. Despite a great deal of interest in the distinctive impacts of the business environmental features (Bourgeois, 1980; Dess and Beard, 1984; Ward et al., 1995) and the dimensions of supply chain relationship (Lorenzoni and Lipparini, 1999; Ofek and Sarvary, 2001; Kim et al., 2011; Williams et al., 2013) on business performance, this study emphasizes the criticality of the missing interactive effects between these two constructs on the operational sustainability. Hence, it offers a new theoretical standpoint for the concept of the operational sustainability based on the business continuity and the financial performance. Further, it integrates the CAS with literatures of supply chain and task business environment. This study offers a more rigorous and scientific analysis to the managers elucidating how to foster the CAS view of supply chain to increase the operational sustainability.

Study Limitations

The use of cross sectional data may limit the discussion of causality in which the longitudinal researches replicating this study would increase our understanding. Also, this approach relies on survey respondents to provide opinions which may have a demand characteristic rather than using externally reported information (York and Miree, 2004). The use of the existing databases sometimes affects the operationalization of constructs (Narasimhan and Jayaram 1998) as some of the relevant items in GMRG questionnaire fail in this study due to the reliability and validity issues.

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