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Structure-integration relationships in Oil and Gas Supply Chains

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Structure-integration relationships in Oil and Gas Supply Chains

1. Introduction

The traditional post-industrial classification of organizational structures as 'mechanistic' or 'organic' has evolved significantly in the last few decades. This can be attributed to emerging trends like globalization, outsourcing, unstable market dynamics, and socio-political uncertainties (Wilden et al., 2013). Today, there are several definitions of organizational structure (OS) across different disciplines, but the general consensus is that OS determines a firm's internal/external relationships, authority, and communication (Huang et al., 2010; Spiliotopoulou et al., 2015). Although theorists have used different typologies to describe the dimensions of OS, they can be generally grouped into 'structural' or 'structuring' dimensions (Daft, 2012; Dalton et al., 1980). Structural dimensions are the physical characteristics of an organization, such as the size, span of control, and hierarchical arrangement of functions (flat/tall) (Koufteros et al., 2007). In contrast, structuring dimensions refer to the policies and organizational processes, which encourage or limit the behavior and roles of employees (degree of formalization and centralization of tasks) (Thompson, 2011). Studies have shown that OS directly affects the performance and competitiveness of organizations and supply chains (SCs) (Cosh et al., 2012; Foss et al., 2015), however the relationship is not altogether straightforward, because it is contingent on the 'fit' between OS, and the operational and business strategies adopted (Koufteros et al., 2007; Wilden et al., 2013).

With the emergence of global and interconnected markets and an increase in cross-regional collaborations, competition can no longer be viewed as just among different companies, but also among SCs (Flynn et al., 2010). During this time, companies focused on developing their core competencies, and outsourced some functions that were previously done in-house. Recent conceptualizations view SCs as 'complex adaptive systems', with path dependent outcomes, self-organization, and susceptibility to slight changes at individual nodes (Carter et al., 2015). In highly complex SCs, the increased embeddedness and complementarity among nodes could significantly affect performance outcomes. Consequently, supply chain integration (SCI) has been heralded in theory and practice as an important strategy for managing the information asymmetries and uncertainties that arise in complex networks. In the extant literature, SCI is predominantly defined as the degree of strategic collaboration and sharing of intra- and inter- organizational processes/routines between partners for efficient flows of tangible/intangible resources and better synchronized SC processes (Flynn et al., 2010; Frohlich and Westbrook, 2001; Schoenherr and Swink, 2012). While there are still on-going debates on the degree of integration required to optimize performance (if any), studies have shown that SCI generally improves operational performance by promoting joint planning, value creation, and problem-solving capabilities (Flynn et al., 2010). SCI has been studied quite extensively in the manufacturing and service sectors (Nahm et al., 2003), however it has received far less attention in the extraction and energy sectors, despite the relevance of energy SCs in every industry.

Oil and gas (O&G) SCs drive global economic development by providing energy and other essential inputs required in nearly all production operations. Generally speaking, the O&G

industry faces complex internal and external challenges such as the ongoing political unrest in the Middle East, unstable production capacities, unpredictable lead times due to regional supply and global demand, as well as global logistics (Chima, 2011). As offshore O&G operations advance into more challenging environments, many O&G SCs use integrated process management systems, such as Enterprise Resource Planning (ERP), Material Requirement Planning (MRP), Collaborative Planning Forecasting and Replenishment (CPFR), and cross-docking logistics to improve their performance (Yergin, 2011). However, one of the fundamental arguments in OS literature is that performance improvements are only attained if organizational strategies "fit" the structures in which they are applied (Prajogo et al., 2016). In addition, OS is affected by a number of contingent factors and the uncertainties associated to industry dynamics, multinational companies, socio-political factors, regional O&G policies, and supra-national bodies like OPEC.

Although studies have demonstrated the importance of SCI strategies in improving communication, collaboration, and information sharing within firms and across their SCs (Koh et al., 2008), very little is understood about how the OS of focal firms affect the successful implementation of SCI initiatives across SCs. Taking into consideration the importance of the O&G industry, as well as the impact of uncertainties on OS and strategy choices, it is important to understand how OS and SCI affect the operational performance of O&G SCs. Using a global sample of 181 O&G firms, this study examines the mediating role of internal, supplier, and customer integration on the relationship among three main dimensions of OS - the degree of centralization, formalization, and hierarchical relationships - and operational performance. Operational performance in the surveyed O&G SCs is captured using widely adopted measures of cost, lead-time, quality, and flexibility. These measures have been used in previous studies to capture aspects of strategic (flexibility), tactical (lead-time), and operational (quality and cost) performance in SCs (Gunasekaran et al., 2004; Neely et al., 1995).

2. Theory and Hypotheses

2.1 Supply chain integration

Although governments and businesses have made great strides in developing alternative energy sources, long-term global energy consumption trends show that O&G consumption is steadily increasing and will continue to account for a significant portion of the global energy mix (BP, 2016). Today, O&G companies scout the globe for high-yielding offshore acreage across several new frontiers in the Middle East, Eastern Mediterranean, and deep-water blocks off the coast of Africa, Brazil, and Australia (Chima, 2011; Mitchell et al., 2012). These exploratory activities present technological, geographical and political challenges because unlike manufacturing counterparts, O&G exploration requires cooperation and complementary inputs from National oil companies (NOCs) and privately run international oil companies (IOCs) (Mitchell et al., 2012). NOCs primarily act as gatekeepers for national O&G reserves, but also participate actively in exploration endeavours upstream. IOCs and servicing companies on the other hand, compliment the NOCs with the necessary know-how for exploration, refining, and distribution owing to their comparatively advanced technical capabilities. Consequently, collaboration between the two, in terms of logistics and data/information sharing is critical; however, this could be somewhat difficult to achieve, due to slight differences in governance structures, management, and operational objectives in the public and private sectors (Chima, 2011; Prajogo et al., 2016; Yergin, 2011).

In such dynamic environments, specific SCs have to be configured by focal firms for each tenured O&G project, and in line with the most recent changes in the external environment (Wycisk et al., 2008). Modern theories of supply chain management describe SCs as 'complex adaptive systems', because they are constantly reconfigured and managed through the co-evolution of NOCs, IOCs, contractors, consumer market, demand patterns, institutional and political factors (Carter et al., 2015; Choi et al., 2001). In practice, NOC's key customers could be IOCs or local O&G companies (petrochemical and refineries), and their key suppliers could be local suppliers, IOCs, or contractors/subcontractors of IOCs. Thus, project performance is directly or invariably linked to the degree of SCI between O&G companies and their key partners on each project.

The predominant view on SCI in the extant operations and supply chain management literature is that it measures the degree of synchronization of tangible material flows (Frohlich and Westbrook 2001, Schoenherr and Swink 2012), intangible information and knowledge flows (Spiliotopoulou et al., 2015), and strategic relational flows across a SC (Flynn et al., 2010; Zhao et al., 2011). SCI is either pursued *internally* across the functional units of a focal firm, or *externally* with relevant tiers of customers and suppliers (Wiengarten et al., 2015). By developing a framework comprising of five "arcs of integration", Frohlich and Westbrook (2001) demonstrated that high degrees of external integration with customers and suppliers results in better SC lead-time, quality, cost, and flexibility. Although there are some notable exceptions, other empirical studies on SCI have since validated this claim (see Childerhouse and Towill, 2011; Schoenherr and Swink, 2012).

Internal or cross-functional integration is also critical for complex adaptive SCs operating in uncertain industries (Carter et al., 2015). O&G projects are prone to several interconnected elements of risk, which affect all material, information, and strategic interactions (Revilla and Saenz, 2017; Wiengarten et al., 2015). These risks include financial (e.g. costs recovery risks, invoicing/payment risks, lawful levies), technical (e.g. engineering design risks; procurement risks, construction, fabrication and installation risks), and economical (e.g. enterprise risks, liquidity and settlement risks, economic lifecycle management risks) issues, amongst other important risk factors (e.g. commercial, legal, fiscal, environmental, technological). Proponents of internal integration in O&G projects have argued that it is more efficient to identify and manage the different elements of risk concurrently at the supplier selection and contracting phases, with the help of capable cross-functional teams (Ebrahimi and Shiravi, 2009; Shiravi and Ebrahimi, 2006). However in practice, many of these risks are appraised independently in different functional units (departments) and this increases the tendency to misidentify the overlapping aspects of such risks. Nonetheless, there are mixed findings regarding the impact of SCI on operational performance. While most authors have empirically demonstrated the positive impact of SCI (Flynn et al., 2010), other studies produced mixed findings (Schoenherr and Swink, 2012) and some have even reported negative relationships, particularly between external integration and performance (Koufteros et al., 2010).

2.2 The structure-strategy-performance interaction: A contingency perspective

Improving operational performance through SCI is partly dependent on the fit between adopted integration strategies and specific operational demands or challenges. External integration improves coordination and collaboration among NOCs, IOCs, and contractors by fostering effective communication and information sharing. Internal integration, on the other hand, enables functional units to develop the capabilities required to adequately identify risks, select clients and manage the information asymmetries associated with uncertainty. However, according to classical arguments in organizational science, strategies must also match the organizational characteristics and structures of firms (Mintzberg, 1979). There are several conceptualizations of the dimensions of OS, however despite differences in terminologies, they can be broadly categorized as 'structural dimensions', such as the level of hierarchical relationships in an organization, and 'structuring dimensions', such as formalization and centralization. Structural dimensions determine the physical structure of organizations and ascribe a hierarchical order to the functions within it. Structuring dimensions by contrast, dictate the policies and actions adopted to encourage or limit the behaviour and roles of employees (Daft, 2012; Dalton et al., 1980).

Generally speaking, structural and structuring dimensions have been used to classify organizations as either "organic" or "mechanistic", and viewed as polar extremes with contrasting levels of formalization, centralization, number of layers, and horizontal relationships (see Daft, 2012). Firms with mechanistic structures have highly centralized authority, formalized tasks/routines, and several hierarchical layers. The employees in such firms are mandated to act in line with their job descriptions, with minimal cross-functional engagements (Cosh et al., 2012; Huang et al., 2010; Koufteros et al., 2007). These organizations typically need tight supervision from high-level managers and function under rigid regulations and well-defined procedures. Organic structures on the other hand, have lower levels of centralization, formalization, and fewer layers of organizational hierarchy (Ji and Dimitratos, 2013). Although previous studies have provided useful insights into the dynamics of mechanistic and organic OS, there are still mixed findings regarding the optimal structure for effective operational performance based on these broad categorizations (Cosh et al., 2012; Daft, 2012; Huang et al., 2010).

Drawing on the structural contingency theory, OS, strategy (SCI), and context (e.g. environment, suppliers, customers) must fit in order to achieve better performance outcomes (Csaszar, 2012; Lin and Germain, 2003; Wilden et al., 2013). Thus, rather than taking the deterministic logic that O&G firms need a particular structure to implement SCI successfully, or assuming that "all cases differ", this study takes a contingency approach to examine how the fit between structure (OS) and strategy (SCI) impacts the performance of O&G SCs (Cosh et al., 2012; Germain et al., 2008).

2.3 Centralization and operational performance: The mediating role of SCI

Centralization refers to the locus of decision-making in an organizations hierarchy (Claver-Cortés et al., 2012; Daft, 2012). Organizations are considered centralized when all decision making follows a sequential top-down fashion, from higher levels of managerial responsibility to lower levels. In decentralized organizations, line managers can delegate decision-making responsibilities to subordinates as the need arises (Beheregarai et al., 2014; Daugherty et al., 2011). In a sense, centralization refers to the dispersion or concentration of decision-making autonomy in a firm (Nahm et al., 2003; Spiliotopoulou et al., 2015). There are two main aspects: first, the extent to which employees are free to carry out assigned tasks without interruptions from superiors; secondly, the degree to which employees participate in decision-making processes (Huang et al., 2010; Ji and Dimitratos, 2013; Koufteros et al., 2007). With the exception of a few studies (e.g. Lin and Germain, 2003), the main body of literature suggests that lower centralization improves organizational performance at functional, organizational, and SC levels (Cosh et al., 2012; Daugherty et al., 2011; Foss et al., 2015; Huang et al., 2010). The main argument is that low centralization encourages communication, improves job satisfaction, and fosters employee creativity and intuition (Csaszar, 2012; Huang et al., 2010). This encourages “lateral and vertical” communication, and allows ‘expert opinion’ to precede ‘designated authority’ when necessary (Daugherty, 2011; Hempel et al., 2012; Ji and Dimitratos, 2013). Experts in such organizations may feel a greater sense of empowerment and responsibility, and would more likely generate innovative solutions to operational problem as they arise. Accordingly, companies with centralized OS tend to have greater communication and information asymmetries across functional units and in their collaborations with other firms (Spiliotopoulou et al., 2015).

In relation to operational performance, it has been reported that low centralization improves lead-time by reducing the bottlenecks in reporting lines for decision-making (Nahm et al., 2003). It further enables efficient internal communication (Csaszar, 2012; Huang et al., 2010), and increases employee participation and creativity (Ji and Dimitratos, 2013; Koufteros et al., 2007). O&G companies usually have multiple concurrent projects, so they sometimes adopt a temporary organizational and financing structure called ‘special purpose vehicles’ (SPVs) to distinguish project assets and operating structure from those of the focal firm/sponsor, and to enable the financing and assessment of each project based on the resource flows they generate (Mitchell et al., 2012; Silvestro and Lustrato, 2014). Therefore it is important to empower employees to engage in teamwork both within and outside their firm boundaries. However, the bureaucratic structuring of decision making in highly centralized firms could reduce the speed and efficiency of resulting SPVs, and impact long-term project success (Huang et al., 2010; Wilden et al., 2013). It has also been suggested that low centralization increases organizational flexibility, responsiveness, information distribution, knowledge gathering, and ability to cope with external uncertainties (Cosh et al., 2012; Hempel et al., 2012). In highly centralized structures, line-managers are required to refer the smallest operational matters to someone higher up the hierarchy for a final decision, which tends to slow down internal processes and the overall operational performance (e.g. lead-time, flexibility) of other interrelated operational units. Organizations with lower centralization on the other hand, improve the deployment and flexibility of operational expertise (Huang et al., 2010), which is important for O&G companies requiring a lot of technical knowledge to successfully carry out projects.

H1a. *Centralization is negatively related to operational performance.*

It is generally agreed that in volatile industries, timely flow of data and information across internal departments and teams is required. In highly centralized companies, the negative impact of centralized decision-making could be reduced by improving and synchronizing internal information sharing capabilities. This enables the generation of knowledge beyond departmental boundaries, and encourages managers to make highly informed and integrated decisions (Koufteros et al., 2010; Zhao et al., 2011). The close interactions between O&G companies and their external partners occur in oilfields and project sites, usually involving operational and mid-level management. When operational decisions are highly centralized, the efficiency of managers is hampered since they may not be permitted to use their latent experience for timely decision-making. A routine breakdown of some drilling equipment, for instance, would require the sourcing manager to get approval from other departments and supervisors, before orders are made to suppliers. Through supplier integration, the efficiency of critical information, material, and relational flows with suppliers is improved, and this fosters better coordination, cooperation, and communication among operational level experts located at different nodes within a SC (Droge, et al., 2012; Koufteros et al., 2012).

Similarly in such structures, the delivery-time of equipment could be prolonged, if line level experts are not given authority to effectively deal with customer request. Having a good level of customer integration allows customers to directly contribute to the focal company's strategies by providing information on changing preferences to improve decision-making (Beheregarai et al., 2014). Therefore, customer integration helps focal firms to better understand the service requirements, preferences, and policies of different tiers of customers. This study proposes that internal, customer, and supplier integration mediates the adverse impact of centralization by improving material, intangible, and relational flows at strategic, tactical, and operational levels among a focal O&G company and its partners.

H1b: *Internal integration mediates the negative impact of centralization on operational performance.*

H1c: *Supplier integration mediates the negative impact of centralization on operational performance.*

H1d: *Customer integration mediates the negative impact of centralization on operational performance.*

2.4 Formalization and operational performance: The mediating role of SCI

Formalization can be defined as the extent to which employees are given standardized rules, regulations, and processes (Daft, 2012; Ingvaldsen, 2015; Liao et al., 2011). It represents the degree to which the rules guiding the behaviors and activities of employees are clearly coded and documented (Claver-Cortés et al., 2012; Cosh et al., 2012). It is important to distinguish between two forms of formalization namely; (1) formalization of routine company practices/procedures, and (2) formalization of non-routine practices/procedures (Adler and Borys, 1996; Daugherty et al., 2011). There are conflicting arguments regarding the impact of both forms of formalization on operational performance. Some argue that if a minimum level of formalization does not exist, it could result in role ambiguity (Cosh et al., 2012; Hempel et al., 2012). Similarly, others have suggested that formalization reduces conflicts in routine practices because roles are clearly documented (see Thompson, 2011).

However a rich stream of literature indicates that highly formalized structures have a negative impact on staff motivation, autonomy, innovation and performance (Daugherty, 2011; Ingvaldsen, 2015). This is because high formalization could limit individual freedom and the discretion needed to carry out tasks in dynamic environments (Koufteros et al., 2007; Wilden et al., 2013). In highly formalized organizations, employees may be discouraged from actively generating new ideas (Ingvaldsen, 2015; Liao et al., 2011). Likewise, it has been suggested that high formalization could also constrain flexibility, communication, and employees' ability to adjust to non-standardized/non-routine job environments (Daugherty et al., 2011; Hirst et al., 2011). O&G companies frequently face non-routine challenges (e.g. drilling failure or reservoir leaks), and it is sometimes essential to be able to make speedy decisions using informal rules (Hempel et al., 2012). Nevertheless, due to high-risk levels, O&G companies are known to implement rigid routines and processes. While there are clear benefits of formalized routine processes, the evidence from previous studies overwhelmingly supports lower formalization of non-routine processes, particularly in volatile environments.

H2a: *Formalization is negatively related to operational performance.*

Highly formalized OS tend to create greater isolation among senior management, functional unit managers, and operational field employees (Ingvaldsen, 2015; Liao et al., 2011). By codifying responsibilities and closely supervising individual roles, formalized firms may restrict the propensity of operational or mid-level managers to take initiative when faced with challenges at offshore locations. It has been noted that internal integration enables the development of systematic coordination between departmental functions, which improves risk identification and problem-solving (Shiravi and Ebrahimi, 2006). Therefore with high internal integration, employees in formalized organizations may be empowered to share knowledge through cross-functional interactions, which could mediate the negative impact of high formalization on operational performance.

It has also been argued that highly formalized structures tend to constrain communication and trust, and significantly affect the "human-touch" in the relational dynamics between focal firms, suppliers and customers (Daugherty, 2011; Hirst et al., 2011; Wilden et al., 2013).

Relationships are perhaps the most crucial success factor in the O&G industry due to the complicated and highly uncertain nature of operations. Accordingly, supplier and customer integration could help focal companies to share operational, financial, and strategic knowledge with their partners for mutual benefits (Droge et al., 2012), thus making information accessible at different hierarchical levels. In other words, information that is ordinarily strategic in formalized OS becomes available at operational level. The O&G industry is fraught with political, regional, supra-national, and economic uncertainties, therefore formalized non-routine policies/procedure could limit the effectiveness of operational or mid-level managers in the frontline with clients and suppliers. Internal, customer, and supplier integration could thus help O&G companies to better manage uncertainties, build relationships, and establish more trust. Even in cases where some degree of formalization is required, this study argues that internal, supplier, and customer integration could serve to counter or mediate the negative impact of high formalization on operational performance.

H2b: *Internal integration mediates the negative impact of formalization on operational performance.*

H2c: *Supplier integration mediates the negative impact of formalization on operational performance.*

H2d: *Customer integration mediates the negative impact of formalization on operational performance.*

2.5 Hierarchical relationship and operational performance: The mediating role of SCI

Hierarchical relationship is the extent to which a firm has a few (flat), or many levels of reporting (tall) within its organizational hierarchy (Huang et al., 2010; Ji and Dimitratos, 2013). In simpler terms, it refers to the number of managing levels in a company's chain of command (Jacobides, 2007; Nahm et al., 2003).

In taller OS, decisions have to pass through several layers of management that are not directly in the 'trenches', which could affect decision quality and lead-time (Huang et al., 2010; Koufteros et al., 2007). Furthermore hierarchical relationship could negatively impact communication, control, and coordination, amongst organizational members (Jacobides, 2007; Ji and Dimitratos, 2013; Koufteros et al., 2007). With more layers of hierarchy, communication channels become complex and the quality of feedback from supervisors to subordinates is standardized and diminished (Foss et al., 2015; Huang et al., 2010). The disadvantages of a taller OS are more evident in uncertain environments where several issues need to be resolved concurrently. In tall structures, the aptitude to identify, report, and resolve potential challenges at operational level is weakened. For example, a well manager who is more knowledgeable on well consolidation processes by virtue of his/her role, would need several levels of approval in order to present optimization suggestions to top management.

***H3a**. Hierarchical relationship is negatively related to operational performance.*

Having several hierarchical divisions between strategic-level and operational managers could obstruct relational, information, and knowledge flows. O&G companies with such structures could therefore suffer operational setbacks due to hierarchical and departmental bureaucracies. However, with high internal/cross-functional integration, such firms can better navigate these hierarchical bureaucracies by using the synergies among functional-units to reduce the 'structural holes' imposed by several reporting lines (Foss et al., 2015). In O&G companies with tall OS, direct interactions between operational-level managers and their counterparts are very impersonal and often slow due to several lines of reporting, however supplier integration strategies could foster mutual understanding between focal companies and key supplier because the transactive memory acquired from previous interactions can be readily applied to problem solving. This could serve to counter the effect of multiple reporting lines on operational decision-making processes (Huang et al., 2010; Ji and Dimitratos, 2013).

Similarly, high levels of hierarchy affect the relationship between focal firms and customers. For example, when there are changes in customers' specifications and requirements, field experts may often need to pass through multiple levels of departmental approval, which could adversely affect project lead-times (Droge et al., 2012; Jacobides, 2007). However, through high customer integration, different levels of management can concurrently access vital/time-sensitive information, thereby improving the problem solving capabilities and response time. Thus it is proposed that internal, supplier, and customer integration mediates the negative impact of hierarchical relationship on operational performance.

***H3b:** Internal integration mediates the negative impact of hierarchical relationship on operational performance.*

***H3c:** Supplier integration mediates the negative impact of hierarchical relationship on operational performance*

***H3d:** Customer integration mediates the negative impact of hierarchical relationship on operational performance.*

Figure 1 below illustrates the theoretical framework with the direct and mediating hypotheses proposed.

Insert figure1

3. Research Methodology

3.1 Survey design and sample

The O&G companies surveyed for this study included NOCs, IOCs, contractors, sub-contractors and other oil servicing companies, which were identified using databases such as RIGZONE, Pegasus, O&G Directory Middle East, O&G UK, and also the research teams own high-level industrial contacts. The questionnaire items for all variables were measured on a 7-point-likert scale and adapted from key studies on OS and SCI as itemized in Appendix A. Pilot studies involving strategic C-level managers (3), SC and purchasing professionals (4), and project and operations managers (3) were conducted to refine the questions. Respondents were subsequently contacted via email with an online, 25 minutes self-administered survey, reflecting on key O&G projects involving operations with key suppliers and customers, between October 2013 and March 2014. A total of 740 questionnaires were administered to O&G companies across the Middle East, Africa, Europe, North America, South America, and Asia. In total, 207 completed questionnaires were received and 23 responses were eliminated due to significant incompleteness. A total of 181 usable responses were used, which represents a response rate of 28%, similar to previous studies (Frohlich, 2002). Around 63% of the 181 responses were sampled from databases, while 27% were from personal contacts. Given the nature of the O&G industry and the limited players (oligopoly), convenience sampling was more effective in reaching inaccessible respondents with minimal information on formal databases. Statistical tests were carried out to ensure that there were no biases related to common methods, non-response and other reliability and validity issues. The tests conducted showed no significant difference in the t-test of mean scores between early and late respondents. Table 1 shows a demographic distribution of the study respondents.

Insert table1

3.2 Measures and control variables

Centralization was measured in terms of the level of participation (of operational managers) in decision-making and hierarchy of authority - items were adapted from Koufteros et al. (2007), Huang et al. (2010) and Liao et al. (2011). Formalization was measured in terms of level of job codification and rule observation - items were adapted from Lee and Grover (1999) and Liao et al. (2011). Hierarchical relationship was measured in terms of the degree of 'tallness' or 'flatness' determined by the average span of control. The items used were adapted from Nahm et al. (2003), Koufteros et al. (2007), Huang et al. (2010) and Turkulainen and Ketokivi (2012). For internal, supplier, and customer integration, the items were adopted from Flynn et al. (2010). To measure operational performance, four qualitative and process-based measures were explored as a single construct (Gunasekaran et al., 2004; Neely et al., 1995). This included qualitative measures of operational cost (ISO, 2001), process lead time (Tersine, 1994), process quality (Kim et al., 2012) and process flexibility (Sanchez and Perez, 2005). The study controlled for the size of the O&G operations measured in terms of the number of suppliers/customers, average sales and operational expenses. While most studies measure size in terms of number of employees, organizational size can also be measured in terms of: 1.physical capacity, 2.number of personnel available, 3.inputs or outputs, and 4.number of discretionary resources available (Kimberly, 1976). Since the aim of this study is to understand the impact of OS and SCI on operational performance in O&G SCs, size is conceptualized in terms of the scale of operational inputs and outputs in the companies sampled. The study also controlled for the region (location) of upstream O&G operations/resources.

3.3 Analysis

Structural equation modeling (SEM) was used to analyze the data collected to establish causal links among the variables explored. First, an exploratory factor analysis (EFA) was carried out to validate the proposed measurement model using SPSS. Subsequently, a confirmatory factor analysis (CFA) was conducted to assess the adequacy and fit of the measurement model, after which the structural path model was determined using AMOS 22 (Byrne, 2013). Preliminary data screening was carried out for outliers, missing variables, skewness and kurtosis. The final data sample was sufficiently symmetric and all the variables fell within the acceptable range for skewness (-.5 + 5) and kurtosis (>/< +/- 1)(Pallant, 2010).

3.4 Exploratory Factor Analysis

A total of 68 items (4-centralization, 4-formalization, 4-hierarchical structure, 9-internal integration, 11-customer integration, 13-supplier integration, 23-operational performance) were subjected to an EFA. The KMO measure of sampling adequacy (0.964) and Bartlett's test of sphericity were also adequate, thus rejecting the null hypotheses that the correlation matrix was proportional to an identity matrix (χ^2 (2278)=17957.406, P<.001). Subsequently, a principal component analysis using Varimax rotation was carried out on the 68 items. Varimax rotation was chosen because it maximizes the extent of variance explained by the factors, while minimizing the correlation amongst the factors. The communalities for all items were above the 0.50 benchmark.

Using the Kaiser-Guttman criterion to retain components with eigenvalues greater than 1, a seven-factor measurement component matrix was extracted, which explained about 83.58% of the total variance in the model (Hair et al., 2006). Complimentary scree-plots also confirmed the seven-factor structure (Figure 2). As shown in Table 2, the factor loadings for all components based on the rotated component matrix were above the theoretical benchmark of 0.5 (Hair et al., 2006).

Insert figure2

Insert table2

3.5 Confirmatory Factor Analysis

The overall fit of the seven-factor measurement model was acceptable based on the adequacy and cut off criteria by Byrne (2013) of key parsimonious and non-parsimonious fit indices. They include; Chi-square (χ^2)=3237.482, degrees of freedom (df)=2169, chi-square goodness of fit (χ^2/df)=1.493, comparative fit index (CFI)=0.942, parsimony comparative fit index (PCFI)=0.897, Normed fit index (NFI)=0.843, root mean squared error of approximation (RMSEA)=0.052, and PCLOSE=0.154. After the measurement model was identified by constraining an item for each construct to 1, the variance inflation factor (VIF) for all construct was within the cut-off point of 10 for multicollinearity (Byrne, 2013).

3.5.1 Validity and Reliability

In testing for convergent validity, the average variance extracted (AVE) for all the constructs measured was above the 0.50 benchmark, with the lowest construct having an AVE of 0.874. This implies that each construct explains more than half of the variance among its items. The seven-factor model also met the Fornell–Larcker criterion for discriminant validity (Hair et al., 2006). In relation model reliability, the Cronbach's alphas and composite reliability (CR) values for every construct met the acceptable threshold as shown in Table 3 below.

Insert table3

3.5.2 Common Methods Bias and Measurement Model Invariance Tests

The single latent factor approach was used to check for possible common methods bias from using a single questionnaire for all the variables explored (Podsakoff et al., 2003). The results did not indicate a significant difference in the standardized regression weights when the common latent factor was added, thus indicating that there was no common methods bias. Additionally, metric and configural measurement model invariance tests were conducted to examine if the factor structure of the measurement model was consistent for multi-groups within the data sample (e.g. Sector=upstream and midstream/downstream; ownership=public, and public/private). A non-significant chi-squared difference was obtained for both the unconstrained (χ^2=19056.6; df=10845) and the fully constrained models for the tested multi-groups, signifying good metric invariance. In addition, a comparison of the standardized regression weights and critical ratios for the differences in regression weights also yielded non-significant z scores for all the items at p-value <0.05. The direct and mediation tests were conducted independently on the full model while controlling for operational size, and region to ensure accuracy and clarity in reporting.

4. Results and Discussion

Table 4 presents the standardized path coefficients and p-values for the direct relationships among the OS variables and operational performance. The results show that, as hypothesised in H1a, H2a and H3a, centralization (-.31) formalization (-.197) and hierarchical relationship (-0.21) each had a significant negative impact on operational performance, in terms of the cost, quality, lead-time and flexibility of O&G SCs. This finding implies that the operational performance of O&G SCs is negatively affected where focal companies are highly mechanistic in terms of the relative level of participation in decision making (centralization), level of job or task codification (formalization), and the span of control for decision making (hierarchal relationships). Table 5 reports the mediated path coefficients through internal (H1b, H2b, H3b) supplier (H1c, H2c, H3c) and customer integration (H1d, H2d, H3d). Findings indicate a significant drop in the path coefficients (β) when the SCI mediators were introduced to direct relationships between centralization, formalization, and hierarchical relationship, and operational performance. The data was bootstrapped to 2000 samples and the standardized indirect effects for all paths, which measures the strength of the mediation, was significant at 95% confidence interval (Hayes and Preacher, 2013). As hypothesized, the results indicated partial mediation, suggesting that high internal, supplier, and customer integration between O&G companies and their partners mediates the negative impact of high centralization, formalization, and hierarchical relationship on operational performance. The overall fit of the hypothesized structural model was adequate (χ^2=3398.686, df=2306, χ^2/df=1.474, CFI=0.941, NFI=0.837, RMSEA=0.051 and PCLOSE=0.277). These findings are further discussed below.

Insert table4

Insert table5

In this study, it was found that centralization, formalization, and hierarchical relationship had a significant negative impact on the operational performance of O&G SCs. This could imply that highly centralized O&G companies slow down or obstruct communication and information flow. For example, if an O&G engineering manager had to refer the smallest operational matters to someone higher up the hierarchy, this could diminish the process lead-time of other departments like procurement and construction.

As argued, firms with high formalization rely on strict supervision of day-to-day operations. In highly volatile operating environments, this constrains flexibility, risk identification, and proactive problem solving. Employees in the O&G industry are skilled and professional and their experience, training, and academic/professional qualifications usually entitle them to better judgment on non-routine policies/processes in daily operations. For instance, if a valve problem suddenly occurs at a remote offshore location, strict (rigid) supervision and formalized rules may be useful, but could also have costly effects when site-commissioning managers strictly adhere to protocol (waiting for approval). Such lengthy and formal protocols may affect the entire process quality and lead-time of the project, and could be costly in terms of damages.

Likewise, the study reported a negative relationship between hierarchical relationship and operational performance. This implies that O&G companies with several layers of hierarchy could restrict the aptitude of operational level managers, to identify potential risks and initiate process improvements. With a highly skilled workforce, many of the process improvements in this industry are adapted from best practice companies or developed locally amongst operational experts and approved by top management. Several levels of reporting could lead to higher costs, lead-time and lower flexibility in adapting best practices or developing new solutions for approval. For instance, a team of well/drilling managers and experts could modify and recommend more effective oil well consolidation practices based on their collective experience (e.g. act of drilling from one to multiple wells from a single pad). In tall OS, such individuals would need several levels of departmental approvals from regional/divisional heads, before such ideas are presented for consideration and possible adoption by senior management. The layers of hierarchy serve to slow down communication and coordination, and may even affect the accuracy of reporting because ideas travel through several layers of hierarchy.

It was found that high internal integration positively mediates the (negative) relationships between centralization-operational performance, formalization-operational performance, and hierarchical relationship-operational performance. O&G companies operate in unpredictable environments and constantly struggle with several overlapping elements of risks as explained earlier. Interdepartmental integration through brainstorming, periodic meetings, and collaborative planning using synchronized operating platforms, enables the development of cross-functional teams. As such, high internal integration encourages joint risk identification, appraisal and mitigation even in very centralized firms. For instance, in order to develop or extend a firms drilling capabilities, high integration through cross functional teams would allow operational managers from various relevant sub-units to collaboratively develop the most cost-effective solutions and dampen the effect of low managerial autonomy imposed by high levels of centralization.

Likewise, formalization creates isolation among employees as a result of codified responsibilities and tight supervision. This often hampers the ability of project managers to take initiative and proffer solutions as soon as operational problems occur. Also, since most projects involve collaborations between NOCs and IOCs working under non-routine policies/procedures, high formalization can impose serious constraints on operational performance due to the differences in operating policies and governance structures of NOCs and IOCs. By adopting internal integration strategies, cross-functional teams are able to learn and adapt faster; drawing on a wide assortment of expertise and experience. O&G firms with several hierarchical divisions between strategic and operational managers (tall OS), experience obstruction in information flow and the ability of operational managers to identify and overcome challenges in a timely/cost effective manner. To reduce exploration and production costs, many O&G companies today source for services from low cost countries like China. While these countries may have the required know-how, the risk management requirements are accentuated because firms need to ascertain that the quality of the products and services purchased meet the legal, social and ethical standards of the industry. Due to the nature of O&G exploration, regulatory requirements are prone to constant changes and updates. High internal integration between the procurement department and the engineering and technical departments is crucial for smooth communication of new standards and procedures. In the absence of strong cross-functional integration strategies, firms with tall OS would usually wait for longer periods for such crucial information to trickle down to operational levels through stacks of bureaucratic layers. Internal integration thus serves as a cost-effective by-pass to bureaucracy; the alternative being an expensive organizational restructuring.

High supplier and customer integration was found to positively mediate the (negative) relationships between centralization-operational performance, formalization-operational performance, and hierarchical relationship-operational performance. As argued previously, in O&G companies with high degree of centralization, operational level managers are not given the necessary authority to deal with day-to-day challenges effectively. In such structures, something as common as a breakdown of routine drilling equipment (e.g. rotary hose and water tanks) would require the sourcing manager to get approval from departmental heads and supervisors, before orders can be placed to suppliers, with adverse consequences on process quality and lead-time. One major issue affecting the industry is scarcity of inputs in terms of qualified labor, raw materials and metals, rigs, vessels and other services. For instance, the demand for steel currently far outweighs the supply in the industry, and it usually attracts a high premium to secure enough steel for new projects. Consequently, mismatches between supplier's lead-time and project lead-time could be very costly.

In addition, highly centralized O&G firms may lack the flexibility required to alter order lot-sizes in sync with supplier's output. However, through customer and supplier integration, even highly centralized firms can align their processes and demand to their supplier's capabilities, thus dampening the costly effect of high centralization on lead-time. Through effective supplier integration (synchronized-ordering-systems), sourcing managers and their external counterpart are better equipped to coordinate and manage processes, despite the constraints placed by their internal OS. Similarly, when centralization is high, a customer service manager may be constrained to effectively deal with the request of several customers in a correct and timely fashion. In the O&G industry, there are several nested customers within a project (IOCs/NOCs), who may not be the final customers of the project output, but may have conflicting requirements and commitments. Some customers may have overlapping commitments with other concurrent O&G projects. Customer integration therefore, helps the focal company to better understand the requirements of all tiers of customers in terms of their service requirements, preferences, timing, and policies. Furthermore, O&G companies with formalized non-routine policies/procedures restrict operational managers from promptly reacting to external uncertainties.

High formalization of non-routine policies/procedure also restricts the efficiency with which operational managers handle customer challenges as described earlier. O&G firms with several hierarchical relationships tend to move the locus of decision making further away from the operators, although they are often required to work offshore for months on end. This can have adverse effects on key performance measures like cost, quality, lead-time and flexibility, particularly when there are disruptions to normal process flows. By implementing supplier integration strategies, mutual understanding is fostered between focal companies and key suppliers, and the transactive memory acquired from previous interactions can be applied to problem solving by operational experts on both sides (e.g. strategic partnerships with major suppliers). For example, if a drilling failure occurs, such companies could react more effectively by including hands-on well and drilling managers. If new equipment are required, the well manager could interact with suppliers on specifications without the need for higher departmental approval. Customer integration can also have a dampening effect on the negative consequences of tall OS. If there are sudden alterations to customer specifications (supply disruptions or changes in demand), the first individual to know of such changes and its implication would be the operational manager dealing directly with the clients. With high customer integration, information about such sudden changes would be available to all concerned levels within the OS simultaneously, which reduces the overall response lead-time in tall OS. Therefore a good level of customer integration fosters the development of operational capabilities beyond hierarchical distinctions.

5. Conclusion, implications and future research

By including insights from the contingency theory, this study developed and validated a framework to explain the effect of SCI on OS and performance in O&G SCs. Results of the study indicated that as O&G companies develop SCI capabilities, the negative impact of highly mechanistic structure on operational performance is diminished. In line with previous studies, it was found that lower levels of centralization (Cosh et al., 2012; Foss et al., 2015), formalization (Daugherty, 2011; Ingvaldsen, 2015, Wilden et al., 2013), and hierarchical relationships (Huang et al., 2010; Koufteros et al., 2007) improve organizational performance. Contrary to some authors that have argued for more rigid structures (Lin and Germain, 2003), this study shows that internal, supplier, and customer integration mediate the negative relationship between OS and performance. This resonates with previous studies that have used strategies such as SCI as mediators to improve organizational performance (Droge et al., 2012; Koufteros et al., 2012). The study contributes directly to the organizational literature by clarifying the organic and mechanistic dichotomy and distinguishing between the "structuring" and "structural" dimensions of OS. It also demonstrates that structuring dimensions such as formalization and centralization had a more significant impact on operational performance. The study further adds to operations management literature by demonstrating the role of internal and external SCI on performance improvement, especially in uncertain and volatile operating environments, with implications for practitioners. Restructuring and reforming rigid OS could be expensive and difficult to implement in practice. However it was demonstrated that, by investing in internal and external integration strategies, firms could mediate the negative impact of highly mechanistic OS on operational performance. As inter and intra firm integration and communication improve, mechanistic firms can gradually become more organic in their operations without the associated lead-time and cost implications of re-structuring the entire organization.

Although this study offers significant insights, there are some limitations and opportunities for future research. First, while findings suggest that integration helps mediate the adverse effect of mechanistic OS, it may be useful for future researchers to conduct longitudinal studies to monitor the effect of long-term internal and external integration on OS and performance. Secondly, it would be interesting to expand the scope of study beyond the O&G industry to include other extraction-based industries. Lastly, future studies may examine the impact of the interaction effects between the SCI dimensions (internal, customer, and supplier integration) on OS (centralization, formalization and hierarchical relationships) and operational performance to better understand how each dimension of integration affects the performance of other dimensions.

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Appendix-A Measures

Centralization
The power to make considerable operational decisions is concentrated in the organization
Even small operational matters have to be referred to someone higher up the hierarchy for a final decision
Your firm senses that staff would need a great level of control over their responsibilities
Your company encourages lower level (middle managers) participation in operational decision-making process where problems occur

Formalization
Your firm has formal strategic planning processes, which result in a written mission, long-range goals and strategies for implementation
Your company has strategic plans (coded&put in writing) to respond to customer/supplier
Your firm relies on strict supervision (rules&procedures) in controlling day-to-day operation
If a written rule does not cover some situation, staff make up informal rules for carrying out their tasks

Hierarchical relationship
A large hierarchical distance exists between operational managers and senior executives
We have a tall OS
There are many levels in our organizational chart
Our organization structure is relatively flat

Internal integration
"Data integration among internal functions"
"Enterprise application integration among internal functions"
"Integrative inventory management"
"Real-time searching of the level of inventory"
"Real-time searching of logistics-related operating data"
"The utilization of periodic interdepartmental meetings among internal functions"

"The use of cross-functional teams in process improvement"
"The use of cross-functional teams in new product development"
"Real-time integration and connection among all internal functions from raw material management through production, shipping, and sales"

Supplier integration
"Information exchange with our major supplier through information networks"
"The establishment of quick ordering systems with our major supplier"
"Strategic partnership with our major supplier"
"Stable procurement through network with our major supplier"
"The participation level of our major supplier in the process of procurement and production"
"The participation level of our major supplier in the design stage"
"Our major supplier shares their production schedule with us"
"Our major supplier shares their production capacity with us"
"Our major supplier shares available inventory with us"
"We share our production plans with our major supplier"
"We share our demand forecasts with our major supplier"
"We share our inventory levels with our major supplier"
"We help our major supplier to improve its process to better meet our needs"

Customer integration
"Linkage with our major customer through information networks"
"Computerization for our major customer's ordering"
"Sharing of market information from our major customer"
"Communication with our major customer"
"The establishment of quick ordering systems with our major customer"
"Follow-up with our major customer for feedback"
"The frequency of period contacts with our major customer"
"Our major customer shares Point of Sales (POS) information with us"
"Our major customer shares demand forecast with us"
"We share our available inventory with our major customer"
"We share our production plan with our major customer"

Operational performance
Quality
Rate the level of your company's ability in utilizing information/data from quality programs
Rate the level of your company's supplier surveys, which indicate the level of qualities set or met by your suppliers
Rate the level of your company's quality systems, which measure and monitor the standard of

internal quality

How well does your quality management practices determine and reduce defective, failed, or non-conforming item, during or after inspection

Lead-time

Rate the level of your company's order process for supplier selection

Rate the level of your company's system/methods for sending orders to suppliers

Rate the level of your supplier's delivery ability/speed.

Rate the level of your company's adherence to deadlines set by clients.

Flexibility

Rate the level of your company's capability to discover alternative suppliers for each of its components and raw materials.

Rate the level of your company's ability to have access to widespread and alternative equipment in different regions.

Rate the level of your company's ability to introduce new/alternative incentive criteria for supply of equipment.

Rate the level of your company's responsiveness to changes occurring in industry business practices

Cost

Capital cost:

Rate the level of your company's design cost

Rate the level of your company's equipment costs

Rate the level of your company's fabrication costs

Rate the level of your company's installations costs

Rate the level of your company's commissioning costs

Rate the level of your company's insurance spare costs

Rate the level of your company's project reinvestment cost

Operating costs:

Rate the level of your company's man-hour costs for each function

Rate the level of your company's spare parts costs for each unit

Rate the level of your company's energy consumption costs

Rate the level of your company's logistics support costs

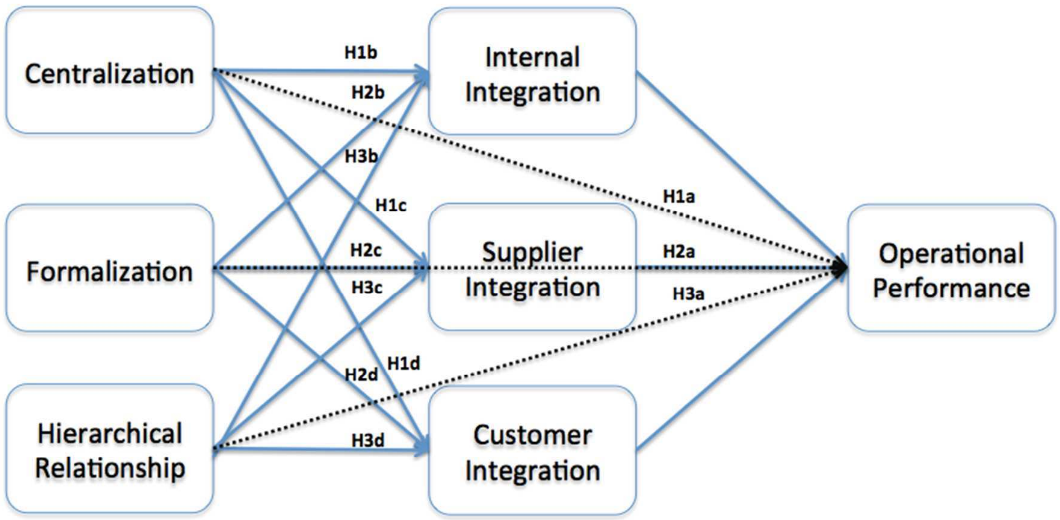

Figure 1: Structural model showing direct effects between OS dimensions and OP, and also the mediating role of SCI (II, SI, CI) on the relationship between OS and OP

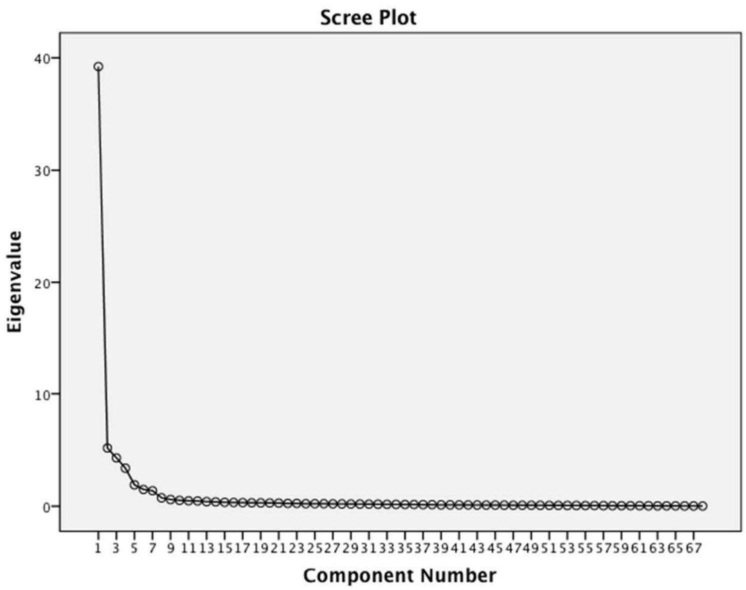

Figure 2: Scree test

Table 1. Background characteristics of sample (N=181)

Sample characteristics	Classification	Total	%
Position	Strategic C-Level Manager	96	53
	Supply chain and purchasing professionals, project and operations managers	85	47
Size of Organization(operation)	High input/output	73	40.3
	Low input/output	108	59.7
Region	Middle-East	83	45.9
	Africa, Asia(pacific), Europe&Eurasia, North&South America	98	54.1
Type of Business	Service Provider	70	38.7
	Manufacturing/service provider	111	61.3
O&G-sector	Upstream	109	60.2
	Downstream	72	39.8
Ownership	Public-companies	76	42
	Public&Private partnership	105	58

Table 2. Rotated Component Matrix

Factor Loadings	**Factor1-OP**	**Factor2-SI**	**Factor3-CI**	**Factor4-II**	**Factor5-HR**	**Factor6-Form**	**Factor7-Cent**
Ccost1	**.816**						
Ccost3	**.814**						
Ocost2	**.797**						
Ccost5	**.789**						
Ccost7	**.789**						
Qlty1	**.787**						
Ccost4	**.781**						
Ocost3	**.780**						
Flex4	**.779**						
Ocost1	**.779**						
Ltime2	**.778**						
Qlty2	**.774**						
Flex3	**.774**						
Ccost2	**.772**						
Ccost6	**.770**						
Qlty4	**.753**						
Qlty3	**.752**						
Ltime1	**.751**						

Ltime4	**.750**						
Ocost4	**.746**						
Flex1	**.743**						
Ltime3	**.724**						
Ltime2	**.719**						
Sintg8		**.864**					
Sintg4		**.852**					
Sintg12		**.846**					
Sintg10		**.842**					
Sintg5		**.840**					
Sintg9		**.837**					
Sintg2		**.827**					
Sintg11		**.825**					
Sintg3		**.822**					
Sintg7		**.821**					
Sintg6		**.815**					
Sintg13		**.811**					
Sintg1		**.797**					
Cintg7			**.845**				
Cintg11			**.829**				
Cintg6			**.827**				
Cintg5			**.826**				
Cintg4			**.824**				
Cintg10			**.822**				
Cintg8			**.816**				
Cintg9			**.816**				
Cintg2			**.815**				
Cintg3			**.782**				
Cintg1			**.774**				
Iintg7				**.807**			
Iintg9				**.792**			
Iintg5				**.785**			
Iintg2				**.784**			
Iintg6				**.778**			
Iintg8				**.772**			
Iintg1				**.767**			
Iintg4				**.765**			
Iintg3				**.752**			
Hierstr3					**-.838**		
Hierstr1					**-.818**		
Hierstr2					**-.785**		
Hierstr4					**.623**		
Form2						**-.750**	
Form1						**-.699**	
Form3						**-.677**	
Form4						**.662**	
Cent3							**-.732**
Cent1							**-.714**
Cent2							**-.703**
Cent4							**.549**

Table 3. Mean values, standard deviations, Composite reliability(CR), Average variance extracted(AVE) Cronbach's alphas(α) and bivariate correlations between study variables (diagonal bold numbers=square root of AVE)

	CR	AVE	α	Form	OP	SI	CI	II	HR	Cent
Form	0.822	0.815	0.945	**0.903**						
OP	0.987	0.764	0.987	-0.698	**0.874**					
SI	0.987	0.850	0.986	-0.614	0.638	**0.922**				
CI	0.982	0.831	0.982	-0.592	0.655	0.551	**0.911**			
II	0.980	0.845	0.980	-0.669	0.686	0.606	0.585	**0.919**		
HR	0.814	0.798	0.939	0.565	-0.570	-0.578	-0.513	-0.586	**0.893**	
Cent	0.797	0.776	0.931	0.618	-0.724	-0.585	-0.587	-0.664	0.570	**0.881**

Table 4. Relationship OS and OP

Independent	Path	Dependent	Standardized path coefficient
Cent	→	OP	-.313**
Form	→	OP	-.197**
HR	→	OP	-.29*

*Significant at 0.05level, **Significant at 0.005level, ***Significant at<0.001

Table 5. Mediation effect of SCI

Relationship	Direct effect without-mediator	Direct effect with-mediator	Indirect effect	t-value	Bootstrap confidence interval	
					Upper	Lower
H1b Cent→II→OP	-.445***	-.311***	.013**	-5.169	-.162	-.501
H1c Cent→SI→OP	-.445***	-.309***	.013**	-5.731		
H1d Cent→CI→OP	-.445***	-.309***	.013**	-5.646		
H2b Form→II→OP	-.350***	-.190**	.007**	-3.395	-.068	-.351
H2c Form→SI→OP	-.350***	-.188**	.007**	-3.476		
H2d Form→CI→OP	-.350***	-.187**	.007**	-3.493		
H3b HR→II→OP	-.120	-.023	.17**	-0.327	-.126	-.152
H3c HR→SI→OP	-.120	-.022	.17**	-0.323		
H3d HR→CI→OP	-.120	-.021	.17**	-0.331		

*Significant at 0.05level, **Significant at 0.005level, ***Significant at<0.001