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AN APPRAISAL OF SUPPLY CHAIN MANAGEMENT MATURITY IN THE OIL AND GAS SECTOR OF PAKISTAN

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ABSTRACT

Oil and gas (O&G) supply chain management faces various challenges owing to its complexity and inflexibility mainly because of the rigid procurement process, long lead-time, complex multi-modal transportation and distribution involved. The same challenges are equally true for Pakistan's O&G industry. Although in the developing stage, the O&G supply chain has gained some level of maturity. As such, this study appraises the maturity level of supply chain and operation management practices of the Pakistan oil and gas industry using the Supply Chain Maturity Assessment Test (SCMAT). To carry out the assessment, a quantitative survey was conducted with 13 companies in the O&G industry of Pakistan. From the responses regarding the variables already defined in the SCMAT, companies were assessed to develop their maturity points and maturity levels. It is concluded that a higher score on variables of maturity demonstrates a higher level of maturity that in turn represents a more open and empowered management style.

Disciplinary: Management Sciences, Supply Chain Management.

1. INTRODUCTION

The O&G industry has an extensive worldwide supply chain that involves transportation at the national and international levels, inventory management, information technology management, and import-export facilitation. However, the supplied commodity of the chain is scarce, and the industry is experiencing geographical challenges regarding O&G exploration in the world's harshest environment. The rise in global demand for O&G and the inflexibility associated has made supply chain management (SCM) more multifaceted and more challenging.

However, best practices of the supply chain provide a significant strategy to O&G companies to leverage their capabilities and improve their performances through sharing knowledge and abilities

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acquired in the collaborative setting (Lockamy III & McCormack, 2004; Mentzer et al., 2001). But the question is on how to determine the level of capabilities the companies have acquired in the organizational processes. One way to determine supply chain capabilities is to analyze how mature the company SCM practices are. Maturity is described in terms of its wide-ranging collaboration across the supply chain with its partners in order to execute adopted integrative practices. As proposed by Bowersox and Daugherty (1995), the underlying idea is to attain an advanced level of supply chain maturity.

Extensive research has been conducted to delineate and assess supply chain performance through maturity models (Gunasekaran et al., 2001). By using these maturity models, one can measure and appraise the present status of internal and external collaborative processes of a company and to propagate the best practices of the supply chain (Lockamy III & McCormack, 2004; Simon et al., 2015).

Following the innovative work on the Quality Management Maturity Grid by Crosby (1980), numerous studies have been conducted to develop maturity models. Kohlegger, Maier, and Thalmann (2009) have identified more than 70 maturity models in software and system engineering area. A major influencing factor of many of the existing maturity models is the "Capability Maturity Model" (CMM) (Battista & Schiraldi, 2013; Netland et al., 2007). However, the focus of maturity models has now widened and the trend has dissipated domains more than 20 including project, risk, product development, human resources, process and SCM (Wendler, 2012).

Among the many maturity models, the most known for the supply chain is the "supply chain management process maturity model", describing the maturity of a business supply chain (Lockamy III & McCormack, 2004). The model uses the "Supply Chain Council's SCOR framework" to assess the intensity of process integration in a business chain of supplies. Most recently, Simon et al. (2015) proposed a model for the evaluation of supply chain maturity. Another contribution is the "supply chain capability maturity model" (SCCMM) developed by Giachetti and Garcia-Reyes (2010). The model was tested in a number of Mexican firms to verify its ability in identifying the maturity levels for the firms. The Logistic Maturity Model (LMM) proposed by Battista and Schiraldi (2013) has the purpose of giving guidelines for process continuous improvement, i.e. mapping as-is logistic processes and establish a roadmap for the improvement and reaching desired logistic performance. The authors characterize the model as a specific maturity model with a focus on logistics.

In short, mostly the existing models are helpful to measure the quality of specific processes: collaboration, degree of integration, continuous improvement and so on, but not comprehensive enough for the industry to adopt largely and handle all decision areas of operation strategy. Moreover, in the authors' knowledge, the O&G industry lacks the supply chain maturity model for assessing the industry's best practices in a coherent manner.

The emphasis of this research is, therefore, to appraise the SCM maturity in the O&G sector, and to uncover the decision areas where best practices can be adapted to improve and develop the effective oil supply chain. In pursuance to the overall objective, a structured methodology is used to appraise current SCM practices and issues through appropriate measures of maturity model which allows an analysis of the overall O&G industry's adherence to SCM best practices.

2. OIL AND GAS INDUSTRY

Energy consumption is on the rise (IEO, 2016). The demand for energy from 2004-2030 is

predicted to enhance by 1.7% per year that will reach 15.3 billion tons of oil per annum. This rise in energy demand will be equivalent to two times the amount of current demand (Aminuddin & Mazari, 2004). Growth in energy trade is therefore projected in the near future and specifically, a substantial increase in the imports of the main O&G consuming countries will be very high. As the economic tendency of a country is closely linked with the supply of oil (Hilmola, 2011), any disruption in the supply will adversely affect the economies. However, the instability in the O&G market is also remarkable due to several erratic factors, for instance, frequent changes in the O&G price of oil, political turmoil or policy changes (Ahmad et al., 2016). These factors are no doubt, causing variations in the demand and supply of O&G and consequently, there is an effect on the entire supply chain of oil.

In Pakistan, the main sources of energy are a mix of oil, gas, LPG, and coal. 80% of the country's energy needs are met from O&G while 16% of the crude oil demands are fulfilled through the country's own resources. Pakistan's economy is highly dependent on the import of petroleum products and considered one of the utmost gas dependent economies of the world. 49% of the petroleum products are consumed by the transport sector, 42% by power generation and 5% by industrial sectors. The scarcity of gas resources in the country has also increased. Pakistan's available gas reserves are 27.8 Trillion: In short, Consumption of energy has grown to 39.8million tons of oil equivalents in 2014 as compared to 17 million tons in 1991. This reflects a 3.6 percent annual compound growth rate of 3.6 percent (Wasti, 2015). Principal energy supplies are increased to 50.9 million tons of oil equivalent during July-March 2015, showing a growth rate of 4.4 percent. To meet the demand of the country, currently, fifteen O&G producing companies and eight refineries are functioning. The main producing companies are Oil & Gas Development Company Limited (OGDCL) a national O&G Company having the highest share of 50%, MOL Hungarian O&G Company (MOL) contributed 19.98%, United Energy Pakistan (UEP) 15.5% and Pakistan Petroleum Limited (PPL) 7.4% during 2013-14. Refineries have the capacity to refine 18.79 million tones as shown in Table 1.

Table 1: O&G Production and Refinery Capacity in Pakistan

O&G Production				Oil Refineries in Pakistan	Capacity Millions Tons per year
Sr. #	Company	Gas	Oil		
1	OGDCL	1,171	42,969	Pak-Arab Refinery Limited (PARCO)	4.5
2	PPL	648	6,420		
3	MPCL	593	642	National Refinery Limited (NRL)	2.71
4	Eni	489	353		
5	BHP	286	1,393	Pakistan Refinery Limited (PRL)	2.1
6	MOL	287	17,293		
7	OMV	310	46	Attock Refinery Limited (ARL)	1.92
8	UEP	206	13,464		
9	PEL	20	-	Byco Oil Pakistan Limited (Byco-1)	1.74
10	Dewan	18	136		
11	POL	15	1,943	Byco Petroleum Pakistan Limited (Byco - II)	5.45
12	Hycarbex	11	-		
13	POGC	10	-	ENAR Petrotech Refining Facility (I&II)	0.33
14	OMV	18	1,259		
15	OPL	9	616	Total	18.75
	Total	4,091	86,534		

(Source: Ministry of Petroleum and Natural Resources Monitoring and Evaluation Unit, Government of Pakistan).

Owing to the high demand for O&G in the country (see Table 1), it is a must for the industry to look for ways to improve their current operational practices and remove bottlenecks in the process of

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the supply chain. This requires in the first place to determine the level to which the O&G industry of Pakistan is following best practices.

Supply chain management is the integration of supply chain partners in such a manner so that the right product is manufactured and distributed to the right locations, in time and with minimized operational costs (Simchi-Levi et al., 2008). In order to accomplish this task; Information, material, labor, financial assets, capital and other resources have to be properly managed. Therefore, the partners in the chain must consider the costs versus benefits of every decision it formulates along the supply chain (Chima, 2007).

In addition to the cost-benefit analysis, supply chain partners must also focus on growing complex issues regarding coordination and communication to establish successful relationships with manufacturing, storage, delivery, contracting and customer services (Dowty & Wallace, 2010). Primarily the supply chain in oil is integrated vertically, with a push system perspective (Gainsborough, 2005; Hull, 2002; Stabell, 2001). Demand-pull come into view only at setting up activities for the deliverance of the products to the consumers.

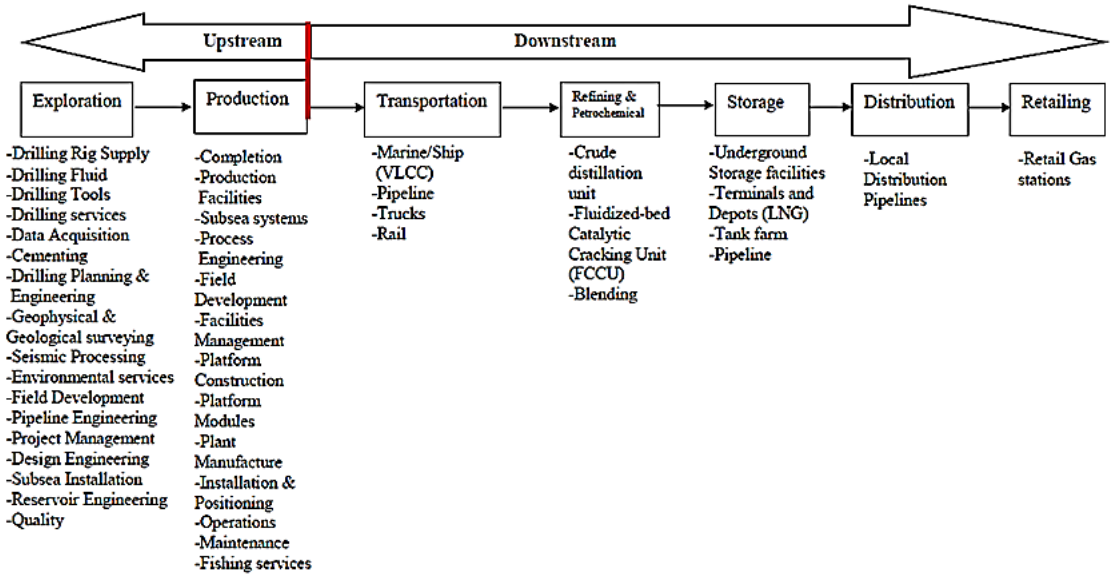

Figure 1: Typical O&G Value Stream

Three main stages are involved in the extraction of O&G; exploration, construction of the field, and production (Hallwood, 1991). The main activities can then be categorized as upstream and downstream activities. Figure 1 categorizes the activities of extraction and production of the raw O&G which are part of upstream section of the industry whilst all other activities such as processing (refining and petrochemicals), logistics and delivery service, storage and distribution to deliver the product to the consumer is part of the downstream section of the supply chain.

Despite the significance of SCM, the petroleum industry has nervousness about teamwork and information sharing (Hussain et al., 2006). The logistics affair is only one of many areas, which will have an impact on the performance of the supply chain in the O&G industry

Overall, a collaborative approach to data standards, information exchange, total process tracking, and automation are considered as the prerequisite for more seamless operations in the O&G industry (Kukareko, 2013). Supply chain optimization is the main prospect for the majority of companies to considerably decrease cost and improve performance. Gainsborough (2005) emphasizes that seeking opportunities for optimization of the O&G supply chain is highly prioritized in the industry due to the great potential for cost savings. Optimization endeavors to reach the most efficient, optimal way to

control the supply chain so as to satisfy end users' requirements with the lowest possible cost.

3. METHODOLOGY

3.1 SC MATURITY ASSESSMENT TEST (SCMAT)

It is important to address to which degree Pakistan's O&G industry manages the issues of operation strategy; hence, the proposed model should include best practices that consider the SCM issues. SCMAT, developed by Netland et al. (2007), is an appropriate model for the purpose. It is appropriate because this maturity model contains detailed, tested and verified maturity measures with reference to SC and operations management (Netland & Alfnes, 2011). SCMAT is based on the belief that an evaluation tool needs detection of the best practices in the areas under observation. Therefore, the core of SCMAT is 48 stated best practices, which are appraised regarding maturity. Supply Chain Council defines best practices as "existing, planned and repeatable practices that have had proven and positive impact on supply chain performance". In addition, SCMAT is also compatible with Chima (2007), strategies, which are useful for improving the operational performance of the supply chain, this strategy focus on customer service segmentation, logistics customization, market-based situational planning, strategic partnership, etc.

The level of maturity for different operations is measured using maturity scales and nearly every maturity model has some sort of maturity stage. The maturity means the impression of improvement from some preliminary state to a more advanced state. Thus, in the case of a company, it passes through several transitional maturity phases on the way to maturity. Maturity models depict a series of maturity levels with objectives and best practices to accomplish in order to advance to the next successive maturity level (Looy et al., 2011).

It is noteworthy that most of the best practices in SCMAT are applicable to the O&G industry. However, the industry relies more on asset management and reliability than on customization, velocity, flexibility (Jacoby, 2012). In this study, we will not be making any adjustments when applying SCMAT in the O&G industry in Pakistan. However, when interpreting the results of the test, one must be aware of the principles established in Jacoby (2012) study.

3.2 APPLICATION OF SCMAT TO O&G SUPPLY CHAIN IN PAKISTAN

This study focuses on the key actors of service and supply companies from the upstream and downstream sides of the Oil & Gas industry of Pakistan. Non-Probability sampling was chosen, i.e. a purposive sampling, selecting specifically or typical interesting cases.

Although supply chain management is a recognized fact, however, in Pakistan, it is practiced in a limited scope. During the sample selection and data collection process, it was ensured, that the companies were involved formally in the field of SCM and already appointed people in pertinent positions, answers from respondents who don't have knowledge cannot be relied on, which rise the bias (even or random) (Forza, 2002). The companies, with no managerial or executive positions within the field of the supply chain, are excluded from this study, as they cannot provide clear evaluation, based on the scope of study that is SCM.

The unit of analysis in this study is the O&G companies in Pakistan. However, respondent classification is essential to verify who will give the information. The 13 respondents who responded

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to the questionnaire are key informants (Table 2). The reason to choose these respondents is that "they are supposed to be knowledgeable about the issues which are being researched in this study and the selected key respondents are also willing to communicate" (Kumar et al., 1993).

These key informants are chosen to have the top management (senior managers/general managers) positions in the investigated companies and also have interaction with the SCM and logistics operation. The reason to target these positions is that their response is to be considered as the company's response and that these roles have the knowledge and prerequisite to answer the questionnaire regarding the use of best practices.

Table 2: Sample profile of companies

Company Activity	Number of Responses
Upstream	6
DownStream	5
Services/Engineering	2
Total	13

In order to eliminate the single respondent bias on the circulation of the questionnaire, it was conversed with the key respondents to respond to the questionnaire after feedback from the supply chain or logistics functions within the company. With this is in mind, this approach relies heavily on the key informant's view of SCM best practices, and to what degree they distinguish that their companies are using these best practices. With the respondents holding adequately important hierarchical positions and with the anonymity of the responses, the definition of a key informant is supported (Seidler, 1974).

3.3 NATURE OF QUESTIONNAIRE

A self-assessment survey instrument was adopted from Torbjørn H Netland et al. (2007) using a 5-item Likert scale measuring the frequency of the best practices by asking the respondent the following question: "To which extent does our supply chain use best practice stated?" The alternatives ranged from 1 = "Never or do not exist", 2 = "Sometimes or to some extent", 3 = "Frequently or partly exist", 4 = "Mostly or often exist", and up to 5 = "Always or definitely exist". This maturity scale is the same for all the best practices that are to be appraised in the test. The respondents were emailed the survey. The authors emphasized the simplicity characteristics as stated by Fraser et al. (2002). The simplicity characteristics are vital for this study due to time and resource restrictions. 17 companies were contacted to take part in the study and an aggregate of 13 questionnaires was acknowledged, which becomes a response rate of 76%. It is imperative to have a response rate higher than 50% within operations management (Flynn et al., 2010). 13 out of the 17 companies from upstream, downstream and services companies responded, and they found no confusion in filling the questionnaire. It is valuable to make sure of the reliability of the available sample. Even if the number of companies is quite small, but the study should meet the standard of good trustworthiness of small samples according to the criteria presented by Forza (2002).

4. RESULTS AND DISCUSSIONS

For this study, the data analysis is to examine and define the maturity level of each company, i.e. total maturity points. The maturity of each company's SCM for each maturity decision area is demonstrated in the following Table 3. The sample has a mean value of 176.77, demonstrating

INTEGRATED maturity, with a median of 188, also indicating that maturity is INTEGRATED, and a standard deviation of 33.18. The maturity of specific decision areas differs throughout the company and between companies. That is a company that scores lower on total maturity points than another company can score higher on a specific maturity variable.

The highest score achieved among these companies is 207. But none of the companies scored up to the extended level i.e. 212 or greater. Keeping in view to superlative performance i.e. maturity level 5 (extended), within each decision area. Organization (overall score 3.88) that has the highest maturity score in the overall sample of the O&G companies of Pakistan. On the other hand, the decision areas Information, Resources and Materials have the lowest overall score relative to world-class performance within those decision areas.

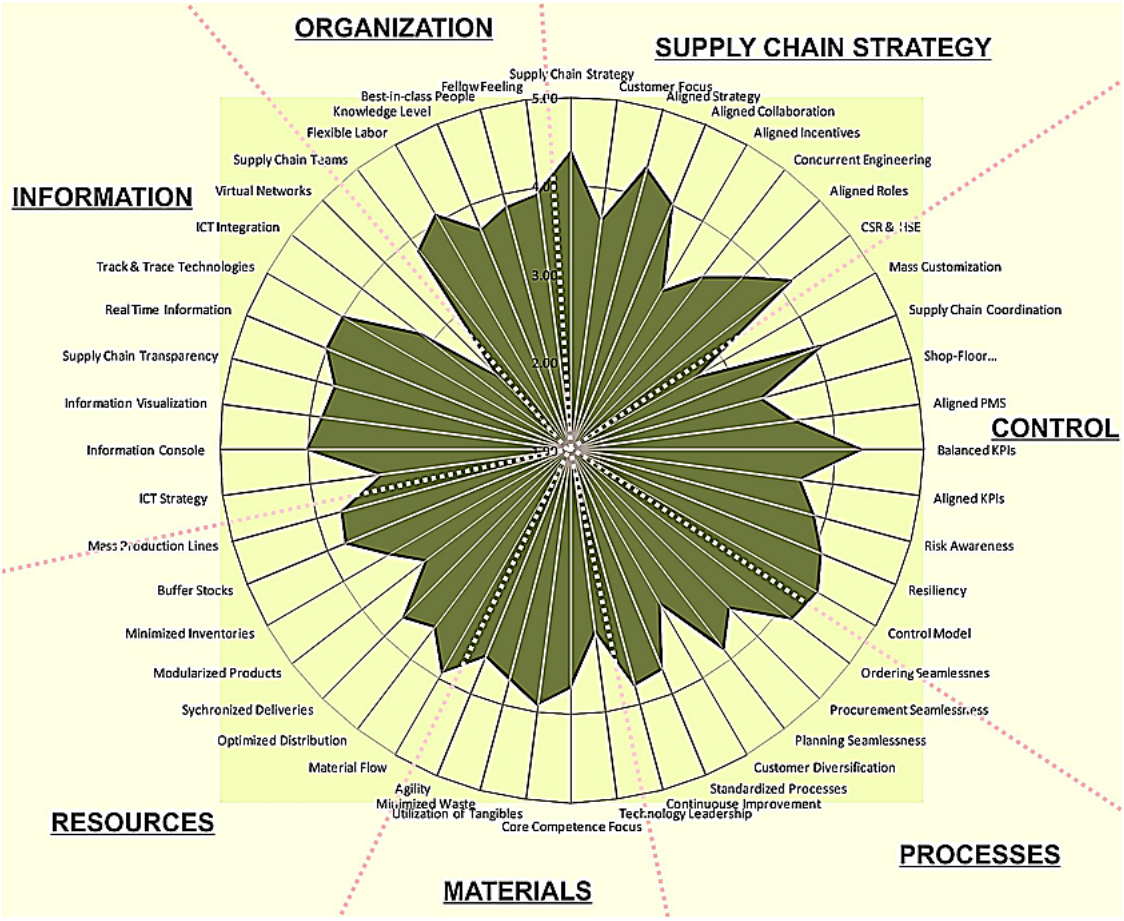

Figure 2: A radar diagram from SCMAT outcomes.

The radar chart in Figure presents the 48 stated best practices and their mean value maturity scores for the O&G industry of Pakistan, within seven object classifications. Using this chart, the participating companies can do a cross-comparison between their supply chain maturity and the maturity of the industry. The results can also be useful to mark areas that need improvement in order to line up the strategy with capabilities, and as a result to raise the level of maturity. From the radar chart, there are thirteen best practices that have an overall industry maturity score over 4.

The results of the top and bottom performing companies in Figure 3, their best practices score per decision area compared. It is obvious that the top-performing company is using much more “best practices”. The decision area Organization is the only one that is close to the same score.

During drilling operations, technical hurdles and downtime occur. In such circumstances, the suppliers responsible for may be penalized, but the cost to the oil companies is far greater in terms of

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lost progress. Partners in the supply chain should share costs, risks and benefits when the goal is to raise the performance of the supply chain, i.e. incentives are aligned. This is supported by our study in which the *Aligned Incentives* achieved a mean score of 3.08 and a linked maturity.

Companies need to have metrics that classify how business strategy is met, and what is relevant to their customers. Pakistan's O&G industry appears to only partially use KPIs which are regularly calculated and reported to the whole supply chain. Thus, the best practice aligned KPIs end up with an overall score of 3.62. The O&G industry of Pakistan uses performance management systems (PMS) to extend to transform supply chain strategy into goals, plans, metrics, and tasks designed for every entity (group and/or individual) in the supply chain. The best practice *Mass customization* scored a mean value of 2.62 (defined level), which is assembling and promoting the system, which consolidates the adaptability and personalization of specially designed items, with the low unit costs connected with large scale manufacturing.

The research revealed that the O&G industry of Pakistan struggles with process standardization and continuous improvement across the supply chain. This is evident with the overall score of 3.67 in the best practice of continuous and incremental improvement. However, the results of this study reveal that most companies still have a way to go before processes are standardized between the supply chain partners, i.e. defined, updated and documented.

Table 3: Distribution by the company for SCM maturity variables

Company	Variables of Maturity (pts.)							Maturity Points	Maturity Level
	Strategy	Control	Processes	Resources	Materials	Information	Organization		
OGDCL	31	34	19	17	29	24	15	169	Linked
MOL	34	36	22	20	27	27	22	188	Integrated
PPL	37	43	26	20	25	30	23	204	Integrated
POL	12	16	11	11	11	8	11	80	Defined
OPL	35	31	25	19	30	29	18	187	Integrated
DEWAN	33	36	25	19	28	30	23	194	Integrated
APL	32	32	21	22	22	21	20	170	Linked
PSO	26	32	20	16	25	32	19	170	Linked
SNGPL	20	27	16	12	25	31	19	150h	Linked
PARCO	36	36	25	19	27	30	20	193	Integrated
ARL	35	41	27	20	26	36	22	207	Integrated
SCHLUMBERGER	34	36	24	19	27	32	19	191	Integrated
LMKR	35	36	25	19	24	35	21	195	Integrated
Mean Value	30.77	33.54	22	17.92	25.08	28.08	19.38	176.77	Integrated
Standard Deviation	7.29	6.69	4.58	3.2	4.73	7.26	3.36	33.18	
Median Value	34	36	24	19	26	30	20	188	Integrated

The results clearly demonstrate that the industry is still lagging in ICT strategy and ICT integration, a decision area of information. The mean score of the industry is slightly above the 3 (maturity level linked), and for the virtual networks, the mean score of the industry is slightly above 2 (maturity level defined). Although such systems exist which provide equivalent access to supply chain partners for forecasting, the status of inventory, sales data points, but the industry does not seem to have understood the potential performance outcome of implementing such systems. However, there should be a cultural change within the organization to support sophisticated information technology which eases collaboration.

With higher profit margins, asset risk management (risk, utilization, and productivity) is an important part of the supply chain (Jacoby, 2012). This study reveals that the O&G industry of Pakistan has high utilization of machines, transportation vehicles, inventory and facilities (i.e. a score

of 3.92 on the best practice utilization of tangibles). Still, improvement is necessary to reach integrated maturity, and it will be important in the future for a reduction in operating costs.

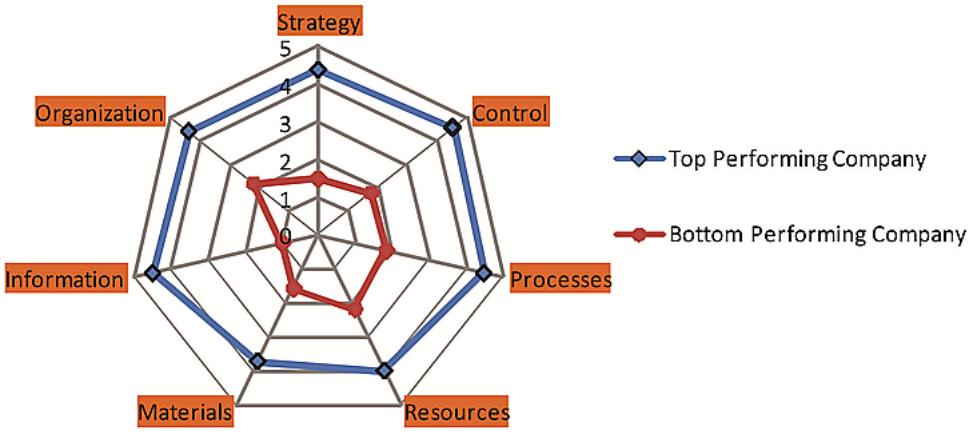

Figure 3: Comparison of the use of best practices in different decision areas

The results show that the best practice of *mass production lines* is in use within the participating companies (score 3.69), near to the integrated maturity level. The companies are deciding on whether to have supply chains that are make-to-order, make-to-stock, or make-to-engineering (includes the design process) for specific products, instead of having one supply chain which might not be suited for all products and services. Jacoby (2012) contends that upstream activities fall into make to plan and make to stock supply chains where the material flow is continuous. On the other hand, the oil field service companies seem to be sensitive regarding significant rig downtime or longer production times, and hence, increase in operational cost that could delay deliveries to oil operators but the industry almost reaches to integrated maturity (score 3.77) in the best practice concerning buffer stocks which shows level of importance on the part of oil field service companies.

The industry reaches a score of 3.69 on the best practice *synchronized deliveries*, which consider synchronization of delivery of products and/or complementary services from different actors in the supply chain to fulfill customer needs. The results of this study do not expect to fully concur on this as the Pakistani Oil & Gas industry more than frequently decides the degree of collaboration keeping in view different factors like the importance of product, availability and the degree of customization.

Areas that are within the maturity stage 1-2 and 4-5 should be the primary focus of the companies. Because the areas with a low level of maturity are well-thought-out to have remarkable improvement potential and areas with a high level of maturity can create further competitive advantage by being best in class. The focus should also be on the strategic decision areas that are most important for the O&G industry. In the context of the O&G industry of Pakistan, the results proved that there is a lack of IC strategy in all processes, ICT systems are not integrated and standardized to facilitate connectivity across supply chain players.

SCMAT does not provide answers to why a company is at a certain maturity level, it only poses questions that need to be examined further. Hence, there is a need to appraise and have a strategic discussion around the obtained results from the test to establish projects for supply chain improvement in line with business strategy.

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5. CONCLUSION

This research appraised the maturity of the supply chain of the O&G sector of Pakistan in a comprehensive and structured way. From the study, it was observed that O&G SCM is complex and challenging, and the industry in Pakistan is still in the development stage for effectively managing its supply chains. To know how capable the industry's supply chain is to meet the challenges, the SCMAT maturity model was used to assess the current state of supply chain practices. The model relied on a Likert type questionnaire where qualitative data regarding supply chain best practices in seven decision area namely strategy, control, processes, materials, resources, information, and organization was chosen. From the collected data, maturity levels in individual decision areas and overall maturity of the supply chain were determined. Companies with a low level of maturity in any decision area have the potential to be improved and areas with high maturity levels can provide a competitive advantage to the company's supply chain. From the maturity points, it is evident no O&G company in Pakistan reached to the extended level that is level 5. However, the mean score indicates that the industry supply chain stands at the Integrated level, level 4.

To get the world-class "extended level", the supply chain managers should simplify their value streams and focus on areas that have the potential for improvement. The results of the maturity test are also useful to provide support to strategic operational activities.

The empirical basis of the research is narrow, but it meets the principles of good reliability and its results can be applied to analyze at what maturity level the O&G industry of Pakistan is standing in relation to supply chain and operations management best practices. The study does not consider complete Pakistan's O&G sector, but only companies having managerial and executive positions within logistics and supply chain. In future research, other companies which do not have logistics and supply chain positions should also be included. However, in that case, along with a questionnaire, face to face interviews should be emphasized to minimize the possibility of misinterpretation of the best practices.

Cross-industry benchmarking is a very useful exercise to improve business processes and competitiveness. In future research, it would be worthwhile for seeking industry that is more mature than O&G Industry, for making a comparison of how mature is that industry from Oil & Gas industry and to which level O&G industry can learn from the more matured industry.

4. AVAILABILITY OF DATA AND MATERIAL

Data used or generated from this study is available upon request to the corresponding author.

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