A Scale for Measuring Sustainable Manufacturing Practices and Sustainability Performance: Validity and Reliability

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ABSTRACT

Purpose: In quantitative studies, providing a valid and reliable instrument is necessary to ensure accurate results when measuring sustainable manufacturing practices (SMPs) and sustainability performance (SP). Therefore, this study aims to evaluate the validity and reliability of the measurements of SMPs and SP.

Methodology/Approach: The population of this study is top managers who have experience in the oil and gas industry (O&GI) in Iraq. Two tests were carried out in the present study: the pre-test and the pilot test.

Findings: In the pre-test, the comments made by six academician experts and three practitioners were used to rephrase the measurements items and modify them according to the requirements of the O&GI by the Iraqi context. Moreover, in the pilot test was all the items were reliable and were sufficiently correlated with their constructs.

Research Limitation/implication: There are some limitations to the current study. First, due to the small size of the study population, the pilot test sample in the current study was only 12 respondents. Future researchers can increase the sample size for the pilot test when they have a large population. Second, the validity and reliability of the measurements were tested in the current study in the oil and gas industry only. Future studies can test these measurements in other industries or small and Small and medium-sized enterprises (SMEs).

Originality/Value of paper: Theoretically, there are four contributions to the body of knowledge: first, introduce measures for SMPs according to the product life cycle view, it is limited in the literature. Second, these measures can be used by researchers to study the extent of SMPs and the SP of companies using descriptive statistics. Third, these measures can be used to investigate the impact of SMPs on SP by regression testing or structural equation modelling. Fourth, measures can be modified into open-ended questions for use in qualitative or

mixed studies. Practically, there are two practical implications which explain in the conclusion.

Category: Research paper

Keywords: sustainable manufacturing practices; sustainability performance; pre-test; pilot test; oil and gas industry

1 INTRODUCTION

Sustainability performance (SP) become an essential issue and a significant concern in the oil and gas industry (O&GI) in Iraq (Ibrahim, Hami and Othman, 2019). This is because of the imbalance among the dimensions of SP that includes: economic, environmental and social sustainability. For example, the report of the ESCWA reported the proportion of Iraqi exports of oil equivalent to 99% of the total annual exports (UN-ESCWA, 2018). This establishes the importance of this industry in the economic development in Iraq. Nonetheless, this industry considers the main reason for environmental emissions and social damage (Elhuni and Ahmad, 2017).

Actually, due to their nature and size, the O&GI has main impacts of health, safety global and environment (Schneider et al., 2011). Also, particulate matter and volatile compounds of filters in oil and gas companies cause many diseases, both for workers and the community in the same area, such as cancer diseases and respiratory diseases (EPA, 2003). Moreover, the main areas for the Extract and production of oil in Iraq, 70% of them have pollution matters in the environment and involve areas such as Kirkuk, Maysan, Basrah, Salah al-Din, Baghdad and Mosul (Al-Haleem, Awadh and Saeed, 2013). Nevertheless, to obtain a balance among the pillars of SP, there should be sustainable practices and activities in the O&GI.

In this respect, empirical evidence in literature has confirmed that sustainable manufacturing practices (SMPs) according to the product life cycle view: sustainable product design (SPD), sustainable manufacturing process (SMP), sustainable supply chain management (SSCM) and sustainable end-of-life management (SEoLM) (Abdul-Rashid et al., 2017a), improve economic, environmental and social sustainability and thus balance it. To achieve this improvement and balance, there should be measurements valid and reliable regarding SMPs and SP.

According to Creswell and Creswell (2018), in quantitative studies, when there is any adapt on one or combine measurements, the prior validity and reliability may not apply for the new measurements. Hence, it has become significant to assessed new validity and reliability for the new measurements before conducting the main study. Therefore, this study aims to evaluate the validity and reliability of the measurements of SMPs and SP among the O&GI in Iraq. The results of this study can be beneficial in several aspects. The researchers will

have a valid and reliable instrument to measure SMPs and SP, particularly in the O&GI. Besides, top management and managers in the O&GI will obtain a deeper perception of how to measure SMPs and SP. Theoretically, there are four contributions to the body of knowledge: first, introduce measures for SMPs according to the product life cycle view, it is limited in the literature. Second, these measures can be used by researchers to study the extent of SMPs and the SP of companies using descriptive statistics. Third, these measures can be used to investigate the impact of SMPs on SP by regression testing or structural equation modelling. Fourth, measures can be modified into open-ended questions for use in qualitative or mixed studies. Practically, there are two practical implications. First, managers can measure their companies' implementation of SMPs using a 6-point Likert scale. Second, measure the level of SP achieved and compare with the performance in previous years.

2 METHODOLOGY

The O&GI is one of the most top sectors that largely contributed to the GDP of Iraq (OPEC, 2018). This contribution is very important, especially in employment opportunities and exports. Consequently, the population of this study is top managers and senior executives who have experience in the O&GI in Iraq. In parallel to the enormous contribution to the GDP of the country and its large contribution to the environmental and social impacts to the nation because its harmful operational activities. on the other side, the pre-test was conducted to verify the face validity (Hair et al., 2013). Then, the pilot test was carried out to establish the reliability of the measurements used in the current study (Saunders, Lewis and Thornhill, 2016).

Scaling design of the items will be used on a "6-point Likert scale": "1" = "Strongly Disagree" (SD); "2" = "Moderately Disagree" (MOD); "3" = "Slightly Disagree" (SLD); "4" = "Slightly Agree" (SLA); "5" = "Moderately Agree" (MOA); and "6" = "Strongly Agree" (SA). The reason for using the 6-point Likert scale was to ensure that participants did not easily check the "indifference" option or "midpoint", as usually occur with a 5-point scale. The midpoint means the neutral response when answering the questionnaire with of exist an odd number of categories used in a scale (Hair et al., 2017). He also emphasised that the researcher usually uses the scale without the midpoint when many respondents are expected to choose neutrals on a particular issue. This is because it provides an easy option that needs a few efforts and is easily justified (Krosnick and Fabrigar, 1997). Garland (1991) argued that the participants would answer based on the content of the questions when given an even number of a response scale. Additionally, participants from Asian countries tend to choose the middle category response than those from Western countries (Si and Cullen, 1998; Thrulogachantar and Zailani, 2011). It was also found that the validity and reliability of the findings tend to be higher for the even number response scale a six-point in particular (Chomeya, 2010) when compared to the odd number

response scale (Krosnick and Fabrigar, 1997; Andrews, 1984; Alwin and Krosnick, 1991; Birkett, 1986; Coelho and Esteves, 2007).

The designed questionnaire was divided into three sections, which were the first section: focuses on SMPs implemented by oil and gas companies in Iraq, second section: focuses on identifying SP that can be achieved through the implementation of SMPs and the third section: provide a profile of the company and personal. Appendix (Table A1) states the items in the first and second sections of the questionnaire and the references adapted from them.

3 RESULTS AND DISCUSSION

3.1 Pre-test (Validity)

The pre-test process involves face validity. The face validity is done through systematic assessment of the measurement based on subjective judgment by the experts (Hair et al., 2013) to verify the measurement's ability to measure what it is supposed to measure in the study (Hair et al., 2017). They also pointed out that this validation method is commonly used in management and business research. Therefore, the study measurements that adapted from previous studies for the SMPs and SP were sent to six experts who are familiar with the constructs of this study to attest the face validity of the measurements. Additionally, three oil and gas industry's practitioners were also contacted for the same purpose. Their feedback, recommendations and comments have been made. Results of face validity by the experts in the pre-test is shown in Table 1.

Table 1 – Results of Face Validity by Experts in the Pre-Test

Expert Type	Variable	Comment	Action
Academicians	SMPs	• Add the words "Our company practices" at the below of each dimension of sustainable manufacturing practices.	• *"Our company practices".*
		• Modify the item by changing the word "Eliminating" to "Eliminates" in the item of "Eliminating the use of hazardous materials during the design of the products".	• *"Eliminates the use of hazardous materials during the design of the products".*
		• Modify the item by changing the worded "Design the products which will prolong the life of materials".	• *"Design the products which will prolong its lifetime".*
		• Modify the item by changing the words "Savings of energy" to "Save energy" in the item of "Savings of energy during the manufacturing process".	• *"Save energy during the manufacturing process".*
		• Modify the item by changing the word "process" to "processes" in the item of "Utilise lean production process".	• *"Utilise lean production processes".*
		• Modify the item by changing the word	• *"Adopts of sustainable*

Expert Type	Variable	Comment	Action
		"Adoption" to "Adopts" in the item of "Adoption of sustainable suppliers".	*suppliers".*
		• Modify the item by changing the word "Using" to "Use" in the item of "Using a less, cleaner or reusable packaging".	• *"Use a less, cleaner or reusable packaging".*
		• Modify the item by changing the worded "Providing recycling support using components and material coding standards".	• *"Provide recycling support for materials and components used".*
Academicians	SP	• Summarising the existing statement below the sustainability performance then put it at the below of each dimension of performance.	• *"In the last three years, please describe your company's achievements for economic performance caused by the current practices (as you described in sections one and two)".*
		• Delete "s" from "emissions" and add "es" to "gas" in the item "Reduced emissions of greenhouse gas".	• *"Reduced emission of greenhouse gases".*
		• Delete "s" from "wastes" in the item "Reduced solid wastes".	• *"Reduced solid waste".*
		• Delete "s" from "wastes" in the item "Reduced liquid wastes".	• *"Reduced liquid waste".*
Practitioners	Profile of company and personal	• Change the options "Private/ local" and "Private/ foreign" in the question "What is ownership of your company?" in section three to one option only as "Private" and add one more option as "Foreign".	• Done.
		• Add the options as "OHSAS 18001", "ISO 29001" and "All" in the question "Does your company have the following certifications?" in section three.	• Done.
		• Add the option as "General Manager" and "Chief executive officer" in the question "What is your current position in your company?" in section three.	• Done.

3.2 Pilot Test (Reliability)

After the questionnaire is constructed (Sekaran and Bougie, 2016; Kumar, 2014), it is necessary to test it before using it to actual data collection (Dawson, 2009; Oppenheim, 2000; Adams, Khan and Raeside, 2014; Fink, 2017). This is because, without a trial test, we will not be able to tell if the questionnaire will succeed (Saunders, Lewis and Thornhill, 2016). Moreover, because this study adapted the measurements from different sources (Hair et al., 2014) regarding the constructs of SMPs and SP.

Data collection in the research process usually begins with a pilot test (Cooper and Schindler, 2014). Saunders, Lewis and Thornhill (2009) defined a pilot test as "small-scale study to test a questionnaire, interview checklist or observation schedule, to minimise the likelihood of respondents having problems in answering the questions and of data recording problems as well as to allow some assessment of the questions' validity and the reliability of the data that will be collected".

There are many essential purposes for conducting the pilot test include understanding or interpreting questions by respondents (Kumar, 2011; Sekaran and Bougie, 2010) and clarity of wording of the questions and estimate achievement times (De Vaus, 2002; Adams, Khan and Raeside, 2014). Also, the pilot test will help to clarify the extent the flow and sequences of questions (Bryman and Bell, 2015; Oppenheim, 2000), as well as it will enable to get some evaluation of the validity of the questions and the potential reliability of the data to be collected (Saunders, Lewis and Thornhill, 2016). In order to achieve the purposes of the pilot test, Bell and Waters (2014) suggested to give the respondents a short questionnaire attached to the original questionnaire of the study includes a set of questions to know the following: (1) How long did it take to complete the questionnaire?, (2) were the questionnaire instructions clear?, (3) are there any unclear or vague questions? If there is, please specify, and why?, (4) do you have any objection to answering any question?, (5) do you think any significant topic has been deleted?, (6) do you think the layout of the questionnaire is clear/ attractive? and (7) any other comments?

Indeed, to make sure the questionnaire has achieved the purposes mentioned above (Oppenheim, 2000), the pilot test should be conducted with respondents who are similar to those that will be used in the full study (Saunders, Lewis and Thornhill, 2016; Zikmund et al., 2013; Hair et al., 2014). Naturally, the closer the link between the pilot sample and the final sample, the better (De Vaus, 2002). Given this, the reliability test must be carried out.

Principally, reliable measurements mean that they achieve the same result on repeated occasions (De Vaus, 2002). Cronbach's alpha was used for this purpose based on the recommendations of several researchers (e.g., DeVellis, 2016; Saunders, Lewis and Thornhill, 2016; Colton and Covert, 2007). Cronbach's alpha ranges from 0 to 1, the lowest acceptance value 0.70 (Hair et al., 2013). Moreover, the item analysis method was used by corrected item-total correlation test to estimate the reliability of responses within an instrument (Colton and Covert, 2007; Field, 2009), as well as, explains the most correlated items with the construct, meanwhile the value of any item is less than .30, it is deleted (Nunnally and Bernstein, 1994; Field, 2009; Hair et al., 2017). Bradburn, Sudman and Wansink (2004) recommended that no more than 10-12 participants are sufficient to detect the difficulties and weaknesses in the pilot test questionnaire. Likewise, Van Belle (2008) recommended that the sample size for the pilot test should be not a minimum of 12 participants. Besides, Fink (2013) stated that the minimum number of participants for a pilot test is 10 (cited in

Saunders, Lewis and Thornhill, 2016). In short, the literature has illustrated that the sample of the pilot test is few and is not considered an issue either in quantitative or qualitative studies (Khattab and Wahid, 2015). Thus, 12 sets of questionnaires were distributed; all the questionnaires that were returned were usable. Using SPSS.V.25, the reliability of the measurements and the item analysis was analysed (Field, 2013; Pallant, 2011), as displayed in Appendix (Table A2).

Based on the pilot study feedback by the seven questions that attached to the original questionnaire of the study (Bell and Waters, 2014), certain words were reconstructed to provide a better understanding to respondents in the main survey. Also, the pilot test revealed that on average, respondents took about 15 to 20 minutes to complete the survey instrument. In addition, Table A2 (Appendix) shows that the result of reliability ranges from 0.794 to 0.906 suggested that all the Cronbach's alpha values were greater than 0.70, which indicate that the 56 measurements were reliable (Hair et al., 2014). Besides, based on the item analysis, all the items correlate higher than 0.30 for the corrected item-total correlation, which ranged from 0.344 to 0.946. These indicate that all items are correlated with their constructs. Therefore, all items have been retained without the need to delete any of them.

4 CONCLUSION

In conclusion, providing a valid and reliable instrument is necessary to ensure accurate results when measuring SMPs and SP. In this respect, two tests were carried out in the present study: the pre-test to establish the validity of the measurements, and the pilot test to check the reliability of the measurements. In the pre-test, the comments made by academician experts and practitioners were used to rephrase items and modify them according to the requirements of the O&GI by the Iraqi environment. Moreover, in the pilot test, some significant findings were identified: an average, respondents took about 15 to 20 minutes to complete the questionnaire, the response rate was 100% high, all the items were reliable and were sufficiently correlated with their constructs. Therefore, this study provides valid and reliable measurements that can give a better understanding to researchers, top management and managers in the O&GI on how to measure SMPs and SP. Theoretically, there are four contributions to the body of knowledge: first, introduce measures for SMPs according to the product life cycle view, it is limited in the literature. Second, these measures can be used by researchers to study the extent of SMPs and the SP of companies using descriptive statistics. Third, these measures can be used to investigate the impact of SMPs on SP by regression testing or structural equation modelling. Fourth, measures can be modified into open-ended questions for use in qualitative or mixed studies. Practically, there are two practical implications. First, managers can measure their companies' implementation of SMPs using a 6-point Likert

scale. Second, measure the level of SP achieved and compare with the performance in previous years.

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AUTHOR CONTRIBUTIONS

Y.M.I. – writing—original draft preparation; N.H. – supervision; N.H., S.S.A. – review and editing.

CONFLICTS OF INTEREST

The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

APPENDIX

Table A1 – Measurement Items of SMPs and SP and Their References

Code	Item	Reference
SPD		
SPD.1	Eliminating the use of hazardous materials during the design of the products.	Abdul-Rashid et al. (2017a), Abdul-Rashid et al. (2017b)
SPD.2	Design the products which will facilitate disassembly of retired products, separation of parts according to materials, as well as reprocessing of materials.	
SPD.3	Design the products which will facilitate repair, rework and refurbishment.	
SPD.4	Design the products which will reduce material use.	
SPD.5	Design the products which will reduce energy consumption.	
SPD.6	Use environmental-friendly materials (e.g. recyclable materials).	
SPD.7	Design the products which support maintenance.	
SPD.8	Design the products which will prolong the life of materials.	
SMP		
SMP.1	Savings of energy during the manufacturing process.	Abdul-Rashid et al. (2017a), Abdul-Rashid et al. (2017b)
SMP.2	Emissions reduction during the manufacturing process.	
SMP.3	Improve manufacturing and machines efficiency.	
SMP.4	Utilise lean production process.	
SMP.5	Commitments to sustainable programmes, standards or regulations.	
SMP.6	Setting sustainable targets and objectives.	
SMP.7	Measure and inspection of material flows or wastes.	
SSCM		
SSCM.1	Adoption of sustainable suppliers.	Abdul-Rashid et al. (2017a), Abdul-Rashid et al. (2017b)
SSCM.2	Influence suppliers to practice sustainable initiatives.	
SSCM.3	Sustainable collaboration with suppliers.	
SSCM.4	Impact customers to accept sustainable practices, services or products.	
SSCM.5	Using a less, cleaner or reusable packaging.	
SSCM.6	Use energy-efficient transportation.	
SSCM.7	Use energy-efficient logistics (e.g. warehouse location and routes).	
SEoLM		
SEoLM.1	Prolong the service life of products or materials by providing support services to customers.	Abdul-Rashid et al. (2017a), Abdul-Rashid et al. (2017b)
SEoLM.2	Providing hazardous waste treatment in the company for products after recovery from the market.	
SEoLM.3	Providing and managing product warranty returns.	

Code	Item	Reference
SEoLM.4	Providing and managing recalls (e.g. reconditioning, reselling).	
SEoLM.5	Providing recycling support using components and material coding standards.	
Economic Sustainability		
EcS.1	Increased net profits.	Bansal (2005), Paulraj (2011), Elhuni and Ahmad (2017), Zhu and Sarkis (2004)
EcS.2	Increased revenue growth.	
EcS.3	Increased revenue through the sale of waste products.	
EcS.4	Increased return on assets.	
EcS.5	Increased return on investment.	
EcS.6	Decreased costs.	
EcS.7	Commitment to production plan %.	
EcS.8	Improving delivery performance.	
Environmental Sustainability		
EnS.1	Reduced emissions of greenhouse gas.	Frank, Nwuche and Anyanwu (2016), Paulraj (2011), Zhu and Sarkis (2004), Elhuni and Ahmad (2017)
EnS.2	Reduced flaring gas.	
EnS.3	Reduced solid wastes.	
EnS.4	Reduced liquid wastes.	
EnS.5	Reduced water usage.	
EnS.6	Reduced oil spills.	
EnS.7	Reduced energy consumption.	
EnS.8	Reduced consumption of hazardous/harmful/toxic materials.	
EnS.9	Reduced environmental accidents.	
Social Sustainability		
SoS.1	Increased local procurement and supplier development.	Elhuni and Ahmad (2017), Frank, Nwuche and Anyanwu (2016), Bansal (2005), Infante et al. (2013)
SoS.2	Increased preventing corruption.	
SoS.3	Increased workforce diversity.	
SoS.4	Increased workforce engagement.	
SoS.5	Increased workforce training and development.	
SoS.6	Decreased rates of work-related injury frequency.	
SoS.7	Decreased rates of work-related occupational illnesses.	
SoS.8	Decreased rates of work-related deaths.	
SoS.9	Participation in community affairs.	
SoS.10	Provide societal health facilities.	
SoS.11	Improved health and safety community.	
SoS.12	Increased social investment.	

Table A2 – Results of the Reliability Test in the Pilot Test

Dimension	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
SMPs				
SPD	SPD.1	0.796	0.884	0.906
	SPD.2	0.596	0.903	
	SPD.3	0.818	0.882	
	SPD.4	0.532	0.907	
	SPD.5	0.727	0.893	
	SPD.6	0.818	0.882	
	SPD.7	0.652	0.898	
	SPD.8	0.670	0.896	
SMP	SMP.1	0.613	0.877	0.886
	SMP.2	0.406	0.903	
	SMP.3	0.661	0.872	
	SMP.4	0.744	0.861	
	SMP.5	0.848	0.848	
	SMP.6	0.744	0.861	
	SMP.7	0.753	0.860	
SSCM	SSCM.1	0.344	0.800	0.794
	SSCM.2	0.726	0.728	
	SSCM.3	0.591	0.755	
	SSCM.4	0.434	0.784	
	SSCM.5	0.592	0.754	
	SSCM.6	0.592	0.754	
	SSCM.7	0.403	0.790	
SEoLM	SEoLM.1	0.836	0.853	0.892
	SEoLM.2	0.927	0.823	
	SEoLM.3	0.775	0.861	
	SEoLM.4	0.685	0.882	
	SEoLM.5	0.531	0.908	
SP				
Economic Sustainability	EcS.1	0.819	0.880	0.904
	EcS.2	0.665	0.895	
	EcS.3	0.730	0.888	
	EcS.4	0.741	0.889	

Dimension	Item	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted	Cronbach's Alpha
	EcS.5	0.946	0.868	
	EcS.6	0.574	0.902	
	EcS.7	0.639	0.897	
	EcS.8	0.488	0.909	
Environmental Sustainability	EnS.1	0.638	0.846	0.864
	EnS.2	0.409	0.868	
	EnS.3	0.840	0.825	
	EnS.4	0.364	0.869	
	EnS.5	0.476	0.861	
	EnS.6	0.545	0.855	
	EnS.7	0.763	0.833	
	EnS.8	0.592	0.850	
	EnS.9	0.753	0.836	
Social Sustainability	SoS.1	0.847	0.879	0.899
	SoS.2	0.517	0.896	
	SoS.3	0.579	0.893	
	SoS.4	0.528	0.895	
	SoS.5	0.596	0.892	
	SoS.6	0.800	0.881	
	SoS.7	0.402	0.902	
	SoS.8	0.860	0.878	
	SoS.9	0.600	0.892	
	SoS.10	0.501	0.897	
	SoS.11	0.477	0.898	
	SoS.12	0.774	0.885	