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**Article**

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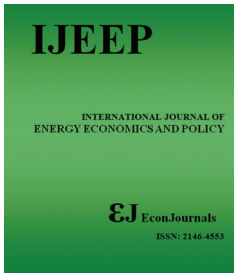

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# Integrating Sustainable Maintenance into Sustainable Manufacturing Practices and its Relationship with Sustainability Performance: A Conceptual Framework

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**ABSTRACT**

It appears that companies' interest in achieving economic returns has made them neglect the environmental and social effects of their activities. With this imbalance in sustainability performance (SP) that causes environmental pollution and social damage, there is an urgent need to strike a balance between economic, environmental and social sustainability. Therefore, this study aims to achieve this balance in SP by providing a proposed framework that integrates sustainable maintenance (SMA) into sustainable manufacturing practices (SMPs). Effective adoption of SMPs and SMA has a significant positive influence on SP. Nevertheless, there are limited studies conducted on integrating SMA into SMPs and how it could impact SP. The theoretical contribution of the present study depends mainly on expanding existing knowledge about highlighting the moderating role of SMA on the relationship between SMPs and SP, including in the oil and gas industry.

**Keywords:** Sustainability Performance, Sustainable Manufacturing Practices, Sustainable Maintenance, Oil and Gas Industry
**JEL Classifications:** Q52, Q56, Q58, Q380

## 1. INTRODUCTION

Sustainability performance (SP) is a key issue and a major concern in the oil and gas industry (O&GI) in Iraq. This is due to the lack of balance between the dimensions of SP (i.e., economic, environmental and social). For instance, OPEC (2018) noted in the annual statistical bulletin, in 2017, the value of Iraqi oil exports amounted to USD 63314 million, equivalent to 33% of the GDP which is valued at USD 191216 million. By the same token, the report of the ESCWA reported for the same year, the proportion of Iraqi exports of oil equivalent to 99% of the total annual exports (UN-ESCWA, 2018). This establishes the significant role of this industry in the development of the Iraqi economy. Nevertheless, the O&GI considers the major contributor to environmental pollution and social damage (Elhuni and Ahmad, 2017).

Indeed, to illustrate, because of their complexity and volume, the O&GI has major impacts of environmental, health and safety worldwide (Schneider et al., 2013; Schneider et al., 2011). Besides, 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). According to the compensation committee in the Iraqi Ministry of Oil, the number of occupational accidents, including diseases due to work for 2017, which paid compensation to workers in the oil sector is 703 cases until September (IMO, 2017). Furthermore, the central locations for the exploration and production of oil and gas in Iraq, 70% of them contain environmental pollution issues and include regions such as Baghdad, Basra, Kirkuk, Maysan, Salah al-Din and Mosul (Al-Haleem et al., 2013).

In addition to the above, and through literature review, studies confirmed that the sustainability of companies requires taking environmental and social effects in consideration in addition to the economic side and balance it (Annunziata et al., 2013; Ashrafi, 2014; Carley et al., 2014; Cavagnaro and Curiel, 2012; Christen et al., 2006; Dao et al., 2011; Elkington, 1997; 1999; 2004; Hami, 2015; Hassan et al., 2015; Parida and Kumar, 2010; Shukla et al., 2017; Székely and Knirsch, 2005; Venkatraman and Nayak, 2015), including the O&GI (Anis and Siddiqui, 2015; Liyanage, 2007; Liyanage et al., 2009; Schneider et al., 2011). However, the study of the dimensions of SP which includes economic, environmental and social from a comprehensive and balanced perspective in practical implementation is still missing (Garetti and Taisch, 2012; León and Calvo-Amodio, 2017), including in the O&GI (Anis and Siddiqui, 2015). Subsequently, this study is interested in studying of SP the economic, environmental and social to address the issue of research, which aims to help O&GI to balance the three dimensions of SP in the context of Iraq.

The vital question that arises is about how to address the issue of research about balance the dimensions of economic, environmental and social sustainability. In this respect, sustainable manufacturing practices (SMPs) have not been widely studied and documented by researchers (Alayón et al., 2017; Despeisse et al., 2012; Roberts and Ball, 2014). Additionally, several empirical evidence suggests that SMPs contribute to improved economic, environmental and social sustainability (e.g., Abdul-Rashid et al., 2017a; Abdul-Rashid et al., 2017b; Gimenez et al., 2012; Habidin et al., 2013; Hami, 2015; Hami et al., 2016; Hartini and Ciptomulyono, 2015; Shubham et al., 2018; Zubir et al., 2012). Therefore, there is a necessary need to study SMPs as they will contribute to addressing the practical issue of SP in the O&GI in Iraq.

Furthermore, a number of studies established that maintenance leads to improved performance (Ahuja and Khamba, 2008; 2009; Al-Najjar and Alsyouf, 2004; Alsyouf, 2007; Hamzah, 2011; Hooi and Leong, 2017; Kaur et al., 2012; Löfsten, 1999; Maletič et al., 2014; Mohamed and Valérie, 2016; Vassu and Lazim, 2016). Frank et al. (2016) concluded in their study in the O&GI that maintenance significantly affects economic, environmental and social performance. Similarly, Baluch et al. (2010) showed that maintenance enhances the company's competitiveness and improves its performance of economic, environmental and social. Also, maintenance activities have significant impacts on the company's economic, social and environmental performance (Chiang et al., 2014; Liyanage et al., 2009). Moreover, according to Pires et al. (2016) in previous studies rarely considered the four dimensions which involve economic, technical, environmental and social and safety in maintenance. Amrina and Aridharma (2016) pointed to the need to study sustainable maintenance (SMA). Zhang et al. (2017) stressed that literature in SMA is the most limited. Similarly, Ararsa (2012) noted that studies on SMA are still in infancy.

However, many companies still do not have a full understanding of the importance of effective maintenance activities and their significant role in achieving SP (Liyanage and Badurdeen, 2010). Additionally, Franciosi et al. (2018); and Pires (2015) recommended through their systematic review that more research should be conducted on the impact of maintenance on SP. Similarly, Seychelles (2017) suggested further investigation on the relationship between maintenance and SP. Therefore, there are two main reasons for investigating in SMA: First, theoretically, to bridge the gap in the literature and the second reason practically, because it will contribute to addressing the practical issue of SP in the O&GI in Iraq.

In fact, companies that have an interest in SMPs are more inclined to adopt SMA (Ararsa, 2012; Franciosi et al., 2018; Garetti, 2011; Garetti and Taisch, 2012; Granados, 2014; Ighravwe and Oke, 2017b; Jasiulewicz-Kaczmarek, 2013a; Liyanage, 2007; Liyanage and Badurdeen, 2010; Stuchly and Jasiulewicz-Kaczmarek, 2014). This is because they have the same goal of improving SP (Abdul-Rashid et al., 2017b; Abdullah et al., 2017; Adebambo et al., 2015a; Alayón et al., 2017; Baluch et al., 2010; Chiang et al., 2014; Frank et al., 2016; Habidin et al., 2013; Hami, 2015; Hami et al., 2016; Liyanage et al., 2009). Besides, many studies have examined the relationship between SMPs and SP (Abdul-Rashid et al., 2017a; 2017b; Abdullah et al., 2017; Adebambo et al., 2014; 2015b; Adebanjo et al., 2016; Das, 2018; Esfahbodi et al., 2017; Gimenez et al., 2012; Habidin et al., 2013; Hami et al., 2016; Hami et al., 2015; Luthra and Mangla, 2018; Roni et al., 2014; Zubir et al., 2012). However, SMA has not been given any consideration in their studies. Accordingly, to the best of the knowledge of the authors, surprisingly, the moderating effects of SMA are ambiguous and have not been closely studied in any previous study. This gap points to the need for a theoretical framework to investigate the moderating impacts of SMA on the relationship between SMPs and SP. Therefore, this study aims to encourage the O&GI to achieve a balance in the dimensions of economic, environmental and social sustainability by providing a proposed framework that integrates SMA into SMPs.

The results of the current study are expected to benefit many aspects in different areas. Academicians will obtain a better perception of the importance of integrating SMA into SMPs to achieve a balance in the dimensions of economic, environmental and social sustainability. Additionally, policymakers and top management in the O&GI will gain a better understanding on how to balance the SP dimensions, based the focus on SMPs and SMA.

The present study contains two sections viz.; following this introductory section is section 2, the conceptual framework which provides insights from empirical literature and theoretical framework about SMPs, SMA and SP, followed by section 3, which involve conclusions of this study.

## 2. LITERATURE REVIEW AND DEVELOPMENT OF MODEL

### 2.1. SMPs

SMPs have gained vital importance over the past few years. Adebanjo et al. (2016) noted that there is a growing interest worldwide in the implementation of sustainable management practices. Also, interest in sustainable practices has increased

as a result of grown interest in sustainable manufacturing SM over the years (Alayón et al., 2017). In other words, SM plays a significant role in manufacturing companies, and SMPs contribute to creating the right environment for companies (Gupta et al., 2015). It is because of linking the operations and decisions of industrial companies to environmental and social factors related to their activities (Cerinšek et al., 2013).

SMPs have become a required necessity expected from all industries (Habidin et al., 2013), and companies should prefer to implement them (Nordin et al., 2014), as they lead to overcoming the challenges, they face in the industry (Yucel and Gunay, 2013). There is increasing pressure on companies in all sectors by society, clients and other stakeholders to apply SMPs (Nordin et al., 2014). These pressures came as a result of the environmental effects of manufacturing practices through the inefficient use of resources, increased emissions and wastes, posing a significant threat to the global ecosystem and the welfare of society (Al-Ashaab et al., 2013). Which led to awareness and interest in SMPs by manufacturers (Habidin et al., 2016). Accordingly Despeisse (2013) defined SMPs as "an action or set of actions improving the manufacturing system's environmental performance."

Previously, manufacturing companies focused on the volume of profits realized regardless of the environmental impact of their activities (Al-Ashaab et al., 2013). Whereas, at present, it is necessary to use environmentally friendly practices in manufacturing to eliminating their harmful effects on the environment (Nordin et al., 2014). In addition to minimising possible hazards while maintaining the success of the business (Abdullah et al., 2017), besides great social benefits (Kibira and McLean, 2008). Likewise, Al-Ashaab et al. (2013) noted that the adoption and continuous improvement of SMPs are achieving economic, social and environmental benefits. In other words, SMPs achieve efficiency in resources and responsibility towards society (Badurdeen and Jawahir, 2017). Therefore, the adoption of SMPs according to the product lifecycle perspective improves SP.

Depending on the perspective of the product life cycle, SMPs can be classified into four dimensions concerning the phase at which the practices are implemented. These dimensions include the sustainable product design, sustainable manufacturing process, sustainable supply chain management and sustainable end of life management (Abdul-Rashid et al., 2017a, 2017b; Jasiulewicz-Kaczmarek, 2013a; Millar and Russell, 2011; Russell and Millar, 2014). Which it is considered the dimensions of SMPs in the present study, because it is appropriate for O&GI (Abdul-Rashid et al., 2017b; Millar and Russell, 2011; Russell and Millar, 2014). Hence, the product life cycle perspective is more appropriate for the O&GI when implementing SMPs.

## 2.2. SP

The terms "sustainability" and "Sustainable Development" are synonymous with many researchers (Aras and Crowther, 2009). Levels of interest in sustainability have increased in the last two decades by many stakeholders such as industry, government and people in general (Fiksel, 2006). Since its start, sustainability has been defined in many beliefs, ways, contexts, values, and disciplines (Aleixo et al., 2016). There are many definitions of sustainability contained in the literature (Glavič and Lukman, 2007; White, 2013). The definition of sustainability first emerged in the 1980s in the World Conservation Strategy drafted by UNEP in 1980 and became more widely used (Basiago, 1995; Du Pisani, 2006; Worster, 1993). Where sustainability is defined in Brundtland report as "*the development that meets the needs of the present generation without compromising the ability of the future generations to meet their own needs*" (WCED, 1987. p. 8). Despite the fact that it is very extensive, but it is one of the most definitions popular (Pei et al., 2010), and the distinct widely to portray sustainability and SD in the different fields of studies (Hami et al., 2015). In other words, the actions of people in the present will affect the next generation (Bell and Morse, 2008). This shows that sustainability is a human-oriented idea because humanity is the target and is viewed for sustainability regarding human values (Arsat, 2014). Therefore, companies are responsible for sustainability, including the O&GI.

The importance of sustainability has made organisations focus on their SP. It is after the concept of sustainability came the concept of SP (Chardine-Baumann and Botta-Genoulaz, 2014), which is considered an important initiative in manufacturing companies (Singh et al., 2015). In addition, it is a modern subject and evaluated by companies more modern (Chardine-Baumann and Botta-Genoulaz, 2014). Thus, it is gaining considerable attention from academicians and practitioners (Štreimikienė et al., 2009).

In 1994 John Elkington introduced the term "*triple bottom line*" or (*TBL*), 1 year later he also developed "*3P formulation*" which include "*people, planet and profit*" (Elkington, 2004. p. 1-2). Which has been widely recognised by researchers and practitioners (Zhang et al., 2017). Most definitions of SP depend on *TBL* because it covers the three dimensions - economic, environmental and social (Krajnc and Glavič, 2005). Besides that *TBL* describes SP at the company level (Sezen and Çankaya, 2013). The concept of *TBL* suggests that the socially and environmentally responsible practices of the company can achieve positive economic performance (Gimenez et al., 2012).

Elkington (1997. p. 70) defined *TBL* as "*focusing on economic prosperity, environmental quality, and — the element which business bad preferred to overlook — social justice*". Also stressed the simultaneous pursuit to achieve of these three dimensions (Elkington, 1997. p. 397), and consider them at once and balance them in practice (Zhang et al., 2017), because their balanced implementation leads to the continuous improvement to all stakeholders (Wu et al., 2015). This is because when companies implement three dimensions simultaneously and balancing them will outperform their SP on companies seeking only economic performance and companies that focus on environmental and social performance without interest to economic performance (Carter and Rogers, 2008).

In the same sense, combining and align the three dimensions will lead to effective synergies (Chardine-Baumann and Botta-Genoulaz, 2014; Chen and Kitsis, 2017; Husted and Sousa-Filho, 2017; Mohamed and Valérie, 2016). Many researchers confirm this

in their definition of SP which is consistent with the definition of Elkington (e.g., Artiach et al., 2010; León and Calvo-Amodio, 2017; Rezaee, 2016; Savitz, 2014).

### 2.3. SMPs and SP

In line with the significant positive impact of SMPs on SP, Hami (2015) and Hami et al. (2016) in their studies conducted in Malaysia in 150 companies of manufacturing industry, SMPs was reported to have a positive and significant impact on SP. Similarly, in the context of manufacturing plants in 20 countries, Gimenez et al. (2012) found a positive relationship between SMPs and SP. Also, Masocha (2018) demonstrated that environmental sustainability influenced SP in the context of SMEs. Similarly, a study by Gadenne et al. (2012) in the context of medium to large organisations in Australia that organisational SP was influenced by SP management practices. In addition, in a separate study in Malaysia to understand the influence of corporate social responsibility practices on corporate social responsibility performance among automotive suppliers, Fuzi et al. (2017) supported the positive influence of corporate social responsibility practices on corporate social responsibility performance. Husted and Sousa-Filho (2017) demonstrated in their study in services and manufacturing industries for nine countries that the adoption of sustainability governance leads to the improvement in SP. Literature as above shows mostly a significant positive relationship between SMPs and SP. Thus, based on the arguments above and assumptions of stakeholder theory (Friedman and Miles, 2002), which propose that some advantages, benefits, firms decision-making power should be taken away from shareholders and given to stakeholders (Stieb, 2009), the following proposition is offered:

P1: SMPs have a significant positive relationship with SP.

### 2.4. SMA

These days, it is essential for academicians and practitioners to focus not only on the technical aspect of maintenance activities but as an integrated set of technical, economic, environmental and social and safety dimensions (Bengtsson and Lundström, 2018). This is because the maintenance activities and breakdowns in industrial companies result in harmful emissions, waste, dangerous accidents and consumption of energy and resources (Liyanage and Badurdeen, 2010), including in the O&GI (Liyanage, 2010; Zhang and Yu, 2017). While the adoption of SMA by companies will make a significant difference in the economic, environmental, social and safety and technical (Franciosi et al., 2018; Jones and Cooper, 2007; Liyanage and Badurdeen, 2010). Likewise, additionally the economic and environmental dimensions, SMA included social and safety dimension and worked to achieve a balance among these three dimensions (Jasiulewicz-Kaczmarek, 2013a; 2013b; 2013d; Stuchly and Jasiulewicz-Kaczmarek, 2014). Moreover, companies that interesting on sustainable manufacturing face a new challenge in their implementation of SMA (Amrina and Aridharma, 2016; Jasiulewicz-Kaczmarek, 2013a; 2013b; 2013c; 2013d; Stuchly and Jasiulewicz-Kaczmarek, 2014). This is because of the complexity of manufacturing practices and processes (Al-Turki et al., 2014; Jin et al., 2016; Jin et al., 2016; Lee et al., 2014), the need to make changes in policies and procedures of maintenance, attention to environmental and social and safety aspects as well as financial aspects (Jasiulewicz-Kaczmarek, 2013a; 2013d; Jasiulewicz-Kaczmarek and Stachowiak, 2016; Stuchly and Jasiulewicz-Kaczmarek, 2014), competition pressure in manufacturing (Emmanouilidis and Pistofidis, 2010) and the government regulations towards SD in manufacturing (Ighravwe and Oke, 2017a). However, in recent years, changes in manufacturing paradigms have forced companies and managers to recognise the changing role of maintenance regards sustainability (Al-Turki et al., 2014; Ararsa, 2012; Baluch, 2012; Jasiulewicz-Kaczmarek, 2013a; 2013b; 2013d; Jin et al., 2016; Lee et al., 2014; Ratnayake and Markeset, 2010). Likewise, in recent few years, the importance of incorporating sustainability into maintenance function has been recognised (Bengtsson and Lundström, 2018; Ighravwe and Oke, 2017a; Iung and Levrat, 2014; Kayan et al., 2017; Sari et al., 2015; Sénéchal, 2017). This is due to it provides lost costs and energy consumed during the product lifecycle (Nezami and Yildirim, 2011). Therefore, it is necessary to adopt SMA by companies that follow a sustainability approach in their business.

Jasiulewicz-Kaczmarek (2013a; 2013d); and Stuchly and Jasiulewicz-Kaczmarek (2014) defined SMA "*as proactive maintenance operations striving for providing balance in social (welfare and satisfaction of operators and maintenance staff), environmental and financial (losses, consequences, benefits) dimensions.*" Whereas, this study defined SMA as all maintenance activities that support the sustainability of the company, through the reduction of environmental impact, the safety and social and safety welfare of employees, the implementation of technical factors at the highest possible level and reducing maintenance costs.

### 2.5. SMA and SP

According to Ali et al. (2010), the efficiency in maintenance tasks and activities comes through the selection of proper maintenance. Although studies on SMA and SP are limited (Pires et al., 2016; Y. Zhang et al., 2017), studies in most case studies have confirmed that SP is achieved through the choice of SMA (Granados, 2014; Ighravwe and Oke, 2017a, 2017b; Pires et al., 2016; Sénéchal, 2016; Sénéchal et al., 2015). Zhang et al. (2017), who studied in the context of port infrastructures in Japan, explained that the use of technology in equipment maintenance has positive effects on the all of SP dimensions. Mahmood et al. (2015) concluded that the implementation of maintenance and overall equipment effectiveness have a positive impact on economic development and the protection of the environment and social welfare in the Malaysian manufacturing companies. Henderson et al. (2014) illustrated the shift to a contemporary and positive view of maintenance contributes to the improvement of all dimensions of SP. In another context, Frank et al. (2016) conducted a study of maintenance among oil and gas companies in Nigeria. They reported a positive relationship between maintenance and economic, environmental and social sustainability. Based on the discussion and the arguments in the above, SMA has a significant positive relationship with the SP of companies. Therefore, based on the arguments above and assumptions of natural resource-based view (NRBV) theory (Hart, 1995), which proposition that clean technology that encompasses a range of activities and processes undertaken by companies lead to achieving sustainable competitive advantage, creating value for shareholders and

achieving sustainability (Hart and Dowell, 2011), the following proposition is offered:

P2: SMA has a significant positive relationship with SP.

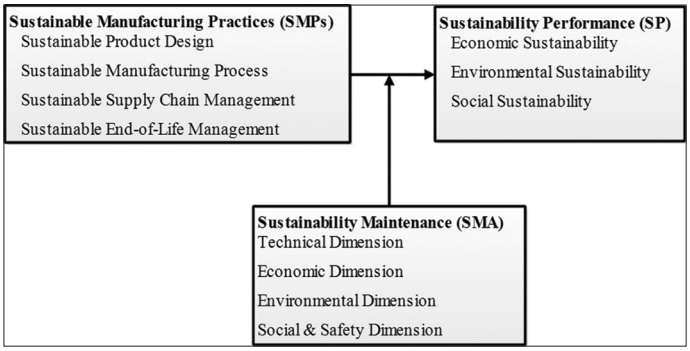
### 2.6. Sustainale Maintenance as a Moderating Variable

Indeed, after the Second World War and as a result of rapid technological developments in the manufacturing environment, maintenance was considered as significant enhance function to production, operations and manufacturing (Baluch, 2012). Similarly, Fraser et al. (2015); Jasiulewicz-Kaczmarek (2014); and Jasiulewicz-Kaczmarek and Drozyner (2013) maintained that maintenance plays a critical role in industrial companies as a support function for manufacturing. Besides, to achieve the best possible performance of the company (Mostafa et al., 2015; Mostafa et al., 2015), the strategies and objectives of maintenance and manufacturing should be integrated (Fredriksson and Larsson, 2012; Graisa, 2011; Jasiulewicz-Kaczmarek and Stachowiak, 2016). This integration helps manufacturing companies save on costs, time and resources (Moubray, 2003), as well as achieving economic benefits and competitive advantages (Enofe and Aimienrovbiye, 2010). Therefore, in order for companies to continue, they must keep pace with the rapid development of manufacturing and maintenance paradigms.

The moving of the manufacturing paradigms towards sustainable development has led to a change in the maintenance paradigms towards of product lifecycle, which involves four phases (Ait-Alla et al., 2016; Jasiulewicz-Kaczmarek, 2013d; Jasiulewicz-Kaczmarek and Drozyner, 2013; Stuchly and Jasiulewicz-Kaczmarek, 2014). This is due to the trend toward SMPs (Ighravwe and Oke, 2017a). From a practical perspective, each phase of the product life cycle must be supported by maintenance (Jasiulewicz-Kaczmarek, 2013a; Jasiulewicz-Kaczmarek and Drozyner, 2013), from product design to end-of-life (Starr and Bevis, 2010). These phases can be utilised to manufacturing equipment and manufacturing products (Garetti, 2011; Granados, 2014). In this regards, to illustrate and justify the new process of understanding maintenance, Takata introduced the term "*maintenance value chain*" (Takata et al., 2004). This emphasis on the life cycle view of sustainable manufacturing has produced the redefinition of the task of maintenance as being "*a prime method for life cycle management whose objective is to provide society with required functions through products while minimizing material and energy consumption*" (Takata et al., 2004. p. 653). In the same vein, the role of maintenance in the phases of the product lifecycle leads to the availability and reliability of equipment, improve environmental efficiency, achieve safety (Cunha et al., 2004; Granados, 2014; Levrat et al., 2008; Tousley, 2010). Thus, maintenance plays a vital role in interacting with all phases of the product lifecycle within SMPs.

The success of sustainable manufacturing operations and practices in improving SP is achieved through their integration with maintenance activities (Enofe and Aimienrovbiye, 2010; Franciosi et al., 2017; Liyanage and Badurdeen, 2010; Sénéchal et al., 2015). Similarly, SMA is considered as a facilitator of SMPs (Garetti, 2011; IMS2020, 2010), which will improve the SP of economic, environmental and social (Franciosi et al., 2018; Franciosi et al., 2017; Ighravwe and Oke, 2017b). Based on the discussion and the arguments in the above, it concludes that the impact of SMPs on SP will be stronger if SMA moderates between them. Accordingly, based on the arguments above and assumptions of NRBV theory the following proposition is offered:

**Figure 1:** A conceptual framework for sustainability performance




P3: SMA positively moderates the relationship between SMPs and SP.

In short, the proposed a conceptual model of this study is formulated by combining the stakeholder theory and the NRBV theory. Meanwhile, the current study integrating SMA into SMPs with to examine their effects on SP, as depicted in Figure 1.

## 3. CONCLUSION

The present paper offers a conceptual framework that investigates the moderating effect of SMA on the relationship between SMPs and SP. This research gap has been addressed in the present study. Previous empirical studies pointed that there is evidence that adopting SMPs were and SMA in companies improves SP and achieves a balance among economic, environmental and social sustainability.

The proposed conceptual framework in the current study will have some potential theoretical and practical implications. Firstly, as a contribution to the body of knowledge, academicians will obtain a better perception of the importance of integrating SMA into SMPs to achieve a balance in the dimensions of economic, environmental and social sustainability. Secondly, the O&GI can put in place SMPs and SMA framework, to achieve SP. More clearly, the proposed framework will be important to policymakers and top management in the O&GI will gain them a better understanding of how to the balance of SP dimensions, based the focus on SMPs and SMA.

This study attempts to connect the significance of sustainable practices that respond to the expectations of increasing stakeholders. This study explored SMA in the O&GI. Consequently, it could help the government in reaching its objective of making Iraq become a better economy over the next years, within economic prosperity, carbon emissions are a low, efficient use of resources and social justice.

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