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The Development of a Comprehensive Sustainable Supply Chain Performance Measurement Theoretical Framework in the Oil Refining Sector

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***Abstract*—**The oil refining industry plays vital role in the world economy. Oil refining companies operate in a more complex and dynamic environment than ever before. In addition, oil refining companies and the public are becoming more conscious of crude oil scarcity and climate changes. Hence, sustainability in the oil refining industry is becoming increasingly critical to the industry's long-term viability and to the environmental sustainability. Mainly, it is relevant to the measurement and evaluation of the company's sustainable performance to support the company in understanding their performance and its implication more objectively and establishing sustainability development plans. Consequently, the oil refining companies attempt to re-engineer their supply chain to meet the sustainable goals and standards. On the other hand, this research realized that previous research in oil refining sustainable supply chain performance measurements reveals that there is a lack of studies that consider the integration of sustainability in the supply chain performance measurement practices in the oil refining industry. Therefore, there is a need for research that provides performance guidance, which can be used to measure sustainability and assist in setting sustainable goals for oil refining supply chains. Accordingly, this paper aims to present a comprehensive oil refining sustainable supply chain performance measurement theoretical framework. In development of this theoretical framework, the main characteristics of oil refining industry have been identified. For this purpose, a thorough review of relevant literature on performance measurement models and sustainable supply chain performance measurement models has been conducted. The comprehensive oil refining sustainable supply chain performance measurement theoretical framework introduced in this paper aims to assist oil refining companies in measuring and evaluating their performance from a sustainability aspect to achieve sustainable operational excellence.

***Keywords*—**Oil refining industry, oil refining sustainable supply chain performance measurements, performance measurements, sustainability.

I. Introduction

OIL refining industry plays an important role in the global economy as it is considered requisite to industrialized nations. It serves a central part in many industries like transportation, power generation, and petrochemical [1]. The oil refining industry is particularly a strategic industry since it affects global economies [2]. The oil refining supply chain comprises of multiple and complex sub-chains that are segmented in nature, and any failure is critical as it will affect the other segments.

The growing public awareness of sustainability and the concerning effects of global warming put a strain on the oil refining companies to take sustainability in their supply chains more seriously. Oil refining companies primarily focused on re-engineering their supply chain to meet sustainable measures and standards [3]-[11]. Accordingly, oil refining companies attempt to focus on operational excellence, which can be achieved by a well-integrated supply chain management system. Besides, companies seek to have a performance measurement system to measure their supply chain's performance and identify areas of improvement to increase competitiveness for the supply chain to succeed [12], [13].

Previous studies stated that there is a limited number of papers that consider the oil refining supply chain performance measurements [14]-[17]. These studies also indicate that they are initiatives to develop supply chain performance measurements in the oil refining sector. Review of literature also shows that most of the previous studies like [18], [19] assign a widely used management tool (such as the Balanced Scorecard (BSC) and Supply Chain Operations Reference (SCOR)) to identifying the oil refining criteria under the assigned model perspectives. The main aim of these models is to evaluate the performance of the oil refining company's supply chain considering the selected criteria to measure supply chain performance. The literature review shows that sustainable characteristics are not presented in the BSC model while the security-related aspects are not considered in the BSC and the SCOR models.

Oil refining industry has special characteristics that distinguish it from other kinds of process industries. Review of literature indicates that the oil refining industry is yet to adopt a consistent guidance for the performance measurement models to observe and consider its main characteristics [1]. Any initiatives to measure the oil refining supply chain performance will be comprehensive if an appropriate supply chain performance measurement model is capable of considering and linking the oil refining special characteristics to the assigned supply chain performance measurement model. The literature review demonstrates that oil refining industry still has unreliable and undependable performance measurement system capable to comprise the main characteristics of the oil refining industry and incorporates sustainability theme. This type of model is intended to be used by oil refining companies as a guideline model to assist them in measuring and evaluating their sustainability performance.

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References [20]-[22] attempt to develop sustainable supply chain theoretical models. They have indicated that their studies are only first attempts and initial steps towards developing a comprehensive framework. These studies suggested that more efforts are needed to recognize performance measurement indicators that can be used to measure the supply chain performance from the sustainability perspective. SCOR (2017) announces an initiative to adopt the SCOR environmentally sustainable model [20]. However, the SCOR model is yet to consider integrating a more detailed the social sustainability aspects. Besides, oil refining company reports like [20]-[22] indicated that they are making progress towards sustainability prospect, but still more efforts are required to reach maturity stage with regards to sustainability aspect [23]. A competent supply chain performance measurement model capable of incorporating all the sustainability aspects of oil industry is vitally to this industry.

In response to the need for a comprehensive sustainable model for measuring the oil refining supply chain performance, this study introduces a sustainable theoretical framework. This sustainable supply chain performance measurement model is capable of comprising the oil industry's specific characteristics and assists the oil refining companies in measuring and evaluating their performance. This developed framework seeks to serve as a reference to assist oil refining companies in tailoring the model to consider their company's specifications. Hence, following a critical review of relevant literature, widely used sustainable supply chain performance measurement models have been used to identify the performance indicators for the developed model proposed here.

Literature review has shown that there are key and unique aspects surrounding the oil refining industry. In addition, oil refining companies operate in more complex and dynamic environment than ever before. Appropriately, oil refining companies seek to gain a competitive advantage. Subsequently, previous studies indicated that oil refining can gain a competitive advantage, sustainable source of energy and cleaner and healthy environment through integrating sustainability practices in the company's supply chain and supply chain performance measurement [21]-[23]. Accordingly, oil refining companies seek to follow comprehensive supply chain performance measurement model capable to include the oil refining key aspects and incorporate the sustainability theme. However, oil refining companies demand these set of sustainable supply chain performance measurement models, several previous studies indicated that there are still limited studies have been conducted to integrate all the inclusive oil refining key aspects and the sustainability theme in one particular model [21]-[23]. Respectively, this paper seeks to develop supply chain performance measurement model which capable to include the oil refining fundamental aspects and incorporates the sustainability aspects.

The reminder of this paper is organized as follows. The next section introduces a sustainable performance measurement model for the oil refining supply chain. Section III reviews previous papers which consider widely used sustainable performance measurement models. Section IV develops a comprehensive oil refining supply chain performance measurement theoretical framework that incorporates the sustainability aspect. Within Section V, the work is concluded, which identifies that there is still insufficient and inconsistent guidance for measuring the supply chain performance in the oil refining sector from the sustainability lens.

II. A Sustainable Performance Measurement Model for the Oil Refining Supply Chain

Consequent to the previous discussions, the literature review highlights that the world is moving towards sustainability, and the oil refining industry is in lack of sufficient, sustainable oil refining supply chain performance measurement model. Thus, a theoretical model will be developed via four stages. Firstly, the paper seeks to find out from previous studies the essential aspects which reflect the oil refining characteristics. Accordingly, the paper identified and extracted the main oil refining aspects to be included in the model [23]. Secondly, the extensive literature analysis is carried out to obtain key performance indicators (KPI) for each aspect. Thirdly, this paper will attempt to allocate each key performance indicator under one of the three pillars of sustainability, to assure that the oil refining performance measurement model reverses the sustainability insight. Fourthly, this study intends to provide a measurement for each key performance indicator, these measurements are identified by previous studies. The preceding steps will end up with oil refining sustainable supply chain performance measurement theoretical framework [23].

The development of the theoretical model follows a narrative approach, which will be achieved via four stages, namely: summary of previous studies, synthesis of previous studies, analysis phase and authorization text phase. The paper identified 18 main aspects through analyzing the main issues surrounding the oil refining industry, to find the main characteristics of the oil refining supply chain. Secondly, the paper considers six main aspects to be analyzed (i.e. technology, environment, security, transportation, health and personal safety and social) and excluded 12 sectors due to a limited number of publications. Hence, in the progressive section the paper will explore the previous studies concerning these six aspects to determine under each aspect the relevant KPI. Consequently, the paper will attempt to allocate each KPI under one of the three pillars of sustainability: Economic, Environment, Social [23]. The results of each discussion will be illustrated in Figs. 1-6.

A. Technology Aspect

References [21]-[23] are interested in the technological and environmental perspective aspects. Hence, [22] was concerned by bio-refinery technology, a technique used as an alternative development for some of the oil refining process, requiring less temperature, pressure and cost as less energy is used when compared with the standard oil refining process and still environmentally friendly. Besides, [20], [21] attempt to treat petroleum refinery effluents (wastewater contaminants) in a way that protects the environment from being reused again. Thus, technology enables the oil refining companies to have more efficient operations and still maintain less cost, more profit and environmentally friendly techniques. Besides, [24]-[29] have presented some technological, technical solutions, tools, methods and innovations which can assist oil refining companies to be transferred to smart oil refining company. These technologies are wireless communication solutions, data visibility, monitoring control technology, process automation, data coordination, process automation and remote operator's technology [23].

Technological Aspect

- Smart Refinery **(Economic)**
- Bio- refinery **(Economic & Enviroment)**
- Refining Effluents **(Economic & Enviroment)**

Fig. 1 Technological Aspect's KPIs and their Sustainability Allocation

B. Environment Aspect

References [30]-[32] are concerned with assessing the gas flaring system, greenhouse gases and other emissions in refineries and their relevant environmental impacts. In addition, [33], [34] reveal that the quality of crude oil is currently declining, as average reservoirs with higher sulfur and metal contents are considered undesirable characteristics. Additionally, the study points out that using crude oil with low sulfur content in production could lead to increase in energy usage and higher carbon dioxide emissions released to the atmosphere [23]. That is, these studies recommend that there should be trade off when selecting the quality specification of crude oil. Moreover, [35]-[37] indicated that aside from air pollution, there are also land and water pollutions. That is, these studies mentioned that land and water pollutions constitute environmental problems, so the preceding studies advise companies to treat the company's residual in an environmentally friendly manner before discharge. Furthermore, [38] focuses on the total quantity of energy consumed and the total amount of water consumed in oil refining operations. Finally, [13], [39], [40] were interested in reviewing the use of alternative energy sources. These renewable energy sources are an excellent opportunity for energy-saving, greenhouse gas emissions, and less pollution.

Environmental Aspect

- Crude Oil Feedstock's Quality **(Economic & Environment)**
- Flared Gas, Greenhouse Gas Emissions & Other Gas Emission **(Enviroment)**
- Discharge to water, Wastes & oil Spills **(Enviroment)**
- Fresh Water **(Enviroment)**
- Energy Use **(Environment & Econmic)**
- Alternative Energy Sources **(Enviroment)**

Fig. 2 Environmental Aspect's KPIs and their Sustainability Allocation

C. Security Aspect

References [41], [42] reviewed many papers to extract the definition of energy security. These papers observed common concepts behind all energy security definitions: the energy system's ability to react appropriately to sudden changes or uncertainty risks (politically, environmentally, economically, advances in technology). Also, [13], [39] pointed out the positive relation between energy security and low carbon transition through using renewable energy resources. Accordingly, using renewable energy resources will maintain energy security, energy-saving, greenhouse gas emission reduction and economic benefits [23].

Security Aspect

- Energy Security Against Uncertainty Risks **(Economic)**
- Renewable Energy Sources **(Enviroment)**

Fig. 3 Social Aspect's KPIs and their Sustainability Allocation

D. Transportation Aspect

References [14], [43], [44] pointed out that the significant share of the total oil world reserves is with higher metal and sulfur contents (i.e. heavy crude oil). That is, heavy crude oil represents crude oil viscosity which composes difficulty in oil flow through the pipeline (not pumped easily through pipelines) [20]. Accordingly, the preceding papers pointed out that oil transportation had become a complex and highly technical operation, which require an efficient and economical way to transfer heavy crude oil from head well to the refineries.

Transportation Aspect

- Crude Oil Feedstock's Quality **(Economic & Environment)**

Fig. 4 Transportation Aspect's KPIs and their Sustainability Allocation

E. Health and Personnel Aspect

References [45]-[48] were concerned with occupational health and safety risk management, which is considered one of the critical factors that are concerned with health, safety and welfare of employees. Furthermore, the preceding papers identified the product stewardship aspect which reveals that oil refining companies are responsible for notifying everyone involved in the product cycle (using, handling, transporting, storing, and disposing) to know the product's health and environmental safety risks [23]. This information can be established on a safety data sheet that provides general health, safety, and environmental information. These aspects will help oil refining companies create a healthier environment and be more competitive and effective.

Health and Personel Aspect

- Occupational Health and Safety **(Social)**
- Product StewerdShip **(Social)**

Fig. 5 Health and Personnel Aspect's KPIs and their Sustainability Allocation

F. Social Aspect

References [49]-[51] pointed out that several national governments have passed local content rules and legislation requiring foreign companies to give priority to local content (local hiring practice). In addition, companies have to give priority to local and national companies which can supply the company with goods and services used in petroleum operation. Therefore, local content and local procurement are significant for the host country's economic development. Also, [52], [53] explain the company's social responsibility to implement social investment activities to provide a more prominent and healthier society. Similarly, these activities will provide social wellbeing. Besides, [54], [55] discuss the guidelines for developing the workforce skills. The papers mentioned above pointed out that implementing practical training and development programs will increase worker productivity, skills and employee loyalty. Accordingly, all the previous aspects will allow the company to efficiently and effectively accomplish organization objectives and goals [23].

Social Aspect
• Local Content **(Economic and Social)**
• Social Invetment and Workforce Development **(Social)**

Fig. 6 Social Aspect's KPIs and their Sustainability Allocation

According to previous discussions, the paper will illustrate the oil refining SCPM framework in Fig. 7. This figure will represent each KPI's allocation under one of the three pillars of sustainability and the measurement for each KPI.

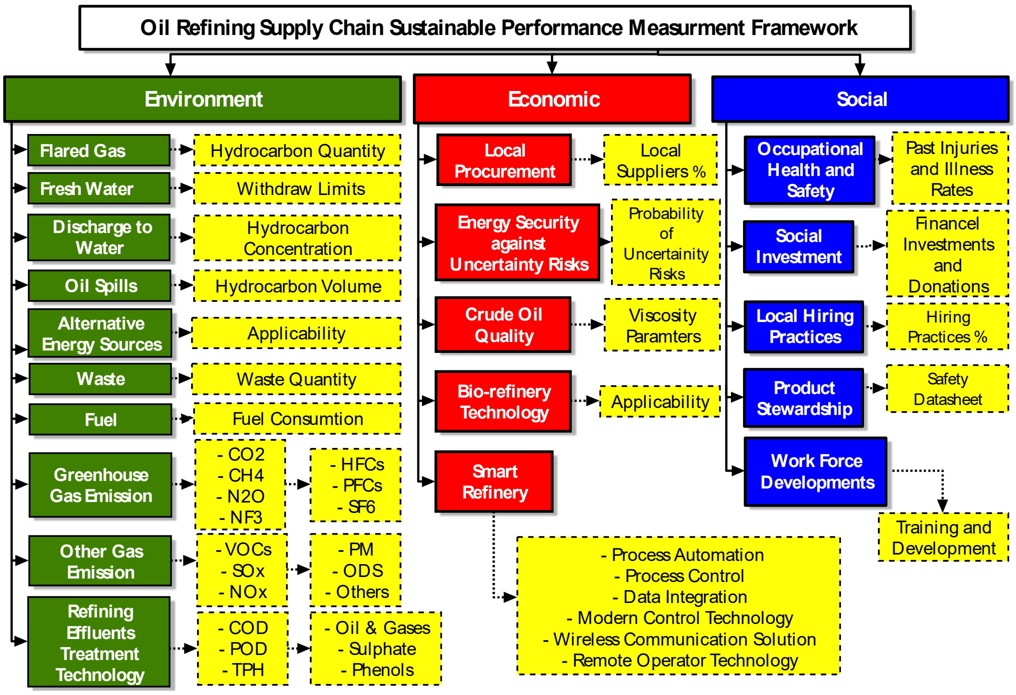

Fig. 7 Oil Refining Sustainable Supply Chain Performance Measurement Model

III. Sustainable Supply Chain Performance Measurement Model

Although the paper attempts to develop a theoretical framework of oil refining supply chain performance measurement model from the sustainability theme, it is also concerned with the limited number of studies that consider the oil refining supply chain performance measurements. A significant number of previous literature that considers sustainable supply chain performance measurement models has been analyzed. Previous studies [54], [55] show that a limited number of papers explicitly incorporate the three pillars of sustainability together (environmental, economic and social aspects) in a particular model. Accordingly, this paper seeks to develop a comprehensive supply chain performance measurement model from the sustainability perspective. That is, the paper will review previous papers that consider the widely used sustainable supply chain performance measurement models. Correspondingly, the paper extracted the main KPI which was defined in previous studies. The extracted KPI will be attached to the previous indicators which were set in the developed oil refining sustainable supply chain performance measurement model. As a result, the assembly of these indicators will end up with the development of a comprehensive oil refining supply chain performance measurement theoretical framework incorporating the sustainability theme.

The theoretical model will follow four stages, namely: summary of sources, synthesis of sources, analysis stage and authorization text phase. Firstly, the paper identified nine keywords extracted from previous studies' keywords, studies which consider the widely used sustainable supply chain performance measurement models. These keywords are:

supply chain performance measurement sustainability model, supply chain performance measurement sustainability business models, supply chain sustainability performance measurements, supply chain sustainable indicators, sustainable supply chain performance index, sustainable supply chain key performance indicators, environmentally sustainable supply chain performance measurement model, economically sustainable supply chain performance measurement model and socially sustainable supply chain performance measurement model. Secondly, the extensive literature analysis is carried out to obtain KPI for each aspect. Thirdly, the paper will attempt to allocate each KPI under one of the three pillars of sustainability to assure that the selected KPI reverses the sustainability insight. Fourthly, it provides a measurement for each KPI, which is identified based on the previous literature review discussions, this analysis will be discussed in the following sections.

Reference [56] pinpoints that there are insufficient theories, framework and model for assessing sustainable supply chain. This study had identified that the set model is an extension of previous studies. This study examined several KPI in the developed model to assess sustainable supply chain performance. These KPI will be summarized in Fig. 8.

Key performmance indicator

- Energy consumption **(Economic)**
- Quantity of solid wastes **(Enviroment)**
- Suitainble return on investment **(Economic)**
- Injury and illness incidents records **(Social)**
- Company- comunity releations **(Social)**

Fig. 8 KPIs Adopted from [56]

Reference [57] proposes an integrated approach for transposing sustainable development principles to supply chain planning models through mathematical programming called the weigh goal programming technique. That is, this developed technique can be used to link sustainability performance to supply chain decisions. As a result, the supply chain planning is optimized while economic, environmental and social performances are all integrated into one model. Practically, this approach can be used as a decision-maker and decision support tool to help the company choose the supply chain operation plan that makes the company achieve its preferences. This study investigated several key performance indicators in the developed model requiring appraise performance in sustainable supply. These key performance indicators will be summarized in Fig. 9.

Key performmance indicator

- Process quality **(Economic)**
- Product quality **(Economic)**
- Safety inspection Audit **(Social)**

Fig. 9 KPIs Adopted from [56]

Reference [58] proposes a dynamic network data analysis framework for supply chain performance assessment by focusing on internal division and their related performance over time. This study was in the area of automotive management sector and worked with capabilities and effectiveness measures. This paper takes into consideration several key performance indicators required to assess performance in sustainable supply. These key performance indicators are summarized in Fig. 10.

Key performmance indicator

- Quantity of solid waste **(Environment)**
- Fresh water consumption**(Environment)**
- Reduction of solid wastes **(Environment)**
- Emission reduction **(Environment)**
- Minimum energy consumption **(Environment)**
- Environment policy, stratgy and targets **(Environment)**
- ISO 14001 certification **(Environment)**
- Community developmemt **(Social)**
- Disable employee job opportunites **(Social)**
- Injury and illness incidents **(Social)**
- Appropriate physical working condition **(Social)**
- Appropriate working hours **(Social)**
- Engineering controls, personnel protective equipment and cloths **(Social)**
- Research and development **(Economc)**

Fig. 10 KPIs Adopted from [56]

Reference [59] provides a critical review to identify and analyze the sustainable metrics that have been presently set in the literature and employed in the business. This study pinpoints that there is a gap between the expected sustainability results and its implementation in reality. Thus, the study highlights that this occurs when there is a lack of reference and unclear sustainability performance metrics in theory. This study recommends that future papers should consider integrating the 3-sustainability perspective when developing sustainable supply chain performance measurements to assist the companies in understanding better and have a balanced decision-making process. Performance indicators have been considered in this study and are summarized in Fig. 11.

Key performmance indicator

- Quantity of recycled/ reused/recover of solid wastes **(Environment)**
- Environmentaly freindly practice **(Environment)**
- Safety inspection audit **(Social)**
- Emergengy plan **(Social)**
- Safety orientaion and control **(Social)**
- Local hiring practice **(Social)**

Fig. 11 KPIs Adopted from [56]

Reference [60] is concerned with developing a sustainable supply chain measurement framework to be used as a tool to evaluate the sustainable performance of a supply chain. That is, this study developed the framework based on fuzzy entropy and fuzzy multi-attribute. Also, the proposed framework was tested using data from middle size Turkish grocery retailers. Thus, certain key performance indicators are considered in this paper which are required to define performance in sustainable supply, these key performance indicators are summarized in Fig. 12.

Key performommance indicator

- Fresh water consumption **(Environment)**
- Waste minmization **(Environment)**
- Renewable resources **(Environment)**
- Energy consumption **(Environment)**
- ISO certification **(Environment, Economic and Social)**
- Soft skills development and tranining **(Social)**
- Workers motivation and compensation **(Social)**
- Annual employee turnover **(Social)**
- Diversity and equal opportunity **(Social)**
- Annual of recordable injuries **(Social)**
- Facility, euipment and maintence **(Economic)**

Fig. 12 KPIs Adopted from [56]

Reference [61] conducted a systematic literature review to identify and analyze the metrics that have been presently addressed in green supply chain measurement and sustainable supply chain measurements. This study will identify comprehensively the metrics currently set to be used by interested parties as a reference point. This study highlights explicitly that the sustainable supply chain management area requires new metrics to be developed. A summary of the measures identified here are captured in Fig. 13.

Key performommance indicator

- Green house gas emission **(Environment)**
- Quantity of recycled/reused/recover of water **(Environment)**
- Industry's Association member **(Environment)**
- Atmospheric acidification **(Environment)**
- Quantity of oil spills **(Environment)**
- Environment audits and assesment **(Environment)**
- Employee environment training and awarness **(Environment)**
- Discharge to water **(Environment)**
- Reduction of air emission **(Environment)**
- Solid wastes **(Environment)**
- Quantity of recycled/ reuse/recover of solid wastes **(Environment)**
- Capital employed **(Economic)**
- Subsidies **(Economic)**
- Frienge befits **(Social)**
- Corruption/ Bribery policy **(Social)**
- Bussiness codes **(Social)**
- Employee engagement **(Social)**
- Employee representive on corporate board of directors **(Social)**

Fig. 13 KPIs Adopted from [56]

Reference [62] concerned to conduct a comprehensive literature review from 2000 to 2015 to find out the evolution of sustainable supply chain measurements. Thus, this study attempts to understand the evolution of sustainability issues analyzed by analyzing trends across industries and economies. Recognized by the study address, a social problem is scared. Besides, the studies which address the three dimensions of sustainability are limited. Similarly, the studies are scattered and far from reaching a theoretical consolidation. This research recommends growth in sustainable supply chain measurement-based studies. Also, recommend more studies are vital to address sustainable supply chain performance measurement for particular industries. Some of the measures proposed here are now captured in Fig. 14.

Key performommance indicator

- Appropriate physical working condition **(Social)**
- Safety inspection audit **(Social)**
- Safety warning signs **(Social)**
- Worplace first aids **(Social)**
- Community funding support **(Social)**

Fig. 14 KPIs Adopted from [56]

Reference [63] pointed out that most of the previous studies focus on environmental aspects. Also, this research stated that limited initiatives that tackle all sustainability issues. This research was concerned with developing a comprehensive sustainable measurement model to be used as a reference to assist corporations in measuring their sustainable performance. Also, this developed model attempts to guide corporations to integrate sustainability in their current performance measurement system. Several indicators are identified here and summed up in Fig. 15.

Key performommance indicator

- Greenhouse gas emission **(Environment)**
- Fresh water consuption **(Environment)**
- Quantity of recycle/reused/ recover of solid waste **(Environment)**
- Quantity of oil spills **(Environment)**
- Oil spills removal **(Environment)**
- Renewable energy sources **(Environment)**
- Environment audits and assesment **(Environment)**
- Soft skills development and trainig **(Social)**
- Annual employee turnover **(Social)**
- Diveristy and equal opportunity **(Social)**
- Safety inspection audit **(Social)**
- Community funding and support **(Social)**
- Product stwerdship **(Social)**
- Corruption/ bibery policy **(Social)**
- Bussiness codes **(Social)**

Fig. 15 KPIs Adopted from [56]

Reference [64] interested in reviewing previous studies to investigate the drivers of sustainable supply chain management. Thus, this study is willing to examine the factors which influence the sustainable supply chain measurement by reviewing previous studies. That is, the study recognized that due to the rapid growth of the worldwide industry and the negative effects on society and the environment escalates the demand for sustainable supply chain measurements. Various measures considered here are summarized in Fig. 16.

Key performmance indicator

- Employee engagement **(Social)**
- Compan - Community releations **(Social)**
- Business codes of conduct **(Social)**

Fig. 16 KPIs Adopted from [56]

Reference [65] concerned to analyze the previous studies interested in the sustainable supply chain performance measurements. This study recognized that there are limited studies that address social sustainability measures. Also, there was a lack of studies developed in the health care and pharmaceutical sectors. Performance indicators examined in this study and are summarized in Fig. 17.

Key performmance indicator

- Greenhouse gas emission **(environment)**
- Energy consumption **(Environment)**
- Crude oil feed stock qulity **(Economic)**

Fig. 17 KPIs Adopted from [56]

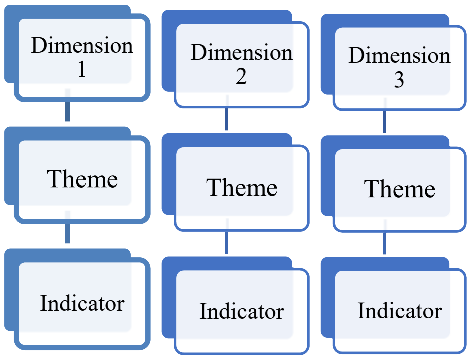

Fig. 18 Model Structure

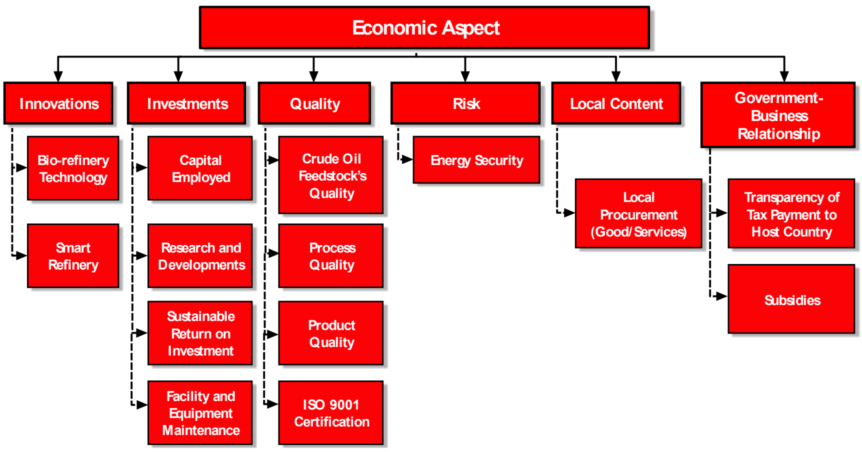

Fig. 19 Environmentally Sustainable Themes and KPI

According to previous discussions, the paper will illustrate the comprehensive oil refining sustainable supply chain performance measurement theoretical framework in Figs. 19-21. The framework will be divided into three frameworks because it is challenging to address all the indicators in a single model. Thus, there will be an environmentally sustainable framework that will be represented in Fig. 19. Besides, there will be a sustainable economic framework, which will be illustrated in Fig. 20. Furthermore, the socially sustainable framework will be represented in Fig. 21. That is, the proposal of each figure will have three levels, as seen in Fig. 18, the first level will represent one of the sustainability three dimensions (environment, economic and social), the second level will represent the themes for each dimension, and the third level will represent KPI for each theme.

IV. Conclusion

This paper has presented a comprehensive oil refining sustainable supply chain performance measurement theoretical framework. A review of relevant literature showed that limited research has focused on oil refining supply chain performance measures. Sustainability aspects are widely neglected in the existing oil refinery performance measurement models. Furthermore, most previous studies assigned widely used management tools such as the BSC and the SCOR by identifying the oil refining criteria under the assigned model perspectives to evaluate the oil refining company's supply chain performance on these criteria. Some desirable characteristics for the oil refining theme (such as the environmental aspect) are not considered in the BSC model and security aspect is not considered in the BSC and SCOR models. Hence, in developing the sustainable theoretical model, various oil refining criteria under the BSC and SCOR perspectives have been considered, especially since that oil refining industry has specific characteristics that distinguish it among other kinds of process industries. The review of literature showed that oil refining industry still did not reach an adequate scope to have consistent guidance for the performance measurement model to comprise the oil refining industry's main characteristics. Accordingly, this paper has proposed a comprehensive oil refining supply chain performance measurement model from sustainability aspect. This study reviewed the limited available literature, identified the existing KPI and the ones that need to be added to the developed model (oil refining sustainable supply chain performance measurement model). Furthermore, the paper allocated each KPI under one of the three pillars of sustainability to develop oil refining supply chain performance measurement theoretical framework from the sustainability theme. Respectively, the paper examined previous studies to identify KPI that are used to measure the supply chain performance from the sustainability perspective. Thus, this paper's contribution was to develop a comprehensive oil refining sustainable supply chain performance measurement theoretical framework. That is, this framework introduced in this paper seeks to assist oil refining companies in measuring and evaluating their performance from a sustainability aspect to achieve sustainable operational excellence.

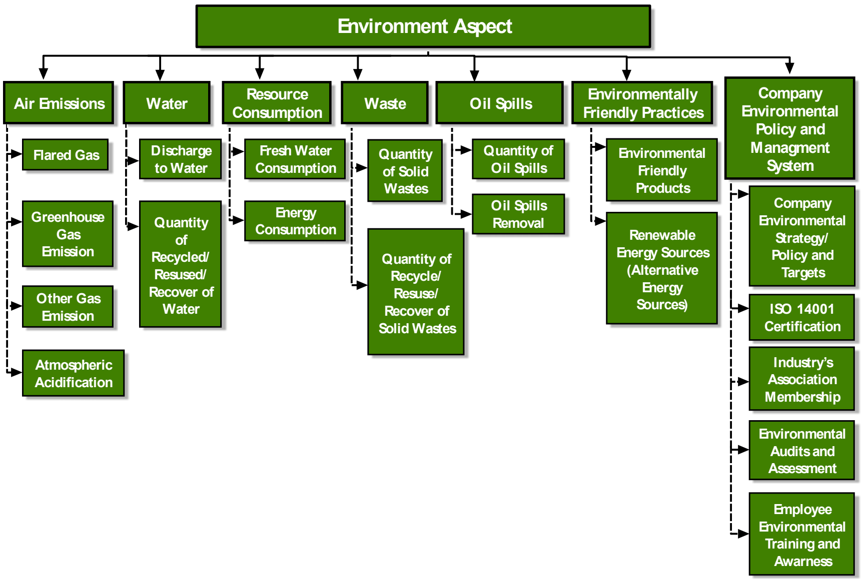

Fig. 20 Economically Sustainable Themes and KPI

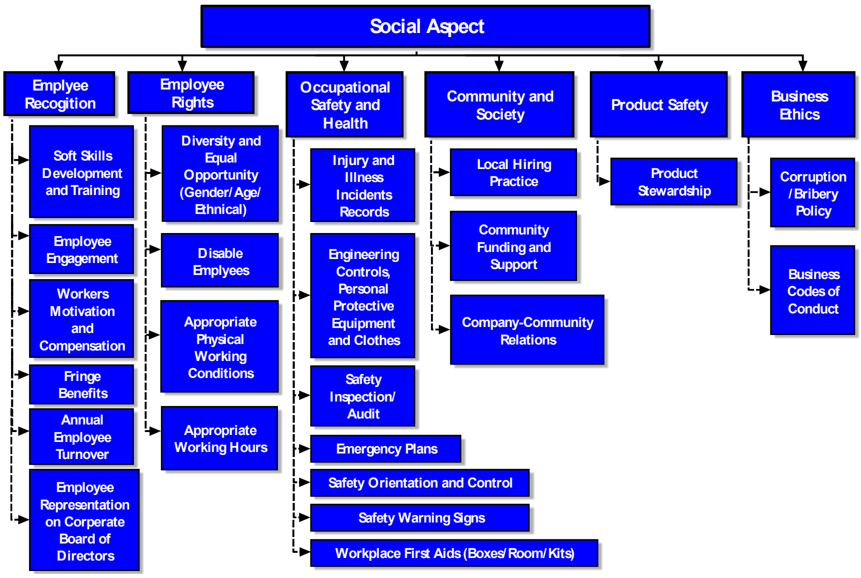

Fig. 21 Socially Sustainable Themes and KPI

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