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Developing a Framework for Closed-Loop Supply Chain and Its Impact on Sustainability in the Petrochemicals Industry

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Abstract: Companies rely on formulating, implementing, and monitoring strategies in social, environmental and economic aspects to ensure that they achieve their goals and keep abreast of developments related to sustainability requirements. Therefore, our study develops a system to integrate the closed-loop supply chain approach in the petrochemical sector. The research follows the quantitative-based approach by collecting data through a questionnaire directed to employees in the supply chain departments, including 230 questionnaires that were collected. Correlation and structural equation models (SEM) were used. This technique consists of multiple regression analysis and factor analysis and analyses the structural relationship between the underlying structures and the measured variables. The results indicated a significant relationship between the supply chains that have a loop from the following perspectives: economic motivations, customer awareness, environmental legislation, and sustainability. By increasing financial reasons, customer awareness and environmental legislation, sustainability will increase as they all move in the same direction. Therefore, the overall effect of a closed-loop supply chain is positive and significant.

Keywords: closed-loop supply chain; petrochemicals; cost effectivity; product stewardship

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1. Introduction

Sustainability and its practice have attracted the attention of the world (companies and researchers), receiving a great degree of importance and recognition since 1992, which coincides with the Rio de Janeiro Summit. It has slowly, but without hesitation, led to changes in global economies. It includes several aspects, such as economic, social, environmental and political, not only at the macro-level but also at the micro-level. This issue is pushing companies to incorporate sustainability into their strategies. To achieve and adapt objectives related to sustainability requirements, companies usually rely on methods for formulating, implementing and monitoring their systems in terms of environmental, social and economic aspects [1]. For all three aspects, several approaches or definitions have been proposed.

The economic sustainability aspect is linked with the company's financial capacity to support economic production indefinitely. On the business side, the economic side of sustainability is defined as the efficient sustainability of a company's assets over time. Moreover, economic sustainability could also be introduced as the present and future value of natural resources (e.g., drinking water). However, economic sustainability includes products, consumption, investment, local markets and the global economy as financial accounts have the long-term costs of using material and human resources [2].

The environmental sustainability aspect guarantees human survival and sustainability in the long term. Zhong and Wu [2] focused on developing methods that limit human activities that deplete natural resources. Hence, environmental sustainability is considered

a responsible human–environment interaction, including the avoidance of the degradation and depletion of natural resources while preserving the long-term environmental quality. There is also a clear shift in industrial establishments regarding production and consumption patterns and increased competition in the market. With the increase in consumers' awareness of environmental dimensions, companies tend to apply environmental regulations in their various functions and activities, especially for those operating in more polluting sectors. Companies usually use the environmental management system framework, based on ISO 14,001 standard. Through this standard, companies can achieve various returns, improve their economic and environmental performance, and guarantee their competitive products, contributing to their continuity and durability [3].

Social sustainability is related to the quality of life in all societal segments. It represents the overall care and cooperation enacted by companies and individuals for the interest of society. Social sustainability requires that all members of society accept the differences and consider them as a centre of strength and superiority, which provides growth and well-being for all [4].

However, to simultaneously enhance sustainability dimensions, closed-loops have been recognised as possible drivers because closing supply chains accelerate a change from a linear to circular economy [5] and towards sustainability. Thus, companies have been interested in developing new management concepts, including the closed-loop supply chain, with different perspectives [6]. Recently, closed-loop supply chain management (CLSCM) has acquired a substantial and noticeable consideration, and unprecedented consideration in the industry and academic community [7,8]. Supply chain management (SCM) is described using different stages, namely, designing, controlling and operating systems to create the maximum value over the lifespan of products and recovering the value dynamically with different sizes and types of returns over time [9]. In addition, closed-loop supply chain management prepares a systems for product recycling and reuse in manufacturing products [10]. The closed-loop supply chain system also considers the entire product life cycle, e.g., purchasing and storing the raw materials, producing the final products, getting the market, and finding end-users. The entire life cycle strongly affects the attainability of the desired corporate objectives. However, it is essential to mention that the closed-loop supply chain lies in two different flow directions. These are the forward logistics flow and the reverse supply chain flow of materials, products, and information [11].

Furthermore, current studies mention environmental rules and regulations as a significant motivator for industrial businesses to establish CLSC. Despite this clear understanding of environmental regulations, few studies have been conducted on the methodological elements of incorporating environmental management into CLSC management. Like any CLSC design, environmental strategy results from a series of feedback loops, including the manufacturing business, external stakeholders, and competitive and organisational forces. As a result, there is an obvious need to emphasise the importance of environmental management [12].

The idea that CLSCs can help industrial businesses is based on two principles. First, CLSCs add value during times of increased competition by cutting costs or boosting revenue. Second, to encourage better environmental stewardship, the CLSC addresses environmental concerns raised by a growing number of various stakeholder groups such as customers, consumers and the general public. However, as previously indicated, the link between EMS and CLSCs still represents a challenge. To improve performance processes, companies focus their attention on developing the good management of closed-loop supply chains, including raising awareness about information systems and modern technology increasing CLSC processes' implementation. Thus, this paper discusses the impact of closed-loop supply chains (Environmental Legislation, Customer awareness and Economic motivations) on sustainable development by examining the following hypothesis, which is divided into three sub-hypotheses:

H_1: *There is a significant impact of closed loop-supply chain on sustainability.*

H_{1a}: *There is a significant impact of environmental legislation on sustainability.*

H_{1b}: *There is a significant impact of customer awareness on sustainability.*

H_{1c}: *There is a significant impact of economic motivations on sustainability.*

This paper is structured in six sections, described as follows: Section 1 provides the introduction and includes background information on the impact of the closed-loop supply chain on sustainability. Section 2 introduces a literature review that discusses and investigates the relationship between the closed-loop supply chain and sustainability. Section 3 illustrates the research methodology (quantitative research-based) and data-collection technique, conducted using a questionnaire. Section 4 introduces data analysis and findings. Section 5 includes a discussion, and Section 6 represents the conclusion, including limitations and recommendations for further research.

2. Literature Review

To comprehensively analyse a closed-loop supply chain, it is vital to clarify its definitions. Thus, studies [7,13] have emphasised Sustainable supply chain management (SSCM) definitions. SSCM as manufacturing, utilisation, recycling (reuse), or eliminating products in the loop closed method [13]. The closed-loop supply chain (CLSCM) is a return process in which manufacturers create added value and increase all supply chain activities [7]. Even in industries that require raw materials, the closed-loop supply chain system reduces the raw material quantities used and moves towards recycling [14]. Closed-loop supply chains management (CLSCM) are the process of designing and controlling a network or system to make significant value creation via total product durability and life cycle, considering a dynamic value recovery process over time [9].

2.1. Sustainable Supply Chain Management

Sustainable supply chain management (SSCM) is defined as the management of materials, information, and capital flows within the supply chain as well as the collaboration between companies within the supply chain while taking into account all of the economic, environmental and social goals implied by stakeholders' and customers' expectations. The purposeful, transparent, and full integration of the triple bottom line (TBL) into the systematic coordination of business operations to reinforce the long-term link between businesses and their supply chains is referred to as sustainable supply chain Management (SSCM). The SSCM literature highlights the necessity of information flow, cooperation, coordination, and communication across the supply chain network, to improve organisational and supply chain sustainability performance. The goal of SSCM is to include sustainable development in supply chain management. Integrating sustainability principles into major business sectors provides a competitive advantage, which is especially crucial given the changing global environment [15].

Based on several definitions of sustainable supply chain management (SSCM), SSCM must be studied as a unit analysis via a network of companies, including various types of macro-environmental actors. Such network analyses are essential since concerns with sustainability in the enlarged network substantially influence the entire company. Focus firms are "those firms that typically (1) control or control the supply chain, (2) provide direct customer interaction, and (3) develop the product or service provided," according to the SSCM. Focus companies have learned that addressing sustainability issues in this environment, which solely includes direct participants in the communication and nutrition network, may not help to achieve the Sustainable Development Goals [16].

Furthermore, Vandchali et al. [17], explored the influence of a supply chain network (SCN) design on target enterprises' Relationship management methods (RMS) and strategies for implementing sustainable practices across the SCN. To investigate the influence of the SCN structure on four RMS, the authors used five metrics to visualise the SCN structure, such as transparency, strength, supplier dependence, buyer dependency, and distance. The statistics give additional information about SCN's sustainability initiatives

by demonstrating specific links between each element and the RMS. The findings might assist managers in determining how much resources to commit to maintaining sustainable practices within their SCNs [17].

Because sustainable supply chain management (SSCM) is challenging to adopt, numerous researchers have sought to discover acceptable strategies that eliminate the effects of barriers and respond to the challenges of sustainable supply chain management (SSCM). Delphi opaque, trial and ambiguous decision-making approaches were used to limit the list of choice criteria from a vast inventory of identified impediments. However, Heidary Dahooie et al. [18] identified the most significant barriers, such as "lack of sustainable product and service promotion" and "weakness of social and community-related pressures", with the essential SSCM practices being "implementation of preventive and maintenance strategies to increase equipment effectiveness" and "implementation of reverse logistics".

2.2. The Differences between CLSCM and Traditional Supply Chain

Companies have recognised that the environmental performance of products and manufacturing processes plays a vital role and significantly affects sustainable manufacturing and services. In addition, Europe, North America, and Japan are speedily implementing regulations and legislation concerning companies' environmental performance. Therefore, companies have increased their proactive measures in anticipation of any developments or changes in environmental performance over time [19]. The differences between CLSCM and traditional supply chain systems are represented by the following aspects, see also Table 1:

- A traditional supply chains' primary goal is to maximise economic benefits by reducing costs and supporting and improving the efficiency of companies' supply chains. However, CLSCM also aims to maximise economic benefits by rationalising the consumption of materials and energy, which helps in reducing emissions and environmental pollutants.
- The focus of CLSCM includes companies' internal and external management in terms of an environmental supply chain management structure, which distinguishes CLSCM from the traditional supply chains.
- On the business side, CLSCM is considered an integrated business model. This is due to companies adopting green supply chain systems, in which the raw materials and production and delivery planning and design are emphasised, decreasing carbon emissions and other environmental impacts.
- Traditional supply chains begin with suppliers of raw materials and end with consumers. They are considered a one-way, irreversible way as products flow in one direction, called "Cradle-to-Grave". On the other hand, the management patterns of CLSCM are two-way, and is termed "Cradle-to-Reincarnation" [19].

Table 1. Comparison Between Traditional Supply Chain and CLSCM.

Issues Considered	Traditional Supply Chain	CLSCM
Primary goal	Maximise economic benefits by reducing costs, supporting and improving the efficiency of companies' supply chain.	Maximise economic benefits by rationalising the consumption of materials and energy, which helps in reducing emissions and environmental pollutants.
Focus		The focus of CLSCM includes companies' internal and external management in terms of an environmental supply chain management structure
Business model		CLSCM is considered as an integrated business model. This is due to companies adopting green supply chain systems, where the raw materials and production and delivery planning and design are emphasised, decreasing carbon emissions and other environmental impacts.
Suppliers and consumers	Traditional supply chains start with suppliers of raw materials and end with consumers. They are considered a one-way, irreversible way as products flow in one direction, called "Cradle-to-Grave".	On the other side, the management patterns of CLSCM are two-way, and this is what is called "Cradle-to-Reincarnation". Thus, CLSCM considers the usage and end-of-life phase (e.g., recycling or processing the resulting waste), in which materials enter the production processes as "raw materials" for the same or new production purposes [19].

2.3. The Relationship between Closed-Loop Supply Chain Dimensions and Sustainability

Environmental legislation is considered a dimension closed-loop supply chain as environmental legislation is a wide-ranging term, which describes the group of treaties, statutes, regulations, and general formal laws that discuss the effects of the activities of humans on the natural environment [20]. However, customer awareness as legislation is one of the closed-loop supply chain dimensions [21]. Additionally, economic motivations as one of the closed-loop supply chain dimensions is the inclination for humans to calculate the costs and the revenues, which involves following a particular end to choose that line of action that will give one the most significant returns inappropriate [22].

Several studies examined the effect of closed-loop supply chain dimensions (customer awareness, environmental legislation and economic motivation) on sustainability, and different results were obtained. Few studies found a significant positive effect of customer awareness on sustainability [23–26] and others found a significant positive impact of environmental legislation on sustainability [25,27–29]. There are no studies that examined the relationship between economic motivation and sustainability. Therefore, this paper contributes to studying this relationship.

3. Research Methodology

Our research was based on quantitative data, using a deductive approach. We collected the primary data from 230 employees who worked in the field of the supply chain through the questionnaire. The questionnaire was disseminated to 290 employees who worked in the supply chain field, 256 were answered, and 26 were not valid for analysis. Thus, we obtained 230 questionnaires for further research. The response rate was 79.3%. The framework of the paper is illustrated in Figure 1 where the independent variable considered in this research is the closed-loop supply chain, which includes four dimensions, namely; customer awareness [20], environmental legislations [21] and economic motivations [22], and the dependent variable considered is sustainability [30].

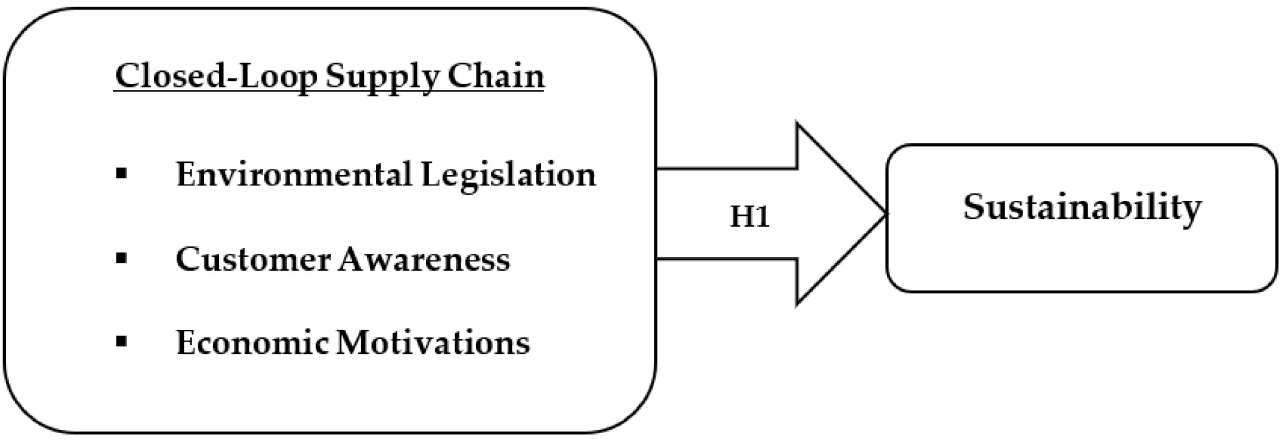

Figure 1. Research Framework.

Table 2 shows the research variables and their measurements according to the conducted questionnaire.

Table 2. Research Variable Measurements.

Variables	Measurements	References
Environmental Legislation	Guideline by government offices has incredibly affected our association's ecological procedure.	Brammer et al., 2012
	Environmental and natural enactment can influence the proceeded with development of our firm.	
	The stricter environmental and ecological guideline is a significant motivation behind why our firm is worried about its effect on the ecological system.	
	Tougher environmental and ecological enactment is required to endure and develop lone firms that are earth mindful.	
	Our firm's environmental and natural attempts can help form future environmental and ecological enactment in our industry.	
	Our industry is confronted with rigorous environmental regulations.	
Customer Awareness	Firms should do more promotion	Ahmad and Al-Aidaros, 2017
	The adoption of a closed-loop supply chain will help reduce harmful effects on the environment.	Kumar, 2020
	The government's decision to exempt closed-loop supply chain from registration formalities	
Economic Motivation	I don't appear to settle on choices without anyone else	Herrmann et al., 2013
	I appear to lose my ability to know the best throughout everyday life	
	It's simpler for me to begin than to complete projects and tasks	
	I don't appear to get moving on anything	
	I don't appear to have the drive to complete my work	
Sustainability	We know enough about sustainability	Bojnec et al., 2015
	Our operations mission is concerned with sustainable growth, social responsibility and environmental protection.	
	It is well known that sustainability is the central pillar of the company	
	Environmental difficulties are exploited legislation for the benefit of the company by developing new goods and products concerning the environment	
	Ecological regulations restrict our business	
	Due to the existence of environmental constraints, consideration is being given to returning production to countries where the requirements for environmental necessities are lower	
	Sustainability and continuity are the significant main pathway for long-term development of venture and advancement of the enterprise.	

As previously mentioned, this research adopts the quantitative approach. The reliance on quantitative data, quantitative analysis, and research in the form of such secondary data is one of the main difficulties of this type of analysis [31]. Sometimes, the complete data set required to explain the relationships between research variables and validate the results is not available. Thus, precision is required to identify the data from the earliest research stage [32]. The data-collection process and analysis derived from the theoretical framework should be relevant for observations and answers to the research's issue. For testing, statistical approaches and techniques have been used to assign the hypotheses' results. In addition, they will offer insights into how much of the variance of independent variables can be explained by the independent variables and what are correlative relationships, if any, is required to be taken [33].

To study the relationship between the two dimensions of the closed-loop supply chain and sustainability, correlation and structural equation (SEM) models were used. This technique consists of multiple regression analyses and factor analysis and is used to analyse the structural relationship between the underlying structures and the measured variables [34].

4. Results and Findings

Table 3 exhibits the validity and reliability test of research variables. We can perceive that the data indicated Kaiser–Meyer–Olkin benchmark of sampling correctness and an adequacy (KMO) more prominent than 0.6, which is characterised as significant [30]. The average variance extracted (AVE) was discovered to be over half (more than 50%). In addition, all of Cronbach's alpha values are greater than 0.7, which indicates a high consistency between the statements (a good internal consistency reliability), meaning that the statements are reliable to measure the variable. Moreover, those statements with a weak factor loading are excluded from the analysis. The valuation suggested an adequate and satisfactory convergent validity and a sufficient reliability.

Table 3. Data testing using Validity and Reliability.

Variables	KMO	AVE	Cronbach's Alpha	Items	Factor Loading
Environmental legislation	0.790	55.595	0.835	EL1	0.558
				EL2	0.509
				EL3	0.487
				EL4	0.641
				EL5	0.622
				EL6	0.519
Customer awareness	0.657	76.211	0.835	CA1	0.612
				CA2	0.861
				CA3	0.814
Economic motivation	0.803	68.154	0.842	EM1	Deleted
				EM2	0.609
				EM3	0.619
				EM4	0.761
				EM5	0.738
Sustainability	0.898	75.023	0.942	Su1	0.760
				Su2	0.825
				Su3	0.802
				Su4	0.802
				Su5	0.706
				Su6	0.768
				Su7	0.589

4.1. The Descriptive Analysis

Table 4 includes the mean of each variable and the standard deviation. We can perceive the mean value, indicating that responses are in the acceptance level, as it is greater than the average value of the variables (Environmental Legislation, Customer Awareness, Economic Motivation, and Sustainability are 3.4087, 3.2087, 3.9174, and 4.2652, respectively). This further indicates that most of the respondents' answers were included in the selection, showing neutral and agree as descriptive statistics acts as a tool that explains and provides a clear understanding of the characteristics of a particular data set.

Table 4. Research Variables Descriptive Analysis.

	N	Mean	Std. Deviation	Frequency				
				1	2	3	4	5
Environmental legislation	230	3.4087	0.72865	3	10	121	82	14
Customer awareness	230	3.2087	0.64741	3	8	169	38	12
Economic motivation	230	3.9174	0.90470	3	14	44	107	62
Sustainability	230	4.2652	0.80071	3	6	15	109	97

4.2. Normality Testing for the Research Variables

There are two types of tests that are used to verify the normal state of the data, namely formal and informal. Table 5 illustrates the official test of the natural state assumption for search variables of the normality test. While the resulting *p*-values are less than 0.05, the search variables are not normally distributed.

Table 5. The Formal Normality Test.

	Kolmogorov–Smirnov		
	Statistic	df	Sig.
Environmental legislation	0.295	230	0.000
Customer awareness	0.409	230	0.000
Economic motivation	0.271	230	0.000
Sustainability	0.266	230	0.000

As the formal test shows that the values are not normally distributed, an informal test detects the approximate normality. Table 6 shows the informal normalcy test, as the skewness values are more significant than the accepted level of ±1 as well as the kurtosis values, which means that the data in the study are not typical. According to the formal test of the normal distribution of the data and the informal test of the normal distribution, the results indicate the use of non-parametric tests. Therefore, the relationship between the variables in the research is measured and described by the Spearman correlations.

Table 6. Informal Testing of Normality.

	N	Skewness		Kurtosis	
	Statistic	Statistic	Std. Error	Statistic	Std. Error
Environmental legislation	230	−0.054	0.160	0.833	0.320
Customer awareness	230	0.646	0.160	2.759	0.320
Economic motivation	230	−0.764	0.160	0.459	0.320
Sustainability	230	−1.443	0.160	3.135	0.320

4.3. Testing Regressions Assumptions

This Section investigates and verifies the regression assumptions for the above-conducted models. The problems of multicollinearity, autocorrelation and heteroscedasticity are discussed below.

Multicollinearity: By testing VIFs, it could be discovered that the VIFs of the Research Variables are less than 5, implying that there is no problem of multicollinearity between the independent variables, see Table 7.

Table 7. VIF values for Research Variables.

Independent Variables	VIF
Environmental legislation	1.222
Customer awareness	1.120
Economic motivation	1.135

Autocorrelation: The model was subjected to the Durbin–Watson test, a statistical test that compares the null hypothesis that the residuals are not auto-linked to the alternative hypothesis that they do. It can be seen that dL = 1.623 and dU = 1.725 in the Durbin–Watson tables for lower and upper values at K = 5 regressors. The null hypothesis of no autocorrelation is supported because these model test results are more significant than 1.725 in all stated models. This means that autocorrelation is not a concern.

$$\text{Durbin} - \text{Watson value} = 1.920$$

Homoscedasticity Assumption: Calculation is performed through a scatter plot of standard residues against non-standard predicted values to investigate the assumption visually. The results show that the relationship between the variables is homoscedastic, as shown in Figure 2.

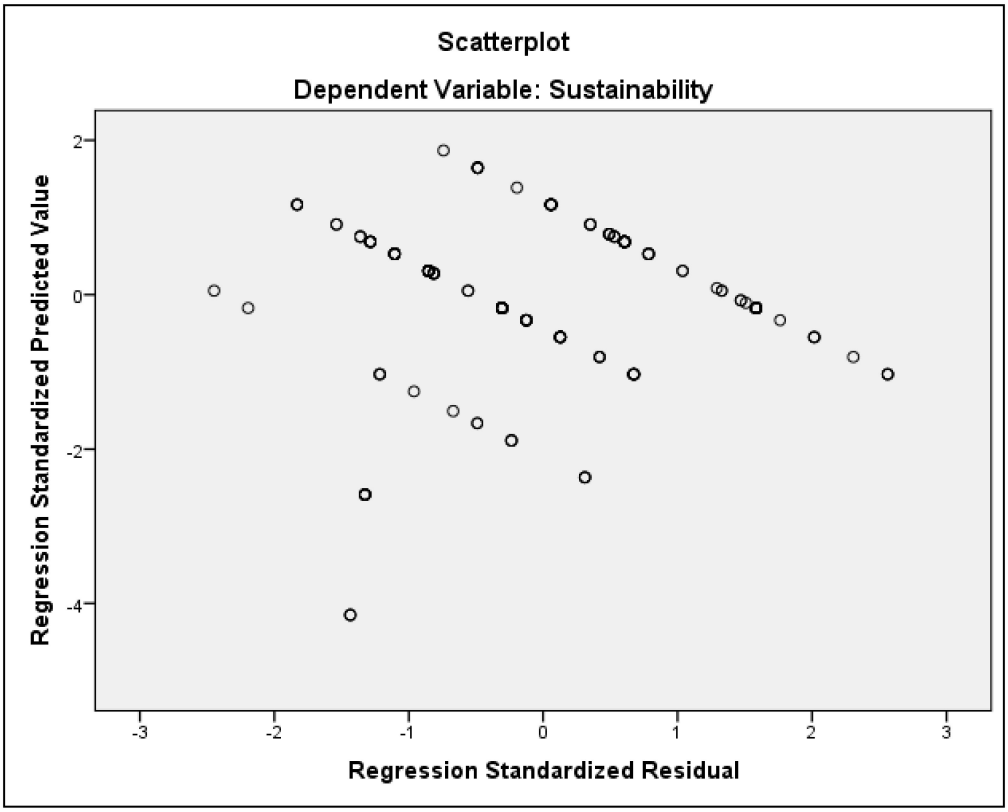

Figure 2. Scatter Plot for Heteroscedasticity.

4.4. Resulting and Findings

Table 8 demonstrates the correlation matrix template for the relationship between Environmental Legislation, Customer Awareness, Economic Motivation, and Sustainability. Table 8 shows the impact of Environmental Legislation and Economic Motivation, on sustainability, as equivalent *p*-values are less than 0.05. Additionally, it was noted that correlation coefficients are 0.281, and 0.564, respectively. At the same time, there is an insignificant relationship between Customer Awareness and Sustainability are identical and the equivalent *p*-value is more than 0.05.

Table 8. Correlation Matrix between Closed-Loop Supply Chain and Sustainability.

		1.	2.	3.	4.
1. Environmental legislation	Spearman's Correlation	1.000			
	Sig. (2-tailed)				
	N	230			
2. Customer awareness	Pearson Correlation	0.266 **	1.000		
	Sig. (2-tailed)	0.000			
	N	230	230		
3. Economic motivation	Pearson Correlation	0.162 *	0.038	1.000	
	Sig. (2-tailed)	0.014	0.565		
	N	230	230	230	
4. Sustainability	Pearson Correlation	0.281 **	0.092	0.564 **	1.000
	Sig. (2-tailed)	0.000	0.165	0.000	
	N	230	230	230	230

Note. (* Correlation is significant at the 0.05 level (2-tailed)), (** correlation is significant at the 0.01 level (1-tailed)).

Table 9 exhibits an analysis of SEM for the effect of environmental legislation, customer awareness, and economic motivation on sustainability. It was noticed that there was an impact of environmental legislation, customer awareness and economic motivation on sustainability. The estimated values were 0.256, 0.152.0.629, respectively (Estimates > 0, *p*-value < 0.05). As for R square, it is equal to 0.704, which means that the model shows a 70.4% variance of sustainability.

Table 9. SEM Analysis of the Effect of Closed-Loop Supply Chain on Sustainability.

			Estimate	*p*	R^2
Sustainability	<—	Environmental legislation	0.256	***	0.704
Sustainability	<—	Customer awareness	0.152	0.017	
Sustainability	<—	Economic motivation	0.629	***	

Note. (*** means that $p < 0.001$, which indicates that the hypothesis is significant).

Table 10 displays the indicators corresponding to the model, which can be verified and clarifies that the results of the assumptions are between acceptable and satisfactory. Figure 3 illustrates an SEM model indicating how susceptible the closed-loop supply chain is to sustainability.

Table 10. The Model Fit Indices.

CMIN/DF	GFI	AGFI	CFI	RMSEA
2.356	0.857	0.812	0.932	0.077

Note. (CMIN/DF is Minimum Discrepancy Per Degree of Freedom, RMSEA is Root Mean Squared Error Approximation, GFI is Goodness-Of-Fit Index, AGFI is Adjusted Goodness-Of-Fit Index, CFI is Comparative Fit Index).

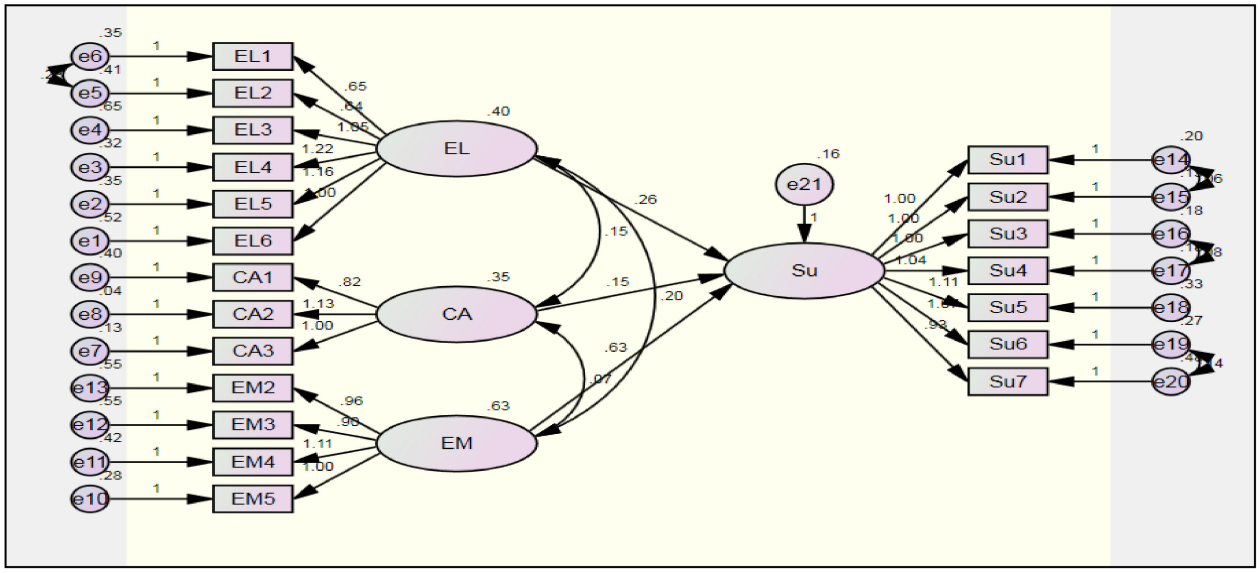

Figure 3. The Analysis of SEM of the Effect of closed-loop supply chain on sustainability.

5. Discussion

This Section identifies how the research hypotheses were achieved. The first sub-hypothesis of the study is concerned with the significant relationship between Environmental Legislation and Sustainability. The second sub-hypothesis is concerned with the vital connection between Environmental Legislation and Sustainability. The third sub-hypothesis is concerned with the significant relationship between Economic Motivation and Sustainability.

To investigate the first sub-hypothesis, "H_{1a}: There is a significant impact of environmental legislation on sustainability", SEM analyses were applied. Environmental legislation has a significant positive effect on sustainability, as the corresponding *p*-value is less than 0.05 and an estimate greater than zero. Considering the second sub-hypothesis, "H_{1b}: There is a significant impact of customer awareness on sustainability", SEM analyses were applied. There is a significant positive effect of customer awareness on sustainability, as the corresponding *p*-value is less than 0.05 and an estimate of greater than zero. Considering the third sub-hypothesis, "H_{1c}: There is a significant impact of economic motivations on sustainability", SEM analyses were applied. Perceived Usefulness has a significant positive effect on efficiency, as the corresponding *p*-value is less than 0.05 and an estimate greater than zero.

The data was analysed and examined empirically to assess the research hypotheses. When testing the research hypothesis for the relationship between the closed-loop supply chain (customer awareness, environmental legislation, and economic motivations) and sustainability, the findings showed support for the first sub-hypothesis, which states, "There is a significant impact of environmental legislation on sustainability". In contrast, the results do not support the second sub-hypothesis, which states, "There is a significant impact of customer awareness on sustainability." Finally, the results supported the third sub-hypothesis, which states that "There is a significant impact of economic motivations on sustainability".

Therefore, the previous studies [26,29–31] supported the study's first hypothesis, which supports a significant positive impact of the two variables (environmental legislation and sustainability). However, the study was unable to provide any support for the second sub-hypothesis that deals with a positive relationship between the two variables (customer awareness and sustainability), as previous studies were able to [24–27]. The study conducted research into a relationship not covered by any previous studies. Therefore, the third hypothesis states a positive impact and statistical significance influence of economic

motives on sustainability. The study was able to support this hypothesis. In Table 11, the research hypotheses are presented, and the final results of the analysis are shown.

Table 11. Main Findings.

Hypothesis	Description	Results
H_1	There is a significant impact of closed-loop supply chain on sustainability	Partially Supported
H_{1a}	There is a significant impact of environmental legislation on sustainability	Supported
H_{1b}	There is a significant impact of customer awareness on sustainability	Not Supported
H_{1c}	There is a significant impact of economic motivations on sustainability	Supported

6. Conclusions

This research intended to thoroughly discuss the relationship between closed-loop supply chain (Environmental Legislation, Customer awareness and Economic motivations) and sustainability with its three dimensions (Economic, Social and Environmental), introducing the above relationship in the context of developing countries. The data were collected from 230 employees who worked in the field of the supply chain in Egypt. Based on data analyses and results outcomes, the following recommendations are proposed: the first recommendation is to create a streamlined structure for closed-loop supply chain management that includes all departments. The second is related to the organisation, which should also seek to build a strategy concerned with strengthening the relationship between consumers and suppliers as a patron that helps in enhancing competitiveness and improving customer satisfaction skills. The goal is to develop efficiency and control of the manufacturing and distribution stages via participation in practices, planning, technology, and returns. In addition, the organisations should build a closed-loop supply chain management environment based on an open system. Such an open system leads to timely communication, providing information about the product, seeking and answering customer inquiries, and efficiently providing post-sale services to help the customer meet requirements for a continuous performance evaluation. The companies adopt the strategic or tactical approach to the supply chain tool on establishing long-term connections and relationships with suppliers, active communication and partnership with suppliers because efficiency in closed-loop supply chain management is a key to the organisation's long-term success. The closed-loop supply chain-management practices provide continuous and sustained improvement. Companies must see closed-loop supply chain practices as sources of motivation that encourage them to develop their relationships with their partners in the supply chain. Moreover, companies should pay more attention to closed-loop supply chain management as they play a fundamental role in improving company performance by improving sustainable development. One of the most critical roles that companies must play is to conduct systematic studies whose results consist of the strengths and weaknesses of the closed-loop supply chain.

The added value of this paper lies in several aspects. The first is related to the research, as this study developed a new model, an integrated closed-loop supply chain approach, adopted in Egypt, a developing Middle East country, lacking a closed-loop supply chain approach in the petrochemical industry. Therefore, a new framework was developed, which could be employed in other countries and modified for various industries or sectors.

Furthermore, our research provides a clear understanding for decision makers regarding the factors influencing the closed-loop supply chain in the petrochemical sector's acceleration towards sustainability. However, there are policy implications in Europe and other developed countries regarding closed loops initiatives, where companies can receive incentives for improving sustainability performances. Studies such as this can enhance policy decision making in developing countries, by adopting good practices from front-running countries.

However, our paper has some limitations. The first is related to the geographical and sectoral coverage as the research was conducted in Egypt within one sector of the petrochemical industry. The second limitation is the sample, which in our case was 230. The third limitation can be linked to the number of variables considered in our study. To overcome the mentioned limitations, further research is needed, especially considering closed-loop activities in other sectors and regions, broadening geographical coverage and the sample. Furthermore, additional comparative studies between the regions within the same industry bring even more in-depth views of challenges, gaps, and solutions. Additionally, further research is needed, including even more variables that affect those mentioned in our study.

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References

1. Baumgartner, R.J. Managing corporate sustainability and CSR: A conceptual framework combining values, strategies and instruments contributing to sustainable development. *Corp. Soc. Responsib. Environ. Manag.* **2014**, *21*, 258–271. [CrossRef]
2. Zhong, Y.; Wu, P. Economic sustainability, environmental sustainability and constructability indicators related to concrete-and steel-projects. *J. Clean. Prod.* **2015**, *108*, 748–756. [CrossRef]
3. Heras-Saizarbitoria, I.; Molina-Azorín, J.F.; Dick, G.P. ISO 14001 certification and financial performance: Selection-effect versus treatment-effect. *J. Clean. Prod.* **2011**, *19*, 1–12. [CrossRef]
4. Vallance, S.; Perkins, H.C.; Dixon, J.E. What is social sustainability? A clarification of concepts. *Geoforum* **2011**, *42*, 342–348. [CrossRef]
5. Winkler, H. Closed-loop production systems. *CIRP J. Manuf. Sci. Technol.* **2011**, *4*, 243–246. [CrossRef]
6. Fatimah, Y.A.; Govindan, K.; Murniningsih, R.; Setiawan, A. Industry 4.0 based sustainable circular economy approach for smart waste management system to achieve sustainable development goals: A case study of Indonesia. *J. Clean. Prod.* **2020**, *269*, 122263. [CrossRef]
7. Kazemi, N.; Modak, N.M.; Govindan, K. A review of reverse logistics and closed loop supply chain management studies published in IJPR: A bibliometric and content analysis. *Int. J. Prod. Res.* **2019**, *57*, 4937–4960. [CrossRef]
8. Kim, J.; Do Chung, B.; Kang, Y.; Jeong, B. Robust optimisation model for closed-loop supply chain planning under reverse logistics flow and demand uncertainty. *J. Clean. Prod.* **2018**, *196*, 1314–1328. [CrossRef]
9. Darbari, J.D.; Kannan, D.; Agarwal, V.; Jha, P.C. Fuzzy criteria programming approach for optimising the TBL performance of closed loop supply chain network design problem. *Ann. Oper. Res.* **2019**, *273*, 693–738. [CrossRef]
10. Zhou, L.; Naim, M.M.; Disney, S.M. The Impact of Product Returns and Remanufacturing Uncertainties on the Dynamic Performance of a Multi-Echelon Closed-Loop Supply Chain. *Int. J. Prod. Econ.* **2017**, *183*, 487–502. [CrossRef]
11. Ramanathan, U.; He, Q.; Subramanian, N.; Gunasekaran, A. Closed-Loop Supply Chain Collaboration: A Study of the Packaging Industry. In Proceedings of the BAM2018: British Academy of Management Conference, Bristol, UK, 4–6 September 2018.
12. Ferguson, M.E.; Souza, G.C. *Closed-Loop Supply Chains: New Developments to Improve the Sustainability of Business Practices*; Auerbach Publications: Boca Raton, FL, USA, 2010.
13. Gaur, J.; Mani, V. Antecedents of closed-loop supply chain in emerging economies: A conceptual framework using stakeholder's perspective. *Resour. Conserv. Recycl.* **2018**, *139*, 219–227. [CrossRef]
14. Islam, M.T.; Huda, N. Reverse logistics and closed-loop supply chain of Waste Electrical and Electronic Equipment (WEEE)/E-waste: A comprehensive literature review. *Resour. Conserv. Recycl.* **2018**, *137*, 48–75. [CrossRef]

15. Tsai, F.M.; Bui, T.D.; Tseng, M.L.; Ali, M.H.; Lim, M.K.; Chiu, A.S. Sustainable supply chain management trends in world regions: A data-driven analysis. *Resour. Conserv. Recycl.* **2021**, *167*, 105421. [CrossRef]
16. Rezaei Vandchali, H.; Cahoon, S.; Chen, S.L. Creating a sustainable supply chain network by adopting relationship management strategies. *J. Bus.-To-Bus. Mark.* **2020**, *27*, 125–149. [CrossRef]
17. Vandchali, H.R.; Cahoon, S.; Chen, S.L. The impact of supply chain network structure on relationship management strategies: An empirical investigation of sustainability practices in retailers. *Sustain. Prod. Consum.* **2021**, *28*, 281–299. [CrossRef]
18. Heidary Dahooie, J.; Zamani Babgohari, A.; Meidutė-Kavaliauskienė, I.; Govindan, K. Prioritising sustainable supply chain management practices by their impact on multiple interacting barriers. *Int. J. Sustain. Dev. World Ecol.* **2021**, *28*, 267–290. [CrossRef]
19. Bhatia, M.S.; Kumar Srivastava, R. Antecedents of implementation success in closed-loop supply chain: An empirical investigation. *Int. J. Prod. Res.* **2019**, *57*, 7344–7360. [CrossRef]
20. Mohtashami, Z.; Aghsami, A.; Jolai, F. A green closed loop supply chain design using queuing system for reducing environmental impact and energy consumption. *J. Clean. Prod.* **2021**, *242*, 118452. [CrossRef]
21. Brammer, S.; Hoejmose, S.; Marchant, K. Environmental management in SME s in the UK: Practices, pressures and perceived benefits. *Bus. Strategy Environ.* **2012**, *21*, 423–434. [CrossRef]
22. Garg, P.; Gupta, B.; Dzever, S.; Sivarajah, U.; Kumar, V. Examining the relationship between social media analytics practices and business performance in the Indian retail and IT industries: The mediation role of customer engagement. *Int. J. Inf. Manag.* **2020**, *52*, 102069. [CrossRef]
23. Sirgy, M.J.; Gurel-Atay, E.; Webb, D.; Cicic, M.; Husic-Mehmedovic, M.; Ekici, A.; Herrmann, A.; Hegazy, I.; Lee, D.J.; Johar, J.S. Is materialism all that bad? Effects on satisfaction with material life, life satisfaction, and economic motivation. *Soc. Indic. Res.* **2013**, *110*, 349–366. [CrossRef]
24. Buerke, A.; Straatmann, T.; Lin-Hi, N.; Müller, K. Consumer awareness and sustainability-focused value orientation as motivating factors of responsible consumer behavior. *Rev. Manag. Sci.* **2017**, *11*, 959–991. [CrossRef]
25. Gong, M.; Gao, Y.; Koh, L.; Sutcliffe, C.; Cullen, J. The role of customer awareness in promoting firm sustainability and sustainable supply chain management. *Int. J. Prod. Econ.* **2019**, *217*, 88–96. [CrossRef]
26. Jermsittiparsert, K.; Joemsittiprasert, W.; Phonwattana, S. Mediating role of sustainability capability in determining sustainable supply chain management in tourism industry of Thailand. *Int. J. Supply Chain. Manag.* **2019**, *8*, 47–58.
27. Saha, D.; Paterson, R.G. Local government efforts to promote the "Three Es" of sustainable development: Survey in medium to large cities in the United States. *J. Plan. Educ. Res.* **2008**, *28*, 21–37. [CrossRef]
28. Dernbach, J.C.; Mintz, J.A. Environmental laws and sustainability: An introduction. *Sustainability* **2011**, *3*, 531–540. [CrossRef]
29. Abioro, T.; Adefeso, H.A. Local government and Sustainable development in nigeria. *J. Sustain. Dev. Afr.* **2014**, *16*, 76–87.
30. Lesinskyi, V.; Yemelyanov, O.; Zarytska, O.; Symak, A.; Petrushka, T. Development of a toolkit for assessing and overcoming barriers to the implementation of energy saving projects. *East.-Eur. J. Enterp. Technol.* **2020**, *5*, 107. [CrossRef]
31. Tomšič, N.; Bojnec, Š.; Simčič, B. Corporate sustainability and economic performance in small and medium sized enterprises. *J. Clean. Prod.* **2015**, *108*, 603–612. [CrossRef]
32. Choy, L.T. The strengths and weaknesses of research methodology: Comparison and complimentary between qualitative and quantitative approaches. *IOSR J. Humanit. Soc. Sci.* **2014**, *19*, 99–104. [CrossRef]
33. Ott, R.L.; Longnecker, M.T. *An Introduction to Statistical Methods and Data Analysis*; Cengage Learning: Boston, MA, USA, 2016.
34. Duncan, J.M.A.; Boruff, B.; Saunders, A.; Sun, Q.; Hurley, J.; Amati, M. Turning down the heat: An enhanced understanding of the relationship between urban vegetation and surface temperature at the city scale. *Sci. Total Environ.* **2019**, *656*, 118–128. [CrossRef] [PubMed]