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The analysis of the impact of different supply chain factors using statistical perspective

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Abstract. Supply Chain Management (SCM) is an essential part of modern business and involves the coordination of procurement, production, and logistics. Effective SCM allows organizations to remain competitive and reduce costs. With the growth of the global marketplace, SCM is becoming increasingly important for businesses to compete. The most important aspect of SCM is to understand the components of the supply chain, which form a network of organizations involved in value-added processes and activities. The supply chain network consists of multiple components, indicating that the success of an organization's SCM depends on the combination of multiple influencing factors. This paper utilizes the supply chain data of several well-known companies, uses a dozen variables such as inventory turnover ratio, lead time, and supplier count as independent variables, and analyzes the effects of these different supply chain influencing factors on operational efficiency, supply chain resilience, and supplier relationship through multiple linear regression models. This study finds that many different supply chain factors, like transportation cost efficiency, delivery time, and others, have the greatest impact on the above-mentioned factors. This analysis may help companies to comprehensively assess their supply chain maturity and strategically enhance their supply chain attributes to achieve their business development goals.

Keywords: Supply Chain Management, Multiple Linear Regression, Operational Efficiency, Supply Resilience.

1. Introduction

Supply Chain Management (SCM) is a key component of modern business strategy, encompassing the coordination and integration of multiple activities such as procurement, production, and logistics. For an organization, efficient supply chain management can maintain competitiveness, reduce costs, and ensure timely delivery of products to consumers [1]. The complete supply chain is a network of organizations that are linked upstream and downstream and are involved in different processes and activities that generate value in the form of products and services provided to the final consumer. And there are many types of methods to perform supply chain management and enhancement, which include Agile SCM, Lean Manufacturing, and Cross-Docking, etc. These supply chain management methods can positively affect inventory levels, improve order fulfillment, and increase customer satisfaction by enhancing the company's benefits. Many elements may influence the supply chain, and various attributes of the supply chain help assess its performance [2]. Understanding the specific impact of different SCM

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practices on operational metrics and relational aspects is critical for organizations to achieve sustainable growth and increased resilience in a dynamic business environment [3].

The purpose of this study is to explore how different supply chain factors affect a firm's operational efficiency, supply chain resilience, and supplier relationships. This paper will find out which practices of supply chain management have a significant impact on operational efficiency, resilience, and supplier relationships. And it will elaborate on the main factors that affect operational efficiency, resilience, and supplier relationships. Operational efficiency represents the supply chain's ability to reduce waste, including time, cost, and resources, during the production and distribution process It is a crucial attribute to evaluate, as a highly operationally efficient supply chain can bring great benefits to an enterprise [4]. Supply chain resilience, on the other hand, is the measure of the supply chain system's capability to respond to the risk factors that can threaten the supply chain and its ability to bring the supply chain back to its previous condition or even improve it in light of various levels of risk [5-6]. This attribute is the agility of the supply chain to counter a disruption, that is, to replenish supply, and this has a direct effect on the robustness of a company's supply chain [7]. Supplier relationships focus on the level of connections between the enterprise and its suppliers. Thus, it is vital for an enterprise to build a strong partnership with its suppliers in order to gain a competitive advantage. Beneficial supplier relationships lead to better product quality, lower costs, and faster delivery, which in turn leads to innovation, increased competitiveness, and business opportunities for companies. The purpose of this study is to reveal the precise functions of these approaches in increasing firms' operational efficiency, enhancing supply chain resilience, and optimizing supplier relationships. The research aims to determine and evaluate the particular effects of supply chain factors on operational efficiency, to examine the impact of these factors on supply chain resilience in the response of the supply chain to disturbances and changes, and to investigate the impact of the supply chain factors in building and sustaining cooperation with suppliers. This research work does not only seek to contribute theoretical knowledge but also to help organizations in choosing and applying supply chain management strategies.

2. Methods

2.1. Data Source

In order to ensure the authority and accuracy of the data source, the supply chain event database of several well-known companies is used as the data source in this paper [8]. The database captures dozens of supply chain factors and three supply chain attribute scores from these companies. In order to ensure the comprehensiveness of the data and the accuracy of the modeling, 999 sets of supply chain data were collected from this database. Some supply chain factors with missing data are eliminated, resulting in a final dataset of 15 supply chain factors.

2.2. Variable Description

Table 1 show the independent and dependent variables in the 18 variables used in the study.

Table 1. Independent and Dependent variables of the model

Independent Variable	Dependent Variable
Inventory Turnover Ratio	Operational Efficiency Score
Lead Time (days)	Supply Chain Resilience Score
Supplier Count	Supplier Relationship Score
Order Fulfillment Rate (%)	-
Customer Satisfaction (%)	-
Supply Chain Agility: High (ref = Medium)	-
Supplier Lead Time Variability (days)	-
Inventory Accuracy (%)	-
Transportation Cost Efficiency (%)	-

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Table 1. (continued).

Supply Chain Integration Level: High (ref = Medium)	-
Supply Chain Complexity Index: Low (ref = Medium)	-
Supply Chain Complexity Index: High (ref = Medium)	-
Cost of Goods Sold (COGS)	-
Revenue Growth Rate out of (15)	-
Supply Chain Risk (%)	-

As shown in Table 1, 18 variables are categorized into independent and dependent variables. Independent variables are the supply chain factors of these firms, and dependent variables are the attribute scores of the supply chain that can be assessed as influenced by these factors.

2.3. Mathematical Statistics Method

The mathematical statistical method used in this study is the Multiple Linear Regression Model.

The relationship between the response variables y_i and the predictor variables x_i can be modeled through a linear regression, where there are p predictor variables $x_1, x_2, \cdots, x_p$ and a single response variable y_i.

The relationship between the response variable y_i and the predictor variables x_i can be modeled with a multiple linear regression model. In this model, there are p predictor variables $x_1, x_2, \cdots, x_p$ and a single response variable y_i. The mathematical expression for the multiple linear regression model is

$$y_i = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + \cdots + \beta_p x_{ip} + \varepsilon_i \quad (1)$$

where ε_i is random error item, $\beta_0, \beta_1, \cdots, \beta_p$ are regression coefficient. And this equation represents a multiple linear regression model [9].

3. Results and Discussion

3.1. Descriptive Analysis

As shown in Table 2, several metrics exhibit significant characteristics., in which Supplier Count, shows great variability, ranging from 100 to 1,300,000, with a mean of 43,202.98 and a standard deviation of 213,665.67. This indicates that there are significant differences in the number of suppliers managed by different firms, with some firms relying on a small number of suppliers, while others manage a large network of suppliers.

Cost of Goods Sold (COGS) also shows significant variation ranging from 300 to 1500, with a mean of 719.02 and a standard deviation of 271.88. This demonstrates the variability in the cost of goods sold by different firms, potentially attributed to their business model and size. On the contrary, Order Fulfillment Rate and Inventory Accuracy show consistency. The Order Fulfillment Rate ranges from 87% to 99%, with an average of 91.73% and a standard deviation of 2.89, indicating that most companies are able to achieve a high order fulfillment rate. Inventory accuracy ranged from 95% to 99%, with an average of 97.41% and a standard deviation of only 1.17, indicating that most companies excel in inventory management.

Table 2. Descriptive Statistical Analysis Results

Variable	N	Minimum Value	Maximum Value	Average Value	Standard Deviation
Inventory Turnover Ratio	999	1	50	6.33	5.48
Lead Time (days)	999	2	22	11.45	4.20
Supplier Count	999	100	1300000	43202.98	213665.671
Order Fulfillment Rate (%)	999	87	99	91.73	2.89

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Table 2. (continued).

Customer Satisfaction (%)	999	85	94	89.21	2.27
Supplier Lead Time Variability (days)	999	1	10	3.28	1.59
Inventory Accuracy (%)	999	95	99	97.41	1.17
Transportation Cost Efficiency (%)	999	80	92	87.15	2.38
Cost of Goods Sold (COGS)	999	300	1500	719.02	271.88
Revenue Growth Rate out of (15)	999	8	20	10.83	1.95
Supply Chain Risk (%)	999	3	15	8.95	2.86
Operational Efficiency Score	999	75	90	83.45	2.31
Supply Chain Resilience Score	999	80	95	88.09	2.86
Supplier Relationship Score	999	78	90	83.88	2.85

Table 3 is a correlation analysis. Several key metrics with significant characteristics have been found:

The correlation coefficient between Order Fulfillment Rate and Supply Chain Resilience Score is as high as 0.860, with a significance level of $p < 0.001$, which suggests that a high Order Fulfillment Rate is usually accompanied by a high Supply Chain Resilience Score, implying that supply chains are more adaptive and flexible in the presence of efficient order processing. This suggests that when order processing efficiency is high, a high Supply Chain Resilience Score usually follows, indicating that the supply chain is more adaptable and flexible .

The correlation coefficient between Supply Chain Risk and Supply Chain Resilience Score is -0.873 with a significance level of $p < 0.001$, which shows a strong negative correlation between the two, which indicates the importance of reducing supply chain risk in order to improve supply chain resilience.

There is also a strong positive correlation between Transportation Cost Efficiency and Supply Chain Resilience Score, with a correlation coefficient of 0.809 and a significance level of $p < 0.001$, indicating that high Transportation Cost Efficiency is usually accompanied by high Supply Chain Resilience Score, suggesting that optimizing transportation costs can help improve supply chain resilience. Score, indicating that optimizing transportation costs helps to improve supply chain resilience and responsiveness.

Finally, there is a positive correlation between Customer Satisfaction and Order Fulfillment Rate, which indicates that an increase in Order Fulfillment Rate usually leads to an increase in Customer Satisfaction, which plays an important role in improving the competitiveness and market position of enterprises.

Table 3. Correlation Analysis Results

	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1 Inventory Turnover Ratio	1													
2 Lead Time (days)	-0.013	1												
3 Supplier Count	-0.012	-0.037	1											
4 Order Fulfillment Rate (%)	0.032	-0.783***	0.031	1										
5 Customer Satisfaction (%)	0.072*	-0.095**	0.017	0.104**	1									
6 Supplier Lead Time Variability (days)	-0.008	0.804***	-0.030	-0.696***	-0.071*	1								
7 Inventory Accuracy (%)	-0.006	-0.672***	-0.027	0.499***	0.073*	-0.726***	1							
8 Transportation Cost Efficiency (%)	0.010	-0.647***	-0.024	0.622***	0.069*	-0.788***	0.625***	1						
9 Cost of Goods Sold (COGS)	0.023	-0.248***	0.036	0.601***	0.070*	-0.376***	0.284***	0.355***	1					
10 Revenue Growth Rate out of (15)	-0.003	-0.644***	0.118**	0.674***	0.055	-0.579***	0.492***	0.448***	0.535***	1				
11 Supply Chain Risk (%)	-0.016	0.853***	-0.026	-0.867***	-0.093**	0.795***	-0.557***	-0.712***	-0.429***	-0.621***	1			

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Table 3. (continued).

12 Operational Efficiency Score	0.077*	-0.128***	0.017	0.153***	0.105**	-0.192***	0.184***	0.226***	0.139***	0.090**	-0.164***	1		
13 Supply Chain Resilience Score	0.051	-0.722***	-0.012	0.860***	0.097**	-0.756***	0.558***	0.809***	0.559***	0.498***	-0.873***	0.223***	1	
14 Supplier Relationship Score	0.029	-0.627***	-0.041	0.786***	0.077*	-0.646***	0.619***	0.613***	0.624***	0.508***	-0.757***	0.191***	0.839***	1

***p < 0.001; **p < 0.01; *p < 0.05.

3.2. Inferential Analysis

This paper selects 999 cases from the database, assuming a linear relationship between the three dependent variables and the 14 independent variables, and picks 14 groups of influences with low covariance for analysis. In this paper, those cases were used as training samples and analyzed by multiple linear regression using SPSS. This paper will analyze the three dependent variables: Operational Efficiency Score, Supply Chain Resilience Score and Supplier Relationship Score separately. And analyze the results of their regression, i.e., parameters such as regression coefficients, to derive the factors affecting these three parameters that can be assessed for the level of the supply chain. This will be of great significance for the company as it improves its supply chain in the future.

The multiple linear regression coefficient estimates were obtained through SPSS, and the analysis results for the three different supply chain attribute scores are shown in Tables 4, 5, and 6.

Table 4. Regression Analysis Results (Operational Efficiency Score)

	Unstandardized Coefficient		β	t	P	Covariance Statistics	
	B	SE				Tolerances	VIF
Constant	46.236	16.090		2.874	0.004		
Inventory Turnover Ratio	0.028	0.013	0.066	2.155	0.031	0.988	1.012
Lead Time (days)	0.068	0.048	0.124	1.430	0.153	0.126	7.983
Supplier Count	-0.004	0.033	-0.004	-0.120	0.905	0.972	1.029
Order Fulfillment Rate (%)	0.037	0.067	0.047	0.558	0.577	0.134	7.463
Customer Satisfaction (%)	0.086	0.032	0.084	2.699	0.007	0.972	1.029
Supply Chain Agility: High (ref = Medium)	-0.369	0.471	-0.058	-0.784	0.422	0.170	5.889
Supplier Lead Time Variability (days)	-0.088	0.116	-0.061	-0.758	0.448	0.146	6.842
Inventory Accuracy (%)	0.133	0.143	0.067	0.926	0.355	0.178	5.623
Transportation Cost Efficiency (%)	0.146	0.056	0.150	2.627	0.009	0.286	3.498
Supply Chain Integration Level: High (ref = Medium)	0.573	0.420	0.098	1.363	0.173	0.183	5.476
Supply Chain Complexity Index: Low (ref = Medium)	0.168	0.302	0.028	0.556	0.579	0.377	2.653
Supply Chain Complexity Index: High (ref = Medium)	-0.076	0.262	-0.014	-0.291	0.771	0.403	2.478
Cost of Goods Sold (COGS)	0.001	0.000	0.062	1.256	0.210	0.386	2.593
Revenue Growth Rate out of (15)	-0.070	0.057	-0.059	-1.235	0.217	0.408	2.452
Supply Chain Risk (%)	-0.017	0.073	-0.021	-0.229	0.819	0.114	8.757
R2				0.078			
R2 (After adjustment)				0.064			
F				5.571***			

***p < 0.001.

According to the data analysis results in Table 4, the three variables with the largest absolute values of standardized regression coefficients are Transportation Cost Efficiency (%) (0.150), Lead Time (days) (0.124), and Supply Chain Integration Level (0.098), and all three variables have positive coefficients.

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The coefficients of all three variables are positive. This indicates that Transportation Cost Efficiency, Lead Time and Supply Chain Integration Level have a significant positive effect on Operational Efficiency Score. Therefore, these three supply chain factors are identified as the main factors affecting the Operational Efficiency Score. In order to improve the level of Operational Efficiency, companies should focus on improving Transportation Cost Efficiency, shortening Lead Time, and enhancing Supply Chain Integration Level.

Table 5. Regression Analysis Results (Supply Chain Resilience Score)

	Unstandardized Coefficient		*β*	*t*	*P*	Covariance Statistics	
	B	*SE*				Tolerances	VIF
Constant	27.051	5.668		4.773	0.000		
Inventory Turnover Ratio	0.012	0.005	0.024	2.698	0.007	0.988	1.012
Lead Time (days)	0.059	0.017	0.087	3.537	0.000	0.126	7.983
Supplier Count	-0.021	0.012	-0.016	-1.805	0.071	0.972	1.029
Order Fulfillment Rate (%)	0.441	0.024	0.446	18.718	0.000	0.134	7.463
Customer Satisfaction (%)	0.001	0.011	0.001	0.078	0.938	0.972	1.029
Supply Chain Agility: High (ref = Medium)	-0.337	0.166	-0.043	-2.035	0.042	0.170	5.889
Supplier Lead Time Variability (days)	-0.022	0.041	-0.012	-0.526	0.599	0.146	6.842
Inventory Accuracy (%)	-0.106	0.051	-0.044	-2.104	0.036	0.178	5.623
Transportation Cost Efficiency (%)	0.387	0.020	0.322	19.763	0.000	0.286	3.498
Supply Chain Integration Level: High (ref = Medium)	1.238	0.148	0.171	8.361	0.000	0.183	5.476
Supply Chain Complexity Index: Low (ref = Medium)	0.441	0.106	0.059	4.146	0.000	0.377	2.653
Supply Chain Complexity Index: High (ref = Medium)	0.298	0.092	0.059	4.311	0.000	0.403	2.478
Cost of Goods Sold (COGS)	0.002	0.00	0.151	10.756	0.000	0.386	2.593
Revenue Growth Rate out of (15)	-0.336	0.020	-0.229	-16.780	0.000	0.408	2.452
Supply Chain Risk (%)	-0.307	0.026	-0.308	11.915	0.000	0.114	8.757
R^2				0.925			
R^2 *(After adjustment)*				0.924			
F				810.580***			

***p < 0.001.

According to the results of the data analysis in Table 5, the three variables with the largest absolute values of standardized regression coefficients are Order Fulfillment Rate (%) (0.446), Transportation Cost Efficiency (%) (0.322), and Supply Chain Risk (0.308). The coefficients of these three variables are significantly higher than the coefficients of other factors, and among them the standardized regression coefficients of Order Fulfillment Rate and Transportation Cost Efficiency are positive, while the standardized regression coefficient of Supply Chain Risk is negative. This indicates that Order Fulfillment Rate and Transportation Cost Efficiency have a very significant positive effect on Supply Chain Resilience, while Supply Chain Risk has a very significant negative effect on Supply Chain Resilience. negative effect on Supply Chain Resilience. Therefore, these three supply chain factors were

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identified as the main factors affecting the Supply Chain Resilience Score. In order to improve the Supply Chain Resilience, enterprises should focus on improving the Order Fulfillment Rate and Transportation Cost Efficiency in the supply chain, and effectively reducing Supply Chain Risk. By optimizing these key factors, enterprises can significantly improve the resilience and stability of their supply chains.

Table 6. Regression Analysis Results (Supplier Relationship Score)

	Unstandardized Coefficient		*β*	*t*	*P*	Covariance Statistics	
	B	*SE*				Tolerances	VIF
Constant	33.305	9.127		3.649	0.000		
Inventory Turnover Ratio	0.006	0.007	0.11	0.757	0.449	0.988	1.012
Lead Time (days)	0.063	0.027	0.093	2.340	0.020	0.126	7.983
Supplier Count	-0.039	0.019	-0.030	-2.082	0.038	0.972	1.029
Order Fulfillment Rate (%)	0.423	0.038	0.429	11.140	0.000	0.134	7.463
Customer Satisfaction (%)	-0.020	0.018	-0.016	-1.114	0.266	0.972	1.029
Supply Chain Agility: High (ref = Medium)	1.657	0.267	0.212	6.209	0.000	0.170	5.889
Supplier Lead Time Variability (days)	-0.109	0.066	-0.061	-1.657	0.098	0.146	6.842
Inventory Accuracy (%)	0.250	0.081	0.103	3.077	0.002	0.178	5.623
Transportation Cost Efficiency (%)	-0.086	0.032	-0.072	-2.718	0.007	0.286	3.498
Supply Chain Integration Level: High (ref = Medium)	-1.133	0.238	-0.157	-4.755	0.000	0.183	5.476
Supply Chain Complexity Index: Low (ref = Medium)	1.889	0.171	0.253	11.032	0.000	0.377	2.653
Supply Chain Complexity Index: High (ref = Medium)	0.184	0.149	0.027	1.236	0.217	0.403	2.478
Cost of Goods Sold (COGS)	0.003	0.000	0.304	13.388	0.000	0.386	2.593
Revenue Growth Rate out of (15)	-0.342	0.032	-0.234	-10.617	0.000	0.408	2.452
Supply Chain Risk (%)	-0.385	0.042	-0.386	-9.263	0.000	0.114	8.757
R^2				0.805			
R^2 *(After adjustment)*				0.802			
F				270.712***			

***p < 0.001.

According to the results of the data analysis in Table 6, the three variables with the largest absolute values of standardized regression coefficients are Order Fulfillment Rate (%) (0.429), Supply Chain Risk (%) (0.386) and Cost of Goods Sold (COGS) (0.304). The standardized regression coefficients of Order Fulfillment Rate and Cost of Goods Sold (COGS) are positive, while the standardized regression coefficient of Supply Chain Risk is negative. This indicates that Order Fulfillment Rate and Cost of Goods Sold (COGS) have a significant positive effect on Supplier Relationship while Supply Chain Risk has a significant negative effect on Supplier Relationship. Therefore, these three supply chain factors were identified as the main factors affecting Supplier Relationship Score. In order to improve the Supplier Relationship level of a company, companies should focus on improving Order Fulfillment Rate and Cost of Goods Sold (COGS) and reducing Supply Chain Risk.

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4. Conclusion

This research aims to analyze the effects of various supply chain factors on operational efficiency, supply chain resilience, and supplier relationships through multiple linear regression on 999 cases of various companies' supply chains. The findings of this research reveal that the variables that are critical to supply chain management affect the performance of firms in the supply chain.

First, operational efficiency, transportation cost efficiency, delivery time, and supply chain integration level are the main factors in the supply chain process. The results indicate that the transportation cost efficiency, delivery time and supply chain integration level are all beneficial to the improvement of enterprises' operational efficiency. Second, the factors that affect supply chain resilience include order fulfillment rate, transportation cost efficiency, and supply chain risk. The findings of the study indicate that the order fulfillment rate and transportation cost efficiency positively and significantly influence supply chain resilience, while the supply chain risk negatively influences supply chain resilience. Finally, the supplier relationship is influenced by the order fulfillment rate, cost of the goods sold, and supply chain risk. The result of the analysis implies that enhancing the order fulfillment rate, managing the cost of the goods sold, and lowering the supply chain risk are the key factors for enhancing the supplier relations.

This study provides empirical evidence and specific suggestions on how enterprises can optimize supply chain management through statistical methods. Therefore, by increasing the transportation cost efficiency, delivery time, supply chain integration level, order fulfillment rate, cost of goods sold, and supply chain risk, companies can greatly increase their operational efficiency as well as supply chain resilience and supplier relationships. This makes it easier for enterprises to increase their competitiveness and achieve stable development in a competitive and constantly changing market environment. The results of this study are based on the current market and economic environment, and future changes in the market environment may affect the applicability of these findings. Therefore, it is suggested that future market trends and changes may further validate and expand the findings of this study.

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