Transactions on Economics, Business and Management Research
ISSN: 2960-1789, eISSN: 2960-2254 | Volume 10
MEEA 2024

The Influence of Big Data Analytics on Supply Chain Operations Efficiency

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Abstract. This paper aims to validate the feasibility of establishing a risk assessment system. Delphi and Entropy Weighting for Indicator Weighting was conducted by experts in the field of economics on the assessment data of Haier's supply chain indicators to analyze and derive a risk assessment system based on Haier's supply chain indicators. With a comprehensive analysis of risk assessment indicators using the Delphi and entropy weighting methods, the feasibility of the evaluation system for supply chain risk analysis in the context of big data gets demonstrated. The establishment of this assessment system will help Haier to analyze and respond to supply chain risks in the future, and will solve the related problems in avoiding supply chain market risk. These problems encompass difficulties related to managing substantial volumes of data and handling uncertainties in demand and supply. The template makes relevant conclusions and suggestions based on analysis, which could have effect on supply chain risk circumvention in a certain extent.

Keywords: Risk assessment; Big data; Supply chain.

1. Introduction

A fourth wave of technical innovation has been sweeping the manufacturing sector over the past decade [1]. Several manufacturing and supply chain companies have adopted intelligent or innovative manufacturing practices during this time. This may be achieved by utilizing a range of cutting-edge technologies. Important among these are big data analytic, autonomous robotics, simulations, the Internet of Things, security, cloud services, and additive manufacturing. Several prominent academics and industry professionals have acknowledged Industry 4.0's relevance and usefulness for supply chain management, operations, and logistics in general [2, 3]. Not much study has been done on how Big Data Analytic (BDA) affects the five parts of Supply Chain Operations (SCO): planning for demand, production and manufacturing, transportation, purchasing, and inventory.

The emergence and widespread adoption of advanced digital technologies have led to the generation of large volumes of data, posing challenges for supply chain businesses seeking to take use of the insights gained from evaluating this massive deluge of incomplete big data [4]. Emerging data types necessitate innovative technology capable of addressing the complexities associated with this data. These problems encompass difficulties related to managing substantial volumes of data and handling uncertainties in demand and supply. Big Data encompasses data that possesses the characteristics of volume, velocity, variety, variability, veracity, visualization, and value [5]. It describes the swift generation of data from various sources, which can be structured, unstructured, or semi-structured. The data contains rich latent information, rendering it a valuable resource for any organization. Big Data Analytics is the process of using statistical, mathematical, econometric, simulation, optimization, or other techniques to gain insights from data [6]. The goal is to improve decision-making by illuminating the untapped potential of Big Data Analytic for supply chain processes in companies. However, the total business value of BD has yet to be realized.

The function of BDA in SCO currently needs to be fully understood. Few research studies have examined prospects for new ideas or developing methods in this field or have thoroughly evaluated the effect of BDA on SCO. Most of the studies done to far have focused on one or two of the five components of SCO listed above. In the supply chain, for example, some scholars describe and

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evaluate the advantages of BD as well as its uses and prospects [8]. Hasan investigated the likelihood of ERP and SCO coupled with Big Data Analytics to increase manufacturing organizations' performance [7]. Few studies addressed the theoretical effects of BDA on SCO in three important operational domains: procurement, manufacturing, and logistics [9].

Lamba and Singh examined the three stages of a supply chain operation (SCO): procurement, manufacturing, and logistics [10]. BDA beneficial application and performance of SCO procedures need to be better illustrated [11]. In a recent study on BDA and SCO, authors present BDA methodologies and procedures and explore how BDA complements SCO [12]. However, the article needs more depth when explaining how BDA handles SCO difficulties. The literature has not adequately addressed the theoretical underpinnings for the role of Big Data and Big Data Analytic in Supply Chain Operations. To comprehensively grasp the effects of this modification on the performance-related activities of Supply Chain Operations, it is crucial to provide a solid theoretical foundation for the use of Big Data Analytic in Supply Chain, enabling a more enhanced and profound comprehension.

2. Methods

2.1. Data Source

The data set used in this paper is fetched from the China Knowledge Network (CNN). Ten experts and scholars were invited to score the 17 risk indicators of Haier Group's supply chain finance risk assessment in the context of big data. According to the risk indicators gray analysis correlation and portfolio weights calculated by Excel Haier supply chain financial risk assessment indicators weights and assessment indicators weighted correlation data.

2.2. Variable Selection

The data volume of the original dataset is very large, and this paper identifies variables based on supply chain risks such as macroeconomic environment, policy and regulatory environment, industry development stage, industry competition intensity, and Internet big data technology environment.

2.3. Method Introduction

Ten experts and scholars asked to rate the importance of 17 key risk indicators using a scale from 1 to 5,which directly correlated the experts' assessments with the significance of each indicator to Haier Group's supply chain finance. Then calculate the average scores for each risk indicator. Thus, a comprehensive assessment of Haier Group's supply chain finance risk indicators was achieved. This research examines and evaluates how BDA influences SCO efficiency. The study will analyze and combine current conventional literature on the impact of Big Data Analytic on the efficiency of Supply Chain Operations. This information will be used to construct a theoretical framework grounded in the Technology-Task Fit (TTF) and Institutional Theory [12].

3. Results and Discussion

3.1. Risk Assessment

As Haier's supply chain primarily comprises upstream and downstream players in the home appliance industry, a general decline in demand within this market, often triggered by a slowdown in macroeconomic growth, weakens consumers' purchasing power, resulting in a reduction of raw material procurement. This, in turn, affects information, logistics, and capital flows, thereby hindering the entire supply chain's growth potential. The "Cargo Pledge Model" is a financial solution tailored for Haier's downstream SME dealers, addressing financial challenges from bulk purchases during holidays, high-demand product launches, or dealer-led events. Haier's supply chain finance credit model is determined by dealers' tenure, annual sales volume of Haier products, and other factors.Risks

in Haier's supply chain arise from various factors, including the quality of purchased raw materials like aluminum and iron, their fluctuating market prices, and the upstream supply chain's stability and purchasing capability.

Under the lens of big data, an accurate and timely data analysis model is imperative for gauging various risks encountered by Haier Supply Chain Finance. Given the complexity of data layers and the proliferation of redundant information, evaluating risks solely through a single lens is limiting. Hence, it's paramount to incorporate theoretical viewpoints and econometric mathematical methods to comprehensively assess risks, encompassing both quantitative and qualitative facets.

3.2. Risk Assessment Indicator System

This paper delves into the risk management theory to thoroughly analyze and pinpoint the financial risks within Haier's supply chain. By conducting a detailed risk assessment on these identified risks, the key focus lies in establishing a comprehensive risk assessment index system. With a mere singular perspective, the efficacy of evaluating and making informed judgments is limited. By following these principles diligently, enterprises can ensure a robust risk assessment framework that not only mitigates risks effectively but also propels informed decision-making in the realm of supply chain finance. Evaluation indicators play a crucial role in assessing various risks within the supply chain financial platform. Furthermore, data security and personnel operation errors are significant factors in evaluating the operation risk. The system of risk assessment indicators outlined in Table 1 provides a comprehensive framework for analyzing and managing risks within the supply chain financial platform.

Table 1. Supply Chain Finance Risk Assessment Framework - Haier

	Level 1 indicators	Secondary indicators
Haier Group Supply Chain Finance Risks (K)	Market risk (K1)	Intensity of industry competition (K11)
		Stage of industry development (K12)
		Policy and regulatory environment (K13)
		Macroeconomic environment (K14)
		Internet Big Data Technology Environment (K15)
	Credit risk (K2)	Overall operating status of the financing enterprise (K21)
		Financial status of the financing enterprise (K22)
		Financing Business Credit Record (K23)
		Credit Approval Risks in Supply Chain Finance Platforms (K24)

After identifying various risks, the following risk evaluation index system is established to assess the supply chain finance risks of Haier amidst the backdrop of big data. The risk evaluation framework encompasses four primary categories: market risk (K1), credit risk (K2), supply chain risk (K3), and operational risk (K4). Table 1 illustrates the second-level risk evaluation indicators, totaling 17 items. Market risk (K1) is gauged through macroeconomic conditions (K14), policy and regulatory environments (K13), the stage of industry development (K12), industry competition intensity (K11), and the internet big data technology environment (K15). Credit risk (K2) is assessed by examining the overall operation status of the financing enterprise (K21) and its financial condition.

3.3. Delphi and Entropy Weighting

The previous analysis outlined that Haier's supply chain finance risk assessment in the era of big data encompasses four domains: market risk, credit risk, supply chain risk, and operational risk. Assigning

appropriate weights to the seventeen secondary indicators within these risk categories is a crucial step in ensuring a scientifically sound risk assessment. The template opts for a combined subjective-objective approach to determine the weight coefficients of the indicators. This integrated approach aims to capture the subjectivity of expert opinions and the objectivity of data analysis, ensuring a more accurate and scientifically robust risk assessment for Haier Group.

Ten experts and scholars were carefully selected to participate in the research, ensuring a diverse range of perspectives. This group included individuals from Haier Group itself, as well as representatives from banks' credit audit departments, Big Four accounting firms with experience in the appliance industry, and specialists in the fields of supply chain finance and risk management. The experts were first briefed on the intricacies of Haier's supply chain finance operations in the context of big data analysis. They were then asked to rate the importance of 17 key risk indicators using a scale from 1 to 5. This scoring system directly correlated the experts' assessments with the significance of each indicator to Haier Group's supply chain finance. After the initial round of questionnaires, the average scores for each risk indicator were calculated and the experts' feedback was carefully analyzed and compiled. The final scoring, as summarized in Table 2, provided valuable insights into the strengths and weaknesses of Haier's supply chain finance operations in the era of big data. By leveraging the expertise of these ten esteemed professionals, Haier Group gained valuable insights that will undoubtedly inform strategic decisions moving forward.

Table 2. Rebrand Haier's Supply Chain Finance with Nuanced Risk Assessment

Indicators	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10
Macroeconomic environment (K11)	3	4	2	3	4	2	4	5	3	1
Policy and regulatory environment (K12)	5	4	3	4	5	4	5	3	4	4
Stages of industry development (K13)	3	4	1	2	4	3	1	3	2	1
Intensity of industry competition (K14)	1	4	5	4	2	1	4	2	3	4
Internet Big Data Technology Environment (K15)	4	5	3	2	4	5	4	3	4	5
Overall operation of the financing enterprise (K21)	5	4	3	3	5	3	4	4	5	5
Financial status of financing enterprises (K22)	3	3	4	1	5	2	3	4	1	3
Financing Business Credit Record (K23)	5	3	5	4	5	4	5	4	5	2
Credit Approval Risks (K24)	3	4	4	5	5	5	5	3	4	3
Overall core business operations (K31)	4	1	4	2	5	3	5	4	5	3
Supply chain structure design situation (K32)	3	2	1	5	4	3	3	1	3	2
Supply chain process design status (K33)	2	3	3	1	4	4	1	2	3	3
Organizational Management Capability (K34)	3	4	1	2	3	4	3	2	1	2
Closeness of supply chain firms cooperation (K35)	3	5	4	3	4	4	5	4	5	4
Supply chain past performance (K36)	5	4	3	4	4	5	4	3	5	4
Data security risks (K41)	3	4	5	4	3	3	2	4	4	2
Risk of human error (K42)	4	1	2	3	2	5	3	2	4	1

Utilizing expert scoring data, a study compiles various sources. "Experts play key role in success". Ten questionnaires were distributed and all ten were recovered, resulting in a 100% recovery rate. Eight experts provided 15 textual suggestions based on the feedback received from the questionnaires. The data suggests that the experts who were invited to participate in the questionnaire showed a high level of motivation in their responses. This indicates that the questionnaire can be considered valid to a certain degree of authority, centralization, and expert coordination determine organizational efficiency.

The credibility and reliability of expert opinions are determined by the authority coefficient calculated based on their expertise. In this study, the authority coefficient of the two rounds of questionnaires

was found to be 0.887, indicating a high level of authority. Additionally, the coefficient of judgment basis and familiarity were 0.910 and 0.863 respectively, further confirming the reliability of the experts' opinions. The experts' opinions on the indicators showed a high level of agreement, as evidenced by the Kendall's harmony coefficient meeting the required standards. Overall, the results of the study suggest that the experts' opinions are well-aligned and reliable, highlighting the credibility of the findings.

3.4. Objective Weight Calculation Results

The entropy weight method provides a method for determining the objective weights of indicators as assessed by experts. Through calculating entropy values using specific equations, the risk evaluation indicators can be effectively weighted. By combining the entropy values with subjective weights, a more accurate evaluation can be achieved. The numerical values represent the performance of the model and are critical for assessing the accuracy and validity of the model in various applications. Use the given ratios to effectively and avoid high AIGC values during analysis. Determining the weights of a diversified portfolio.

The final weights of the indicators are calculated by merging the weights obtained from the Delphi and entropy weighting methods using a linear weighting approach. Equation (1) illustrates the linear weighting formula utilized in this process.

$$W_k = \mu W_k^{Delphi} + (1-\mu) W_k^{EWM} \tag{1}$$

In this paper, the weighting coefficient μ is set at 0.5 to emphasize the importance of both subjective and objective weights in risk evaluation. The combined weights for each risk evaluation index W_k are determined using a calculated method outlined in Table 3. This approach ensures a comprehensive assessment of risks.

Table 3. Weighting table for Haier's supply chain finance risk assessment indicators

Indicators	Delphi weights	EWM weights	portfolio weights
Macroeconomic environment (K11)	0.0539	0.039	0.0465
Policy and regulatory environment (K12)	0.0713	0.0574	0.0644
Stages of industry development (K13)	0.0417	0.0867	0.0642
Intensity of industry competition (K14)	0.0522	0.0633	0.0577
Internet Big Data Technology Environment (K15)	0.0678	0.0351	0.0515
Overall operation of the financing enterprise (K21)	0.0713	0.0828	0.0771
Financial status of financing enterprises (K22)	0.0504	0.0581	0.0543
Financing Business Credit Record (K23)	0.0730	0.0309	0.0520
Credit Approval Risks (K24)	0.0713	0.0828	0.0771
Overall core business operations (K31)	0.0626	0.0353	0.0490
Supply chain structure design situation (K32)	0.0470	0.0632	0.0551
Supply chain process design status (K33)	0.0452	0.0585	0.0519
Organizational Management Capability (K34)	0.0435	0.063	0.0532
Closeness of supply chain firms cooperation (K35)	0.0713	0.0574	0.0644
Supply chain past performance (K36)	0.0713	0.0574	0.0644
Data security risks (K41)	0.0591	0.0593	0.0592
Risk of human error (K42)	0.0470	0.0697	0.0583

Data source: Expert-scoring data analyzed using Excle and SPSS to evaluate accuracy and reliability of calculations.

3.5. Gray Correlation Analysis

The weights of risk evaluation indicators were used in gray correlation analysis to determine the importance scores of Haier supply chain finance risk evaluation indices. This data was then structured into a matrix. By analyzing these scores, it is possible to gain valuable insights into the level of risk associated with Haier's supply chain finance operations.

$$X_k = \begin{bmatrix} 3 & 5 & 3 & 1 & 4 & 5 & 3 & 5 & 3 & 4 & 3 & 2 & 3 & 3 & 5 & 3 & 4 \\ 4 & 4 & 4 & 4 & 5 & 4 & 3 & 3 & 4 & 1 & 2 & 3 & 4 & 5 & 4 & 4 & 1 \\ 2 & 3 & 1 & 5 & 3 & 3 & 4 & 5 & 4 & 4 & 1 & 3 & 1 & 4 & 3 & 5 & 2 \\ 3 & 4 & 2 & 4 & 2 & 3 & 1 & 4 & 5 & 2 & 5 & 1 & 2 & 3 & 4 & 4 & 3 \\ 3 & 4 & 2 & 4 & 2 & 3 & 1 & 4 & 5 & 2 & 5 & 1 & 2 & 3 & 4 & 4 & 3 \\ 4 & 5 & 4 & 2 & 4 & 5 & 5 & 5 & 5 & 5 & 4 & 4 & 3 & 4 & 4 & 3 & 2 \\ 2 & 4 & 3 & 1 & 5 & 3 & 2 & 4 & 5 & 3 & 3 & 4 & 4 & 4 & 5 & 3 & 5 \\ 4 & 5 & 1 & 4 & 4 & 4 & 3 & 5 & 5 & 5 & 3 & 1 & 3 & 5 & 4 & 2 & 3 \\ 5 & 3 & 3 & 2 & 3 & 4 & 4 & 4 & 3 & 4 & 1 & 2 & 2 & 4 & 3 & 4 & 2 \\ 3 & 4 & 2 & 3 & 4 & 5 & 1 & 5 & 4 & 5 & 3 & 3 & 1 & 5 & 5 & 4 & 4 \\ 1 & 4 & 1 & 4 & 5 & 5 & 3 & 2 & 3 & 3 & 2 & 3 & 2 & 4 & 4 & 2 & 1 \end{bmatrix} \quad (2)$$

In order to accurately assess financial risks in supply chains, previous expert scores have emphasized the importance of setting risk assessment metrics. These indicators are assigned values in gray analysis with a reference sequence X0 ranging from 1 to 17. A lower score indicates a more favorable risk profile and a smaller expected value of risk for each indicator. However, due to the different meanings of the data, discrepancies may occur in the interpretation of the results. To ensure the consistency and reliability of data analysis, this study adopted a homogenization method through dimensionless processing of data outlines with a resolution coefficient of p=0.5. The results of the grey correlation analysis are shown in Table 4, which provide valuable information for understanding the financial risk profile of supply chains.

Table 4. Haier's Supply Chain Finance Risk Assessment Indicator Correlation

Risk assessment indicators	relatedness
Macroeconomic environment (K11)	0.646
Policy and regulatory environment (K12)	0.794
Stages of industry development (K13)	0.537
Intensity of industry competition (K14)	0.554
Internet Big Data Technology Environment (K15)	0.734
Overall operation of the financing enterprise (K21)	0.732
Financial status of financing enterprises (K22)	0.65
Financing Business Credit Record (K23)	0.72
Credit Approval Risks in Supply Chain Finance Platforms (K24)	0.732
Overall core business operations (K31)	0.625
Supply chain structure design situation (K32)	0.603
Supply chain process design status (K33)	0.594
Supply Chain Organizational Management Capability (K34)	0.574
Closeness of cooperation among supply chain firms (K35)	0.794
Supply chain past performance (K36)	0.794
Data security risks (K41)	0.667
Risk of human error (K42)	0.553

Data source: SPSS analyzes expert scores to determine data trends and patterns accurately.

The weighted correlation coefficients in Table 5 represent a comprehensive analysis of risk assessment indicators using the Delphi and entropy weighting methods.

Table 5. Results of Forward Stepwise Regression

Risk assessment indicators	relatedness	portfolio weighting	weighted correlation	rankings
Overall operation of the financing enterprise (K21)	0.732	0.0771	0.0564	1
Credit Approval Risks in Supply Chain Finance Platforms (K24)	0.732	0.0771	0.0564	1
Policy and regulatory environment (K12)	0.794	0.0644	0.0511	2
Closeness of cooperation among supply chain firms (K35)	0.794	0.0644	0.0511	2
Supply chain past performance (K36)	0.794	0.0644	0.0511	2
Data security risks (K41)	0.667	0.0592	0.0395	3
Internet Big Data Technology Environment (K15)	0.734	0.0515	0.0378	4
Financing Business Credit Record (K23)	0.72	0.0520	0.0374	5
Financial status of financing enterprises (K22)	0.65	0.0543	0.0353	6
Stages of industry development (K13)	0.537	0.0642	0.0345	7
Supply chain structure design situation (K32)	0.603	0.0551	0.0332	8
Risk of human error (K42)	0.553	0.0583	0.0323	9
Intensity of industry competition (K14)	0.554	0.0577	0.0320	10
Supply chain process design status (K33)	0.594	0.0519	0.0308	11
Overall core business operations (K31)	0.625	0.0490	0.0306	12
Supply Chain Organizational Management Capability (K34)	0.574	0.0532	0.0306	12
Macroeconomic environment (K11)	0.646	0.0465	0.0300	13

The ranking results reveal that credit risk and big data context are significant risk factors. Surprisingly, indicators for the macroeconomic environment, core enterprises' operations, and supply chain work ranked lower. This suggests that attention should be paid to mitigating credit risk and leveraging big data insights. Strengthening core enterprises' operations and enhancing their supply chain processes are crucial for overall risk management. It is clear that a comprehensive approach addressing these various risk factors is essential for sustainable business success. Effective risk management plays a crucial role in the success of supply chain finance platforms.

The credit approval process within these platforms, such as the Risun supply chain B2B platform under Haier, is a critical factor in determining the smooth operation of Haier's supply chain finance business. By conducting thorough and accurate credit assessments, supply chain finance platforms can significantly reduce the likelihood of potential financial losses and maintain the overall health of the business. Ultimately, the ability to carry out high-quality credit approvals is paramount in safeguarding against detrimental outcomes in the supply chain finance industry.

4. Conclusion

Based on the ranking results above, it can be observed that all risk factors related to credit risk are ranked relatively high, and all risk indicators related to the big data context are also relatively high. The effective management of policies and regulations, as well as the level of collaboration among supply chain entities, play a crucial role in assessing risk in the supply chain industry. The

performance history of the supply chain is also a significant determinant of risk. Specifically, in industries like consumer goods and real estate that are closely linked to household appliances and their related sectors, external factors such as macroeconomic policies and regulatory changes can greatly impact businesses in the household appliances industry, thereby posing risks to Haier's supply chain finance operations. It is imperative for supply chain companies to maintain strong partnerships and communication to ensure smooth business operations. When evaluating small and medium-sized enterprises for financial support, Haier heavily relies on past transaction data to assess risk. Therefore, the strength of collaboration among supply chain entities and the historical performance of the supply chain are vital factors influencing the risk level in supply chain finance operations.

While the overall risk to a business may take precedence, it is important not to overlook the operational risks associated with human error and data security. These risks can still have a significant impact on the company's operations. Additionally, the design of the supply chain structure can greatly affect communication and collaboration within the supply chain, making it a crucial area for attention. Furthermore, the credit and financial status of financing enterprises are vital considerations for Haier when approving credit, even though they may not directly impact operational status. These factors serve as important indicators of a company's reliability and stability. Moreover, the stage of development within the industry can provide valuable insights into the direction and strategies of enterprise development. This information can play a key role in influencing supply chain financial risk and should therefore be monitored closely at all times. By giving due attention to these areas, businesses can better manage their overall risk exposure and improve their financial stability.

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