

Analyzing the effects of data mining techniques on management decision making and information exchange in the industrial sector: the role of cooperation as a moderating factor in Saudi Arabia

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ABSTRACT

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This research explores the influence of data mining methods on the managerial decision-making in Saudi Arabia's industrial sector, emphasizing the moderating function of cooperation. A total of 500 questionnaires were distributed to information technology managers, with 265 responses selected for data analysis. Smart PLS 4 software was used for the data analysis, and statistical measures were used to analyze the correlations between variables. The findings show that data mining approaches have a substantial positive relationship with improving decision-making and information exchange within external and internal contexts. The study also demonstrates that cooperation plays an important moderating role in these interactions, emphasizing the significance of building a cooperative atmosphere to improve the influence of data mining methods on decision-making and information sharing. The study's conclusions have practical relevance for organizations in the industrial sector. Organizations may improve their decision-making processes and information sharing by adopting data mining tools and boosting collaboration, enhancing performance and competitiveness.

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1. Introduction

Data mining is a method for extracting useful patterns from large amounts of data (Kumar & Mohbey, 2022). This process entails extracting implicit, previously unknown, and helpful knowledge and information for practical application from massive amounts of noisy, confused, random, and incomplete data (Li & Tiwari, 2022). It is a powerful new technology that may substantially assist organizations in focusing on the most important information in their database. It utilizes machine learning, statistical analysis, and visualization approaches to identify and forecast information in a manner that the user can comprehend (Hicham, Jeghal, Sabri, & Tairi, 2020). The most important data mining approach is prediction, which builds a model that can categorize data and find links between independent and dependent data using a set of pre-classified instances (Hicham et al., 2020). Integrating visual data mining tools into real-time decision-making is becoming more important when dealing with complicated and temporal data (Al tarawneh, Alqaraleh, Ali, & Bani Atta, 2023; Alhaj et al., 2023; Khouj et al., 2022). Businesses create and collect massive volumes of temporal data daily (Aishwarya & Jabbar, 2022; Jawabreh, Shniekat, Saleh, & Ali, 2022; Nawaiseh et al., 2022; Shan et al., 2022). It is feasible to automate the processes of gathering important temporal information and regularities from electronic records and providing advice for decision-making by employing data mining methods (Ltifi, Benmohamed, Kolski, & Ayed, 2016). Using temporal visualization methods enables (1) graphical data presentation and interpretation; (2) matching results; (3) assisting in the identification of temporal patterns; (4) indicating changes in large data pools over time; and (5) improving cognitive perception. According to (Ali, Jones, Xie, & Williams, 2019), interaction and the dynamic character of visual representations are essential elements of temporal data visualization

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(Ltifi et al., 2016). Furthermore, according to (Alsaadi, 2022), the data environment supports all decision-support requirements by providing high-quality information made available by precise and efficient cleaning routines, consistent and legitimate data transformation rules, and documented presumptions of data values. Another collaboration between newly acquired knowledge and expert knowledge arises when the application domain changes too fast, and it is difficult, if not impossible, to update the system built by the expert promptly (Al-Hussein, Alabdallat, Abu, Rumman, & Ali, 2023; Shan et al., 2022; Shniekat, AL_Abdallat, Al-Hussein, & Ali, 2022). This research aims to explore how data mining tools could help managers make decisions in the industrial sector and how cooperation can act as a moderating factor.

The article is divided into five parts. Section 1 introduces the background before section 2 provides a literature overview of data mining methodologies that promote information exchange with internal and external environments, decision-making, and collaboration. Section 3 then lays down the theoretical framework before section 4 discusses the research method, followed by a discussion and conclusion in section 5.

2. Literature Review

There is a wide range of literature on data mining approaches for enhancing corporate decision-making (Al-Rawashdeh, Jawabreh, & Ali, 2023; M Kanan et al., 2023; Mohammad Kanan et al., 2023). Researchers from a variety of disciplines are investigating the consequences of the tools and procedures used to make enormous volumes of data accessible to decision-makers in light of recent advances in information technology as well as its accessibility (Kanan et al., 2022; Khouj et al., 2022; Sarka, Heisig, Caldwell, Maier, & Ipsen, 2019). As a result of this, a significant amount of study has been carried out in the fields of Management of Information and Data Mining to examine the many applications that each has in the process of decision-making in corporations. When integrated with business intelligence (BI) and knowledge management, data mining becomes completely clear. This is because data mining is an essential component of this overall architecture (Moscoso-Zea, Castro, Paredes-Gualtor, & Luján-Mora, 2019). However, BI and knowledge management are not synonymous. Knowledge management is a collection of practices for the production, development, and use of knowledge to enhance the firm's performance. Meanwhile, BI refers to the applications and technology used to gather, retrieve, and analyze data to make sound business choices, unlike data management, which focuses on factual information, knowledge management emphasizes the subjective knowledge of humans. According to (L. Li & Tiwari, 2022), data mining is an efficient method of gathering actionable corporate insight for use in knowledge management.

Data mining is a technique for extracting meaningful information from large datasets; it is also known as database knowledge discovery (Edastama, Bist, & Prambudi, 2021). It's often understood to be a method for gaining insight from massive amounts of data. Decision-makers have an edge in the market when they use efficient and effective data mining methods. Data mining relies heavily on the disciplines of statistics, database management, information science, machine learning, and visualization. Data mining software has several practical applications, including the commercial and financial sectors. (Chen & Du, 2009) used data mining and artificial neural networks to create a model that might predict financial distress. The research included an experimental investigation of Taiwanese businesses. The findings demonstrated the viability and efficiency of the proposed techniques to bankruptcy prediction. The identification of fake financial statements is one of the most researched data mining applications in the fields of finance and business.

Previous research in this area has shown that spotting fraud using conventional auditing methods is challenging. There have been several attempts to employ data mining techniques to develop models that may foresee the occurrence of managerial fraud (An & Suh, 2020). Furthermore, previous research has shown that neural network algorithms can be effectively used for going concern reporting, portfolio management, customer credit risk calculation, company financial performance projection, and stock market price prediction (Amani & Fadlalla, 2017).

In recent years, data mining and its associated methods and technologies have witnessed tremendous expansion in their application areas (Aggarwal et al., 2021). The task-oriented nature of data mining has previously been effectively handled by employing intelligent agent systems, which distribute jobs, cooperate, and synchronize operations to accomplish their ultimate goal—the extraction of information. Association rules provide a simple and helpful descriptive form for rule models in data mining (Zhu et al., 2023). Studying how cooperative behavior occurs among agents in multi-agent systems is an important and interesting issue. A cooperative multi-robot chase is a typical multiagent task (Shan et al., 2022; Shniekat et al., 2022). Its most basic form consists of multiple predators attempting to catch countless quarries attempting to evade capture. Variations of this game have also been discussed in the literature (Liu & Wu, 2018). If data mining information is used in multi-agent systems to identify the cooperative connection between agents, in that case, it would be highly advantageous to solve the issue of coordination and cooperation among agents (Li, Pan, Hong, & Li, 2009).

Based on the previously noted studies, the bulk of the literature on data mining methods was generated in industrialized nations. To the best of the researcher's knowledge, no studies on the viewpoints and opinions of data users in the industrial sectors on the use of data mining methods have been conducted. This study aims to shed light on how data mining techniques are used to improve communication with the firm's both inner and outer surroundings and aid in managerial decision-making. Cooperation as a moderating element is also explored. As a result, we came up with these hypotheses:

H1: Data mining techniques have an impact on improving the information exchange with the external environment.

H2: Data mining techniques have an impact on improving the information exchange with the internal environment.

H3: Data mining techniques have an impact on decision-making.

H4: Cooperation among data mining techniques has a moderate impact on the information exchange with the external environment.

H5: Cooperation among data mining techniques has a moderate impact on the information exchange with the internal environment.

H6: Cooperation among data mining approaches has a moderate impact on decision-making.

Theoretical Framework

This study aims to investigate how data mining techniques can improve the decision-making processes in management by facilitating information exchange with both internal and external environments. Additionally, the study examines how cooperation can moderate this impact in the Saudi industrial sector. The theoretical framework is presented in Fig. 1.

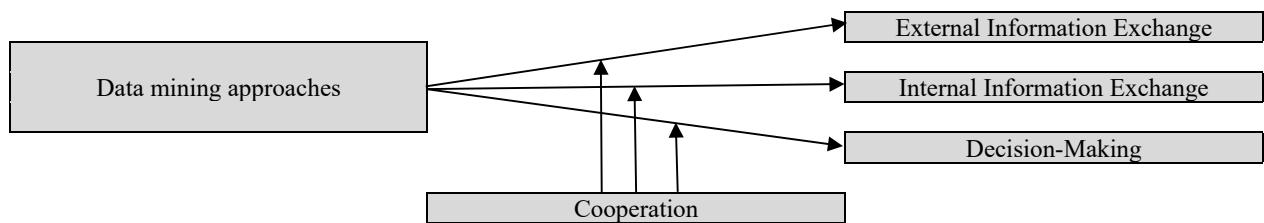


Fig. 1. Theoretical Framework

3. Research Methodology

The declared goals of this study are to examine the role of collaboration as a moderating variable in data mining for managerial decision-making and to provide insight into the efficacy of data mining in this context. The primary objective of the research was met by the administration of surveys to managers actively involved in making decisions and to workers in the Saudi industrial sector who are responsible for running decision support systems.

The questionnaire is split in half. In the first part of the questionnaire, we ask about the respondents themselves (their demographics, their education and work history, and so on). The second section is designed to collect data on how people feel about data mining, enhancing communication with outsiders, enhancing communication inside a company, and enhancing decision-making. Using a seven-point Likert scale ranging from (1) strongly disagree to (5) and (7) strongly agree, the questionnaires' questions were drawn from previously conducted studies.

The study included all Saudi industrial enterprises with shares listed on the Tadawul or Saudi stock exchanges. Employees (IT managers) of industrial enterprises with direct ties to technological advances and systems that support decisions carried out the survey. There were 500 people working in central management, but only 265 received the survey and their responses collected. The data were examined using the partial least squares structural equation modeling (PLS-SEM) approach. The study included evaluating the measurement model's reliability and validity, testing the hypotheses, and investigating the structural model.

In summary, this study utilized quantitative research methodology and a survey questionnaire to gather data from a random sample of 265 IT managers. The data was analyzed using the PLS-SEM approach.

4. Analysis and Discussion

The measurement and structure models may be disentangled from the PLS structural equation. The structural model illustrates the path coefficients between and among the latent variables, while the measurement model defines the conceptual model's reliability and validity (Hair, Risher, Sarstedt, & Ringle, 2019). This research is currently at an intermediate stage of the research process, halfway between the first two. The metric framework that will be employed in this study is shown in Fig. 2.

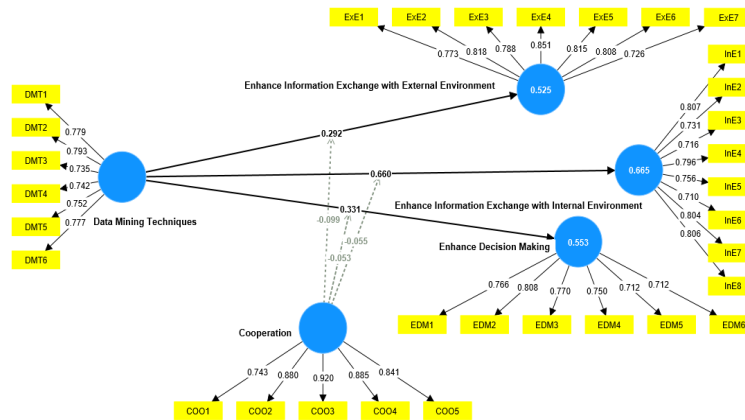


Fig. 2. Measurement Moodle

Outer Loadings

The outer loadings in PLS-SEM, as defined by (Hair Jr, Howard, & Nitzl, 2020), describe the connection between the latent construct and its observable indicators. The factor loadings of every factor on its related construct are shown in the SmartPLS software's route diagram. The outer loading values for each indicator may be read as the strength of the association between the indicator and its construct, and they should ideally be >0.7 . Bootstrapping methods may be employed to calculate the standard error and test for the significance of the outer loadings, with p -values of <0.05 suggesting a strong link between the indicator and its construct. Evaluating exterior loadings in SmartPLS is one way to guarantee the accuracy of the measured indicators (Hair et al., 2019). As Table 1 shows, all of them were >0.7 . Hence, they were all approved.

Table 1

Outer Loadings

	Cooperation	Data mining techniques	Enhance decision-making	External Information Exchange	Internal Information Exchange
COO1	0.743				
COO2	0.880				
COO3	0.920				
COO4	0.885				
COO5	0.841				
DMT1		0.779			
DMT2		0.793			
DMT3		0.735			
DMT4		0.742			
DMT5		0.752			
DMT6		0.777			
EDM1			0.766		
EDM2			0.808		
EDM3			0.770		
EDM4			0.750		
EDM5			0.712		
EDM6			0.712		
ExE1				0.773	
ExE2				0.818	
ExE3				0.788	
ExE4				0.851	
ExE5				0.815	
ExE6				0.808	
ExE7				0.726	
InE1					0.807
InE2					0.731
InE3					0.716
InE4					0.796
InE5					0.756
InE6					0.710
InE7					0.804
InE8					0.806

Construct Reliability and Validity

As Table 2 demonstrates, Cronbach's alpha and composite reliability had been utilised to check the uniformity of the study's four explanatory factors. The dimensions of cooperation, data mining techniques, decision-making, and information exchange

with external and internal environments had Cronbach's alpha values of 0.907, 0.858, 0.848, 0.905, and 0.900, respectively, indicating high levels of internal consistency. The overall dependability of the four variables was excellent, with values of 0.911, 0.866, 0.847, 0.906, and 0.908, respectively (Hair Jr et al., 2020). This suggests that the four variables are good, consistent indicators of the ideas they are meant to measure.

Table 2
Cronbach's Alpha and Composite Reliability

	Cronbach's alpha	Composite reliability (rho a)	Composite reliability (rho c)	The average variance extracted (AVE)
Cooperation	0.907	0.911	0.932	0.733
Data mining Approach	0.858	0.866	0.893	0.582
Decision-making	0.848	0.847	0.887	0.568
External Information Exchange	0.905	0.906	0.925	0.637
Internal Information Exchange	0.900	0.908	0.919	0.588

Model for Structural

Structural equation modeling (Hair Jr et al., 2020) is a statistical method for analyzing complicated interactions among several variables via the use of a graphical representation of these relationships as a web of connected constructs and routes. This research used a structural equation model to study the influence of data mining approach on decision-making, the information exchange with external environments, and the information exchange inside organizations. Cooperation can have a positive impact on the relationship between data mining approaches, leading to better decision making and improved sharing of information both within and outside of an organization. The direct and indirect relationships between these factors were investigated using a model in which they were all represented as latent constructs (Jahmani, Jawabreh, ALFaahmwee, Almasarweh, & Ali, 2023).

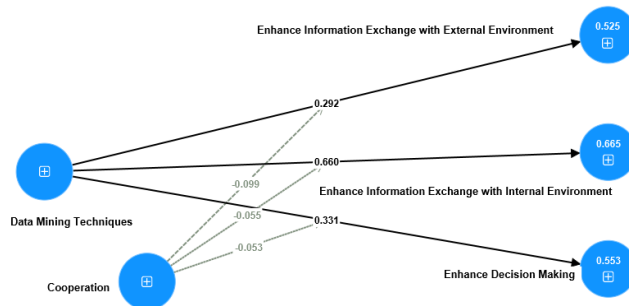


Fig. 3. Structural Model

Discriminant Validity

Each construct tested in research must be distinct from the others and measure a different notion, which is why discriminant validity is an important statistical term. Based on a comparison of the square roots of the average variance extracted (AVE) for each construct to the correlations across the constructs, the Fornell–Larcker criteria were used to evaluate the measures' discriminant validity in this research. As Table 3 shows, the findings indicate sufficient discriminant validity since the AVEs for each component are larger than the correlations between them (Fornell & Larcker, 1981).

Table 3
Discriminant Validity

	Cooperation	Data mining Approach	Enhance decision-making	External Information Exchange	Internal Information Exchange
Cooperation	0.856				
Data mining Approach	0.420	0.763			
Decision-making	0.677	0.556	0.754		
External Information Exchange	0.662	0.517	0.621	0.798	
Internal Information Exchange	0.550	0.773	0.686	0.650	0.767

Path Coefficients

This study's statistical analysis not only looked at the direct links between the independent variable (ID) and the dependent variable (DV) but also at the moderating influence of collaboration in these relationships. Here, *T* statistics and *p*-values were used to determine the significance of both the direct and moderating effects. The following are the important test findings, taking into consideration the moderating role of cooperation:

For the association between "cooperation" and "enhance decision-making," the *T* statistic value was 9.731 (*p* = 0.001), showing a highly significant and positive link between cooperation and decision-making enhancement. This shows that collaboration is important in increasing the influence of the ID on the DV in decision-making.

Similarly, the association between “cooperation” and “enhance information exchange with the external environment” had a *T* statistical value of 9.975 ($p = 0.001$), indicating that there is a substantial positive link between cooperation and boosting information exchange with the external environment. This implies that cooperation functions as a moderator, amplifying the impact of the ID on the DV in terms of external environment with the external environment information exchange.

The *T* statistic value for the connection between “cooperation” and “information exchange with the internal environment” was 4.922 ($p = 0.001$), showing a strong positive link between collaboration and the augmentation of information exchange within the internal environment. This shows that in terms of information exchange inside the internal environment, cooperation moderates the link between the ID and the DV.

These findings illustrate the importance of cooperation as a moderator in the interactions between the ID and the DV. The research indicates that the influence of the ID on the DV changes depending on the degree of collaboration present, treating cooperation as a moderator. Cooperation improves the impact of the independent variable on decision-making and information exchange within the industrial sector, both internally and externally.

Table 4
Coefficients

	Original sample (O)	Sample mean	Standard deviation	T Value	P values
Cooperation → Decision-making	0.512	0.512	0.053	9.731	0.000
Cooperation → External Information Exchange	0.491	0.489	0.049	9.975	0.000
Cooperation → Internal Information Exchange	0.245	0.244	0.050	4.922	0.000
Data mining Approach → Decision-making	0.331	0.332	0.061	5.405	0.000
Data mining Approach → External Information Exchange	0.292	0.296	0.050	5.788	0.000
Data mining techniques → Internal Information Exchange	0.660	0.663	0.052	12.713	0.000
Cooperation × Data mining Approach → Decision-making	-0.053	-0.045	0.039	1.372	0.170
Cooperation × Data mining Approach → External Information Exchange	-0.099	-0.096	0.034	2.922	0.003
Cooperation × Data mining techniques → Internal Information Exchange	-0.055	-0.053	0.023	2.407	0.016

R Square Analysis

In statistical analysis, the R^2 values indicate how much the independent variable, which in this case is data mining methods, accounts for the variability in the dependent variables, which in this case include improved decision-making, external information exchange and internal environment respectively. The R-squared score for enhanced decision-making was 0.553, which indicates that 55.3% of the observed changes can be attributed to the analyzed data mining procedures. In other words, the variance in enhanced decision-making can be well explained by the independent variable. A similar R-squared score (0.525) suggests that data mining approaches may account for around 52.5% of the variance in the variable "enhance information exchange with the external environment." This indicates that data mining methods have a significant effect on improving the industrial sectors' communication with their external environments. Finally, the R-squared value for enhanced information exchange with the internal environment was 0.665, which indicates that data mining approaches can account for around 66.5% of the variability in this variable. This suggests that data mining methods have a significant impact on boosting the information flow inside the internal environment of the industrial sector. Understanding the connection between data mining techniques and improved industrial decision-making and information exchange is facilitated by these R-squared values, which reveal how much the variation in the dependent variables can be accounted for by the independent variable.

Table 5
R-squared Results

	R-square	R-square adjusted
Decision-making	0.553	0.548
External Information Exchange	0.525	0.520
Internal Information Exchange	0.665	0.661

5. Discussion and Conclusion

In considering the moderating influence of collaboration, this research sheds light on how data mining tools affect the management decision-making process in Saudi Arabia's industrial sector. The outcomes prove that there is a link between the independent variable (data mining techniques) and the reliant variables (Decision making, External Information Exchange, and Internal Information Exchange within the organization). The study also highlights the essential moderating function played by collaboration in these connections.

Data mining approaches may explain a large percentage of the variation in decision-making and information exchange, as shown by the high R-squared values for the dependent variables. This indicates that businesses in the industrial sector could use data mining approaches to improve their internal decision-making and external information exchange. In addition, the correlations are strong and legitimate, as shown by the substantial *T* statistics and *p*-values. Organizations are more likely to see gains in decision-making and information exchange when they adopt data mining practices, as shown by the positive

correlations. Furthermore, the moderating influence of cooperation shows that when businesses promote a cooperative atmosphere, the impact of data mining methods on decision-making and information exchange is amplified. Significant ramifications for Saudi Arabia's industrial sector may be drawn from this study's results. Organizations may make better choices and boost their information exchange procedures, both of which contribute to enhanced performance and competitiveness, when they acknowledge the value of data mining tools and the necessity of collaboration.

In conclusion, this research elucidates the effect of data mining methods on managerial decision-making in Saudi Arabia's industrial sector, emphasizing the moderating function of collaboration. The findings highlight the favorable connections between data mining approaches and improved decision-making and information exchange in external and internal contexts. Cooperation was also identified as a significant moderator, one that amplifies the impact of data mining methods on decision-making and information exchange. To reap the full benefits of data mining methods, the research stresses the need to create a collaborative culture inside businesses. While this study does shed light on some important questions, more work has to be carried out to fully comprehend data mining methods, collaboration, and their effects on managerial decision-making in the industry. Below are a few topics for further study. Aspects other than collaboration may affect the connection between data mining and decision-making or information exchange, meaning it is important to investigate the possibility of their presence. Understanding the underlying dynamics requires looking at other moderating factors. The long-term consequences of data mining methods on decision-making and information exchange may be better understood through longitudinal research. Understanding the significance of these connections requires looking at them across time.

The precise circumstances in which data mining methods are most useful may be gleaned through comparative studies comparing the efficacy of various data mining approaches or studying the variations in the impact of data mining techniques across different industrial sectors. Quantitative analysis is useful, but qualitative research approaches may provide a more in-depth understanding of people's subjective feelings and perspectives as they participate in the decision-making process and information exchange. The various processes at play may be better understood through a qualitative study.

Future research might benefit from delving further into these questions, as it could pave the way for more refined methods of using data mining tools and could promote collaboration in the industrial sector, both of which would lead to enhanced modes of decision-making and information exchange.

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