NSS
Neutrosophic Sets and Systems, Vol. 83, 2025
University of New Mexico

Neutrosophic model for Analyzing the Effect of the Enterprise Resource Planning Functions on Business Processes

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Abstract: In today's dynamic business environment, we seek to improve the efficiency of decision-making and operational processes by implementing the Enterprise Resource Planning (ERP) systems. The ERP systems provide an integrated database with a single platform that supports various functional areas of the organization for improving the management of business processes. The implementation of the ERP system requires understanding the effect of each function of the ERP system on Business Processes (BP) to maximize its use. Most studies have looked at critical success factors that help ERP systems succeed and other related issues, but they haven't examined how each ERP function impacts business processes. There are several studies that have addressed the ERP systems and different aspects of them, especially the successful implementation of the ERP systems; the ERP systems offer many functions and features that can help different areas within organizations. So, it's important to examine how these functions impact various parts of the organization. This will help improve their use and address any issues. This work intends to address the ERP systems with various aspects and their functions. Also, this work aims to introduce a neutrosophic model for analyzing the effect of the ERP functions on business processes. This work utilizes the neutrosophic numbers to handle uncertainty during the analyzing process. The proposed model considers the cost and benefits during the analysis of the effect of each function on BP. The proposed model was tested in a case study, and the results showed that it is an effective and straightforward new method for dealing with uncertainty. It considers costs and benefits during analysis, providing a clear understanding of how each part of the ERP system affects Business Processes.

Keywords: Business Processes (BP), Enterprise Resource Planning (ERP) Business Process Management (BPM), Single valued triangular neutrosophic numbers (SVTrN-numbers)

1. Introduction

The ERP systems provide integrated organizational functions to achieve business needs and improve performance [1]. The ERP systems integrate a suite of software modules to cover various functional areas of the business, such as finance, human resources, procurement, inventory, production management, sales, and supply chain management [2]. The effective role of ERP systems in enhancing business operations is addressed by [3] within organizations and identifying their impact on various business operations. This highlights the significance of ERP systems in streamlining processes and fostering efficiency across different departments. By understanding their

impact, organizations can leverage these systems to optimize performance and meet their business objectives more effectively. The ERP system links different modules to each other to perform various business functions. ERP systems integrate business data to provide centralized data resource management for facilitating decision-making [5]. The ERP systems handle data on a big scale that can support Business Process Management systems (BPM) through various stages of management to enhance operational efficiency and adaptability. According to [6], ERP systems significantly and positively influence BPM, thereby promoting organizational agility. This integration allows organizations to respond swiftly to market changes and customer needs, ultimately leading to improved competitiveness. Moreover, the seamless flow of information between departments ensures that all stakeholders are aligned, which fosters a collaborative environment conducive to innovation. However, some experts argue that relying heavily on ERP systems can lead to rigidity, as organizations may become overly dependent on predefined processes that limit flexibility. Additionally, the complexity of integrating BPM with existing systems can create challenges that hinder rather than enhance operational efficiency. This dependence on predefined processes may stifle creativity and adaptability, preventing organizations from responding swiftly to market changes. Furthermore, the integration of BPM with legacy systems often requires significant time and resources, which can detract from the overall efficiency and effectiveness of business operations.

The ERP applications are complicated and challenging to set up because they need to work well with a company's various business processes. These processes often involve multiple areas like finance, accounting, sales, marketing, production, warehousing, and sometimes even human resources. Consequently, even after implementation, employees frequently fail to use or adopt many ERP projects. Therefore, organizations struggle to convince and motivate employees to adapt smoothly to these applications and may sometimes need to reengineer their business processes to benefit from them. These challenges highlight the importance of addressing not only the technical aspects of ERP implementation but also the human factors that influence user acceptance. By focusing on effective change management strategies, organizations can enhance employee engagement and increase the likelihood of successful ERP adoption. It is also noted that weak top management support, poor quality of ERP system testing prior to implementation, and weak digital transformation plans are the most significant factors in ERP system failure. This means that without strong leadership, thorough testing, and clear plans for a successful digital transformation, the chances of successfully using an ERP system are greatly lowered. By addressing key problems, we can create a better environment for the success of digital transformation projects and help ensure systems are smoothly implemented in line with business processes. The implementation of the ERP system requires understanding the effect of each function of the ERP system on Business Processes (BP) to maximize its use. However, analyzing the effect of the ERP functions on BP has many aspects.

There are many studies that have been focused on addressing the critical success factors of ERP systems and the other aspects of it, such as [1][3][4][5]. However, these studies did not handle the effect of each function of the ERP system on BP. Also, these studies did not consider the costs and

benefits. This work is intended to address the ERP systems with various aspects and their functions. Also, this work aims to introduce a neutrosophic model for analyzing the effect of the ERP functions on business processes. This work uses neutrosophic numbers to manage uncertainty in the analysis. The suggested model considers both costs and benefits while looking at how each function affects BP. The proposed model was tested in a case study, and the results showed that it offers an effective and straightforward new method for dealing with uncertainty. It considers both costs and benefits during the analysis, providing a clear understanding of how each part of the ERP system affects business processes. The academic contribution of this work lies in its innovative approach to integrating Business Processes Management with ERP system evaluation, which enhances decision-making under uncertainty. By offering a structured method for assessing the impacts of various functions, it advances the field of business process management. The practical contribution of this work is its application of this structured method in real-world scenarios, allowing organizations to make informed decisions that optimize their ERP systems. This not only improves operational efficiency but also supports strategic planning in an increasingly complex business environment. The practical and academic contribution of this work is significant. By bridging the gap between theory and practice, it not only enhances decision-making frameworks but also serves as a valuable resource for future research. This approach opens new avenues for exploring the interplay between cost management and operational efficiency in various organizational contexts.

This work is organized as shown in figure 1: the first section gives the introduction; the second section introduces the ERP systems and business process management; the third section discusses functional areas of ERP systems to support business process; the fourth section describes successful ERP systems implementation; the fifth section presents the relationship between ERP systems and intelligent systems; the sixth section presents challenges of implementing ERP systems; the seventh section discusses the neutrosophic numbers; the eighteenth section explains the proposed model for analyzing the ERP systems and gives numerical example and shows results with discussing the finding of the proposed framework; the nineteenth section gives conclusion and future work; finally gives references. The following figure summarize the structure of this work

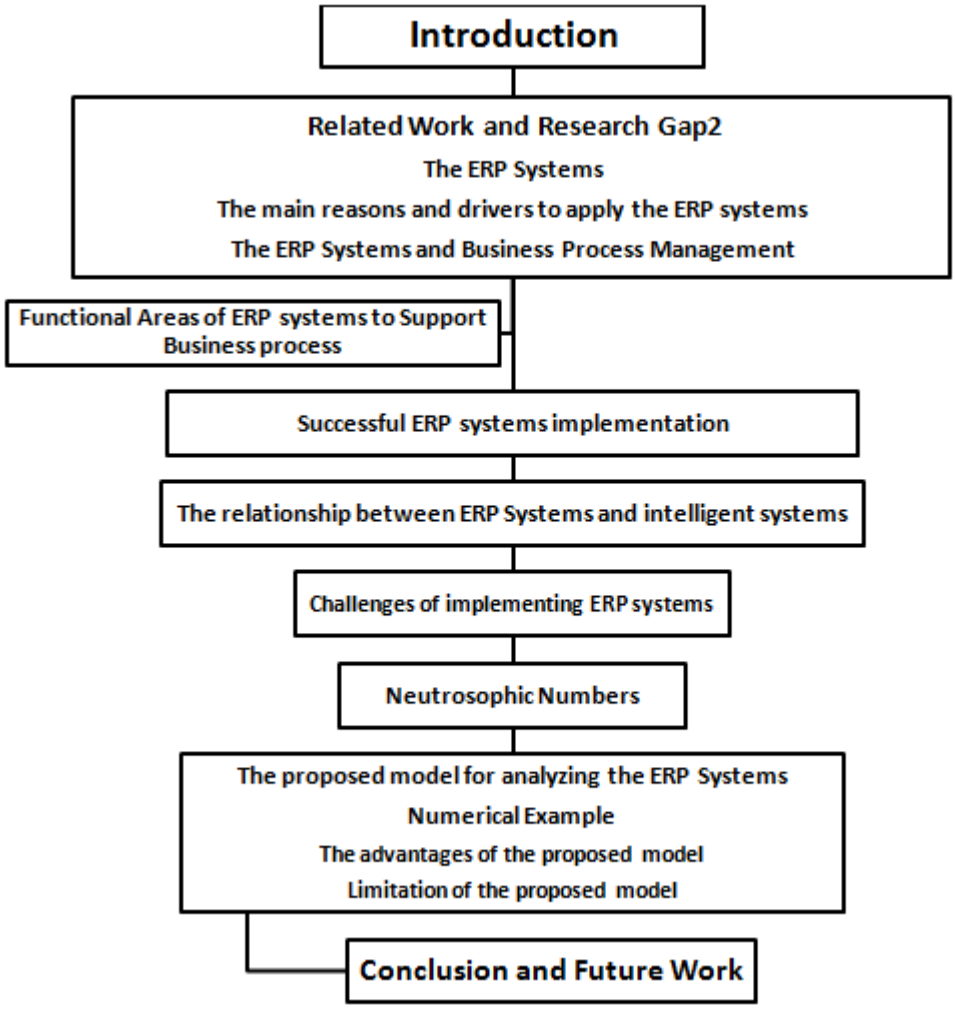


Fig. 1: Components of ERP system

2. Related Work and Research Gap

There are several studies that have been addressed the ERP systems and different aspects of it [1][3][4][5][8][10][12][13][14][15][16][25][26]; However, the ERP systems introduced many functions that can cover and support different applications areas within organizations; therefore, there is a need to analyze the effect of the ERP functions on the different applications areas within organizations to maximize its use and handle any drawbacks. The implementation of the ERP system requires understanding the effect of each function of the ERP system on Business Processes (BP) to maximize its use. However, analyzing the effect of the ERP functions on BP has many aspects. There are many studies that have been focused on addressing the critical success factors of ERP systems and the other aspects of it, such as [1][3][4][5]. However, these studies did not handle the effect of each function of the ERP system on BP. Also, these studies did not consider the costs and benefits. Thus, this work aims to:

1. Discuss the main functions of ERP systems with different applications areas departments within organization.

2. Introduce a novel model to analyze the effect of ERP systems on different applications areas departments within organization.
3. Handle uncertainty during the analysis process using neutrosophic numbers to
4. Help the decision maker to handle each case according to its requirements and conditions

The proposed model is tested in a case study, and the results showed that it offers an effective and straightforward new method for dealing with uncertainty. It considers both costs and benefits during the analysis, providing a clear understanding of how each part of the ERP system affects business processes. The academic contribution of this model lies in its innovative approach to integrating Business Processes Management with ERP system evaluation, which enhances decision-making under uncertainty. By offering a structured method for assessing the impacts of various functions, it advances the field of business process management. The practical contribution of this model is the application of it in real-world scenarios, allowing organizations to make informed decisions that optimize their ERP systems. This not only improves operational efficiency but also supports strategic planning in an increasingly complex business environment. The practical and academic contribution of this work is significant. By bridging the gap between theory and practice, it not only enhances decision-making frameworks but also serves as a valuable resource for future research. This model opens new avenues for exploring the interplay between cost management and operational efficiency in various organizational contexts.

2.1. The ERP Systems

The ERP systems integrate and automate business processes across an organization. The ERP system combines software modules to support business processes such as finance, human resource management, supply chain, logistics, sales, and customer service and other as shown in the following figure [4]:

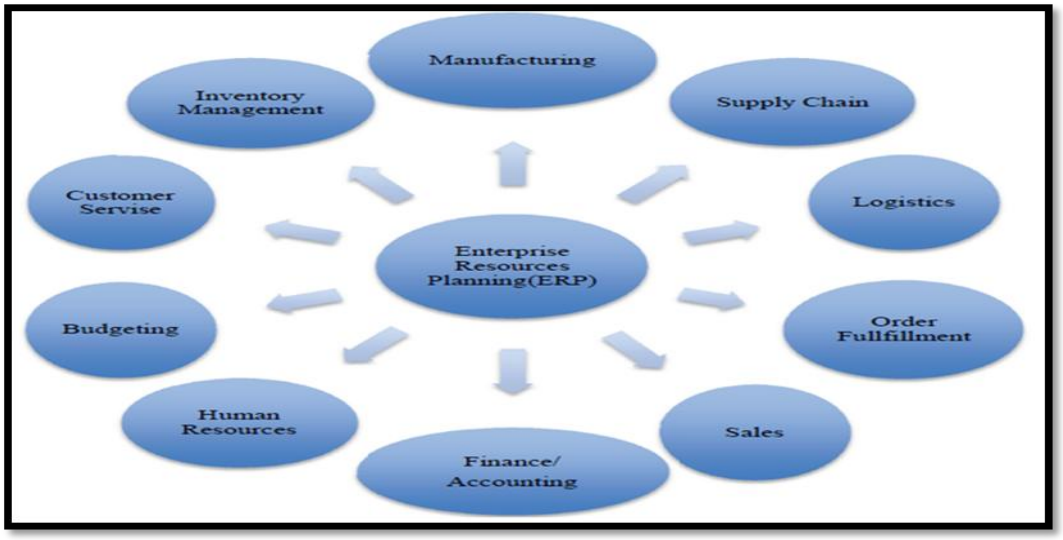


Fig. 2: Components of ERP system

The ERP system links different modules to each other to perform various business functions. ERP systems integrate business data to provide centralized data resource management for facilitating decision-making

2.1.1. The main reasons drivers to apply the ERP systems

The effective role of ERP systems in enhancing business operations is addressed by [3] within organizations and identifying their impact on various business operations. The main reasons and drivers to apply the ERP systems can summarized as the follows:

- The need to real-time data
- Minimize business processes costs
- The need to an integrated application
- Apply the ERP as a step to re-engineer and enhance business processes
- Improve decision making
- Increase sales
- Achieve competitive advantages

2.1.2. The ERP Systems and Business Process Management

The integration of BPM with legacy systems often requires significant time and resources, which can detract from the overall efficiency and effectiveness of business operations. These processes often involve multiple areas like finance, accounting, sales, marketing, production, warehousing, and sometimes even human resources. Consequently, even after implementation, employees frequently fail to use or adopt many ERP projects. Therefore, organizations struggle to convince and motivate employees to adapt smoothly to these applications and may sometimes need to reengineer their business processes to benefit from them. As [7] pointed out, the ERP implementation enhances BPM by optimizing processes, enhancing data accuracy, and fostering collaboration. The effect of ERP systems on maximizing the benefits of BPM can be summarized as the follows:

1. Productivity Improvement
2. Operational Efficiency
3. Enhancing data accuracy
4. Optimizing Processes
5. Fostering Collaboration
6. Promoting Agility
7. Cost Reduction
8. Facilitate Changes

The database of ERP systems centralized data throughout an entire organization to support various types of functions such as marketing and sales, finance and accounting, human resources management, and so on to achieve business goals and support inside and outside stakeholders. The database of ERP systems and its work is introduced in the following figure [8]:

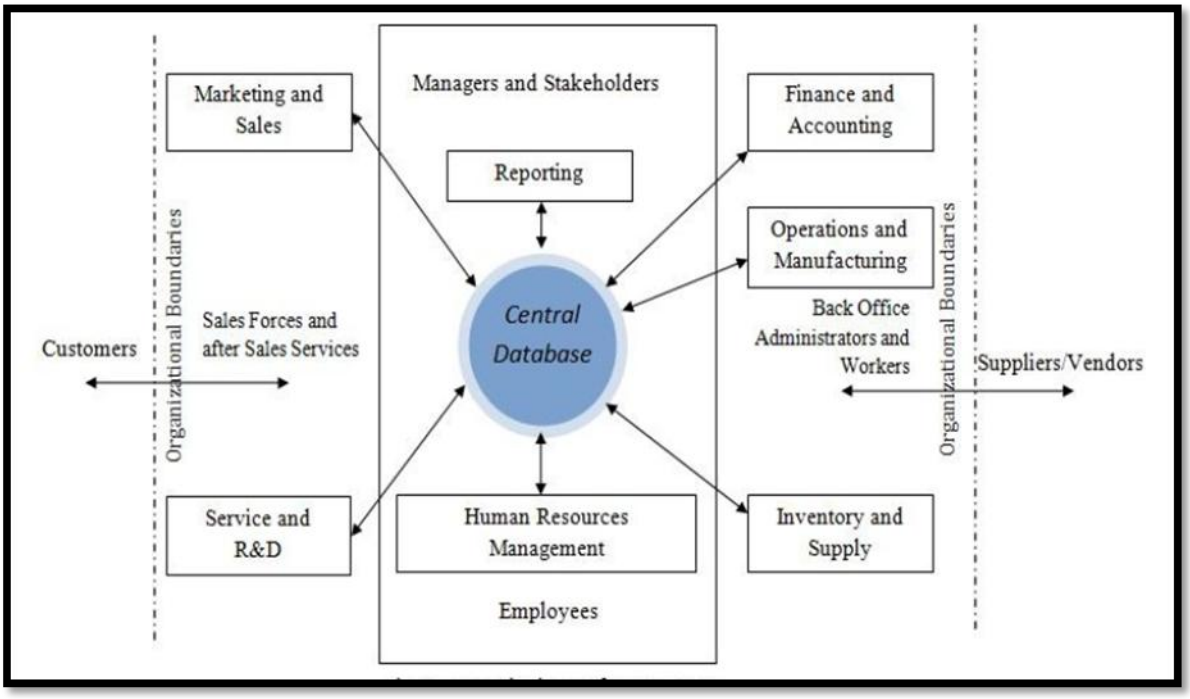


Fig. 3: Database of ERP systems and its work

The ERP systems play an important role in enhancing business efficiency by [9][10]:

1. Automating manual tasks
2. Enhancing demand forecasting and inventory management
3. Facilitating process standardization
4. Streamlining communication across departments
5. Defining and automating repetitive tasks
6. Centralizing documents and files
7. Generating and assigning tasks to employees, establishing deadlines, and monitoring progress
8. Coordinating data flow of business processes and optimizing operations.

3. Functional Areas of ERP systems to Support Business process

As [11] stated that ERP systems provide a suite of software modules covering functions various areas of the business. According to [12] the main functions areas can be summarized by the following figure:

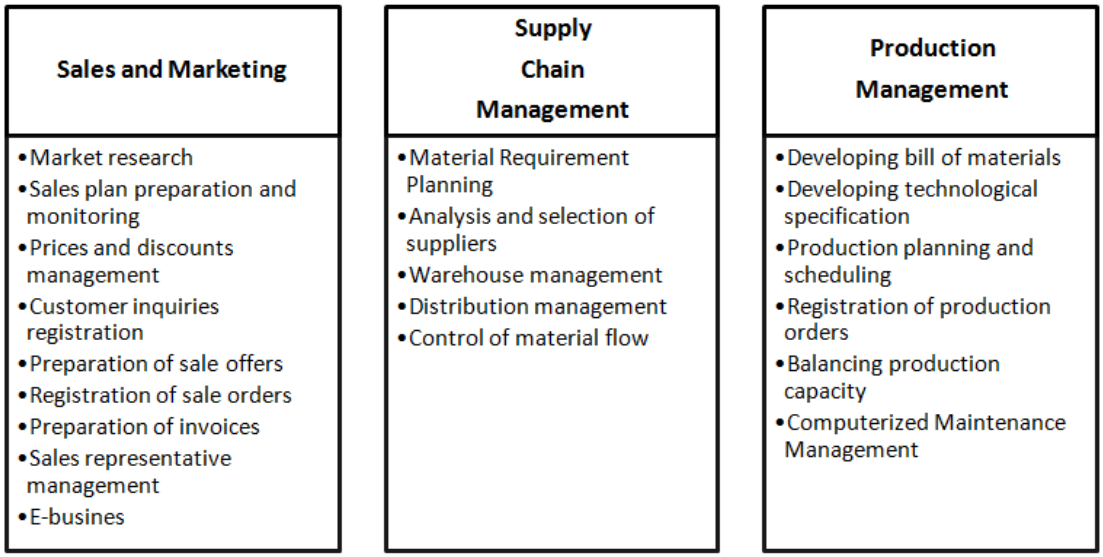


Fig. 4: The main Functional Areas of ERP systems to Support Business process

ERP systems provide comprehensive data collection to support managers with a holistic view and control over the organization [13]. ERP systems enable centralized resource management for enhancing decision-making and cost savings. As [14] pointed out, there is a significant impact of ERP systems on internal audit effectiveness and organizational operations. According to [15] the implementation of ERP systems has a significance effect on business strategy that can support organizational capabilities which lead to improved performance. The following figure summarized the Impact of ERP implementation on organization performance.

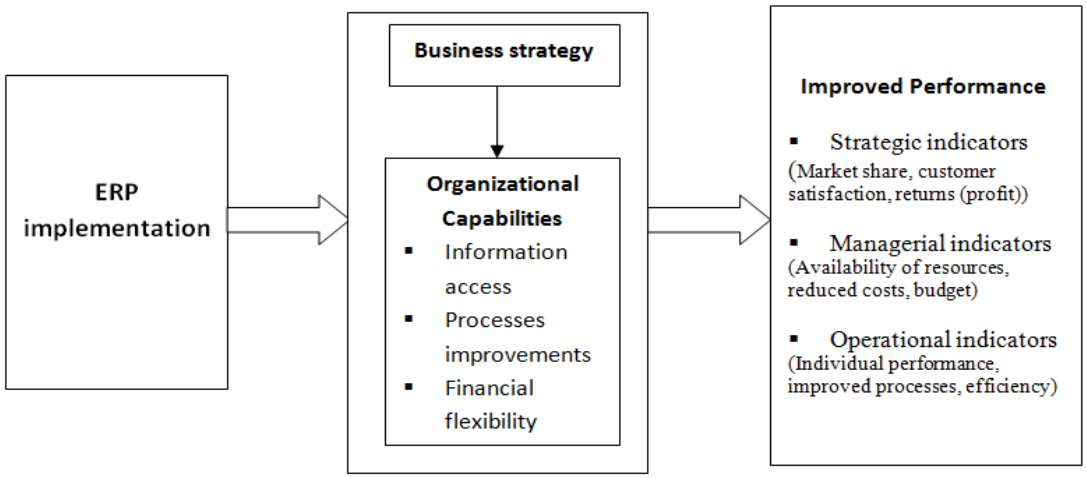


Fig. 5: Impact of ERP implementation on organization performance

4. Successful ERP systems implementation

There are many researches that addressed the impact of various factors on ERP implementation success, competitive advantage, and enhance user satisfaction. As [16] stated top management support for project management, business process reengineering, and corporate culture significantly influences ERP implementation success. There are some studies addressed successes of ERP along

the various steps of ERP implementation. Markus and Tanis [17] addressed the success factors of ERP implementation along with implementation phases as the following figure:

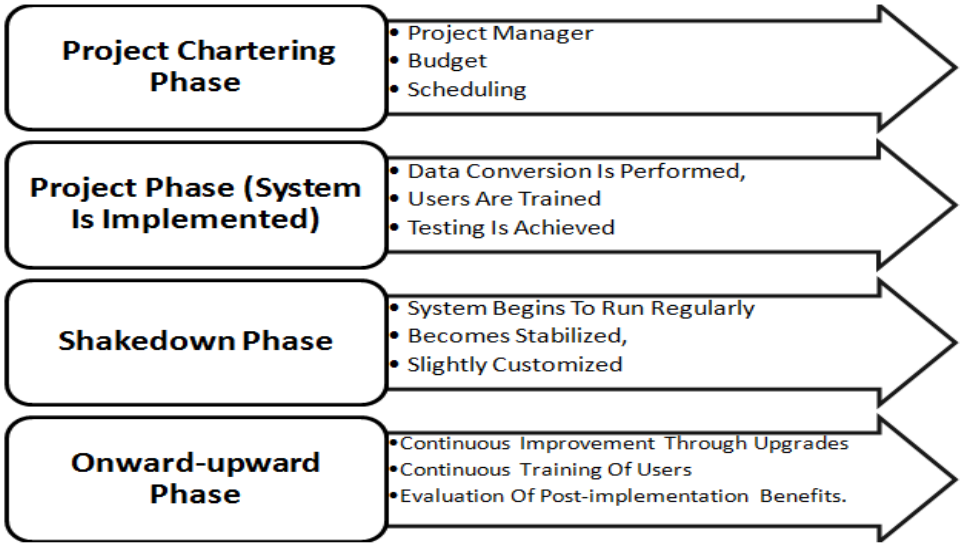


Fig.6: Success factors of ERP implementation along with implementation phases

5. The relationship between ERP Systems and intelligent systems

The ERP systems have data from various areas to provide a centralized data that can support other systems as intelligent systems which have the ability to analyze data and provide correct information for improving decisions [5][19]. The ERP systems and intelligent systems have different features and can support each other to meet business needs and process complexities. The ERP systems and intelligent systems can support business processes as shown in the following figure:

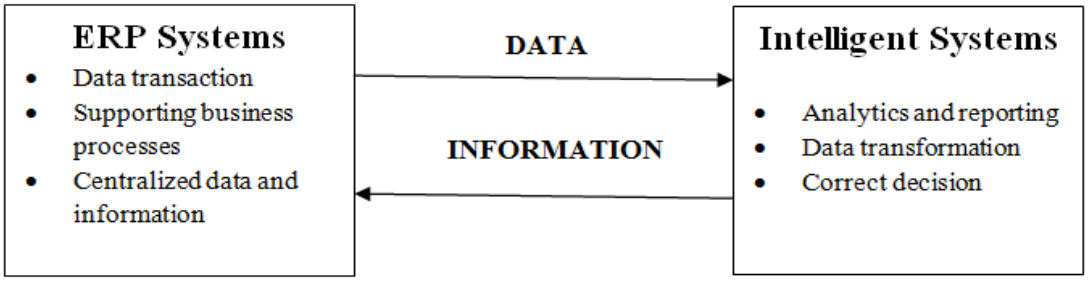


Fig. 7: The relationship between ERP Systems and intelligent systems

6. Challenges of Implementing ERP systems

There many challenges of implementing ERP systems. Challenges include initial resistance to change, the need to align them with existing and future processes, and the need for training [20][21]. As [22] pointed out, the challenges of implementing ERP systems include goal setting, training, software configuration, and project management and iterative testing to ensure ERP success and avoid failures. According to [21] it is critical to select the suitable ERP tools, vendors, and

methodologies to enhance operational efficiencies, control costs, reduce risks, optimize ERP functionality, and minimize the risk of failures. In addition to these challenges, there are requirements for implementing the ERP Systems which include on scalability, Scalability, adaptability to enhance BP. The following figure provides an overview of requirements for implementing the ERP Systems to enhance business process management.

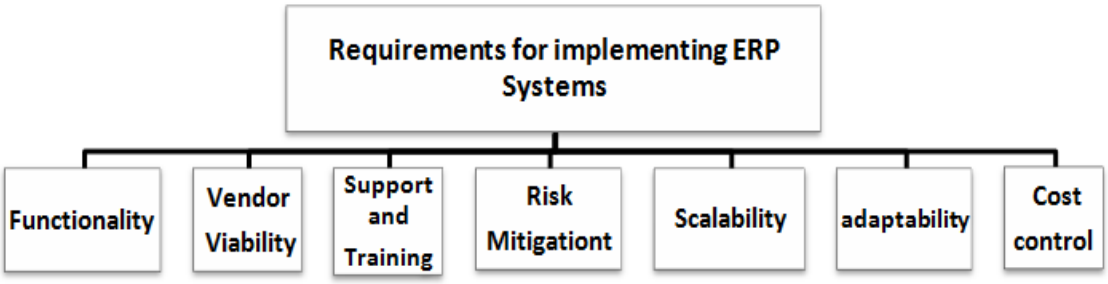


Fig 8: Requirements for implementing ERP Systems

7. Neutrosophic Numbers

Single valued triangular neutrosophic numbers (SVTrN-numbers) is a special case of neutrosophic set to handle ill-known quantity and inconsistent information in Multi-Criteria Decision Making (MCDM), analyzing, and ranking problems. Neutrosophic set is provides a comprehensive view and generalization of Fuzzy sets [23] as shown in the following figure:

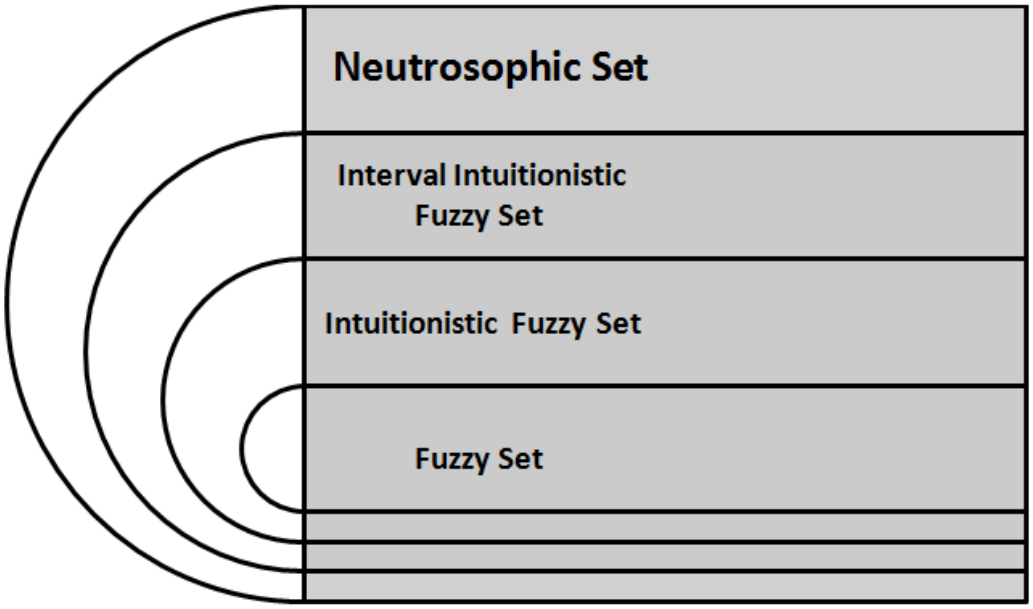


Fig. 9: The umbrella of Neutrosophic sets

Definition 1: According to [24] the SVTrN-numbers a can be defined as the follows:
let ā = ((a1, a2, a3); Ta ,Ia ,Fa) where is a SVTrN-number whose truth-membership, indeterminacy-membership and falsity-membership functions are respectively defined by:

$$T_a(x) = \begin{cases} T_a \dfrac{(x - a_1)}{(a_2 - a_1)}, & a_1 \le x < a_2 \\ T_a & x = a_2 \\ T_a \dfrac{(a_3 - x)}{(a_3 - a_2)}, & a_2 \le x < a_3 \\ 0, & \text{otherwise} \end{cases}$$

$$I_a(x) = \begin{cases} \dfrac{(a_2 - x + I_a(x - a_1))}{(a_2 - a_1)}, & a_1 \le x < a_2 \\ I_a & x = a_2 \\ \dfrac{(x - a_2 + I_a\,(a_3 - x))}{(a_3 - a_2)}, & a_2 \le x < a_3 \\ 1, & \text{otherwise} \end{cases}$$

$$F_a(x) = \begin{cases} \dfrac{(a_2 - x + F_a(x - a_1))}{(a_2 - a_1)}, & a_1 \le x < a_2 \\ F_a & x = a_2 \\ \dfrac{(x - a_2 + F_a\,(a_3 - x))}{(a_3 - a_2)}, & a_2 \le x < a_3 \\ 1, & \text{otherwise} \end{cases}$$

The multiplication of triangular neutrosophic number by constant value, aqddition, subtraction, and multiplication of two triangular neutrosophic numbers can be performed as defined by [22]

8. The proposed model for analyzing the ERP Systems

The proposed model aims to introduce an enhanced a decision support model with more readable and applicable equations for analyzing the effect of the enterprise resource planning functions on different business processes. The proposed method consists of eight steps as the following:

Phase 1: The decision maker determines the ERP function that need to be analyzed and order them based on to their requirements.

Phase 2: Determine the weight of each function

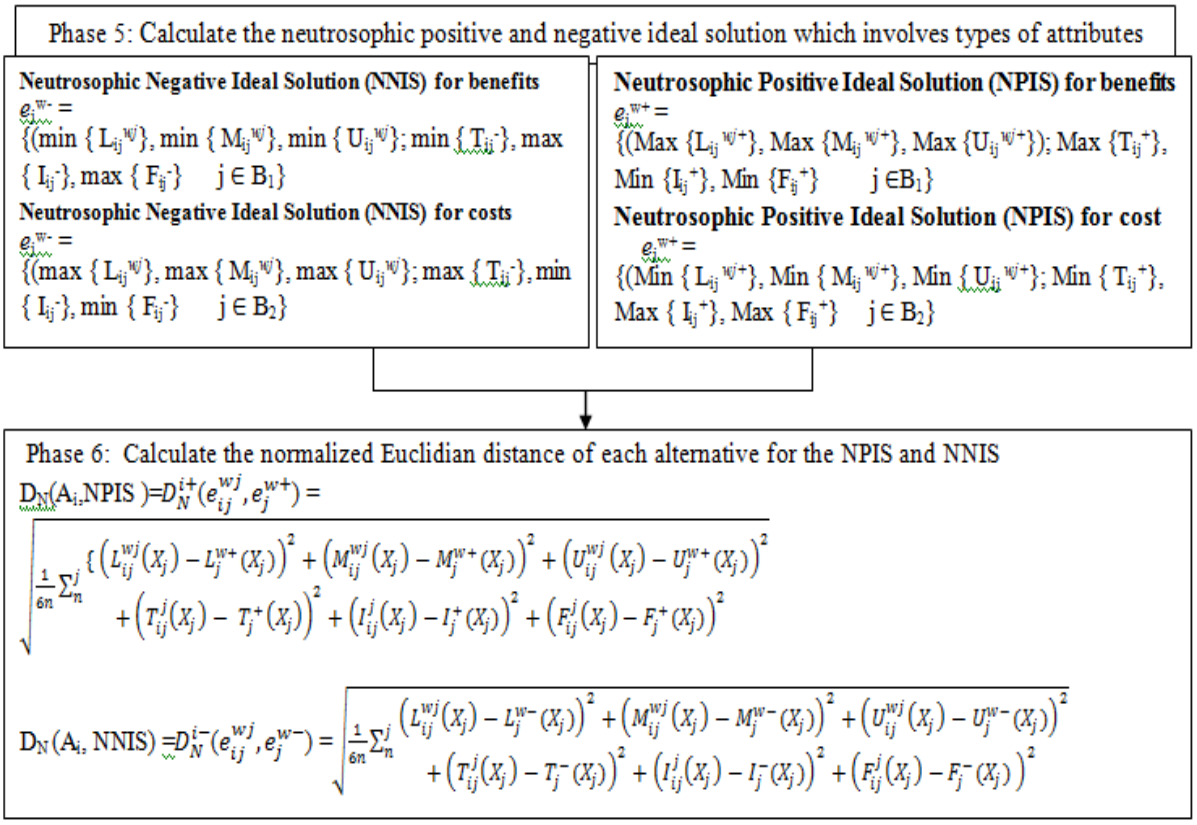
Phase 3: Build the estimation matrix which consists of m alternatives and n criteria as the following:

$$[Aij]m*n = \begin{pmatrix} A_{11} & A_{12} & \cdots & A_{1n} \\ A_{21} & A_{22} & \dots & A_{2n} \\ \vdots & & \ddots & \vdots \\ A_{m1} & A_{m2} & \cdots & A_{mn} \end{pmatrix}$$

Phase 4: Calculate the weighted matrix as

Ew= E*w={eijwj} m*n = {Lijwj, Mijwj, Uijwj; Tij, Iij, Fij }m*n

Phase 5 & Phase 6: can be represented as the follows:



Step 7: Calculate the closeness coefficient of each alternative

$$C_i = \frac{D_N^{i-}(e_{ij}^{wj}, e_j^{w-})}{D_N^{i+}(e_{ij}^{wj}, e_j^{w+}) + D_N^{i-}(e_{ij}^{wj}, e_j^{w-})} \quad \text{where} \quad 0 \le c_i^* \le 1$$

Step 8: Analyze the effect of the ERP functions on BP the according to values of ci

8.1. Numerical Example

A business organization needs to analyze and discover the effect of implementing the ERP system on business processes of four functions: Preparation of sale offers, Warehouse management, Production planning and scheduling, and Material Requirement Planning. This organization needs to take into the effect of cost and benefit during the analysis process. Use the following linguistic scale table:

Table 1: linguistic scale

Linguistic variables	Neutrosophic numbers
Very Low (VL)	(0, 1, 2; 0.10, 0.85, 0.90)
Low (L)	(1, 2, 3; 0.20, 0.75, 0.80)
Medium Low (ML)	(2, 3, 4; 0.35, 0.65, 0.60)
Medium (M)	(3, 4, 5; 0.50, 0.50, 0.50)
Medium High (MH)	(4, 5, 6; 0.60, 0.35, 0.30)
High (H)	(5, 6, 7; 0.80, 0.20, 0.15)
Very High (VH)	(6, 7, 8; 0.90, 0.10, 0.05)

Extremely (E)	(7, 8, 9; 1.00, 0.00, 0.00)

Step 1: Ask the decision maker determines criteria and order them based on to their requirements from the most to the least important as follows:

1. Benefits
2. Cost.

Step 2: Calculate the weight of estimation criteria as follows:

1. Weight of Benefits = 0.75,
2. Weight of Cost= 0.25.

Step 3: Build the estimation table which consists of m ERP functions and n analyzing criteria according to the linguistic scale which was presented in table 1as the following:

*Table 2.*Estimation table of the ERP functions and n analyzing criteria

Criteria (n) **ERP functions (m)**	**Efficiency of BP**	**Operational and training costs**
	Benefits (B1)	**Costs (B2)**
Preparation of sale offers	(5, 6, 7; 0.80, 0.20, 0.15)	(2, 3, 4; 0.35, 0.65, 0.60)
Warehouse management	(4, 5, 6; 0.60, 0.35, 0.30)	(1, 2, 3; 0.20, 0.75, 0.80)
Material Requirements Planning	(7, 8, 9; 1.00, 0.00, 0.00)	(2, 3, 4; 0.35, 0.65, 0.60)
Production planning and scheduling,	(6, 7, 8; 0.90, 0.10, 0.05)	(2, 3, 4; 0.35, 0.65, 0.60)

Phase 4: Calculate the weighted matrix as

Ew= E*w={eij^{wj}} $_{m*n}$ = {Lij^{w}j, Mij^{wj}, Uij^{wj}; Tij, Iij, Fij }m*n

$$\begin{pmatrix} (4,5,5;\ 0.80,0.20,0.15) & (1,1,1;\ 0.35,0.65,0.60) \\ (3,4,5;\ 0.60,0.35,0.30) & (0,1,1;\ 0.20,0.75,0.80) \\ (5,6,7;\ 1.00,0.00,0.00) & (1,1,1;\ 0.35,0.65,0.60) \\ (5,5,6;\ 0.90,0.10,0.05) & (1,1,1;\ 0.35,0.65,0.60) \end{pmatrix}$$

Step 6: Calculate the Euclidian distance of each alternative from the NPIS and NNIS

Table 3. The NPIS

NPIS	**Benefits (B1)**	**Cost (B2)**
	(5, 6, 7; 1.00, 0.00, 0.00)	(0, 1, 1; 0.20, 0.75, 0.80)

Table 4. The NNIS

NNIS	**Benefits (B1)**	**Cost (B2)**
	(3, 4, 5; 0.80, 0.35, 0.30)	(1, 1, 1; 35, 0.65, 0.60)

Step 7: Calculate the normalized Euclidian distance of each alternative from the NPIS and NNIS

Table 5. The normalized Euclidian distance of the effect of ERP functions for the NPIS and NNIS

ERP functions	$D_N^{i+}(e_{ij}^{wj}, e_j^{w+})$	$D_N^{i-}(e_{ij}^{wj}, e_j^{w-})$
Preparation of sale offers	.7732	.4168
Warehouse management	.7130	.5129
Material Requirement Planning	.2988	1.0153
Production planning and scheduling	.5078	.5127

Step 7: Calculate the closeness coefficient of BP modeling technique by using eq. (8)

Table 6. The closeness coefficient of ERP functions

The closeness coefficient of ERP Functions	
Preparation of sale offers	.3502
Warehouse management	.4183
Material Requirements Planning	.7753
Production planning and scheduling	.5850

Step 8: rank the ERP functions for analyzing their effect on BP as shown in the following figure:

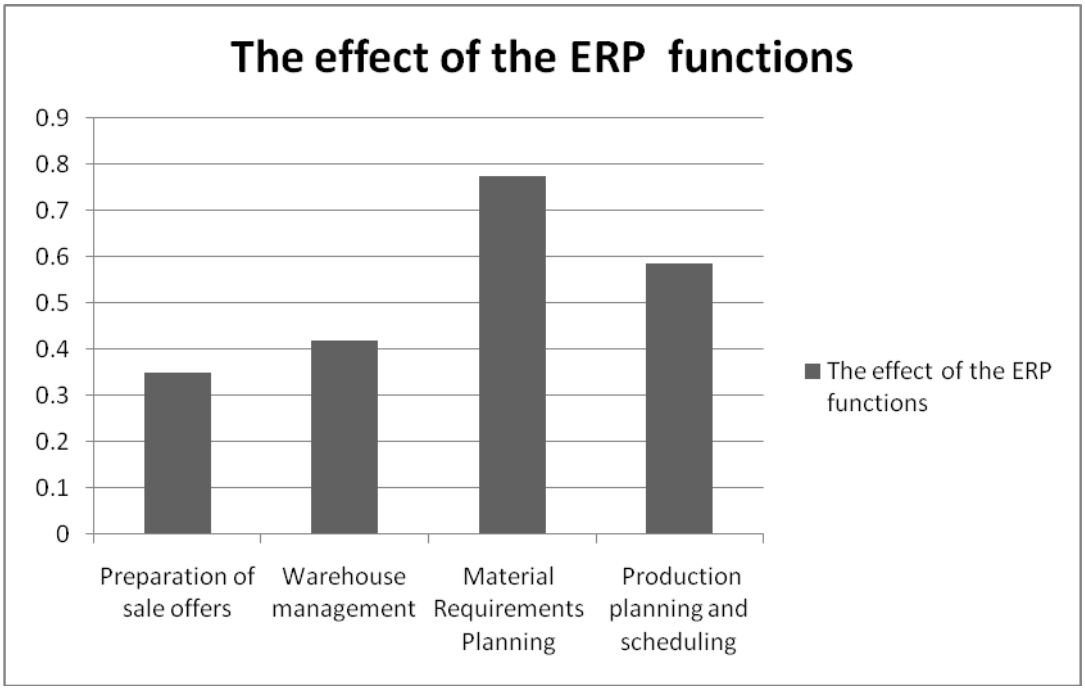


Fig. 10: The effect of the ERP functions on BP

From figure 9 the effect of material requirement planning on BP has the great value on BP; by analyzing the effect of each ERP function can be ranked form the most effect to the least effect as: Material Requirement Planning > Production planning and scheduling > Warehouse management > Preparation of sale offers.

8.2. The advantages of the proposed model

There are many studies that have been focused on addressing the critical success factors of ERP systems and the other aspects of it such as [1][3][4][5][8][10][12][13][14][15][16][25][26].However, these studies were not handled the effect of each functions of ERP system on BP. The proposed model is applied to analyze the effect of four ERP functions (Preparation of sale offers, Warehouse management, Production planning and scheduling, and Material Requirement Planning) on business goals and according to their requirements. The results showed that the proposed model can enable the decision maker to understand the effect of ERP functions (Preparation of sale offers, Warehouse management, Production planning and scheduling, and Material Requirement Planning) and takes into account costs and benefits for analyzing the effect of ERP functions on BP. The findings of the proposed model can be summarized as the following:

1. The proposed model presents equations in more simple way that makes it more readable and applicable.
2. The proposed model takes into account the costs and benefits during the analyzing of the ERP functions to give real understanding of each function.
3. The proposed model provides a flexibility to reflex the view point of decision makers toward special case according to the requirements of its business needs
4. The proposed model can handle costs and benefits with simple equations and balance between costs and benefits for analyzing each function of ERP system.
5. The proposed framework uses the neutrosophic numbers to handle confusion and lack of clarity during analyzing the effect of the ERP systems on BP.
6. The academic contribution of this work lies in its innovative approach to integrating Business Processes Management with ERP system evaluation, which enhances decision-making under uncertainty.
7. By offering a structured method for assessing the impacts of various functions, it advances the field of business process management.
8. The practical contribution of this model is the application of it in real-world scenarios, allowing organizations to make informed decisions that optimize their ERP systems. This not only improves operational efficiency but also supports strategic planning in an increasingly complex business environment.
9. The practical and academic contribution of this work is significant. By bridging the gap between theory and practice, it not only enhances decision-making frameworks but also serves as a valuable resource for future research.

10. The proposed model opens new avenues for exploring the interplay between cost management and operational efficiency in various organizational contexts.

8.3. Limitation of the proposed model

The main limitations in the practical implementation of the proposed framework can be stated as the follows:

- By applying the proposed model and handling its equations and calculations to the practical cases, participants stressed that the proposed system requires specialists to implement and deal with the complexity of equations.
- The implementations of the proposed model for the practical cases emphasized on the equations are clear to specialists, but they need further clarification to non-specialists.
- The proposed model requires very precise and accurate calculations to avoid inaccurate results.

9. Conclusion and Future Work

The implementation of the ERP system requires understanding the effect of each function of the ERP system on BP. However, analyzing the effect of the ERP functions on BP has many aspects. This work intends to address the ERP systems with various aspects and their functions. Also, this work aims to introduce a neutrosophic framework for analyzing the effect of the ERP functions on business processes. This work utilizes the neutrosophic numbers to handle uncertainty during the analyzing process. The proposed model takes into account the cost and benefits during the analysis of the effect of each function on BP. The results showed that the suggested framework offers an effective and simple new method to manage uncertainty while considering the costs and benefits of how each function affects BP. This indicates that the framework not only simplifies the management of uncertainty but also provides a balanced view of the financial implications tied to each ERP function's impact on business processes. Consequently, organizations can make more informed decisions by weighing both the advantages and costs associated with their ERP implementations.

In the future, we can improve this work in various ways. (1) Incorporate innovative and comprehensive methods for analyzing the impact of ERP systems on the business environment. (2) Explore the integration of machine learning techniques to enhance predictive accuracy and identify trends within the data. By leveraging advanced analytics, we can better understand the dynamic relationships between functions and their contributions to overall business performance. (3) Apply more new mathematical methods under a neutrosophic environment to give more accurate results. This approach aims to refine the analysis of ERP systems by utilizing cutting-edge mathematical techniques that account for uncertainty and imprecision. As a result, businesses can achieve more precise insights into their operational dynamics and decision-making processes.

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Received: Nov. 22, 2024. Accepted: April 9, 2025