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Implementing and Evaluating SAP Solutions at the Union Pacific Railroad: Multi-Criteria Decision Analysis Using the COPRAS Method

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ABSTRACT

Union Pacific is making a transformational effort by adopting SAP solutions to improve its operations. The company is migrating its back-office systems to SAP S/4HANA Cloud with the aim of streamlining finance, sourcing, logistics, human resources and cost management. The transition will help reduce technical debt, simplify processes and improve decision-making through better data integration. In addition, Union Pacific is using SAP Transportation Management (TM) to improve logistics, focusing on improving freight movement, carrier management, bidding, tendering and invoicing, which is an operational

Research significance: The integration of SAP Transportation Management (TM) and SAP S/4HANA cloud migration within Union Pacific delivers significant improvements in logistics optimization, operational efficiency, and decision-making. By using SAP TM, Union Pacific is improving freight movement, carrier management, bidding, tendering, and invoicing, directly improving the speed and accuracy of service delivery. This technology transformation allows suppliers to better manage supplier data and conduct smooth business transactions by providing training materials and support tools to help them register and manage their profiles within the SAP business network. Seamless data exchange ensures that supplier information is accurate and up-to-date, further facilitating efficient business operations.

Methodology: The alternative options for infrastructure are SAP S/4HANA Cloud, SAP Ariba, SAP Transportation Management, Mobile Plant Maintenance App, Supplier Registration and Training, and System Integration, Data Analytics and Reporting. The evaluation criteria Operational Efficiency, Data Integration and Accuracy, Implementation Costs, Disruption During Transition.

Result: According to the results, Data Analytics and Reporting was ranked highest, while Mobile Plant Maintenance App was ranked lowest.

Conclusion: Data Analytics and Reporting has the highest value for Union Pacific Railroad Company according to the COPRAS methods approach.

Keywords: Union Pacific, SAP TM, Freight movement, Logistics, Carrier management, Bidding, Tendering, Invoicing, Operational efficiency, Service delivery.

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Introduction

Union Pacific is leveraging SAP TM to enhance freight movement and logistics. The system will optimize carrier management, bidding, tendering, and invoicing, boosting operational efficiency and service delivery. As part of the SAP implementation, Union Pacific has created training materials and support tools to assist suppliers in registering and managing their profiles on the SAP Business Network, ensuring accurate supplier data and facilitating smooth business transactions. Additionally, Union Pacific has developed an internal mobile app using SAP UI5 technology to oversee the inspection and repair of intermediate containers and chassis. This app integrates with SAP Plant Maintenance, Materials Management, Sales and Distribution, and Finance modules, allowing for real-time data input and advanced asset tracking.

SAP S/4HANA Cloud Migration: Union Pacific is moving its back-office systems – including finance, sourcing, internal logistics, human resources and expense management – to SAP's cloud suite. The migration aims to simplify business processes, reduce technical debt and provide unified data to support improved decision-making. Durant was now able to obtain UPRC funds by raising rates for completed construction. This created a direct conflict between his personal business affairs and his duties as a UPRC officer. Although Durant's syndicate had awarded the contract, the financial risk to his investors was too great, as they would bear the burden of any debts if construction failed. To more effectively manage investment risk and to have greater oversight of the construction of the Union Pacific Railroad, they needed a legal structure. [1] The Union Pacific was not initially a transcontinental railroad. Its western terminus was at Oakton, where it connected with the Central Pacific.

There was no commercial activity at Oakton, and the Union Pacific soon began moving toward its own terminus on the Pacific coast. In 1881, it began construction of the Oregon Narrow Gauge Line, which ran from Granger, Wyoming, through the Snake River Valley to northeastern Oregon. Three years later, it connected with the Oregon Railway and Navigation Company's line at Huntington, allowing the Union Pacific to reach Portland and the coast. [2] Meanwhile, the important role of the contracting and financing company in the construction of the western section of the first transcontinental railroad has often been overlooked. This article attempts to provide a brief history of the company and its relationship to the Central Pacific Railroad and its related lines.

For about a decade before the Civil War, the idea of building a railroad connecting the Atlantic and Pacific coasts was a major point of national debate. [3] The Pacific Coast terminus was different - Oregon for the road and California for the rail - and the two proposed routes largely overlapped each other east of the Great Salt Lake. The road and rail intersected in three places, and apart from their starting points, they were no more than a hundred miles apart. The distance from the "middle line" at the Great Bend of the Missouri River to the western slopes of the Rocky Mountains across the Salt Lake and Snake

River plains were approximately a thousand miles, meaning that the two routes ran parallel for one-third of the width of the continent. [4] You can see the challenge. They are not slaves." Being a Chinese worker on the Central Pacific is not the same as being a slave or the property of someone else. However, it reduces them to the status of a tool used for tasks such as grading land and drilling through mountains. They are expendable, exchangeable, and replaceable. Chinese workers were considered to be tools of labor and fixed assets for the Central Pacific Railroad. The living conditions of Chinese workers, [5]

Allocating empty cars to a customer involves several steps. First, we need to identify empty cars that meet the customer's criteria. Then, we need to schedule trains with sufficient capacity to transport the cars to the customer's location (since cars will be transferred to different trains at intermediate points). This implies that both train schedules and car allocations need to be considered together for an effective solution. However, since this project is an initial step in developing an automated system for allocating empty freight cars in UP, we decided not to consider both car allocation and train schedules at the same time. [6] In approving the merger, the STB's objective was to protect potential efficiencies in the combined networks of the two railways by addressing competition concerns on certain routes through track rights, rather than through rail-to-rail sales.

The board highlighted the significant benefit of the merger in integrating the financially struggling SP into a larger, financially stronger rail system. This integration would help maintain efficient operations and ensure adequate investment in its infrastructure. [7] As previously mentioned, ERPs have undergone significant changes over the past sixty years, influenced by different time frames and assumptions. To be effective tools for integration and value creation, ERPs must be implemented within a technology ecosystem that supports the organization's operations and strategy. This article emphasizes the need to consider the evolution of organizations with existing ERPs, moving from traditional monolithic systems to modern cloud-based and postmodern ERP systems. These advanced systems incorporate technologies such as artificial intelligence, robotic process automation, and digital innovations. [8] In any organization, top management plays a key role in setting the strategic direction.

Their support is crucial for the successful implementation of business process reengineering (BPR). Top management must have a strong understanding of BPR and be actively involved in making important decisions throughout the process.. In addition, they should motivate employees and maintain positive engagement with the BPR team. A collaborative work environment, which is often highlighted in the literature, is another important factor. Organizations bring together

employees from different roles and levels, which makes effective communication essential in fostering a dynamic workplace. Such collaboration reduces resistance to change and facilitates a smooth BPR implementation. [9] Enterprise Resource Planning Systems (ERPs) incorporate the concept of instrumental rationality, which is the driving logic behind the implementation and control processes of modernity. This logic supports objective, value-neutral development and the use of efficient and effective methods to achieve specific goals. It also governs the creation and evolution of abstract structures such as discipline, ethics, trust, and professionalism.

As a result, this logic is implemented through management hierarchies, specialties, and related physical systems, which are separated from these abstract structures. [10] This analysis emphasizes the need for software vendors to take ERP system adoption seriously. It also deepens the understanding of how accounting-related arguments are integrated into legal processes. In particular, the analysis shows that the characteristics, justifications, and effects of ERP systems and their implementation are influenced by language. Discourses shape the perception of ERP systems as key tools for ensuring integration and accountability in operations. In addition, the analysis aims to focus on practice, focusing on technical features that can be customized to different contexts during software configuration. [11] Skills in procurement and supply management emphasize driving innovation within internal and external supply chains. Internal supply management encompasses the skills and expertise related to developing new products and improving the transformation of supply inputs into high-value outputs. External supply innovation focuses on the use of mergers, acquisitions, and joint ventures for internalization, as well as the skills of making strategic purchasing decisions and effectively selecting and developing suppliers.

In summary, the article highlights the key factors that influence the power dynamics between buyers and suppliers. [12] This paper is structured to begin with a brief review of current developments in sustainable public procurement and contracting. From the perspectives of these different sectors, we observe that new regulations, such as public contracts and related policies, are being established to support environmental sustainability. In addition, a number of researchers have explored the economic aspects, focusing on the potential value derived from sustainable procurement. Environmentally responsible strategies have been shown to enhance competitive advantage and improve financial performance. [13] The implementation of electronic procurement practices has brought new responsibilities to procurement managers. For example, managing electronic systems and processes such as tendering and supplier certification has become a central responsibility in many procurement departments.

Furthermore, defining the role of procurement in strategic relationships (SRs) that involve the exchange of essential goods and services between organizations with different needs is a major challenge. [14] More than goods, information exchange serves as a significant driver of competitive advantage, and this extensive information sharing creates strong barriers to entry and exit. At the heart of this dynamic is the critical issue of trust. Essentially, these close relationships raise the question: How much should a company trust its trading partners with sensitive and detailed information? This concern is well-founded, as a supplier has the potential to become either a competitor or a collaborator. [15] This process consists of two main stages, each with its own distinct but complementary goals: (1) supplier selection, which focuses on identifying the right suppliers for service contracts, and (2) supplier evaluation, which aims to assess the performance of existing suppliers. Due to the different objectives of these stages, the criteria and methods used in each should be clearly defined and handled separately. [16] To achieve this, Section Two begins by reviewing the theoretical foundations of the supplier satisfaction literature.

In Section Three, five hypotheses are developed based on this literature. The methodology section follows, providing insights into the model and how the variables are measured. Section five describes the measurement of these variables, while section six presents the results of the survey. These results are then analyzed in Section Seven. Finally, Section Eight proposes recommendations for future research, considering the limitations of the study and its theoretical and managerial implications. [17] As global competition intensifies, profitability cannot rely on raising prices. Instead, businesses must compete by innovating products, ensuring high quality, and providing fast response times, often achieving all of these factors simultaneously and at low cost. This competitiveness is impossible to achieve without a well-managed supply chain. Companies with highly efficient supply chains are the success stories of modern business, and they will remain so. [18] Procurement functions strategically by linking a company's short-term goals with its long-term competitive advantage.

It serves as a tactical solution to address current portfolio needs and a strategic path to future value creation. In today's rapidly changing market, staying competitive requires strong internal processes and an effective external supply network. Future studies could focus on how procurement contributes to strengthening a company's competitiveness and securing its long-term viability. [19] This discussion highlights concerns about the potential link between procurement maturity and performance, its potential limitations, and the reasons why efforts to improve procurement maturity through best practices do not always lead to better financial outcomes. To address these questions, this study presents empirical evidence supporting the link between maturity and performance, using reliable firm-level data. This study uses the most comprehensive maturity model available in the literature. Furthermore, it contributes to theory

by introducing the concept of purchasing absorptive capacity and defining a "minimum maturity point" as the threshold required to implement best practices. [20]

Materials and Method

The novelty of this study lies in developing new performance metrics for Total Production Maintenance (TPM) and introducing a fuzzy COPRAS method to estimate these metrics, which eliminates the need for smoothing to avoid information loss. In the proposed fuzzy COPRAS method, all calculations are performed using fuzzy arithmetic. As a result, this study provides new performance metrics affecting TPM, which are estimated within a fuzzy framework. To the best of the literature and the authors' knowledge, this is the first study to use the fuzzy COPRAS method to estimate newly developed performance metrics for TPM. [21] This study uses TOPSIS, VIKOR, and COPRAS methods to assess safe areas during the COVID-19 pandemic. To our knowledge, no previous research has used MCDM techniques to identify safe areas in the context of COVID-19. These popular MCDM methods were selected to assess safety levels in 100 areas during the pandemic. Furthermore, the findings were compared and analyzed with the data report used in the study. [22] The COPRAS method was originally considered a precursor to MCDM. Since uncertainty is a fundamental feature of MCDM, an extended version of the COPRAS method has been developed to solve MCDM problems under uncertain conditions. [23] They proposed that stability studies are best assessed using MCDM methods when multiple criteria groups are involved.

As a result, the approach that incorporates hybrid MCDM models for use in a stable framework provides a new perspective based on the reviewed literature. In addition, a new hybrid method that combines BMW and COPRAS methods in a fuzzy context has been developed and applied for the first time. [24] The contribution of this work is user-friendly, avoids complex mathematics and incorporates stakeholders' preferences into the evaluation criteria. The relative importance of these criteria is determined using fuzzy AHP, and the COPRAS method is used to calculate the overall score and ranking for each IIT. This helps the decision maker to choose the best alternative based on multiple, conflicting criteria. [25] To improve decision-making in group settings, they introduced a modified approach to DEMATEL methods for soft numbers using space-intuitive fuzzy numbers. Arabameri et al. evaluated them with the COPRAS method, including logistic regression, augmented regression trees, and random forests, and developed three new ensemble models.

In addition, this paper proposes a new evolution of the DEMATEL method, which is designed to directly address the hesitation of decision-makers and capture uncertainty more effectively. [26] To rank alternatives, it is necessary to determine the value of each attribute and their associated values, followed by using a decision-making method to evaluate the alternatives based on functional requirements. Attribute data can be quantitative or qualitative. This method was initially designed to address only qualitative criteria, but in practice, some attributes may not have quantitative data and may be presented in qualitative or linguistic terms, such as corrosion resistance or welder skill requirements. In these cases, the data can be converted into quantitative values using a judgment-based fuzzy transformation criterion. [27] The COPRAS method is used to determine the final value by calculating both positive and negative ideal solutions, ensuring that the selected alternative has the highest value for the positive ideal solution and the lowest value for the negative ideal solution.

Furthermore, the data for the alternatives is normalized during the calculation process to eliminate any discrepancies in the data. [28] Although numerous studies have investigated supplier selection using various MCDM methods, there is still a need for a straightforward and systematic mathematical approach to deal with the uncertainties and ambiguities in supplier selection problems. The COPRAS method addresses this gap. [29] If these parameters are not adequately defined and assessed, rehabilitation efforts in neglected areas will fail to achieve their objectives, increasing the likelihood of adverse effects on the urban environment and quality of life. There is no comprehensive, multi-sectoral assessment that would help in developing a hierarchy of indicators according to each country's priorities, goals and resources. For the selection of indicators in complex contexts that require specialized knowledge, a multi-criteria quantitative assessment is more appropriate. [30]

Alternative

SAP S/4HANA Cloud is an advanced enterprise resource planning (ERP) system that enables real-time processing of both transactional and analytical data. Union Pacific is migrating its back-office functions, including finance, logistics, and human resources, to this platform to improve operational efficiency.

SAP Ariba is a cloud-based solution designed to streamline procurement, supplier collaboration, and supply chain management. Union Pacific uses this tool to improve supplier engagement, streamline invoicing processes, and effectively manage contracts.

SAP Transportation Management (SAP TM) focuses on improving logistics and freight management by overseeing the entire transportation lifecycle, from planning to execution and monitoring. For Union Pacific, it plays a key role in optimizing freight movement and improving logistics operations.

Union Pacific has developed an application using SAP UI5 technology to manage the maintenance and inspection of its intermediate containers and chassis. The app integrates with SAP's Plant Maintenance and Materials Management modules, ensuring better asset tracking and efficient service delivery.

To support supplier collaboration, Union Pacific provides training and tools to help suppliers register and maintain profiles on the SAP Business Network. This ensures accurate supplier information and facilitates smooth business transactions.

System integration involves connecting various SAP solutions, including S/4HANA Cloud, SAP Ariba, and SAP TM, with existing legacy systems. This process ensures seamless communication and integrated operations across platforms.

Finally, Union Pacific uses SAP's advanced analytics and reporting capabilities to generate actionable insights. These tools integrate data analytics into business operations and improve decision-making by improving planning and forecasting processes.

Evaluation Parameters

Benefits

Operational Efficiency

Operational efficiency refers to an organization's ability to use its resources – such as time, labor, and materials – effectively to achieve desired results, minimizing waste. For Union Pacific Railroad's SAP implementation, this meant streamlining business processes, reducing the need for manual tasks, and ensuring optimal resource utilization in areas such as procurement, logistics, maintenance, and financial management.

Data Integration and Accuracy

Data integration involves bringing together data from multiple sources to create a unified and comprehensive view. For Union Pacific, this means consolidating data from systems such as finance, procurement and logistics into a single platform, which supports more informed decision-making. Ensuring data accuracy is critical in this process, as it ensures that the consolidated information is reliable, accurate and up-to-date, reducing errors and discrepancies across various business functions.

Non-Benefits

Implementation Costs

Implementing a sophisticated ERP system like SAP S/4HANA Cloud or integrating tools like SAP Ariba or SAP TM requires a significant financial commitment. Costs typically include licensing, system customization, consulting services, infrastructure upgrades, and employee training. For large organizations like Union Pacific, these costs can increase significantly due to the complexity of existing legacy systems and the broad scope of operations. In addition, implementation costs extend to ongoing costs for system maintenance and regular updates.

Disruption during Transition

Switching to new systems often disrupts regular business operations. Employees may have difficulty adapting to new workflows, resulting in temporary inefficiencies. Essential functions such as finance, logistics, and supply chain management may experience delays or errors during the initial implementation phase. Additionally, technical issues or mis configurations during the rollout can hinder operations, affecting customer service and business continuity until the system becomes fully stable.

Analysis and Dissection

Table 1. Union Pacific Railroad Company

	DATA SET			
	Operational Efficiency	Data Integration and Accuracy	Implementation Costs	Disruption During Transition
SAP S/4HANA Cloud	9	10	7	6
SAP Ariba	8	8	6	5
SAP Transportation Management	9	8	7	6
Mobile Plant Maintenance App	7	9	8	7
Supplier Registration and Training	8	7	6	5
System Integration	10	9	9	6
Data Analytics and Reporting	9	10	7	5

Table 1 provides an assessment of the various initiatives implemented by Union Pacific Railroad, which are rated on four key metrics: operational efficiency, data integration and accuracy, implementation costs, and disruption during change.

Each initiative is rated on a scale of 1 to 10, with higher scores indicating better performance or less disruption. Operational Efficiency: The initiatives that perform best in this category are SAP S/4HANA Cloud, SAP Transportation Management, and Data Analytics and Reporting, each receiving a score of 9. These initiatives play a key role in improving operational processes. The Mobile Plant Maintenance App also makes a valuable contribution, with a slightly lower score of 7.

Data Integration and Accuracy: SAP S/4HANA Cloud and Data Analytics and Reporting lead this category with a score of 10, reflecting exceptional data management. System Integration follows closely with a score of 9, indicating strong data alignment capabilities. Implementation costs: Scores range from 6 to 9, with the Mobile Plant Maintenance App achieving a maximum score of 8, indicating cost-effectiveness. Both SAP S/4HANA Cloud and SAP Transportation Management, which ranked 7th, show balanced cost considerations. Disruption during change: Scores on this measure are consistently low, indicating minimal operational disruption. SAP Ariba and Supplier Registration and Training score 5, highlighting a smooth implementation with minimal transition challenges.

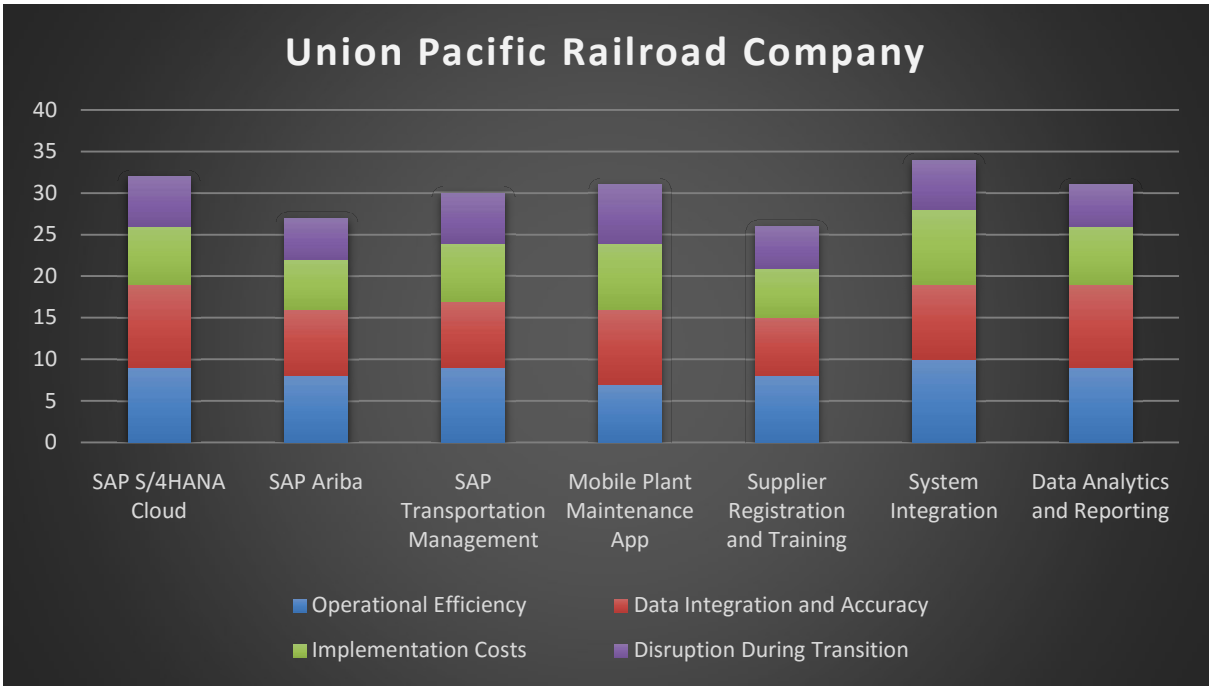

Figure 1. Union Pacific Railroad Company

Figure 1 provides a comparative overview of key initiatives undertaken by Union Pacific Railroad, assessed across four metrics: operational efficiency, data integration and accuracy, implementation costs, and disruption during change. Each metric is represented as a separate segment within a stacked bar chart, providing a detailed view of the performance of each initiative. Operational Efficiency: This metric, highlighted in blue, demonstrates consistently high contributions across initiatives. SAP S/4HANA Cloud, SAP Transportation Management, and Data Analytics and Reporting achieve significant performance, demonstrating their ability to effectively improve operational processes.

Data Integration and Accuracy: This metric, highlighted in orange, reflects the company's commitment to reliable data management. SAP S/4HANA Cloud, System Integration, and Data Analytics and Reporting lead in this category, emphasizing their strong data integration capabilities. Implementation Costs: Implementation cost, displayed in gray, shows moderate variation across initiatives. The mobile plant maintenance application achieves a favorable balance, while other initiatives effectively manage costs within reasonable limits. Disruption during change: This metric, depicted in light orange, shows minimal disruption to all initiatives. SAP Ariba and Supplier Registration and Training are particularly successful in ensuring smooth and efficient changes.

Table 2. Normalized Data

	Normalized Data			
	Operational Efficiency	Data Integration and Accuracy	Implementation Costs	Disruption During Transition
SAP S/4HANA Cloud	0.2195	0.2381	0.2059	0.2069
SAP Ariba	0.1951	0.1905	0.1765	0.1724
SAP Transportation Management	0.2195	0.1905	0.2059	0.2069
Mobile Plant Maintenance App	0.1707	0.2143	0.2353	0.2414
Supplier Registration and Training	0.1951	0.1667	0.1765	0.1724
System Integration	0.2439	0.2143	0.2647	0.2069
Data Analytics and Reporting	0.2195	0.2381	0.2059	0.1724

Table 2 presents normalized data for the performance metrics of Union Pacific Railroad's key initiatives, enabling direct comparisons across operational efficiency, data integration and accuracy, implementation costs, and disruptions during change. Normalized values range from 0 to 1, with higher values indicating stronger relative performance. Operational Efficiency: System Integration leads with the highest normalized score of 0.2439, highlighting its superior performance across initiatives. SAP S/4HANA Cloud, SAP Transportation Management, and Data Analytics and Reporting perform equally well with scores of 0.2195, while Mobile Plant Maintenance Application lags behind at 0.1707. Data Integration and Accuracy: SAP S/4HANA Cloud and Data Analytics and Reporting receive the highest scores of 0.2381, demonstrating their excellence in data management. System Integration and Mobile Plant Maintenance Application also perform admirably, while Supplier Registration and Training ranks lowest at 0.1667. Implementation Costs: System Integration excels in cost efficiency with a high score of 0.2647, followed by Mobile Plant Maintenance App at 0.2353. Other initiatives in this category show moderate performance. Disruption During Change: Mobile Plant Maintenance App exhibits the lowest disruption during implementation, scoring 0.2414. SAP Ariba, Supplier Registration and Training, and Data Analysis and Reporting have relatively low scores, indicating high levels of disruption.

Table 3. Weight

	Weight			
SAP S/4HANA Cloud	0.25	0.25	0.25	0.25
SAP Ariba	0.25	0.25	0.25	0.25
SAP Transportation Management	0.25	0.25	0.25	0.25
Mobile Plant Maintenance App	0.25	0.25	0.25	0.25
Supplier Registration and Training	0.25	0.25	0.25	0.25
System Integration	0.25	0.25	0.25	0.25
Data Analytics and Reporting	0.25	0.25	0.25	0.25

Table 3 outlines the weights assigned to the performance measures for Union Pacific Railroad's key initiatives. Each measure—operational efficiency, data integration and accuracy, implementation costs, and disruption during change—has been assigned an equal weight of 0.25 across all initiatives. This equal weighting ensures that no single measure has a greater influence on the overall assessment. By distributing the weights equally, Union Pacific demonstrates its commitment to evaluating all four measures equally. This approach highlights the importance of striking a balance between operational efficiency, accurate data integration, cost control, and minimal disruption during implementation. It suggests a holistic perspective on evaluating and selecting initiatives based on their overall performance. The equal weighting model is particularly beneficial when there is no

clear priority among the measures because it allows for a fair comparison of initiatives. It ensures that initiatives that excel in one area but lag behind in another are not over-rewarded or unfairly penalized. This method promotes consistency and transparency in assessing the feasibility and effectiveness of various initiatives.

Table 4. Weighted normalized decision matrix

	Weighted normalized decision matrix			
SAP S/4HANA Cloud	0.05	0.06	0.05	0.05
SAP Ariba	0.05	0.05	0.04	0.04
SAP Transportation Management	0.05	0.05	0.05	0.05
Mobile Plant Maintenance App	0.04	0.05	0.06	0.06
Supplier Registration and Training	0.05	0.04	0.04	0.04
System Integration	0.06	0.05	0.07	0.05
Data Analytics and Reporting	0.05	0.06	0.05	0.04

The weighted normalized decision matrix presented here illustrates the different system components, shown as rows, and their corresponding weighted values across four criteria, shown as columns. These values are calculated to highlight the relative importance of each component in the decision-making process. Each row represents a specific system or module, such as SAP S/4HANA Cloud, SAP Ariba, SAP Transportation Management, etc. The numbers in the matrix are weighted normalized scores, which indicate how well each system performs on each criterion. For example, SAP S/4HANA Cloud has a score of 0.05 on all criteria except the third, where it also has a score of 0.05, indicating consistent performance across all assessed aspects. In contrast, SAP Ariba has somewhat lower scores on the second and third criteria, indicating relatively weak performance in these areas compared to the others. The mobile plant maintenance application shows a slight advantage on the third and fourth criteria, with a score of 0.06, indicating strong performance in these specific areas. On the other hand, the Supplier Registration and Training module has lower normalized scores, which may reflect less importance on these criteria. Ultimately, this matrix helps to evaluate and compare different systems based on their performance on weighted criteria, supporting more informed decisions.

Table 5. Bi & Ci

	Bi	Ci
SAP S/4HANA Cloud	0.114	0.103
SAP Ariba	0.096	0.087
SAP Transportation Management	0.102	0.103
Mobile Plant Maintenance App	0.096	0.119
Supplier Registration and Training	0.090	0.087
System Integration	0.115	0.118
Data Analytics and Reporting	0.114	0.095

Table 5 shows the Bi and Ci values for different system components, which represent two distinct evaluation metrics. Bi is likely to reflect the benefit or efficiency level of each system, while Ci represents the associated cost or associated negative factor. For example, SAP S/4HANA Cloud has Bi and Ci values of 0.114 and 0.103, respectively, indicating relatively high benefit and moderate cost. Similarly, SAP Transportation Management shows Bi and Ci values of 0.102 and 0.103, respectively, indicating a well-balanced performance and cost evaluation. The mobile plant maintenance app has a high Ci value of 0.119, indicating that its costs or disadvantages may outweigh its benefits of 0.096. This indicates that while the application offers some benefits, its high costs or challenges may be a concern. System integration is notable with a Bi value of

0.115 and a Ci value of 0.118, indicating strong benefits but also relatively high costs or challenges. In contrast, supplier registration and training has Bi and Ci values of 0.090 and 0.087, indicating that it provides low benefits and costs, making it likely to be a low-priority system. Overall, these values help to compare the benefits and costs for each system and aid in decision-making.

Table 6. Min(Ci)/Ci

	Min(Ci)/Ci
SAP S/4HANA Cloud	0.8452
SAP Ariba	1.0000
SAP Transportation Management	0.8452
Mobile Plant Maintenance App	0.7319
Supplier Registration and Training	1.0000
System Integration	0.7398
Data Analytics and Reporting	0.9223

Table 6 shows the minimum (Ci)/Ci ratios for different system components, which represent the relationship between the minimum cost (minimum (Ci)) and the actual cost (Ci) of each system. This ratio serves as a measure of cost efficiency, indicating how closely each system's cost matches the minimum cost observed in the data. A ratio closer to 1 indicates high-cost efficiency because the system's cost is close to the minimum, while a lower ratio indicates a greater deviation from the minimum cost, reflecting low efficiency. For example, SAP Ariba and Supplier Registration and Training both have a ratio of 1.0000, meaning their costs are very low compared to other systems, indicating high cost efficiency. On the other hand, Mobile Plant Maintenance Processor has a very low ratio of 0.7319, indicating that its cost is significantly higher compared to the minimum, indicating low efficiency in terms of cost. Systems such as SAP S/4HANA Cloud and SAP Transportation Management have ratios of 0.8452, reflecting moderate cost efficiency. System integration and data analysis and reporting have ratios of 0.7398 and 0.9223 respectively, which shows that system integration is less cost-effective, even though data analysis is close to the minimum. This table helps to compare the relative cost-effectiveness of different systems.

Table 7. Qi & Ui

	Qi	Ui
SAP S/4HANA Cloud	0.210	100.0000
SAP Ariba	0.209	99.7613
SAP Transportation Management	0.198	94.3301
Mobile Plant Maintenance App	0.179	85.2561
Supplier Registration and Training	0.204	96.9263
System Integration	0.198	94.3922
Data Analytics and Reporting	0.219	104.1487

Table 7 shows the Qi and Ui values for various system components. Qi represents the performance or benefit score, while Ui seems to reflect the associated utility score, which indicates the overall value or effectiveness of each system based on the Qi metric. The Qi values range from 0.179 to 0.219, with Data Analysis and Reporting having the highest Qi value of 0.219, indicating that it provides the best performance or benefit. In contrast, the Mobile Plant Maintenance application has the lowest Qi value of 0.179, indicating that it performs relatively poorly compared to the other systems. The Ui values range from 85.2561 to 104.1487, reflecting the utility or overall value of each system, with higher values indicating higher utility. Data

Analysis and Reporting leads with a Ui of 104.1487, indicating that it provides the highest overall utility when considering performance and value. SAP S/4HANA Cloud, with a Qi of 0.210 and a Ui of 100.0000, maintains a solid balance between performance and usability. On the other hand, systems such as the Mobile Plant Maintenance application and SAP Transportation Management exhibit low Ui values, indicating their reduced usability despite their moderate performance scores. This table helps you compare systems based on both their performance and overall usability for informed decision-making.

Table 8. Rank

	Rank
SAP S/4HANA Cloud	2
SAP Ariba	3
SAP Transportation Management	6
Mobile Plant Maintenance App	7
Supplier Registration and Training	4
System Integration	5
Data Analytics and Reporting	1

Table 8 lists the rankings for different system components based on their overall ratings across a variety of criteria. These rankings may reflect the relative performance and value of each system. Data Analytics and Reporting ranks first, indicating that it excels across all factors, delivering high benefit, usability, or cost-effectiveness. SAP S/4HANA Cloud ranks second, indicating strong overall performance with a balanced rating across multiple metrics, slightly behind Data Analytics and Reporting. SAP Ariba ranks third, indicating that it performs well but falls short of the top two systems in some areas. Supplier Registration and Training ranks fourth, demonstrating efficient performance, although it is given lower priority compared to higher-ranking systems. System Integration ranks fifth, showing decent performance but indicating potential for improvement compared to top systems. SAP Transportation Management, in sixth place, and Mobile Plant Maintenance Application, in seventh place, reflect relatively weak performance due to low usage, high costs, or less favorable ratings in certain areas. These rankings help compare the strengths and weaknesses of organizations, providing insights into their overall performance and areas for improvement.

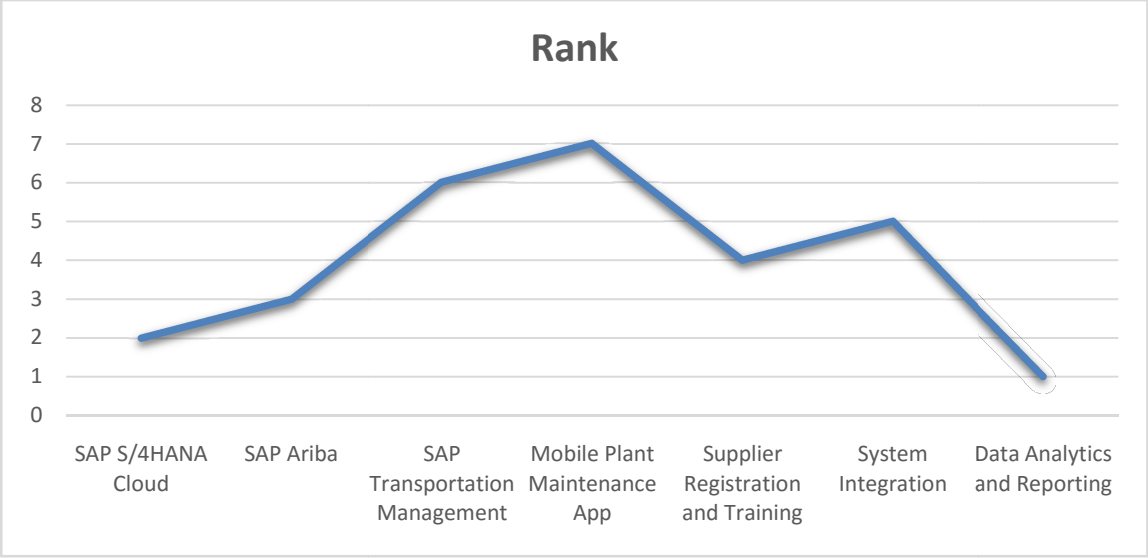

Figure 2. Rank

The "Ranking" line chart illustrates the rankings of six SAP-related domains. The x-axis lists the domains, while the y-axis shows their rankings, where lower values indicate higher priority or preference. The chart begins with SAP S/4HANA Cloud ranked at 2, indicating its high importance. SAP Ariba follows with a slightly lower ranking of 3. This trend picks up with SAP Transportation Management at 5 and Mobile Plant to continue expanding its SAP Ariba implementation through 2025. Maintenance at 7, indicating reduced importance in these areas. The highest ranking, indicating the lowest priority, is found in Supplier Registration and Integration, which is positioned at 8. Following this, the chart for Data Analysis and Reporting sees a modest improvement at 6, before dropping sharply to 2, showing another major focus with SAP S/4HANA Cloud.

Conclusion

Union Pacific Railroad is embracing a transformative digital transformation by implementing SAP solutions to modernize its operations, increase efficiency, and improve its interactions with suppliers. This large-scale initiative covers several key business areas, positioning Union Pacific to address the evolving needs of the transportation industry while ensuring its long-term competitiveness. One of the primary aspects of this transformation is the modernization of its enterprise resource planning (ERP) systems. Union Pacific is migrating its back-office systems, including finance, sourcing, internal logistics, human resources, and expense management, to SAP's cloud suite, specifically SAP S/4HANA. The transformation is designed to streamline business processes, reduce technology debt, and improve decision-making by providing a more unified and integrated data base. This strategic move will allow for improved integration across multiple departments and more agile responses to market changes. In addition to the ERP modernization, Union Pacific is enhancing its procurement and supplier management processes by adopting SAP Ariba. The platform will support more efficient supplier profile management, bidding, contracting and invoicing. With implementation already underway in 2024, Union Pacific plans

This transformation will not only improve procurement operations, but also strengthen relationships with suppliers by

fostering a more transparent and streamlined process. Another area of focus is transportation management, where Union Pacific is using SAP Transportation Management (TM) to improve freight movement and logistics. The system will improve carrier management, bidding, tendering and invoicing, ultimately leading to greater operational efficiency and better service delivery. These improvements will be critical in maintaining Union Pacific's leading position in the rail transportation industry, ensuring on-time deliveries and improving customer satisfaction. To further improve operational efficiency, Union Pacific has developed an in-house mobile application using SAP UI5 technology to manage the inspection and repair of intermediate containers and chassis. The application seamlessly integrates with various SAP modules, allowing for real-time data entry and better asset tracking. Such innovations will support more efficient maintenance operations and ensure that Union Pacific's assets are always in optimal condition.

This study introduces innovative performance metrics for Total Productive Maintenance (TPM) and a fuzzy COPRAS method for evaluating these metrics, which eliminates lag to prevent information loss. The use of fuzzy arithmetic in the COPRAS method provides a new approach to TPM evaluation. In addition, the study explores the application of MCDM techniques including TOPSIS, VIKOR and COPRAS to evaluate safe areas during the COVID-19 pandemic, marking the first application of such methods in this context. The research also presents a hybrid model incorporating BMW and COPRAS in a fuzzy environment that contributes to more effective decision-making in an uncertain environment.

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