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APPLIED RESEARCH

Improvement and Implementation of Sustainable Key Performance Indicators in Supply Chain Management: The Case of a Furniture Firm

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ABSTRACT Businesses today recognize the importance of business performance management (BPM) as an effective business strategy and practical solution to a robust supply chain management process. At the same time, businesses seek to deepen their footprints in global markets, to actively use critical metrics, KPIs (Key Performance Indicators), in business performance management, to make performance management compatible with strategic goals, up-to-date and sustainable. KPIs are priority indicators determined to achieve the strategic objectives of the enterprise. Updating the KPIs used to measure, monitor and analyze business performance also has a critical place in performance management. This article presents a case study of a novel approach to real-time updating and monitoring KPIs integrated into supply chain management (SCM) software. The proposed approach bridges the gap between measuring and implementing business performance. The study analyzes and aligns the relationships of duplicate KPIs. It systematically carries out the KPI weights of the managers in line with the strategic goals and improves performance management by eliminating the weakness in the KPI change. It also provides a framework for sustainable performance management and discusses the case study with implications of KPIs that affect performance management success.

INDEX TERMS Business performance management, key performance indicators, performance improvement (PI), iterative KPI algorithm.

I. INTRODUCTION

The performance of businesses is critical for sustainable competitive advantages and continuous improvement [1]. Sustainable competitive advantage and constant gain are supported by monitoring and controlling the performance of the business. For this reason, performance monitoring and improvement studies always maintain their importance [2]. Businesses aware of this situation must reconsider their performance measurements with quantitative criteria for traceability. Because performance measurement is critical in increasing efficiency and effectiveness, especially in SCM [3], at this point, quantitative measures are usually set for performance measurement and evaluation [3], [4], [5].

Businesses should be able to respond to many changes, such as adapting to technological change, maintaining their competitive advantages, increasing their capacity, and at the same time, constantly measuring their corporate performance. This necessity requires real-time monitoring of performance measurements in production and operations management [6], [7]. Performance monitoring and regulation usually take place on a semi-annual basis from the operational to the strategic level. However, in periods when the workload of the enterprise increases, the period can be up to one year. On the other hand, the criteria that define these periods are related to the key performance indicators (KPIs) in a way that supports each other. However, they are defined

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differently at the operational and strategic levels. While KPIs provide data for different purposes, they also support the management's decision-making processes [8], [9]. Increasing this effect and monitoring the performance relations between organizational levels is possible by harmonizing the KPIs (supporting the target, not contradicting each other). Therefore, KPIs should be monitored so that businesses can compete, achieve business success and continuously improve their performance. Monitoring and continuously improving KPIs can only be designed with a sustainable new process. At this point, restructuring, management, and evaluation of KPIs are prominent issues.

Having sustainable business performance management with updateable KPIs is vital for the development/improvement of business processes. Businesses are aware of this critical use of sustainable supply chain performance appraisal and the limited metrics of the models studied [10]. The automatically updated KPI, which has many aspects and is seen as a priority area, offers businesses the opportunity for managerial integration and expansion [11]. When it comes to ensuring sustainable performance, the processes carried out in the enterprises are the key to success [12], [13]. In this context, company managers who focus on success agree on integrating sustainable performance into implementation processes [12], [14], [15]. Limited practice and case need for sustainable performance Performance measurement system for enterprises remains the subject of research [16]. Efficiency and performance evaluation are critical elements in measuring the success and development of a business. Because this context is so broad, performance measurement criteria are limited to job prospects in supply chain management. The limitation is determined by four criteria: area, focus, target, and organizational level [17]. In the same study, performance measures in the field criteria were associated with the strategic context in quality, cost, flexibility, and innovation [17]. The most widely used KPI perspective used as a field criterion is the Balanced Scorecard (BSC) model [4]. In addition, employees use it to distinguish between strategic, tactical, and operational perspectives in their work [18]. Therefore, from a general standpoint, it has been shown that the performance measurements are shaped by the indicators of the sector and the competitive field, based on the BSC model, from the perspective of management levels. Another critical issue in performance measurement is the interdependence of KPIs. KPI dependency highlights the need for a sustainable performance system to support managers' decision-making [16].

At this point, a measurement system that determines the interdependence between KPIs is necessary and valuable [16]. In cases where the dependencies, relationships, and control of KPIs cannot be done, anomalies may emerge in the performance improvement process [9]. For example, it is unclear which KPIs defined at the operational level contribute to the strategic goals and how much they contribute. Uncertainty leads to instability in updating KPIs, while the targeted expectations for performance improvement cannot be met.

The system proposed in this study with the case study aims to dynamically update and monitor integrated KPI measurement values. Considering the characteristics of the business, KPIs should be defined correctly on the operational ground. The challenge is the uncertainty and complexity of business processes. One of the ways to meet this challenge is to conduct a thorough analysis to ensure that KPIs are visible. Operational KPIs show real-time activities and benchmarks of the organization, while strategic KPIs highlight critical criteria for businesses to achieve their future goals. Through these key criteria, meaningful information about procedures and employees is obtained while at the same time providing status information on achieving strategic goals. Businesses need supply chain collaboration to unlock new/critical information and dynamic capabilities [19], [20]. When collaborative, the best possible strategic decisions are made in real-time with data-driven operational-level monitoring [21].

Systematic studies are also carried out on finance and quality in making decisions and achieving strategic goals. These areas are also the focus of KPIs. It is a well-defined and clarified purpose or path plan to ensure sustainable performance in decision-making and improving strategic goals. The planned/followed path to reach these goals is visualized with the strategic map. This map, proposed by Kaplan and Norton in 2001, shows how strategic value can be generated. This map has led to the formation of strategy-oriented organizations. In these formations, KPI activities are best characterized by four aspects (four balanced scorecards) [22]. Scorecards organize performance measures under four main categories: financial performance, customer relations, internal business practices, and organizational capacity. It is known that these four balanced scorecard perspectives are directly related to strategic goals. The metrics on the scorecard are designed to reflect cause-effect relationships between outcomes (latency measures) and critical factors (leading measures) [23]. A correctly implemented and timely balanced scorecard will help businesses better articulate and communicate their strategy, measure the drivers of their performance, and determine the superiority of one strategy over another [19], [23]. A business that uses the balanced scorecard technique uses this card as a map of its strategic goals. Every strategic goal consists of measurable KPIs. KPIs are within a specific time frame, and the business should be able to monitor and control its activities. Monitoring and control are critical for goal-oriented decision-makers in practice. It also requires defined KPIs to clarify all operations and green supply chain assessment [24], [25]. As a result, KPIs must be updated automatically during the strategic map and planning process to adapt to fast and changing global markets. In practice, resources and timeframes are specified in the action plan by managers at all levels. These sequential actions are performed manually to implement, monitor, edit, and update the action plan. However, the sequence of manually executed steps and the update period is often not timely.

Our motivation is to update KPIs in real-time and create traceable processes. The article also highlights the performance importance of monitoring and updating KPIs and innovative approaches. It provides the framework for real-time alignment with strategic goals while regularly monitoring and developing KPIs. KPIs are converted into an auto-updatable structure using an iterative technique. This iterative approach makes businesses more dynamic, resilient, and resistant to change. While this situation increases the reflexes and competitiveness of the companies, it improves the monitoring and control processes of the managers. It also contributes to all performance management processes that are updated automatically.

Business performance management systems are briefly examined in the second part of the study. The third part describes the KPI update of the iterative algorithm at the business management levels. The fourth part includes the application example of the ''Aytaş Home'' iterative algorithm representing the furniture industry. In the fifth part, the results of the iterative approach developed are discussed, and suggestions are given for future studies.

II. BUSINESS PERFORMANCE MANAGEMENT SYSTEM

Different methodologies have been defined to maintain success/performance in management strategies and harmonize plans/operations [26]. The goal is to provide critical insights into the operations, processes, and overall business condition. For example, activities to meet analytical performance measurement systems and KPI targets are part of improving performance and insights. As businesses seek continuity and traceability in their activities, a set of tasks is defined for achieving performance goals, planning, performing, and day-to-day work [2].

The performance of achieving objectives in the business is affected by various factors, such as measuring and monitoring execution procedures [3], [27]. These factors can be extracted from business management software to generate KPIs. In addition, KPIs should be determined, monitored, and updated through this software [28], [29]. Getting a view of the current KPI and process flow can be difficult. This may lead to complexity in performance appraisal, an inability to achieve strategic goals, and an understanding that is not based on systematic thinking. Researchers have proposed many methodologies to overcome these challenges, such as Balanced Scorecard (BSC), performance evaluation matrix, performance pyramid, and activity-based costing (ABC) solutions. In particular, the SCOR model provides a reasonable basis for applying a standard definition of management processes, their interrelationships, framework, and metrics to measure performance. The SCOR model is a structured process for orientation and performance improvement in the organization [19].

Additionally, the SCOR model improves supply chain design's performance [10] and service architecture [19]. Our study is limited and structured as a case study in the SCOR model. Despite the evidence for these methodologies, the search for quantitative analysis for mutual concordance and updating continues [30], [31], [32] because there is a bottleneck in systematically updating KPIs defined at strategic and operational levels.

Manually running or managing a performance appraisal system does not meet the desire for quick decision-making since non-dynamic systems often fail to capture the results of the ever-changing competitive environment. This is because measurement systems, once defined, are often used in the same way for a long time. The solution is to recalibrate the defined KPIs of the business with software technologies and scientific methods in the wind of competition and change. The iterative adjustment of KPIs poses another challenge [33]. Maintaining ever-changing metrics can cause a set of difficulties in meeting performance and administrative demands [2]. Therefore, updating and monitoring KPIs is vital to ensure consistency/alignment at business levels [9].

Recently, decision-making techniques have been used to evaluate KPIs [2]. The analytical hierarchy process (AHP) approach establishes a relationship between objectives and strategies [9], [34]. The fuzzy logic technique analyzes KPIs for decision-making in uncertain environments [35]. It also has special applications as hierarchical measurement systems under the fuzzy logic technique [36]. In practice, little work has been done to use this technique in performance management [2]. Another decision-making technique is grey relational analysis [2], [21], which comprises financial performance and metrics analysis. The limited and static capabilities of decision-making techniques do not meet today's expectations [32], [37]. For this reason, the search for solutions regarding the dynamic evaluation and monitoring process in performance measurement continues [38].

The need to optimize KPIs at management levels is recognized. The difficulty of optimizing and updating KPIs leads to a search for different solutions. The resulting solution will facilitate decision-makers with traceable, optimized compliant KPIs [39] because improving organizational performance requires a realistic, methodical strategy to integrate and align compliant KPIs at all levels [40].

In times of intense competition, there is not much time to see and evaluate all options [41], [42], [43]. Visual presentations (dashboards) are valuable in understanding the complex relationships between executives' tendency to make quick decisions based on performance and KPIs [44]. Most studies do not include operational procedures for visualizing KPIs and analyzing their success [2], [45]. Fig. 1 shows the six stages of the performance management cycle that follows a top-down process.

Managers finalize objectives and perform models for feasibility analysis after an integrated strategy, make plans for goal setting, and monitor the development of these plans [46]. Strategic goals are set by avoiding conflicts between business activities and KPIs. Updating KPIs that support the goals set is an action that requires constant control across activities.

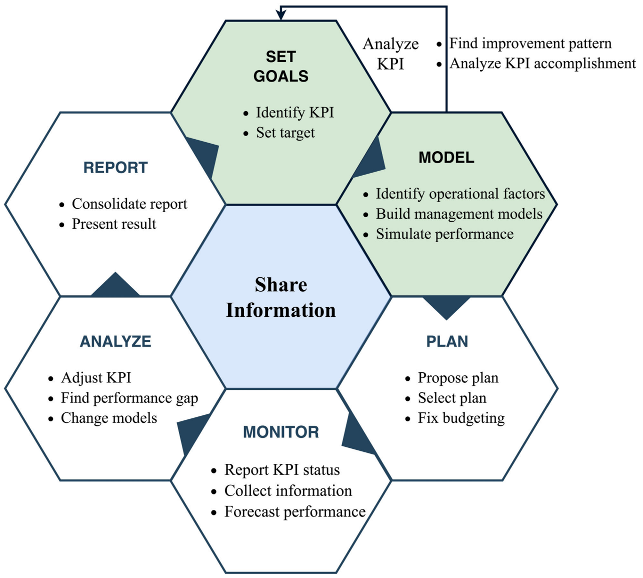

FIGURE 1. Improved business performance management cycle model [3].

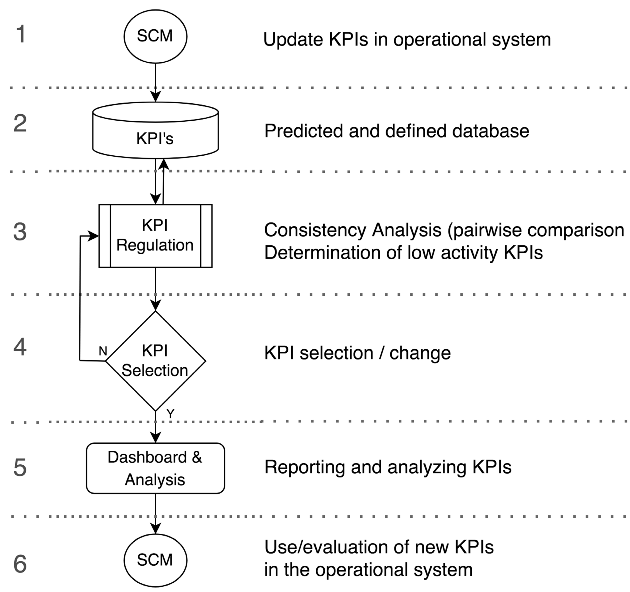

FIGURE 2. Step-by-step KPI update algorithm flowchart.

The change and management of KPI measurements/weights in the operation process show the business reflex. This indicator is continuously supported by the evaluation and update software during the first two steps of the performance management cycle. In addition, objectives are structured appropriately to avoid conflicts between the business's activities and performance indicators.

III. ITERATIVE KPI UPDATE ALGORITHM

The business performance management cycle model considers performance levels hierarchically [2]. Managers develop goals based on business strategy. They also create models for evaluating actionable information and monitoring progress by formulating plans to achieve tactical-level goals [46]. At the tactical level, exceptions are handled after decision-makers review and take corrective action. At the strategic level, all the work done, including the alignment of KPIs with business objectives, is examined in detail, and the steps are clarified. In this framework, weights/metrics can be updated, or new KPIs can be added. These updates are based on an analysis of existing data. In addition, several problems can be observed, such as the complexity of defining KPIs, difficulty in making decisions, and updating in a timely manner. For example, promptly responding to changing market and customer needs with KPIs and synchronization is among the significant challenges [47].

Once business objectives and KPIs are set, they cannot be re-adjusted before the performance management cycle takes effect. Changing KPIs is delayed due to the time-consuming looping/evaluation procedure. Making the performance management cycle more dynamic and updatable is critical. Fig. 2 illustrates the flow chart showing the basic steps of the algorithm that we have developed to meet this need and makes the evaluation and change of KPI measurements dynamic. The performance management cycle is systematized with dynamically retrieved data from the existing system. Systematically updated KPIs eliminate many of the challenges faced by decision-makers. For example, the actions of updating and changing KPIs have been included in the algorithm and ceased to be among the routine tasks of the manager.

In an iterative circular structure, feedback is given to help improve performance management against regulations and analyze KPI performances. Collected data is reviewed, and KPIs are rearranged. The proposed iterative algorithm optimizes the data in terms of weights and transforms them into dynamic, trackable, and controllable KPI values. A different example of the conversion to KPI values was shown by J. Cai et al. with the cost transformation matrix (PCTM = KPI success cost matrix) [2]. The PCTM matrix uses the business performance management cycle and the process-oriented SCOR model. The PCTM matrix uses cause-and-effect relationships between KPIs to reveal cost relationships based on functions. In addition, the article highlights the contribution of KPIs to success in an iterative and interactive process. A structural comparison of the proposed approaches is given in Table 1.

Both approaches have different features in the focus of the KPI iteration process. In particular, a cost and risk view is obtained with the PCTM approach. It also serves as support data for decision-making processes. However, for the success of this service, it is necessary to monitor and update KPIs using the data of an integrated system. Our study has solved a fundamental problem with a new and dynamically trackable KPI iteration algorithm. Thus, the KPIs that require long-term monitoring have been controlled. At the same time, the KPIs to be used in practice have been determined by considering the performance criteria in the literature. The following section uses KPIs in algorithm implementation and system development.

TABLE 1. Comparison of the proposed approach and PCTM structural properties.

Structural Comparison									
Feature	Model	Ranking	Repeat	Cost	Risk	Mathematical Structure	Quantitative Assessment	Ready Data	Dashboard
PCTM	+	+	+	+	+	+	+	-	-
New Approach	+	+	+	+	+	+	+	+	+

PCTM: KPI cost transformation matrix

IV. IMPLEMENTATION OF ITERATIVE KPI UPDATE ALGORITHM IN "AYTAŞ HOME" COMPANY

Changing the data that is the source of the KPI in the SCM triggers the update of the indicators. The performance and sustainability of the system depend on the most relevant KPIs and sub-systems [48]. The change of the SCM information system data, which is the source of the KPI, triggers the flowchart update step in Fig.2. Source data updated in the first step is stored in KPIs for analysis and identification in the second step. The processed KPI data stored in the third step is organized iteratively and with a relative emphasis on using the pairwise comparison method. AltKPI (sbKPI) values that change in the order of importance are changed in the fourth step and reported to the decision-makers. This step draws attention to changing performance indicators in dynamic business processes, thus increasing the accuracy of the forecasts and action plans of the decision-makers. In the last stage, which is the sixth step, the renewed KPIs are arranged for use within the SCM. All tasks within the algorithm's scope, such as data processing and pairwise comparison operations, are solved in an extremely quick way with computer and software technologies.

In the operation of the algorithm, continuity and healthy execution of the cyclical data flow is a necessity. This requirement also provides traceability and control by organizing the constantly flowing data into indicators. Regulated indicators help reduce potential risks in the system [48]. For regulated indicators to be used effectively in decision processes, decision problems need to be modeled. Thomas L. Saaty invented the AHP approach, which is used to model and solve multi-criteria decision problems. Many decision problems, such as technical performance analysis, planning, forecasting, and resource sharing, have been solved using this system. Problem-solving in the analytical hierarchy method is based on three fundamental ideas. These are decomposition/hierarchical structure, pairwise comparison, and alternative synthesis [36].

AHP, measurement theory, subject approach, and methodology are more than a way to choose one of the finite alternatives. AHP uses pairwise comparisons to transform the studied problem into a hierarchical structure. It is performed using actual measurement values or a preference scale for each criterion and option combination. Obtained values are arranged in matrix format. After examining the matrices, the most critical and dominant options are determined. The solution is simplified by separating and placing components using a hierarchical structure and AHP. The hierarchical structure begins with the creation of goals, criteria, and sub-criteria. The pairwise comparison matrix in the AHP method provides a fast solution for measuring performance criteria with the help of the developed algorithm. Thus, it will enable the development and implementation of iterative dynamic performance systems.

A. ITERATIVE DYNAMIC PERFORMANCE EVALUATION SYSTEM (IDPES)

"Aytaş Home" (AH), a furniture manufacturer and store chain company, draws attention to its supply chain. It provides services to 38 countries on three continents and has 350 sales points in Turkey. It is one of the largest market partners with 2026 different products and 1115 suppliers. Within AH, processes are carried out with the ERP (Enterprise Resource Planning) system application. The data accumulated under the ERP system were determined with the support of the business's employees for the application. In addition, within the framework of the strategic goals of AH, four KPIs and twelve sub-KPIs have been determined as a result of intensive hierarchical work. The relationships, weights, and harmony of the data that are accumulated on the system of the determined KPIs have been defined by the AH employees. Definitions, the motivation of the personnel in practice, and the readiness the work on the performance management process are essential criteria for us to choose AH. Data relations and contributions required for updating KPIs have been shared with the managers.

Our methodology integrates the hierarchical design of KPIs determined in the AH application area and the pairwise comparison technique into the production information system by designing them behind a dashboard. The configuration of KPIs in a digital platform can be monitored and controlled instantly. In our first performance study in AH, targets and KPIs were aligned with targets. Then, the primary production KPIs were determined by the main KPIs that defined the AH goals. Because in operation processes, production KPIs are specified later [3], [49]. The hierarchical design showing the designated areas for AH is shared in Fig. 3.

The "iterative dynamic performance evaluation system" (IDPES), designed as a combined model as shown in Fig. 3, was implemented in AH. IDPES defines target KPIs under four headings. Then, the sbKPIs of the determined KPIs are monitored and controlled under three titles. The first measurement values and division of labor indicators of the model determined in Table 2 are shared. Metrics are configured in the dashboard behind the monitoring and control of KPIs.

TABLE 2. Key performance indicators for the application model (AH).

KPIs			sbKPIs		
CC	Cost Control	0.47	MMC	Material	0.11
			EMC	Employee	0.31
			LC	Logistics	0.58
ERI	Enterprise Resource Integration	0.28	ERP	Enterprise Resource Planning	0.72
			SCE	Supply Chain Integration	0.19
			SSI	Integration of Sustainability Strategies	0.10
IE	Innovation and Emterpreneurship	0.16	BDA	Big Data Analytics	0.16
			PD	Performance Dashboard	0.30
			AR/VR	AR & VR	0.58
SR	Strategic Risks	0.09	SUR	Supply Risk	0.14
			DR	Design Risk	0.29
			DTCCR	Digital Transformation and Climate Change Risk	0.57

CC: Cost monitoring and control
- MMC: Material procurement cost and control
- EMC: Labor costs and control
- LC: Logistics costs and control

ERI: Coordination and integration of corporate resources
- ERP: Enterprise resource system implementation
- SCE: Applications compatible with the supply chain of the enterprise sourcing system
- SSI: Sustainable improvements aligned with corporate strategies

IE: Innovation actions to adapt to changing markets
- BDA: Evaluation of corporate data with big data analytics
- PD: Visualizing and reporting location-independent and accessible corporate data in the context of performance
- AR/VR: Compatible solutions and initiatives within the digital transformation ecosystem.

SR: The effects/risks of global anomalies on corporate strategies
- SUR: Risks that may be experienced in the supply of corporate requirements
- DR: Risks of new and different product design in the context of competition in global markets
- DTCCR: Risks brought by accepted scales within the scope of digital transformation and climate change

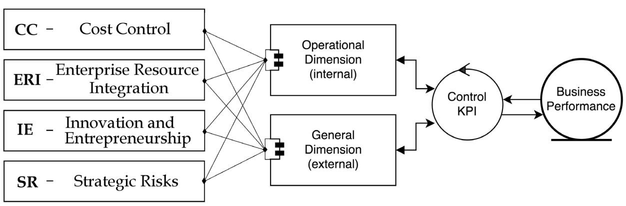

FIGURE 3. Hierarchical design of the AH application model.

These metrics and configurations contribute to the goals of KPIs at all AH levels from the bottom up. Therefore, hierarchically organized KPIs reveal employee responsibilities while supporting corporate business objectives [50]. In addition, measurement data and results are shared by comparing the KPIs defined in the composite structure.

AH primarily identifies five years of action with their KPIs, including the current year. First, a hierarchical structure includes the target KPI and sbKPI definitions. The hierarchical structure is then transformed into a homogeneous set of criteria. Therefore, creating homogeneous composite-defined KPIs and sbKPIs displays the relationship in a hierarchical structure. The effects of SbKPIs on next-level KPIs are compared. The algorithm builds the Enterprise Performance Transformation Matrix (EPTM) matrix by calculating business performance indicators representing the target using the pairwise comparison method shown in Fig. 4. CI = Consistency Index, RI = random consistency index, and CR = Consistency ratio values were calculated for pairwise comparison in the EPTM matrix.

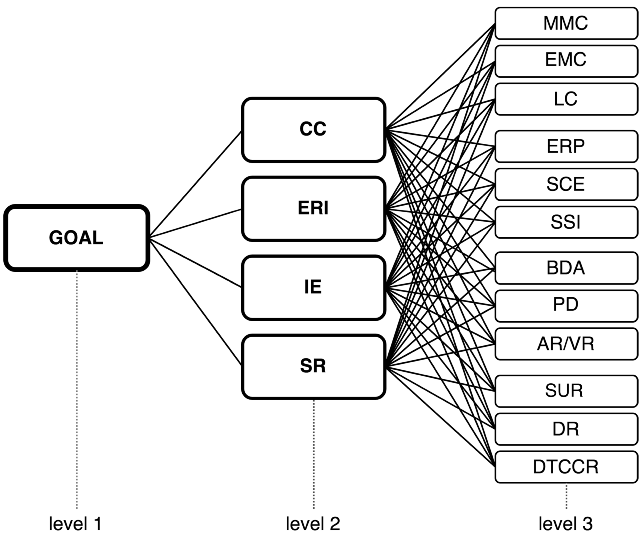

FIGURE 4. Hierarchical structure of KPI.

Alternative rankings of KPIs are obtained with the help of pairwise comparisons over EPTM matrices. Comparisons are made from top to bottom. The relative importance (priority) value vector is taken after the matrices have been created. At each level, the relevance of KPIs and sbKPIs varies. The consistency ratio of the pairwise comparison matrix is calculated by dividing the consistency index by the random value derived for the same-sized matrix read from the unexpected consistency index table. Saaty T. (1980:21) explained random inconsistency values for matrices of different sizes.

TABLE 3. KPI (AH) determined for the strategy-oriented organization.

Performance Indicator	CC	ERI	IE	SR
CC	1	2	3	4
ERI	1/2	1	2	3
IE	1/3	1/2	1	2
SR	1/4	1/3	1/2	1

TABLE 4. New matrix of normalized values.

Performance Indicator	CC	ERI	IE	SR
CC	12/25	12/33	6/13	4/10
ERI	6/25	6/23	4/13	3/10
IE	4/25	3/23	2/13	2/10
SR	3/25	2/23	1/13	1/10
Column Total	25/12	23/6	13/2	10

The hierarchical design for iteration is structured at three levels.

- The strategic purpose of the business is decided in the first stage.
- KPIs that contribute the most to the strategic purpose are determined at the second level.
- Indicators of business units (sales, production, finance, etc.) are defined as sbKPI at the third level.

With the iterative method, managers redefine the KPIs that support their goals. This action improves their ability to react quickly to change and make sound decisions. Among the hierarchically updated KPIs in the background, the most effective KPI that supports the goal is made visible. This update simplifies sorting and analysis. The EPTM matrix also calculates relative importance values and consistency for KPIs.

IDPES defines four main categories of KPIs in AH. Table 3 shows the definition and pairwise comparison matrix of selected KPIs for AH.

In pairwise comparisons, a KPI has one against a similar related KPI. Faced with a less relevant KPI, obtaining the basic parameters, the result is greater than "1" [3], [48]. Results may fluctuate between 1/2 and 1/9 compared to a more significant KPI. All values above the diagonal matrix are "1" as they will compare with themselves. Elements on the diagonal are indicated as "aij" at the edges, and the values of the diagonal are shown as "1/aij" relative to "aij." The total behavior of "1" is obtained by examining the matrices. To get the values, the following numbers are traced:

- The sums of the matrix columns are calculated.
- The column total is divided by each column value.
- The arithmetic mean of the new matrix is calculated for each row.

1st column sum: $(1+\frac{1}{2}+\frac{1}{3}+\frac{1}{4})=\frac{25}{12}$; other columns can be calculated similarly.

Table 4 shows the normalized and cleared values of the KPIs.

The arithmetic mean values for each matrix row containing the normalized relative importance values are calculated in Table 5. (Line 1 is an example of the calculation.)

$$\text{Row 1}: \frac{\frac{12}{25}+\frac{12}{33}+\frac{6}{33}+\frac{4}{10}}{4}=0.47,$$

With the relative importance values on KPI targets, it can be said that CC = 0.47 is the primary key performance indicator, while SR = 0.09 has the lowest effective importance value. If changes are required to rank strategic and target-oriented KPIs at level 2, approval is obtained, and corrections are made. The inconsistency of our pairwise comparison matrix findings should be below a certain threshold. For this control condition, consistency testing is both necessary and sufficient.

The consistency ratio is obtained by comparing the proportional size of CR = CI/RI with a value of 0.10. When the CI consistency index is calculated using the relevant methods (for CC);

$$\sum_{j=1}^{n} a1jwj = (1\times 0.47)+(2\times 0.28) + (3\times 0.16)+(4\times 0.09)=1.87$$

Table 6 shows how matrix elements are divided into vector elements by their relative importance values. The first row of the calculation is shared.

$$KPI_1 \text{ calculated value for} = \frac{\sum_{j=1}^{n} a_{1j}w_j}{w_1} = \frac{1.87}{0.47} = 3.98$$

The relative importance values obtained for consistent KPIs are meaningful and interpretable. Administrators monitor the calculated metrics of the defined KPIs on the dashboard. Monitoring happens recursively and is up-to-date. Thus, duplicate and updated metrics provide more powerful insights to the manager. The power of the senses and the accuracy of the decisions made directly affect the alignment of KPIs to the target.

Finding the most accurate value that describes the chosen KPIs to achieve the goal is known as analysis. Analysis results allow sequencing and modifying sbKPIs to accomplish the goal.

As a result, the analysis and control of sbKPIs directly affect performance, given its contribution to the goal.

In the AH example, the importance values of all sbKPIs are calculated similarly.

$$sbKPI_j = \sum_{i=1}^{n} w_i p_{ij} \text{ in the formula}$$

$sbKPI_j$: j'th sub KPI ($j = 1, 2, \ldots, m$),

W_i: Weight of the KPI ($i = 1, 2, \ldots, n$),

P_{ij}: Shows the weight of the j'th sub KPI relative to the i'th KPI.

In Table 7, sbKPIs are defined in a hierarchical framework alongside KPIs. Relative importance values are determined

TABLE 5. Relative importance values of KPIs.

Performance Indicator	CC	ERI	IE	SR	Relative Significance Range
CC	12/25	12/33	6/13	4/10	0.47
ERI	6/25	6/23	4/13	3/10	0.28
IE	4/25	3/23	2/13	2/10	0.16
SR	3/25	2/23	1/13	1/10	0.09
Column Total	25/12	23/6	13/2	10	

TABLE 6. Consistency level values of KPIs.

Performance Indicator	CC	ERI	IE	SR	Relative Significance Range	$a_{ij}w_j$	$a_{ij}w_j/w_i$
CC	12/25	12/33	6/13	4/10	0.47	1.87	3.98
ERI	6/25	6/23	4/13	3/10	0.28	1.11	3.96
IE	4/25	3/23	2/13	2/10	0.16	0.64	4.0
SR	3/25	2/23	1/13	1/10	0.09	0.38	4.22

TABLE 7. EPTM matrix relative importance values (AH).

sub KPIs Calculations			Sub KPI's MMC	EMC	LC	"CC" sub KPIs Relative Significance Vector	"ERI" sub KPIs Relative Significance Vector	"IE" sub KPIs Relative Significance Vector	"SUR" sub KPIs Relative Significance Vector
Performance Indicator	CC	MMC	1.00	0.33	0.20	0.11	0.28	0.26	0.25
		EMC	3.00	1.00	0.50	0.31	0.37	0.33	0.33
		LC	5.00	2.00	1.00	0.58	0.35	0.41	0.43
	ERI	MMC	1.00	4.00	7.00	0.72	0.16	0.41	0.43
		EMC	0.25	1.00	2.00	0.19	0.38	0.26	0.37
		LC	0.14	0.50	1.00	0.10	0.47	0.33	0.21
	IE	MMC	1.00	0.50	0.33	0.16	0.41	0.22	0.33
		EMC	2.00	1.00	0.50	0.30	0.26	0.29	0.41
		LC	3.00	2.00	1.00	0.54	0.33	0.50	0.26
	SR	MMC	1.00	0.50	0.25	0.14	0.45	0.59	0.26
		EMC	2.00	1.00	0.50	0.29	0.35	0.28	0.33
		LC	4.00	2.00	1.00	0.57	0.20	0.13	0.41

before significant values are found in all sbKPIs.

$$MMC = \sum_{1=1}^{n} w_i p_{i1} = (0.47 \times 0.11) + (0.28 \times 0.72) + (0.16 \times 0.16) + (0.09 \times 0.14) = 0.29$$

$$EMC = \sum_{1=1}^{n} w_i p_{i2} = (0.47 \times 0.31) + (0.28 \times 0.19) + (0.16 \times 0.30) + (0.09 \times 0.29) = 0.27$$

$$LC = \sum_{1=1}^{n} w_i p_{i3} = (0.47 \times 0.58) + (0.28 \times 0.10) + (0.16 \times 0.54) + (0.09 \times 0.57) = 0.44$$

Dynamically updated metrics cause sbKPIs to be prioritized or modified. The AH example indicates that the EMC with the lowest relevance has the appropriate value. EMC is the least effective of the CC sbKPIs. ERI, IE, and SR sbKPIs are included in the same assessment. Accordingly, changing or renewing KPIs and sbKPIs provides decision-makers with the necessary insights about strategic goals.

For this reason, KPI weights can be used effectively in making action-oriented decisions while achieving goals. The values obtained in Fig. 5 were also interpreted according to the highest relevance. The most relevant KPIs are the indicators to use for decision-making. Evaluation in both directions is prominently reported and visualized in a live system.

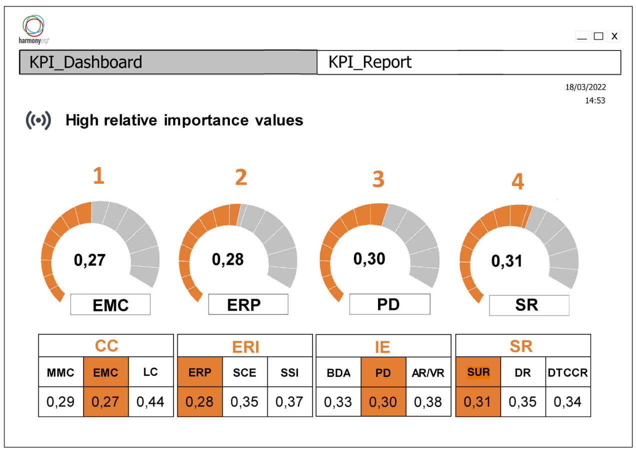

FIGURE 5. Low relative importance values (AH).

Visualized and reported data is used to gain the ability to monitor and control critical information or KPIs. It contributes to monitoring and controlling real-time supply chain performance on topics such as cost analysis, materials, integration, digital transformation, sustainability, and climate change. Especially in times of crisis, such as epidemics and wars, data associated with KPIs provides essential support to decision-makers. Problems and uncertainties encountered in the supply chain can be overcome by making such decisions on time. Today, it has evolved from a static execution process where KPIs are set at an average of 48 months to a real-time short (6 months), medium (12 months), and long (36 months) KPI update process. In IDPES, KPIs and sbKPIs were determined according to current research results. In addition, with IDPES, primarily cost-oriented sbKPIs are configured to be defined with multiple targets (CC, ERI, IE, SR).

The unique and innovative features of IDPES are given below.

- Dynamic update structure integrated into SCM,
- Real-time monitoring and flexibility,
- Fast solution and consistency in planning and control times,
- Ease of defining critical KPIs, sbKPIs.

B. IDPES RESULTS

Businesses have different business processes that contribute to the same goal. KPIs that describe different business processes are associated with each other. Associated KPIs hierarchically contribute to the purpose of the business. The concrete values of the contribution provided are the KPI weights. From the operational to the strategic management level, KPI measurement values are affected by the results of various activities. The sum of these impacts or KPI weights indicates their contribution to the strategic goal. Traceable indicators of strategic plans are one of the critical problems managers want to solve. In addition, the desire to monitor and manage KPIs integrated into SCM is based on the desire to gain and improve competitive advantage. The literature shows that performance measurement must be managed effectively for organizations to develop and maintain their competitive edge. A new approach is needed to sustain business performance management [51], [52]. This proposed new approach integrates the dynamically updated and enterprise-specific performance measurement system into the SCM. The design should also consider the efficiency measurements of business processes and the activities carried out in line with sustainability. The research method used in the article offers a new approach method in the iterative updating of KPIs for sustainable performance management. This approach lays the foundation for the sustainability and traceability of the determined KPIs on the AH sample. At this point, it is critical to update KPIs sustainably in their application areas [14], [53]. The IDPES system is the outstanding original value of our study in terms of sustainability and traceability.

Applied techniques, new scientific approaches, and technologies are combined in the IDPES system. IDPES made it possible to update and monitor KPIs with real-time data from ERP. Adapting known techniques and evaluating these data have increased the reliability of the results obtained from IDPES. The KPIs defined in the IDPES have been determined according to the sustainability and competitive sensitivity of AH. The systematic updating and renewal of KPIs take place with the help of an algorithm in the performance management cycle. The algorithm uses a proven decision-making technique that produces a systematic/dynamic solution. This ranks the weights of KPIs with the help of an iterative algorithm developed in the pairwise comparison technique. The decision-making technique that provides a fast and sustainable solution using algorithms is considered a competitive advantage for managers. This advantage saves time in producing fast, sustainable, and timely solutions for challenging business processes. Managers/experts aware of this challenge try to update KPIs systematically with the help of developing technology. Another aspect of the study is the expectation of ease of integration and monitoring in existing information systems. Integration of IDPES into SCM and data filtering are vital to the business. IDPES presents an example of a new KPI approach focusing on importance, maintainability, updating, and traceability. IDPES has transformed into a traceable systematic framework thanks to the iteration cycle, the correct algorithm, research, and implementation. In this framework, the measurable values of the KPIs that make up the processes are ordered and adjusted from end to end. Thus, KPIs with high relationships and complexity can be updated sustainably. At the same time, it is pointed out that different techniques can be adapted at the performance management cycle level.

Today, although cost and quality criteria are determined in the ERP systems of business, it is necessary to decide on the measures and sub-criteria of cost control, institutional resource integration, innovation and entrepreneurship, and strategic risks. Thus, it will be sustainable in digital transformation, and it will be developed in environmentalist practices. The IDPES system's development in the business was carried out with an IDPES system group consisting of the general manager, purchasing, production planning, and quality control experts. The department experts made the impact analysis and evaluation of the KPIs defined in the IDPES system, which was monitored for approximately fifteen months (453 days) in the enterprise where the implementation study was carried out. All the evaluations and expert opinions before and after the IDPES system are presented in tables.

Before IDPES implementation:

Purchasing specialist:

- Cost KPI is evaluated only at the end of the period.
- Predictive computation is intensive.
- The control period is long (48 months).
- No tracking.
- The accuracy of the targets is uncertain.

After IDPES: Table 8.

The recently experienced problems in the supply chain have had different reflections on manufacturing companies. In the case of the AH firm, material procurement came to the fore, and the process was carried out carefully. In the same period, employees saw their traceable KPIs as control

TABLE 8. CC application metrics (KPIs) and effects.

KPIs				sbKPIs	First Calculated Weight		Current Calculated Weight	Question to the expert	IDPES Answer
CC	Cost Control	0.47	MMC	Material	0.11	⇑	0.42	What is the reason for the increase in material KPI?	"The problems experienced increased the metrics when finding and supplying materials."
			EMC	Employee	0.31	⇓	0.19	What effect did you observe on employees?	Employees had a diminishing impact on their CC metrics. However, instant monitoring/control of KPIs motivated us to set more challenging targets.
			LC	Logistics	0.58	⇓	0.49	How did the effects of the recent problems on LC result?	The problems experienced in material supply and sales decreased the LC measurement value.

TABLE 9. ERI application metrics (KPIs) and effects.

KPIs				sbKPIs	First Calculated Weight		Current Calculated Weight	Question to the expert	IDPES Answer
ERI	Enterprise Resource Integration	0.28	ERP	Enterprise Resource Planning	0.72	⇓	0.65	Could you briefly evaluate the effects of ERP?	It helps to make processes more understandable and transparent. KPIs are also taken into account in resource planning. KPI values give signs of potential problems. It has reduced the workload in decision processes.
			SCE	Supply Chain Integration	0.19	⇑	0.22	What effects do you observe in integration?	The positive effect of the KPI systematic using supply chain data creates a clue to the solution to different problems.
			SSI	Integration of sustainability strategies	0.10	⇑	0.13	Have strategically significant impacts been realized?	In the context of competitive advantage, the positive returns of the KPI iterative infrastructure pave the way for new sustainable strategies.

and support values in their business processes. This control support has prompted employees to make better decisions and motivate themselves in their business processes. The change in material supply and sales values decreased the performance values on the logistics side. The traceability of the changes in the IDPES system has made significant contributions to decision-makers. It has enabled evaluations about almost every process affected by the shift in defined sbKPIs. Before IDPES implementation: Production planning specialist:

- KPI measurements are made manually
- No entry or integration into SCM.
- Uncertainty is intense in setting KPIs.
- KPIs cannot be controlled, and there is no monitoring.

After IDPES: Table 9.

Integration of KPIs into SCM is critical for up-to-date and sustainable performance appraisal. At this point, IDPES has become a traceable and controllable solution by eliminating uncertainty. IDPES has almost eliminated the entire workload from the definition of performance evaluation to its evaluation.

Before IDPES implementation: Quality control specialist:

- Since uncertainty about performance is intense, and our innovation courage is weak.
- Uncertainty makes planning for innovation difficult.

After IDPES: Table 10.

The traceable performance process obtained from IDPES has increased the interest and expectation for the performance dashboard. Reflection on innovation in sbKPIs has been weak as the data is compiled within a limited period of time. In the case of long-term monitoring, the innovation's BDA and AR&VR sbKPIs are considered to be of interest. Before IDPES implementation: Quality control specialist:

- There is a verbal evaluation of strategic risks.
- No measurable identification and action.
- No records are kept.

After IDPES implementation: Table 11.

With IDPES, it has become possible to evaluate strategic risks. SR's KPIs are recorded and can be tracked. This situation has moved AH's business processes to a more reliable ground. The traceability of the application measurement values obtained from IDPES has created excitement among the employees. The same excitement was observed in the efforts to verify the measurement values. The variability of the values taken in a limited period according to the first calculated weight values shows the disparity between the predictions and the actual values. The department experts have evaluated that the values produced by the IDPES system and the application values (LC, EMC, MMC, ...) will be aligned after a while.

Gains obtained as a result of the implementation of the IDPES system:

- IDPES defines a sustainable performance management system within the scope of AH'.
- The traceability and control of the KPI data represented in the business processes of IDPES have been ensured.

TABLE 10. IE application metrics (KPIs) and effects.

KPIs				sbKPIs	First Calculated Weight		Current Calculated Weight	Question to the expert	IDPES Answer
IE	Innovation	0.16	BDA	Big Data Analytics	0.16	–	0.16	Has any work been done on Big Data?	Data processing and process improvement studies within the data analytics framework are at the planning stage.
			PD	Performance Dashboard	0.30	⇑	0.73	Is there any planning and work related to the performance dashboard?	The first step of the performance dashboard application was carried out. The barrier to information sharing in performance improvement has been overcome. Knowledge sharing promoted conceptual benefits and employee self-confidence.
			AR/VR	AR&VR	0.54	⇓	0.11	Has AR&VR received the necessary attention? Has the study been done?	AR&VR studies are at the research level.

TABLE 11. SR application metrics (KPIs) and effects.

KPIs				sbKPIs	First Calculated Weight		Current Calculated Weight	Question to the expert	IDPES Answer
SR	Strategic Risks	0.99	SUR	Supply Risk	0.14	⇑	0.75	Has there been a change in procurement risks?	The importance of monitoring and control has been seen. It is considered to make a significant contribution to SR. It has reduced the time/steps spent on risk assessments.
			DR	Design Risk	0.29	⇓	0	Has there been any risk assessment regarding design?	The expected effect of DR could not be obtained.
			DTCCR	Digital Transformation and Climate Change Risk	0.57	⇓	0.25	What effect did the DTCCR have?	The effect of defined DTCCR on SR remained very low.

- Thanks to IDPES integration, SCM is integrated for easy access to real-time data.
- Dashboard brought ease of access, monitoring, and control to KPIs.
- IDPES displays instant status information with concrete values thanks to traceable KPIs.
- KPIs are iteratively updated promptly.
- AH has achieved performance measurement and management to develop a competitive advantage.
- Data support needed for strategic, tactical, and decisions were provided.
- In addition, the traceability of strategic targets has positively affected employee motivation.
- IDPES has made it easier to understand the scope of activity and actual actions of AH for sustainable development.
- IDPES has provided benefits in assessing the system's current state and identifying the elements needed for improvement.

V. RESULTS

Business performance management systems are at the crossroads of different approaches and exciting opportunities, given continuous information processing and technological advances, along with developments in business strategy, monitoring, decision-making, and performance management systems in general. On the other hand, business performance management is entirely at the heart of the updatable design of KPIs. At this point, "IDPES," an iterative dynamic performance evaluation system as a case study, provides iterative updating and monitoring of defined business KPIs.

In our study, IDPES was structured according to the needs of AH, from field criteria to metrics and performance measures. Studies conducted within this framework are primarily defined as KPIs within the enterprise and customer-oriented metrics/attributes [54], [55]. Quality, time, cost, and flexibility are among the defined metrics [56]. In addition, decision-making is defined as a desirable option [57]. Updating KPIs supporting decision-making processes is still among the topics of interest [57]. The metrics used by J. Cai et al. [2] The PCTM (KPI success cost matrix) matrix given by the structural comparison of Table 1 is defined in the application area according to the company's requests. The PCTM matrix is realized by non-dynamic KPIs under the heading of cost. The same work iteratively updates the KPIs defined in PCTM with a mathematical model. The framework proposed with PCTM has solved the problem of combining performance measures using a systematic approach [2]. It also

TABLE 12. IDPES-deviations in predicted and implementation weight measurements.

KPIs	CC-Cost Control 0.47			ERI - Enterprise Resource Integration 0.28			IE - Information 0.16			SR - Strategic Risks 0.09		
sbKPIs	MMC Material	EMC Employee	LC Logistics	ERP Enterprise Resource Planning	SCE Supply Chain Integration	SSI Integration of sustainability strategies	BDA Big Data Analytics	PD Performance Dashboard	AR/VR AR&VR	SUR Supply Risk	DR Design Risk	DTCCR Digital Transformation and Climate Change Risk
First Calculated Weight	0.11	0.31	0.58	0.72	0.19	0.1	0.16	0.3	0.54	0.14	0.29	0.57
Current Calculated Weight	0.42	0.19	0.49	0.65	0.22	0.13	0.16	0.73	0.11	0.75	0	0.25
Percentage Change (%)	282%	39%	16%	10%	16%	30%	0%	143%	80%	436%	100%	56%

helps improve performance in the supply chain management process by managing complex relationships between KPIs and improving the process of determining KPIs. While the PCTM is iteratively updated, there are no updates to the supply chain management data associated with the KPIs.

It bridges the gap between the IDPES study, the supply chain management process, and the updating process of KPIs. So much so that all data affecting KPIs are directly supported and managed by supply chain management data. Therefore, IDPES has been implemented in the supply chain management system (ERP) on the ground of AH'. Thus, the expectation of monitoring and reporting the results obtained from IDPES through the supply chain management system without additional work has been met. In addition, IDPES has become a source of support in decision-making processes.

This study has examined the IDPES system developed for sustainable performance management on the ERP system of AH, a chain of stores in Turkey. Thanks to the developed IDPES system, AH's ERP system data is used instantly. The AH department experts determined the KPI definitions and weight measurements required for the IDPES system. The IDPES implementation process and its results were evaluated with the participation of department heads.

Table 12 shows the weight values calculated by the main KPIs of IDPES, ERI, IE, and SR, and the weight values obtained from its application in the IDPES, which includes the KPI algorithm. The weight of the subKPI MMC, one of the main KPIs determined as 0.47 by the experts, is 0.11. The first calculated weight of the CC is obtained as 0.42 by applying the first calculated weight to the IDPES, which includes the recommended KPI algorithm. Likewise, the sub-KPIs EMC and LC were calculated as 0.49 and 0.19 with varying weight values of 0.31 and 0.58, respectively, determined by the experts. While the weight value of the predicted costs for CC-MMC changed upwards, the weight values of MMC and LC changed downward. Thus, it has been seen that the 282% change in the material costs shown in MMC in CC, which is the main criterion, directly affects corporate decisions. Weight values and percentages determined by experts for the main KPIs ERI (ERP, SCE, SSI), IE (BDA, PD, AR/VR), SR (SUR, DR, DTCCR) in the table below and obtained from its application in IDPES changes are presented similarly.

In our application study, it is expected that the weight values of the main KPIs and the deviations of the predicted and IDPES weight values will be the least. The first calculated weight values show how the business processes are affected by internal and external factors. The 282% deviation of the sub-KPI MMC within the primary KPI, the CC, and the 436% deviation of the SUR within the SR required a detailed examination of the business processes. It provides instant status information to the employees in the business processes carried out with the traceability of the indicators. Obtaining this information allows decision-makers to plan, control and direct.

IDPES provided a critical, innovative perspective to the business, as the real-time changes of changing performance indicators can be monitored and maintained. Action-oriented decisions of these results will constitute another vital activity for managers. In implementing the IDPES system, AH application area data and strategic objectives are limited.

VI. DISCUSSION

The weights and interdependencies determined in the AH application area for IDPES vary for different sectors and application areas. The details shared in the article define the minimum qualifications for implementing the sustainable IDPES system in other areas. For IDPES, performance measurement, and traceability, performance information to the managers in the organization, and the use of the software have emerged as a necessity. As a result, business performance can be monitored and controlled, and IDPES indicators have made a sustainable contribution. At the same time, decision-makers can make more accurate and balanced decisions as their subCPs gain experience in implementing IDPES.

Real-time IDPES, process-based EPTM matrices, and cause-effect relationships between KPIs are used. Differences/problems in filtering and integrating enterprise resource planning systems data adaptations are not addressed. The measurement values of the KPIs have been partially corrected, as it is the first study to implement AH. Pairwise comparison techniques, flexibility, and software adaptation made our job more manageable. The proposed approach, algorithm, and IDPES provide significant convenience in decision-making when ERP is integrated. This system (IDPES) updates KPIs in real-time and converts them into dashboards. Also, traceable KPIs are a source of information for different problems. The KPI is a case study in refining and correlating performance indicator data.

The purpose of the KPI iteration process differs from the other two techniques. However, it is known that methodologies that consider an algorithm-based systematic basis directly affect success. IDPES met limited (update and monitoring) expectations with the EPTM approach. The AH application example is open to development and improvement. In this context, research continues in the literature to find a more efficient and successful method.

VII. CONCLUSION

In the globalizing world, businesses should be able to monitor and analyze their performance/status in real-time to achieve and maintain targeted success and profitability. Companies often develop their solutions through business management software. At this point, business performance analyzes are made with various programs. These analyses require combining the operational and management information of the organization. At the same time, the evaluation and sharing of the information obtained may cause some delays or problems. Real-time monitoring, instant response, and analysis of consolidated details are indispensable for organizations. Today, real-time measurement, update, and monitoring solutions are needed in performance management. This study presents an approach for real-time monitoring and updating KPIs at all levels, and IDPES is developed to make the performance management of business dynamic. IDPES provides iterative updating and monitoring of defined business performance management metrics. Performance measurement carried out manually in AH is structured to be integrated into the information system with IDPES. KPIs used in performance measurement have been redefined. Determining the initial and manual sbKPI metrics prepares the algorithm to work. Business performance management functions in AH are made easy and expandable with IDPES. In business performance management, updating and tracking iterative KPIs has become dynamic. In addition, its use has been facilitated by its integration into the existing enterprise resource planning.

Control and definition of KPIs have been systematized. The proposed approach makes two critical theoretical contributions to updating and monitoring KPIs, which are the EPTM approach and the IDPES system. Thus, it allows for the evaluation of KPIs and the development of algorithms. The EPTM implementation has simplified the selection/modification of KPIs with the development of software code. IDPES will explore KPIs to implement and explore different methodologies. Secondly, it allows KPIs to be evaluated from different perspectives in the results of corporate strategic plan objectives. For example, the enterprise will raise awareness of the pitfalls of making instant and quick decisions for the various risks and opportunities. Iterative KPIs with accurate assessments make updated planning and execution processes more realistic.

Based on our current research, IDPES has identified four main KPIs and twelve sub-KPIs in its implementation. The monitoring and control of business performance constitute its real-time infrastructure. In addition, an innovative approach has been proposed, and the system developed to overcome the uncertainty encountered in business performance management. In addition, an innovative approach has been proposed, and the system has been developed to overcome the uncertainty encountered in corporate performance management. At the same time, weight changes and effects of MMC, SCE, SSI, PD, and SUR were observed during extraordinary periods. This study's implementation results verified the consistency of KPIs and sbKPs. Today, it has shown that material, integration, sustainability, instant reporting, and risks are essential in business performance management. The existing IDPES system continues to be developed. IDPES will validate different manufacturing and service enterprise information systems in the future. Software capabilities are needed to explore other methods in the performance management cycle. However, it should not be forgotten that the chosen technique should yield consistent results to reach fast and accurate solutions. Thanks to the integration with corporate information systems, KPI data can be processed, and future goals can be estimated.

The weights of the main and sub-performance indicator values can be fuzzed in the KPI update algorithm to improve the consistency and accuracy of the calculated values. Thus, the fuzzy class ranges of the indicator weights can be determined. Combining fuzzy logic and the pairwise comparison technique will allow the development of new algorithms. It can be used in current algorithms to optimize performance indicator values. At the same time, combining pairwise comparison with fuzzy logic and rule-based expert system algorithms is a new research topic. Future studies of business performance management in digital transformation will provide the use and application of an innovative model and integrated algorithm with a systematic approach.

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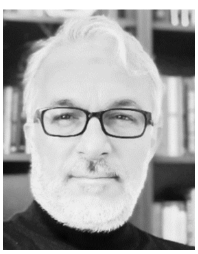

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