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A survey on exploring key performance indicators

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Abstract

Key Performance Indicators (KPIs) allows gathering knowledge and exploring the best way to achieve organization goals. Many researchers have provided different ideas for determining KPI's either manually, and semi-automatic, or automatic which is applied in different fields. This work concentrates on providing a survey of different approaches for exploring and predicting key performance indicators (KPIs).

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1. Introduction

Indicators or key performance indicators (KPIs) in business environment are mostly quantitative information; it illustrates structures and processes of a company. Now KPIs are very important for planning and controlling through supporting information, creating transparency and supporting decision makers of the management [1].

Lord Kelvin defined KPIs as “When you can measure what are speaking about and measure it in numbers, you know something about it, when you cannot express it in numbers, your knowledge is of meager and unsatisfactory kind; it may be the beginning of knowledge but you have scarcely, in your thoughts advanced to the stage of science.”[2].

Many companies are working with the wrong measures, many of which are incorrectly named key performance indicators (KPIs). Very few organizations really monitor their true KPIs. That is because only few organizations, business

leaders, writers, accountants, and consultants have explored and knew what a KPI actually is.

There are four types of performance measures (Fig. 1): [3]

1. Key result indicators (KRIs): it tells you how you have achieved in a perspective or critical success factor.
2. Result indicators (RIs): tell you what you have done.
3. Performance indicators (PIs): tell you what you must do.
4. KPIs: tell you what to do to highly increase performance.
 - To describe the relationship between these four performance measures by using an onion analogy.

“The outside skin describes the overall condition of the onion, the amount of sun, water, and nutrients it has received; and how it has been handled from harvest to the supermarket shelf. The outside skin is a key result indicator. However, as we peel the layers off the onion, we find more information. The layers represent the various performance and result indicators, and the core represents the key performance indicator”.

KPIs act as a set of measures focusing on those sides of organizational performance that are critical for the success of the organization. KPIs are seldom new to the organization. They may have not been recognized or they were gathering dust somewhere unknown to the current management team.

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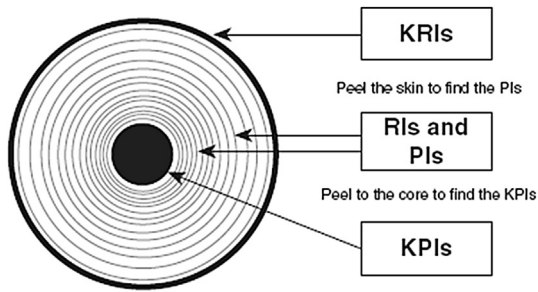


Fig. 1. Four types of performance measures.

Wei Peng divides the KPI to three Types as follows: [4]

1.1. Leading indicator

A KPI that measures activities that have a significant effect on future performance, which are causal roots of the outcome (i.e. lagging indicator) they influence, and actionable for the future performance against one or more lagging indicators.

1.2. Lagging indicator

A KPI that measures the output of past activities.

1.3. Diagnostic measure

A KPI that is neither leading nor lagging, but signals the health of processes or activities. For example: Number of clients that sales people meet with each week may be a leading indicator of Sales Revenue. (A weak indicator or outcome); “Complex repairs completed successfully during the first time or visit” be a leading indicator of “Customer relief. Leading indicators are very powerful metrics in that they owns the predictive and insightful causal relationship(s) within the business process(s), and authorize the actionable course to continue the process improvement. Therefore, creating effective leading KPIs is important to the success of any business organization so that it is smart to changes quickly, and also is prepared for the coming changes. However, identifying leading indicators is often hard requires months to collect needs, measure definitions and rules, prefer metrics, and encourage feedback, etc.

• Characteristics of KPIs: [3-5]

From wide analysis and from discussions with workshop sharer covering most organization types in the public and private sections, we were able to define the characteristics of KPIs based on Parameter, David and Wayne W. Eckerson.

1. Sparse: The fewer KPIs the better
2. Drillable: Users can drill into detail
3. Simple: Users understand the KPI. Clearly indicate what action is required by staff.
4. Actionable: Users know how to affect outcomes. Have a significant impact (e.g., affect one or more of the critical

success factors [CSFs] and more than one BSC perspective).

5. Owned: KPIs have an owner. Are acted on by the CEO and senior management team (e.g., CEO calls relevant staff to enquire what is going on).
6. Referenced: Users can view origins and context
7. Correlated: KPIs drive desired outcomes. They encourage appropriate action (e.g., have been tested to ensure they have a positive impact on performance, whereas poorly thought-through measures can lead to dysfunctional behavior).
8. Balanced: KPIs consist of both financial and non-financial metrics.
9. Aligned: KPIs don't undermine each other.
10. Validated: Workers can't circumvent the KPIs.
11. Regulated: Are measured frequently (e.g., 24/7, daily, or weekly).
12. Distributed: Are measures that tie responsibility down to a team (e.g., CEO can call a team leader who can take the necessary action).

Business monitoring or control is usually supported by an information system that gives information about several Key Performance Indicators (KPIs). Business monitoring is a critical activity that research problems in business performance and alarms of their existence with its source. It is one of the key functions for companies because it enables decision makers to take corrective actions sooner better than later, but it is also a challenging action because of the large quantity and high speed of data that need to be processed [6].

Publishing across one or more Balanced Scorecards and multiple dashboards. Traditionally, business monitoring are based on the evaluation of the mass values of KPIs by users who regularly check the scorecard to make sure that everything is correct. For example, the KPI “Customer retention increased by 3%” considers the customers kept all our stores in the present year. In order to give a more complete view for KPI monitoring, dashboards provide detailed information [6].

Usually a business strategy includes many challenges that make fail to achieve their objectives:

1. If it includes too many KPIs, this can weaken the focus on aims.
2. A large list of KPIs that does not have clear connections to business objectives may be a sign of a bigger problem.
3. A shortage of strategic focus on selecting KPIs is a difficult process.
4. Lack of understanding of the performance measures lead to a failure in monitoring and reporting of measures [6,7].

The following is a typical succession for developing KPIs inside an organization: [7]

1. Identify a problem, situation or objective you are trying to address, e.g., decrease the number of defective products at the end of the industrializing process.

2. Develop a view on how you would like the results to look, e.g., target number of defective products to reduce it from 20% to 5%.
3. Develop a process for how you want things to be done, e.g., this could include reengineering the whole process or it could be achieved by introducing quality affirmation review at different stages of production.
4. Develop effectiveness KPIs before capacity KPIs. This is because you first need to define your benchmark, e.g., how many units you produce in a given period of time, before you can begin to think about measuring related efficiencies.
5. Develop stakeholder and financial KPIs before other KPIs. Stakeholder KPIs for a government organization. For example, every child receives education. For a company, it is that the financial KPIs, such as growth and profit targets, will lead all other strategic objectives. So, it's logical to set these KPIs before any others.
6. Develop product KPIs before input KPIs for each objective. It's not possible to start thinking about input KPIs before product has been determined. For example, you need to know what your production target is, i.e., how many cars you need to produce, before you begin to think about KPIs relating to the manufacture of those cars.
7. Select best-fit KPIs, share, accept and document them. Companies should always have flexible and creative minds when developing KPIs, as their final goal is to drive the performance changes required by the corporate strategic plan. KPIs cause divisions and departments to act differently, improve certain processes and lead discussion and agenda subjects at the administrative level. Well-designed KPIs makes management able to ask the right questions, instead of giving perfect answers and results.

2. Previews works

In this Section, we divided the previews work according to three classes as the following:

2.1. Manual approaches

In Ref. [2] (Arora, 2015) the researcher has developed a prototype for performance analysis based on KPI. A KPI construct questionnaire Survey was conducted. The validity of the research tool was confirmed by content validity wherein all the stakeholders were invited to review the questionnaire content. By the Delphi technique, the not so important parameters were removed and only relevant parameters/criteria were accepted for the questionnaire. Next, the KPIs were ranked on the basis of their importance. But the author explain the limitation of his research Represented in Unfamiliarity towards the concept, Difficulty in assigning task and Difficulty in quantifying.

In Ref. [8] (Andersson Granberg, 2013) aims to identify a set of Airport Key Performance indicators, author divide the airport into five activity areas, and an initial selection of indicators is made for each area. This is then used as a base for

the questionnaire, where specific opinions from Swedish and Spanish airport managers are collected. The survey results are then used propose a final set of indicators. Based on that ranking, handpicked a manageable number of indicators that can be used to monitor the airport and quickly get information when some process or area fails to live up to the desired standard. But these indicators have not been tested operationally. Their usefulness has thus far been validated through the survey where airport managers in the Sweden and Spain have ranked the different indicators.

In Ref. [9] (Hany Abd Elshakour M. Ali, 2012) developed a set of KPIs that can be implemented by construction executives in measuring the performance at the company level in Saudi Arabia. List of 47 performance indicators classified under five performance perspectives were identified to assess performance of construction organization. The statistical analysis of the collected responses regarding the degree of importance of the 47 performance indicators is provided using 10 most significant KPIs which include profitability, quality of service and work, growth, financial stability, cash flow, external customer satisfaction, safety, business efficiency, market share, and effectiveness of planning. Energy use, main water use, and impact on biodiversity are the lowest ranked indicators for measuring performance of construction companies. The 10 indicators consistently perceived as being highly important can be used as a basis to build a model for evaluating the performance of construction companies and also can be considered as the first step for developing a competitive benchmarking approach. But author tell that It is recommended that more in-depth studies should be performed to better Understand KPIs.

In Ref. [10] (Khalifa, 2015) developing a group of strategic key performance indicators (KPIs) to monitor and improve the performance of a tertiary care hospital, including different services. The author used qualitative survey methods through conducting semi structured interviews with higher management officers as well as hospital department heads and performance professionals. Suggested Fifty eight KPIs then sorted into ten categories and finally were approved by the higher management. Each of these KPIs, and each of the ten categories, has specific value(s); some reflects the effectiveness or efficiency of healthcare provision, such as re-admission rate and average length of stay, some reflects timeliness, such as waiting time for admission, for an outpatient appointment or in the emergency room, and some reflects safety and patient centeredness, such as infection rates and mortality rates. But this way to selecting KPIs still manual way and depending on this method is still manually and depends on the personal experiences of the members in the selection of key performance indicators.

2.2. Selection approaches

In Ref. [4] (Peng, 2007) Proposed a Semi-automatic system in two production printing workflow scenarios to iteratively discover leading indicators from real-time workflow events, equipment logs, and other metrics sources, to enable

incremental adjustment of the underlying domain model and/or addition or subtraction of data collection points. The System Scheme for KPI Analysis Leading Indicator Discovery consist of 10 steps illustrate an iterative learning methodology to discover the leading indicators in a business process over time via data mining techniques combined with domain knowledge guidance. Also compute the time shift between the time series indicators to discover the leading indicators. But the approach not make investigate and prototype an operational intelligence platform that enables the timely access to heterogeneous operational data, and has the ability to predict and proactively adapt to the perceived changes.

In Ref. [11] (Claudia Diamantini, 2013) propose a methodology for the design of a strategic support information system, aimed both at monitoring enterprise daily activities and at supporting decision making by means of Key Performance Indicators (KPIs). Approach aims at identifying the subset of requested KPIs that can be actually computed over the sources. The KPIs are represented by means of an ontology (aimed to provide a formal reference model for KPIs. The ontology serves as a global shared model capable to define descriptive properties of indicators together with the mathematical formulas needed to calculate them). So author described a semi-automatic methodology devoted at checking if a set of requested KPIs can be computed from available data of the enterprise. This approach need to improve the mapping support by extending the proposed approach with state of the art results in the Semantic Web field.

In Ref. [12] (Keck, 2014) developed a prototype KPI recommendation application. Running alongside a traditional CRM solution, the prototype application provides company agents with the most appropriate information generated at runtime and customized to each specific customer and case. User Interface builds on machine learning techniques to construct a ranking model of Key Performance Indicators (KPIs) that are used to select and present the most important customer metrics that can be made available to business users in time critical environments. The underlying models used for KPI selection and a comparative evaluation of machine learning and closed form solutions to the ranking and selection problems. Results show that the machine learning based method outperformed the closed form solution with a 66.5% accuracy rate on multilabel attribution in comparison to 54.1% for the closed form solution.

In Refs. [13], Ning et, al. discusses the methods by which KPI indicator system of enterprises is selected. KPI system is a system determines layered and classified indicators obtained from layer decomposition of strategic objective. The principle of determination of KPIs is SMART. Determined the individual, departmental enterprise objectives then these objectives are linked to the strategic objectives in a layered hierarchy. Using this hierarchy, KPIs for each layer (performance, departmental, enterprise) are determined. The system starts by the current determined KPIs which are assessed and classified into the previous three layers. Then according to the current situation of the enterprise and the actual situation of each unit in the enterprise, then the importance of the

indicators is determined dynamically according to determined criteria which values depends on the current situation for each layer, then each indicator is given a grade. An example of these criteria is the function domain class, as the KPI system is applied on a mobile communication company system, the function domain class of this system is divided into 7 classes (finance, network quality, market operation, group customers, capital expenditures, business support, and safety production). Finally, according to these grades, concrete indicators are determined. However, although the proposed KPI system determines the importance of the indicators dynamically, but the system still depends on a set of predetermined indicators that are previously established which may lead to missing some concrete indicators that are not revealed in the initial set.

2.3. Predict approaches

In Ref. [14] (Stefanovic, 2014) introduces a predictive supply chain performance management model which combines process modeling, performance measurement, data mining models, and web portal technologies into a unique model. Author presents the supply chain semantic business intelligence (BI) model which encapsulates data sources and business rules and includes the data warehouse model with specific supply chain dimensions, measures, and KPIs (key performance indicators). And describes two generic approaches for designing the KPI predictive data mining models based on the BI semantic model: (i) using OLAP data mining dimensions, (ii) using prediction tables. However the model is a general approach and there is no determined technique of predicting of KPIs.

In Ref. [15] (Yin S. W., 2014) introduces a robust version of practical industrial applications (PLS) to deal with outliers and missing values. The basic idea of PLS in prediction is to identify the regression coefficient between the measurable variables and the product quality variables. Based on it, the KPI can be predicted using the online measured process data. As PLS is totally based on the measured process data, the characteristics of the data are then quite critical for the success of PLS. In practical industrial processes, outliers and missing values are two common characteristics of the measured data that are caused by variety of reasons like hardware failure, formatting errors, non-representative sampling, etc. So Author presents an EM-PRM-based KPI-related prediction and diagnosis approach against outliers and missing data, simultaneously. Based on the partial robust M-regression (PRM) method and the expectation maximization (EM) framework, author first realizes the EM-PRM-based KPI related prediction approach. Afterwards, author develop the EM-PRM-based fault detection approach which can distinguish the fault related to the KPI and the fault unrelated to the KPI, so that the false alarm rate can be significantly reduced in the sense of KPI-related classification of faults.

In Ref. [16] (Suryadi, 2007) aims to develop a model of key performance indicators (KPI) measurement in higher education institution. The proposed model is based on combination between Analytic Hierarchy Process (AHP), trend analysis and

comparative data. KPIs are determined as description of key success factors related to institution sustainability. These KPIs are categorized into academic, research and supporting KPI. Each KPI has different degree of importance and is weighted using Analytic Hierarchy Process (AHP). On the other hand, KPI's points are set based on its trend over last three years and its current level compared to benchmark or competitor performances. Combination between trend and comparative level is reflected by three types of point: Good (100), Fair (50) and Poor (0). Total Score of all KPIs corresponds to these three types of point and KPI weights. The proposed model contributes in measuring and explaining institution success using multi dimensions of KPI. And it is a tool for organizational self-assessment. The proposed model is standing on the following principle: "there is no the best performance; but there are always better performances to achieve". Better performance of HEI is reflected by growth of organization results which are demonstrated by current level compared to historical performances; and besides, it is reflected by comparison between current level and the competitor performances or benchmarks. . But the author Adopted on a closed set of KPIs. And there could be other set not used or undiscovered.

In Ref. [17] (An, 2004) present a system dynamics model (SD) based upon a scenario from supply chain management domain. Purpose is to demonstrate an alternative approach of building Sense-and-Respond systems. Specifically, author use system dynamics to formally define the KPIs of both the retail inventory and the supplier backlog. The system dynamics modeling and simulation exposes the KPI dynamics behavior and causality relationship between KPIs. Combining with the optimal control, the SD runtime could give the best action should take to achieve the objective defined by objective function. in Refs. [18], Tomic and Milic focused on the KPI values, as KPIs usually have clearly defined target values that help determine whether business goals have been met or not. Tomic and Milic presented an approach for automated interpretation of business performance indicator values using domain knowledge and expert system technology to transform business data into information. Information is then presented as natural-language-like sentences and incorporated into reports. The proposed approach is focusing in reporting to provide a better insight for the data. An implementation of this approach is applied as an educational tool which are presented and evaluated. It was introduced as a teaching aid which had some limitations including speed and responsiveness. Although explanation is provided in the reports is considered to be useful and easy to understand but need to be more comprehensive. Comparing this work with our thesis target, the proposed system focuses on interpreting a pre-determined set of KPIs automatically, while one of our main objectives is the automatic exploration of the KPIs.

In Ref. [19] Abd El-Mongy et al. proposed a prediction system that uses Association Rules to discover the relations between KPIs. Abd El-Mongy et al. then developed an integrated solution for accurate KPIs values prediction by using the discovered relations between KPIs and KPIs history of values and applied both Fuzzy and Neural network

Components to predict KPIs values. The proposed system used the output of both components to feed a decision tree to generate more accurate prediction result. A comparison between the proposed system and the output of both components in separate has been established which showed that the proposed system has more accurate results. However, the proposed approach focused on extracting the relations among pre-determined KPIs which was the step for predicting the KPIs' values, this reveal to a needed enhancement of exploring the most interesting KPIs.

Shana and Venkatachalam in Ref. [20] built a model to predict the result of students registered in a course by analyzing the factors that affect the performance of students. The main goal of this research was to analyze the students' data to identify the key performance indicators which affect the result (success or failure) of the students in the course, and analyze various classification models, then identify a high accuracy prediction model to predict the target result. The proposed system applied Model Building Using Correlation Analysis, Chi-Square Analysis, Information Gain Analysis and Gain Ratio Analysis methods on an initial set of 20 attributes. Then according to the methods' analysis results, it selected 7 attributes as the list of factors that influence the performance of students. However, although the research started with a determined set of attributes which is used to determine the influencing factors, but list of attributes can be extended when working on a larger dataset which exploits the need for dynamic prediction to the effective factors for the problem.

3. Conclusion

The paper demonstrates different approaches for exploring key performance indicators in different directions including manual, selection, or prediction approaches. As there are different ideas, however, we noticed that the prediction approach is still a vital field for research as most of the research are based on a determined point. Our future direction after this extensive research review is to propose a new approach for predicting KPI's with no determined point to start and provide a complete prediction for the KPI's including the suitable KPI's for the problem and their possible value range. Moreover, we aim for our approach is to apply it in different field as a generic approach.

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