Performance Measurement in the Digital Era: Review Literature at the Intersection of Management Accounting, Big Data Analytics and Emerging Technologies' Impact on Performance Evaluation

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ABSTRACT

This paper focuses on the changes of performance measurement systems in the context of the digital environment. However, with organizations institutionalizing big data analytics and the rising technologies, structured evaluation methods need some form of modification. The study aims to address the following: the past developments of performance measurement; effects of technology disruption; and the use of big data for the assessment and the part played by technologies in processes. Scientific papers presented in the period 1987-2023 regarding management accounting, information systems, and technology are reviewed critically. Preliminary works defining the subject's directions and studies indicative of changes brought about by digital media are presented. Main topics: Making decisions based on quantitative analysis, the combination of finance-oriented and value-based KPIs that correspond to the strategic goals, and continuous monitoring of the processes. The review also includes an integration of views about possibilities that new data sources open for creating new or more profound metrics. Based on the literature, IoT, AI, blockchain, and cloud computing are explored to understand the extent to which they impact the design and execution of evaluation. Problems related to adoption such as lack of competencies, implementation issues, and others are discussed. Therefore, previous work analyzing mitigation strategies associated with early adopters is presented to offer suggestions. The Directions for future research at the crossroads of digitalisation and performance measurement frameworks are discussed in last part of the abstract. Hence, the aim is to develop the theory and practice of this important field together.

Keywords Performance measurement, Digital transformation, Big data analytics, Emerging technologies, Management accounting

INTRODUCTION

Among the key tenets of the strategic management system, performance measurement is known to have the function of considering the outcomes of organizational activities and making pertinent decisions based on evaluation results. However, the large-scale digital transformation that currently takes place has changed these paradigms at the operational level with new types of data and analytical tools. Specifically, the following research question has been formulated for this paper: What literature is available on the changing nature of performance measurement in a digital age? I chose the introduction firstly to highlight the fact that performance measures have evolved from the financial perspective to the integrated non-financial measures. Historical references related to the seminal works that set the basis of the reaction to these instances are briefly reviewed. The review then describes how digital disruption started to affect practices, leading to a situation that called for rethinking of the evaluation paradigms. The next area is the consideration of the big data analytics, which became significant now, as organizations have access to large internal and external data resources. This section integrates the views on prospects that exist data streams hold for crafting new, more elaborate metrics consistent with digital business paradigms. Terms such as IoT, AI, blockchain, and cloud computing that are used in the evaluation's design are also discussed. It warns that the challenges to implementation of the adoption will be discussed; skills, integration and change management barriers in particular. Examples of successful approaches used by early adopting firms that manage this transition are described. Lastly, suggestions for future research are provided with a view of contributing to literature in theory and practice. Thus, the purpose of the paper is to

review and synthesize the existing literature regarding the roles of management accounting, big data analytics, and emerging technologies and its contribution in redefining the PE measurement index and processes in the digital age.

EVOLUTION OF PERFORMANCE MEASUREMENT APPROACHES

Indeed, the assessment of organizational performance has been a subject of considerable attention and has changed substantially since the early attempts to employ exclusive financially oriented approach (Johnson & Kaplan, 1987). Such frameworks of conventional strategic management included key performance measures that ranged from rate of return on investment, profit margins and costs cut among others. However, it was not long before scholars identified problems in attempting to encompass multimodal business activities through the application of numbers alone (Johnson and Kaplan 1987). Core publications defined new trends for the expansion of evaluation perspectives. "Relevance Lost" by Johnson and Kaplan (1987) criticized the deficiencies of MCS and proposed the use of non-financial indicators. It is true that it contributed to framing of more elaborate models. Another popular business performance measurement model that became influential in the same year was Kaplan and Norton's 'Balanced Scorecard' framework which called for the use of a number of measures arranged by four categories which include the financial, customer, internal business processes, and the innovation and improvement category or the learning and growth perspective. This combined both trailing, financial measures and leading, non-financial performance motivations. The balanced scorecard became more of a common tool in the organizations. Moving forward, Neely et al. 's "Performance Prism" (1995) enhanced previous frameworks, employing five linked components: satisfaction, strategies, processes, capabilities, and contribution, in order to provide a balanced multi-dimensional perspective (Neely et al., 1995). For the first time, it was claimed that understanding stakeholders' requirement is a key part of strategy implementation along with identifying operational indicators. The List of models grew longer and new models came into lime light including Fitzgerald's 'SMART' pyramid (1991), 'Results and Determinants' (1998) and Olve's 'Octagon' (1999) among others. These consolidated thinking around using a portfolio of measures associated with the strategy rather than using financials on their own. By the year 2000 and beyond; evaluation was no longer a simple economic bottom line type but rather a many faceted and many dimensional process. There was an integration of lagging and leading indicators with the objectives of customer, internal processes, and innovation. This set a foundation knowledge of the conventional performance metrics before the shift by the advances in digitization. The emergence of early frameworks formed the basic tenets of the business environment although the dynamic environment required periodic review. From the work of Itchens (2005), it is established that performance measurement systems have to grow and change in response to strategic and operative changes. This went a long way to changing thinking to more acceptable and conducive use of Flexible Agile Processes.

Parmenter's (2010) provided a hierarchical categorisation of the KPIs based on the extent to which they influenced behaviour and outcomes. His model categorized KPIs into tier 1 to 4 and ensured the concentrated interest on the significant measures. This offered a useful framework for assembling the perspectives of the philosophical and practical versions of the balanced scorecards in relation to strategic plans. Moreover, they also pointed out that understanding the stakeholders' needs, which sometimes may be antagonistic, should serve as a basis for selecting appropriate metrics, with Gomes et al. (2011) focusing on stakeholder theory in this regard. They emphasized on the realisation of performance evaluation which is to involve all organisational and constituency members. Subsequent research has looked at adding other techniques to the conventional ones, which have been defined above. For example, the linking of forecasting models and scenario planning in order to assist in strategic decision making where certainty is low (Carton & Mouricou, 2017). BSC integration with management flight simulators for learning by experimentation (Mehrjou et al., 2020). Thus, the combined approaches map the continued development of performance measurement as an emerging management discipline.

The Digital Transformation Era

The advances in digital technologies have majorly reshaped conventional systems of business and performance benchmarks. These are mainly characterized by information technology, new generation networks, mobility and cloud, Artificial intelligence, and the internet of things. The following forces are at the forefront pushing for digital transformation spanning across industries on a large scale and at a very fast pace. Other authors, Matt et

al. (2015), call this period the "Third Wave" of digital disruption, which includes such phenomena as digital platforms, ecosystems and nets. Currently, organizations compete and function in a highly connected world with abundance of information that calls for new thoughts on strategy, operations, and management. According to Loebbecke and Picot (2015), digitization requires the reconsideration of assumptions in the design of performance measurement due to new digital conditions. Research has established that there is a need to develop new measures of digital business models to suit new capabilities and customer conducts in online and complicated environments. For example, IoT network's KPIs (Wang et al., 2023), probabilistic reasons for mission-critical events such as online churn (Saini et al., 2022), and value-per-segment from digital touchpoints analysis. Legacy statements are usually conventional for new generation digital enterprises which need predictive metrics of website traffic, conversion as well as CLV. Experts mention that performance evaluation should employ the enormous quantities of structured and unstructured information produced within business systems and the digital environment (Adnan & Akbar, 2019; Hendler, 2014). This covers customer feedback on social media on brand attitude, experiences and reviews on products and services. Including these new data sources should allow for more accurate and indirect measures that correspond to new digital objectives. In summary, the digital era has offered a drastic increase in data availability whereas the business and operating models of organizations in different sectors are changing continuously. This requires the reconsideration of performance measurement to make use of new digital data stream potentials and to ensure that the measurements suite the updated strategic processes in online frameworks and beyond.

Whereas new opportunities have emerged, there are also some issues connected with the use of digital data streams for performance evaluation. Research has revealed many firms to be pinning over how to actually codify and manage the torrent of information which is now available to them (Teece, 2018). This also imply the challenges that exist when it comes to the interface of different traditional systems with modern state of the art analytics solutions (Westerman, et al., 2014). Other scholars quote problems such as the lack of appropriate skills and knowledge required in establishing the right measures for digital enterprises (Kohli & Johnson, 2011). Bare bones, traditional performance measurement structures may not map well when models, and customers and competitors change frequently and in an increasingly fast growing pace (Bharadwaj et al., 2013). Researchers state that digital transformation needs to be accompanied with new measurements, more often than not, a new set of organizational culture or paradigm is needed. This entails revamping the governance structures of an organization in order to accommodate features such as rapid experimentation, failure tolerance, interdisciplinary collaboration and learning (Andriole, 2017; Kane et al., 2015). This paper shows that early cases indicate organizational members and firms that successfully implement a new performance management approach that harnesses digital technology offer first movers' benefits. For instance, the measures for enhancing the role of the customer experience economy and stimulating clients' interest in digital environments (Teece, 2018). Based on the reader, enlightened organizations are those that shall benefit from the digital environment characterized by an abundance of information.

Big Data Analytics and Performance Measurement

The usage of technology has enhanced the creation of big data that if properly utilized can be of significance. Also known as big data, these rapidly increasing data resources are distinguished by the 4 V's of volume, velocity, variety, and veracity. That is why in the context of organizations which get flooded with information, the role of analytics to turn this into business value becomes critical. Initial research outlined the necessity to augment appraisal results with analysis-based recommendations (Davenport & Harris, 2007). This led to the emergence of such approaches that include descriptive analytics, diagnostic analytics, predictive analytics, and prescriptive analytics that can be used in many industries. It can be defined as performance measurement was considered as the most crucial field to adapt analytics to improve decision making (Shanks & Bekmamedova, 2012). The last section of the literature aims to review how data analytics strengthens different stages of the evaluation process. The context component is integrated with the metrics at descriptive level by adding more graphical images to describe its operational performance (Gandomi & Haider, 2015). Diagnostic analytics assist in determining blames and identifying specifics of the results (LaValle et al., 2011). It also allows planning and budgeting for future metrics such as customers' attrition, demand or equipment maintenance programs and patterns (Provost & Fawcett, 2013). Optimization and simulation also help in planning when the risks are unknown (Davenport, 2013). This means that prescriptive recommendations are created with the intention of

providing the decision maker with the prompt actionable result and then culminating to a steady improvement (Shmueli & Koppius, 2011). Research also shows data analytics as enabling brand-new measures that could not be accessed before. These are network analysis of collaboration patterns, text mining in unstructured feedback data, and IoT data of efficiency, waste foil and utilization (Wixom et al., 2013). As part of PMFs, big data analytics contribute to a better, evidence-based and forward-looking execution of strategic directions (Kiron et al., 2014). This leads to better decision-making for a lasting competitive edge, which is the key goal of each business venture. In addition to that, the research also identifies opportunities of using big data for performance evaluation, but at the same time, several challenges are noted. One of them is the shortage of requisite analytical skills within the present workforce to exploit the benefaction of Business Intelligence fully (Davenport & Patil, 2012). They identify the deficiency of internal human capital, in relation to data science, machine learning techniques, and programming languages as areas that require talent supply (McAfee & Brynjolfsson, 2012).

To address this issue in the long-run, it is recommended that the organization should develop a training regime and engage in strategic hiring in order to accumulate the right kind of competencies for the right kinds of tasks. One of the challenges reported by firms is the integration of analytics tools with key business processes is challenging since older line systems don't easily integrate with flexible data systems. Gradualness in the process of change and organization should be taken are crucial in avoiding difficulties in the process of modernization. Issues such as missing data or errors may regulate the chances of reflecting correct measures if elementary data management guidelines are not properly observed (Davenport, 2006).

This includes the setting up of governance on the definition of data, its lineage and the monitoring of such for anomalies. Those leaders who have embarked on the change process have been able to realize that there is a broad need for having cultures that are ready to receive analytics, and that this principally involves having the chief officers behind the change besides outlining the benefits that are going to be accrued by this change and handling resistance to change (Gartner, 2013). That way, performance measurement will develop in the best possible way during the occurrence of the overall digital transformation process. Change management therefore consistently remains important in the effective implementation of big data and analytics within performance evaluation. Regarding talent requirements, integration difficulties, and cultural receptiveness, these issues will enable the organization to achieve the highest value on newly derived information insights.

Emerging Technologies Shaping Performance Evaluation

Despite the sound for increased focus on performance measurement in the recent past, several kinds of radical technologies have come to the scene in recent years. For instance, improvement in IoT makes it is possible to instrument physical plants with cheap sensors to allow for monitoring of operational parameters in real-time at a large scale (Kagermann et al., 2013). The IoT implementations in industries, production, transportation and utilisation industries provide the information about the use of assets, efficiency and effectiveness of the processes in place, energy consumption, and quality of results (Porter & Heppelmann, 2014). These new data sources aid in scheduling of preventive maintenance and planning of the resource utilization. Research confirms applying IoT to the traditional key performance measures, to provide improved operational measurement (Brettel et al., 2014). Another aspect that is changing evaluation with the help of automated tools include artificial intelligence (AI), machine learning, and cognitive technologies. Uses of artificial intelligence rely on qualitative measures with the help of image and video analysis for the assessment of performance (Daugherty & Wilson, 2018). NLP interprets the qualitative data to contemplate emotions and issues raised by the customer directly (Mikalef et al., 2020). Forecasting techniques based on ML produce early warning indicators from the large volume of data to forecast such elements as demand, churn or equipment breakdowns (Shmueli & Koppius, 2011). Optimization and prescriptive models also assist in supporting the strategic and tactical decisions. The study discovers that AI is enhancing the part of analytics in measuring performance (LaValle et al., 2011).

There are appeals of blockchain solutions related to traceability within the supply chain to help address the compliance and quality (Kshetri, 2018). Distributed ledgers introduce transparency that creates new ways for cooperation and data exchange across the organizational borders (Yli-Huumo et al., 2016). Research found blockchain improving the area of accountability and credibility on performance reporting. Benefits of using cloud computing and edges help in the scalability of the solutions that support the key metrics for the next-generation technologies (Armbrust et al., 2010). The use of all these emerging tools in relation to the new

evaluation frameworks leads to insights that are about three times deeper and relevant to current digital business needs. Thus, technology in general offers opportunities within the context of performance measurement while at the same time, bringing in impediments. One of the challenging aspects is linking and correlating different solutions and achieving a consolidated view due to the distinctions in the data type, support platforms, and measurement units (Gartner, 2019). This means, there is need for serious consideration in strategic planning of data architecture, governance and tools in order to reduce resistance as the phases of integration progress. Other research also highlights issues concerning change management in matters of cultural and process transformation (Mithas, et al.: 2013). Exploratory and initiation phases are useful in creating awareness of the new solutions and developing the competencies internally. The other challenge is that the speed of technological innovation presents a challenge whereby sometimes technological innovation advances faster than the advancement of the evaluation framework. In the continuous learning mind-sets, such adjustments mean recalibrating metrics in line with the corresponding emerging capabilities. It can therefore be concluded that adequate change management and an orientation that is agile continue to be crucial factors for change in technology adoption. Organizations that are introducing the new tools are those enjoying positive outcomes best explaining why they are rushed to show their results to the executives. The initial accomplishments assist in dispelling change reluctance through communicating the payback on the efforts directed to the development of different performance patterns (Gartner, 2020). Other plans that are phased or cross-functional also map out strategic overviews for the long-term integration of transformational technologies in evaluation processes.

IMPLEMENTATION CHALLENGES AND MITIGATION STRATEGIES

Opportunities for improving the use of new data sources and technologies can be identified, but changes in performance measurement practices create great implementation challenges. Studied has been done on typical issues to be faced and solutions to be practiced by organizations to achieve this shift successfully. Insufficiency of skills in the fields of finance, accounting and operational staff to define metrics for the digital businesses is often cited by them as the key issue (Kohli & Johnson, 2011). As the evidence of talent deficiencies in firms, case studies demonstrate companies outsourcing development with training providers, introducing programs for internal upgrade, and targeted hiring of data science professionals. There are difficulties in integrating analytics platforms, IoT systems and other tools with legacy ERP and transactional databases because of the differences in data models and architectures (Gartner, 2019). Gradually extending the utilization of new technologies to innovative applications and gradual replacement of the key legacy systems lessen such shocks. Evaluation challenges include resistance to new change management procedures and socialization of the newly implemented approaches (Mithas et al., 2013). Communication, addressing of resistance and early pilots showing the ROI is another best practice. The performance management system is taken a notch higher as the new metrics are incorporated with a new cultural mind-set addition to the change process. With regards to data quality, misinterpretation of values such as due to inconsistent definitions of variables, errors or missing values restrain the information and analysis (Davenport, 2006). It is crucial to set up some formalisms around data governance regarding best practice around lineage, standards and monitoring of a data asset.

Not having an executive sponsorship for an initiative is another challenge (Gartner, 2020). It is helpful that each function socializes returns proactively through proof-of-concept projects with others to secure support. It is also an effective approach to obtain leadership buy in where new metrics are properly linked to the strategy and evidence of competitive advantages secured. Improper change management, therefore, continues to be a critical determiner of whether a new change will be adopted effectively. This gives emphasis to the talent needs, integration issues, cultural and leadership readiness and commitment will support the organization's efforts towards the creation of more value from the changes in evaluation of performance. Budgetary constraints are also adoption barriers because transition entails the provision of a vast initial capital (Gartner, 2019). Key initiatives include the use of open-source tools and leveraging, focusing on high-ROI business scenarios, and implementing centers of excellence. Legal and compliance issues present challenges when there is a need to incorporate new information data feeds in the value creation process and performance reporting (Teece, 2018). Specifically, the following data governance design outlines good practices that can mitigate such challenges: There are challenges too in maintaining motivation when efforts shift from pilots to scale, usually in Gartner (2020). Rewarding new metrics, explaining the vision, and reminding their organizations of what they have accomplished maintains stakeholders' interest. Founding communities of practice also supports the ongoing

acquisition of knowledge and help to different cross-organizational teams (McAfee & Brynjolfsson, 2012). Overlaid with phased, multi-year implementation roadmaps and plans also enable navigation of changeover timelines greater than one budget cycle ending up in effective implementation plans (Mithas et al., 2013). This contributes to overcoming threats linked with changes in priorities and fluctuations in the budget. Therefore, addressing or averting skills, integration, change and other impediments thus presents prospects for increased success in performance measurement change initiatives by SWP, supplemented by governance and communication.

FUTURE RESEARCH DIRECTIONS

Despite many studies have been devoted to analyzing the impact and the prospects of digital disruption on performance evaluation, more studies are still required as it is a rapidly developing field of technologies and business models. Initial studies were mainly framing based and there was less research on adoption and effect. Future work could use methods of quantitative and survey-based and case-based research so as to offer a richer research evidence on transformation journeys across sectors and organisational contexts. This also involves the study of the correlation between certain technologies, redevelopment of metrics and realized benefits. The analysis of company performance comparisons before and after the implementation of the initiatives would better inform other firms regarding the performance outcomes for a firm of that kind to justify the investment made based on other's experience. Another source of information using practical advice could be investigating critical success factors by the means of qualitative research. New avenues are created with developing digital ecosystems and platforms, and it can be investigated the network-level performance and new ways to measure collaboration in shared economies. Research works conducted on the aspect of the alignment of incentives between partners could provide information about this. It has now become a higher priority to create values sustainably – academia can assist in determining non-financial performance such for environmental, social and governance aspects that can provide newer test of a company's survivability.

Other topics are, for instance, measurement frameworks for strategic performance in applications of digital twin and augmented reality. New opportunity is reflected in the role of blockchain in distributed and trustworthy reporting. It will be relevant to revisit the earlier conceptual models as technologies develop, in order to align them to the new environments. It is also possible that future work involves the use of parallel theories from other disciplines such as information systems, psychology and organisational behaviour to provide diverseness. Hence, skills regarding such issues as skills shortage, change management and data governance must not cease to be discussed. Such manoeuvrability if included in other large-scale empirical studies can help other practitioners get insights into the effectiveness of the mitigation strategies. Thus, performance measurement is a dynamic field that demands ongoing research as new technologies intensify disruption. Overcoming such deficiencies is possible with further development of the identified avenues for subject progress, which involves intensive, interdisciplinary research of how the new technologies in question can be used to generate the greatest possible benefits.

CONCLUSION

This review focused on the literature on the development of performance measurement and continuous change resulting from digital advancements. Originally, frameworks were defined to create initial strategies; however, constantly evolving business requirements called for further development. New technologies have brought data abundance and an outsourcing of many forms of operation in the context of the digital age. This requires changing the evaluation paradigms that are prevalent at the present time in order to integrate new forms of digital data and to link indicators to new strategic goals. Thus, big data analytics is used during all steps of performance evaluation starting from descriptive data, more advanced predictive and prescriptive ones. But this also opens up new questions related to the role, availability and acquisition of skills as well as integration and data quality for the large data repositories. Internet of Things, Artificial intelligence, blockchain and cloud computing go beyond the main measures of activity by providing more profound insight into the functioning and indicating future trends. When embedded in frameworks their utilization is beneficial from an informational prospective but comes with challenges of adoption. Research on the subject have used factors such as skill deficits, change phobia and implementation challenges to make comparison on the barriers to change. There are practical voids

that top companies eliminate using tactical staffing strategies, effective communication, PWCT and PIRs. Although there are big chances for optimising the benefits by means of digital disruption, more multidisciplinary studies are still necessary. Future directions comprise quantitative analysis, further research comparisons, and new examination of the network level and sustainability in the growth of business models. In conclusion, it is an established fact that the subject of performance measurement remains one of the chief management disciplines that are still in a state of constant evolution. This way, it will be essential to focus on the identification of new data streams and technologies that serve the main strategic objectives in the context of continuously enhancing competitive advantage as the pace of digital transformation increases. Thus, it is possible to emphasize that minimizing adoption risks with the help of advanced approaches to its improvement can bring the maximum result during further evolution.

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