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Abstract: Performance measurement systems have gotten remarking development since the 1980s. It is also experiencing a step from classical PMSs to a broad diversification of PMSs. However, it seems that the practices in industries are not following the rapid academic rhythm. This paper presents a survey of performance measurement models and frameworks and analyses how these research results are implemented, or not, into software tools available on the market. It thus pointed out the gap between academic research results and supporting tools in the domain of the performance measurement management of engineering projects.

Keywords: Performance Measurement, Project Evaluation, Indicators.

1. INTRODUCTION

Having a relevant performance measurement system in a company has become crucial since the 1980s so that, from that time, research has been developed on several PMS models.

For the Classical Performance Measurement Systems (CPMSs), some common features like "balanced", "integrated" and "strategy-relevance" arose; a set of methods was quickly adopted in the industry (Bititci, Trevor and Begemann, 2000; Yadav, Sagar and Sagar, 2013), like Performance Pyramid System (Lynch and Cross 1991) or the Balanced Scorecard (Kaplan and Norton 1992, 1996). The latter became very popular because it considered both financial and non-financial measures (Choong, 2013; CIMA, 2009).

Concurrently, with the advanced information technology, supporting software tools for performance measurement appeared on the market; many software suppliers sold their products asserting that they help companies evaluating the effective performance of their management. However a survey we made on theoretical proposals in research on the one side, compared to available tools on the market on the other side, revealed that a wide gap existed between the techniques supported by those tools and the performance measurement models and frameworks elaborated by researchers. Hence the objectives of this paper are:

– present this survey that analyses both academic researches and supporting software tools in the domain of performance measurement management,

– Make a cross-case analysis of the "fitting rates" between "features" that the academic research is presenting and "features" that software vendors are delivering.

Section 2 reviews the literature on performance measurement models and frameworks. Section 3 presents the survey on software supporting tools. Section 4 makes a cross-case analysis between academic research and IT software functions.

2. LITERATURE REVIEW ON PERFORMANCE MEASUREMENT MANAGEMENT

Performance measurement has its long history that dates back to the early nineteenth century. In its recent history, we identify two important periods, 1989-2001 and 2002-present when 1989 corresponds to the birth of integrated Performance Measurement Matrix (Keegan et al. 1989) and 2002 to a broad diversification of PMSs.

2.1 Performance measurement systems (1989-2001): a turnover—addressing the balance between financial and non-financial measures

Since the late 1980's, performance measurement has experienced a great turnover. The main stake was addressing the need for a balance between financial and non-financial measures (Giannopoulos, 2013; Edson et al. 2013). Developing a better integrated and more relevant strategy oriented and dynamic performance measurement systems became a recurrent goal in the field. In this period, most of the results are model bound and are presented as comprehensive performance measurement systems (PMSs). Among the most successful ones, this paper analyses and

compares 6 classical PMSs: Performance Measurement Matrix (Keegan et al. 1989), Performance Pyramid System (Lynch and Cross 1991), Result and Determinants Framework (Fitzgerald et al. 1991; Fitzgerald and Moon 1996), Balanced Scorecard (Kaplan and Norton 1992, 1996), Dynamic Performance Measurement System (Bititci, Trevor and Begemann, 2000) and Performance Prism (Neely et al. 2001). The perspectives and the characteristics of these PMSs are summarized in table 1.

Table 1 Towards a balance between financial and non-financial measures- Classical PMSs (1989-2001)

PMSs: classical Performance Measurement Systems (1989-2001): a turnover—addressing the need for a balance between financial and non-financial measures; Better integrated performance measurement systems						
Name of PMSs models and framework	**PPM**: Performance Measurement Matrix	**PPS**: Performance Pyramid System	**RDF**: Result and Determinants Framework	**BSC**: Balanced Scorecard	**DPMS**: Dynamic PMS	**PP**: Performance Prism
Perspectives	External/cost; External/non-cost; Internal/cost; Internal/non-cost	Vision; Market, Financial; Customer Satisfaction, Flexibility, Productivity; Quality, Delivery, Cycle time, Waste	Results-- competitiveness, financial performance; Determinants-- quality, flexibility, resources, and innovation	Financial perspective; Internal business perspective; Innovation/learning perspective; Customer perspective	An external monitoring system; An internal monitoring system; A review system; An internal deployment system	Stakeholder satisfaction; Strategies; Processes; Capabilities; Stakeholder contribution
Main pillars	1.Performance measures must be derived from strategy; 2.Performance measures integrated vertically and horizontally; 3.Performance measures supporting the multidimensional environment; 4. Performance measures based on cost relationships and behavior.	1.Putting corporate vision in focus; 2. Linking corporate strategy to operation; 3. Ensuring correct direction by the vertical and horizontal alignments.	1. Incorporating that results are lagging indicators; 2.Determinants are leading indicators; 3. Defining carefully the performance indicators needed to achieve the performance objective.	1. The balanced scorecard is based on four perspectives surrounding the company's vision and strategy; 2. No pre-defined measures, measures rely on cases; 3. Goals and measures are bounding together.	1. Adopt a broader definition for performance measurement; 2. A control loop to include corrective action; 3. Numerous interrelated performance measures; 4. Review mechanism.	1. Identify stakeholders; 2.Make the strategies to satisfy stakeholders; 3.Put the processes in place to deliver the strategies; 4. Identify capabilities to operate processes; 5. Propose the want and need from stakeholders.
Common characteristics	Balanced, integrated, strategy-oriented, multi-perspectives, dynamic and stakeholder focus					

2.2 Performance measurement systems (2002-present): Towards a broad diversification of methods for performance management

After the integrated and balanced CPMSs, it seems that broader avenues for this domain were opened by researchers since 2002. Researchers from different disciplines have brought fresh blood into the PMS research by blending the methods of system dynamic, total quality management, supply chain management and so on into the traditional PMSs. In this trend, several different directions are identified: BSC-related approaches, Visual Performance Measurement Systems (VPMS), Project Performance Measurement Systems (PPMSs), Supply-Chain Performance Measurement Management (SCPMM), Quantitative Models for PMSs (QM-PMSs), PMSs for SMEs, and IT-PMS implementation (see table 2), and some general characteristics can be found:

1) Multi-crossed disciplines. Many methods and theories of other disciplines are brought to extend the performance measurement and management.

2) Toward case-analysis. Researchers present their PMSs by a more empirical analysis with the combination of quantitative and qualitative methods.

3) Extend and go beyond the traditional BSC framework. Traditional BSC model has presented some shortcomings when implemented in enterprise environment during a decade, some researchers emphasized to extend and go beyond the BSC approaches.

4) Collaborate between academic and practice for "knowledge transfer". Researchers owning management consulting enterprises have proposed their concepts of performance measurement and concurrently developed a supporting performance software with case company for completing it (Busi and Strandhagen, 2004); however, there are others who haven't designed their software in their researches, shifting the challenge from designing an expensive intra-software to buying a commoditized, high quality and inexpensive model from software vendors (Meekings, Povey and Neely, 2009).

Table 2 Towards performance management with the diversification (2002-present)

PMSs: Performance Measurement Systems (2002-present): Towards performance management; "knowing-doing framework"; Inter-organizational performance measurement; quantitative research; PMSs for SMEs		
Directions	Main contributions	Characteristics

BSC-related approaches	BSC-TQM	Kanji's business scorecard: Kanji and Sá (2002)	It integrates the total quality management principles and critical success factors with the BSC model.
		TQM–BSC Linkage: Hoque (2003)	TQM–BSC linkages; TQM–BSC linkage issues matrix;
	Beyond-BSC	Dynamic multi-dimensional performance framework: Maltz et al (2003)	It breaks the limitation of BSC and takes five dimensions into the framework: Financial performances; Market/customer; Process; People development; Future.
	BSC-SDM	System dynamics-based balanced scorecard: Barnabe (2011)	Matching the dynamics principles with the BSC framework
		Proactive balanced scorecard: Chytas et al. (2011)	It has used fuzzy cognitive map and simulation to improve the implementation of BSC framework
	BSC-SCM	A balanced scorecard approach for supply chain performance: Bhagwat and Sharma (2007)	It considered the use of a BSC framework to measure and evaluate SCM with specific metrics for each of the perspectives;
Visual Performance Measurement Management (VPMM)		Visual strategy and performance measurement techniques for organizations: Bititci, Cocca and Ates, (2015)	End-to-end visual strategy and performance management approaches are proposed to case companies and are found effective.
		Visual management function identification: Tezel, Koskela and Tzortzopoulos (2009)	Based on the Identification of main functions of visual management in different disciplines, an idea of completing a visual management framework for construction organizations is proposed.
Project Performance Measurement Systems (PPMSs)		A multi-dimensional project performance measurement system: Lauras, Marques and Gourc (2010)	It focused on 3 particular axes for the analysis of project performance: project task, performance indicator categories, and a breakdown of the performance triptych (effectiveness, efficiency, relevance).
Supply-Chain Performance Measurement Management (SCPMM)		A framework for supply chain performance measurement: Gunasekaran, Patel and Mc Gaughey (2004)	It considers the four major supply chain activities: plan, source, make/assemble, and deliver); every activity consists of metrics classified at strategic, tactical and operational.
		Green supply chain management on performance: Green Jr et al. (2012)	A comprehensive GSCM practices performance model is proposed and empirically assessed;
PMSs in SMEs		Key contingency factors for PMS in SMEs: Garengo and Bititci (2007)	Corporate governance structure, advanced information practices, a change in a firm's business model and an authoritative management style are four key contingency factors for PMS in SMEs.
Quantitative Models for PMSs (QM-PMSs)		Performance improvement based on a Choquet integral aggregation: Berrah, Mauris and Montmain (2008)	It designed a method for quantifying the causal relationship between the various criteria based on a Choquet integral aggregation operator.
IT-PMS implementation		Monitoring extended enterprise operations using KPIs and a performance dashboard: Busi and Strandhagen (2004)	It combined the concepts of KPIs, dashboards, and ICT to support extended enterprise performance management self-developed software.
		Performance plumbing: Meekings, Povey and Neely (2009)	It includes 4 key elements-performance architecture, performance insights; performance focus and performance action with Suggesting Commodity software for supporting the implementation of performance measurement framework.

3. SUPPORTING SOFTWARE TOOLS SURVEY

According to the Balanced Scorecard Institute (BSI), there are over a hundred balanced scorecard and/or performance management automation development companies (BSI, 2015). Several options have no dedications and develop IT-PMSs with general utilization. Some of the options are dedicated to performance management for certain departments or industries. Others develop specifically tools which are primarily designed for specific engineering, for example, systems engineering. □

We have thus chosen to distinguish several criteria in our survey: PMS with general utilization", "Dedicated to specific management" (such as project management, asset management; supply chain performance management), "dedicated to specific Engineering" (for example Systems Engineering). Getting through hundreds of software vendors websites, we have selected 6 software vendors for "PMS with general utilization", 4 for "dedicated to specific management", and 3 for "dedicated to specific Engineering" which have common characteristics of popularity and professionalization for software development.

Table 3 Supporting software tools for performance measurement

Support types	Software/ Enterprise/ Users	About KPIs/ Visual tools and functions	Modules and Main features
General utilization	Cognot BI/ IBM/ Every level of employees	KPIs-based/ Scorecards and strategy maps	Its Metric Studio provides a comprehensive performance monitoring.
	BSC designer/ Top-managers and CEOs	KPIs-based Leading indicators and lagging indicators/ Strategy map and Balanced scorecard with alerts function; □	Strategy map design; KPIs design; Track strategy execution and monitor current performance with KPIs; Cascading scorecards by business goals or by KPIs.
	Necto /Panorama/ Inter-and intra-organization	No reference about KPIs/ Dashboards & simplified infographics with alerts function and easily connected to multiple data sources;	Collaborating and sharing knowledge (integration); Data discovery and analytics; Creating a workboard; Automated tools to share insights and alerts.
	Signalsfromnoise/ Lightfoot/ Front-line staff; Supervisors; Managers.	No reference about KPIs/ Intuitive *sfn* dashboards and SPC chart format with alerts function;□	Easy installation; flexibility to extend and add data sources from providers along with a service journey; availability across the whole organization; easy integration with multiple operational systems; up-to-the-minute information.

	Visual KPI/TRANSPARA/ Decision makers, Executives; Operations	A go-to rapid prototyping tool for testing KPIs/ Dashboards with alerts & analytics function;	Designed for real-time operations; Find problems before they find you; Lightweight analytics on your phone; using the Microsoft Excel-based Visual KPI Designer and focusing on rapid prototyping and changes.
	EPM Suite/ Corporater business in control/all levels of the organization	highly flexible and powerful metrics management functionality/ Dashboards	Dashboards and KPIs; Strategic Initiative & Projects; Budgeting and Planning; Performance Reporting.
Dedicated to specific management	QuickScore /Spider strategies/ No referred	It helps find metrics and KPIs flexibly/ Dashboards	Create beautiful strategy maps; Scoring your metrics; Many ways to update; Instant aggregation; Calculated metrics; Track goals over time.
	Maximo asset management /IBM/ Asset management	No reference about KPIs/ Dashboard	6 modules: asset, work, service, contract, materials, and procurement management.
	Cognos Supply Chain Performance Procurement Analytics(SCPPA) /IBM/ Supply chain management	It measures supplier performance across a range of KPIs/ Dashboard	Analyze spending to ensure goods are purchased from cost-effective sources; Analyse buying patterns, deliveries and how well different suppliers respond to your needs; Compare supply chain needs to sales trends and future product plans.
	Quickbrain/ CRAZYLOG/ Plant Life Cycle Management	No reference about KPIs/ Screenshots and Smart-drawings with Pack e-CMMS and Pack e-DMS.	10 modules: DOC; MAINT; COMS; EVENT; STOCK; ILS; BI; DRAW-E; PID-SCAN; Screenshots.
Dedicated to specific Engineering	Squore/Squoring/ Project managers; Systems engineers	It provides KPIs or integrate existed KPIs in enterprises/ Squore decision-making dashboard; Software and systems project management dashboards;	"Custom"--Help define KPIs; "technical debt"—optimize the quality of software development; "acceptance"—secure and rationalize acceptance processes; "automotive"—manage embedded systems projects; Systems engineering—manage the performance of systems engineering projects.
	Ajera /Deltek/ Project managers and Accountants	Ajera dashboards (no alert function)	role-based: For a principal—improve profit margins; For department manager—improve visibility and decision making; For project manager—manage client relationships; For controller—increase department efficiency.
	arKItect /Knowledge Inside/ Systems engineer	A graphic editor	2 products: SEA and Designer. SEA offers an easy-to-use environment for modeling multi-disciplinary systems and specifications and work products; ArKItect Designer can customize the tool according to customer own needs.

With the diversification of functions in tools, we felt concerned by the question "whether the performance of them delivered the same values resulting of academic research of performance measurement?". In the following section, we do a cross-case analysis to answer it.

4. CROSS-CASES ANALYSIS BETWEEN ACADEMIC RESEARCH AND ITS SOFTWARE FUNCTIONS

For doing the cross-case analysis, we chose 13 software vendors classified as "PMS with general utilization", "Dedicated to specific management", and "dedicated to specific Engineering" as analysis objectives in the vertical columns (see table 3). As for the characteristics of academic researches, we have chosen respectively some common and specific characteristics from the two different periods of performance measurement models and frameworks as analysis indicators to measure the fitting between academic and practice. In the period of Classical Performance Measurement Systems (1989-2002), there are some common focuses including balanced, integrated, strategy-relevance, and multi-perspectives; concurrently the characteristics of dynamic and stakeholder-focus are specifically referred in certain researches (Bititci, Trevor and Begemann, 2000; Neely et al. 2001) (see table 1). In the second generation of PM models and frameworks (2002-present), we have chosen 6 main different development directions with an important common characteristic of "KPIs-based" and a meaningful characteristic of "connected to multiple data sources" as analysis indicators (see table 2).

(1) Fitting rate analysis

With the fitting process completed in table 4, we find that academic results of performance measurement models and frameworks have gotten different focus in the practices of IT supporting software development. Some characteristics commonly stressed in academic like "balanced", "strategy relevant" and "integrated" are not receiving the attention of software vendors; inversely some not well-referred concepts like "connected to multiple data sources" and "visualization" have received 100% stress in the sample software tools. It seems that software development has advanced a little more in some aspects than academic research. See table 5.

Table 5 Fitting rates analysis between software tools and academic researches

Characteristics	Fitting rates
Multi-perspectives; Connected to Multiple data sources; VPMM; KPIs-based.	High fitting rates (≥ 60%)
Balanced; integrated; strategy-relevant; stakeholders focus; Dynamic; PPMS; SCPMM; QM-PMSs; PMSs for SMEs.	Low fitting rates (<60%)

(2) Unbalanced analysis among performance measurement models and frameworks

Firstly, for several classical PMSs, only the Balanced scorecard has been used across the world, whereas many other frameworks have tended only to have regional appeal, many vendors developed their software tools for supporting enterprise performance measurement with consideration of famous scorecard, but ignoring the advantages of other PMSs; as a result, developed software tools based on balanced scorecard exposed some disadvantages because of

Table 4 the mapping of the academic research on performance measurement and supporting software tools

Analysis objects / Analysis indicators		CPMSs: Classical Performance Measurement Systems (1989-2002)						PMSs: Performance Measurement Systems (2002-present): Towards performance management							
		Common characteristics				Specific characteristics		Different research directions						characteristics	
														Common	Specific
Subjects	Software	Ba.	In.	St.-re.	Multi-pe.	St. fo.	Dyn.	BSC-related	VP-MM	PP-MS	SC-PM-M	QM PM Ss	PMSs for SMEs	KPIs-based	CM.
General utilization	Cognot BI	✓	✓	✓	✓				✓					✓	✓
	BSC designer	✓	✓	✓	✓			✓	✓				✓	✓	✓
	Necto		✓		✓				✓					✓	✓
	Signalsfromnoise		✓		✓				✓						✓
	Visual KPIs								✓					✓	✓
	EPM Suite	✓	✓	✓	✓			✓	✓		✓			✓	
Dedicated to specific management	QuickScore	✓		✓	✓			✓	✓				✓	✓	
	Cognos SCPPA										✓			✓	✓
	Maximo Asset management								✓						✓
	Quickbrain				✓				✓				✓		✓
Dedicated to specific engineering	Squore		✓		✓				✓	✓				✓	✓
	Ajera		✓		✓				✓	✓				✓	✓
	arKItect				✓				✓	✓					✓
Fitting rate		30%	54%	30%	91%	0	0	22%	100%	44%	11%	0	22%	70%	100%
Notes: Ba. refers to Balanced; In. for integrated; St-re. is for strategy-relevance; Multi-pe. is for multi-perspectives; St. fo. is for stakeholders focus; Dyn. for Dynamic.															

the weakness of the scorecard—which is conceptualized as a tool for controlling for senior managers and not as an improvement tool for factory operation levels and for example, and inadequate instructions on how proper measures can be identified and initiated, and lacking a competitor perspective□

Secondly, "Performance measures must be derived from strategy" dominated the direction of relevant software development; however the PRISM proposed by some scholars (Neely et al. 2001), has denied the traditional opinion that measures should be derived from strategy, instead, he thought that the starting point should be "who are the stakeholders and do they want and need?"; but his proposal has not been followed by main software vendors. Similarly, DPMS model (Bititci, Trevor and Begemann, 2000) has identified that current knowledge and techniques are sufficiently mature to create the DPMS, however, no software vendors who are trying this idea.□

Thirdly, the classical PMS—Balanced Scorecard (Kaplan and Norton 1992, 1996), provoked to minimize information overload by limiting the number of measures used. It keeps adding new measures whenever an employee or a consultant makes a good suggestion, force managers to focus on the handful of measures that are most critical; however, in the market of SCORECARD, the vendors and developers did not focus the critical measures, even though they proposed to use KPIs, but which seemingly are disparate and larger elements.

Is there an opportunity to change our academic language to make it more aligned with that of the industry? Is it an issue that software vendors evolve to integrate advances in research? The way how researchers communicate scientific results to those who could benefit from applying them is considerably important. In the domain of performance measurement for enterprise management, it seems that the software vendors are playing the roles of transferring scientific results into industrial department; they contribute to advance the applicable development of performance measurement theories. However, from our analysis results, it's obvious that the software vendors are not delivering completely true values of academic researches into industries with segmentary and limited understanding about the theoretical results. It is necessary to reconsider the construction of communication mechanism between academic and practitioners. Some issues can be considered in further: 1) the "black box" exists in the relationship between the software vendors and scholars; for more part, the researchers don't develop their frameworks into software tools, and when the software vendors try to develop some supporting software tools, have they really considered all important aspects from scientific results? 2) Communication mechanism among companies, vendors, and scholars: in this tri-roles relationship, the vendors play an important role in promoting the transfer of scientific results; in this paper, even though the fitting between enterprises and vendors, enterprises and scholars are not considered, it is very important to do a further survey about it.□

5. CONCLUSION

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