Visualization techniques supporting performance measurement system development

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Structured abstract:

Purpose

This paper aims to understand how performance measurement system development process can be supported by visualization techniques. It analyses the suitability of different visualization techniques in the tasks needed in designing, implementing and using performance measurement.

Design/methodology/approach

The research builds upon literature review and analysis. The empirical access to five recent performance measurement system development projects is also utilized in order to evaluate the applicability of visualization techniques. The emphasis is in information visualization and the following techniques are examined: maps, diagrams, networks, visualized models, graphs, charts and dashboards.

Findings

The study provides a concise overview on visualization techniques highlighting the managerial tasks related to performance measurement system development process. It contributes as a discussion opener inviting more academicians to study the topic of visualization in management and to further test and broaden the proposals presented in the paper.

Research limitations

Further in-depth empirical research is needed regarding each phase of performance measurement development process. A further study could also stress more the proactive use of performance measurement paying attention also to the external environment.

Practical implications

The topic of information visualization is practically-driven. The results support practitioners in evaluating and choosing visualization techniques supporting their timely challenges in the performance measurement development.

Originality/value

Few studies on information visualization have been carried out in the context of management science. Visualization can integrate human in the data exploration process and improve understanding over large data sets without complex quantitative methods. Visualization techniques have been proposed as powerful means to enhance the effectiveness of performance measurement. This study structures and clarifies the ambiguous topic of visualization and performance management and suggests areas for further research.

Keywords: performance information, performance measurement system, performance management, strategy implementation, strategy map, visualization

Article classification: research paper

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1. Introduction

There is a lot of indication that the potential of performance measurement systems (PMS) is rarely exploited in practice (Bourne et al., 2005). The logic of PMSs, e.g. underlying cause and effect chains can be unclear. Measurement results are possibly not communicated properly (Jääskeläinen and Sillanpää, 2013). Since lots of performance information is available, overall picture is easily lost.

Visualization techniques can be powerful means to address the abovementioned challenges. Visualization concerns the representation of data, information and knowledge in a graphic way in order to gain insights, draw conclusions, develop an elaborate understanding or communicate experiences (Lenger and Eppler, 2007). Visualization can accelerate perception, e.g. by combining and structuring data (Chen, 2004). It can be used to improve understanding over large data sets without complex quantitative methods. Well-designed visual representations can replace calculations with simple perceptual interpretations and improve comprehension, memory, and decision making (Heer et al., 2010). Visualization integrates human in the data exploration process (Keim, 2002). In addition, visualization can help to overcome the dominant logic of the firm by challenging self-imposed limitations (Platts and Hua 2004).

Despite the clear potential, still quite few visualization methods are used in management (Lengler and Eppler, 2007). While visualization has been studied in several fields such as information management and strategic management, few successful stories have been published so far (Zhu and Chen, 2008). Visualization has been often studied in a laboratory-like setting without specified context of application. Visualization has recently gained increasing attention also in the field of performance measurement (Cocca et al., 2012). However, the topic is still quite and ambiguous new in the field. Visualization is easily perceived almost as synonymous to dashboards. Performance dashboards are an all-inclusive package of different visualization techniques and there is indication of their positive business impacts (Yigitbasioglu and Velcu, 2012). However, visualization regarding PMS is much more than just designing impressive dashboards (Chiang, 2011).

This paper *aims to understand how a PMS development process can be supported by visualization techniques*. The literature provides only a few examples of visual tools employed at different stages of the process (Cocca et al., 2012) which each include slightly different managerial tasks and arguably different visualization forms (cf. Yigitbasioglu and Velcu, 2012; Zhu and Chen, 2008). The explorative approach of the paper intends to provide more structured understanding on the roles and opportunities of visualization techniques in the field of performance measurement. The topic has previously been rather practically-driven and this study intends to facilitate academic debate. Thus, the secondary objective is to bind the current knowledge around the topic which has been argued to remain localized in narrow research areas (cf. Cocca et al., 2012). The research is based on literature review and analysis regarding different visualization techniques and characteristics of functional PMS development. The reviewed techniques and their potential is analyzed in light of tasks and capabilities required in designing, implementing and using PMSs. Five empirical cases are also utilized to discuss and illustrate the findings.

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2. Literature review: visualizations techniques and their characteristics

There are many ways to classify visualization techniques. Lengler and Eppler (2007) distinguish data visualization and information visualization. Data visualization includes pie charts, histograms, tables etc. Information visualization refers to exploring, comparison and classification of data. Keim (2002) discusses dynamic and interactive visualization, depending on whether the changes to the visualizations are made automatically (dynamic) or manually by direct user interaction (interactive). Dynamic visualization may mean, e.g. the automatic updating of figures based on most recent results. Examples of user interaction is drilling down or filtering measurement results. The scope of different visualization techniques is described next with a classification differentiating two different forms of visualizations often linked to the managerial context. The third form of visualizations highlights the combination of different techniques in the form of managerial dashboards commonly discussed in relation to performance measurement systems.

Maps, networks and visualized managerial models

Various kinds of maps have been used to visualize strategy. Performance information can also be organized into hierarchies which can be efficiency captured by map visualizations. Most common map in the field of performance measurement is the strategy map popularized by Kaplan and Norton (1996). It describes the linkages between measurement objects driving the strategy of an organization. There are positive experiences of strategy maps, which supplement PMSs and increase attention paid to key performance indicators (KPI) (Banker et al., 2004). Roadmapping is also used in management to improve communication and implement strategy (Kernbach and Eppler, 2010). It has been argued to have at least two advantages (Platts and Hua, 2004): it reduces the complexity of abstract concepts and it illustrates and explains causal relationships (similarly to strategy map).

Organizations consist and are highly dependent of complex social actor networks. Analysis of such networks is beneficial, e.g. in making hiring decisions, optimizing the flow of information among employees and facilitating innovations from the social networks of staff. Visualization is increasingly used to describe these networks and interpret structural components such as centrality, betweenness, and structural similarity. Network maps typically present social network data through node-link format. (Zhu et al., 2010) One challenge in network mapping is that such maps are often drawn upon data reflecting one point in a time. However, network mapping has a lot of potential in facilitating the use of data from external sources (e.g. social media). (Huhtamäki et al., 2012) This enables novel approaches to performance measurement necessary, e.g. in marketing purposes.

Visualization is also a way to illustrate managerial concepts and models. It can be efficient in promoting new ideas and in making them more scientific. As an example, visualization has had an important role in promoting the claims of the Balanced Scorecard (BSC). One of the advantages of visualized managerial models is the allowing of multiple interpretations of the same image giving flexibility to the presented ideas. (Free and Qu, 2011)

Graphs and charts

Graphs, charts and similar visualization forms are good examples of functional visualization (Chen, 2004) highlighting the ease of using information more than affecting the mind of interpreter. These visualizations are common in statistics and there is already a lot of knowledge on their applicability in different data forms and data combinations.

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A line chart or line graph displays information as a series of data points connected by straight line segments. It is a basic visualization common in many fields and powerful in providing an overall view of the entire data set. When considering time-series data, the ability of graphs to present relative changes is often valued, since raw values are less important. Time-series data may also be aggregated. A stacked or stream graph is a visual summation of time-series values and often supports drill-down into a subset of individual series. (Heer et al. 2010)

Bar chart (and column chart) is often used in emphasizing individual values, rather than overall trends. It is useful in comparing items with few categories (Abela, 2009). Scaling is sometimes regarded as its drawback. If the value scale does not begin from the zero, interpretations may be misleading. Histogram is similar to bar chart and has been regarded as a decent way to describe distributions (Heer et al., 2010).

Dashboards and other PMS visualizations

Visualization in connection to performance measurement is easily perceived as designing management dashboards. Chiang (2011) defines a dashboard as a visualization presenting all the necessary information in a space fitting into computer screen. It presents all the KPIs and enables interactive use, e.g. drilling down measurement results. Visualization is also dynamic and is updated automatically with software. Dashboards combine different visualization techniques and are often consisted of simplistic visualization forms such as traffic lights and gauges. Even though the visualization of dashboards is to some extent interactive, the underlying data does not necessary satisfy ad-hoc managerial information needs.

Dashboards can be designed for different purposes such as strategic, operative and analytical (Cocca et al. 2012). Schmidt (2005) argues that the dashboard approach is a logical development of the use of BSC. It makes PMSs more flexible and automates the costly and time-consuming data preparation inherent in BSC. Pauwels et al. (2009) regard that dashboards can complement traditional BSC approach by facilitating the analysis of external environment such as competitors. Dashboards are usually expected to collect, summarize, and present information from multiple sources such as legacy, ERP, and BI software (Yigitbasioglu and Velcu, 2012). Pauwels et al. (2009) regard that a dashboard provides a common organizing framework for data, which is obtained from diverse sources, organizational levels and time periods. Dashboard allows different executives in different departments and locations to share the same information from their own viewpoints.

It is notable that very few academic studies can be found on the topic of dashboard design. In addition, many earlier studies have concentrated on the technical aspects (Yigitbasioglu and Velcu, 2012) of design leaving managerial perspective with less attention. A quite widely applied and reported method for combining measurement information from different sources for managerial purposes is performance matrix or objectives matrix (see Figure 1).

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	Unit cost of calculated care day, €	Percentage of customers with deteriorating condition	Average number of customers per number of employees	Degree of utilisation of premises, %	Rate of short sickness absences, %
Measurement result	**15,50**	**4**	**0,55**	**100**	**3,6**
10	12	0	0,28	100	3
9	12,5	1	0,29	99,9	3,2
8	13	2	0,3	99,7	3,4
7	14	4	0,31	99,5	3,7
6	15	6	0,34	99	4
5	16	8	0,37	97	4,5
4	17	10	0,4	95	5
3	19	13	0,5	92,5	6
2	21	16	0,6	90	7
1	23	20	0,7	85	8
0	25	25	0,8	80	10
Score	5	7	2	10	7
Weight	45	15	15	15	10
Weighted score	225	105	30	150	70
Total score	580				

Figure 1: Illustration of the matrix-based visualization

Objectives matrix utilizes a set of performance measures to compose a single measurement result. Every measure has its own weight (0-10) in the calculations. In a traditional application of the matrix, the expected values of different measures are scaled in order to produce a score from 0 to 10 for each measure. By first multiplying the score of each measure by the weights and then summing up the results, the matrix produces a total score from 0 to 100. The disadvantage of the method in comparison to modern dashboards is that it is not interactive as such.

3. Research structure and methodology

This study intends to examine information visualization supporting managerial requirements in PMS development process and pays less attention to data visualization, more common in statistics. The structure of this study follows the common phasing of the development of PMSs which includes design, implementation and use of systems (Neely et al., 2000). The following tasks and their information requirements are used as basis for analyzing the presented visualization techniques:

- Design (e.g. understanding cause-effect relationships between measurement objects, communicating strategy)
- Implementation (e.g. influencing and informing key stakeholders)
- Use (e.g. communicating and analyzing measurement results)

The update phase of performance measurement process is excluded from the analysis, since it repeats the features of previous three phases. There are two key aspects that can be examined in the implementation of PMS: technical and social (e.g. Jääskeläinen and Sillanpää, 2013). This study concentrates on the latter aspect. In the case of use phase, this study concentrates solely on three distinguishing comparative tasks in performance management: trend analysis (comparison to previous results), benchmarking (comparing results from other similar organizations or units) and goal analysis (comparison to defined target levels). This choice relates to a further focusing decision of examining recurring managerial usage of performance

information. Therefore, ad-hoc information needs possibly utilizing measurement information are not included in this study. It is also notable that in addition to the nature of managerial task, the applicability of different visualization forms is also dependent on the personality of interpreter. This aspect is not in the focus of this study.

It has been stated that interview and case studies could provide more in-depth understanding of the benefits of visualization techniques in real management settings (Zhu and Chen, 2008), since previous research has often been limited to very narrow laboratory-like experiments. This study has empirical access to five cases in which performance measurement was developed during 2007–2014. The case contexts and their development projects are described in more detail in the Appendix. The main aim of the projects was not to investigate applicability of different visualizations, but to develop measurement systems (or their usage) in general. The emphasis in these projects was more in satisfying managerial information needs with appropriately defined measures, than in designing information systems. The empirical data in the form of field notes, observations and firm-specific documentations gathered during around 70 workshops and training sessions is utilized in this study in order to illustrate and evaluate the applicability of visualization techniques, whenever appropriate. Since visualization techniques were not utilized in all the investigated tasks (especially PMS implementation) during the case projects, the analysis of suitable visualization techniques is complemented by literature review. Existing performance measurement literature is used to elaborate the tasks or characteristics related to the purposeful or mature design, implementation and use of PMSs.

4. Visualization and PMS development process

Designing of a PMS typically consists of discussion about drivers of strategy or success factors since measures should be aligned with strategy (Cocca and Alberti, 2010; Tung, 2011). Especially in large organizations, the overall picture of measurement objects is complex leading to challenges in actually implementing strategy at the operative level (Kernbach and Eppler, 2010). There should be means to address this problem. As a manager of a municipality (Case 1) put it:

- It is important that personnel understand the overall logic of a PMS and the linkages between strategic and operative of measurement.

Visualization can be useful in describing cause-effect relationships between measurement objects as well as illustrating the interconnections between actors, organizational levels and other organizational entities. Such visualizations can also provide means to challenge strategy (Grafton et al., 2010) and enable double-loop learning.

In the cases 1-3, map visualizations were widely regarded as beneficial in increasing the understanding of the phenomena to be measured. For example, the participants of measurement development workshops in the case 2 commented the presented maps as useful in understanding and prioritizing measures, as well as in analyzing the prevailing status of measurement, i.e. in which aspects there are no functional measures for the drivers of strategy (e.g. employee competencies). Figure 2 illustrates a map diagram used in the case 2. It is specifically focused on the drivers of productivity, a key success factor in that case.

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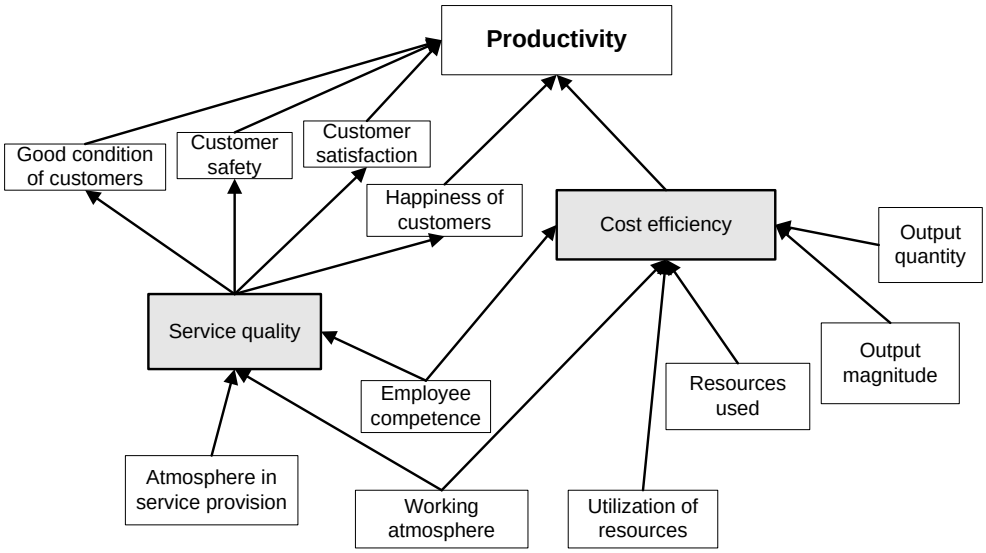

Figure 2 Map of different productivity affecting factors in case 2

Use of visualized measurement frameworks such as the BSC can provide a structured approach for defining measures (Van Aken et al., 2005) and assure the balance of a PMS (Cocca and Alberti, 2010). However, a formal measurement framework was only utilized in case 5, essentially due to the external requirements of the directive ministry. In the other cases, the perspectives of measurement were typically derived satisfyingly from the strategy without a specific measurement framework.

Understanding of causalities between measurement objects is necessary in successful design of PMSs (Cocca and Alberti, 2010; Van Aken et al., 2005). Tree diagrams can be useful in highlighting causalities but most notably in illustrating the sub-components of KPIs. In the case 3, a tree diagram (see Figure 3) was deemed useful in identifying the driver measures of cost-efficiency, which was one of the KPIs of the whole organization. The representatives of case 3 specifically valued that the diagram illustrated the drill-down possibilities in the planned information system.

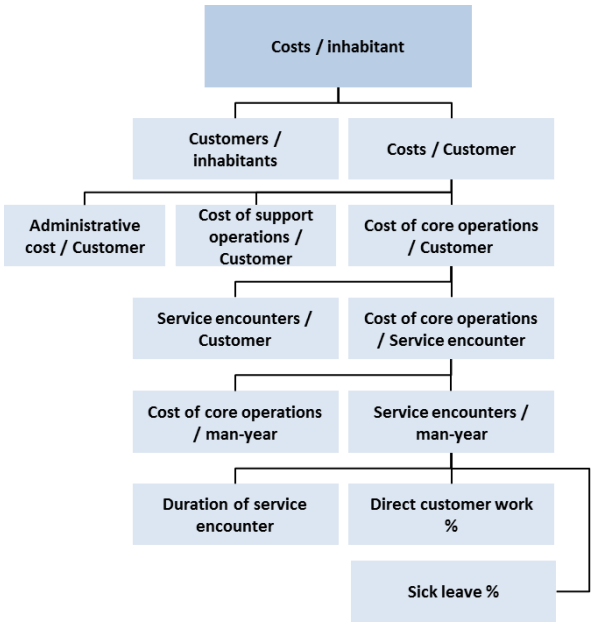

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Figure 3 Tree diagram in case 3

In addition to strategy maps in their conventional form, specific kinds of maps were successfully utilized in cases 1 and 3. In these maps, the managerial levels (e.g. operative, middle, top) with broader performance perspectives and their interconnections were illustrated. Such visualizations also supported the illustration of the synergies and co-operation of units and highlighted horizontal processes. Figure 4 illustrates the map drawn in case 1 which addresses three organizational levels and their proposed measurement-related interconnections both from the top-down and bottom-up. Specific kinds of arrows were used to indicate measures which are aggregated from the bottom-up.

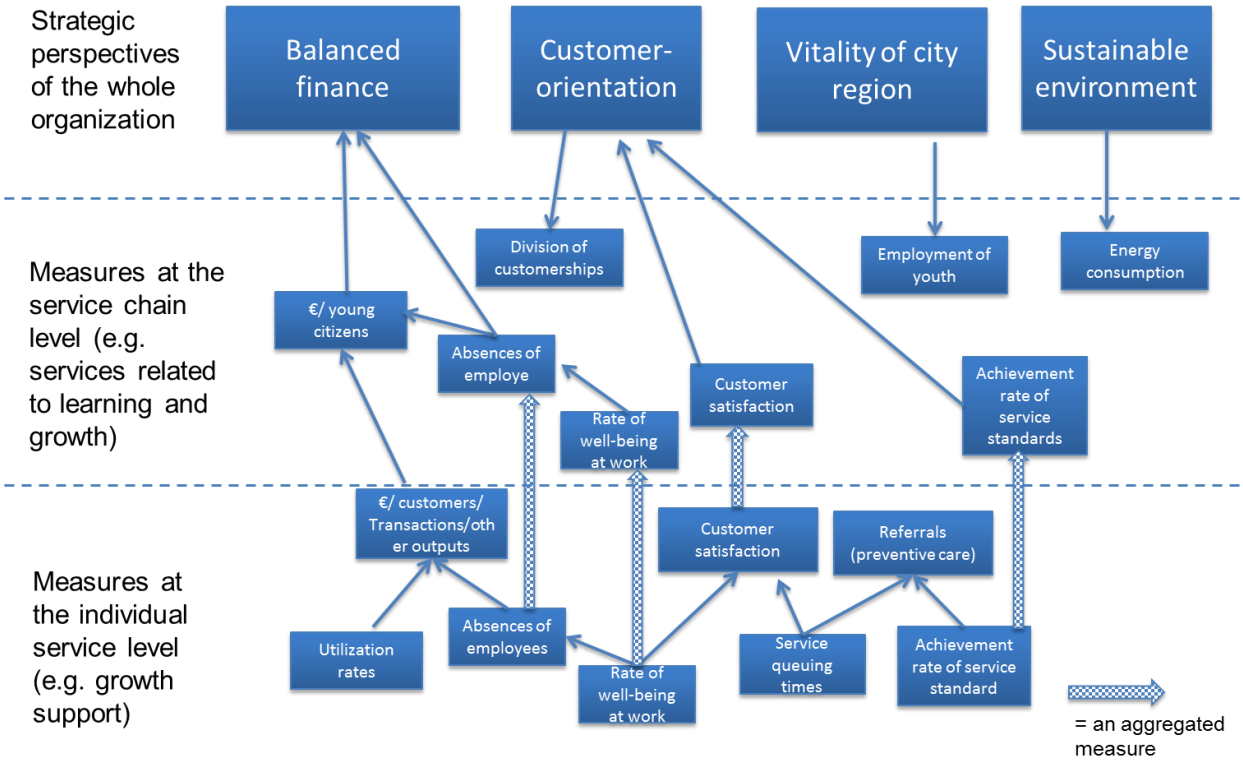

Figure 4 Strategy map in case 1

It has been suggested that a PMS should cover the key stakeholders (Cocca and Alberti, 2010) as well as all critical functions and work units in an organization (Van Aken et al., 2005). Map visualizations on organizational connections proved their potential in building bridges between the efforts of individual employees and the strategic success factors defined at the top organizational level. In addition, the representatives of cases 1 and 3 commented that the map visualizations were useful in avoiding overlapping between the PMSs of numerous organizational levels and units. This potentially facilitates the design of compact and managerially relevant PMSs for each examination level. However, there are also other possible visualizations that can be more powerful in highlighting this aspect in designing PMSs. It is proposed that actor network maps could be used to clarify the roles and interconnections between actors and organizational entities. This could be done before the actual defining of measurement objects and drawing a strategy map.

In the design phase, visualization appears to be most useful in defining and understanding what is measured while there is less support in the actual design of measures. It should also be noted that

visualizations are not prerequisite or guarantee of success. In any case, illustrations seem to support the communication of a desirable PMS structure.

Social **implementation** of a PMS is essentially dependent on the success of obtaining personnel commitment and managerial support (Cocca and Alberti, 2010; Tung, 2011). Measurement definitions should be clearly communicated to the employees (Van Aken et al., 2005). In the case 2, the above-described map visualizations were used in training purposes of new PMSs and they were perceived as equally useful in providing understanding of the overall logic of measurement during the implementation phase. Map visualizations focused attention on measurement objects and phenomena and their connections, which were perceived important in order to avoid confusion caused by technical measures and formulas.

Cross-functional representatives in the implementation work of PMSs have been suggested (Van Aken et al., 2005) meaning that the logic of PMSs should also be clarified to personnel not necessary familiar with accounting or strategic management. Consequently, communication deals not only with rational or logical aspects since resistance and prejudices towards measurement may be rooted more deeply in the organizational culture. Therefore, it is proposed that some kind of visual metaphors could be useful since they affect the mind and feelings of the interpreter. However, these kinds of visualizations were not used in the examined case development projects. According to Kernbach and Eppler, (2010), visual metaphors are an indirect way of communication since interpreter has to first mentally reconstruct the displayed visualization correctly. They can be used to transfer existing knowledge to new areas. Easily understandable visual metaphors are useful in transferring knowledge and they also help to remember and convey it (Eppler and Burkhard, 2007). Hence, they appear to be worth testing to support the implementation phase especially when participating employees are not familiar with performance measurement.

In the **use** phase, performance information is utilized in different managerial purposes. Since measurement results are not meaningful as such, various kinds of comparisons must be carried out. Comparison of measurement results between organizational entities supports in performance benchmarking (Najmi et al., 2005). The commonly used trend analysis of measurement results is useful in monitoring the past performance (Tung et al., 2011) and in analyzing the impacts of past decisions (Van Aken et al., 2005). Understanding on the gaps between set targets and achieved results is a way to identify needs for corrective actions (Grafton et al., 2010). All these analyses require different visualization techniques. In the case 2, comparison of results between organizational units was supported with bar charts highlighting individual values and their differences. Presentation of these charts to employees commonly started a discussion of differences between the operating environments, facilities and customer characteristics of the units and thereby facilitated the identification of means to improve performance.

Trends or time series have commonly been illustrated with graphs and there appears to be a common understanding of their functionality in such purpose. Graphs were used in cases 2 and 4 to illustrate the trend of measurement results in the period of five years. It appeared that the graphs condensing information were valued especially by the top managerial level as a comment by a director participating in case 4 illustrate:

- "These dashboard views should be complemented by graphs illustrating annual changes in results. Well-being at work does not change that much within a year. The visualizations should include comparisons of results to a specific base period of time."

When considering goal analysis or the comparison of measurement results against set objectives, traffic lights have been widely utilized as a part of managerial dashboards with promising results. Advantage of such visualization is that measurement results do not require constant monitoring. Only red light means that something needs to be done. However, it is notable that traffic lights are still a mean to monitor achieved results but not actually to plan the future. The representatives of case 5 regarded important to constantly monitor the achievement of target delivery times. They deemed a simplistic traffic light demonstrating the success in deliveries as the most essential and influential part of the measurement system.

Management dashboards are used to consolidate measurement information in standard reports (Yigitbasioglu and Velcu, 2012). Objectives matrix is a simple example of management dashboard which combines different analysis possibilities and condenses a lot of information to be seen at a glance. It was applied in the cases 2 and 4. In the case 2, comparison analysis was regarded as its key advantage. Similar units used similar matrices and unit managers actively compared and discussed their own measurement results. Matrix was also regarded to have 'built-in' target-orientation, since the visualization method describes which measurement results are regarded poor, average and good. Time series of total measurement scores was also monitored with a matrix. In case 4, conventional matrix visualization was complemented by describing comparisons to the higher organizational levels (see Figure 5) and the visualization is currently utilized by the organization for managing their human resources.

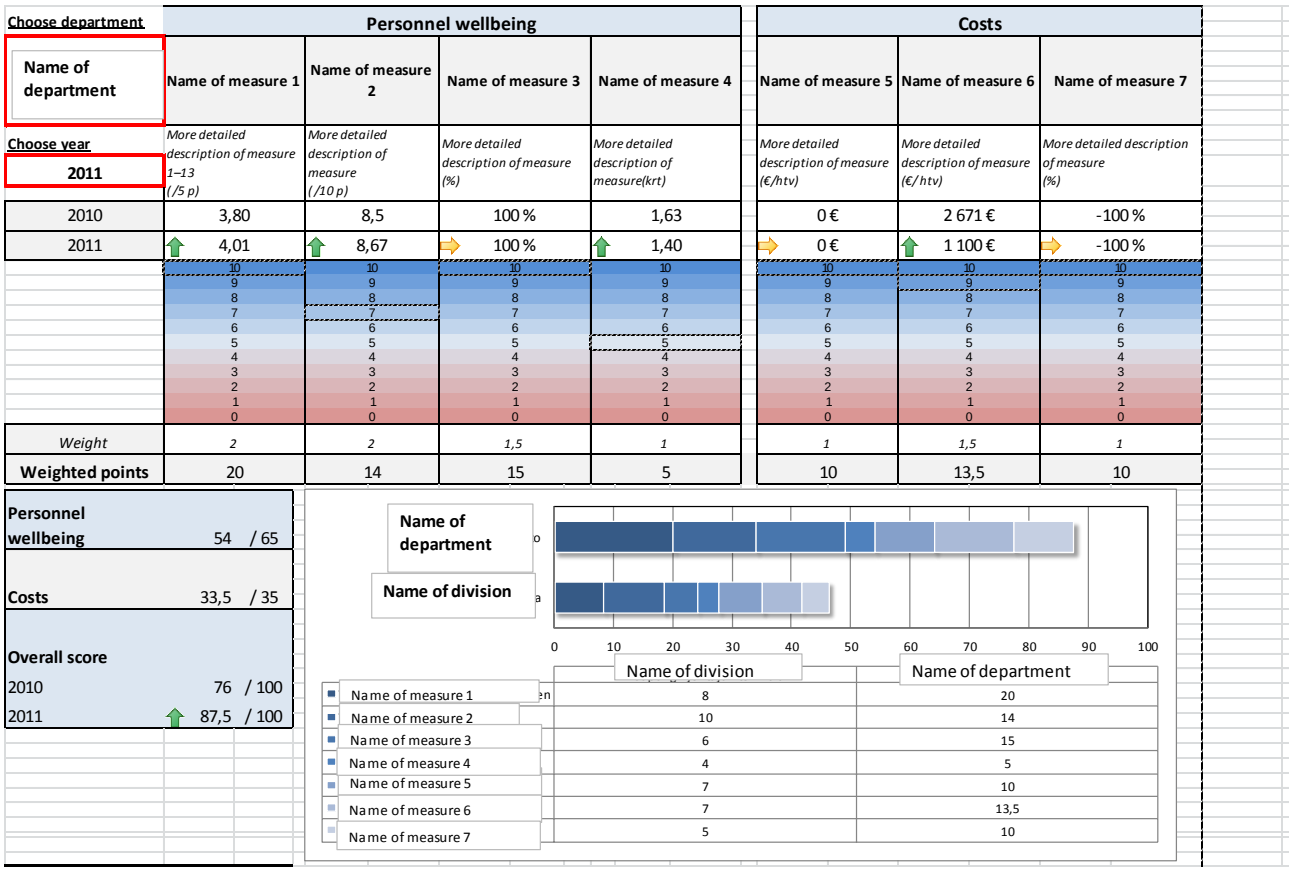

Figure 5: Matrix-based visualization in case 4

While the matrix method is static as such, most of the modern management dashboard solutions include interactive aspect which usually means that a software user has the possibility to drill down measurement results. It is notable that this may also affect the choice of measures. In the case 3, a modern software solution was intended to be purchased. This affected the decision to use similar measures (i.e. measures with the same component that can be summed) at different organizational levels in order to facilitate drilling down. Also earlier studies (Pauwels et al., 2009) have found that dashboards enforce consistency in measures across departments and business units.

One requirement for successful use of a PMS is that performance monitoring process is defined (Cocca and Alberti, 2010). In the case 4, visualization also played a role in the definition of managerial process around performance measures. In this purpose, visualization took the form of an annual clock including forums (e.g. executive group) with specified and recurring topics (e.g. target setting), and schedules. Figure 6 illustrates a working version of such visualization.

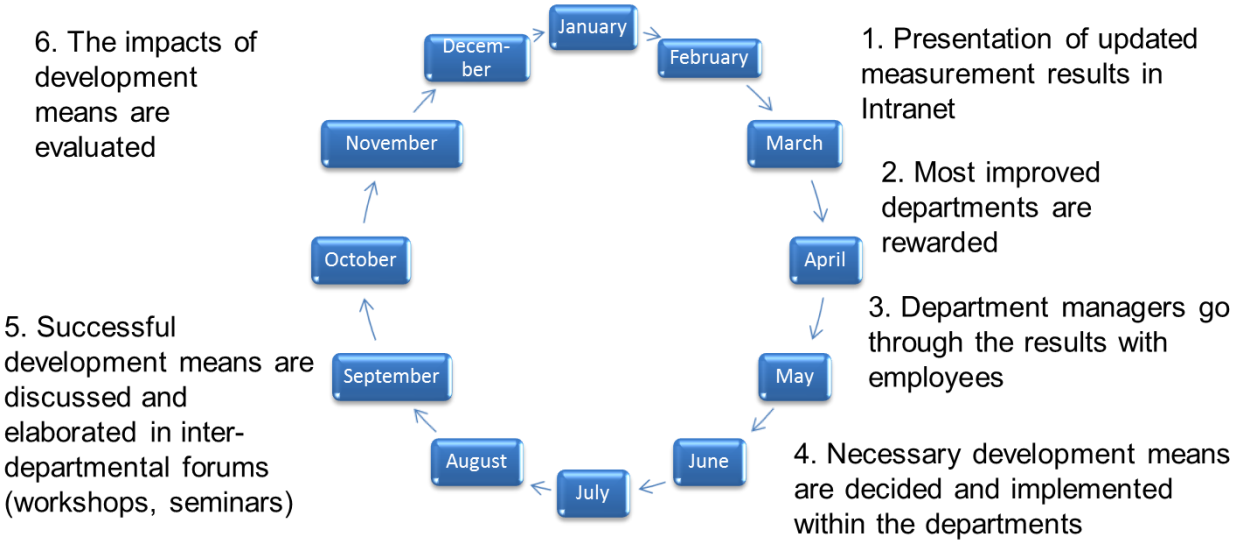

Figure 6: Illustration of performance management process in case 4

As the main result of this study, Table 1 summarizes the proposed use of visualization techniques in a PMS development process based on the results of this study. It describes the main empirical observations from the examined case contexts. Since not all of the potential visualizations were utilized in the cases, the proposals are also supported by PMS development phase-specific requirements obtained from the previous literature.

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Table 1 Proposed usage of visualization techniques supportive to PMS development process

Phase	Visualization technique	Empirical results on benefits in the phase	Phase-specific task or PMS requirement in the prior literature
Design	Strategy map	- Illustrates the cause and effect relationships between measurement objects or strategy driving success factors - Supports in evaluating the status of existing PMSs and in prioritizing measures - Enhances understanding on the role and relationships between internal organizational levels and units as well as external actors such as customers.	- Aligning of measures with strategy (Cocca and Alberti, 2010; Tung, 2011) - Ability of a PMS to challenge strategy (Grafton et al. 2010)
	Measurement framework, e.g. BSC	- N.A.	- Structured approach for defining measures (Van Aken et al., 2005) - Balancing measures (Cocca and Alberti, 2010)
	Tree diagram	- Supports in defining the driver measures of KPIs - Useful in demonstrating drill-down possibilities in information systems	- Defining proposed cause-effect relationships between measures (Cocca and Alberti, 2010; Van Aken et al., 2005)
	Actor network map	- N.A.	- PMS covering different stakeholders (Cocca and Alberti, 2010) - PMS covering all critical functions and work units in the organization (Van Aken et al., 2005)
Imple-mentation	Strategy map	- Enables comprehensible communication on the overall logic of measurement by concentrating on key success factors instead of technical formulas	- Clear communication of measurement definitions (Van Aken et al., 2005)
	Visual metaphor	- N.A.	- Obtaining personnel commitment and managerial support (Cocca and Alberti, 2010; Tung, 2011) - Involving cross-functional representatives in the implementation (Van Aken et al., 2005)
Use	Bar chart/column chart	- Supports comparison of measurement results between organizational units in order to identify more specified objects for development efforts (comparison analysis)	- Performance benchmarking to competitors or other counterparts (Najmi et al., 2005)
	Graph	- Supports in understanding trends over the period of several years (trend analysis) - Valued by top level decision-makers	- Tracking and monitoring of past performance (Tung et al., 2011) - Analysis of the impacts of past decisions (Van Aken et al., 2005)
	Traffic light	- Useful in understanding the achievement of key objectives	- Identification of needs for corrective actions (Grafton et al.,

		(goal analysis)	2010)
	Objectives matrix	- Provides an overall view and combines comparison, trend and goal analysis	- Availability of consolidated measurement information in standard reports (Yigitbasioglu and Velcu, 2012)
	Annual clock	- Illustrates the managerial process for utilizing the PMS	- Defining of the performance monitoring process (Cocca and Alberti, 2010)

5. Conclusions

The design of PMSs has been studied a lot and there is a wide understanding on the desired features of performance measurement. Visualization appears as a topical theme which has potential in increasing the effectiveness and benefits gained from PMSs. In this context, the topic of information visualization is notably practically-driven and there have been hardly any research publications on visualization supporting performance measurement development. Many different visualization forms are marketed and argued to be better than some other ones but few studies are supporting the claims in managerial settings.

This paper provided a concise overview of the multifaceted literature on information visualization from the point of view of the tasks and desired characteristics of the PMS development process as presented in the previous literature. It also illustrated how visualization techniques supported the development of PMSs in five case environments. As its main contribution, the paper proposes potential visualization techniques for the design, implementation and use of a PMS. It reveals that visualizations can have many different supportive roles in performance measurement. Dashboard designs relate to only narrow part of tasks around a PMS development, most notably reporting. Visualizations such as strategy map appear essential in many different tasks such as clarifying and prioritizing the objects of measurement, communicating the logic of PMSs to the employees and challenging strategy during the PMS use. There is also potential for new visualization techniques which could better describe internal and external organizational relationships.

The secondary contribution of this paper is to act as a discussion opener inviting more academicians to study the topic of visualization in management. One starting point could be to elaborate the proposals of this study. In addition, the results of this study support practitioners in evaluating and choosing visualization techniques supporting their timely challenges of developing PMS. The results reveal that many managerial information needs can be satisfied when conventional visualization forms are properly applied.

This study has also limitations. It is notable that the focusing choices of this study affected the examined visualization techniques. Further research is required in order to elaborate the findings. Only limited empirical data supported the proposals which clearly require more testing in the future. Many of the cases concentrated more on the design phase of measurement development while implementation and the actual usage of measurement results gained less attention. Further in-depth research is needed regarding each phase of the PMS development process. While the empirical case contexts highlighted the internal use of performance information in the reactive monitoring of results, a further study could stress the proactive use of performance measurement paying attention also to the external environment. This task could be supported by many visualization forms not discussed in this paper, such as interactive dashboards and network mapping.

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Appendix: cases projects of the study

Case context	Description of the measurement development project and visualization techniques used	Highlighted phase(s) in the PMS development
Case 1: a middle-sized (50 000 – 100 000 inhabitants) municipality	The project (2012 - 2014) aimed to improve performance measurement in the whole organization. Visualization took the form of a map supporting the identification of relevant organizational levels and illustration of the connections between chosen measurement levels.	Design
Case 2: six social services of a large municipality (> 200 000 inhabitants)	The project (2007 - 2010) aimed to improve productivity measurement. Visualization (a strategy map) supported in understanding the most essential factors affecting productivity. Strategy maps were also presented during the training sessions when implementing the new measurement systems. Objectives matrix was used in reporting.	Design, implementation, use
Case 3: two social services of a large municipality	The project (2011 – 2013) aimed to improve the effectivity measurement of cross-functional services. Map visualization was utilized to understand the overall measurement logic in the municipality. Tree diagrams were used to illustrate sub-components of KPIs.	Design
Case 4: human resources management in a large municipality	The project (2012 – 2014) examined a PMS capturing the key factors affecting productivity and well-being at work. A dashboard supported the comparison analysis of measurement results and an annual clock clarified the performance management process.	Use
Case 5: a small professional public service organization	A balanced performance measurement system was developed during 2011 – 2013. Visualization supported trend analysis and goal analysis.	Design, planning of the use