MEASUREMENT OF BUSINESS PROCESSES

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Abstract:
To be able to manage the processes it is essential to possess information on the current progress of the processes as well as past performance. This requires to create for each process particular indicators that measure its performance. By comparing the past values of indicators the process owner may calculate the progress made in improving the quality of process. Most business processes are described by at least few measures, which may be on different levels and often may be expressed in different units. Using business intelligence systems, there is a need to express the performance of the process using a single complex indicator. The use of information technologies to manage processes makes it possible to automate many activities that previously were performed by the process owner. This paper presents the significance of business process management (BPM) as well as tools and methods supporting BPM. There are recommendations with regard to the design of process performance measures and proposition of the five aggregation function based on both compensatory and non-compensatory models, that may be used in business intelligence systems.

Keywords: business process management, information technology, process measurement, aggregation functions

1. INTRODUCTION

In a competitive market, the efficiency of business processes becomes one of the key challenges. Much has been written in the literature about business process management as well as about process definition. The most known process definition is the one by M. Hammer who defined process as end-to-end work across an enterprise that creates customer value (Hammer & Champy,1993), (Hammer, 2010 p. 4). The definition of process under this article shall be as follow: process is standardized and repeatable sequence of steps towards intended effect on the basis of available resources.

It is difficult not to agree with the J. vom Brocke & M. Rosemann, that Business Process Management (BPM) has emerged as a comprehensive consolidation of disciplines sharing the belief that a process-centered approach leads to substantial improvements in both performance and compliance of a system. Apart from productivity gains, BPM has the power to innovate and continuously trans form businesses and entire cross-organizational value chains. The paradigm of “process thinking” is by no means an invention of the last two decades but had already been postulated by early economists such as Adam Smith or engineers such as Frederick Taylor (Vom Brocke & Rosemann, 2010, p. 7).

The quality of business process management is one of the key factors in building a competitive position. According to Capgemini at a time when many market sectors are facing slow revenue growth, customer churn, and increased pressures on costs, BPM is a critical weapon in the battle for efficient, effective processes that cost less. It allows organizations to become more customer-centric, and to respond in a more agile way to business challenges and opportunities, however uncertain the business environment. Other benefits include better regulatory compliance, even where regulations are altering almost daily (Capgemini, 2012, p. 29). Melão & Pidd described four perspectives on business processes, which brief description is presented in table 1.

Table 1: Four perspectives on business processes by Melão & Pidd

Perspectives	Descryption
Business processes as deterministic machines	The first view regards a business process as a fixed sequence of well-defined activities or tasks performed by ‘human machines’ that convert inputs into outputs in order to accomplish clear objectives.
Complex dynamic systems	Rather than viewing a business process as an assembly of interchangeable components, this second viewpoint focuses on the complex, dynamic and interactive features of business processes. (...) Viewed in these open systems terms, a business process can have inputs, transformation, outputs and boundaries.
Interacting feedback loops	This third perspective extends the organic viewpoint by highlighting the information feedback structure of business processes. Like the organic perspective, the stress is on the complex, interactive and dynamic features of business processes using systems thinking principles.
Social constructs	Instead of seeing a business process as a predictable machine or as a dynamic organism pursuing clear objectives, this fourth perspective emphasizes business processes as made and enacted by people with different values, expectations and (possibly hidden) agendas.

Source: Melão & Pidd, 2000, p.112-120.

2. BUSINESS PROCESS MANAGEMENT TOOLS

The use of information technologies to manage processes makes it possible to automate many activities that previously were performed by the process owner. Authors of recent report from Transparency Market Research about *Business Process Management Market* concluded that business process management software is achieving boom as organizations believe that automation of the process can generate more on revenues and outcome. Software is the strategic business assets which support the organizations to achieve. Business processes and business process management techniques are becoming accepted. In today’s economic climate, companies demand higher productivity, better cost control, and improved risk management to cope with frequent market changes and increasing competitive pressure. To deliver continuous business improvement and operational excellence, companies need to focus on their processes and manage them well (Transparency Market Research, 2014). Information technology is becoming more significant in the business process management. It therefore seems reasonable to agree with Grigori et al. that process design and automation technologies are being increasingly used by both traditional and newly - formed, Internet - based enterprises in order to improve the quality and efficiency of their administrative and production processes, to manage e - commerce transactions, and to rapidly and reliably deliver services to businesses and individual customers (Grigori et al., 2004, p.1). J. Tupa claims that process performance measurement tools and techniques applied to enterprise environments are essential for enterprise continuous improvement. It is the reason why the next generation of process management leads to Process Performance Management or Corporate Performance Management (Tupa, 2010, p. 17).

The increasing popularity of tools to manage the process also implies some negative consequences. As Jeston & Nelis put it: there is a danger of organizations believing that once they have purchased a process-modeling tool, it will solve all their problems and the process improvements will just follow. Nothing could be further from the truth. A process-modeling tool is just a piece of software, and without a methodology or framework, skilled resources to use it and a genuine commitment from organizational leadership, it is useless (Jeston & Nelis, 2008, p. 9).

Table 2: Comparison of notations and the features they support for process modeling

	BPMN	UML	EPC	YAWL	IDEF3	i*	NFR	EEML	URN
Sequence Flow	+	+	+	+	+	+/-	+/-	+	+
Roles	+	+	+	+	-	+	-	+	+
Activities	+	+	+	+	+	-	-	+	+
Events	+	+	+	+	-	-	-	+	+
Process Hierarchies	+	+	+	+	+	-	-	+	+
Goal modeling	-	-	-	-	-	+	+	+/-	+
Goal model Evaluation	-	-	-	-	-	-	+	-	+
Goal/Process Traceability	-	-	-	-	-	-	-	-	+

Source: Pourshahid et al., 2009, p. 274.

A lot of tools and methods to support processes management have been developed since the 90's. Most of them are very useful for mapping processes. Some of them also offer support at the level of modeling, evaluation and traceability of process goals. Based on research done by Pourshahid, A., Amyot, D., Peyton, L., Ghanavati, S., Chen, P., Weiss, M., & Forster, A. J. (Table 2.) it seems reasonable to agree, that each process modeling languages have their own strengths and weaknesses. Most process modeling languages do not provide suitable capabilities for goal modeling. On the other hand, goal modeling languages have limited support for process modeling. The only modeling language that supports both is EEML, whose goal modeling capabilities are weaker than common goal modelling notations, none of the existing process and goal modeling languages provides the same capability as the User Requirements Notation (URN). (Pourshahid et al., 2009, p. 275.)

3. DESIGNING PROCESS MEASURES

To be able to manage the processes it is essential to possess information on the current progress of the processes as well as past performance. This requires to create for each process particular indicators that measure its performance. By comparing the past values of indicators the process owner may calculate the progress made in improving the quality of process. For the individual indicators analysis Shewhart Control Charts and statistical analysis of time series may be used.

Selecting process indicators is not an easy task and implies serious consequences for the entire organization. Hauser & Katz show in their article, that metrics can have unintended and unanticipated consequences. They have unanticipated consequences simply because managers and employees are smart and creative in their efforts to succeed. The firm becomes exactly what it seeks to measure (Hauser & Katz, 1998, p. 23).

The indicators of process may be divided into different categories, for example: environment, output, quality, efficiency, and impact. The definitions of each category are below.

• Environment - This category includes factors which impact the work of the internal audit function indirectly. These could be viewed as audit process “inputs” that are not necessarily under the control of audit management but nevertheless have a large imp act on their success or failure.
• Output - This category includes the end results or products of the internal audit function, including assurance audits and advisory services.
• Quality - This category expands on the previous category, and focuses on the quality of the end results. It also includes measures of the quality of auditing staff.
• Efficiency - This category measures the output and quality of the internal auditing process versus its costs. The purpose of this category is to determine if internal auditing work is efficiently using its time and resources.
• Impact - This category measures the ultimate impact of an internal audit function on its organization’s effectiveness. (Hill et al. 2009, p.4).

The methodology of creating indicators is well established in the literature. Table 2 contains recommendations with regard to the design of performance measures, that may be used to design process indicators.

Table 3: Recommendations with regard to the design of performance measures

	Recommendation	**Source**
1	Performance measures should be derived from strategy	(Dixon et al. 1990), (Kaplan, & Norton, 1992), (Globerson, 1985), (Lea & Parker, 1989), (Crawford & Cox, 1990), (Lynch & Cross, 1992), (Fortuin, 1988), (Maskell, 1991), (Azzone et al., 1991), (Goold, 1991).
2	Performance measures should be simple to understand	(Lea & Parker, 1989), (Lynch & Cross, 1992), (Fortuin, 1988), (Maskell, 1991), (Azzone et al., 1991), (Goold, 1991), (Goold & Quinn, 1990).
3	Performance measures should provide timely and accurate feedback	(Dixon et al. 1990), (Globerson, 1985), (Fortuin, 1988).
4	Performance measures should be based on quantities that can be influenced, or controlled, by the user alone or in co-operation with others	(Globerson, 1985), (Lynch & Cross, 1992), (Fortuin, 1988).
5	Performance measures should reflect the "business process" – i.e. both the supplier and customer should be involved in the definition of the measure	(Globerson, 1985), (Lynch & Cross, 1992), (Fortuin, 1988).
6	Performance measures should relate to specific goals (targets)	(Globerson 1985), (Fortuin, 1988), (Goold & Quinn, 1990).
7	Performance measures should be relevant	(Lynch & Cross, 1992), (Fortuin, 1988), (Azzone et al., 1991).
8	Performance measures should be part of a closed management loop	(Kaplan & Norton, 1992), (Globerson 1985).
9	Performance measures should be clearly defined	(Globerson, 1985), (Fortuin, 1988).
10	Performance measures should have visual impact	(Lea & Parker, 1989), (Fortuin, 1988).
11	Performance measures should focus on improvement	(Lea & Parker, 1989), (Lynch & Cross, 1992).
12	Performance measures should be consistent (in that they maintain their significance as time goes by)	(Lynch & Cross, 1992), (Fortuin, 1988).
13	Performance measures should provide fast feedback	(Fortuin, 1988), (Maskell, 1991).
14	Performance measures should have an explicit purpose	(Globerson, 1985).
15	Performance measures should be based on an explicitly defined formula and source of data	(Globerson, 1985).
16	Performance measures should employ ratios rather than absolute numbers	(Globerson, 1985).
17	Performance measures should use data which are automatically collected as part of a process whenever possible	(Globerson, 1985).
18	Performance measures should be reported in a simple consistent format	(Lynch & Cross, 1992).
19	Performance measures should be based on trends rather than snapshots	(Lynch & Cross, 1992).
20	Performance measures should provide information	(Fortuin, 1988).
21	Performance measures should be precise – be exact about what is being measured	(Fortuin, 1988).
22	Performance measures should be objective – not based on opinion	(Fortuin, 1988).

Source: Neely et al., 1997, p.1137.

Having taken into account recommendation presented in table 3 performance measure record sheet were proposed (Neely et al., 1997, p.1151):

- Title
- Purpose
- Relates to
- Target
- Formula
- Frequency of measurement
- Frequency of review
- Who measures?
- Source of data
- Who owns the measure?
- What do they do?
- Who acts on the data?
- What do they do?
- Notes and comments

4. AGGREGATION FUNCTIONS

Most business processes are described by at least few measures, which may be on different levels and often may be expressed in different units. Using business intelligence systems, there is a need to express the performance of the process using a single indicator. To show performance of the process using a single number it is necessary to use an aggregation function, which codomain's will be limited for example to a set: <0, 1>. The most important issue in constructing the formula of an aggregation function is to adopt or to reject the assumption of trade-off between indicators describing the process.
Much has been written in the literature about multicriteria analysis. There are well-established distinction between compensatory and non-compensatory models. The compensatory models imply that high values of some components may compensate low values of others while non-compensatory models do not allow for such trade-off. (Green & Srinivasan, 1978, pp. 7-13), (Gilbride & Allenby, 2004, pp. 392-393), (Elrod et al., 2004), (Kaplan et al., 2011), (Liu & Arora, 2011). Below are examples of the five aggregation function based on both compensatory and non-compensatory models.

Aggregation function based on vector model:

$$\boldsymbol{Af}(\boldsymbol{i}_1 \dots \boldsymbol{i}_m) = \sum_{j=1}^{m} \boldsymbol{w}_j \boldsymbol{i}_j \quad , \ \boldsymbol{m} > 1 \qquad (1)$$

Where:
Af – aggregation function
i_j – value of j-th measure
w_j – weight of j-th measure
m – number of measures

Aggregation function based on ideal point model:

$$\boldsymbol{Af}(\boldsymbol{i}_1 \dots \boldsymbol{i}_m) = \left[\sum_{j=1}^{m} \boldsymbol{w}_j \left|\boldsymbol{i}_j - \boldsymbol{I}_j\right|^{r}\right]^{1/r}, \ \boldsymbol{r} \geq \mathbf{1}, \ \boldsymbol{m} > 1 \qquad (2)$$

Where:
Af – aggregation function
i_j – value of j-th measure
I_j – ideal value of j-th measure
w_j – weight of j-th measure
m – number of measures

Aggregation function based on part-worth model

$$\mathbf{Af}(\mathbf{i}_1 \dots \mathbf{i}_m) = \sum_{j=1}^{m} \mathbf{U}_j(\mathbf{i}_j) \quad , \ \mathbf{m} > 1 \qquad (3)$$

Where:

Af – aggregation function
i_j – value of j-th measure
m – number of measures
U_j – is the utility function denoting the part-worth of different levels of j-th measure

Aggregation function based on conjunctive model:

$$\mathbf{Af}(\mathbf{i_1} \dots \mathbf{i_m}) = \prod_{j=1}^{m} \mathbf{P_j} \quad , \mathbf{m} > 1 \tag{4}$$

$$\mathbf{P_j} = \begin{cases} \mathbf{1} & \mathbf{if} \quad \mathbf{i_j} \geq \mathbf{Ic_j} \\ \mathbf{0} & \mathbf{if} \quad \mathbf{i_j} < \mathbf{Ic_j} \end{cases}$$

Where:
Af – aggregation function
i_j – value of j-th measure
m – number of measures
Ic_j – is the critical value of j-th measure (the lowest acceptable value of j-th measure)

Aggregation function based on disjunctive model:

$$\mathbf{Af}(\mathbf{i_1} \dots \mathbf{i_m}) = \mathbf{min}\left\{\sum_{j=1}^{m} \mathbf{P_j}, \mathbf{1}\right\} \quad , \mathbf{m} > 1 \tag{5}$$

$$\mathbf{P_j} = \begin{cases} \mathbf{1} & \mathbf{if} \quad \mathbf{i_j} \geq \mathbf{Ic_j} \\ \mathbf{0} & \mathbf{if} \quad \mathbf{i_j} < \mathbf{Ic_j} \end{cases}$$

Where:
Af – aggregation function
i_j – value of j-th measure
m – number of measures
Ic_j – is the critical value of j-th measure (the lowest acceptable value of j-th measure)

Aggregation functions: (1), (2), (3) are based on compensatory models, while the remaining are based on non-compensatory models. On the basis of the a study on how evaluation of the process is done by the process owner, such a hypothesis may be formulated: in the construction of aggregation functions a non-compensatory models would perform better. Aggregation functions based on compensatory models may prove to be acceptable in situations where there are no significant differences in levels of indicators which are aggregated. It also seems reasonable to use the weights for individual indicators, as in business process management indicators are usually not equivalent. Below is a draft of the algorithm for obtaining the synthetic index of performance for the process measured by many indicators.
The algorithm for creating the synthetic performance index of the business process:

1. *For each indicator adjust values measured on different scales to a notionally common performance scale.*
2. *Determine the weight of indicators.*
3. *Selection of an aggregate function.*
4. *Calculate the synthetic performance index.*

5. SUMMARY

The problem of measurement in business processes described in this article is important both for the practical management of business processes and to construct supporting tools such as business intelligence systems. Finding proper aggregation function for creating the synthetic performance index of the business process would be an important step in the use of IT in processes management. Formulated hypothesis "in the construction of aggregation functions a non-compensatory models would perform better" requires further research to its verification. The relevant research shall be undertaken and results published in the near future.

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