Chapter 6

Performance Management by Causal Mapping: An Application Field of Knowledge Management

Sarah Kölbel, Wolfgang Ossadnik and
Stefan Gergeleit

Additional information is available at the end of the chapter

http://dx.doi.org/10.5772/intechopen.70297

Abstract

As implied by the performance management (PM) concept, modern corporate management has to focus on cause-and-effect relationships underlying a firm´s financial performance generation. To determine the causes of financially desirable effects, subject-bound experiences and knowledge of employees, called tacit knowledge, should be realised. For this, knowledge management (KM) offers various elicitation techniques to reveal corporate-specific success factors (SFs) of financial performance generation from the corporate experts´ implicit knowledge. The identified factors have to be organised within a network of cause-and-effect relationships. In this framework, PM can apply the instrument of mapping to structure the individually revealed knowledge, to aggregate and visualise it for the entire company. For a valid representation of the causal relationships, the subjective bias arising within the mentioned process has to be minimised. In the literature, a variety of mapping methods can be found that differ in their approaches and their level of significance. As such a method, causal mapping will be presented in this paper. For providing intersubjectivity, the decision-making trail and evaluation laboratory (DEMATEL) as a multi-criteria approach will be debated in the context of mapping as a research field.

Keywords: causal mapping, knowledge management, performance management, implicit knowledge, explicit knowledge, success factors, DEMATEL, subjectivity, intersubjectivity

1. Introduction

In today's information age, companies face high competition and pressure while trying to perform successfully in the long term. To meet the dynamic competitive environment and the globalisation of markets accessible, companies are forced to hunt for competitiveness resulting from the efficient use of general and specific knowledge. Accordingly, knowledge is becoming a competitive factor and provides an essential cause for company success. Therefore, it is important not only to consider obviously accessible knowledge but also to directly accomplish a performance-related use of the specific, implicit knowledge of a company. These individual experiences and knowledge such as fundamental components of human capital inhere a huge chance to improve the steering and control processes of performance generation and hence to master competition successfully. In the context of such a performance management (PM), expert knowledge is indispensably focused on relations between causes and effects to generate financial performance. By considering cause-and-effect relationships underlying the financial performance generation process the traditional perspective of measuring value realisation is extended to causally ambitioned value generation management. As a consequence, such a causal knowledge reveals options for actions influencing the financially as well as non-financially dimensioned causes, which are linked to future financial performance. Thus, PM provides relevant starting points to control the financial performance generation process.

In reality, companies comprise many departments with multiple environmental factors and, as a consequence, there exist many latent or manifest interdependently structured characteristics relevant for performance generation. Without knowledge of such relations, the management cannot efficiently control desirable effects by their causes. A map of causal relationships could care for more transparency in this respect. However, expert knowledge on success factors (SFs) and their causal relations is usually not available in the explicit form of a graphical representation. Instead, subjectively based knowledge, stemming from individuals´ observations and experiences, which are called implicit or tacit knowledge, might be identifiable and pending to be elicited.

Knowledge management (KM) recognised as a subdiscipline of PM can be applied to convert this implicit knowledge into explicit subjective knowledge on causal relationships, which can be identified and depicted by construction of a tailor-made causal map. Through the construction of the causal linkages during the mapping process, a subjective judgment bias can arise. With regard to this problem of subjectivity, specific methods of the multi-criteria research field, in particular the decision-making trail and evaluation laboratory (DEMATEL), can be used in the mapping context. DEMATEL provides a reduction of a potential personal bias when applying one of the common mapping methods. For this, a fictional case study will be presented adopting the target of achieving intersubjectivity.

2. Performance management and performance measurement

PM and performance measurement can generally be associated with a strategic management and control to focus on long-term financial success. To realise this objective, to implement strategies promisingly and for the alignment of the entire organisation to a consistent development of success potentials, the strategic factors relevant for financial success need to be identified. Through the control of the critical SFs via measureable key performance indicators (KPIs), the company´s financial performance can be influenced beneficially [1, 2]. This requires the identification of upstream causes of the financial success, which can be dimensioned financially or non-financially. With the subsequent consideration of non-financially dimensioned SFs, which often are deeply rooted in the intuitive knowledge of managers and employees, PM offers a concept of steering and control extending the restrictions of traditional control procedures entirely based on logical decompositionally constructed financial ratios [3–6].

According to Neely et al. [7], performance measurement can be described as the 'process of quantifying the efficiency and effectiveness of action'. An evaluation of the efficiency and effectiveness of action always requires the reflection of the corporate strategic objectives [3]. Thus, performance measurement enables a holistic assessment of the company's performance. For analysing the whole performance generation process, it necessitates the additional identification of cause-and-effect relationships. The specific SFs of a company are integrated into a cause-and-effect network. Each factor can directly or indirectly be linked with the company's financial performance [8–10]. A cause-and-effect relationship will only be defined as causal, if a strong correlation between cause(s) and effect(s) exists and the cause of action temporally precedes the effect. Additionally, the relationship has to be plausibly explicable [11]. With an accurate specification of the causal relationships among the factors, a comprehensive understanding of the performance generation is provided. Moreover, in decision-making situations, the consequences of chosen actions on the company's success can be estimated [5, 9].

Within this context, the 'performance' is determined as a multi-criteria and therefore multi-dimensional construct, which—in a causal sense—cannot only be measured ex post, but also ex ante. Performance measurement thereby is classified in a superordinate control context of PM as an integral part of it. At this point PM describes the process of planning, implementing and executing the corporate strategy by a coherent system of actions. In linkage with a strategy, it determines values of measurable KPIs respectively operating numbers. If, due to the permanent monitoring of the operating numbers, a significant variance is identified, the PM can initiate appropriate (feedback- or feedforward-directed) strategic action [1, 6]. In conclusion, for a comprehensive analysis and control of the performance generation, SFs and their company-specific causal relationships need to carefully be identified and examined in depth. Therefore, PM captures KM as a complementary discipline.

3. Knowledge management: explicit and implicit knowledge

KM implies the acquisition, development, transfer, storage and use of knowledge in a company [12–15]. A condition for knowledge generation is generic information like scientific theories and models. The information is based on data defined as simple facts or events etc., which are not systematised for a specific context. Thereby, the information forms a structured, meaningful summary of explicit data points in order to take a conclusion or prediction. In particular, knowledge represents the generic skill to connect and use recent information with previously collected information in several new application fields. As a consequence, the knowledge carriers evolve a new understanding or subjective perception of the actual situation, which generates a new knowledge basis [13, 16]. Here, knowledge can generally differ in explicit and implicit one [17].

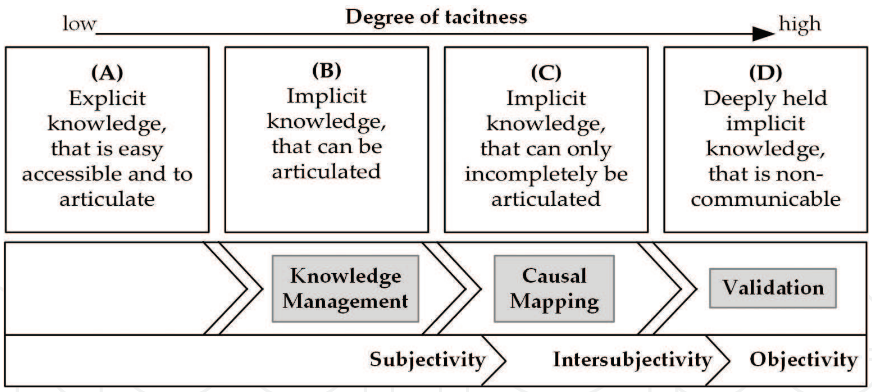

Figure 1. Degree of tacitness and the steps to objectivisation.

Explicit knowledge is communicable and thus not exclusively available to the person who possesses and uses it. It declares the relevant know-what [18, 19]. Knowledge concerning company-specific cause-and-effect dependencies can furthermore be drawn on the subject-bound, intuitive experience-based knowledge of competent employees and managers. This as 'tacit' specified implicit knowledge is difficult or impossible to verbalise as well as to formalise in contrast to explicit knowledge [18]. It is understood as individual specific know-how.

According to Ambrosini and Bowman [20], knowledge can be graded in relation to the degree of tacitness as shown in **Figure 1**.

Between the explicit knowledge (A) and deep-rooted tacit knowledge (D), which cannot generally be revealed, the communicable knowledge (B and C) have to be specified. One specification comprises the implicit knowledge (B), which can be appropriately articulated and revealed. But, this knowledge becomes less obvious over time, because the knowledge carriers have not been mentally concerned with it and no third party has demanded for it. Additionally, there exists tacit knowledge (C), which can be articulated only incompletely. Although it is possible to get access to this knowledge, it is not describable by general language use [20]. The implicit knowledge of type B and C is of special importance for a company in order to discover the performance-relevant SFs and develop their hypothetical causal relationships in a map.

The experts´ tacit knowledge has to be externalised by applying adequate elicitation techniques in the context of KM [15, 21, 22]. For this purpose, three groups are basically distinguished in the literature under the term 'knowledge elicitation techniques': observations and interviews, process tracing and conceptual techniques [23]. It generally cannot be defined that one method is more appropriate than another. The choice of a technique for extracting performance-relevant knowledge should be taken case specifically. However, for the development of causal hypotheses, there exists the experience that interview techniques as most commonly applied methods generate more information on company-specific connections than other approaches [22–24].

Subsequently, the externalised implicit knowledge of the performance-related SFs is causally systematised into a more generic and easily comprehensible form by formulating a causal map [25, 26]. Depending on the chosen mapping method, the causal relationships base on purely subjective judgments. This subjective knowledge stands for the relationship of an individual to its environment. Thus, it is not objective. Subjectivity can be seen as an error source in the current subject, although it offers an epistemic value [27]. Increasing comparability and transparency of individual subjective evaluations about causal relationships generate a degree of intersubjectivity [28]. Thus, intersubjectivity is achievable, if only more than one individual can clearly comprehend the formulation and structuring process of causal relations among SFs.

However, strategic forecasts about the future performance developments are only possible to a certain extent or cannot even be performed by application of subjectively and intersubjectively based maps. (Intersections of subjective maps would deliver intersubjectively based ones.) But, only a statistical validation of the causal map generates an objective understanding of the causal relationships, which thus are directly empirically verifiable [5, 29]. As a consequence, valid predication of the performance generation can be given. Initially, the subjective mapping methods are considered more closely in the following section.

4. Subjective mapping

Mapping methods are used to depict company-specific explicit and implicit knowledge, such as control-relevant factors and their causal relationships [20]. There are several definitions and names of mapping methods in the literature [10, 30–32], which can be distinguished according to their type and to their concept of construction.

4.1. Types of maps

Two types of maps with relevance for the current subject are the ‘cognitive mapping’ and the ‘causal mapping’.

Cognitive maps can be seen as a summary of different concepts of mapping that rely on the beliefs of an individual about a specific topic [26]. In its core, a cognitive map refers to how an individual person can explain its environment and to what extent it is able to understand it. It visualises the individual perception of the reality and thus represents person-specific knowledge [28, 33]. This knowledge is needed for a comprehensive assessment of corporate performance because it captures experiences and know-how about corporate-specific internal and external factors in a detailed way [31].

Causal maps generally illustrate the individual understanding about linkage of events occurring at a certain time [26]. In the context of PM, the instrument of causal mapping is suitable for displaying company-specific explicit as well as implicit information describing the influences of performance relevant causes on the top objective of financial performance [20]. Causal maps consist, on the one hand, of nodes, which can represent control-relevant SFs and, on the other hand, of arrows, which are used to represent the cause-and-effect relationships between these nodes [34]. The node, from where the path of an arrow begins, is interpreted as the cause of the consequently influenced effect. The effect is depicted through the node where the arrow finally ends. The direction of an arrow implies the assumed causality. Thus, a causal map can be interpreted as a cognitive map, which describes the process of performances in a company [8]. But, a cognitive map is always constructed from a single individual, whereas a causal map can also represent the cause-and-effect relationships as an aggregated result of several individuals [35]. **Figure 2** gives an example of a causal map [22]. The contained factors might be measured directly and would be manifest in that case. Otherwise, they are latent and can be operationalised by one or more selected measure(s). Measurable data are transferable into an indicator system of strategic success generation.

4.2. Development and participation in causal mapping approaches

A causal map based on local tacit knowledge can be formed by a group of experts itself [36] or by aggregating the individual maps of the group members [37, 38]. After the development of individual causal maps, it might be a scientific objective to measure the differences between these maps [24, 39]. But, in the related literature, approaches are most favoured that aim for a specific form of an aggregation of individual maps. The aggregation can follow specific 'counting rules' of factors and relations depicted as arrows [8, 34]. Moreover, the finalisation of an aggregated group map is widely spread via group discussions and workshops [31, 38]. Such a group aggregation process can also be computer-supported [40–42]. In order to realise the advantages of causal mapping, it is absolutely necessary to involve a sufficient number of experts in the mapping process [43].

To construct a causal map, one of the elicitation techniques mentioned in section three has to be applied. Afterwards, the mapping process can be conducted by an interviewed expert itself, by the support of qualitative software, solely by an external researcher, a consultant or a team —so-called ethnographical protocol interpretation—or by the interaction of external persons and company experts [8, 20, 44]. The most relevant and applied mapping techniques that can be distinguished from each other and contain essential attributes are the ethnographical protocol interpretation and the interactive mapping.

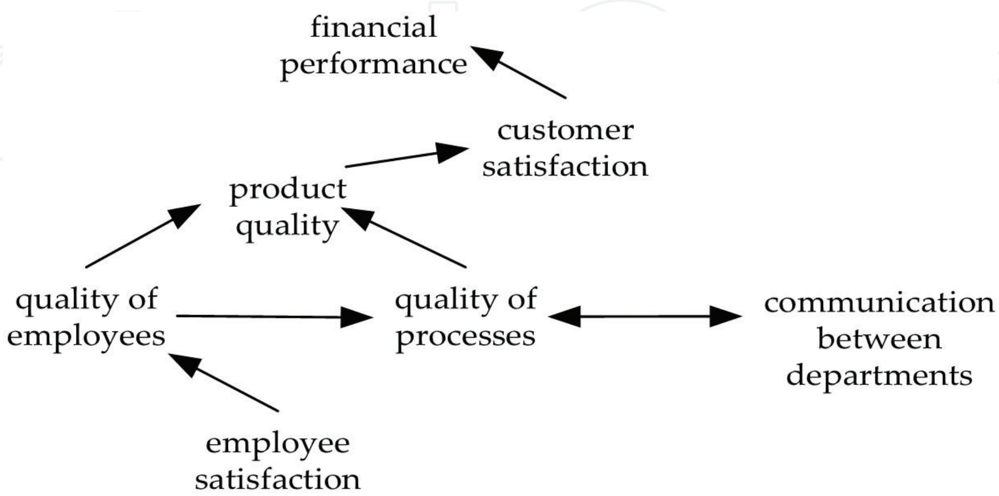

Figure 2. Example of a causal map.

http://dx.doi.org/10.5772/intechopen.70297

In addition, there is another approach developing a causal map by group discussion without applying any elicitation technique advance. According to Akkermans and van Helden [45], experts are asked to collectively form one causal map. Herein, the objective basically is to construct a unified view of a group of experts through their discussion. By group discussion, the different individual perceptions are summarised and structured to finally achieve a common understanding of the problem.

When reviewing the mapping procedures in the related literature, it is obvious that the epistemological perspective is far from a comprehensive as well as general approach. The individually conducted steps differ from case to case. A mixture of several techniques is always conceivable and a clear distinction between the documented techniques is difficult to specify. The question 'how to map?' generally depends on the preferences and objectives of internal and external experts that are involved in the process of causal mapping. Notwithstanding the construction process of a causal map, there are advantages and disadvantages provided by causal mapping.

4.3. Advantages and disadvantages of causal mapping

The advantages of causal mapping are apparently associated with a corporate's financial success and the implementation of a strategy: causal mapping enforces (a) the elicitation, (b) the visualisation and (c) the communicability of performance-relevant knowledge.

Already in the starting phase of elicitation, involved individuals develop a more extensive understanding of the corporate performance and its causes. They are invited to reflect all processes in their company and, therefore, will be able to distinguish between performance-relevant factors and those which have less importance. Furthermore, concerned individuals start to reflect their daily operation in a critical manner and may generate an alignment of their work to the principles of PM and performance measurement. Involving a sufficient number of experts from all departments of a company as participants in the mapping process amplifies the acceptance of the respective system. During the implementation of this system, employees do not only provide their causal knowledge but are also motivated to scrutinise it. They develop as well as apply the respective indicator system in a reflective manner and adjust their decisions and chosen actions to this system [46]. Due to this reflexion, learning effects emerge. Besides, the visualisation by causal mapping provokes a focus on those factors that have the largest influence onto the financial performance objective. It induces different people within a company to reflect about it. Moreover, the visualisation creates an extensive comprehension about the effects of certain actions as causes. The existing cause-and-effect chains to achieve a better (or even a worse) performance become obvious [10]. At least, the management of a company is equipped with a mapping tool that enhances the communication of a vision, of strategies as well as objectives and measures based on a common understanding of the performance generation. By causal mapping, the employees communicate on causal relations and become more aware of them. This contributes to an efficient management of the company [10].

Since the cause-and-effect relationships are primarily derived from the experience and knowledge of employees, they are categorised as subjective. The experts from different functional areas may have an unequal perception of processes. During the amalgamation of explicated assessments of cause-and-effect relationships from different subjective perspectives, inconsistent results can occur. Therefore, it will be necessary to aggregate or to synthesise these partial perspectives in a sufficiently complex overall model of causal relationships [47].

Nevertheless, every aggregation of subjective statements can generate biases because involved managers and employees are specialised on their area of responsibility and herein collect their experiences. The subjectivity of the statements might be driven by factors like organisational blindness, vanity, satisfaction as well as dissatisfaction or the degree of motivation. Further, in group discussion, participants might answer strategically in the way to not annoy others [10, 40, 41]. As a consequence, it is not sure that the most important causal relationships among factors will be detected. Instead, it might be the case that less relevant SFs and relationships will be determined. All these challenges have to be overcome and a corrective against the biases resulting from subjective statements has to be offered.

Therefore, the multi-criteria DEMATEL method can be introduced as a technique that is able to decrease the amount of subjectivity in constructing a causal map. Thus, it enables to achieve an intersubjective validity by providing a transparent and replicable process of mapping among all participants. The technique is more appropriate to get an equilibrated and balanced causal map for the purpose of all employees. Group discussions and aggregation approaches cannot meet the requirements of unifying the variety of different individual opinions. DEMATEL, as presented in Section 5, collects the individual opinions in a more unbiased way.

5. Intersubjective mapping

Between 1972 and 1976, Fontela and Gabus have developed the DEMATEL approach for structuring and solving multi-criteria problems in a multi-personal context [48, 49]. DEMATEL can represent an algebraic method of analysis, which aggregates the collected individual implicit knowledge to identify and quantify the causal interdependencies between the detected SFs [50]. Furthermore, it strictly structures the given SFs according to their relevance in performance generation [51]. Finally, the determined causal relationships of the performance-related SFs are illustrated in an appropriate causal map, described as impact relation map (IRM) [50].

5.1. DEMATEL

In this section, some essentials of the DEMATEL approach are briefly described (**Figure 3**) [52].

In the first step, an $n \times n$ individual evaluation matrix X^k of each expert k (k = 1, …, H) is determined as follows [52, 53]:

$$X^k = \begin{pmatrix} x_{11}^k & \cdots & x_{1j}^k & \cdots & x_{1n}^k \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1}^k & \cdots & x_{ij}^k & \cdots & x_{in}^k \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{n1}^k & \cdots & x_{nj}^k & \cdots & x_{nn}^k \end{pmatrix} = \left[x_{ij}^k\right]_{n \times n} \tag{1}$$

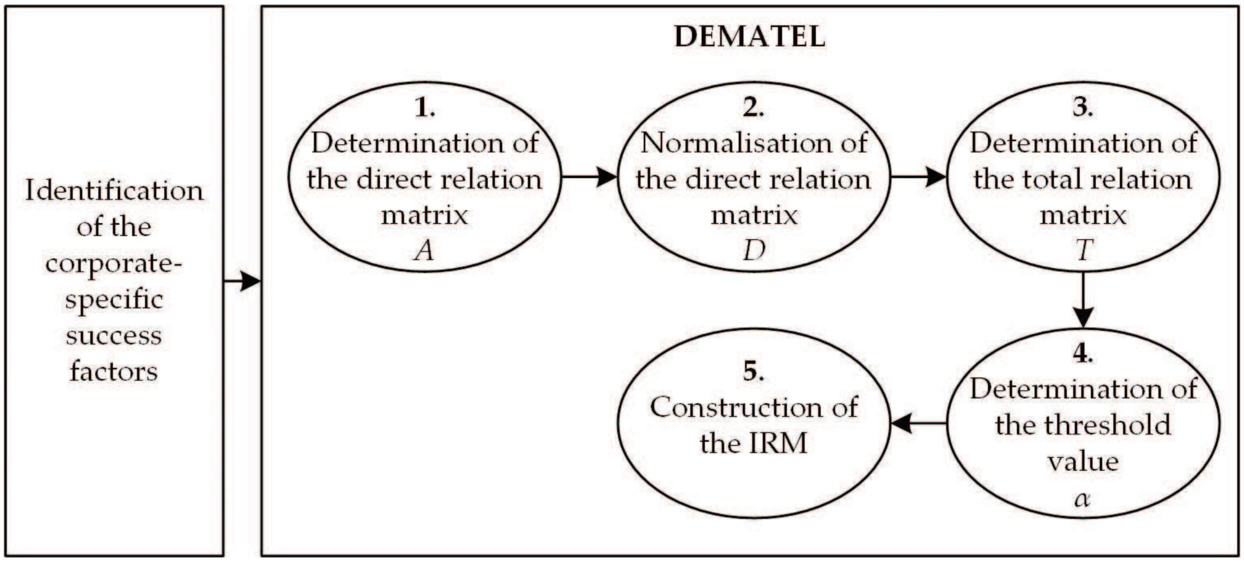

Figure 3. Procedure steps of DEMATEL.

For this purpose, H skilled employees pairwise compare the given factors $i(i = 1, \ldots, n)$ and $j(j = 1, \ldots, n)$ on a Likert scale from 0 to 4 (with 0 = no effect, 1 = very small effect, 2 = small effect, 3 = strong effect, 4 = very strong effect) to identify how strong the factor i directly influences the factor j. The results are described by the matrix elements x_{ij}^k. In addition, for all cases $i = j$, each x_{ij}^k takes the value 0, since the factors are compared to themselves [52]. Hence, it can be formulated the assumption that a cause cannot be its effect at the same time.

According to Eq. (2), the direct relation matrix A is calculated by the aggregation of all individual evaluation matrices. The numerical value a_{ij} illustrates the group perception about the direct causal relationship between the factors i and j. If the condition $a_{ij} \le 1$ is fulfilled, no cause-and-effect relationship exists [52].

$$A = [a_{ij}]_{n \times n} = \frac{1}{H} \sum_{k=1}^{H} [x_{ij}^k]_{n \times n} \quad (2)$$

In the second step, the direct relation matrix A is normalised to the matrix D as follows [52, 54]:

$$D = \frac{A}{s} = [d_{ij}]_{n \times n} \quad (3)$$

$$s = \max\left\{\max_{1 \le i \le n} \sum_{j=1}^{n} a_{ij}, \max_{1 \le j \le n} \sum_{i=1}^{n} a_{ij}\right\} \quad (4)$$

Here, the normalisation value s can be specified as the maximum value of the set of maximal column and row sum of the matrix A. Besides, the column sum $\sum_{i=1}^{n} a_{ij}$ of the matrix A represents the total direct effect, which all factors i exert on the factor j. Compared with this, the total direct impact of factor i on all other factors j is described by the row sum $\sum_{j=1}^{n} a_{ij}$ of the matrix A [53, 55].

To determine the direct and indirect interdependent relationships of the SFs, the total relation matrix T has to be calculated in the subsequent step [52]. For generating indirect convergent effects, the potentiation of matrix D needs to convert to infinite as follows [50]:

$$T = \lim_{m \to \infty} (D + D^2 + \cdots + D^m) \tag{5}$$

According to Eq. (6), the total relation matrix T is calculated under consideration of the normalised matrix D as well as the $n \times n$ identity matrix I [52]:

$$T = D(I - D)^{-1} = [t_{ij}]_{n \times n} \tag{6}$$

Before transferring the identified causal relationships of the SFs in an IRM, a threshold α as average influence intensity has to be specified in the fourth step. The threshold α is determined as the quotient from the sum of all values t_{ij} divided by the number of elements N of matrix T and follows the formula [56, 57]:

$$\alpha = \frac{\sum_{i=1}^{n} \sum_{j=1}^{n} [t_{ij}]}{N} \tag{7}$$

For a further reduction of complexity and to develop a clearly structured and manageable map, only the elements t_{ij} of the matrix T, which exceed the stated threshold α, are transferred in the map. The cause-and-effect relationship values t_{ij}, that satisfy the condition $t_{ij} > \alpha$, are classified as sufficiently significant and thus as performance-relevant influences [53].

In the last step of the DEMATEL approach, the identified SFs and their performance-relevant relationships are depicted in a causal IRM. Furthermore, the factors can be classified into causes and receivers [14]. For this purpose, the row sum $r_i = \sum_{j=1}^{n} t_{ij}$, as well as the column sum $c_j = \sum_{i=1}^{n} t_{ij}$, of the total relation matrix T have to be calculated [52]. The column sum c_j describes the total direct and indirect effect that all factors i exert on the factor j (called as degree of receiving). Assumed a high degree of receiving, minor changes of the factors i already lead to strong alteration of the factor j. However, the row sum r_i represents in which extent the factor i has an effect on all other factors j (called as degree of causing). A high degree of causing means that a small change of factor i causes great alterations of the other factors j. Moreover, in the case of $i = j$, the total of the row and column sum ($r_i + c_j$) illustrates the accumulated outgoing and received effects of a factor. The higher the determined influence intensity, the higher the relevance of this factor for the corporate management will be [53, 54].

By forming the difference of the row and column sum ($r_i - c_j$) for the case $i = j$, the factors will be specified as causes or receivers according to its resulting net effect. If $c_j < r_i$, then the factor will be defined as a cause, because its impact on the other factors is higher than the other factors' influence on it. But assumed $c_j < r_i$, the factor is mostly influenced by other factors and thus will be assigned to the group of receivers [53, 54].

Finally, all identified SFs and only their performance-relevant causal relationships will be visualised in an IRM. This causal map is framed as kind of coordinate system, of which the abscissa represents the values of the full effects ($r_i + c_j$) and the ordinate axis is scaled to the net effect values ($r_i - c_j$) [53, 54]. In the following section, the approach of DEMATEL will be illustrated in a fictional case study example.

5.2. Case study as an application example

The example of a causal map is demonstrated for a typical company and its PM. For this propose, the financially and non-financially dimensioned SFs are identified and their causal relationships are analysed as well as visualised in a causal map. To construct the map in a manner to achieve intersubjectivity, the DEMATEL method is applied. By conduction of semi-structured interviews with 15 experts from the company and in the following group discussion between an external research team and expert group, a pool of eight strategically relevant factors can be developed. These identified SFs are mentioned as follows: financial success (FC), competitive environment (CE), structural circumstances (SC), product range (PR), product quality (PQ), pricing (PRI), image (IM) as well as ability to supply (AS).

5.2.1. Identification of causes and receivers

First of all, the 15 experts pairwise evaluate the causal relationship structure among SFs on a Likert scale from 0 (no effect) to 4 (very strong effect). The individual evaluation matrices X^k (with k = 1, ith) are described by Eq. (1) and are aggregated to the direct relation matrix A by Eq. (2). After that, the matrix A is normalised to matrix D according to Eqs. (3) and (4). With the help of Eqs. (5) and (6), the final total relation matrix D can be calculated. **Table 1** shows the results which describe the direct influence intensity that SF i exerts on a SF j:

For more clarity in the causal structure, only these influence relationships between the SFs are considered in the IRM, of which the influence intensity is greater than the calculated threshold of α = 0.1426 {Eq. (7)}. In **Table 1**, the sufficiently significant results are marked in bold. Consequently, nearly half of the amount of causal relationships among the factors is specified as above-average causal interdependent and thus can be determined as very performance-relevant relation.

Factors	FS	CE	SC	PR	PQ	PRI	IM	AS
FS	0.1157	**0.1825**	0.0345	0.1235	0.1014	**0.1548**	**0.1535**	0.0785
CE	**0.2940**	0.1303	0.1015	**0.2041**	0.1380	**0.2142**	**0.1944**	0.1132
SC	**0.2905**	**0.1508**	0.0260	**0.1467**	0.0891	**0.1786**	0.1166	0.0464
PR	**0.2808**	**0.2318**	0.0404	0.0769	0.1031	**0.1755**	**0.2556**	**0.1438**
PQ	**0.2995**	**0.2257**	0.0414	0.0880	0.0700	**0.2018**	**0.2881**	0.1083
PRI	**0.2507**	**0.2019**	0.0796	0.0705	0.1106	0.0911	**0.2215**	0.0636
IM	**0.2658**	**0.2067**	0.0294	0.1257	0.1187	**0.1688**	0.1074	0.0940
AS	**0.2019**	**0.1630**	0.0232	0.0727	0.0674	**0.1433**	**0.2019**	0.0390

Table 1. Total relation matrix.

Factors	r_i	c_i	$r_i + c_i$	$r_i - c_i$	Characteristic
Financial success	0.9445	1.9988	2.9433	−1.0544	Receiver
Competitive environment	1.3897	1.4927	2.8824	−0.1030	Receiver
Structural circumstances	1.0446	0.3761	1.4207	0.6685	Cause
Product range	1.3080	0.9082	2.2163	0.3998	Cause
Product quality	1.3229	0.7980	2.1209	0.5248	Cause
Pricing	1.0896	1.3280	2.4176	−0.2385	Receiver
Image	1.1164	1.5391	2.6555	−0.4227	Receiver
Ability to supply	0.9121	0.6868	1.5989	0.2253	Cause

Table 2. Classification of the SFs as causes and receivers.

To organise the SFs in the groups 'causes' and 'receivers', the row sum r_i and column sum c_i as well as their difference have to be calculated in the subsequent step as follows:

According to **Table 2**, the SFs 'structural circumstances', 'product range', 'product quality' and 'ability to supply' are identified as causes, under the condition that $r_i > c_j$ and thus the results of their difference are positive. However, the SFs 'financial success', 'competitive environment', 'pricing' as well as 'image' fulfil the condition $c_j > r_i$. As a result, the calculated difference between the row and column sum is negative and thus the factors are specified as receivers. Moreover, within the groups 'causes' and 'receivers' the SFs can be clearly ranked by their total influence intensity ($r_i + c_i$) in respect of their significance for the performance generation. It can be realised for the group 'causes' that the SF 'product range' is the most influencing factor, which largely determines all other SFs. In contrast the SF 'structural circumstances' has the lowest impact on the whole system. Considering the group 'receivers', the SF 'financial success' is mostly influenced by the other SFs compared to the SF 'pricing', which is less determined by the other ones.

5.2.2. Tailor-made impact-relation map

In this section the identified SFs and only their above-average calculated influence intensity from **Table 1** as well as the group specification of receivers and causes from **Table 2** is finally visualised in an appropriate IRM (**Figure 4**).

According to the coordinate system in **Figure 4**, the ordinate represents the difference between received and outgoing effects of a factor. Factors that can be characterised as causes, for example 'ability to supply', are always pictured in the positive range. Whereas, receivers like the factor 'pricing' are depicted in the negative value range. Furthermore, the abscissa displays the overall intensity of the influence relationship of an individual factor. The further away a factor is located from the coordinate origin, the greater its total influence intensity in the whole system is. Following **Figure 4**, the factor 'financial success' is the most performance-relevant factor in relation to the others.

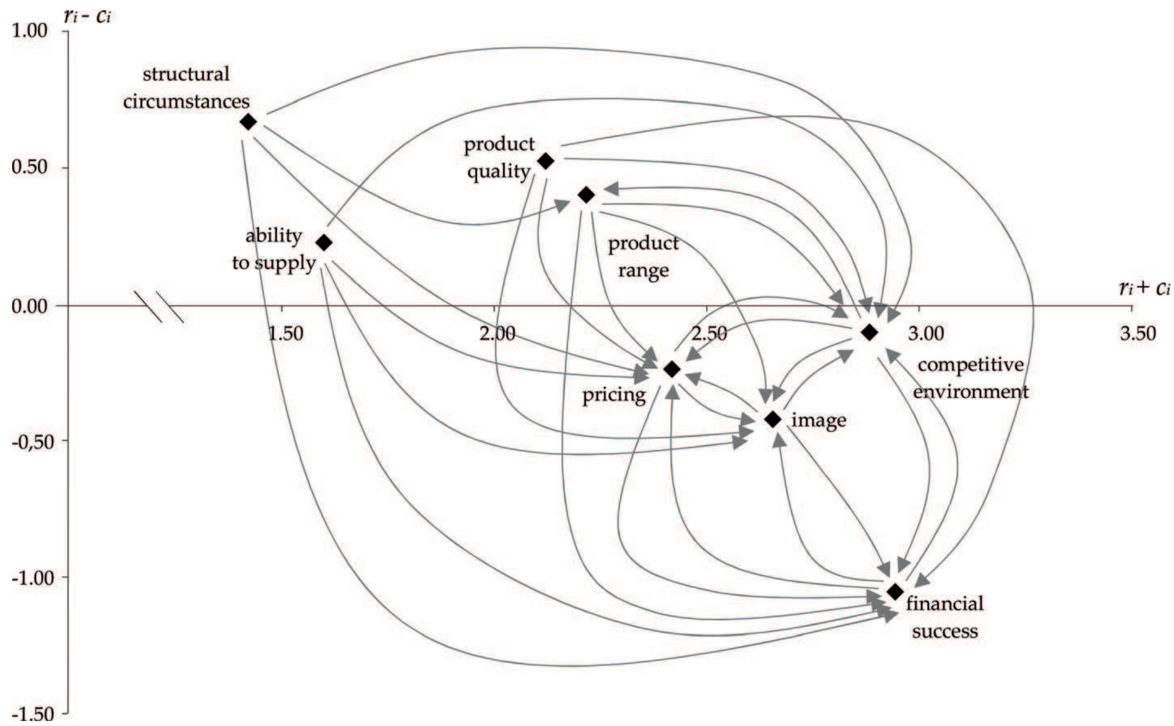

Figure 4. Impact-relation map.

Generally, through the construction of an IRM, a better comprehension of the relevant direct and indirect causal relationships can be developed. Besides, the IRM underlines which SFs are most important for the corporate management and the focus should lay on them. Compared to a qualitative causal mapping process DEMATEL strictly distinguishes the SFs between causes and receivers and quantifies their cause-and-effect relationships [53, 54]. However, because the individual evaluations are ordinal a cardinal interpretation of the SFs´ causal relations cannot be provided. Only a systematisation by building a hierarchy among SFs is possible.

6. Conclusion

Causal knowledge on SFs underlying financial performance generation is an important prerequisite for an effective PM. For this purpose, important parts of the PM have to be drawn on the subjective experiences and knowledge of the employees. It is the current task for KM to extract the subject-bound tacit knowledge and make it explicitly available for the management of an organisation. Subsequently, by application of a convenient mapping method revealed tacit knowledge has to be aggregated, structured as well as systematised in a more general and for the employees' applicable manner. In addition, the complex financial performance generation process will be represented and analysed as for performance relevance of the SFs and their causal relations. In this way, a general and clarified understanding of the performance generation is achievable among the employees.

The concept of causal mapping and the multi-criteria DEMATEL method illustrate approaches how to construct a causal map from the base of externalised tacit knowledge. Both methods differ in procedures and in results. Causal mapping offers a low quality of the identified causal structures of SFs because of the lack of quantitative assessment and the highly subjective aggregation of the implicit knowledge. However, applying DEMATEL in the mapping context, the subjective bias can be minimised by a systematic and transparent pairwise evaluation of the SFs. Because of its replicability it achieves intersubjectivity. But since the discovered causal relationships among the factors are only interpretable on an ordinal scale, strategic forecasts of future performance developments are only possible to a limited extent.

To achieve an objective validity, the existence of adequate data and the use of suitably selected statistical procedures are necessary. If for all variables of the causal map manifest time series data are available, the validation of causal relationships can be done by using a multivariate time series model. When the variables of the causal map are not directly observable, but can be operationalised as latent variables with appropriate factors, structural equation modelling can be used to validate the cause-and-effect relationships among the SFs [29]. The statistical validation of the causal relationship network objectifies the previous ordinal data in metric forms to achieve relative comparability and clear predictability. So, the significance of the map is optimised compared to the one constructed by DEMATEL. Finally, in the context of PM, the performance realisation and generation can be represented and analysed qualitatively as well as quantitatively by the validated map in a comprehensible way.

Author details

Sarah Kölbel, Wolfgang Ossadnik* and Stefan Gergeleit

*Address all correspondence to: wolfgang.ossadnik@uni-osnabrueck.de

Department of Management Science/Management Accounting and Control, University of Osnabrück, Osnabrück, Germany

References

[1] Kaplan RS, Norton DP. Strategy Maps: Converting Intangible Assets into Tangible Outcomes. 1st ed. Boston, MA: Harvard Business School Press; 2004. p. 454

[2] van Veen-Dirks P, Wijn M. Strategic control: Meshing critical success factors with the balanced scorecard. Long Range Planning. 2002;**35**(4):407-427. DOI: 10.1016/S0024-6301(02)00066-3

[3] Lebas MJ. Performance measurement and performance management. International Journal of Production Economics. 1995;**41**(1-3):23-35. DOI: 10.1016/0925-5273(95)00081-X

[4] Malmi T. Balanced scorecards in Finnish companies: A research note. Management Accounting Research. 2001;**12**(2):207-220. DOI: 10.1006/mare.2000.0154

[5] Ittner CD, Larcker DF. Extending the boundaries: Nonfinancial performance measures. In: Chapman CS, Hopwood AG, Shields MD, editors. Handbook of Management Accounting Research. 3rd ed. Amsterdam: Elsevier; 2009. pp. 1235-1251. DOI: 10.1016/S1751-3243(07)03002-7

[6] Ossadnik W. Performance management of internationally acting firms as a challenge for management accounting and control and stimulant of their further development [Performance Management international agierender Unternehmen als Herausforderung für die Controllinglehre und Stimulanz für deren Weiterentwicklung] . In: Funk W, Rossmanith J, editors. International Accounting and International Controlling [Internationale Rechnungslegung und Internationales Controlling]. 3rd ed. Wiesbaden: Gabler; 2016. pp. 1-31

[7] Neely A, Gregory M, Platts K. Performance measurement system design: A literature review and research agenda. International Journal of Operations & Production Management. 2005;**25**(12):1228-1263. DOI: 10.1108/01443570510633639

[8] Abernethy MA, Horne M, Lillis AM, Malina MA, Selto FH. A multi-method approach to building causal performance maps from expert knowledge. Management Accounting Research. 2005;**16**(2):135-155. DOI: 10.1016/j.mar.2005.03.003

[9] Aranda C, Arellano J. Consensus and link structure in strategic performance measurement systems: A field study. Journal of Management Accounting Research. 2010;**22**(1):271-299. DOI: 10.2308/jmar.2010.22.1.271

[10] Franco-Santos M, Lucianetti L, Bourne M. Contemporary performance measurement systems: A review of their consequences and a framework for research. Management Accounting Research. 2012;**23**(2):79-119. DOI: 10.1016/j.mar.2012.04.001

[11] Edwards JR, Bagozzi RP. On the nature and direction of relationships between constructs and measures. Psychological Methods. 2000;**5**(2):155-174. DOI: 10.1037//1082-989X.5.2,15

[12] Gold AH, Malhotra A, Segars AH. Knowledge management: An organizational capabilities perspective. Journal of Management Information System. 2001;**18**(1):185-214. DOI: 10.1080/07421222.2001.11045669

[13] Bolloju N, Khalifa M, Turban E. Integrating knowledge management into enterprise environments for the next generation decision support. Decision Support Systems. 2002;**33**(2):163-176. DOI: 10.1016/S0167-9236(01)00142-7

[14] Wu WW. Choosing knowledge management strategies by using a combined ANP and DEMATEL approach. Expert Systems with Applications. 2008;**35**(3):828-835. DOI: 10.1016/j.eswa.2007.07.025

[15] Rowe BJ, Widener SK. Where performance measurement and knowledge management meet: Evaluating and managing corporate knowledge. Journal of Accounting and Finance. 2011;**11**(2):91-106

[16] French S, Maule J, Papamichail N. Decision Behaviour, Analysis and Support. Cambridge: Cambridge University Press; 2009. p. 472

[17] Polanyi M. The logic of tacit inference. Philosophy. 1966;**41**(155):1-18

[18] Nonaka I. A dynamic theory of organizational knowledge creation. Organization Science. 1994;**5**(1):14-37. DOI: 10.1287/orsc.5.1.14

[19] Lubit R. Tacit knowledge and knowledge management: The keys to sustainable competitive advantage. Organizational Dynamics. 2001;**29**(4):164-178. DOI: 10.1016/S0090-2616(01)00026-2

[20] Ambrosini V, Bowman C. Tacit knowledge: Some suggestions for operationalization. Journal of Management Studies. 2001;**38**(6):811-829. DOI: 10.1111/1467-6486.00260

[21] Zack M, McKeen J, Singh S. Knowledge management and organizational performance: an exploratory analysis. Journal of Knowledge Management. 2009;**13**(6):392-409. DOI: 10.1108/13673270910997088

[22] Ossadnik W, Kaspar RH, Schinke SM. Constructing a tailor-made performance management system supported by knowledge elicitation tools and dynamic modeling. International Journal of Business Research and Management. 2013;**4**(4):75-98

[23] Cooke NJ. Varieties of knowledge elicitation techniques. International Journal of Human-Computer Studies. 1994;**41**(6):801-849. DOI: 10.1006/ijhc.1994.1083

[24] Markóczy L, Goldberg J. A method for eliciting and comparing causal maps. Journal of Management. 1995;**21**(2):305-333. DOI: 10.1177/014920639502100207

[25] Eden C, Ackermann F, Cropper S. The analysis of cause maps. Journal of Management Studies. 1992;**29**(3):309-324. DOI: 10.1111/j.1467-6486.1992.tb00667.x

[26] Huff AS. Mapping strategic thought. In: Huff AS, editor. Mapping Strategic Thought. Chichester: Wiley; 1990. pp. 11-49

[27] Ferreira A, Otley D. The design and use of performance management systems: An extended framework for analysis. Management Accounting Research. 2009;**20**(4):263-282. DOI: 10.1016/j.mar.2009.07.003

[28] Eden C, Jones S, Sims D, Smithin T. The intersubjectivity of issues and issues of intersubjectivity. Journal of Management Studies. 1981;**18**(1):37-47. DOI: 10.1111/j.1467-6486.1981.b00090.x

[29] Malina MA, Norreklit HSO, Selto FH. Relations among measures, climate of control, and performance measurement models. Contemporary Accounting Research. 2007;**24**(3):935-982. DOI: 10.1506/car.24.3.10

[30] Fiol CM. Maps for managers: Where are we? where do we go from here? Journal of Management Studies. 1992;**29**(3):267-285. DOI: 10.1111/j.1467-6486.1992.tb00665.x

[31] Langfield-Smith K. Exploring the need for a shared cognitive map. Journal of Management Studies. 1992;**29**(3):349-368. DOI: 10.1111/j.1467-6486.1992.tb00669.x

[32] Luft J, Shields MD. Mapping management accounting: Graphics and guidelines for theory-consistent empirical research. Accounting, Organizations and Society. 2003;**28**(2-3): 169-249. DOI: 10.1016/S0361-3682(02)00026-0

[33] Eden C. Strategic thinking with computers. Long Range Planning. 1990;**23**(6):35-43. DOI: 10.1016/0024-6301(90)90100-I

[34] Laukkanen M. Comparative cause mapping of organizational cognitions. Organization Science. 1994;**5**(3):322-343. DOI: http://dx.doi.org/10.1287/orsc.5.3.322

[35] Eden C. Analyzing cognitive maps to help structure issues or problems. European Journal of Operational Research. 2004;**159**(3):673-686. DOI: 10.1016/S0377-2217(03)00431-4

[36] Nelson RE, Mathews KM. Cause maps and social network analysis in organizational diagnosis. Journal of Applied Behavioral Science. 1991;**27**(3):379-397. DOI: 10.1177/0021886391273009

[37] Weick KE, Bougon MG. Organizations as cognitive maps: Charting ways to success and failure. In: Sims HP, Gioia DA, editors. The Thinking Organization: Dynamics of Organizational Social Cognition. 1st ed. San Francisco: Jossey-Bass; 1986. pp. 102-135

[38] Eden C. Cognitive mapping. European Journal of Operational Research. 1988;**36**(1):1-13. DOI: 10.1016/0377-2217(88)90002-1

[39] Montazemi AR, Conrath DW. The use of cognitive mapping for information requirements analysis. MIS Quarterly. 1986;**10**(1):45-56. DOI: 10.2307/248879

[40] Tegarden DP, Sheetz SD. Group cognitive mapping: A methodology and system for capturing and evaluating managerial and organizational cognition. Omega. 2003;**31**(2):113-125. DOI: 10.1016/S0305-0483(03)00018-5

[41] Ackermann F, Eden C. Using causal mapping with group support systems to elicit an understanding of failure in complex projects: Some implications for organizational research. Group Decision and Negotiation. 2005;**14**(5):355-376. DOI: 10.1007/s10726-005-8917-6

[42] Scavarda AJ, Bouzdine-Chameeva T, Goldstein SM, Hays JM, Hill AV. A methodology for constructing collective causal maps. Decision Sciences. 2006;**37**(2):263-283. DOI: 10.1111/j.1540-5915.2006.00124.x

[43] Wouters M, Wilderom C. Developing performance-measurement systems as enabling formalization: A longitudinal field study of a logistics department. Accounting, Organizations and Society. 2008;**33**(4-5):488-516. DOI: 10.1016/j.aos.2007.05.002

[44] Hodgkinson GP, Maule AJ, Bown NJ. Causal cognitive mapping in the organizational strategy field: A comparison of alternative elicitation procedures. Organizational Research Methods. 2004;**7**(1):3-26. DOI: 10.1177/1094428103259556

[45] Akkermans H, van Helden K. Vicious and virtuous cycles in ERP implementation: A case study of interrelations between critical success factors. European Journal of Information Systems. 2002;**11**(1):35-46. DOI: 10.1057/palgrave.ejis.3000418

[46] Wouters M. A developmental approach to performance measures—Results from a longitudinal case study. European Management Journal. 2009;**27**(1):64-78. DOI: 10.1016/j.emj.2008.06.006

[47] Ossadnik W, Schinke SM, Kaspar RH. Group aggregation techniques for analytic hierarchy process and analytic network process: A comparative analysis. Group Decision and Negotiation. 2016;**25**(2):421-457. DOI: 10.1007/s10726-015-9448-4

[48] Fontela E, Gabus A. Current perceptions of the world problematique. In: Churchman CW, Mason RO, editors. World Modeling—A Dialogue. Amsterdam: North-Holland Publisher; 1976. pp. 81-88

[49] Tsai WH, Chou YW, Lee KC, Lin WR, Hwang E. Combining decision making trial and evaluation laboratory with analytic network process to perform an investigation of information technology auditing and risk control in an enterprise resource planning environment. Systems Research and Behavioral Science. 2013;**30**(2):176-193. DOI: 10.1002/sres.2129

[50] Lin CL, Tzeng GH. A value-created system of science (technology) park by using DEMATEL. Expert Systems with Applications. 2009;**36**(6):9683-9697. DOI: 10.1016/j.eswa. 2008.11.040

[51] Li Y, Duan W, Sun Y, Zhang Q. A group DEMATEL approach based on interval estimation. Journal of Convergence Information Technology. 2013;**8**(10):292-299. DOI: 10.4156/jcit.vol8.issue10.36

[52] Yang JL, Tzeng GH. An integrated MCDM technique combined with DEMATEL for a novel cluster-weighted with ANP method. Expert Systems with Applications. 2011;**38**(3):1417-1424. DOI: 10.1016/j.eswa.2010.07.048

[53] Chen FH, Hsu TS, Tzeng GH. A balanced scorecard approach to establish a performance evaluation and relationship model for hot spring hotels based on a hybrid MCDM model combining DEMATEL and ANP. International Journal of Hospitality Management. 2011;**30**(4):908-932. DOI: 10.1016/j.ijhm.2011.02.001

[54] Wu HY. Constructing a strategy map for banking institutions with key performance indicators of the balanced scorecard. Evaluation and Program Planning. 2012;**35**(3):303-320. DOI: 10.1016/j.evalprogplan.2011.11.009

[55] Miao R, Xu F, Zhang K, Jiang Z. Development of a multi-scale model for customer perceived value of electric vehicles. International Journal of Production Research. 2014;**52**(16):4820-4834. DOI: 10.1080/00207543.2014.890757

[56] Tzeng GH, Chen WH, Yu R, Shih ML. Fuzzy decision maps: A generalization of the DEMATEL methods. Soft Computing. 2010;**14**(11):1141-1150. DOI: 10.1007/s00500-009-0507-0

[57] Behera PK, Mukherjee K. Application of DEMATEL and MMDE for analyzing key influencing factors relevant to selection of supply chain coordination schemes. International Journal of Information Systems and Supply Chain Management. 2015;**8**(2):49-69. DOI: 10.4018/IJISSCM.2015040104