

UTILIZING DEMATEL METHOD IN COMPETENCY MODELING

Katerina Kashi

katerina.kashi@vsb.cz

Jiri Franek

jiri.franek@vsb.cz

VŠB – Technical University of Ostrava, Czech Republic

Abstract

Competency models, which should be designed for all key positions in the company, show what competencies are necessary for individual position(s). The question is what the key competencies for each position are. Main objective of this paper is to present results from a pilot research aimed at utilization of the DEMATEL method in competency modeling and to determine if there are any causal relations among key competencies within the competency model. The case study has been executed in an automotive company for the position of a top manager. Firstly, the authors deal with the description of competency models, its development and utilization. Secondly, the DEMATEL method is described. Thirdly, the authors illustrate how the competencies can be decomposed and DEMATEL is used to determine if and what causal relations there are within the groups of competencies and individual competencies. At the conclusion of this paper the authors deal with the models' evaluation results.

Key words: competency models, DEMATEL method, managerial competencies, causal relations.

1. Introduction

Competency models, which should be designed for all key positions in the company, show what competencies are necessary for individual position(s). The question is what the key competencies in each position are and if there are any causal relations among them. Main objective of this paper is to present results from a pilot research aimed at utilization of the DEMATEL method in competency modeling and to determine if there are any relations among key competencies within the competency model for top managers

of an automotive company. Firstly, the authors deal with the description of competency models, its development and utilization. Secondly, the DEMATEL method is described. Thirdly, the authors illustrate how the competencies can be decomposed and DEMATEL is used to determine and rank key competencies for position of a top manager. At the conclusion of this article the authors deal with the models' evaluation results.

2. Competency models

According to Marelli et al. (2005), competency model is a framework, which lists the competencies required for effective performance in a specific job or group of jobs. A competency is a human capability, which is required for effective performance. A competency can be comprised of personal characteristics, knowledge, skills and abilities. Personal characteristics can include: work habits, cooperation with others, manners, mental agility etc. Knowledge is acquired through learning and experience and can be described as an awareness, information or overall understanding about rules, principles, concepts, theories etc. Skills represent the capacity to actually perform physical or mental task with a specific outcome such as managing a six sigma project. Ability is often a composition of several capacities, which enable us to learn and perform. These are usually very difficult to develop since they have a strong component of innate capacity, e.g. the ability to think analytically is more natural for some individuals than others for whom it may be quite challenging to develop.

Well-designed competency models can be used by the company in many ways, it can serve as a base for: recruitment, performance management, succession planning, recognition and awards, compensation and training and development. According to Lucia and Lepsinger (1999) the development and utilization of competency model can also serve the company to: attract talents, retain key employees, and ensure that people's behavior is aligned with company's values and strategy etc. According to Lucia and Lepsinger (1999) the behaviors, which are necessary for effective performance differ from one company to another.

3. DEMATEL method

The DEMATEL method is used to construct interrelations between criteria/factors (Fontela, Gabus 1974, 1976) and to find the central criteria to represent the effectiveness of factors/aspects. It has been successfully applied in many areas, such as marketing strategies, control systems, safety problems, developing the competencies of global managers and group decision-making (Chiu et al. 2006; Liou et al. 2007; Wu, Lee 2007; Lin, Wu 2008). Furthermore, a hybrid model combined with AHP/ANP method has also been used for example, e-learning evaluation (Tzeng et al. 2007), airline safety measurement (Liou et al. 2007). Therefore, in this paper the DEMATEL is applied to detect complex relationships and build an impact-relation map (IRM) of the criteria, but also to obtain the influence levels of each element over others. The DEMATEL method is used to construct the interrelations between criteria to build an IRM. The method consists of following basic steps.

At first the initial average matrix of pair-wise comparisons from experts is calculated. In this step, respondents are asked to indicate the degree of direct influence each factor/element i exerts on each factor/element j , which is denoted by a_{ij} . We assume that the scales 0, 1, 2, 3 and 4 represent the range from “non-influence” to “very high influence”. Each respondent would produce a direct matrix, and an average matrix A is then derived through the mean of the same factors/elements in the various direct matrices of the respondents. The average matrix A is represented as following equation:

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix} \quad (1)$$

In the second step the initial influence matrix is calculated. The initial direct influence mat X ($X = [x_{ij}]_{n \times n}$) can be obtained by normalizing the average matrix A . Specifically, the matrix X can be obtained through equations (2) and (3), in which all principal diagonal elements are equal to zero.

$$X = s \cdot A \quad (2)$$

$$\lambda = \min \left[\frac{1}{\max_i \sum_{j=1}^n |a_{ij}|}, \frac{1}{\max_j \sum_{i=1}^n |a_{ij}|} \right] \quad (3)$$

Then in the third step the full direct/indirect influence matrix is derived. A continuous decrease of the indirect effects of problems along the powers of X , e.g., $X^2, X^3, \dots, X^k$ and $\lim_{k \rightarrow \infty} X^k = [0]_{n \times n}$, where, $0 \leq x_{ij} < 1$ and $0 \leq \sum_i x_{ij}$ or $\sum_j x_{ij} < 1$ only one column or one row sum equals 1.

The total-influence matrix is listed as follows:

$$T = X + X^2 + \dots + X^k = X(I + X + X^2 + \dots + X^{k-1})(I - X)(I - X)^{-1} = X(I - X^k)(I - X)^{-1}$$

then

$$T = X(I - X)^{-1}, \quad (4)$$

where $\lim_{k \rightarrow \infty} X^k = [0]_{n \times n}$ and $T = [t_{ij}]_{n \times n}$, $i, j = 1, 2, \dots, n$. Then the method presents each row sum and column sum of matrix T as follows:

$$r = (r_i)_{n \times 1} = \left[\sum_{j=1}^n t_{ij} \right]_{n \times 1}, \quad (5)$$

$$c = (c_j)_{n \times 1} = (c_j)'_{1 \times n} = \left[\sum_{i=1}^n t_{ij} \right]'_{1 \times n}, \quad (6)$$

where r_i denotes the row sum of the i th row of matrix T and shows the sum of direct and indirect effects of factor/element i on the other factors/elements. Similarly, c_j denotes the column sum of the j th column of matrix T and shows the sum of direct and indirect effects that factor/element j has received from the other factors/criteria.

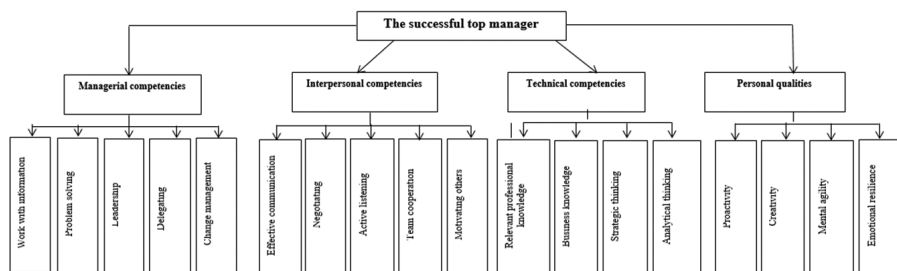
In addition, when $i = j$ (i.e., the sum of the row and column aggregates) $(r_i + c_i)$ provides an index of the strength of influences given and received, that is, $(r_i + c_i)$ shows the degree of the central role that factor i plays in the problem. If $(r_i - c_i)$ is positive, then factor i is affecting other factors, and if $(r_i - c_i)$ is negative, then factor i is being influenced by other factors (Tzeng et al. 2007).

In the fourth step a threshold value is determined and the IRM is constructed on a X, Y graph. Setting a threshold value, α , to filter the minor effects denoted by the factors of matrix T is necessary to isolate the relation structure of the factors. Based on the matrix T, each factor t_{ij} of matrix T provides information about how factor i affects factor j . In practice, if all the information from matrix T converts to the IRM, the map would be too complex to show the necessary information for decision making. In order to reduce the complexity of the IRM, the decision-maker sets a threshold value for the influence level: only factors whose influence value in matrix T is higher than the threshold value can be chosen and converted into the IRM. The threshold value can be decided through the brainstorming of experts. When the threshold value and relative IRM have been decided, the IRM can be shown.

4. Applying DEMATEL within the competency model

Based on previous research of the authors the competencies were divided into four groups to managerial competencies, interpersonal competencies, technical competencies and personal qualities. Then each of these competencies was further divided into individual competencies. Proposal of the decomposition of competencies for the utilization of DEMATEL is shown in figure 1 (Kashi, Friedrich 2013).

Figure 1. The decomposition of competencies for the utilization pair-wise comparison



Source: authors' own elaboration

Following table shows division of each group of competencies and their description (Kashi, Friedrich 2013).

Table 1. The competencies explanation – see Sanghi (2007), modified by authors

MAN	work with information	manager's ability to work well with new information, its organization and also the ability to convey the message to his/her subordinates
	problem solving	the ability to weight pros and cons in an uncertain or ambiguous situations and calling for a high level of judgment or perhaps intuition
	leadership	the skill or rather gift to lead people
	delegating	the skill to hand over any work which can be done by others. This can be used as highly motivating tool for empowering employees
	change management	the manager's ability to deal with change, implement and execute any changes in company, i.e. within company's restructuring or product change
INT	effective communication	the ability of good communication skills
	negotiating	how well can the manager negotiate i.e. with his/her suppliers, employees, co-workers etc.
	active listening	the ability to listen to his/her subordinates' needs, ideas without immediate refusal
	team cooperation	how well does the manager cooperate with other team members, is he/she supportive and helpful
	motivating others	very important skill of a top manager, the ability to motivate his/her subordinates for the best performance possible
TECH	relevant professional knowledge	top manager's specific knowledge i.e. HR manager's knowledge of the legislation and labor code, quality manager – the knowledge of ISO norms etc.
	business knowledge	the thorough understanding of general business functions and specific areas knowledge
	strategic thinking	the ability to come up with alternative viable strategies or business models that deliver customer value. It is a management competency required to carry-out strategy.
	analytical thinking	the ability to use logical and optimization techniques to make decisions
PER	proactivity	manager's ability to respond quickly but within the company long term goals. This competence also includes abilities such as dedication, commitment and responsibility
	creativity	the ability to come up with original solutions or ideas
	mental agility	the ability to grasp problems quickly, to understand whole situation in a timely manner
	emotional resilience	the manager's ability to deal with stressful situations, i.e. working under stress, meeting deadlines etc.

Next these competencies were pair-wise compared according to (1) according to a 0-4 scale. The pair-wise comparison has been done for the groups of competencies and then for individual competencies within the group. This evaluation was done by brainstorming where the assessors, based on consensus, rated each competency based on his/her personal knowledge, experience, etc. Three experts, the authors and HR manager have participated in the evaluation. An example is shown in table 1.

	Managerial	Interpersonal	Technical	Personal
Managerial	0	0	0	0
Interpersonal	3	0	0	4
Technical	0	0	0	0
Personal	3	4	0	0

Then the matrix D and matrix T were calculated. Consequently the threshold value was set and cause and effect diagram were build. The important evaluation competencies were determined by (r_i+c_i) values. According to table 2, the interpersonal and personal competencies were the most important group of competency with the highest (r_i+c_i) value = 3.6667, followed by managerial competencies with (r_i+c_i) value 2.0, whereas the technical competency showed to have a 0 value of (r_i+c_i) , which means that it is neither affected nor affecting other competencies.

Table 3. The sums of given and received among competency groups

	Managerial	Interpersonal	Technical	Personal	r_i	c_i	r_i+c_i	r_i-c_i
Managerial	0	0.0000	0	0.0000	0.0000	2.0000	2.0000	-2
Interpersonal	1	0.4848	0	0.8485	2.3333	1.3333	3.6667	1
Technical	0	0.0000	0	0.0000	0.0000	0.0000	0.0000	0
Personal	1	0.8485	0	0.4848	2.3333	1.3333	3.6667	1

Table 4. The direct and indirect effects of the criteria

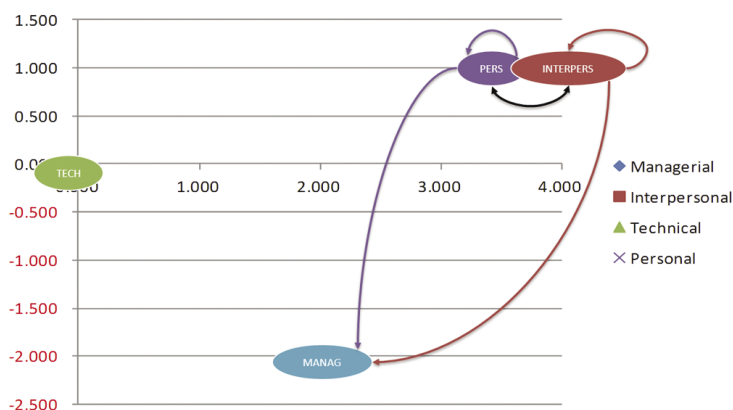
Criteria	(r_i+c_i)	(r_i-c_i)
Managerial	2	-2
Interpersonal	3.6666667	1
Technical	0	0
Personal	3.6666667	1
Managerial		
Work with info	2.8423188	0.5867173
Problem solving	3.3174174	-0.5556273
Leadership	2.8779299	0.6446404
Delegating	2.6995808	-1.3408039
Change management	4.1033867	0.6650735

Interpersonal		
Effective communication	3.1375162	0.2997541
Negotiating	2.0604758	0.0161966
Active listening	2.7030254	0.7931415
Team cooperation	3.3397707	-1.1257582
Motivating others	3.0868566	0.016666
Technic		
Professional knowledge	5.8510638	0.5744681
Business knowledge	7.7659574	-0.9574468
Strategic thinking	10.402619	-0.1472995
Analytic thinking	9.7250409	0.5302782
Personal		
Proactivity	4.9388889	0.0611111
Creativity	1	1
Mental agility	5.0555556	-0.0555556
Stress resilience	6.0055556	-1.0055556

5. Discussion and results

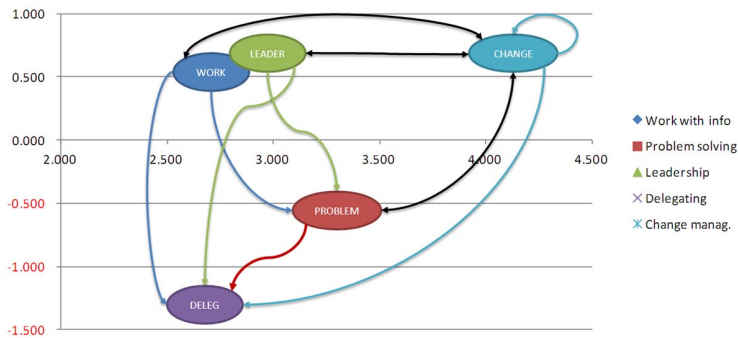
It is evident from table 2 that the most important competency – within the causal relation are the personal and interpersonal competencies, followed by the managerial. Technical competencies are not affected and do not affect any other competency. The causal relations can be better seen in the following figure 2, where are shown the relations among the competency groups, i.e. managerial, interpersonal, personal and technical competencies.

Figure 2. The cause and effect diagram for the competency groups



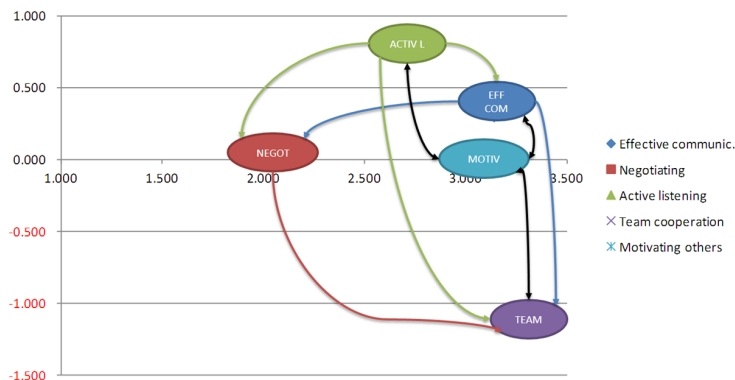
As can be seen from figure 2, the most affecting are the interpersonal and personal competencies. Interpersonal competencies affect themselves and managerial competencies, personal competencies affect themselves and managerial competencies. They also affect each other. Managerial competency does not affect any other competency but is affected by personal and interpersonal competency. Technical competency is neither affected nor affecting other competencies.

Figure 3. The cause and effect diagram for the Managerial competency group



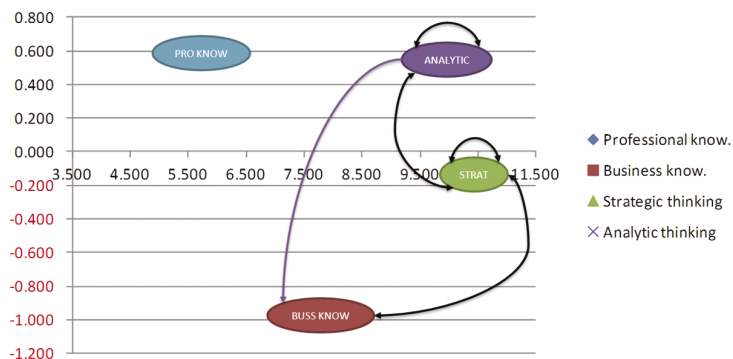
Here the explanation is more complex. The most important here is the change management, which is affecting the work with information, leadership, problem solving and delegating, i.e. it is affecting all of the other competencies; it is affected by problem solving, leadership, work with information and itself. Second important is leadership, which is affected by problem solving and delegating and it is affected by change management. Work with information is affected only by a change management and is affecting problem solving and delegating. Problem solving is only affecting delegating, but it is affected by change management, leadership, and work with information. Delegating does not affect any other competencies; but it is affected by work with information, leadership and problem solving.

Figure 4. The cause and effect diagram for the Interpersonal competency group



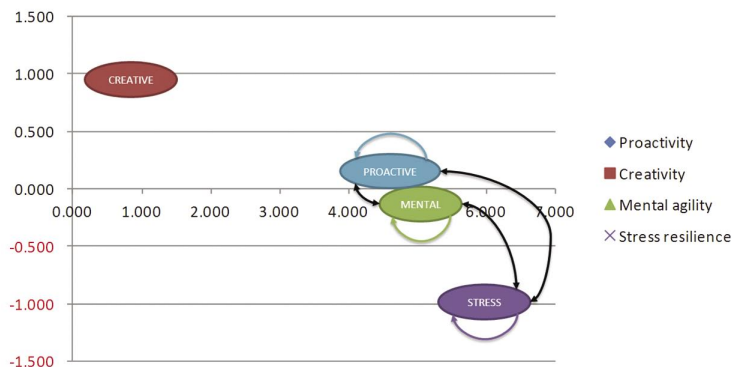
Here, active listening affects on effective communication, motivation, negotiation and team cooperation. This competency affects all other competencies however it is only affected by motivation. Effective communication is affecting team cooperation and negotiation and is affected by motivation. Negotiating is affecting only team cooperation, but it is affected by effective communication and active listening. Motivation is affecting only team cooperation and is affected by effective communication and active listening.

Figure 5. The cause and effect diagram for the Technical competency group



Here, professional knowledge does not affect or is affected by any other competencies. Analytic thinking is affecting itself and business knowledge. Strategic thinking is affecting itself and business knowledge. Business knowledge does not affect any other competency, but it is affected by strategic thinking and analytical thinking.

Figure 6. The cause and effect diagram for the Personal competency group



Here, creativity does not affect and is not affected by any other factors. Proactivity affects mental agility and itself and it is affected by stress resilience. Mental agility affects itself and stress resilience. Stress resilience affects itself and is affected by mental agility and proactivity.

6. Conclusion

Main aim of this paper was to utilize DEMATEL method in order to find the causal relations among competency groups and individual competencies. The results implied that the company's management should mostly concentrate on improving the employees interpersonal, personal and managerial competencies. The technical competencies were found to be not affecting nor affected by other competencies. By the aspect of prioritizing the importance of competencies and the cause and effect relationship among individual competencies, this case study found that effective communication and team cooperation are the most critical within the interpersonal competencies; and stress resilience, mental agility and proactivity are the most critical within personal competencies. Within managerial competencies the most critical are change management and problem solving. Most critical competencies within the technical ones are strategic thinking, analytical thinking and business knowledge.

In case the company wants to develop competencies of their employees they should concentrate on developing those most critical ones, i.e. those that are affecting other competencies.

Acknowledgement

This paper is financed by Student Grant Competition of the Faculty of Economics, VŠB-Technical University of Ostrava; project's registration number is SP2014/126. All support is greatly acknowledged and appreciated.

References

1. Fontela, E., Gabus, A. (1974), DEMATEL, innovative methods, Report no. 2, Structural analysis of the world problematique. Battelle Geneva Research Institute, Geneva.
2. Fontela, E., Gabus, A. (1976), The DEMATEL observer. Battelle Geneva Research Center, Geneva.
3. Chiu, Y.J., Chen, H.C., Tzeng, G.H., Shyu, J.Z. (2006), Marketing strategy based on customer behavior for the LCD-TV, *International Journal of Management and Decision Making*, Vol. 7 No. 2/3, pp. 143-165.
4. Kashi, K., Friedrich, V. (2013), Manager's Core Competencies: Applying the Analytic Hierarchy Process Method in Human Resources. In: *Proceedings of the 9th European Conference on Management Leadership and Governance*, Academic Conferences and Publishing International Limited, Reading, pp. 384-393.
5. Lin, C.-J., Wu, W.-W. (2008), A causal analytical method for group decision-making under fuzzy environment, *Expert Systems with Applications*, Vol. 34 No. 1, pp. 205-213.

6. Liou, J.J. H., Tzeng, G.-H., Chang, H.-C. (2007), Airline safety measurement using a hybrid model, *Air Transport Management*, Vol. 13 No. 4, pp. 243-249.
7. Lucia, A., R. Lepsinger. (1999), *The Art and Science of Competency Models – Pinpointing Critical Success Factors in Organizations*. Wiley, San Francisco.
8. Marelli, A.F., Tondora, J., Hoge, M.A. (2005), Strategies for Developing Competency Models, *Administration and Policy in Mental Health and Mental Health Services Research*. Vol. 32 No. 5/6, pp. 533-561. Available at: <http://www.springerlink.com/index/10.1007/s10488-005-3264-0> (accessed 15 March 2014).
9. Wu, W.-W., Lee, Y.-T. (2007), Developing global managers' competencies using the fuzzy DEMATEL method, *Expert Systems with Applications*, Vol. 32 No. 2, pp. 499-507.
10. Saaty, T.L. (1994), *Fundamentals of Decision Making and Priority Theory with the Analytic Hierarchy Process*. RWS Publications, Pittsburgh.
11. Saaty, T.L., Peniwati, K., SHhang, J.S. (2007), The analytic hierarchy process and human resource allocation: Half the story. *Mathematical and Computer Modelling*, Vol. 46 No. 7/8, pp. 1041-1053. Available at: <http://linkinghub.elsevier.com/retrieve/pii/S0895717707000842> (accessed 15 March 2014).
12. Sanghi, S. (2007), *The Handbook of Competency Mapping*. Sage, London.
13. Tzeng, G.H., Chiang, C.H., Li, C.W. (2007), Evaluating intertwined effects in e-learning programs: a novel hybrid MCDM model based on factor analysis and DEMATEL. *Expert Systems with Applications*, Vol. 32 No. 4, pp. 1028-1044.
14. Zmeškal, Z. (2012), Aplikace dekompozičních vícekritériálních metod AHP a ANP ve finančním rozhodování, paper presented at 6th International Scientific Conference Managing and Modelling of Financial Risks, 10th-11th September 2012, Ostrava, available at: <http://www.ekf.vsb.cz/konference/cs/okruh/mfr/sbornik/dokumenty/Zmeskal.pdf> (accessed 15 March 2014).
15. Zmeškal, Z. (2003), Soft Approach to Company Financial Level Multiple Attribute Evaluation, in: *Proceedings of the 21st International Conference Mathematical Methods in Economics*, Prague Czech Univ. of Agriculture, pp. 273-280.