The ANP Representation of the BSC

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***Abstract**. The development and empirical verification of the balanced scorecard (BSC) model, using the multi-criteria decision-making method (MCDM) called the analytic network process (ANP), are the key issues of the presented research. The research was based on a case study of modelling the BSC for Ydria Motors LL (YM), a manufacturing company.*
Findings from the empirical analysis showed that the BSC and the ANP are complementary methods. Therefore, it can be asserted that introducing the ANP to implement the BSC and vice versa, improved the decision-making approach and the quality of the obtained results.

Keywords. analytic hierarchy process (AHP), analytic network process (ANP), balanced scorecard (BSC), decision-making, performance measurement systems (PMSs), strategy

1 Introduction

Organisations cannot successfully execute strategies if strategic analyses and formulations are poor (Hrebiniak, 2006). Among the number of approaches for measuring business performance, several have attained a dominant position, e.g. analytic hierarchy process (AHP; Saaty, 1980), analytic network process (ANP) (Leung, Lam, & Cao, 2006; Saaty, 2001) and balanced scorecard (BSC) (Kaplan & Norton, 2004).

The AHP is a theory of measurement through pairwise comparisons and relies on expert judgements to derive priority scales. The AHP helps analysts to organise theoretical aspects of a problem into a hierarchical structure, similar to a family tree. By reducing complex decisions to a series of simple comparisons and rankings, then synthesising the results, the AHP helps analysts to arrive at the best decision, and provides them with a clear rationale for the choices made (Saaty, 2008). In addition to the AHP, the ANP is a useful tool for prediction and for representing a variety of competitors with their interactions and their relative strengths to wield influence in making decisions (Saaty, 2001).

The ANP is employed to identify causal relationships (Janeš, 2014) of a BSC's strategy map (Rahimnia & Kargozar, 2016). The inclusion of a BSC provides a framework to ensure that all important criteria are examined and relevant ones are included in the decision model. The ANP provides a convenient means of including BSC indicator interactions and their prioritisation (Tjader et al., 2014). Both methods support the decision-making process (Saaty, 2001), and they have been used in combination with several additional statistical and managerial methods.

The specific objectives of this paper are:

- To briefly present methods used in developing the ANP-BSC model;
- To analyse the benefits of the proposed approach in combining the ANP and the BSC;
- To present an ANP-BSC model on a case study of Ydria Motors LL (YM).

The remainder of the paper proceeds as follows. In the next section, the conceptual background of the method used is presented. The methodology section presents construct operationalisation and validation procedures. This section is followed by the data analysis and results section, which discusses the testing of the proposed research methodology. The paper concludes with a discussion of the empirical findings and implications for research and practices.

2 Conceptual background

2.1 The Analytic Network Process

The AHP helps analysts to organise theoretical aspects of a problem into a hierarchical structure; it organises the basic rationale by breaking down a problem into smaller and smaller constituent parts. This then guides decision makers through a series of pairwise comparison judgments to express the relative strength or intensity of the impact of the elements in the hierarchy (Saaty & Kearns, 1985). The AHP faces certain limitations when the complexity of decision problems increases and interactions among criteria and sub-criteria are not implicitly covered (Saaty, 1980, 2001). To avoid these limitations, generally known as the rank-reversal problem, the ANP was developed by considering the dependency and feedback among elements (Sipahi & Timor, 2010). The ANP is recognised as an improved or general form of AHP, and is capable of evaluating a wide range of criteria, including tangible and intangible factors that have a bearing on the outcome without bothering about their linear hierarchy. The ANP allows for complex interactions and influences among the various components of the decision problem, thus making it a better choice for studying more complex decision problems (Chung et al., 2016). The ANP brings all of the decision objectives, criteria, alternatives and actors, e.g. decision makers, into a single unified framework, and it facilitates the interaction and feedback of elements within groups-clusters (inner dependence) and between groups-clusters (outer dependence).

Building the ANP model requires defining the elements and their assignment to clusters, as well as their relationships, i.e. indicating the flow of influence between the elements. Like the AHP, the ANP is also founded on a ratio scale measurement and pairwise comparisons of elements to derive the priorities of selected alternatives (Saaty, 2001). The main function of the ANP is to determine the relationship of a network structure on the degree of interdependence. Once the measures are identified, the second most important question is the weightage that should be given to each particular measure in designing the model. For example, the BSC's measures are derived from the interrelated strategic objectives of the organisation; hence, in deriving their weightages, these relationships are quite useful (Thakkar et al., 2006). Therefore, influence is a central concept in the ANP. It is a useful tool for prediction and representation, and for representing a variety of competitors with their surmised interactions and their relative strengths to wield influence in making decisions. When the decision-making process involves attributes that have a dependency relationship, the problem should be modelled as an ANP (Saaty, 2001). Most complex real-world decision problems have numerous inter-dependent elements that can be captured and processed utilising the feedback and interaction capabilities of an ANP model (Saaty & Ozdemir, 2004; Tjader et al., 2014). According to Thakkar et al. (2006), the ANP is a multi-attribute decision-making approach based on knowledge, experience and perceptions of experts in the field. Even though it does not provide an optimal solution (from a cost perspective), it is valuable for decision making, involving intangible attributes that are associated with strategic factors (Saaty & Begičević, 2010). Use of the ANP approach provides the means to accommodate the interrelationships of organisational goals to determine the weightages for various BSC perspectives, and this makes the results more valuable and realistic.

Recently, contributors have applied the ANP in many managerial areas. Ravi, Shankar, and Tiwari (2005) combine the BSC and the ANP to conduct reverse logistics operations for end-of-life computers. Nakagawa and Sekitani (2004) utilise the ANP for supplier selection (Gencer & Gürpinar, 2007) and supply-chain performance evaluation (Jharkharia & Shankar 2007). Niemira and Saaty (2004) use the ANP for financial-crisis forecasting. Leung, Lam, and Cao (2006) use the AHP and the ANP to facilitate the implementation of BSC. Gencer and Gürpinar (2007) suggest that the user-friendly software would help managers apply the ANP more easily in decision making (Kadoić et al., 2016). Wu and Lee (2007) use the ANP for knowledge management strategy selection. Lin, Chiu, and Tsai (2008) utilise the ANP to find the most optimal dispatching method. The achievements of the ANP can be observed from its diverse applications and areas of usage such as economics, business, benchmarking, education, manufacturing, project management (Cheng & Li 2005), product development, sociology, politics, etc. (Begičević, Divjak, & Hunjak, 2007; Kuo & Lin, 2012; Moalagh & Ravasan, 2013; Tavana et al., 2013; Wudhikarn, Chakpitak, & Neubert, 2015).

2.2 The Balanced Scorecard

The most important management decision-making issues are strategic planning, strategic analysis and the evaluation of strategy execution. Organisations cannot successfully execute strategy if strategic analysis and formulation are poor (Hrebiniak, 2006; Janeš, 2014). However, managers struggle with closing the gap between strategy and actual results (Kumar Srivastava & Sushil, 2014).

Among a number of approaches for strategy execution monitoring, Kaplan and Norton (2004) achieved a dominant position with their BSC. Thus, the BSC system considers the traditional financial key performance indicators (KPIs) as well as leading KPIs of future performance. In this way, it provides key information about the activities of the managers (Janeš, 2014).

In addition to many benefits, the BSC approach has several critical deficiencies. Tangible 'proxies', such as defect and absenteeism rates, are used to capture the intangible attributes (Janeš, 2014). The BSC lacks dynamics and, consequently, lagging and leading indicators are listed at the same time; cause and effect are not separated in time; and no consideration is given to policies that could generate short-term results which may be completely different from those in the long term (Barnabè, 2011). Moreover, objective surrogate measures often inaccurately reflect intangible criteria. Nonetheless, subjective evaluations are vulnerable to accusations of favouritism, whereas objective measures may be perceived as transparent. Another critical consideration is how the weights of the subjective and objective criteria should be determined if both types of criteria are used in the BSC (Leung, Lam, & Cao, 2006).

Therefore, a number of researchers have tried to resolve some of the aforementioned deficiencies by applying a multi-criteria decision-making method (MCDM) such as the technique for order of preference by similarity to ideal solution (TOPSIS), AHP or ANP. MCDMs have a distinctive fitting to the weaknesses and complexions of the BSC, especially multiple criteria considerations (Bentes et al., 2012). Hence, the AHP has been empirically identified to add several advantages to the BSC such as multi-criteria prioritisation, comparative analysis of business performance, and qualitative and quantitative determination. It seems reasonable to suggest that the more complex the interactions, the greater the need to utilise the ANP (Leung, Lam, & Cao, 2006). Therefore, the ANP was suggested and used with the BSC to cope with the dependency issue as well as other deficiencies of the BSC. Moreover, the algorithm for the ANP accounts for all of the performance measures included in the BSC. This alleviates the negative influence of judgment biases when decision makers use the BSC as part of their performance management (Hu, Wen, & Yan, 2015).

3 Research methodology

The proposed approach uses the ANP and aims at identifying the causal relationships of a BSC's strategy map (Janeš, 2014; Rahimnia & Kargozar, 2016). Basically, what the method does is to estimate the importance of the relationships, and then select those relationships that are considered important according to a defined criterion.

The inclusion of the BSC provides a framework to ensure that all important criteria are examined and relevant ones are included in the decision model (Quezada et al., 2014; Tjader et al., 2014).

The methodological approach used in the presented research was based on a comprehensive review of academic and grey literature, a pool of the existing models, meta-analysis and a number of stakeholders' consultations. Further, it was based on background research, a literature review and an analysis of AHP, ANP and BSC characteristics.

The research was performed as a case study of modelling the BSC system for a manufacturing company and founded on the complementary use of qualitative and quantitative methods. A strategic map of the company that contains the causal relationships between its strategic goals and their respective KPIs has been set and confirmed with the YM Company's executive management (Bititci et al., 2006; Janeš, 2014).

In this paper, the objective was to analyse the benefits of the proposed approach of combining the ANP and BSC methods.

The method was carried out using the following steps (Quezada et al., 2014; Wudhikarn 2016):

1. With qualitative analysis and the designed BSC system (Janeš, 2014; Kaplan & Norton, 2004, 2012), a starting-point, i.e. identification of the strategic objectives, for the quantitative analysis was prepared.
2. Design of the ANP model. The strategic objectives (nodes) were grouped into the four perspectives (clusters) of the BSC. Only those arcs that corresponded to the identified cause-effect relationships were considered.
3. Pairwise comparisons were carried out. The objective was to obtain the importance of all nodes of one cluster in relation to every node of all other clusters.
4. The pairwise comparison process was used to build the comparison matrices and to obtain the corresponding priorities, which were input into the supermatrix. The proposed method uses the priorities of the relationships included in the supermatrix and the priorities of the nodes obtained from the limiting supermatrix.
5. Analysis of the network should be performed when the resulting network has nodes without arcs, which was not the case in the presented investigation.

4 The ANP-BSC model of the YM Company

The YM Company is organised as a competence centre that produces and develops machines, appliances and electric motors for home appliances.

The company's understanding of its business performance sustainability, which is based on comprehensive data tests and semi-structured interviews with the three YM Company's executive managers, contributed to the selection of the strategic goals in the BSC's perspectives. The strategic goals are arranged according to importance as stated by the executive management:

1. Financial perspective: Expansion of opportunities for revenue (Revenue), Cost efficiency, Net operating result, Return on assets (ROA).
2. Customer perspective: Competitiveness, High responsiveness, Reputation, Satisfied customers.
3. Internal process perspective: Development of products and devices (Development of PD), Process optimisation, Development of suppliers, Environmental protection.
4. Learning and growth perspective (LG): Competent managers, Organisation development, Innovation, Social responsibility.

The BSC model was designed with the involvement and consensus of the executive management in eight workshops (Janeš, 2014). The initial ANP model comprehended five perspectives

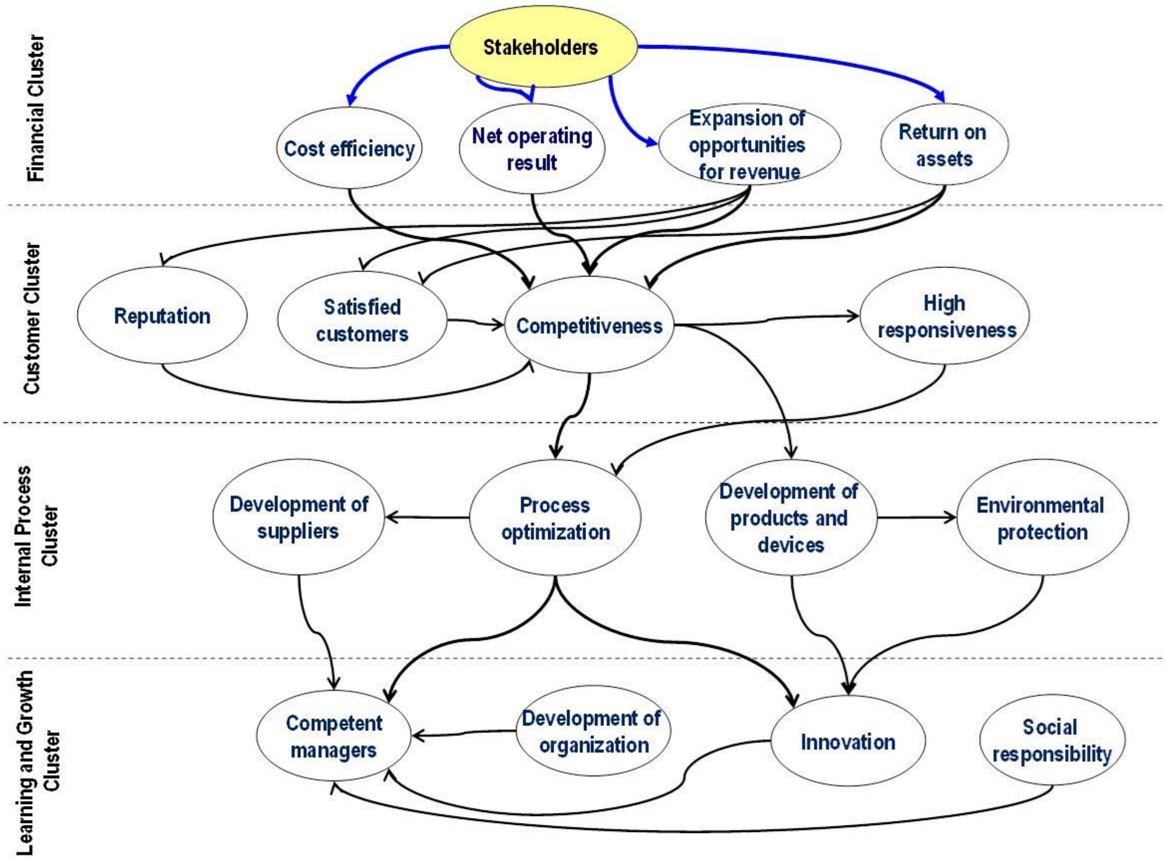

Figure 1. The ANP model with nodes and arcs

(clusters), which included strategic goals (nodes) with cause-effect relationships (arcs). The modelling process only considered relationships on the basis of grounded cause-effect relationships between strategic goals. The cluster, Vision, and its node, Stakeholders, have been added because of the financial perspective estimation, i.e. as an indicator that was comparing the goals of the top perspective. The model is designed based on the Super Decisions simple network template (Figure 1).

Table 1. Comparisons matrix of the financial perspective strategic goals in the ANP model

	Cost efficiency	Net operating result	Return on Assets	Revenue
Cost efficien.	1.0	2	3	0.5
Net operating result	0.5	1.0	2	0.3333
Return on assets	0.3333	0.5	1.0	0.25
Revenue	2	3.0	4	1.0

Note: Strategic goals (nodes) comparisons with respect to Stakeholders. Inconsistency ratio = 0.01160

In the next step, pairwise comparisons between nodes were carried out in order to obtain priorities. Pairwise comparisons were collected from the experts, i.e. with the involvement and consensus of the YM Company's executive management included in developing the ANP-BSC model. An example of the comparisons matrix of the strategic goals (nodes) is presented in Table 1. For each comparisons matrix, the inconsistency ratio was calculated, which was under the limit of 0.1 that must not be exceeded for pairwise comparisons to be reasonable. To this end, the pairwise comparisons for the nodes in each cluster that belong to a parent node were carried out for all the parent nodes in the model (Figure 1). In the presented research, all clusters that represent BSC perspectives are equally important. Thereafter, the unweighted and weighted matrixes were calculated.

In the presented simple, straightforward network of clusters, nodes and arcs, the process of obtaining the limit matrix is performed in order to raise the weighted supermatrix to powers until it stabilises, i.e. until all the columns in the matrix have the same values so the priorities of all nodes can be read from any column (Table 2).

Table 2. Limit matrix with priorities

Perspective-Cluster		Customer
	Strategic goal-Node	Competitiveness
Financial	Revenue	0.020300
	Cost efficiency	0.020300
	Net operating result	0.020300
	ROA	0.020300
Customer	Competitiveness	0.158562
	High responsiveness	0.046817
	Reputation	0.015420
	Satisfied customers	0.011165
Internal process	Development of PD	0.058423
	Process optimisation	0.042340
	Development of suppliers	0.028590
	Environmental protection	0.021127
Learning and Growth	Competent managers	0.106192
	Organisation development	0.020300
	Innovation	0.064771
	Social responsibility	0.020300
Goal	Goal	0.000000
Alternatives (fictive cluster)	ANode	0.324796

Note: The table presents only a part of the limit matrix, which actually contains all the same columns of the Priorities vector. The Vision cluster and the Stakeholders node are excluded because they only served the purpose of the financial perspective estimation. Even without the latter in the model, the priorities remain the same.

The Financial cluster with its nodes, Revenue, Cost efficiency, Net operating result and ROA, appears to have a relatively minor priority according to the limit matrix, which is not the case according to the interviews with the managers. The results from the limit matrix indicate that in the Customer cluster, the highest priority belongs to node Competitiveness (0.158562), which is the most important node among all nodes. Competitiveness is followed by High responsiveness (0.046817). This result is in accordance with the importance stated by the executive management. Reputation (0.015420) and Satisfied customers (0.011165) appear to have a relatively lower priority, which somewhat aligns with the company's ranking of the nodes. In the Internal process cluster, the highest priority node is Development of PD (0.058423), followed by Process optimisation (0.042340) and Development of suppliers (0.028590), which is in accordance with the importance stated by the executive management. Environmental protection has a low priority of 0.021127. In the Learning and growth cluster, the highest priority node is Competent managers (0.106192) followed by Innovation (0.064771), which surpassed Organisational development (0.020300). Namely, Organisation development is at the second level of importance according to executive management. Social responsibility has, according to management, a low priority. However, the analysis ranked it at the same level as Organisational development (0.020300). The cluster, Goal, and its node, Goal, were added for the purpose of ensuring that nodes from the same perspective were mutually compared in pairs, and that the clusters were compared in pairs with respect to the Goal. The fictive cluster, Alternatives, and its node, Anode, were added for the role of enhancing alternatives and, therefore, are not considered in the analysis.

5 Practical implications of the ANP-BSC model

One of the main areas that both the relevant literature and Kaplan and Norton themselves identified as critical is related to the identification, assessment and quantification of causal relationships, which are essential within the BSC (Barnabè, 2011). In this context, the causal relationships have been at the centre of survey interest, because they provide a better relationship model between the four BSC perspectives and their respective strategic goals, which are defined in a subjective way. Even though this way of working is widely accepted in practice, some studies have shown that the declared relationships are not necessarily valid. In order to overcome this situation, the proposed ANP provides a quantitative tool in order to establish the relationships between strategic objectives (Janeš, 2014; Quezada et al., 2014). After the semi-structured interviews with the executive managers, they established that the designed strategy map represented the company's strategy i.e. methods used were perceived firstly with some precaution, but later, when the findings were presented with approval and surprise. Namely the executive management was not convinced what to expect from investigation, but they confirmed that selected and empirically confirmed goals and their respective KPIs were supporting decision-making process (Figure 2; Janeš, 2014).

It should be noted that the arcs (Figure 1) were changed in the opposite direction from the BSC model cause-effect relationships. The ANP model indicated that if the managers' competencies and the development of suppliers were improved, then the process optimisation and labour productivity may improve. Similarly, to improve customers' satisfaction, it is necessary to improve the competitiveness of the optimised production processes.

The advantage of using ANP is that it allows for the inclusion of dependence and feedback on the strategic goals and perspectives in the strategic map. From a practical point of view, the presented method is a good alternative for designing a strategy map of a company, which uses an ANP approach that has been successful in other areas of management. Therefore, it opens new possibilities for research. It should be noted that the presented ANP approach is in accordance with the findings of the Engle-Granger two-step method approach used in previous research performed by Janeš (2014).

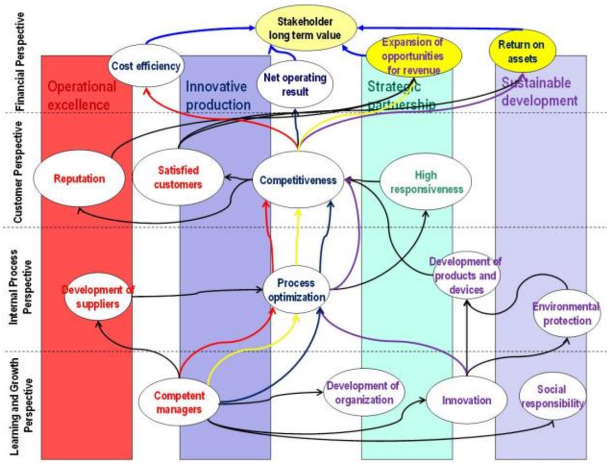

Figure 2. Strategic map of the YM Company
Source: Adapted from Janeš, 2014

6 Conclusions

The literature has identified the necessity to further define the concept of causality within the layout of the BSC, in the direction of relying on specific quantitative tools needed to convert the BSC into a mathematical model. Therefore, based on the reviewed literature, the main characteristics of this approach have been depicted and, in particular, the potentialities of using the ANP to explore the concept of causality in the BSC have been stressed.

A key finding in this research is that the development of the BSC, supported by the ANP, contributes to the explanation of causal relationships in the BSC system. However, it must be emphasised that the generalisation of the research findings was limited to only one manufacturing company. Based on the results, it is recommended that further research be oriented towards expanding the ANP-BSC to other companies, and to use the causal relationships to forecast the future trajectory of the strategy in order to generalise findings and acquire new knowledge.

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