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Quantitative models for performance measurement systems—alternate considerations

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Abstract

This paper revisits the recent works of Suwignjo, Bititci and Carrie (SBC) (Int. J. Prod. Econom. 64 (2000) 231) and Bititci, Suwignjo and Carrie (BSC) (Int. J. Prod. Econom. 69 (2001) 15). We show how a generalizable analytical hierarchy technique based on Saaty's systems-with-feedback approach, also known as the analytical network process (ANP), can be applied, as an alternative methodology, to SBC's quantitative model for performance measurement system. The proposed enhancement to SBC's approach can be completed through the utilization of a supermatrix that can arrive at a solution where the necessary combined weights of the factors influencing the performance measure are a result. In addition, we also show how the ANP approach could be used to enhance the dynamic evaluation of BSC's manufacturing strategy performance evaluation model.

Keywords: ANP; AHP; Performance measurement; Manufacturing strategy

1. Introduction

Suwignjo, Bititci and Carrie (SBC; Suwignjo et al., 2000) and Bititci, Suwignjo and Carrie (BSC; Bititci et al., 2001) provide an innovative framework and supporting system that allows organizations to incorporate and map performance measures in a hierarchical fashion. Central to this approach is the development and application of their tool defined as the quantitative model for performance measurement system (QMPMS) that relies on the analytic hierarchy process (AHP) to quantify factors (tangible and intangible) for performance. They decompose their process into three steps (p. 231 of SBC):

1. identification of factors affecting performance and their relationships,
2. structuring the factors hierarchically,
3. quantifying the effect of the factors on performance.

These three steps are appropriate for use within an AHP framework as described by Saaty (1980, 1996). Yet, the hierarchy they form in SBC is more of a network hierarchy, which incorporates a number of inter-relationships. Using this network formation, we recommend the use of a technique developed by Saaty (1996) that incorporates various "feedbacks" for the generation of a stable

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set of weights incorporating the three effects detailed by SBC. This feedback model has also been defined as the analytical network process (ANP) (Hamalainen and Seppalainen, 1986; Saaty, 1996). SBC do mention the use of ANP for reducing the rank-reversal problem. Yet, the advantages of the ANP approach goes even further allowing for a direct calculation of the combined effects of all the factors, utilizing a Markovian process and a more complete set of relationships that are allowed to flow through the network.

To show how these inter-relationships can be modeled, we will review the various relationships (effects), their formation into a supermatrix and then their calculation. This alternative approach can provide a single coherent model without the many, separate identification and iterations of various hierarchies, paths, and detailed factor aggregations.

In addition, Bititci et al. (2001) (BSC), apply their QMPMS technique for a "dynamic environment" which can be used for manufacturing strategy evaluation and management. We also extend the BSC model for manufacturing performance evaluation to incorporate the feedback mechanisms that can form one coherent long-term strategy for the organization as the current and future dynamics are considered.

Thus the contributions of this paper are to: (1) show how the supermatrix approach can be applied to the QMPMS process with fewer requirements of path (or cognitive map) identification through one aggregate model, and (2) show an alternative modeling of the dynamic nature of strategic decisions based on performance measurement.

2. Mapping QMPMS to the ANP model

2.1. Factor relationships and effects

SBC defined three relationships of factor influences. They did state that this was a critical and important step in the process. The definition and identification of these relationships are also part of the ANP model, which still requires pairwise comparisons as input. The more relationships that are modeled, the more questions that need to be answered by decision makers, auditors, and/or managers, which adds to the complexity of the model. There were three effects identified when describing the relationships within their definition of a cognitive map for the performance measures. The first was a direct effect. This effect may be considered a regular dependency in a standard hierarchy in AHP or ANP. The indirect effect is similar, but the dependency is not direct, it must flow through another factor. The final effect identified by SBC was the self-interaction effect. This effect states that a factor may influence itself in a cyclical manner. ANP labels this effect as an internal (or same-level) interdependency. In the SBC case, the cluster of factors typically used in ANP would be composed of a single factor. One set of effects that was not discussed, but which may occur, is interdependencies among factors, which form a two-way direct or indirect effect. All these relationships are allowed within ANP, it is not necessary to explicitly restructure the relationships to form a hierarchy, as was completed in SBC. Even though, an analyst should be aware of the various relationships.

2.2. Quantifying the effect of the factors on performance using ANP

Similar to QMPMS, the ANP methodology still relies on the results of the standard pairwise comparison results among the factors. The results of the pairwise comparison matrices are relative priorities (weightings) of the factors. We shall not detail this step since it has been explained in SBC and appears in most of Saaty's references. SBC's process of integrating the pairwise comparisons of the various relationships into separate interaction models for each factor can easily be replaced by ANP's supermatrix. To show how this can be completed, SBC's Fig. 4 of the relationships of the total cost per unit (TCU) network is replicated here in our Fig. 1. In this figure, we have also included acronyms for each of the factors that will be used as identifiers in the supermatrix.

In this example there are a number of interactions occurring, even though some internal and