An analytic approach to supply chain development

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Abstract

Supply chain management (SCM) has emerged as an increasingly important approach to improving the performance of logistics systems. SCM is an integrated approach to increase the effectiveness of the logistics chain by improving cooperation between the players in the chain. The objective of this paper is to demonstrate the potential of the analytic hierarchy process (AHP) in supply chain development. The PROPER approach developed by Hannus for business process re-engineering is used as the basic framework, and the potential of the AHP especially in supporting the analysis phase of the supply chain development process is shown with illustrative examples.

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1. Introduction

In the past manufacturing operations have often been viewed as the key link in the supply chain, to be optimised in their own right [1]. In addition, the three fundamental stages of the supply chain, procurement, production and distribution, have been managed independently, and buffered by large inventories [2], with little concern for the impact on the rest of the system. With the rise of supply chain management (SCM) as a new means to provide goods and services to the end customer at the lowest cost and high service level, the one-centric approach for managing the supply chain is no longer appropriate.

The earlier definitions of supply chain management and logistics operations management were nearly equal, since their focus was on the effective performance of the day-to-day activities associated with the optimization of distribution and manufacturing and accelerating the flow of inventory and information through the channel system [3]. Therefore, many writers have used the words logistics and supply chain management as synonyms. For example, Thomas and Griffin have defined SCM as the management of material and information flows both in and between facilities, such as vendors, manufacturing and assembly plants and distribution centres [2]. This definition is also appropriate for logistics, but according to Cooper et al. [4], SCM goes beyond logistics in some given definitions. They have found from the literature that some writers have included in SCM issues like new product development, finance for funding, and marketing concepts. These are the clearest examples of the differences between SCM and logistics which Cooper et al. have found in the literature. Despite this, they have proposed that the word
logistics should not be replaced by SCM, because it would create more confusion in a still emerging field and detract from the need to achieve a much broader level of integration of firms. Furthermore, Cooper et al. proposed a framework for SCM which integrates most, if not all, functions and business processes together. This framework is given in Fig. 1.

The framework given in Fig. 1 emphasises three elements which are the business process, the management components, and the structure of the chain. As a matter of fact, it forces companies to achieve competitive advantage through cooperative coevolving relationships rather than protection of exploitation of resources in an industry, which Bechtel and Jayaram found as core elements of leading firms [5]. In addition according to the literature searches carried out by New [6], SCM papers seem to revolve around the following ideas:

1. Effective purchasing and distribution.
2. A focus on long-term relationships between trading partners.
3. The operational integration of trading organisations.

Based on the previous statements it can be noted that vertical integration in the supply chain should be emphasised, when developing SCM. Furthermore, according to Bechtel and Jayaram, finding and building strong positions in carefully selected supply chains will become a focus of SCM, as firms strive for excellence in cost management and strategic planning.

Since rapid changes are occurring in nearly all markets, suppliers must be flexible enough to restructure their logistics network within a short time. Therefore, business process reengineering (BPR) has gained a position among important approaches when restructuring or improving such issues as supply chain. According to a survey of European Logistics Association the necessity for permanent re-engineering of logistics processes has been accepted by Europe’s logistics leaders and other manufacturers also will follow the trend in the future [7]. Indeed, the main driver behind the BPR philosophy has been the search for more time-effective ways of managing the supply chain [8]. Principally, in BPR dramatic improvements are achieved by fundamental rethinking or radical redesign of the business process. The universal purposes of BPR are to cut costs as quickly as possible and to develop innovative ways of doing things that result in higher customer satisfaction [9]. Because of these objects BPR has been a popular topic with
many researchers [10,11], Ph.D. students [12], as well as a topic in several text books [13,14].

The objective of this paper is to demonstrate the potential of the analytic hierarchy process (AHP) in supply chain development. The PROPER approach developed by Hannus [15] for business process re-engineering is used as the basic framework, and the potential of the AHP especially in supporting the analysis phase of the supply chain development process is shown with illustrative examples.

2. Application of the analytic hierarchy process to supply chain development

The objective of this paper is to demonstrate how a well-known decision support methodology, the analytic hierarchy process (AHP), can be used for supporting supply chain development processes. In this paper, we approach supply chain development from a business process re-engineering point of view focusing on the logistics process. The process re-engineering approach called “PROPER” which has been developed by Hannus [15] is used as the basic framework. The utilisation of the analytic hierarchy process for supporting the “PROPER” approach is demonstrated by illustrative examples.

Hannus [15] has developed an approach for re-engineering core processes of organisations. This approach is called “PROPER” which stands for core process redesign for high performance. The PROPER approach includes three main phases: (1) analysis, (2) design, and (3) implementation. Hannus emphasises that the main phases are not carried out sequentially but the PROPER approach is based on concurrent engineering. In order to shorten the overall time required for core process redesign, the analysis, design and implementation phases have to be implemented simultaneously. The objectives of the analysis phase are to define the core processes, to determine performance measures and objectives, to describe the core processes in adequate detail, to evaluate the possibilities offered by new technologies, and to benchmark the performance levels with best-in-class companies. The outcome of the design phase should include a description of the vision and the “ideal” operating model for the organisation, a description of the redesigned processes, a pilot implementation of the new processes, a list of needed development actions and a plan for the required information technology solutions. The implementation phase consists of actions like the development of the capabilities and competencies required for the redesigned processes, and the actual implementation of the redesigned processes in practice.

Hannus points out that one of the basic ideas behind the PROPER approach is the utilisation of the various schools of thought as tools for process development mentioning especially time-based management (TBM), total quality management (TQM), supply chain management (SCM), activity-based management (ABM), lean management, and business process redesign.

The analytic hierarchy process (AHP) is a theory of measurement for dealing with quantifiable and intangible criteria that has been applied to numerous areas, such as decision theory and conflict resolution [16]. AHP is a problem-solving framework and a systematic procedure for representing the elements of any problem [17]. AHP is based on the following three principles: decomposition, comparative judgements, and the synthesis of priorities. AHP starts by decomposing a complex, multicriteria problem into a hierarchy where each level consists of a few manageable elements which are then decomposed into another set of elements [18]. The second step is to use a measurement methodology to establish priorities among the elements within each level of the hierarchy. The third step in using AHP is to synthesise the priorities of the elements to establish the overall priorities for the decision alternatives. AHP differs from conventional decision analysis methodologies by not requiring decision makers to make numerical guesses as subjective judgements are easily included in the process and the judgements can be made entirely in a verbal mode [19].

As a supply chain development project is normally a group effort, it is important that a decision support tool intended for supporting the project incorporates strong group decision support features. According to Saaty [20], the analytic hierarchy process forms a systematic framework for
group interaction and group decision making. Dyer and Forman [21] describe the advantages of AHP in a group setting as follows: (1) both tangibles and intangibles, individual values and shared values can be included in an AHP-based group decision process, (2) the discussion in a group can be focused on objectives rather than on alternatives, (3) the discussion can be structured so that every factor relevant to the decision is considered in turn, and (4) in a structured analysis, the discussion continues until all relevant information from each individual member in the group has been considered and a consensus choice of the decision alternative is achieved.

In the following, we focus especially on the analysis phase in the PROPER approach. The steps included in the analysis phase are described in further detail and the potential and the possibilities of utilising the analytic hierarchy process to provide a systematic decision support framework for these phases are discussed. The steps included in the analysis phase and the role of the AHP in those steps are summarised as follows:

1. Defining and describing the core processes: The AHP is used for prioritising the processes and sub-processes based on the strategic objectives of the organisation and “actors” influenced by the processes.

2. Defining the performance measures and objectives: The AHP is used for prioritising the key performance areas for the core processes, for analysing the problems related to the key performance areas and for defining the required development actions.

3. Analysing customer requirements, competitive situation and the operating environment: The AHP is used for prioritising customer requirements and required performance levels, for benchmarking the service level provided by one’s own company against that of the competitors, and for analysing the impacts of the emerging opportunities and threats.

4. Analysis of the present processes: The AHP is used for defining and prioritising the problems and required actions related to the processes as well as for gaining understanding about the specific details of a certain problem area.

5. High impact analysis: The AHP is used for prioritising the core processes based on the critical success factors and key performance areas.

6. Benchmarking: The AHP is used for benchmarking the processes of one’s own company against those of the best-in-class companies and for analysing the enablers behind best-in-class performance.

7. Identification of the possibilities provided by new technologies: The AHP is used for prioritising the new technologies based on the critical success factors and the key performance areas.

2.1. Defining and describing the core processes

The first step in the analysis phase of the PROPER approach is to define and describe the core processes of the organisation [15]. Hannus notes that defining the core processes is a demanding task requiring teamwork and iteration, and the following topics are essential for this step: (1) the core processes should be defined based on the strategic objectives of the organisation taking also into account the customers’ and suppliers’ viewpoints, (2) all activities with an impact on the value provided to the customers should be taken into account, (3) the point of view adopted to define core processes should be wide enough to enable the achievement of significant improvements in performance through process redesign, (4) processes often cross organisational boundaries, (5) the links between processes and activities should be taken into account, (6) some processes are similar in different industries which enables the utilisation of benchmarking, and (7) the same processes are not necessarily considered as core processes in all organisations. Hannus recognises the process map as an important tool for defining the core processes.

The AHP shows potential to be used for supporting this phase especially because of its basic characteristics: hierarchical presentation of a problem and prioritisation of the elements in the hierarchy. In defining the core processes, the utilisation of the AHP could be started as follows: (1) the organisations and “actors” that are influenced by the processes are defined (such as the organisation itself,
the customers, the suppliers), (2) the strategic objectives of the defined organisations and actors are defined (such as increasing market share, improving profitability, achieving market leadership), (3) the processes of the organisation are defined, and (4) the processes are divided further into subprocesses and activities. According to Hannus [15], core processes could include, e.g. the following: customer service, product development, production and procurement, sales management and logistics process. Following the principles of the AHP, the aforementioned elements are structured into a hierarchical form (Fig. 2).

The second step in applying the AHP involves deriving priorities for the elements in the hierarchy. The priorities are set by comparing each set of elements in a pairwise fashion with respect to each of the elements in a higher level [18]. A verbal or a corresponding 9-point numerical scale can be used for the comparisons which can be based on objective, quantitative data or subjective, qualitative judgements. In a group setting, there are several ways of including the views and judgements of each person in the priority setting process. In a common objectives context where all members of the group have the same objectives, there are four ways that can be used for setting the priorities: (1) consensus, (2) vote or compromise, (3) geometric mean of the individuals’ judgements, and (4) separate models or players [21]. With the hierarchy in Fig. 2, the prioritisation procedure is started by comparing the organisations and actors in the first level of the hierarchy pairwise with respect to the goal. The procedure is then continued further down in the hierarchy until the lowest level. By synthesising the priorities over the hierarchy, the overall or “global” priorities are calculated for the elements in the hierarchy. Thus, the outcome of the prioritisation provides understanding and consensus on the following topics: (1) the importance of the different organisations and actors on the processes, (2) the importance of the strategic objectives of the different organisations and actors, (3) the overall importance of the processes, and (4) the importance of the subprocesses and activities. Based on the overall importances, the core processes can be selected for further analysis. By prioritising the processes, the re-design efforts can be directed effectively towards the processes with the highest impact on the strategic objectives of the organisations and actors included in the analysis. The AHP methodology and especially the Expert Choice software which is based on the principles of the AHP provide multiple ways of conducting sensitivity analyses on the outcome of the analysis. Thus, the selection of the core processes can be further confirmed by studying the impacts of changes in the priorities of the elements in the higher levels of the hierarchy on the overall importance of the processes.

2.2. Defining the performance measures and objectives

The second step of the PROPER approach involves defining the performance measures and objectives for the core processes [15]. Hannus emphasises that the measures should reflect the objectives of the main interest groups (customers, owners and personnel), the measures should combine operational and financial follow-up data, and the measures should link operational objectives to the corporate level critical success factors and goals. Hannus suggests the use of three main performance measure groups: customer satisfaction, flexibility, and efficiency. In all main measure groups, attention should be paid to at least three main indicators: quality, time and costs.
The AHP can be used effectively to support this step of the PROPER approach. For example, if the focus is on defining the performance measures and objectives for the logistics process, the hierarchy could include the following levels: (1) the goal which is to “define the performance objectives for logistics”, (2) as in the AHP hierarchy presented in Fig. 2, the second level includes all interest groups (like the company itself, the customers, the logistics service providers, etc.) whose strategic objectives should be taken into account in the process development, (3) the third level includes those strategic objectives of the interest groups that have an impact on logistics, (4) the fourth level consists of the logistics key performance areas like reliability, flexibility, quality and added value for the customers, and (5) in the fifth level, the key performance areas are divided further into sub-elements. By deriving priorities for the elements in the hierarchy, the overall importance of the logistics key performance areas and their sub-elements can be determined. These priorities help then to direct attention to those areas with the highest significance to the different interest groups.

As Hannus [15] suggests, the performance level of the company can, at this stage be compared to the performance levels of the best-in-class companies. Based on these comparisons, the AHP-hierarchy for this step can be expanded by adding one more level of elements to the hierarchy. The new level consists of the problems that currently hinder the company from reaching the desired or the best-in-class performance levels with respect to each of the key performance elements and their sub-elements. Furthermore, following the PROPER approach, the actions to be taken in order to improve the performance levels can be defined by adding one more level to the hierarchy. That is, the required actions with respect to each of the defined problems are added to the hierarchy. After deriving priorities for the new elements, the team conducting the process redesign project has an understanding of the most important problems related to the logistics performance and of the priority order of the requested actions. The general hierarchy for this step of the PROPER analysis phase is presented in Fig. 3.

2.3. Analysing customer requirements, competitive situation, and the operating environment

The third step in the PROPER analysis stage consists of a systematic analysis of the customer requirements, the competitive situation and the development of the operating environment [15]. The focus in the analyses should be on defining the possible impacts on the core processes.

The AHP can be used for providing a systematic framework for this step as well. In the area of defining customer requirements, the AHP has previously been applied, e.g. in the following studies: Hölsä [22], Järvinen [23], Hölsä and Tuominen [24], and Korpela et al. [25]. The AHP hierarchy for analysing customer requirements typically includes the following levels: (1) the goal, (2) the main groups of customer service criteria, (3) the sub-elements of the customer service criteria. An example of this hierarchy is shown in Fig. 4.

The importance of the various customer service elements is derived by using the normal AHP procedures, i.e. by using pairwise comparisons and synthesising the derived priorities. Ideally, customers are interviewed individually in order to get an in-depth view. An example of the importance of the service elements presented in Fig. 4 is shown in Fig. 5.
In addition to the importance of the service elements, it is also important to analyse the requested performance levels with regard to each customer service element. In order to gain an understanding about the preferred performance levels with regard to each logistic service element, rating scales are added to the hierarchy. The rating scales are descriptions of the different performance levels. For
example, with regard to delivery time reliability the rating scale could be: a supplier usually delivers the products within 2 days, 1 week, 2 weeks, or 3 weeks of the target delivery date. After defining the rating scales, the customers can use the pairwise comparisons to derive priorities for the different performance levels with respect to each service element. Thus, using the AHP allows the customers to express accurately the levels of service they want to get from the suppliers. The customers can also be asked to analyse the current performance levels of their suppliers by using the AHP hierarchy. This is simply done by assigning the rating that describes most accurately the performance level of a supplier with respect to each service element. The overall outcome of the analysis is the ranking of the suppliers with regard to the overall service level they can provide. For the company carrying out a core process redesign project, this analysis provides a lot of valuable information concerning its own performance level as compared to the competitors. This information can then be utilised further in analysing the problems and required actions concerning customer requirements as follows: (1) the rating scales are removed from the hierarchy, (2) the problems related to the performance level with respect to each service element are defined and added to the hierarchy, (3) the required actions for removing the problems are defined and added to the hierarchy, and (4) priorities are derived for both the problems and required actions. To summarise, the AHP offers a lot of potential as a tool for analysing the customer requirements, for defining the competitive position with respect to customer requirements, and for analysing the problems and the corresponding development actions.

The AHP provides a systematic way for analysing the impacts of the development of the operating environment. In a typical analysis, the focus would be on defining the threats and opportunities resulting from the different environmental trends. With the AHP, the analysis of the opportunities for the logistics process can be structured for example into the following hierarchy: (1) the goal, (2) the key performance areas of the logistics process, (3) the relevant trends, factors or actors that are interpreted as potential opportunities, and (4) the required actions that are needed in order to capitalise on the opportunities. Correspondingly, the potential threats and requested actions can be analysed and prioritised.

2.4. Analysis of the present processes

Hannus [15] states that a basic requirement for re-designing processes is to understand the present way the processes work and the present problems related to the processes. When analysing the present situation, the processes should be divided into detailed levels including the description of the sub-processes and activities. The AHP can be used for supporting the analysis of the present processes at least in two ways: (1) for defining the problems and development needs related to the processes and (2) for analysing in detail a certain essential problem. For example, in order to define the problems related to the logistics process, the AHP hierarchy is structured to include the following levels: (1) the goal, (2) the interest groups affected by the logistics process (like the customers, the logistics service providers), (3) the strategic, logistics-related objectives of the interest groups, (4) the key performance areas of the logistics process, (5) the sub-processes of the logistics process, (6) the problems related to the sub-processes, and (7) the required actions needed for eliminating the problems. In order to reach further details in the analysis, the sub-processes can be divided into activities. By deriving priorities for the elements in the hierarchy, it is possible to gain an understanding of the importance of the sub-processes, the importance of the problems and the priority order of the development actions. Based on the analysis, the most important problems can be chosen for further analysis where the objective is to give a detailed view of the problem, its impacts and the requested actions. The structure of the AHP hierarchy for this analysis could be as follows: (1) the goal, (2) the sub-problems of the main problem, (3) the causes of the sub-problems, and (4) the actions needed for eliminating the causes of the problems. This example of hierarchy follows the example provided by Hannus [15] for a problem analysis. By applying the AHP, the persons conducting the process re-design project can approach the problems related to the present processes in an analytic, systematic way.
resulting in a prioritised list of the problems and the required actions.

2.5. High impact analysis

The objective of the high impact analysis is to define those core processes the re-design of which has the highest impact on the strategic objectives of the company [15]. According to Hannus, the first step in the high impact analysis is to analyse the impact of the core processes on the critical success factors (like customer value, profitability). In the second step, the improvement potential of the processes with respect to the key performance areas (customer satisfaction, flexibility and efficiency) is assessed. The third step involves synthesising the results of the first two steps and prioritising the core processes.

The high impact analysis is a very suitable area for applying the AHP. The impact of the core processes on the critical success factors by structuring a hierarchy with the goal on the highest level, the critical success factors on the second level, and the core processes and their sub-processes on the lowest levels. If there are numerous processes or sub-processes to be analysed, the ratings feature of the AHP can be applied. The improvement potential of the processes with respect to the key performance areas can be analysed with a similar hierarchy just by replacing the critical success factors with the key performance areas. The outcomes of these analyses can be combined by summarising the priorities for each process or sub-process. Based on the summarised priorities, the core processes and sub-processes with the highest potential for re-design can be defined.

2.6. Benchmarking

The purpose of the benchmarking analysis is to define the “best practices” with respect to the core processes [15]. The performance levels of ones own company are compared to the best-in-class companies and the differences between the processes are defined. The gained knowledge is then used as the basis for re-designing the processes.

The AHP has previously been applied to benchmarking by e.g. Eyrich [26] and to logistics benchmarking by Korpela and Tuominen [27]. To support the benchmarking for the logistics process re-design, an AHP hierarchy with the following levels can be structured: (1) the goal, (2) the logistics key performance areas, and (3) the different performance levels (rating scales) with respect to each key performance area. This hierarchy is basically similar to the one proposed by Korpela and Tuominen [27] (Fig. 6). In order to reach further details in the analysis, the hierarchy could be modified by adding, e.g. a level consisting of corporate level strategic objectives above the logistics key performance areas. However, the outcome of this analysis is a comparison of the performance level of one’s own company against that of the best-in-class companies.

In order to understand the differences between one’s own company and the best-in-class companies, the level including the rating scales can be replaced by the enablers for excellent performance with regard to each key performance area. Enablers are defined as the processes, practices and methods that facilitate the implementation of a best practice, or as the characteristics that help to explain the reasons for the achievement of benchmark

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**Fig. 6.** An example of a logistics benchmarking analysis [27].
performance [28]. An example of the analysis of the enablers is shown in Fig. 7. The defined and prioritised enablers form a good basis for the re-design of the processes of one’s own company as they help to understand the reasons behind best-in-class performance.

2.7. Identification of the possibilities provided by new technologies

Hannus [15] states that new technologies can provide significant opportunities for core process re-design. In the PROPER approach, Hannus proposes the same type of analysis for the new technologies as was used for the identification of the core processes with the most potential for redesign. That is, the potential of new technologies is firstly analysed with respect to the critical success factors of the company, and secondly, the potential impact of the new technologies on the key performance areas is analysed. In the third step, the results of the two first steps are combined in order to be able to prioritise the analysed new technologies.

Applying the AHP for this step is a process corresponding to the identification of the core processes. Due to that, the details of the utilisation of the AHP are not discussed here.

3. Conclusions

The objective of this paper is to demonstrate the potential of the analytic hierarchy process in supply chain development. After reviews of the concepts supply chain management and business process re-engineering, the PROPER approach by Hannus for business process re-design has been used as the basic framework. The applicability of the AHP for supporting the analysis phase of the PROPER approach is shown by providing some examples of hierarchy structures.

Owing to its flexibility to support many types of problems, the AHP shows good potential in supporting the PROPER-based supply chain development process. The advantages of the AHP include that it supports group decision making, it enhances the analytical and systematic characteristics of decision making and problem solving, it can be used for documenting the decision processes in order to communicate the results to interest groups, and it helps decision makers to better understand the complex relationships of the problems they are facing.

References