Sub-suppliers model 4.0 and knowledge discovery in industry supply chain

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Abstract

Web 4.0 revolution and the abundance of industrial data in the current business environment allow each industrial company to innovate in a diversity of ways. The novelty approaches for the industry are often related to Industry 4.0, where data plays a key role. This research paper aims to develop a new model of the Sub-Supplier process description „Sub-Suppliers Model 4.0". The model presents the role of knowledge management and Web 4.0 as having a key impact on the processes for business value creation for the industrial organisation. The paper is structured into three chapters. The introduction presents the methods used along with the research question. Chapter one starts with the theoretical bases and state of the art of the Industrial Sub-Supplier Process (ISSP). Chapter two makes a link between the ISSP, knowledge management and knowledge discovery process using data from Supply Chain Management Software for management decision-making. Chapter three of the research starts with web 4.0 tools and proposes a Sub-Suppliers Model 4.0, while trying to explain how the ISSP can be optimized based on the KPIs used. The main research contribution is the novelty integration of the knowledge discovery concept and the implementation of web 4.0 tools into the ISSP.

Keywords: sub-supplier, knowledge, data, model

1. Introduction

Business value generation can be found in each functional domain, but mostly within effective activities within the supply chain process. The supply chain process depends upon many factors - the complexity and unpredictability of the production process, the level of competitiveness of the industrial company, but also from many externals for the industry such as economic environment, social and political environment as well as the ecological requirements. A sub-supplier is a company that produces and delivers to its customers - parts, details, components, assemblies, aggregates, modules, and systems (or sometimes accompanied by relevant services) intended for incorporation into a final or intermediate product. The manufacturer of the finished, final product, the so-called "Original Equipment Manufacturer (OEM)" obtains from various sub-suppliers the parts it needs for assembly into the final product.

From a theoretical point of view, the business activity "Subsupplies" can be considered in different perspectives. For the last several years, much research has been done to identify different sources of competitiveness based on subsupplier

process management. For example, in his research, Joerg S. Hofstetter [1] proposes a sub-supplier management processes framework including out-sub-supplier management and in-sub-supplier management. Regarding the process of digital transformation in Industry 4.0, J. Butt [2] proposes a conceptual framework to support digital transformation in using an integrated business process management approach and discuss the agile supply chain process. Similarly, in a study, the change management importance is linked to knowledge capability for the sustainability management of sub-supplier [3]. Another research work deals with the effects of increasing uncertainties on the design and resilience of supply chains (SC) and aims to show whether changes need to be made in the SC in order to react appropriately to the effects of increasing uncertainties. The focus is on the trade-off between resilience and cost efficiency [4]. Similarly, in regard to change management, another research explains the necessary prerequisites and goals of successful supplier management and the possibilities for using Industry 4.0 in supplier management [5]. Throughout the process of supplier chain management, data is generated at each stage. Thus, Information Systems (IS) are used for collecting and analyzing data. Currently, web-based tools allow industrial companies to make different types of analyses to gain deeper insight into the process. There is much research conducted in analyzing the sub-supply process from different perspectives. This study's tries to propose new insight of sub-supplier chain process related to business value generation based on knowledge discovery within the whole process between the client and sub-supplier. That's why the research question is *"How can knowledge discovery along with web 4.0 tools support the optimization of the sub-supply process of the industrial organisation?"*. The research methods used are literature analyse, desk research, and expert interview.

The research chapters are as follows. The first one makes a detailed overview of the theory used in the supply chain knowledge domain and the process of sub–supplier–client. Then, the next chapter discusses the specifics of knowledge discovery within the subsupplier process and the role of supply chain software systems and Web 4.0 tools. Some web 4.0 tools are presented. The final chapter proposes the Sub-Suppliers Model 4.0 and explains the key role of Knowledge Discovery toward the Sub-supplier process optimization. In this research we do not focus on the related risks and factors of the external environment, which influence the process of sub-supply. The conclusion summarizes the research contributions and presents the next research steps related to the KPIs portfolio for measurement of the Sub-supplier process optimization and innovation.

2. Sub-supplies process - theory basics

There are a number of theories, which apply to the sub-supplier process. Each theory has its own impact on the understanding of each one of the components of the process. The theories are as follows:

- Systems theory
- Profit theory
- Neo-institutional theory
- Information economy theory
- Principal-agent theory
- Theory of transaction costs
- Theory of self-enforcing contracts
- Theory of relational (non-exhaustive) contractual norms
- Social theory of exchange
- Theory of incentives and returns
- Equity-theory
- Resource-based-view-theory
- Theory of market orientation.

According to the systems theory [6], [7], [8], [9], [10], [11], [12] we assume that the business activity "Subsupplies" is a system consisting of the elements "customer" and "subsupplier", in which certain relationships exist between them and exchanges of goods, money and information take place. The activity "subsupplies" is both an open system (subject to the influence of its environment) and a closed system (self-developing, self-managing and influencing its environment). On the other hand, the "subsupplies" system should be both stable and flexible, and for this, relevant management tools are needed.

According to the profit theory [13], [14], one of the leading economic motives is to maximize profit, both for the customer and the sub-supplier, but there are other motives as well. In the benefit spread theory, we assume that the customer seeks to obtain the greatest benefit from its relationship with the sub-supplier, but this also applies to the latter.

To the greatest extent, we consider that the propositions of the neo-institutional theory [15], [16], [17], [18], [19], [20] are applicable to sub-supplies. In the case of sub-supplies, it is a form of coordination of the "business relationship (cooperation)" type. Following the information economy theory [21], [22], [23] we argue that the sub-supply system operates under conditions of incomplete and asymmetric information, and this can lead to a sense of uncertainty and the danger of "opportunistic behavior" on the part of the better-informed partner in the

relationship - the issue that should be investigated, which of the two - the customer or the sub-supplier - is better informed, resp. who is the one in danger.

The subject of the principal-agent theory [24], [25], [26] is the situation in which a principal ("principal") assigns tasks and grants competences to a contractor ("agent"). It is assumed that the available information is incomplete and that there is an "information asymmetry" between the partners, i.e. that the agent has more information than the principal, both before the conclusion of the contract and during its execution (i.e. "hidden information" is available) and can use it opportunistically in his own interest. Asymmetry in information gives rise to agency costs for the principal. In our opinion, this theory also makes a significant contribution to the attempt to understand the phenomenon of "business relations". But in an informational advantage situation, only the agent is considered.

In our opinion, it is quite possible that the exact opposite constellation is also present, that the principal is the better informed partner and uses this advantage. It should be noted that this theory also completely relies on the assumption of an opportunistic behavior, and ignores the functioning of normal, unencumbered by a tendency to fraud business relationships.

According to the theory of transaction costs [27], [28], [29], [30], the reasons for their occurrence are the limited rationality of the partners and the possible opportunistic behavior of one of them. There are three main factors that determine the amount of transaction costs - the specificity of the investment, the frequency of transactions and uncertainty; these factors have an impact on business relations in general, they are especially important for the degree of commitment between partners; the question is, to what extent transaction costs arise in the business relations within the framework of subsupplies, and how strong is their influence on the emergence and functioning of the "subsupplies" system, or in other words - what are the other factors of influence and what is their significance. In our opinion, the statement about the almost inevitable opportunistic behavior of the better-informed partner is controversial; in our opinion, the other possibility of "normal", benevolent, common interest-based relations between the partners should not be excluded.

The theory of self-enforcing contracts [31], [32] states that, with an incomplete legal basis, the contract can be treated as self-enforcing because it will be in force until the parties are convinced that the benefits of its continuation are greater than its termination; and through relatively equal specific investments or resources, the parties demonstrate their interest in cooperation. This could also apply to the sub-supply system.

And according to the theory of relational (non-exhaustive) contractual norms [33], [34] contracts are relational when a whole series of interconnected transactions is carried out, exposed to the impact of constantly changing factors from the environment, and not when it is a question of a separate, isolated act of exchange; contracts are relational, because the so-called normative principle is applied - relations are regulated by a written contract, but also by implicit norms (expectations for ways of behavior accepted by both parties), which in turn are based on the necessary changes in the contract. This statement can also be applied to the sub-supply system.

If we are guided by the social theory of exchange [35], [36], [37], [38], [39], [40] sub-supplies are a matter of limited exchange, when only two partners are involved - a customer and a sub-supplier, and with them the exchange processes take place in both directions anyway. From the content point of view, sub-supplies are a matter of mixed exchange - the object of exchange is a source of functional benefit, but also a carrier of certain symbols; benefit is not only an economic category, but also includes purely social elements, such as trust, recognition, favor.

The theory of incentives and returns [41], [42], [43] states that in sub-supplies both parties strive for an equilibrium between the object of exchange and the counter-compensation, but only from an economic point of view.

According to the equity-theory [44], [45], [46] we assume that there is fairness between a customer and a sub-supplier when the "income-cost" ratio for both is the same. The feeling of injustice increases the dissatisfaction of the buyer and he can take various measures against it, but there can also be dissatisfaction on the part of the sub-supplier and he will react to it, albeit by other means.

If we consider the resource-based-view-theory [47], [48] and the theory of market orientation [49], [50] in relation to the business activity "subsupplies", we assume that the company's resources and the market simultaneously and in interaction predetermine its economic activity, competitive advantages, goals and results it achieves.

The conducted analyses of the existing theories indicate some main characteristics related to business activity of subsupplies (Fig. 1).
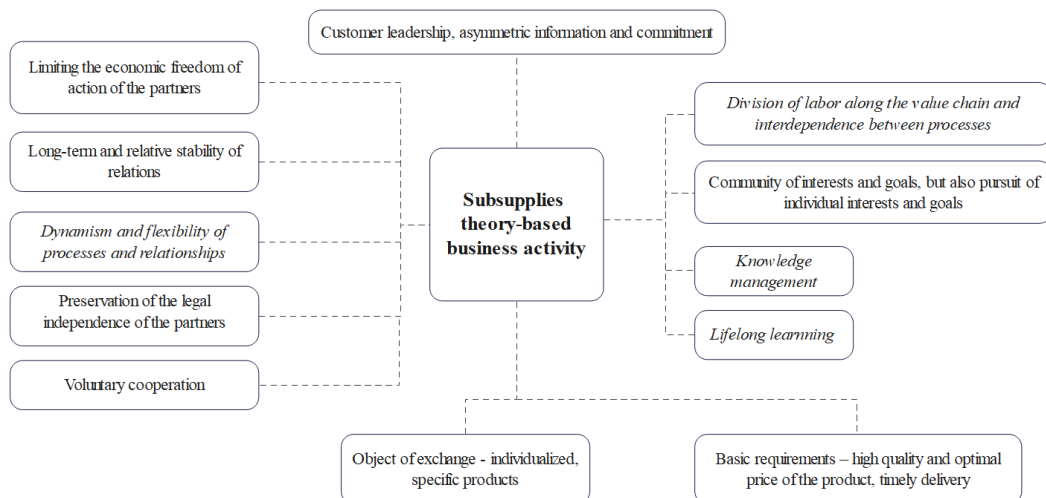
Fig. 1: Subsupplier business activities theory-based model
Source: Author's contribution

3. Sub-suplier process analyses, knowledge management and knowledge discovery

The supplier management process should include [51]:

- Implementation and enforcement of the supplier policy
- Maintenance of a Supplier and Contract Database (SCD)
- Supplier and contract categorization and risk assessment
- Supplier and contract evaluation and selection
- Development, negotiation and agreement of contracts
- Contract review, renewal and termination
- Management of suppliers and supplier performance
- Agreement and implementation of service and supplier improvement plans
- Maintenance of standard contracts, terms and conditions
- Management of contractual dispute resolution
- Management of sub-contracted suppliers.
- Knowledge management and lifelong learning.

By definition Knowledge management (KM) comprises a range of strategies and practices used in an organization to identify, create, represent, distribute, and enable adoption of insights and experiences. Such insights and experiences comprise knowledge, either embodied in individuals or embedded in organizational processes or practice. KM is in the core of the AQPC framework for continuous improvement (Fig. 2) [52].

The PCF is a hierarchical list of business processes. It includes 13 high-level Categories of work, each of which breaks down that work into increasingly granular units or levels called Process Group, Process, Activity, and Task.
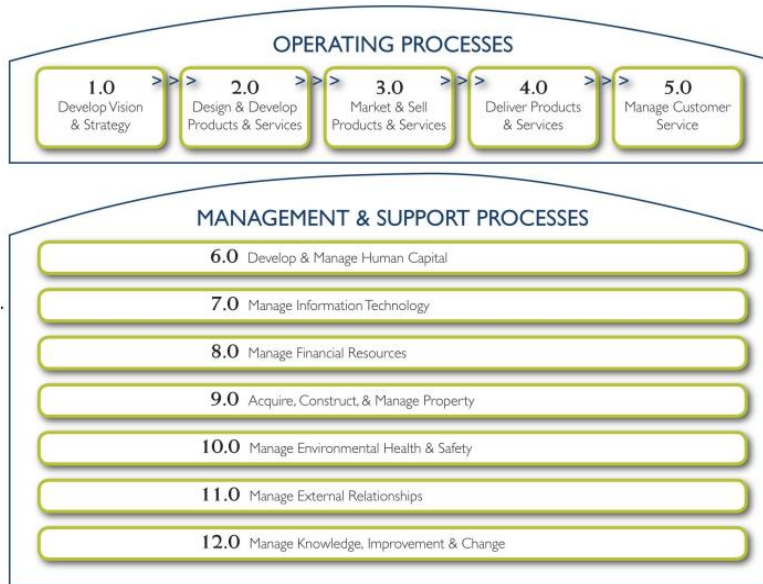

Fig. 2: APQC'S Process classification framework
Source: Author's contribution

Knowledge management and knowledge discovery (KD) are an integral part of sub-supply process. KD is one of the most powerful applications of information systems. The KD process mainly consists of four stages.

1. Data Extraction, cleaning, transformation and loading process. In the first stage, we extract the data. Subsequently, we clean and prepare it for loading into the data marts. The dimensions are transformed into the required format before it is loaded into datamart.
2. Second stage is extraction of useful and relevant data from the datamart. Relevant data is extracted by running queries on the datamart. These queries provide us with a subset of the data in the datamart.
3. The third stage is to analyze the data. In this stage, the data is sliced, diced, summarized. We may also use the data to build statistical models.
4. In the final stage the output is represented in human consumable format. Typically, the business executives require insights in the form of tables, charts and infographics. This information can either be presented on-demand or in the form of customizable KPI (Key Performance Indicators) dashboard.

Knowledge discovery from data is a sequential process of extraction patterns or knowledge from a vast quantity of data [53]. Such quantity of data are generated

into Supply Chain Management Software (SCMS), which automates the flow of processes from raw materials through to delivery of finished goods to the consumer. Currently the industrial organisation can use SCMS along with related to SCMS software. Some examples are:

- Distribution Software;
- Warehouse Management Software;
- Shipping Software;
- Logistics Software;
- Inventory Management Software;
- Freight Software;
- Enterprise Resource Planning Software (Capterra) [54].

Some of the feature of SCMS may include:

- Demand Forecasting - Use historical insights and simulations to forecast customer demand in different situations;
- EDI - Transfer of data from one computer system to another;
- Import/Export Management - Management of imports and exports (ie. international trade);
- Order Fulfillment - Process of taking, organizing, tracking and fulfilling purchase requests for a company's products or services;
- Sales & Operations Planning - Oversee various functions of the organization while balancing and optimizing supply and demand;
- Shipping Management - Organize and track orders being sent and delivered to customers;
- Supplier Management - Manage various aspects of the relationship with suppliers (e.g. interactions, history);
- Transportation Management - Track and organize transportation operations;
- Warehouse Management - Software specialized for managing warehouses and tracking where inventory is located within the warehouses;
- Inventory Management - Track and manage the quantity of resources on hand to maintain proper supply.

4. Sub-suppliers model 4.0

Industry 4.0 creates a disruption and requires companies to rethink the way they design their supply chain. According to McKinsey & Company [55], Supply Chain 4.0 is the application of the Internet of Things, the use of advanced robotics, and the application of advanced analytics of big data in supply chain management: place sensors in everything, create networks everywhere, automate anything, and analyze everything to significantly improve performance and customer satisfaction. Supply chain is strongly related to expansion of web 4.0 technologies. Web 4.0 is all about mobility and the voice interaction between user and machine. Mobile devices allow the user the continuous addition, sharing and distribution of information to the

cyberspace. This is also known as the "**Symbiotic Web**" where what's relevant is the user's activity, not just the data and where the results are based on who the users are, what they do and what they need [56].

In general, cooperation is understood as any form of cooperation between individuals and organizations. In such technology intensify business environment the relationship between a sub-supplier and a client represents as a form of cooperation has a long-term nature and interdependence, passes through different phases, sets different requirements for both parties and implies different agreed tools for managing these relationships. These relationships can be seen as a single system, with elements and processes occurring between them. The basis of this system is the interests of both parties, each partner pursues its own goals, but the emergence and successful functioning of the system is possible when there are common long-term interests and goals between them.

The initial stage of development of the novelty Sub-Suppliers Model 4.0 is the 3 Layer concept cooperation model between Sub-supplier and the client. In Fig. 3 the model is presented.
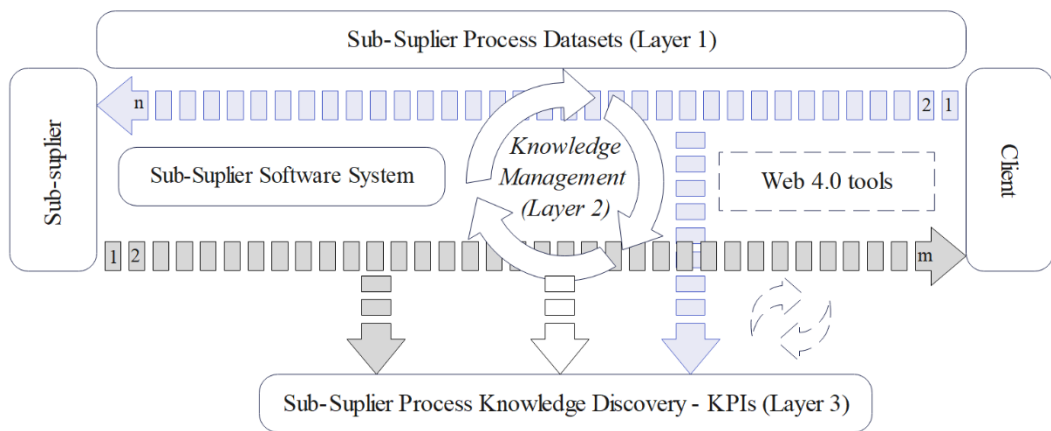

Fig. 3: Sub-Suppliers 3 Layers Model 4.0 – concept
Source: Author's contribution

The model outlines the high degree of variations of the model. Starting with the initial stage of the process, the Occurrence of a customer's need. On each of the stages, there are many options for performance. The stages in brief include:

- Occurrence of a customer's need. Preparation of the technical specification of the product. (customer)
- Search for sub-suppliers. Preliminary selection of sub-suppliers based on available information. (customer)
- Sending an inquiry of interest (client)

- Sending a declaration of interest (subsupplier)
- Preliminary negotiations (client and sub-supplier)
- Evaluation of the sub-supplier based on documents (client)
- Evaluation of the sub-supplier based on an on-site audit (client)
- Assignment of product samples (client)
- Preparation of product samples (subsupplier)
- If necessary – measures to fulfill the client's requirements (subsupplier and client)
- Conclusion of contract for awarding the order (client and sub-supplier)
- Execution of the order (sub-supplier). Performance control (client).
- If necessary – corrective measures (subsupplier and customer)

5. Conclusion

This research has shown that the business activity "subsupplies" is a complex system of relationships between a customer and a subsupplier, which have certain specificities and require adequate management decisions based on reliable information. The process of fulfilling an order goes through various phases and is connected to a huge flow of data that is exchanged between partners. That's why knowledge management and knowledge discovery are becoming an integral part of sub-supply process and such quantity of data are generated into Supply Chain Management Software (SCMS), which can include different elements, as shown. We propose Sub-Suppliers Model 4.0, based on a 3 Layer concept cooperation model between the sub-supplier and the client. The model outlines the high degree of variations of the model. In each of the described stages, there are many options for performance. Applying this model, which web 4.0 tools, we believe that knowledge discovery can support the optimization of the sub-supply process of the industrial organization. The next research steps should be developing a KPIs portfolio for measurement of the Sub-supplier process optimization and innovation.

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