A Comparison of R&D Supply Chains and Service and Manufacturing Supply Chains

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Abstract
This paper is a literature review to compare selected dimensions of manufacturing, services and R&D sectors supply chains. Each supply chain is seen as a system which proper input should be proceed to gain appropriate output. Therefore, to study the supply chains, inputs, outputs and the processors specifications should be considered and the most common characteristics of each sectors' input and output are investigated; additionally, due to wide range of supply chain specifications the factors are brought from the literature to the model to have a unique structure of comparison: **quality**, **cost**, **flexibility**, **competitiveness**, **resource utilization** and **innovation.** The final result is a comparison of the factors in manufacturing, service and R&D sourcing.
Purpose – This paper is a literature review. Due to novelty of R&D sourcing in compare with tangible manufacturing sourcing and intangible service sourcing, and lots of models and

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procedures from manufacturing sourcing were modified in services sourcing, we tried to compare manufacturing and services sourcing bold aspects with R&D souring to find out the possibilities of such modifications. Additionally, exploring on the similarities and differences could lighten up sourcing strategy selection processes.
Design/methodology/approach – Supply chain management is initiated in manufacturing companies, and then various methods, procedures and strategies are modified, developed, and applied at service sector organizations. Therefore, R&D supply chains can be understood by comparing various factors of manufacturing (tangible) and service (intangible) supply chains to find opportunities for modification or innovation in R&D supply chains. The supply chain is a system in which the input should pass out the processor to be converted into the appropriate output. Thus, in this study, inputs, outputs, and processors of supply chains are studied. Using the variation and range of supply chains factors as processor criteria, the most important characteristics of supply chains are studied: quality, cost, flexibility, competitiveness, resource utilization, and innovation.
Findings – The result of the study is a general comparison of R&D, manufacturing, and service supply chains in terms of these criteria: quality, cost, flexibility, competitiveness, resource utilization, and innovation that gives a synergetic view points
Originality/Value – Modifying and developing sourcing strategies and procedures in manufacturing and service sourcing are possible approaches. The possibilities and opportunities in R&D sourcing were evaluated. Subsequently, there are not any other researches which compare R&D sourcing with manufacturing and services.
Keywords – R&D, supply chain management, manufacturing sourcing, service sourcing, synergy, quality, cost, flexibility, competitiveness, resource utilization, research
Paper type – Literature Review
Research limitations: The described criteria are limited: Quality, Cost, Flexibility, Competitiveness, and Resource Utilization therefore the decision making could be done only by those named criteria consideration. While, it could be used by the companies to differ the boldest criteria of R&D, manufacturing and services, it is beneficial especially for the companies who have implemented optimization methods in their manufacturing and services sourcing and now are trying to increase the efficiency of their R&D sourcing.

1. Introduction

Today, in competitive industries, companies try to produce the best product to gain customer satisfaction and market share. To survive in the *fiercely competitive marketplace, companies must* perform in the right way at the right time and the right place at all parts of their value chain. Efficiency and productivity must exist in all individual parts of the supply chain. Moreover, organizations have to use the most appropriate directions and procedures based on appropriate strategies.

Numerous researchers have investigated various features of various types of supply chains. Some researchers examined manufacturing supply network characteristics (Beamon, 1999; Feurer and Chaharbaghi, 1994; Harrison and Van Hoek, 2011), and some focused on the service sector supply chain structures and influential factors (Ellaram et al., 2004; Fitzgerald et al., 1991; Lehtonen and Salonen, 2006; Safizadeh et al., 2008). In the last few decades, researchers have become more interested in the R&D sector due to its essential role in the competitiveness of organizations. Various researchers have emphasized significant factors (Cooper and Kleinschmidt, 1994; Menke, 1991). Several researchers modified manufacturing and service supply chain management models for the R&D supply networks (e.g., Prajogo and Sohal, 2001).

According to previous studies, many methods and procedures have been modified from managing manufacturing supply chains to service sourcing networks. Most studies focused on manufacturing and service supply chains rather than on the R&D supply chain. No research has investigated the differences and similarities of R&D, manufacturing, and service supply chain. Therefore, we address this gap by investigating the significant factors of manufacturing and service supply networks to compare them with the R&D supply chain. The purpose of the paper is to analyze R&D supply chains compared to manufacturing and service supply chains. We answer the following research question: How does the R&D supply chain compare to manufacturing and service supply chains?

2. Rationale of the paper

The purpose of this paper is to compare R&D supply chains with manufacturing and service supply chains. The manufacturing and service supply chains are studied from the literature; thus, the main characteristics are studied and compared with the same factors in R&D sourcing. To simplify the comparison and provide insight, the supply chains are seen as systems with inputs (fig 1), outputs, and processors. Due to the varied roles of inputs and products, the inputs and outputs of manufacturing, service, and R&D supply chains are defined and compared in the third section.

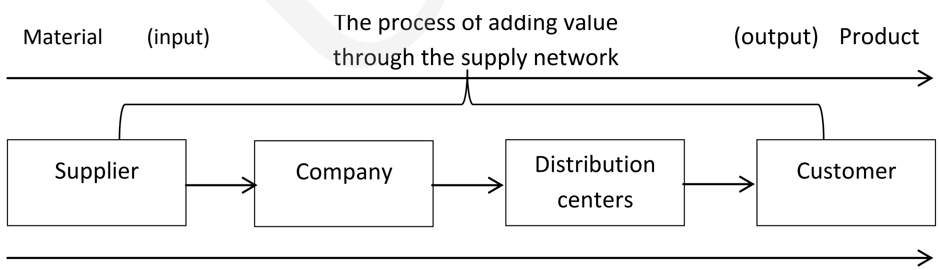

Figure 1: Research Model

Because the range of processor factors is broad, important issues must be compared in terms of the processors. Thus, the performance dimensions Fitzgerald et al. (1991) singled out—quality, cost, flexibility, competitiveness, and resource utilization—are the most crucial issues in this area. They are compared in the fourth section. Other critical factors in supply chain management (SCM) such as lay out of supply chain structure are not described in the paper. We wanted to find the most obvious similarities and differences among the industries as discussed from general viewpoints in the literature. We investigated the factors common to all three industries. However, no unique example is mentioned in the text due to the wildness of topic. All factors are investigated from the buyers' viewpoint.

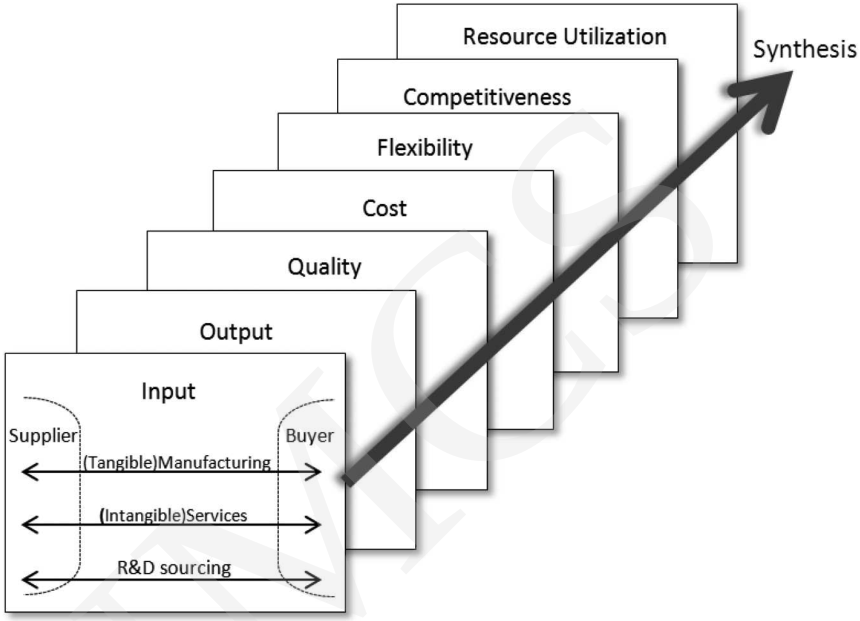

Figure 2:
Rationale of the paper

3. Inputs and outputs

Inputs are the materials, information, permissions, and all properties in the process used to gain the required output, which is called the product. The purpose of supply chain network players in any sector is to deliver products to customers. The product characteristics illustrate the characteristics of the supply chain and its drivers and activities.

3.1 Manufacturing supply chain

Various authors have tried to define input and output in manufacturing. For example, Heshmati (2003) defined inputs as the materials, capital, labor, and energy that undergo appropriate processes through a value-added network, to be converted into outputs, which can be either physical objects or financial benefits. Classifying outputs helps companies define appropriate strategies for each group. For example, Huang et al. (2002) classified products in the manufacturing sector for a suitable supply chain management strategy. Huang et al. (2002) introduced three groups of products: functional, innovative, and hybrid.

3.2 Service supply chain

The inputs of the service sector are nearly the same as inputs in the manufacturing sector with one or two extra issues. For instance, Siegel and Griliches (1992) added purchasing services to the inputs of the manufacturing sector. Classifying and evaluating inputs is easier than calculating and categorizing outputs, due to the wide range of activities in the service sector, which could lead to a larger role for one factor. Lööf and Heshmati (2002) emphasized the role of employees and assumed that the output of the service sector could be measured by the value added per personnel. However, other factors are more important for measuring as the outputs of other service providers. For example, Rosko (2001) identified the number of patients in hospitals. In the service sector, the products (the services provided) encompass activities provided to the customer by the company's personnel. Therefore, the human factor plays a crucial role in the service sector as an input and an output.

3.3 R&D supply chain

With the product life cycle becoming shorter, R&D and rapid development contribute to a company's success. Therefore, the R&D process requires supplementary inputs compared with the service and manufacturing sectors. In the R&D sector, in addition to labor and materials, a company needs specific data, information, and knowledge. Typical inputs for R&D are problems, needs, requests, or, in the best case scenario, requirements. In comparison, outputs are features. Describing the inputs in internal R&D is difficult, and the difficulty increases when inputs are transferred in various parts of organization.

4. Comparison of the performance dimensions of a supply chain

4.1 Quality

The first priority of every company should be quality. Numerous companies have preferred reducing costs to improving quality, although studies have shown the outcome is decreased revenues. A well-known example of this strategy is Toyota. Cole (2011) investigated the company's reasons and characteristics. Quality involves not only the right characteristics of product but also the right activity of the entire supply network. Therefore, some researchers used supply chain quality management (SCQM) to transfer the process of quality evolution through all parts of the supply chain (Carmignani, 2009). Malhotra and Robinson (2005) suggested that quality approaches such as ISO 9001 (2000) should ensure quality from inside the supply chain instead of separate methods for controlling the supply chain and quality.

4.1.1 Quality in the manufacturing supply chain

To modify the old quality management system into SCQM, companies should create a quality assurance system for the supply chain as a unified network. Kuei et al. (2008) described four steps for implementing SCQM in companies. Fish (2011) recommended supportive activities to shift from traditional quality management in the supply chain into SCQM, which could promote the effectiveness of the efforts and ease the implementation of the approach.

4.1.2 Quality in the service supply chain

Bolton and Drew (1991) defined service quality as the ratio of customer observation and company performance, which is different from customer satisfaction. Many studies have used various methods to find the factors of service quality. Grönroos (1988) divided customer observation of companies' activities into two groups: functional and technical. Parasuraman et al. (1985) studied 22 factors the researchers thought were effective elements of the quality of service. The authors claimed empathy, assurance, responsiveness, tangibles, and reliability are the elements of customer perceptions of service quality. They also introduced the SERVQUAL model. Haywood-Farmer (1988) classified possible factors that could be effective in customers' feedback about services into physical, personnel behaviors, and professional judgments.

Most researchers have measured technology only at the company level. However, from the supply chain management perspective, when all of the chain is included in the quality assessment, the process is more effective (Seth et al., 2005). Therefore, researchers in supply chain management try to define service quality from network scale insight. In accordance with the definition of service quality, in the supply chain, service quality is defined as the ratio of customer perception to the performance of each network player and the entire value-added network (Seth et al., 2006).

Even though most studies in the area do not include the requirement to harmonize the entire supply chain, studies have illustrated that service quality programs lead to better performance of the entire supply chain (Mentzer et al., 2000). Seth et al. (2006) promoted service quality models to unify all network players in quality assurance programs by extending Parasuraman et al.'s (1985) SERVQUAL model.

Dale et al. (1997) demonstrated the differences between quality management in service provider organizations and manufacturing companies. The authors found that quality in the service sector is very human-factor centric. The behavior of personnel separate from the technical performance of the service could increase or decrease customer satisfaction.

4.1.3 Quality in the R&D supply chain

Menke (1991) described the success factor of R&D as working on the right project by the right people and the right process, so the framework could illustrate the "right" project, the "right" people, and "the right" process is constructing quality. He also classified the quality assessment stages. As illustrated in Figure 2, Menke's (1991) quality steps are combined with Ulrich and Eppinger's (2008) development process. In addition, the quality measurement and approaches represented by various researchers are shown, to map the quality assurance in each stage of R&D.

The first level is evaluating the feasibility of the project according to the market area, company strategy, and other statistical and qualitative data, which could be learned from the strategy, influence diagram, new product revenue forecast, sensitivity analysis, and decision trees as suitable approaches for evaluating and prioritizing various R&D projects (Menke, 1991).

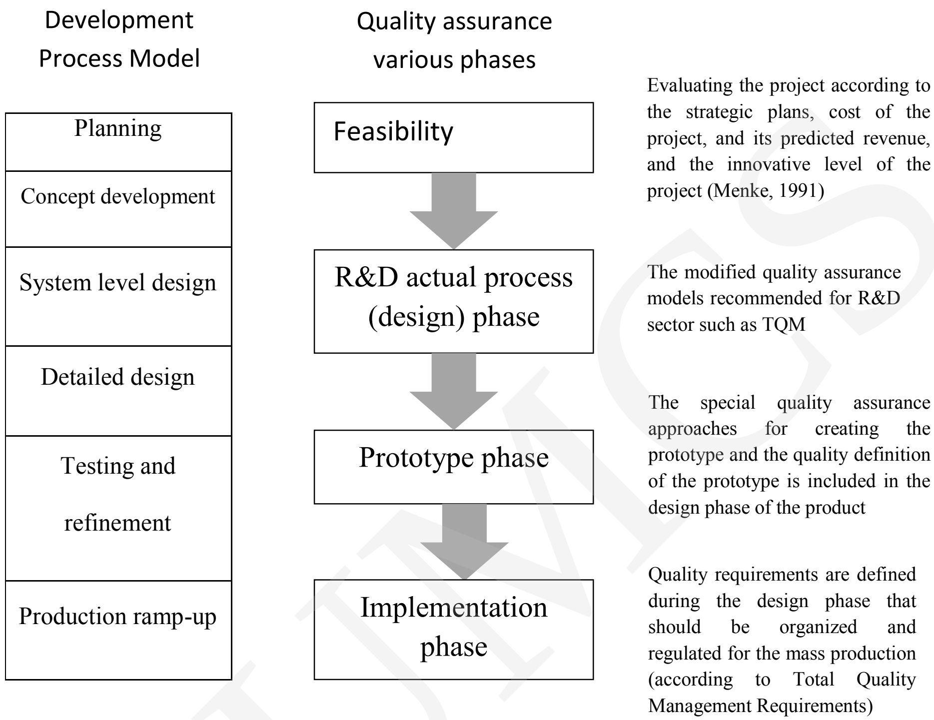

Figure 3: Development process model adapted from Ulrich and Eppinger (2008) and Menke (1991)

For the second and third quality assurance stages, due to the similarity of these processes in the manufacturing and service sectors, the approaches successfully implemented in these sectors have mostly been modified by various authors. For instance, Prajogo and Sohal (2001) modified TQM (Total Quality Management) for the R&D sector, which is one of the most popular quality approaches in manufacturing and had been modified for service provider organizations. In addition, Benner and Tushman (2003) argued that with a mixture of process management and the customer focus approach, a company could build a quality structure in which the process management approaches guarantee the quality processes and customer-focused approaches carry the voice of the customer in the development and innovation process. This is difficult inside an organization, and the difficulty increases when organizational boundaries are crossed.

4.2 Cost

Simchi-Levi et al. (2007) classified cost as one of the features customers use to evaluate companies' products. Lower price is one of the most comprehensive competitive strategies. Thus, reducing costs is a factor, even in luxury products, considered in addition to maintaining the high quality of products to increase a company's profitability.

4.2.1 Cost in the manufacturing supply chain

Beamon (1998) examined four approaches for promoting the profitability of a supply chain that mostly emphasized the role of inventory in the cost efficiency of a company. Pyke and Cohen (1994) investigated inventory cost efficiency; they computed replenishment size and time, order characteristics, and the number of products in each batch to prevent delays. Lee et al. (1993) attempted to reduce inventory levels by allocating production. Altiok and Ranjan (1995) decreased the inventory level by accurately forecasting the time and number of orders. Towill and Del Vecchio (1994), by modifying the filter model, attempted to minimize the amount of inventory and the cost. Ishii et al. (1988) suggested a method for reducing inventory by identifying and eliminating obsolete products.

Camm et al. (1997) accentuated the role of an appropriate distribution system in cost efficiency and suggested a stochastic-based method for promoting the efficiency of the number and location of distribution centers. Lee and Feitzinger (1995), in addition to evaluating the number of distribution centers, calculated a wide range of activity costs in the supply chain from setup costs to inventory costs to form an efficient integrated channel cost.

Subsequently, several studies defined models that included all supply chain players in a unified cost-efficient program. For example, Cohen and Lee (1988) created a model to increase supply chain profitability. According to their model, all parts of the supply chain are controlled. Jonrinaldi and Zhang (2013) optimized the costs of the entire supply chain with fewer restrictions, according to the demand forecast and product life cycle. Tzafestas and Kapsiotis (1994) introduced a procedure for improving the activity of the entire network.

4.2.2 Cost in the service supply chain

One customer preference is lower cost of appropriate services. Frei (2006) recognized various strategies for reducing cost in addition to keeping customers satisfied. He suggested tips for building an efficient supply chain such as labor allocating viewpoint: using cheap labor and outsourcing some activities to other countries with lower-cost labor, trying to automate the process as much as possible to eliminate human failure and make the maintenance line cheaper, and easing tough processes in such a way that they need less-skilled employees. However, due to the broad range of service company activities, these types of procedures vary.

4.2.3 Cost in the R&D supply chain

Typically, there are tradeoffs between low-cost innovation with high revenue and costly research to find new infrastructures and build innovative products. Therefore, time is another factor that makes R&D projects costly; Dunk and Kilgore (2001) showed high competition on cost in short-term projects, rather than innovation. Thoma and O'Sullivan (2011) compared costly innovations in the German car industry and low-cost production lines built in China.

The total costs of R&D projects that gain from quantitative procedures such as Net Present Value (NPV) and qualitative models such as game theory highlight the potential of each project. The company should decide whether the potential goals, revenues, and infrastructures are in line with the company's strategies and invest in the appropriate projects. The time of release and the market situation are crucial for R&D revenue and costs. Uncertainty in R&D typically increases costs when a supplier anticipates risks in delivery and prices the risk.

4.3 Flexibility

Flexibility is the capability of a system to adjust quickly and efficiently to the changes made due to customer requirements, supplier flows, and other environmental or internal factors (Beamon, 1999).

4.3.1 Flexibility in the manufacturing supply chain

Studies have examined various types of flexibility to discover the elements and solve the problem by finding the components. Slack (1991) identified two types of flexibility in the manufacturing sector: range flexibility and response flexibility. D'Souza and Williams (2000) showed volume, variety, process, and material flexibility are components of manufacturing supply chain flexibility. Each has two range and mobility subgroups.

Flexibility has been categorized from different viewpoints. For example, Slack (1991) determined four distinct types of flexibility in a manufacturing network: volume, delivery, mix and new products, which ease the classification of duties for finding the gaps and increase flexibilities. Koste and Malhotra (1999) used a hierarchical approach and studied all parts of the supply chain, beginning with strategic flexibility and continuing to individual personnel and contractor flexibility.

Subsequently, many investigations have determined effective factors in flexibility and measured them. Christopher (1992) described flexibility measuring dimensions, as regular setup and product development time, economy of scope, and the amount of inventory. Slack (1983) noted that measuring flexibility is complicated due to various dimensions and facts (actually and potentially) that flexibility could be influenced by. Sethi and Sethi (1990) realized 15 various dimensions of flexibility in the manufacturing sector that encompass marketing, human factor, and manufacturing criteria.

4.3.2 Flexibility in the service supply chain

Logically, when a high-uncertainty situation occurs (e.g., variation in demand), a company looks for ways to increase numbers or to replace resources that are costly. In the case of temporary fluctuations, a company encounters useless provided inputs. Therefore, the company must find models for controlling these types of changeable conditions, that is, flexibility (Iravani et al., 2005).

However, in the service sector, flexibility is even more complicated. Employees interact closely with customers. One customer satisfaction factor is employee behavior, which differs for various groups of customers. Therefore, in service companies, customization is high, which is an uncertainty factor (Aranda, 2003). Uncertainty is higher in company with high level of customization (Iravani et al., 2005).

Different studies emphasize the role of higher technological devices to increase flexibility especially in companies that provide products in addition to services. However, Gupta and Somers (1996) believed that technology development does not cause increased market share and improved competitiveness.

Chambers (1992) observed that a supply chain cannot be flexible unless all parts of the network are flexible. Suarez et al. (1996) described that from the design and introduction phase to the end of the product life cycle, all activities and duties should be flexible. Moreover, resource management in addition to demand quality and quantity evaluation should be adapted to all the variability and uncertainties that could happen, to prevent unused components and human factors or a lack of resources.

4.3.3 Flexibility in the R&D supply chain

Because of the characteristics of the R&D sector such as outputs, which are vague in some R&D projects, lead time (which could be floating), and the market situation (which could be unknown when the product is introduced), flexibility management in R&D is more complicated compared with the manufacturing and service sectors. Moreover, because of the unstable situations, the flexibility tolerance in R&D should be broader.

Flexibility is a broad concept in various stages of development projects, when the project managers should decide whether to change the directions and plans. The first phase of a R&D project is the evaluation or planning phase, when the company decides which idea could be more productive and efficient in accordance with the current information from customer demand, competitors' situation, and market area. However, when conditions are unstable, big fluctuations could destroy all the project plans. In addition, the entire chain structure should be prepared and flexible enough to react to changes, whether they are harmful or even useful for projects (Santiago and Vakili, 2005).

For the first phase of evaluation and concept studies, many models evaluate various aspects of potential projects such as NPV or others described in the quality section. However, most examine a company's current situation and disregard the uncertainty of the environment (Huchzemier and Loch, 2001). Schwartz and Trigeorgis (2004) adapted the real option theory, which makes R&D projects more flexible by evaluating the process and effective environmental factors in each stage of the project. The authors provided five options in each stage to harness uncertainty, such as defer and abandonment. Huchzemier and Loch (2001) expanded their theory, which contains more uncertainty factors in R&D to make it more applicable for measuring R&D flexibility. Roberts and Weitzman's (1981) sequential model was another effort to identify a method for restraining uncertainty in R&D projects.

4.4 Competitiveness

Competitiveness is the applicable arm of strategy to compete with companies in the marketplace (Cleveland et al., 1989; Kim and Arnold, 1993; Vickery et al., 1991).

4.4.1 Competitiveness in the manufacturing supply chain

Arze and Svensson (1997) emphasized the level of equipment technological potential and employees' knowledge in the degree of competitiveness. El Mhamedi and Binder (1992) highlighted the crucial role of the human factor. Gardiner and Gardiner (1997) described systematic management as another driver. Consequently, researchers created methods and calculated the competitiveness of a manufacturing organization. For instance, Feurer and Chaharbaghi (1994) considered "people, technology, shareholders value, financial strength and customer value" as the factors of competitiveness. They observed that sustainable competitiveness occurs when all factors are balanced.

Kao and Liu (1999) assumed that the two dimensions of technology and management (each has various sub-factors) are the base drivers of competitiveness. Since some factors are not qualitative and cannot be evaluated with mathematical statistics, the authors modeled competitiveness and all drivers with a fuzzy algorithm.

4.4.2 Competitiveness in the service supply chain

Porter (2000) argued that location is an effective factor in service competitiveness that leads to increased productivity. So (2000) described time and price as the most effective factors in the competitiveness of service companies. Moreover, Allon and Federguen (2007) classified the competitiveness factors of the service sector as "price, time and other attributes" which emphasizes on the role of technical characteristics of services.

Due to the variation in the "other attributes" factors in various industries, researchers define "full price," argue about competitiveness by two factors of time and price under the assumption that the technical specifications of all service providers are the same. Therefore, time and price are the only functions of competitiveness from "full price" viewpoint. Carmon et al. (1994) depicted the "full price" function as nonlinear. Allon and Federguen (2007), according to the constant level of "other attributes" in all service provider companies, distinguished three strategies for increasing competitiveness: lower cost, less time, or a decrease in both factors. The core business of service provider organizations is the key point of competition. To improve service and product quality, the enterprise must develop high technology and innovation in services and products. However, due to variations in the service core businesses, close relations between customers and employees, and psychological factors, competitiveness in services is more complex than in the manufacturing sector. However, price and quality are crucial competitive factors.

4.4.3 Competitiveness in the R&D supply chain

R&D is a tool for discovering competitive strategies; therefore, all parts of R&D projects should be formed in accordance with the competitive strategy (Cooper and Kleinschmidt, 1994). Moreover, competitive strategy is one success factor of R&D projects. Ulrich and Eppinger (2008) suggested a classification for competitive strategy that is applicable in several industries. Subsequently, Liao and Cheung (2002) classified competitive strategies in high-tech industries with customer segment focus and marketing insight into five various strategies.

4.5 Resource utilization

Resource utilization, the level of resources used such as space, labor time, and equipment, illustrates how much the company has currently used of its resources and how much resource capacity is unused (Klassen and Mentor, 2007).

4.5.1 Resource utilization in the manufacturing supply chain

The amount of utilization should not be close to 100% because it decreases a company's flexibility (Olhager and Johansson, 2012). There are various models for capacity planning such as waiting line, simulation, and decision trees (Olhager et al., 2001). Consequently, ERP, MRP, BOM, and other resource planning methods and software are useful in this area for supply chains to balance resource utilization to avoid unused resources or low flexibility against uncertainty.

4.5.2 Resource utilization in the service supply chain

Resource utilization and planning structure in the service supply chain are more or less the same as in the manufacturing supply chain. Most methods and software used in manufacturing are modified for services, with a few modifications; for instance, some concepts have different definitions in service companies. All ERP and MPS systems based on the BOM in the service sector depend on Bill of Resources (BOR). Furthermore, in the service sector, the human factor is crucial. Thus, all types of human factor failures should be planned for, such as absences, vacations, etc. In addition, the human factor is rarely 100% used, and the quality decreases with more use (Krajewski et al., 2012).

4.5.3 Resource utilization in the R&D supply chain

As in the manufacturing and service resource utilization procedures, in the R&D supply chain, which has a limited number of personnel and other inputs, the company has to maintain the most efficient performance by selecting the project with high priorities. The priorities can be based on the market situation and the strategic targets of the team or company. Therefore, in R&D, instead of the number of products or provided services, a decision should be made about the quality and quantity of projects.

Wheelwright and Clark (1992) allocated resources with "Aggregate Planning" from studying various aspects of project planning and resource allocation. Other authors created methods for the optimal number of projects in progress and their schedules. Platje et al. (1994) studied single projects in a unified system of portfolios with "rough-cut-project-and-portfolio-planning" to optimize the number of portfolios based on available resources. Pillai and Tiwari (1995) suggested a long-term procedure for prioritizing the portfolios according to the company's strategic goals and scheduling less significant projects in the future for R&D teams.

5. Summary

A summary of the described criteria is shown in Table 1. As shown, in the manufacturing sector, the inputs are material, capital, labor, and expertise. In the service supply chain, the inputs are mainly the same. However, labor is more effective due to the more direct connections with customers. Moreover, in the R&D supply chain, the inputs are the same with an emphasis on knowledge and information, which is known as expertise in supply chains.

Outputs of manufacturing companies are mostly finished products, not in the meaning of ready to use but in the way that the product does not need any other work. In the case of after-sale services, the chain is a service supply chain. The outputs of service providers are the activities provided to customers whether in addition to manufactured products or not. In addition, the outputs of R&D projects can be divided into two groups of new and developed products or services.

Quality is defined in the design specification of products and can be assured with quality management approaches in the manufacturing sector. In the service sector, quality more than technical specifications. It depends on customer perceptions and expectations, which include employees' behavior. Quality can be evaluated with approaches such as SERVQUAL. For the R&D supply chain, quality should be evaluated from the first phase when a concept is selected through the company's strategies and policies and should be evaluated in other steps.

Cost reduction can occur in the manufacturing industry because of efficiency throughout the supply chain, especially inventory and distribution centers or by using cheaper materials and labor. In the service industry, geographic allocation, cheap labor, and technological equipment are the critical factors. In R&D projects, cost efficiency depends on companies' contracts and strategies in addition to the projects' estimated time and revenue.

Flexibility can be divided into various classifications with different methods such as JIT. In service companies, appropriate resource allocation and accurate capacity forecast can increase flexibility. However, in R&D supply chains, the project members should evaluate the project and market situations to decide whether to continue, modify, or abandon the project and avoid additional company losses.

The competitiveness strategy in the manufacturing supply chain is mostly based on cost, quality, or both. In a service company, the strategy is more or less the same. In addition, employees and human behavior play a larger role. In the R&D sector, a company competes with the best technological capabilities, cost leadership strategy, or a customer-focused developed product, although a combination of these strategies is possible.

Resource utilization in the manufacturing industry is based on the production line capacity, which depends on human factors and materials. In the service industry, the human factor is more important than in manufacturing; moreover, the geographic allocation of customers is an important issue. For R&D supply chains, resource allocation emerges when projects are prioritized and selected, according to the material, personnel, market, and competitors. Thus, resource allocation is more complicated.

	Manufacturing	Service	R&D
Input	Capital, material, know-how, and labor	Capital, material, know-how; the role of labor could be more crucial	Crucial role of knowledge and information in addition to manufacturing and service inputs new or developed product, process, or activity
Output	Finished products, physical or monetary value (like software)	Activities by personnel are given to customers	
Quality	Specified in the design of the product or known through quality management approaches; the unified approach for the entire supply chain is more efficient	Known from customer perceptions and customer expectations and service quality control approaches like SERVQUAL	Quality of concepts should be evaluated by company policies and market conditions; the R&D process should include modified quality control methods
Cost	Cost reduction by efficient production, distribution, inventory, and optimization of the entire supply chain	Cheap labor, geographic allocation, and technological equipment could reduce costs	Depends on the contract and strategies' concept and its revenue, which is estimated by some methods before and after the beginning of the project
Flexibility	Volume, delivery, mix, new product, range response, flexibilities; methods like JIT or other strategies such as outsourcing could promote it	By allocating human factor and accurate capacity forecasting try to increase flexibility	Flexibility of the R&D project can be assured by continued evaluation of the project and market situation to continue, modify ,or abandon the project and avoid additional losses
Competitiveness	Best quality or best price or combination of both, which gain by knowledge and equipment.	More innovative, cheaper services, total customer solution, better employee behavior	Technological capabilities, internal infrastructure, and know-how, customer potential and actual needs and market situation
Resource Utilization	Utilization capacity should be synchronized with the production capacity, human factors, and material; resource planning with ERP and MPS databases	Utilization capacity calculated with special recognition of the human factor potential; resource manufacturing planning methods are modified for services	Projects should be prioritized according to the company's strategy; resource planning can be done by shifting or eliminating some project which company does not have enough resources for them.

Table 1: Comparison of R&D sourcing with manufacturing and service supply chains.

6. Conclusions

In accordance with the differences and similarities of the various sourcing networks, some approaches have been modified from one sector's supply chain to the other. For more accurate structures, more specifications should be studied. This study provides a brief picture of various sectors' supply chains. Table 1 shows the answer to the research question according to the criteria. R&D inputs and outputs are almost the same as those in the service and manufacturing sectors. The difference is the critical role of knowledge and data in the R&D value-added network. Quality in R&D should be defined from the first phase when the concept is selected and should be assured during the other phases using the same quality assurance approaches as in the two other sectors. Of course, the entire concept of the project should be under continuous evaluation.

Cost efficiency is more complex in the R&D supply chain due to the vague results of the process and the unknown market situation. The processes should also be assessed in all parts of the project to maintain flexibility and avoid losses in the case of a bad market situation or wrong direction chosen by the R&D supply network players.

R&D is a competitiveness tool. High quality and low cost can be the aim of R&D projects by using innovative technologies or creative logistic methods. Resource allocation is defined the same in the R&D sector and manufacturing and service companies with differences in prioritization policies, which a company should define according to its strategies and market situation.

This research is based on the literature and describes the differences in tangible manufacturing, intangible service sourcing, and R&D sourcing at only a rough level. However, the need for varied managerial understanding is evident. For further research, it would be interesting to see how these practices are differentiated in one organization to provide more accurate research results. Additionally, more researches could be done by exploring more aspects of all the three sourcing types.

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