

The Effect of ICT Qualification on Selection of Long Term Suppliers

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Abstract. Enterprises working in the field of Industry 4.0 or high technology should review the criteria they use when choosing the companies in the supply chain. Even in crisis situations like Covid-19, decision-making criteria should be revised to maintain the functionality of the supply chain. In this study, it has been shown that the importance of ICT competence in companies in the supply chain should be taken into consideration by the parent company and that the selection of firms will change by including it in multi-criteria decision-making processes. In addition to the classic criteria used in the current supply chain evaluation, ICT criteria and sub-criteria have taken into consideration. ICT competencies of companies selected as candidates for supply chain evaluation are at different levels. The level of ICT preferred by the decision-making parent firm is decisive and it is possible to express it analytically with multi-criteria decision-making methods. The parent company needs an agile information and communication network between itself and the supply chain to easily adapt to technological developments and not to be affected by a crisis. Considering the ICT knowledge, skills and competence of the companies to be included in the supply chain, changes the supply chain ranking prepared according to classical criteria.

Keywords. Decision making criteria, decision-making management, ICT competence, supply chain

1. Introduction

According to a report on the global gearbox and gear motor market, this is a highly diversified market with competition distributed across a wide range of industrial and geographic product segments [9]. Each market segment provides varying levels of growth opportunities and competitive landscapes. Each segment requires different product portfolios and competencies to be successful. Companies around the globe are finding themselves navigating an unknown territory, unsure of the out-come and how best to move forward. The current health crisis has generated unprecedented challenges, in many cases leading to growth stagnation. Travel bans have created roadblocks to progress and the path to remaining profitable appears daunting. Nevertheless, ICT stands out among alternative ways of making real connections.

COVID-19 has driven home the need to strengthen global supply chain networks. Supply chains should be dynamic, responsive, and interconnected to an organization's ecosystem and processes [5]. This

requires end-to-end visibility, real-time insights, and decisive actions—particularly in escalating situations. Systems based on exponential technologies can help organizations build smarter supply chains and reduce vulnerabilities in global pandemics—or other unforeseen circumstances. Smarter supply chains that leverage the power of AI (artificial intelligent) and other emerging technologies can help companies maintain business continuity amid disruption and uncertainty.

Traditionally, global companies have based their supply chain design on the assumption that materials flow freely globally, enabling them to source, produce, and distribute products at the lowest-cost locations around the world. However, as the COVID-19 pandemic has demonstrated, unforeseen events can trigger major disruption to entire supply chain networks.

In this study, it is recommended to add ICT competence and sub-components as criteria and sub-criteria in supply chain evaluations, considering that the supply chain and e-technologies contacts accelerated by the current health crisis will come to the fore. For an exemplary gearbox production sector, the effect of different ICT levels on supplier selection is shown.

They are used in a variety of devices and for a broad range of purposes. An industrial gear motor is an element that integrates a gear reducer. Gear motors can deliver high torque at low power and low speed. This is because of the gearhead function, which acts as a torque multiplier and allows small motors to generate higher torque. Most industrial gear motors use AC motors [10]. This article discusses the selection of suppliers in a gear manufacturing facility.

Businesses want to work with the most suitable suppliers who can provide services at the cost and at the desired quality level. The expectations of the main firm are different and varied; choosing the supplier to provide them is one of the major problems. Today, with the impact of globalization and constantly developing technology, competition has become more difficult. In addition to cost and quality, the advanced technology knowledge, skills and competencies of the companies gain importance.

Selection of suitable suppliers reduces procurement costs and the competitiveness of the main company can be effectively increased. In context the criteria used in the selection of suppliers gain importance. These criteria are influenced by the experience of the employees, the developments in the sector and technological changes. Criteria generally set by decision makers, and the results of decisions closely monitored by company employees. Therefore, the questionnaire to use in determining the criteria should be applied not only to decision makers but also to company employees.

The use of computer software in enterprises has passed through various stages. Different functional areas within the company often used their own software applications running on different systems. This difference made it very difficult to share information such as customer information, forecasting, etc. between systems. Even the same information had to be entered multiple times in different ways. These obsolete systems have now been integrated into a single enterprise-wide system used by everyone in the SC (supply chain). This solution is called ERP (Enterprise Resource Planning), which integrates all the data and processes of an organization into a single point.

These ERP systems, which promise to solve preexisting hardware incompatibilities and reduce excessive maintenance and programming costs, are also adopted to use new hardware technologies that emerge in computer networks, telecommunications and web-based applications.

If the ICT score affects the ranking values of the suppliers then the main company that wants to work with the suppliers under the Industry 4.0 needs an ICT-based SC network. In the company will need to increase its score of ICT it will seek from its suppliers according to the Industry 4.0 level targeted.

2. ICT, Inter-Firm Partnerships and Smart Data-bases

For today's businesses, the only thing that is certain is uncertainty. COVID-19 has cast a clear and somber spotlight on the urgent need for resilience and digital capabilities. More than ever, businesses must be able to react to sudden and dramatic changes—in their supply chains, in their customer interactions, in how and where their employees work. But many companies simply aren't there yet.

In a crisis, businesses must quickly answer and address some critical questions. What does that firm sell? How best to interact with customers? Where are the problematic points in the supply chain? In the

COVID-19 crisis, many companies struggled with such assessments and responses. Here, digital and artificial intelligence maturity provides greater resilience [4].

A challenge for globalization is the reshaping of inter-company relations. This multi-actor network increases the level of integration of different partners both internally and externally due to ICT (Information and Communication Technology). In fact ICT, provides better coordination, planning and support for the inter-organizational relationship (IOR) in the SC. With ICT, companies are better able to understand the performance of a single company and the value creation process that influences SC's multi-actor network as a whole [6].

As a result, "communication, information flow, training, certification, integration and cooperation" among SC companies is increasing. Speed, reliability and corporate agility have increased thanks to the conduct of communication, documentation and databases in electronic environment.

ICT are widely used in SC due to their effects on both economic performance and operational agility. In the industrial sector, ICT mainly used to monitor and control the flow of materials in SCs [7]. From this perspective, benefits gained from ICT implementation are vast and varied. ICT-related trends will profoundly affect production. Applications related to ICT have profound effects on production: (1) increased corporate agility and adaptability; (2) flexibility increased because of the growth of the embedded intelligence in the products and processes; (3) physical products go to product/service systems; (4) the product life cycle is redirected to a holistic perspective [1; 2].

Competition between companies and their own optimization efforts are now abandoned. Instead, competition in the international supply chains and optimization of the SC with the help of supply chain management (SCM) coordination has begun. Within this scope, inter-firm partnerships, protocols and project-based collaborations have begun.

SCM tries to make the entire SC work simultaneously. For this purpose, the entire flow of chain members must be managed. To increase the efficiency level in the SC, the level of uncertainty must be reduced; so that the cost of holding stocks of enterprises, and thus the cost of stocks, falls. For all these activities and processes, there is a need for databases that are updated dynamically in the SC and reporting in real time. Even in the case of flexible manufacturing systems, smart databases that report on the future situation should be available, taking into account the developments in the SC when necessary.

3. Supplier Evaluation and Selection Criteria

The supplier selection is one of the strategic decisions that have a significant impact on the performance of the supply chain. Supplier selection problem usually is very complicated, because variety of uncontrollable and unpredictable criteria effect on evaluation and decision-making process. The methods used to evaluate and select suppliers are very diverse. The evolution of supplier selection models is due to the evolution of the nature of selection criteria, from quantitative to a mix of quantitative and qualitative criteria. Assellaou et al. [3] provided insights to the literature that covers supplier selection problem by extending previous survey papers research that have been published in this area. Applications such as performance measurement and evaluation, identification, feedback, training and development used in supplier management.

The first step in the supplier evaluation and selection process is to prepare a list of potential suppliers. One of the sources of supplier information used for the identification of suppliers is the experience of purchasing specialists and the second is supplier information files. The main sources for preparing the supplier information files are catalogs, internet, sales personnel, customer representatives, other purchasing or SC departments.

Noorul Haq and Kannan [7] considered information systems as the sub attitude of the business structure in the main attitude. They found that in most of the investigations they studied, there were about 15 subcritical factors in addition to the main criteria such as cost, quality and service. In their own studies, they used 7 main criteria and 30 sub-criteria.

Several criteria that determine supplier performance. Literature it has been observed that the basic criteria typically utilized for selecting the suppliers are pricing structure, delivery, product quality, and

service etc. While most buyers still consider cost to be their primary concern, most of the researchers continue to consider the price, delivery, and quality as most important criteria. With economic globalization, companies choose suppliers globally from anywhere in the World, especially developing countries which are becoming more competitive because of their low labor and operating costs.

Literature studies on various important criteria for the selection of suppliers continued, Pal et al. [8] used 18 criteria:

Price, Quality, Delivery, Performance History, Warranties & Claims Policies, Production Facilities and Capacity, Technical Capability, Financial Position, Procedural Compliance, Reputation and Position in Industry, Desire for Business, Repair Service, Attitude, Packaging Ability, Labor Relations Record, Geographical Location, Amount of Past Business, Reciprocal Arrangement.

Zhang et al. [12] found that measurements and constructs in all three major variables (ICT, SCM, SC performance) are different and often incomparable, and contextual factors are not systematically considered. Surprisingly, despite these differences, the papers reviewed show that generally, there is a positive direct or indirect effect of ICT on performance and SCM.

Zhang et al. [13] have studied the distinctive roles of inter-organizational ICT and intra-organizational ICT in improving supply chain performance. The paper shows that inter-organizational ICT has a positive direct relationship with supply chain performance and this relationship mediated by supply chain integration. Intra-organizational ICT has no direct relationship with supply chain performance. However, intra-organizational ICT moderates the effect of the supply chain integration on supply chain performance. This study also shows that there is no effect of increased cooperative relationship and information sharing in the case of low levels of intra-organizational ICT.

4. The Effect of ICT as a Main Criterion in Supplier Selection

In a study, the most appropriate supplier selection of a company manufacturing gearboxes dealt with and a survey study conducted to determine the supplier selection criteria [11]. In the questionnaire study, quality control, procurement, R&D and production department experts employed to reflect the requirements of the organization, and the criteria finalized. Thus, the performance of the suppliers handled with 15 main criteria and 34 sub-criteria. Fifteen main criteria evaluated by the questionnaire survey; 7 main criteria and 25 sub criteria have been determined according to importance ratings. These seven main criteria, 25 sub-criteria and 4 alternative supplier firms have been established hierarchical structure. The average scores of the seven main criteria found according to the survey results by Turan et al. [11]. These seven main criteria, 25 sub-criteria and 4 alternative supplier companies have been formed a hierarchical structure.

In this study, four alternative suppliers resolved based on these 7 main criteria and 25 sub-criteria. In order to see the impact of ICT on supplier selection, by adding 1 main criteria of ICT and 3 sub-criteria, a new hierarchical structure was established with 8 main criteria, 28 sub-criteria and 4 alternative supplier companies. Reduced scores of the main criteria are as follows:

1. Quality (9.00)
2. Cost (5.50)
3. Service (4.75)
4. Delivery (1.20)
5. Flexibility (2.50)
6. Reliability (2.80)
7. General structure of the enterprise (1.00)
8. Engineering-technical skills (0-3-5-7-9)

The engineering-technical skills proposed by Noorul Haq and Kannan [7] selected as the eighth main criterion. As sub criteria: 1) ICT knowledge, skills and competence, 2) Electronic environment as documentation, databases and communication, 3) Embedded intelligence in the products and services

were determined. The eighth main criterion was accepted as five separate values between 0 and 9; 0/9, 3/9, 5/9, 7/9 and 9/9. Evaluation of alter-native suppliers was made for these five average points.

In order to facilitate the selection of suppliers, AHP method, which is a multi-criteria decision-making method used. According to AHP main and sub-criteria compared in binary and the resulting matrices normalized. The weight factors (approximate eigenvalue vectors) of the criteria found from these matrices. The consistency ratios of the approximate eigenvalue vectors found also checked. The equation (1) used to calculate the consistency index CI (consistency index):

$$CI = \frac{\lambda_{max} - n}{n - 1} \quad (1)$$

In the CI consistency index formula, λ (max); the largest eigenvalue in the matrix, n: represents the number of columns of each matrix. The consistency ratio (CR) obtained by proportioning the consistency index to the random size of the same size (random-ness index) such as equation (2).

$$CR = CI / RI \quad (2)$$

RI, represents the random value index and is used in the operations by selecting the appropriate one from the values in the random index values. RI is the average value of CI for random matrices using the Saaty scale only accepts a matrix as a consistent one if $CR < 0.1$.

Relative rankings of alternative suppliers found first. For this purpose, the suppliers compared in terms of two sub-criteria under each main criterion and the resulting matrix normalized. Thus, the relative vector of the suppliers found for each sub-criterion (Table 1). The relative vectors of the sub-criteria each main criterion were written in matrix form and the (suppliers) x (sub-criteria) matrix was revealed. These matrices multiplied by the weighting factors of the previously found sub-criteria to find the relative ordered vectors of the suppliers of each major criterion. To find the absolute ordering of suppliers, these vectors combined in the form of (suppliers) x (main criteria) matrix and multiplied by the weighting factors vector of the main criteria and the suppliers' sorted scores were calculated.

Table 1. Main and Sub-Criteria Determined for Optimal Supplier Selection

Main Criteria	Sub Criteria
1. Quality	1. Return Rate
	2. Quality Systems
	3. Order Compliance with Company Process
2. Cost	4. Reasonable price
	5. Price differences
	6. Payment Flexibility
	7. Amount Reductions
3. Delivery	8. Just in Time Delivery
	9. Compliance with Delivery Terms
4. Service	10. Delivery Flexibility and Reliability
	11. Customer service
	12. Quick Response to Demand Change
5. Flexibility	13. Shipping performance
	14. The rate of meeting future needs
	15. Ability to respond to changes in the amount of the product
	16. Ability to respond to changes in supply dates
	17. Responding to Changes in Product Diversity
6. Reliability	18. Organizational status of business enterprise.
	19. Providing guaranteed products
	20. Importance and confidence given to long-term relationships
	21. Past Performance
7. General Structure of the Business	22. Personal number
	23. Capacity
	24. Sector experience
8. Engineering-Technical Skills	25. Facility location
	26. ICT knowledge, skills and competence
	27. Electronic environment as documentation, databases and communication
	28. Embedded intelligence in the products and services

For engineering-technical skills mean scores (ICT scores) = 0/9, 3/9, 5/9, 7/9 and 9/9, the main criteria were compared in pairs. The relative ranking matrix of the suppliers according to the main criteria and finally the ranking values and rating grades of the suppliers were calculated.

For ICT score = 3/9, a binary comparison of the main criteria, the relative ranking matrix of the suppliers according to the main criteria is given in Table 2.

Table 2. Comparison of main criteria (ICT points = 3/9)

Main criteria	Quality	Cost	Delivery	Service	Flexibility	Reliability	Business Structure	Eng. skills
Quality	1	2	3	8	7	5	9	4
Cost	1/2	1	2	7	5	3	8	2
Delivery	1/3	1/2	1	6	4	3	6	2
Service	1/8	1/7	1/6	1	1/2	1/3	2	1/4
Flexibility	1/7	1/5	1/4	2	1	1/2	2	1/3
Reliability	1/5	1/3	1/3	3	2	1	3	1/2
Business Structure	1/9	1/8	1/6	1/2	1/2	1/3	1	1/5
Eng. -tech. skills	1/4	1/2	1/2	4	3	2	5	1

The ranking values given in Table 3.

Table 3. Relative ranking matrix of suppliers according to main criteria (ICT points = 3/9)

Main criteria	Quality	Cost	Delivery	Service	Flexibility	Reliability	Business Structure	Eng.-tech.skills
A	0.2633	0.2633	0.2633	0.2633	0.5579	0.5579	0.0569	0.1219
B	0.0569	0.5579	0.0569	0.0569	0.2633	0.0569	0.1219	0.0569
C	0.1219	0.1219	0.5579	0.5579	0.1219	0.1219	0.5579	0.2633
D	0.5579	0.0569	0.1219	0.1219	0.0569	0.2633	0.2633	0.5579
Total	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

The ranking grades of the suppliers given in Tables 4.

Table 4. Ranking values and grades of suppliers (ICT points = 3/9)

Suppliers	Ranking value	Grade
A	0.2766	2
B	0.1754	4
C	0.2324	3
D	0.3156	1

As a result, the change in the ranking values of suppliers according to ICT points shown in Figure 1.

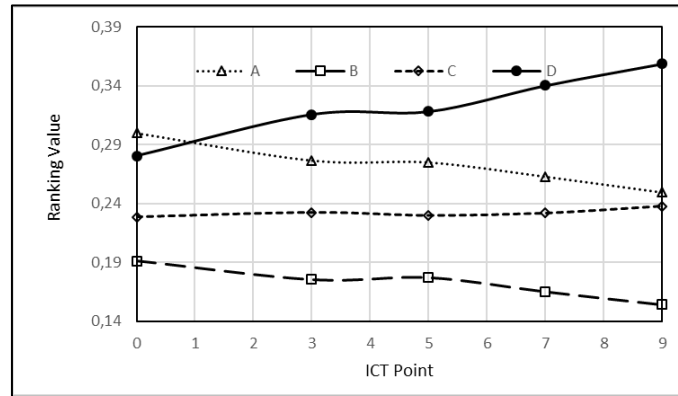


Figure 1. Ranking values of A, B, C and D suppliers evaluated by 8 main criteria and 28 sub-criteria according to ICT scores.

To identify the effect of ICT points on the main criteria, the change of the ranking values of the main criteria according to the ICT points was examined (Figure 2).

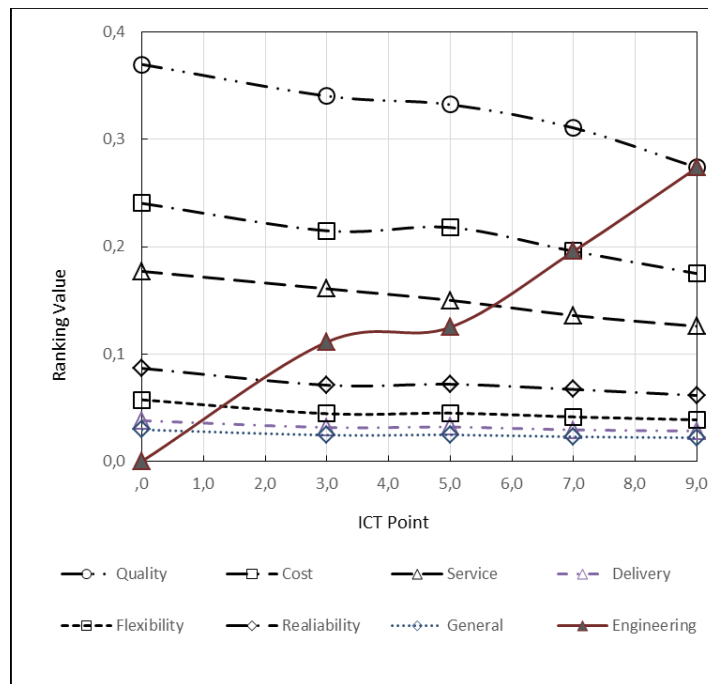


Figure 2. Ranking values of 8 main criteria (Quality, Cost, Service, Delivery, Flexibility, Reliability, General structure of the enterprise, Engineering-technical skills) according to ICT scores.

The ranking values of quality cost and service main criteria ranged from 0.05 to 0.10, while delivery, flexibility, reliability and general structure ranged between 0.007 and 0.025. Therefore, suppliers with high quality cost and service values more affected by the increase in ICT points.

5. Conclusions

Increasing global competition, logistics and technological opportunities and facilitating access to ICT reduce the dependence of sup-pliers on mainstream companies. A parent company with institutional structure recognizes that it is at the same level with its sup-pliers in a network and has to act with them.

Now, instead of the competition between companies and the firms' own optimization studies, with the help of competition between SCs in international scale and coordination of supply chain management-optimization studies in SC begin. In this context, joint ventures, inter-company partnerships, protocols and project-based cooperation observed. Within this framework, enterprises are aware of the need to add the main criteria and the sub-criteria of the ICT to the main criteria and sub-criteria used in the selection of suppliers.

In a survey study, seven main criteria including quality, cost, service, delivery, flexibility, reliability and general structure of the enterprise which influence the selection of the most suitable suppliers and 25 sub-criteria formed under these main criteria and 4 suppliers selected. This study accepted as a reference: To understand the effect of ICT on supplier selection, a new hierarchical structure established with 1 main criteria and 3 sub criteria related to ICT, with eight main criteria, 28 sub criteria and 4 alternative supplier companies.

The average scores of the eighth main criterion accepted as five points between zero and nine. The supplier selection for each of these five values made separately. The ranking values of four suppliers calculated according to each selected ICT score. Since the ranking values of quality cost and service main criteria ranged from 0.05 to 0.10, suppliers with high quality cost and service values more affected by the increase in ICT points.

It is clear that the ICT score affects the ranking value. Accordingly, the main company that wants to work with its suppliers under the Industry 4.0 needs an ICT based SC network. The company need to increase the ICT score it will seek from its suppliers according to the Industry 4.0 level targeted.

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