QFD for a SME Network of the Wood Sector to Improve Competitiveness and Sustainability

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Abstract The QFD methodology, in spite of being quite old, it is not widespread and tested in the Italian ecosystem, in particular in SME networks. In this paper we report our experience in the application of the QFD to a SME network in the wood sector, with the aim to improve the competitiveness and innovation capacity, and prefiguring a new way to collaborate in business relationships, finally increasing sustainably through a short supply chain; through the experience we highlight the QFD potentialities, as tested by the SME network in the definition and development of the first PEFC certified musical instrument.

Keywords QFD · SME networks · Supply chain coordination · Wood sector

1 Introduction

The competitiveness of the Small and Medium Enterprises (SMEs) is fundamental for the development of the Italian and European economy, and nowadays for all of these enterprises the competitiveness strongly depends on the innovation capacity, the development of new products and services, the improvement of the overall quality. This perspective for the SMEs must be supported by new tools. The new technologies and the developments in the ICT field surely represent a big opportunity: new software and new communication means, Internet, mobile devices etc. are for sure some of the major weapons for a global, more interrelated, economy, but together with them a very relevant role is played by new business, organizational and operational models that could drive the enterprises towards a new way to collaborate and to approach the market.

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More specifically, for SMEs the right way to deal with the future challenges of the global competition is to face them with a wider and different vision of the dynamics that regulate their mutual relationships: the small enterprises should no longer perceive themselves as isolated and closed entities that fight with the neighbors to survive, like princes in medieval fortresses, but they should consider themselves as part of a more and more sustainable productive system in which collaboration and comparison could be very useful tools to be more effective in the market. Moreover, it is fundamental for the enterprises to improve their adaptability to the customer requirements, and to become more dynamic, able to rapidly follow the market changes.

In this context we present an experience of use and application of the Quality Function Deployment methodology (QFD) in a SME network of the wood sector. This methodology represents a powerful tool for the improvement of the product design phase; we adopted QFD in a SME network in order to build a stronger awareness, among the different actors of the supply chain, of the role of each of them on quality aspects in the whole production process. But this is just the first step, since the final aim for a SME network is to become more cohesive and competitive. Our effort aims also to highlight the role and the contribution that QFD can play for Eco-Design, as a tool for high-quality sustainable production in a SMEs context.

In this paper first of all we briefly summarize in Sect. 2 some aspects about the QFD methodology. In Sect. 3 we present the context of our work, and the main motivations and drivers for our use case. In Sects. 4 and 5 we describe more in details the approach adopted for the application of the methodology in our SME network, the tool we developed on this purpose and the main results directly arising from the experience. In Sect. 6 we show how this methodology has led us to the definition of a strategic plan that, exploiting the evidences arisen in the previous steps, can drive the network to a new configuration and a new way to collaborate in order to gain efficiency, product quality and customer satisfaction. Finally, in Sect. 7 we summarize our work and we report some conclusions and ideas for the future development of the activities related with the QFD application.

2 The QFD Methodology: Scope, Limits and Applications

Quality Function Deployment (QFD) is a methodology born in the context of the big Japanese industry and then developed in Europe and America in the 90s, as a tool and technical support for product quality design; Quality Function Deployment is closely tied to Concurrent Engineering and Lean Production, two methods that can reinforce "quality and innovation". QFD is "a system for translating customer requirements into appropriate company requirements at every stage, from research through production design and development, to manufacture, distribution, installations and marketing, sales and services" [1].

QFD is a tool that can guide the design of a product to match the real needs of the users; in this sense it represents a clear and powerful way for setting structured and targeted projects, and its commitment normally precedes the development, industrialization and production of new products and services [2]. The complex relationships between customer requirements and technical attributes, and the correlation between different technical attributes can be illustrated in a typical "House of Quality" (HoQ) matrix. The HoQ serves to link the Voice of Customer (VoC) to engineering metrics (EM).

The QFD methodology has been used in many different scenarios [3] and recently is widely used in the context of environmental sustainability in: shipping context [4], remanufacturing (as the ultimate form of recycling) [5], logistic services [6], service quality in vegetarian food industry [7]. These are different applications with a common proceeding schema: firstly taking the voice of the costumer, often using interviews, questionnaires, market research (in order to define "What's" customers' need), then defining the product technical characteristics ("How's" it produced). The focus is to the company, generally a large company.

Although QFD can support the enterprises and the industry with relevant outcomes and contributions [8] the literature shows a limited adoption of it within the SMEs, especially in comparison with other "soft process technologies", depending also on the enterprise dimension and characteristics [9, 10]. This limit is due to the nature of SMEs and to the reduced involvement that most of them have in the design and development of a specific supply chain product. Many SMEs limit the vision of their own activities and their role to a simple customer-supplier relationship, without any awareness of the final product that is realized: the final market is often perceived far away.

3 The Need for Innovation in SME Networks of the Wood Sector

Europe's 23 million SMEs represent 98 % of business, provide 67 % of the work and create 85 % of all new jobs [11], so it's clear that SMEs hold the key for the economic growth. SMEs are often players involved in the value chain of a product without a clear awareness of their role and importance in the supply chain strategy, and sometime of what it means to be part of a network.

One of the factors that strongly marks, or perhaps we should say that has marked, the approach of a SME in a network, in particular in the Italian context, is the "individualism". But the individualism is leading, especially in this moment of history, to the death of many SMEs. The growth in size of the enterprises and the "aggregation" of the small ones are perceived by the entrepreneurs as essential elements to survive, even and more in an internationalization perspective.

In this context, the Italian government has deliberated with the establishment of the so called 'Network Contract' ("Contratto di Rete") in Law 33 of April 2009.

The law says that, with the Network Contract, two or more firms undertake in common one or more economic activities, sharing objective and mission, in order to increase mutual capacity in innovation and competitiveness on the market [12]. The Network Contract is thus a tool to regulate and stimulate the collaboration and the "aggregation" between the SMEs, however maintaining distinct enterprise identities.

There are many business sectors that need to converge towards this new collaborative approach between SMEs: in particular in the wood sector (that is our focus) strengthening competitiveness is one of the priorities, as in the EU Forest Action Plan [13, 14].

The aim is to achieve a better management of the forests of the Community, while maintaining and strengthening the multifunctional role of the forests through a new consciousness of the value of the wood: to provide renewable raw materials, to define sustainable production processes, to support, especially in rural areas, territorial economic development and employment and to preserve environmental resources are the main key points of this initiative. The Plan has four goals, divided into 18 key actions and 53 activities. It recognizes the need for specific approaches and actions, emphasizing the important role of the owners in the sustainable management of the forests; it encourages innovation and research activities, specific training for forest owners and workers, it proposes measures aimed at optimizing the use of forest resources for energy production, also including specific elements that contribute to the achievement of environmental objectives related to the issues of the climate change and the biodiversity.

This vision is followed by the Italian framework program for the forestry sector (PQSF) [15], which has the overall objective of encouraging sustainable forest management in order to protect the territory, mitigating climate change, activating and strengthening the forest industry and ensuring long-term the multi-functionality of the forest resources [16].

Our use case of the QFD application is strongly related with the implementation of the priorities of the European Plan and the Italian framework program for forest management through the Network Contract.

4 QFD for SME Networks

ENEA, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development, comprises many different laboratories that conduct research and innovation activities concerning energy efficiency, renewable energy sources, nuclear energy, environment, sustainability of productive systems. Within the agency, our laboratory, the ENEA DTE-SEN-CROSS lab, provides some support services for SMEs, networked enterprises and productive districts. Among these services we propose the QFD methodology application, with a new perspective: QFD for SME networks; the idea is to view a supply chain, or a SME network as a Virtual-Enterprise, where each actor represents a fundamental member

for the realization of the final product, like different departments in a complex industry. In this perspective efficiency and competitiveness are achievable only if the different actors, always maintaining different identities but with the same dignity, collaborate not in a competitive but in a collaborative way.

ENEA QFD approach is applied to overcome individualism and to introduce more strongly the customer point-of-view in the supply chain production processes. Analyzing a product according to the customer-firm vision is fundamental to innovate and to compete. But this is not enough: in the context explained in Sect. 3, QFD can be viewed as a way to promote and enforce territorial districts, local networks and the sustainability of the productions.

To this aim the three basic points that drive our activities about the QFD methodology are:

- To constantly improve the collaboration and the information exchange between the partners, in order to define and share business strategies among the whole production chain. Partners that are not involved in the management and design of the network strategies cannot understand the needs and the requirements coming from the market and then are less disposed to react and to modify their processes to face supply chain issues.
- To highlight the economic advantages, for all the partners, that overcome the difficulties and the issues coming from this new approach in relationship management, thus ensuring more fruitful and active involvement of each partner (also the smallest ones) in the supply chain activities and production.
- To align the interests of a network or productive system with the interests of each partner, providing a shared vision of the market. In a SME network in fact enterprises (nodes) that are far from the final market have no awareness about its requirements. This negatively affects the product quality and the responsiveness of the network to market change.

Other results that directly come from the previous main points, and that can be the final objectives of such activity, are also: supply chain integration, definition of a new network brand, brand localization, internationalization, product innovation, new commercial channels.

5   Applying the QFD Methodology on the Wood Sector

The application of the methodology has followed several steps. In this section we summarize its application in the wood sector.

Although the QFD methodology is based on a clear set of principles and concepts, and in the main lines it is well identified, the specification of the details and the formalization of the procedures and the steps can vary depending on the needs of the analysis and the context. Then, our first phase concerned the customization of the general approaches found in literature to formalize the specific formulas to use to perform the study. Obviously the core of the QFD remains the adoption of the

requirements/technical-characteristic matrix and the House of Quality. On the other hand, we skipped some aspects of the methodology also in order to make it more simple to use during the work and the discussion with the SMEs. The fundamental point remained to reach a clear identification of the "conventional value" for the products to analyze.

After the definition of our custom version of the QFD methodology, we needed a software that would help us calculate the formulas. Although many implementations are available online (see for example [17–19]), and some of them are free, in the second phase we decided to proceed for a custom implementation that could be tailored for our purposes; the implementation was not complex, difficult or time waste: as many available solutions, we opted for an Excel-based implementation. Excel in fact provides a simple and natural way to develop a software for QFD calculation.

The third phase has regarded the network and node analysis. The starting point for a fruitful QFD application is a complete vision of the network and of the enterprises, in order to have a comprehensive knowledge of the role of each partner, their competencies, their process and organizational structures, their relationships, their weakness and strength points, the target market, also to facilitate their involvement in the network activities. In this phase the role of the Network Manager is essential, since it acts as a glue to connect and mainly involve the partners.

Our use case regarded 9 enterprises, distributed throughout the wood supply chain, with different roles: from the woodman that procures the raw material in the forest, to the sawmill, the consulting company for forest management, and the enterprises that provide the final products to market; in particular we analyzed several final nodes of the chain and we considered some different products of the supply chain, in order to identify those on which to apply the QFD. Among the available alternatives we finally focused the QFD on a wood-based musical instruments: the harpsichord.

Once we got in contact with the enterprises, in the fourth phase we organized a 2 days' face-to-face workshop in order to join the different perspectives and competencies in the elaboration of the QFD analysis. Again, involve each partner is fundamental, but even more it is very important both to convince the participants of the opportunities provided by the QFD and that the analysis have to be as much as possible objective and honest, in order to discover the criticalities of the supply chain, instead of to underline the strong points. The analysis allowed us to highlight all the components, coming from all the supply chain, that determine the quality and the specificity of the harpsichord, with the evaluation of the crucial points to develop and the strength to enhance.

The results of the analysis showed the key role of the raw materials and so we decided to do another QFD analysis focused on the trunk. This specific decision has been taken and implemented due to the attendance of the first nodes of the supply chain, the woodcutters, that have the specific know-how and competence on the trunk. This second-level analysis is possible only in our approach in which we created an aware collaborative working group and we involved all the nodes of the
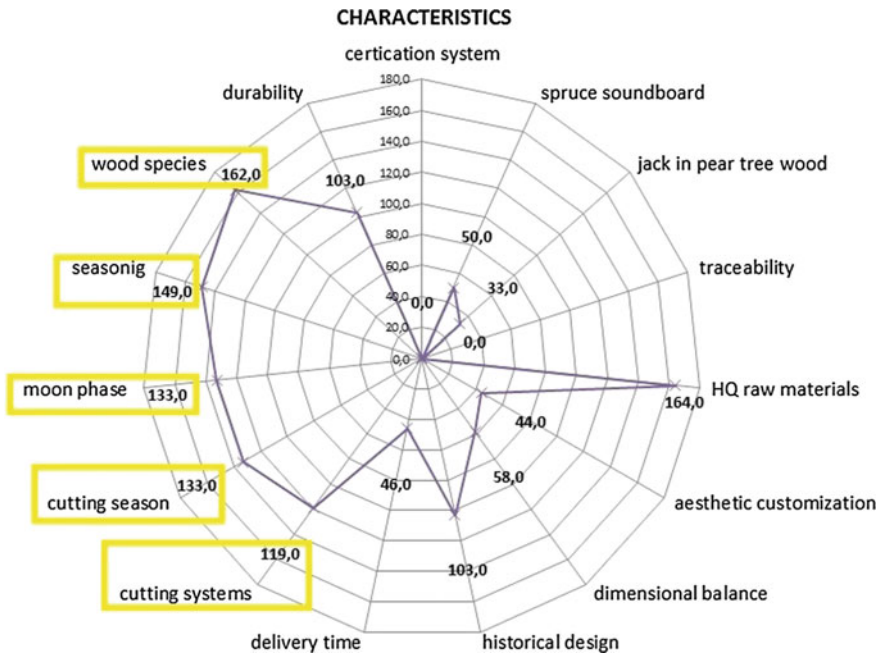
Fig. 1 QFD analysis for the product "Harpsichord"

SME network, in particular all the first elements of the value chain, that depends on woodcutter role end experience.

Wood species, moon phase in cutting, seasoning, cutting season and cutting systems are all characteristics (highlighted in Fig. 1) directly connected with high quality raw materials that, coming from the network nodes, disappear in QFD done within a big organization. The figure shows the intermediate results, with the evidence of the role of the raw materials in the harpsichord.

We also performed a first comparison with the products of the competitors. The workshop ended with a complete QFD analysis of the 2 selected products (the trunk and the harpsichord).

After the end of the workshop, the following phases regarded the analysis of the evidences arisen from the QFD application, in order to elaborate a strategic plan.

The application of the methodology highlighted two critical issues during the workshop, the first being the presentation of the house of quality that seem to be, in the first step, complex for small business owners; the second one is the definition of the values of the characteristics since, if the characteristics are qualitative, sometimes they could be overestimated for their own product.

Regarding the implementation phase, the main difficulty was instead the definition of product requirements because the involved SME, and SMEs in general, don't have a specific commercial unit, market analysis, questionnaires and tools to collect and evaluate in a structured model the voice of the costumer.

6   From the QFD Analysis to the Strategic Plan

A company business strategy can be defined as the way to draw future scenarios, to face the competitive environment and to exploit the resources and opportunities.

In general, talking about strategic plans and objectives for business networks and SMEs is difficult: often the decisions are imposed by the entrepreneur and often few persons take the control of the whole company; a more structured approach to strategy definition is not applied and the company activity is driven mainly by fiscal and financial considerations: the object often is to survive rather than to gain a strategic position in the market.

We start from the results of QFD to define a business strategy for market positioning and promotional policies for a SME network.

From the matrix of relationships (in the HoQ) we determine the "conventional value of the product" [20], that is a no dimensional indicator that summarizes the technical quality of the analyzed product and allows to understand how much a product is able to match with the customer quality requirements.

Once we get the conventional value of the product of the SME network and of the competing products we make a further comparison taking into account the cost and/or the price for the consumer, considering the two "values per unit price", calculated with the following formulas:

$$\frac{Conventional\ Value_{Our\ Product}}{Price_{Our\ Product}} = \frac{Conventional\ Value_{Competitive\ Product}}{Price_{Competitive\ Product}} \tag{1}$$

This comparison is quite complete (it takes into account all the information entered into the relationship matrix), and above all it is very easy to do and very straightforward to interpret; this last feature is very valuable in a decision process which involves many partners, as in a SME network.

The market repositioning of the SME network may be done modifying the market price (the denominator of the value), or changing the "value" of the product characteristics (the conventional value in the numerator).

If the strategic decision of the network is to modify the product, the next step is to decide which characteristics have to be changed and to what extent. It is clear that, in principle, those characteristics which have a bigger relevance (or weight) should be considered first, to have more substantial improvements in the product value. But it is also clear that also the evaluation of the cost variations, and therefore of the price, should be considered to make the comparison more convenient in terms of value per unit price.

The most interesting case regarded the application of QFD methodology to the design of the harpsichord. The musical instrument resumes the design of the original model "Giusti 1681" and the QFD analysis allowed us to highlight the quality parameters of the instrument and to correctly evaluate with the SME network (named 12/IT-01-01 network [21]) the market price and the market penetration strategy, taking into account the value for unit price paid.

Specifically, having a "conventional value" of 5194 and compared with 4839 of the concurrent product, the harpsichord Leita Brothers has shown to be in general 7 % more responsive to customer requirements respect with that of the competition.

From QFD analysis, the raw material characteristics emerged as a relevant factor, that led the network to another fundamental strategic choice: to improve the product quality perceived by the customer.

To this aim the network decided to preserve the Chain of Custody throughout the whole production process, leading to the creation of the first musical instrument certified PEFC (Programme for the Endorsement of Forest Certification) [22–24]. The strategic choice is based on another fundamental pillar, the short supply chain (that contains within a few kilometers the entire production process) and the traceability of the whole production (conforming to the "12-to-Many" © network model) [21] for the creation of a sustainable and high quality product. The network 12/IT-01-01 responds to the harpsichord master desires with a harpsichord conforming to the technical and mechanical characteristics of the original "Giusti 1681", giving particular relevance to the solid wood in a short supply chain that allows both to improve the intrinsic product quality and to emphasize sustainability aspects. In this sense QFD could represent a powerful tool for Eco-design, as it naturally supports collaborative design among the partners in localized SME network, exploiting local competencies and promoting short supply chain. In the outlined use-case, QFD allowed also the optimization of raw material usage and, thanks to the application within a network of strongly related partners, the waste materials could be exchanged and reused in different ways from the enterprises. In the case of harpsichord, all the raw materials came from the local area, and this led to the production of a high quality, eco-friendly, market competitive product of sophisticated design. All these characteristics are not exclusive, but with the right approach can be implemented in a single product.

7   Conclusions

Supporting SME networks to face the global competition is fundamental for both the European and Italian economy. To this aim ENEA DTE-SEN-CROSS laboratory has developed and provides a set of different services for the SMEs. One of the services that we have refined and we are now testing in practical case is the assistance in application of the QFD methodology. This methodology is well-known and quite consolidated from the past in single industry, but our effort is devoted to its application in the context of the SME networks, in which the experiences in Italy are lacking. In this paper we present our approach and use-case in the wood sector. In this experience we improved the network partner collaboration and we supported SMEs to facilitate the product innovation in the supply chain, to improve the product quality, the competitiveness in the market and the responsiveness to final user requirements, to highlight the criticalities in the production process along the whole supply chain. In our experience we have

experimented a new awareness and interest of all the partners towards the issues related with the whole supply chain, and the QFD application has proven useful for the analysis of the product value and to identify possible interventions on the product characteristics. Each partners has deeply understood the role and the high strategic value of the trunk to reach, for the harpsichord production, the goal of a high sustainable product made from certificated Italian wood and with a short value chain.

This analysis has led us to the definition of a strategic plan, which finally represents the intervention mechanisms for supply chain innovation, that it has been well-accepted and translated in the first PEFC certificated musical instrument. On this activity, we will keep on testing the QFD on other SME networks to evaluate different approaches in presenting the methodologies and we are now considering to integrate the QFD in the development of a decision support system.

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