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Total Quality Management and Innovation: Linkages and Evidence from the Agro-food Industry

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Abstract

Total quality management and innovation are two inherently related concepts that appear to have an important role in the performance of agro-food companies. The main aim of this paper is to review and discuss the theoretical and practical linkages between quality management and innovation, focusing on the agro-food industry, which is characterized as a low-tech sector with high demands for quality standards and food safety systems. The presented review identifies and discusses three conceptual frameworks, and the findings indicate the positive effect of quality on innovation and vice versa, while both factors have a positive impact on firms' performance. However, other internal and external factors may affect both firm's quality management and innovation activities. Particularly for the agro-food industry, access to current and new markets is a major motive, objective, and outcome of the quality-innovation nexus, revealing the importance of adopting customer-focused culture.

Keywords Total quality management · Innovation · Agro-food · Quality standards · Quality practices

Introduction

Total quality management (TQM) is a fundamental and comprehensive rule for leading and operating an organization, aiming at continually improving performances over the long term, while focusing on customers (Charantimath 2011). It is both a management philosophy and a set of guiding principles based on a continuous improvement process to the benefit of all stakeholders involved (Dale 2003). In respect to its holistic aspect,

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TQM requires the simultaneous implementation of its key principles (Abrunhosa and Moura E Sá 2008) in all functions of the organization in order to produce products and services that will meet customers' expectations.

The importance of TQM in business organizations may be demonstrated by its major advantages that include both internal and external benefits. Internally, organizations adopting a TQM philosophy are able to eliminate defects and waste, improve processes, reduce cost, and generally have a better cost management system. As a result, they can achieve higher productivity and profitability levels and enhance shareholder and stakeholder value. At the same time, they can improve employee satisfaction and morale and increase customer satisfaction, loyalty, and retention. Furthermore, the adoption of the TQM philosophy is able to strengthen company's competitive position, enhance market image, and improve its adaptability to changing or emerging market conditions. In addition to the above, the linkages between TQM and food safety is extremely important for agro-food companies. As noted by Barendsz (1998), TQM provides an integrated approach involving all parties in the agro-food chain, and this may help in the effective implementation of food safety systems. Food safety certifications may contribute in the aforementioned benefits; however, particular attention should be given in the standardization of risk assessment, the necessity of chain formation in the agro-food sector, and the improvement of global communication (Barendsz 1998; Talib et al. 2013).

In the relevant literature, based on both empirical and theoretical analysis, various practices and elements of TQM are presented. Charantimath (2011) identifies the following key principles of TQM:

a) Customer focus
b) Management commitment
c) Continuous improvement
d) Employee empowerment
e) Fact-based decision making

Given the need of firms to implement TQM philosophy, various excellence models are leveraged as a guide. Specifically, the most widespread excellence models are the European Foundation for Quality Management (EFQM) in Europe, the Malcolm Baldrige National Quality Award (MBNQA) in the US, and the Deming Price in Japan. Moreover, two aspects of TQM are presented in the literature, the "hard" (or technical) side, which refers to management tools, techniques and practices, and the "soft" (or philosophical), which gives emphasis on the leadership and management of human resources (Dale 2003; Wilkinson 1998). Specifically, in regard to the soft factors, the study of Fotopoulos and Psomas (2009) identifies the following elements: leadership, strategic quality planning, customer focus, process management, continuous improvement, information and analysis, knowledge and education, and supplier management.

On the other hand, in a broad definition, innovation refers to new ideas for products/services, new marketing methods and new uses, improvements and new markets for existing products (Simmonds 1986). Furthermore, it could be viewed as a process of creating and implementing ideas in order to produce value for the firm, the suppliers, and the consumers (Popadiuk and Choo 2006). As noted by Carayannis et al. (2020),

innovation should be considered as a process of dynamic change that has three major dimensions: socio-economic, socio-political, and socio-technical. Several other scholars define idea as an offering or a solution (e.g., product, service, process, experience) that adds value to the business organization and/or the customer. This "dual" nature of innovation requires the satisfaction of customer needs on one hand, and a viable business model on the other. Nevertheless, innovation is related to the companies' need to adapt and evolve, in order to meet the changing needs of shareholders and stakeholders.

Regarding the linkage between TQM and innovation, it should be emphasized that both concepts focus on customers. Widespread excellence models formalize customer satisfaction as a quality component, while the TQM approach aims on long-term success through it (Grigoroudis and Siskos 2010). Furthermore, customer satisfaction is identified as a main TQM objective (Drury 2007; Tsang and Antony 2001), while innovative firms aim to increase customer value (Abdallah et al. 2016; Dobni 2008). In addition, two of the elements of TQM, namely, customer focus and continuous improvement could enhance firms' innovation processes (Flynn et al. 1994; Baldwin and Johnson 1996), while both innovation and TQM are aiming on competitive advantage. Moreover, innovation can be viewed as a novel quality process for the improvement of customer delight and thus could be managed and measured. Regarding innovation management, Gupta (2009) suggested four types of innovations (i.e., fundamental, platform, derivative and variation) and identified five innovation phases:

a) Targeting opportunity
b) Exploring ideas
c) Developing alternatives (prototype, etc.)
d) Optimization and commercialization of innovation

Following the concept of "big Q" (strategically managing quality in all business processes, products and services) and "little q" (activities related to ensuring the quality of products and services provided to customers) (Madu 1998), innovation process could be focused on a specific product/service ("little i") or could refer to changes in organizational structure and business model ("big I") (ASQ 2013). Subsequently, the "big I" is based on the following key factors: organizational culture, senior leadership support, capabilities (talent, experience, etc.), processes (tools, techniques, etc.), and strategy (ASQ 2013).

In the aforementioned context, the quality of innovation is an indicator for firms' readiness to innovate, and requires the shift from quality improvement to innovation improvement (Gupta 2009). On the other hand, the study of Baronienė and Neverauskas (2005) suggests that quality management methods should be viewed as management innovation, while TQM and innovation should be connected under the framework of economic knowledge in a way whereby TQM practices enhance firms' ability to face obstacles in innovation processes. Furthermore, firms innovating in quality management methods could respond effectively to changes, while they could easier implement different types of innovation (Baronienė and Neverauskas 2005). In addition, Anttila and Jussila (2016), considering quality and innovation as two distinct partnership disciplines interacting to enhance firms' completive advantage, identified three ways of interaction:

- Quality management could be supportive towards the different phases of "invention-to-innovation" process.
- Innovation is vital for quality improvement processes and new product development.
- Effective integration of quality management and innovation management are necessary, in respect to standardization (e.g., adoption of ISO 9001:2015).

Moreover, Din and Cheema (2013), having identified continuous and discontinuous change as elements of TQM and innovation, suggest that firms should adopt both disciplines for a strategic change, while the TQM approach could be supportive towards the deployment of innovative processes.

The main aim of this paper is to review and discuss the theoretical and practical linkages between TQM and innovation, focusing on the agro-food industry. Although the study of the relevant literature presents heterogeneous findings, the majority of the published works supports a positive relation between these concepts. The paper identifies three distinct conceptual frameworks for the analysis of the TQM and innovation relationship aiming to contribute to the discussion over this complex and multidimensional topic. Reviewing, organizing, and finally grouping the examined studies could provide valuable insights to firms involved with quality and innovation processes. Each framework is separately analyzed, while the methods found in the literature are listed and relevant findings are provided. The paper also provides a holistic view on the links among TQM, innovation, and firms' performance after considering all three frameworks. Furthermore, for the analysis of the current links, the paper mainly considers quality systems rather than TQM practices per se, providing useful outcomes on the correlation between the adoption of specific quality systems and techniques and the implementation of different types of innovation. Moreover, the presented review focuses on all types of innovation, i.e., product innovation, process innovation, marketing innovation, and organizational innovation. It also focuses on the classification of innovations to incremental and radical, since TQM practices tend to enhance incremental innovations, although they could become an obstacle for radical innovations (Moura E Sá and Abrunhosa 2007).

The review focuses in the agro-food industry, since it recognizes the potential contribution of TQM approach on assuring food safety and quality. The adoption of TQM could shift agro-food firms' attention towards quality, by setting people behavior, firms' procedures, and production processes as major priorities (Luning et al. 2006). Agro-food firms are being pushed towards innovative changes on production (e.g., eco-friendly practices), storage, and distribution stages, while they are facing issues such as changing customer needs, variations in the quality of raw materials, contamination of products, packaging, and shelf life limitations (Mambanda et al. 2017). Given the above, agro-food firms need to redefine and expand their established quality processes, by integrating quality assurance and control processes into an effective TQM policy.

The paper is organized in three more sections. The theoretical background of the TQM-innovation relationship is given in the "Background and research questions" section, including the research questions of this study. The "Linking TQM and innovation" section presents analytically the alternative approaches for studying the relationship between TQM and innovation. Specifically, this section examines TQM as a driver of innovation, innovation as driver of TQM, as well as the quality-innovation-

performance nexus. Finally, the "Concluding remarks" section summarizes some concluding remarks.

Background and Research Questions

When studying the TQM-innovation relationship, three alternative conceptual frameworks may be identified: TQM as a driver of innovation, innovation as driver of TQM, and the quality-innovation-performance nexus.

In the context of the first framework, Long et al. (2015) identified process management, people management, and customer focus as the TQM practices that affect the most innovation processes. Additionally, in respect to a set of four TQM dimensions namely, leadership, employee relations, customer focus and continuous improvement, the leadership one has the strongest effect on innovation activities, with process innovation being more affected compared to product innovation (Zandhessami and Jalili 2013). Furthermore, considering a set of quality management practices as a single factor, Kafetzopoulos et al. (2015) supported that TQM practices have a positive impact on both product and process innovation. In respect to different type of innovations, the study of Kim et al. (2012) indicates that TQM practices have indirect effect on all types of examined innovations (i.e., radical and incremental process innovation, radical and incremental product innovation, and administrative innovation), where process management mediates the affect.

Based on a dataset of Spanish firms, it was argued that high innovation capabilities increase the probability for firms to focus on the hard components of TQM and specifically on process standardization (López-Mielgo et al. 2009). Moreover, it was argued that innovative actions in respect to process innovation drives to the adoption of TQM activities (Antunes et al. 2017). These findings may support the second conceptual framework of the study, where innovation is considered as driver of TQM.

Referring to the third framework of the current study, the causality direction between TQM and innovation is a significant issue. Taking into account both directions on the relationship between TQM and innovation performance, Satish and Srinivasan (2010) support the positive correlation between TQM and innovation (for both cases). The linkage between innovation and quality as a bidirectional relationship is supported by various studies (see for example López-Mielgo et al. 2009). Furthermore, it is supported that process innovation has a positive effect on both financial and operational performance, while product innovation only affects financial performance (Antunes et al. 2017). The study of Sadikoglu and Zehir (2010) indicates the (partial) mediating effect of employee performance on both TQM-innovation performance and TQM-firm performance relationships, while innovation performance mediates (partially) the TQM-firm performance relationship.

The literature on the relationship between TQM and innovation presents heterogeneous findings, since, in some cases, conflicting results may be found. The study of Jiménez-Jiménez et al. (2019) denotes a curvilinear relationship between TQM and innovation activities. Moreover, there are cases where a non-significance correlation between TQM and innovation has been found (Singh and Smith 2004), while there are few cases where a negative correlation has been identified (Segarra-Ciprés et al. 2017). In regard to the issues presented on the relevant literature, a large number of studies

implement cross-sectional ad hoc surveys characterized by low response rates (Riillo 2014). Furthermore, the selection of both TQM and innovation measures have a significant impact on the generation of results (Segarra-Ciprés et al. 2017). Moreover, the set of TQM practices and the types of innovation used by each study is a crucial factor. Nonetheless, the vast majority of studies indicated a positive correlation between quality management and innovation.

Regarding the agro-food sector, it should be noted that it is an industry characterized as low-tech and low R&D intensity, where incremental innovations are mainly implemented in respect to product innovation and radical innovations are adopted in fewer cases (Baregheh et al. 2012a, b; Galizzi and Venturini 1996). Additionally, food firms are mainly process-innovation oriented (Capitanio et al. 2010). The strong international competition, the presence of powerful firms in the value chain, and the implementation of relevant law and regulations all require for SMEs agro-food firms to enhance their innovation activities (Tell et al. 2016). In the agro-food sector, innovation is focused on various aspects such as packaging, conservation, additives, food chain management, feeding systems and new products (Finco et al. 2018; Rama 2008). Moreover, both technical innovation and innovation in packaging could enhance the effort of large food and beverage firms to introduce new brands, while process innovation could improve quality of products and reduce relevant costs (Alfranca et al. 2002). In regard to patents on multinational level, it is indicated that there is a limited group of persistent innovators contributing about 80% of all the granted patents (Alfranca et al. 2004).

On the other hand, quality standards and food safety requirements are highly significant for agro-food companies. Specifically, the TQM approach is valuable for this sector, since volatilities in product quality are identified (Boehlje et al. 2009). Factors such as consumers' health and safety and requirements for environmentally friendly agricultural production methods indicate the significance of quality management systems (Kaldis and Gardeli 1997). Designing a TQM system requires the extensive knowledge of the sector, while an effective TQM implementation requires an integrated approach whereby all stakeholders of the agro-food chain are involved (Barendsz 1998). Furthermore, Krieger and Schiefer (2006) identified the following benefits of quality management for agro-food firms:

- Improved market entry
- Improvement in product liability
- Fulfillment of legal requirements
- Improvement in process quality
- Improvement in product quality and food safety
- Improvement in traceability
- Improvement in customers' trust towards product quality and safety

Regarding the food safety management systems, the benefits derived from the adoption of ISO 22000 could be both external and internal, such as the improvement of commercial opportunity and the improvement of internal procedures (Casolani et al. 2018). Moreover, the adoption of ISO 9001 by agro-food firms could introduce management improvements, while it could also be a signal towards foreign suppliers and potential buyers (Wilcock and Boys 2017).

Taking into account the aforementioned literature, this study focuses on the analysis of the relationship between TQM and innovation aiming to answer the following three research questions (RQs):

RQ1: *Under which framework the relationship of TQM-Innovation is analyzed and which are the relevant evidences for the agro-food sector?*
RQ2: *On which level innovative firms in agro-food industry adopt TQM practices?*
RQ3: *What is the behavior of quality-oriented agro-food firms towards innovation?*

It should be noted that the current research mainly explores the relationship between the adoption of quality systems and innovation or between quality and innovation rather than TQM and innovation. Moreover, quality systems, quality standards, and quality management are viewed as required and integral parts of a TQM holistic approach.

Linking TQM and Innovation

TQM as Driver of Innovation

Several studies in the agro-food industry consider TQM or quality management elements as drivers of innovation or innovation performance. As shown in Fig. 1, several TQM dimensions, such as strategy, leadership, human capital, customers, resources, or suppliers, may be examined in order to study the effect of quality management practices in different types of innovation performance (e.g., product, process, marketing, or organizational innovation). These quality management practices may include people management (e.g., employees' participation, teamwork), and/or process management, and focus on customer satisfaction, and quality techniques or certification.

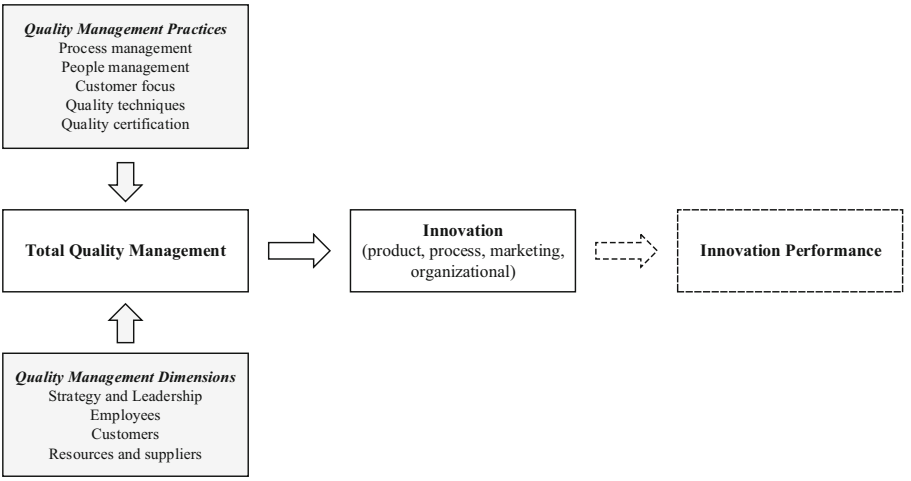

Fig. 1 The quality-innovation linkage

The literature in the agro-food industry examines specific perspectives of the aforementioned context. For example, Capitanio et al. (2010) found that the quality of human capital has a positive impact on product innovation regarding the Italian food sector. This finding is consistent with the TQM literature, since "People" and "Leadership" are major enabler-criteria in the EFQM excellence model. The results of this study are based on principal component analysis (PCA), where white collars to total workers ratio and unit cost of labor are the main variables included in the quality of human capital component. On the other hand, financial structure and capital intensity are described as the two main explanatory variables of process innovation.

Based on a dataset of 436 Greek agro-food companies, Kafetzopoulos and Skalkos (2019) introduce "quality orientation" as the most significant driver of innovation in the framework of studying the impact of different innovation drivers on the four dimensions of innovation capability (i.e., product, process, marketing, and organizational innovation). Process management was the second most important innovation driver. It included elements related to continuous improvement and quality techniques. Quality orientation was defined based on the following actions:

a) Top management participation in quality improvement
b) Quality is a responsibility for all employees
c) Team effort for continuous improvement in respect to new design for existing products and services
d) Invest a lot of money and time to education for quality
e) Quality should be designed into a product/process to minimize the defects that will be possible present

In general, the findings of the study support the role of quality management as an important enabler of firms' innovation capability.

Other studies show that the implementation of both ISO 9001 and ISO 22000 has a positive impact on firm's competitive performance. For example, Kafetzopoulos et al. (2013) studied a sample Greek food firms and applied factor analysis in order to test if the examined variables are reliable measures for the relevant factors, while multiple regression analysis was used to examine the impact of the ISO certifications to the competitive performance of food companies. The main indicators included in the competitive performance factor were the time needed for the introduction of new products and the creation of value for customers (through product quality). Viewing these two indicators as factors embedded in innovation activities, the results of this study seem to support the conceptual framework of Fig. 1, suggesting that quality assurance systems have a positive impact on innovation.

Considering that agro-food sector is characterized as low-tech, the study of Tepic et al. (2014), including projects for both food and beverage and technology-based firms, supports that product potential has a significant and positive impact on the probability of achieving high innovation project performance. Innovation performance is examined in this study as the potential success or failure of the project in the market. Additionally, the study supports that product potential is higher in high performing projects compared to the low performing ones, while non-significant difference between food and beverage and technology-based projects in respect to product

innovation performance is denoted. The product potential variable is measured based on quality indicators, and thus, the quality-innovation linkage is supported.

In a similar context, Batterink et al. (2006) analyzed firms' focus on quality standards and legislation requirements as innovation objectives. Specifically, applying regression analysis techniques in a dataset of Danish agro-food firms, they supported that these "external" innovation objectives have a significant and positive impact on process innovation. However, it was also indicated that focusing on these objectives has a negative effect on product innovation, which is measured as the share of turnover from new products. The authors argued that these findings could derive from the fact that the resources needed for the achievement of the specific objectives could not be redeployed for product innovation activities. Nonetheless, the latter negative correlation may be justified by the fact that the study viewed product quality based only on quality standards and legislation indicators, without considering the TQM as a holistic management approach. Focusing on the legislative aspect of quality management could make quality a barrier to innovation.

The study of Fortuin et al. (2007) implemented the Wageningen Innovation Assessment Tool (WAT) in a dataset including multinational agro-food prospector firms. Aiming to identify the key success factor for innovation performance, regarding innovation projects within organizations, the study provided a questionnaire by which scores for the given statements and also scores for the certainty of the correspondent assessments were assigned. In particular, the study described product superiority as a key success factor for innovation performance. With product superiority reflecting level of quality and fulfillment of customer needs, innovation performance was measured in terms of high technological accomplishment and potential market success after product introduction (similar to Tepic et al. 2014). These findings support the research hypothesis that quality could positively affect firms' innovative activities.

Moreover, quality improvement of products/services and access to new market are important drivers for the adoption of quality assurance systems in the agro-food sector (Karipidis et al. 2009), particularly for SMEs. This evidence indicates again the role of customer satisfaction as common goal for both quality and innovation management. Viewing access to new market as innovation activity, the study supports the argument that quality systems could impact innovative actions.

The Spain food and beverage industry was examined in another study by Briz et al. (2005). Using factor analysis to track the determinants' structure of ISO 9000 certification adoption, the study found that one of the most important factors refers to firm's competitive advantage, in which access to new markets is included. Similarly, analyzing the relevant literature, Kontogeorgos and Semos (2008) indicated that one of the most significant benefits of quality certifications is the access to new markets, which support that firms' effort to innovate is linked with the adoption of quality systems.

Based on both quantitative and qualitative research for a small group of food processing firms, Ma and McSweeney (2008) identified potential critical success factors of product and process innovation. Based on this study, the production of unique and superior products was a highly important and highly implemented activity. Moreover, the innovative firms tend to reappraise the significance of leadership for innovative activities, highlighting once again the linkage of quality and innovation in the food sector.

Table 1 summarizes the previously presented studies in the agro-food industry, indicating the quality and innovation measures used and the major findings regarding the relationship between quality and innovation.

Innovation as Driver of TQM

In this section, an inverse causal relationship is examined, whereby innovation is considered as a driver for TQM. As shown in Fig. 2, within the TQM context, food safety and quality assurance systems can affect the adoption of the TQM philosophy, while the major benefits of this linkage include improved market entry, product liability, process and product quality, food safety, customer satisfaction and trust, traceability, and fulfillment of legal requirements.

The aforementioned linkage is examined in several studies in the agro-food sector. For example, Herath et al. (2007), based on a dataset of Canadian firms operating in the food processing domain, suggested that firms with high level of innovation activities are more likely to adopt food safety and quality assurance practices, such as HACCP. Furthermore, for a dataset of Spanish food and beverage firms, López-Mielgo et al. (2008) supported that the probability of adopting quality control and normalization practices is increased with the implementation of process innovation activities and with R&D activities. The authors highlight the sequential pattern of innovation proposing that food firms' quality standardization is derived from rather basic innovation activities (new innovations introduced based on previous innovative actions, R&D efforts etc.). This sequential pattern of innovation, as shown in Fig. 3, follows three steps. Firstly, companies adopt innovative activities to achieve customer satisfaction, to fulfill the retailers' quality requirements, to comply with relevant regulations or to be proactive aiming for competitive advantage. Subsequently, the firms adopt quality standardization practices while, finally, they obtain quality certifications giving a positive signal to the market. The study also indicated that food and beverage firms have high probabilities to adopt quality systems.

Based on an exploratory study for six Italian food firms, León-Bravo et al. (2019) identified two different approaches in respect to sustainable innovation: 'retro-looking' and 'forward-looking' innovation. Firms producing certified products, such as Protected Designation of Origin (PDO) and Protected Geographical Indication (PGI) products, adopted a "retro-innovation" approach, in which innovations are focused on product improvements (e.g., organic product line), packaging innovations, and integration of supply change. On the other hand, "forward-looking" innovation adopted by SMEs includes more radical changes, such as the development of new products and the creation of new supply chain links (León-Bravo et al. 2019). Both approaches however aimed to higher performance on food quality, which supports the relevant research framework.

Based on the findings of the relevant literature, it was indicated that product innovation plays an important role in fulfilling the changes in demand patterns, which oriented towards product quality attributes, including healthy food, sensory characteristic, convenience feature, and new format attributes for traditional and specialized products (Purba et al. 2018). Moreover, innovations, combined with the adoption of quality management systems, have a positive impact on quality enhancement and

Table 1 Studies in the agro-food sector about the quality-innovation linkage

Study	Techniques/methods	Quality measure	Innovation measure	Quality/innovation linkage
Capitanio et al. (2010)	Regression and principal component analysis Data: Italian food companies	Quality of human capital	Product innovation	Positive correlation
Kafetzopoulos and Skalkos (2019)	Regression analysis Data: Greek agro-food companies	Quality orientation	Product, process, organizational and marketing innovation	Positive correlation for all innovation dimensions
Kafetzopoulos et al. (2013)	Regression and factor analysis Data: Greek food companies	Adoption of ISO 9001 and ISO 22000 certifications	Competitive performance (time needed for new products introduction, creation of value for customers)	Positive correlation
Tepic et al. (2014)	Regression and exploratory factor analysis Data: F&B and tech-based firms	Product potential (superiority in terms of quality and customers' need fulfillment)	Innovation project performance (potential success or failure of the innovative project in the market)	Positive correlation
Batterink et al. (2006)	Linear regression analysis and binary logistic regression Data: Danish agro-food firms	Focus on quality standards and legislation requirements	Product innovation (share of turnover from new products) Process innovation	Negative impact on product innovation Positive impact on process innovation
Fortuin et al. (2007)	Wageningen Innovation Assessment Tool and Cronbach's alpha reliability test Data: multinational agro-food prospector firms	Product superiority (level of quality, fulfillment of customer needs)	Performance in terms of high technological accomplishment and potential market success	Positive relationship (product superiority as a key success factor for innovation performance)
Karipidis et al. (2009)	Literature review	Adoption of quality assurance systems	Access to new market	Positive relationship (innovation as a motivation for quality)
Briz et al. (2005)	Factor analysis Data: Spain F&B companies	ISO 9000 system	Competitive advantage factor including access to new markets	Positive relationship (competitive advantage is a reason to adopt ISO 9000)
Kontogeorgos and Semos (2008)	Literature review	Quality certification	Access to new markets	Positive relationship
Ma and McSweeney (2008)	Quantitative and qualitative research Data: small group of food processing firms	Product quality (production of unique and superior products) Process Leadership	Product and process innovation	Positive relationship (quality as a critical success factors of product and process innovation

Fig. 2 The innovation-quality linkage

process improvement which are significant factors for companies' financial performance (Boehlje et al. 2009).

Table 2 summarizes the aforementioned studies, which support the hypothesis that innovation may be considered as a driver of TQM in agro-food companies.

The Quality-Innovation-Performance Nexus

In several studies in the agro-food industry, the causality of the relationship between TQM and innovation is not clear. In fact, as shown in Fig. 4, a bidirectional relationship may be assumed, where firm's performance plays an important role, either as a mediator or as a result of the quality-innovation linkage.

In this context, focusing on TQM practices, the study of Psomas and Fotopoulos (2010) indicates that quality practices of top management and process have both positive effects on quality improvement. Moreover, quality improvement has a positive and significant effect on customer satisfaction. In addition, customer focus also has a positive and significant effect on customer satisfaction. Finally, the findings show that customer satisfaction positively affects the firms' market benefits. This study supports the provided hypothesis that quality management has a positive impact on firm's performance.

Moreover, Psomas et al. (2014) supported the classification of TQM practices on soft and hard elements. Soft TQM elements have a positive effect on quality improvement and customer satisfaction, while hard elements of TQM have an indirect impact on customer satisfaction and quality improvement, due to their correlation with the soft elements. Furthermore, quality improvement has a positive impact on firm's performance (growth rates, market share, profitability, etc.), suggesting that the adoption of quality management practices could improve firms' performance.

Another characteristic study refers to the pork processing industry. Han et al. (2009) found that quality management practices have a positive impact on firm performance in this particular sector. In addition, integrated IT and logistics management positively affect the former practices. In particular, indicators, such as quality leadership,

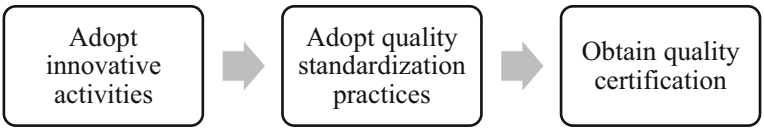

Fig. 3 Sequential pattern of innovation (based on López-Mielgo et al. 2008)

Table 2 Studies in the agro-food sector about the innovation-quality linkage

Study	Techniques/methods	Quality measure	Innovation measure	Quality/innovation linkage
Herath et al. (2007)	Logistic regression Data: Canadian food processing firms	Probability to adopt quality assurance systems Probability to adopt food safety systems	Number of innovations	Positive correlation for both regressions
López-Mielgo et al. (2008)	Bivariate probit model Data: Spanish F&B firms	Probability to adopt quality control and normalization practices	Process innovation R&D activities	Positive correlation
León-Bravo et al. (2019)	Exploratory study Data: 6 Italian food firms	Goal of achieving higher quality	Adoption of "retro-looking" innovation Adoption of 'forward-looking' innovation	Positive relationship (quality as a motivation for innovation)
Purba et al. (2018)	Literature review	Product quality attributes (sensory characteristics)	Product innovation	Positive relationship(product innovation fulfills the changes in demand patterns in respect to quality attributes)
Boehlje et al. (2009)	Literature review	Quality enhancement and process improvement	Process innovation	Positive relationship (process innovation combined with the adoption of management system are positively affecting the quality measures)

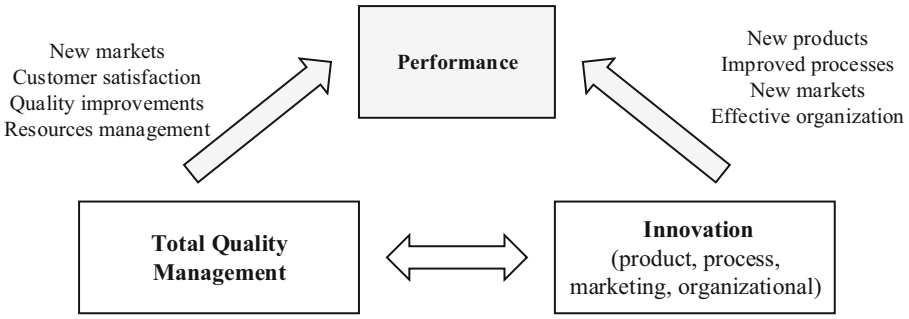

Fig. 4 The quality-innovation-performance nexus

employee involvement in quality management, process management, customer orientation, and quality design, all enhance firms' performance, while the latter factor includes variables such as customer satisfaction, sales growth, market share, and profit. Leveraging a SEM technique for their constructed model, Pipatprapa et al. (2017) supported that innovation, quality management, and market orientation have a positive impact on green performance, while innovation and quality management have both a positively mediating effect on the market orientation-green performance relationship. However, based on their model, a non-significant relationship was found between quality management systems and firms' innovativeness.

Referring to EFQM Excellence Model, studies found that the impact of TQM practices on the agro-food firms' financial performance is highly significant. In particular, Morath and Doluschitz (2009) found that the firms' perception about the significance of the impact that each of the nine areas of the EFQM model (leadership, people, strategy, partnership and resources, processes, products, and services, people results, customer results, society results, business results) has on the economic success (medium- to long-term) differs from the relevant results of their statistical analysis, with resources and partnerships area ranked low based on firms' perception, while the statistical analysis indicated that the area's impact was high. However, on this specific research, it was supported that about 32% of the firms' sample believed that should adopt routine processes for the introduction of alternative and new technologies. These findings could support the positive quality-innovation relationship.

Additionally, for a dataset of 347 Greek food firms certified to various quality systems (ISO 9001, HACCP, etc.), Kafetzopoulos et al. (2013), using SEM approaches, supported that implementing effectively quality systems has a positive impact on firms' operational performance. Moreover, operational performance has a significant effect on firms' financial performance.

Based on empirical study by Aziz and Samad (2016) for SMEs in the food manufacturing industry, the positive impact of firms' innovation capability on their competitive advantage has been confirmed. Grashuis and Dary (2017) indicate the positive relationship among the quality of patented innovations (patent citations used as an indicator of quality) and the firm value (market valuation method) for the food and beverage industry. Using the MBNQA model as a measurement of quality management performance, it was found that the respective scores could be indicators of firms' economic performance (profit/loss), concerning firms that are active in agribusiness

(Savov et al. 2017), evidence that highlights the linkage between quality management adoption and business performance.

Regarding innovations in agro-food firms, Avolio et al. (2014), in a sample of Italian companies, found non-significant correlation between changes in food quality and three types of innovations (product, process and organizational innovation). Moreover, the study showed a negative correlation between food quality and marketing innovation, while authors suggested that an innovative firm does not require for standardization of processes and quality certifications.

Finally, using SEM analysis, Conde et al. (2012) supported that ISO certification, including ISO standards for quality, food safety, and environmental management, has an indirect positive effect on organizational performance through firm's internalization capability, while it does not impact performance directly. Similarly, the study of Capmany (2000) indicated that ISO 9000 certifications are considered to positively influence firms' performance and firms' operational efficiency (see also, Mumma et al. 2002). Furthermore, Oliveira et al. (2019) support that innovation capabilities in respect to operational and management processes do not necessarily influence firm's performance, while innovations in transaction and product development processes have a positive impact on performance. As already identified in the study, access to new markets is a critical factor for seeking ISO 9000 certification (Capmany 2000; Mumma et al. 2002); thus, the satisfaction of the needs of current and potential customers is important in justifying the quality-innovation-performance nexus.

The previous studies are summarized in Table 3, where the different applied techniques and methods, and the alternative measures of quality, innovation, and performance are shown.

Concluding Remarks

Based on the relevant theory, quality management and innovation are two strongly related concepts. Nevertheless, the causal relationships between them are not always clear. In some cases, quality is considered as a major driver for innovation, while in other studies, quality is a main result of innovation activities. This unclear causal relationship is caused by the fact that the one concept is inherently embedded in the other. For example, several scholars argue that innovation is a significant part of quality management systems or quality is a part of any innovation management procedure. In any case, whatever the direction or the type of causal relationship, the most important common element is customer focus. On one hand, TQM defines quality as the satisfaction of expressed or unstated (implied) customer needs, while innovation is focusing on creating value to customers and other shareholders/stakeholders. In this context, therefore, customers may be considered as the "glue" that connects innovation and quality.

This paper, through a literature review, identified three conceptual frameworks regarding the quality-innovation relationship in the agro-food sector. In the first framework, TQM or quality management elements are considered as drivers of innovation or innovation performance, while in the second framework innovation is considered as a driver for TQM. The third conceptual framework considers a

Table 3 Studies in the agro-food sector about the quality-innovation-performance nexus

Study	Techniques/methods	Quality measures (Q) Innovation measures (I) Performance measures (P)	Relationships/findings
Psomas and Fotopoulos (2010)	Factor analysis Multiple regression analysis Data: Greek food firms	Q: TQM practices P: Market benefits, customer satisfaction	Quality management has a positive impact on firm's performance
Psomas et al. (2014)	Factor analysis Multiple regression analysis Data: Greek food firms	Q: Soft TQM P: Business performance Mediator: Quality improvement	Quality management has a positive impact on firm's performance
Han et al. (2009)	Factor analysis Partial least squares Data: Chinese pork processing industry	Q: Quality leadership, employee involvement in quality management, quality process management, customer quality management, quality design P: Firm performance factor (customer satisfaction, sales growth, profit and market share)	Quality management practices have a positive impact on firm performance
Pipatprapa et al. (2017)	SEM Dataset: Thailand food companies	Q: Quality assurance, quality control, quality improvement, quality design, quality policy P: ISO 14031 green performance (environmental condition, operational performance)	Quality management positive impacts green performance Mediating effects of innovation and QM on market orientation green performance relationship Non-significant relationship between QM and innovation
Morath and Doluschitz (2009)	Ordinal logistic regression Dataset: German food companies	Q: Perception of managers for the significance of EFQM nine a reas' impact on economic success Q: EFQM nine areas P: medium- to long term- economic success I: Introduction of alternative and new technologies	Quality management has a positive impact on financial performance Differentiation between authors calculations and managers' perceptions Evidence for positive relationship between quality and innovation
Kafetzopoulos et al. (2013)	SEM Factor analysis Data: Greek food firms	Q: Effective adoption of quality systems (ISO 9001, HACCP, etc.) P: Operational performance P: Financial performance	Effective adoption of quality management has a positive impact on operational performance Operational performance is positively correlated with financial performance
Aziz and Samad (2016)	Regression analysis Data: Malaysian food manufacturing SMEs	I: Firms' innovation capability P: Competitive advantage	Positive impact of innovation capability on completive advantage
Grashuis and Dary (2017)	Regression analysis Data: US F&B companies	I: Quality of patents P: Firm value (market valuation method)	Positive impact of patents with quality on firm value

Table 3 (continued)

Study	Techniques/methods	Quality measures (Q) Innovation measures (I) Performance measures (P)	Relationships/findings
Savov et al. (2017)	Regression analysis Kruskal-Wallis ANOVA Data: Slovakian agro-food companies	Q: MBNQA model scores P: Profit/loss	Quality management adoption positive effect on business performance
Avolio et al. (2014)	Correlation matrix Data: Italian agro-food companies	Q: Food quality changes (standardized quality constraints and quality certifications) I: Product, process, organizational, marketing innovation	Non-significant correlation for three types of innovation Negative correlation between quality and marketing innovation
Conde et al. (2012)	SEM Factor analysis Correlation analysis Data: Spanish agro-food companies	Q: ISO certification (ISO 9001, ISO 14000, ISO 22000) I: Access to foreign markets (internationalization) P: Organizational performance (Sales to employees ratio)	ISO certification has an indirect positive impact on organizational performance through firm's internalization capability
Capmany (2000)	*t* tests Dataset: subgroup of agribusiness firms and subgroup of firms from different industries	Q: ISO 9000 P: Ex-post perceptions for performance indicators such as completive advantage, profit, etc. I: Access to new market as a critical factor for seeking ISO 9000 (ex-ante perception)	Certification is perceived to have a positive effect on firms' performance Access to new market motivates the adoption of ISO 9000
Mumma et al. (2002)	Kendall coefficient of concordance ANOVA Logistic regression Dataset: US agribusiness sites registered for ISO certification	Q: ISO 9000 P: Ex-post perceived operational efficiency I: Access to new market	Certification is perceived to have a positive impact on firms' operational efficiency Access to new market motivates the adoption of ISO 9000
Oliveira et al. (2019)	Partial least squaresSEM Data: Brazilian food processing firms	I: Operational innovativeness, management innovativeness, development innovativeness, transaction innovativeness P: Innovative performance (net income, market share and billing)	Innovativeness in operational and management processes does not influence firm's performance Innovativeness in transaction and product development processes has a positive effect on performance

bidirectional relationship, adding firm's performance either as a mediator or as a result of the quality-innovation linkage.

Generally, in the vast majority of studies in agro-food companies, a positive relationship may be found between TQM or quality and innovation, regardless of the adopted conceptual framework. Thus, this paper supports a significant and positive impact of quality efforts on innovation for the agro-food sector, while innovation efforts positively affect quality. Furthermore, both quality and innovation efforts have positive impacts on agro-food firms' performance. The negative relationships found in few studies may be justified by other internal (e.g., culture) and external factors (e.g., competition) that may affect both firm's quality management and innovation activities. It is important to note that the presented review shows that access to current and new markets is a major motive, objective, and outcome of the quality-innovation nexus, particularly for the agro-food industry.

A major limitation of all presented studies is the unclear definition and measurement of TQM. Since it is basically a management philosophy, it cannot be accurately and directly measured. For this reason, most of the literature focuses on TQM practices or quality assurance activities, rather than the "true" adoption of the TQM philosophy in agro-food companies. Moreover, in some cases, TQM implementation focuses on the legislative aspects of quality management (e.g., rules, obligation for certificates), and as result, quality may become a barrier for innovation activities. Therefore, firms should consider both the "soft" and "hard" factors of quality practices and also perceive quality management as an opportunity for introducing innovative activities.

Future research efforts may analyze the interrelationships of innovation-quality linkage (e.g., quality embedded in innovation) and shift from the quality-innovation relationship to the study between TQM practices and different forms of innovation activities. Finally, distinguishing radical and incremental innovation may provide further useful insights in the proposed conceptual frameworks. It may also be useful to place emphasis on particular characteristics of agro-food companies, such as the adoption of new technologies, the management of human resources, the adaptation to international/national agro-food policies, and the distinctive characteristic of agro-food certifications.

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