MEASURING TOTAL CHAIN PERFORMANCE: THE IMPACT OF QUALITY ASSURANCE SYSTEMS ON THE PERFORMANCE OF A TOMATO CHAIN

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Abstract
Agri-food supply chains are currently being confronted with many requirements regarding the quality of their products. In recent years, concerns about food quality have risen among consumers as a result of several outbreaks of diseases and various environmental concerns. This has stimulated governments to introduce stricter regulations concerning food quality and safety issues. Besides governmental regulations, retailers also impose food quality requirements and standards on their supply chains. Literature shows that the adoption of new certification systems generates advantages and disadvantages in terms of performance. While research on Quality Assurance Systems (QAS) at the firm level has generated contradictory findings, research at the chain level is, to our knowledge, is lacking. The goal of this study is to develop a method for analyzing the impact of different QAS requirements on the performance of the different stages of the supply chain and of the chain as a whole. Performance in this study includes components of efficiency, flexibility, and responsiveness as well as food quality.

Key words: performance measurement, self-explicated method, supply chain, QAS

1. Introduction

Food safety and the environment are important concerns in agri-food production [1]. To assure the quality of products, various types of certification systems have been introduced in agri-food supply chains, such as HACCP, ISO, EUREP GAP, BRC, and IFS. Besides, due to globalization, firms in agri-food supply chains find themselves in a fast-changing environment and faced with high competition. In order to be competitive in the world market, agri-food supply chain firms need to comply with additional demands on food quality requirements imposed by international retailers. Literature shows that the adoption of new certification systems generates advantages and disadvantages in terms of performance [2, 3, 4]. Singels et al. (1999) performed a questionnaire survey among 300 Dutch organizations (some were ISO certified while others did not have any certification). They found no significant difference in performance improvement between organizations with certified quality systems and those without [2]. Carlsson and Carlsson (1996) carried out telephone interviews and a questionnaire survey among 214 ISO certified companies in Sweden [3]. They found that ISO certification leads to improvements of the performance of only a few business aspects, i.e. improvements of internal routines and procedures. Moll and Igual (2005) analyzed the average production costs of citrus cultivated under EUREPGAP certification in Spain and citrus cultivated in the conventional way [4]. They compared fixed costs and variable costs. The results revealed that the variable costs are lower for certified firms than for conventional firms due to lower variable costs as a result of restrictions on the use of fertilizers, pesticides and herbicides following on from EUREPGAP regulations. The results from different studies are contradictory: some research found a positive relationship between certification and performance of the firm, while other research found no effect, or even a negative effect, on performance.
Whereas research on QAS at the firm level has generated contradictory findings, research at the chain level is, to our knowledge, non-existent. Therefore, the objective of this study is to develop a method for analyzing the impact of different QAS requirements on the performance of the different stages of the supply chain and the chain as a whole. In order to study how QAS requirements affect the performance of the chain, an adequate chain performance measurement system is required. Recently, Aramyan et al. (2006) developed a conceptual model for a performance measurement system for agri-food supply chains [5]. In order to achieve the objective of this paper, the performance measurement model

developed by Aramyan et al. is applied to a Dutch fresh tomato supply chain. The tomato chain consists of four stages: 1) breeder, 2) tomato growers, 3) wholesalers and 4) retailers. This study measures perceptions of supply chain members on the impact of different QAS requirements on the performance of the tomato supply chain. These perceptions are obtained using an adapted self-explicated method. In order to analyze the impact of QAS requirements on the performance of the whole chain, the perceptions of the supply chain members are aggregated to the chain level, using importance weights obtained from the chain members.

2. Research methodology

This section consists of the description of PMS developed by Aramyan et al. 2006, which is presented in the next subsection. Subsection 2.2 describes QAS requirements used in this study followed by Survey design (2.3) and Data collection (2.4).

2.1 Performance measurement system model

Measuring the performance of agri-food supply chains is complicated, since these chains have many characteristics that distinguish them from other types of supply chains (e.g. perishability of the products, seasonality, shelf-life constraints, and food safety issues). Therefore, performance measurement systems, developed for other supply chains, which do not include these characteristics, are not fully applicable for measuring the performance of agri-food supply chains. Aramyan et al. (2006) developed a conceptual model for measuring the performance of agri-food supply chains that captures the special characteristics of agri-food supply chains [5]. In their model, they distinguish four main categories of performance indicators. Per category, they suggest a number of measurable performance indicators (see Figure (i)).

The model has been tested by Aramyan et al. (2007) by means of case studies [6]. On the basis of this research, a number of performance indicators achieved noticeably high importance scores. These indicators are used in the present study to measure the performance of the whole supply chain. The chosen indictors are relatively easily measured for all chain members. Moreover, these performance indicators were considered to be mutually independent, which reduces the risks of double-counts in the aggregation procedure.

Agri-food supply chain performance indicators are grouped into four main categories: efficiency, flexibility, responsiveness and food quality. These four categories are the bottom line of the performance measurement system. Each of these main categories contains one or two performance indicators. Efficiency measures how well the resources are utilized [7]. It includes the indicator production costs, which is defined as costs of inputs used to produce output. Flexibility indicates the degree to which the supply chain can respond to a changing environment [8]. It includes the performance indicators volume flexibility and mix flexibility. Responsiveness aims at providing the requested products with a short lead time. It includes the indicator lead time.

The specific characteristics of agri-food supply chains are captured in the measurement model in the food quality category. Two indicators of food quality are product safety and appearance.

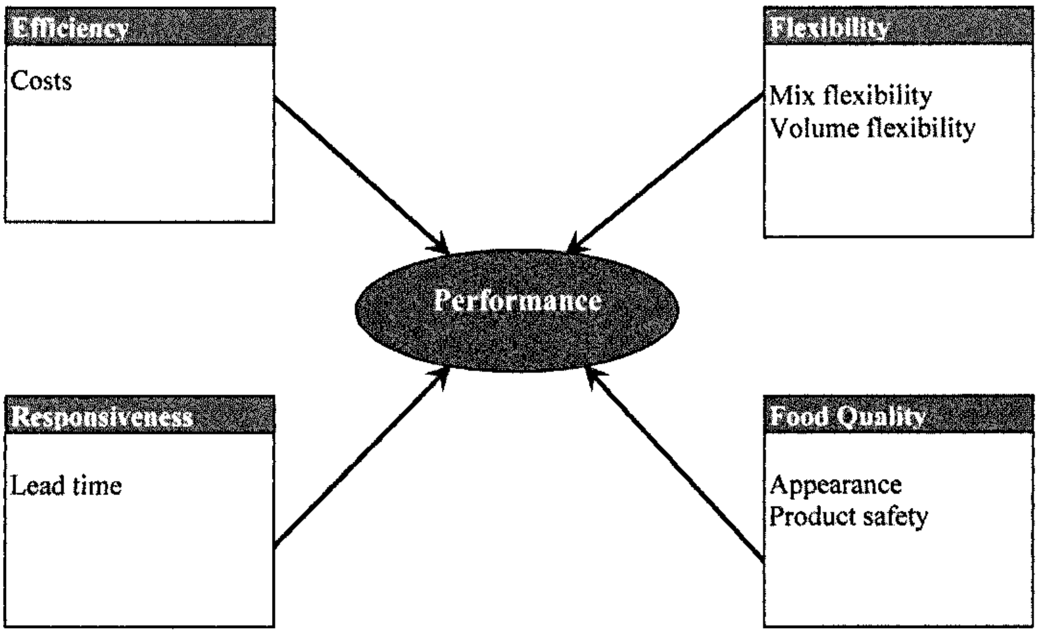

Figure (i). Conceptual model of agri-food supply chain performance with categories and indicators (source: [6])

2.2 QAS requirements used in this study

Based on a review of QAS used in agri-food supply chains, seven key requirements were chosen (five of which are the same for all chain members and two are different for different chain members, i.e. breeders and growers versus wholesalers and retailers) for a four-stage supply chain consisting of breeder, growers, wholesalers and retailers (see Table (i)). The choice for these seven requirements was driven by basic requirements needed to adopt QAS and these have been verified, based on expert opinion, as being the most important requirements for adoption of QAS. The description of the requirements is given in Table (i) together with the chain stages that use these requirements and the QAS from which these requirements are derived.

Requirements	Description	Chain stages*	QAS
1. Records of varieties & rootstocks	Records kept for: • Seed quality (a seed record/certificate of seed quality, purity, etc.) • Pest and disease resistance (the varieties grown have resistance to disease and pests) • Seed/plant treatment (a record of the seed/plant treatment) • Propagation material (records to show propagation material fit for the purpose)	B, G	EUREPGAP
2. Product recall & control of non-conforming products	• Procedure for the control of non-conforming material including rejection, acceptance by concession, or regarding alternative use, shall be in place and understood by authorized personnel • Ability of an effective product recall procedure for all products	W, R	BRC, IFS, ISO 22000
3. Management commitment towards food safety	Business objective of the firm supports food safety	B, G, W, R	ISO 22000, BRC
4. Records of residue analysis and chemical use	Records are kept with information about product residue analysis and the use of chemicals	B, G, W, R	EUREPGAP, BRC, IFS
5. Worker health, safety and welfare	• Risk assessment (safe and healthy conditions for work) • Training (hygiene training, first aid training) • Facilities/clothing (warning signs on equipment, protective clothing, etc) • Work environment/Welfare (records about the concerns of workers about health, safety and welfare and communications about these issues)	B, G, W, R	EUREPGAP, BRC, ISO 22000
6. Hazard Analysis	• Availability of information • Hazard assessment (possibility of elimination or reduction of the hazard) • Identification of critical control points • System of monitoring critical control points	B, G, W, R	BRC, IFS, ISO 22000
7. Traceability	• Documented traceability system • Handling of potentially unsafe products	B, G, W, R	EUREPGAP, BRC, IFS, ISO 22000

* B= Breeder, G= Grower, W= Wholesaler, R= Retailer

Table (i). Description of QAS requirements

2.3 Survey Design

In this research a self-explicated method has been adapted and applied to evaluate the impact of QAS requirements on performance. The self-explicated method is an alternative method to conjoint analysis, which is a technique for measuring consumers' tradeoffs among multi-attributed products [9, 10, 11]. Both the self-explicated method and conjoint analysis are based on the simple premise that consumers evaluate the value of a product by combining the separate amounts of value provided by each product's attribute[1]. Using an additive model, the individual's utility for a multi-attribute product concept can be expressed as the sum of the utilities for its attributes.

$U = u(a_{i1}) + u(a_{i2}) + ... + u(a_{in})$

Where U is utility of product concept, and $u(a_{ij})$ is the utility for level[2] i of attribute a_{ij} (j=1 to n) and (i=1 to m_j), where m_j is the number of levels of attribute j.

In a general set-up of the self-explicated method, respondents first evaluate the levels of each attribute on a desirability scale (e.g. 0-10, where the most preferred level for the attribute receives the value 10 and the least preferred level receives 0). Respondents are then asked to allocate 100 points, for example, across attributes to reflect their relative importance. Part-worths[3] are calculated by multiplying the importance rating with the desirability rating [12, 13, 14]. The difference between conjoint analysis and the self-explicated method is that the self-explicated method is a compositional method that asks respondents directly for part-worths of an attribute level without making choices, while conjoint analysis is a decompositional method in which respondents react to a set of full-profile[4] descriptions.

In this research, the attributes are QAS requirements of EUREP GAP, ISO, etc., which are introduced to a supply chain. By using the self-explicated method, it is possible to see the contribution of each QAS requirement to the total performance of the whole supply chain.

In this study, the self-explicated method has been adapted in the sense that respondents were asked to judge the desirability and importance of the attribute in one question. An example of questions asked to the respondent included "Please indicate the impact of having management commitment toward food safety on your organization's production costs". The reference point was the situation in which the requirement was not present. An 11-point scale was used from -5 (very negative) to 5 (very positive). In this question, for each attribute, the level that has the most positive perceived impact on performance is reflected in the positive or negative answers of respondents, while the rating of importance is reflected in the assigned values indicating how negative or positive the impact is.

The questionnaire consisted of three main parts subdivided into six sections[5]. The first part of the questionnaire consisted of the self-explicated task, where respondents are asked to judge the impact of different QAS requirements on the performance indicators and a number of conjoint holdouts, which were presented to the respondents so that consistency checks could be performed. In the second part of the questionnaire, interviewees were asked to judge the contribution of each supply chain member to the performance of the whole supply chain. For this purpose, the interviewees were asked to divide 100 percentage points between supply chain members for each performance indicator. The last part of the questionnaire consists of an evaluation of the performance

[1] It is assumed that consumers purchase products based on their characteristics, which are called attributes (e.g. size or color of a tomato)

[2] Attribute may have two or more levels (e.g. a small, medium or large tomato)

[3] Estimates of whole preference or utility associated with the level of each attribute used to define the product or service.

[4] An approach to collecting respondents' judgments in which respondents have to judge a combination of each of the attributes

[5] The questionnaire is available upon request from the first author

measurement categories, and an aggregation of performance indicators into performance categories. Here, interviewees focused on the importance of performance categories as part of the supply chain performance.

2.4 Data Collection

Data has been collected in the context of a Dutch tomato supply chain. To represent the whole tomato chain, respondents from the individual links of the chain, starting from breeding companies through to retailers, were interviewed. In total, 20 respondents took part in the case study, i.e. the one breeder in the chain, 13 tomato growers, three wholesalers and three retailers. The choice of one breeder is governed by the fact that there are few breeding companies in the Netherlands, given their capital-intensive nature. To collect data from growers, a workshop was organized. The invitation for the evening workshop was sent to 41 tomato growers in the Netherlands. In November 2006, 13 respondents took part in the workshop. Data collection from other members of the chain was carried out through personal interviews, in a similar way to the growers' workshop but on a smaller scale. The wholesale companies interviewed for this study buy tomatoes from the interviewed growers, as well as from growers in other supply chains. The same applies for retailers with respect to their choice of wholesalers.

3. Results of Analysis

This section starts with analysis of results for individual chain members (3.1) followed by analysis of contribution of supply chain members to different performance indicators (3.2). This section ends with the analysis of aggregated results for entire supply chain (3.3).

3.1 Results for individual supply chain members

Self-explicated analyses started with a validity check of each respondent. Validity checks were performed using conjoint analysis with eight partial-profile holdouts. These checks were performed for the product safety indicator. The results of conjoint analysis were compared with the results of the self-explicated analysis, and respondents with inconsistent answers were omitted from further analysis. To compare the results of the two methods, correlation analyses were performed between part-worths obtained by conjoint analysis and self-explicated methods. The hypothesis was that if the respondent is consistent in his/her answers, there should be a high significant positive correlation between part-worths of the two methods. The consistency check revealed that 18 respondents (90%) were consistent in their answers (significant positive correlation, with correlation coefficients of 0.71 and higher). Two respondents (growers) appeared to be inconsistent in their answers and were omitted from further analysis. The Pearson correlation coefficient was used as a measure of the goodness-of-fit. As its mean value is very close to one (R=0.89), the main effect model (conjoint model) fits the data well, and there seems to be no need for interaction effects. Results of self-explicated analysis are presented in Table (ii). The part-worth estimates show the contribution of each QAS requirement to each performance indicator for each supply chain member on a scale of -5 to 5 (-5 and 5 mean that a requirement has a very negative and a very positive impact, respectively).

Impact on Performance Indicator	Breeder	Grower	Wholesale	Retail
Records of varieties & rootstocks			NR*	NR
1. Impact on Production Costs	-1	3.18		
2. Impact on Volume Flexibility	0	2.91		
3. Impact on Mix Flexibility	0	1.36		
4. Impact on Lead Time	-1	2.64		
5. Impact on Product Safety	4	2.09		
6. Impact on Appearance	3	3.00		
Product recall & control of non-conforming products	NR	NR		
1. Impact on Production Costs			-0.67	-1.67
2. Impact on Volume Flexibility			1.00	-1.33
3. Impact on Mix Flexibility			-0.33	-1.00
4. Impact on Lead Time			-1.67	-1.33
5. Impact on Product Safety			1.00	2.67
6. Impact on Appearance			0	1.33
Management commitment toward food safety				
1. Impact on Production Costs	0	1.00	-1.67	-1.67
2. Impact on Volume Flexibility	0	0.91	-0.33	-1.33
3. Impact on Mix Flexibility	0	0.36	0	-0.67
4. Impact on Lead Time	0	0.82	-0.33	-1.67
5. Impact on Product Safety	1	2.27	3.00	4.00
6. Impact on Appearance	0	0.91	1.00	0
Records of residue analysis and chemical use				
1. Impact on Production Costs	-1	1.00	-1.00	-1.67
2. Impact on Volume Flexibility	1	1.00	0	-1.00
3. Impact on Mix Flexibility	0	0.36	1.00	-1.00
4. Impact on Lead Time	0	0.18	0	-1.67
5. Impact on Product Safety	4	3.82	2.67	2.33
6. Impact on Appearance	4	0.73	1.00	0
Worker health, safety and welfare				
1. Impact on Production Costs	-2	1.45	-0.67	-1.00
2. Impact on Volume Flexibility	0	1.09	0	0
3. Impact on Mix Flexibility	0	0.18	0	0
4. Impact on Lead Time	0	0.64	0	-1.33
5. Impact on Product Safety	0	3.00	0.67	1.67
6. Impact on Appearance	0	1.55	1.00	0
Hazard Analysis				
1. Impact on Production Costs	-3	0.36	-0.67	-1.33
2. Impact on Volume Flexibility	0	0.36	0	-0.33
3. Impact on Mix Flexibility	-1	0	0	-0.33
4. Impact on Lead Time	0	0.18	0	-0.33
5. Impact on Product Safety	0	2.27	2.33	4.00
6. Impact on Appearance	2	0.36	0	0
Traceability				
1. Impact on Production Costs	-1	0.36	-2.67	-1.67
2. Impact on Volume Flexibility	0	0.64	-1.33	-1.67
3. Impact on Mix Flexibility	0	0.55	-1.33	-1.67
4. Impact on Lead Time	0	0.64	-1.33	-1.67
5. Impact on Product Safety	3	2.64	4.00	3.00
6. Impact on Appearance	3	2.18	0	0
*NR =not relevant to the chain member				

Table (ii). Part-worth estimates of the impact of the QAS requirements on each performance indicator for each supply chain member

From the results, we can see that, in general, QAS requirements are perceived to have little impact on performance indicators. If we look at the signs of part-worths, we notice disagreement between supply chain members about the impact of QAS requirements on their performance.

Keeping records of varieties and rootstocks has a positive perceived impact on the production costs of the growers. The reason given for this is generally that this requirement gives an opportunity to comply with the changes in the market. It may increase the costs in the short run, but in the longer run it increases returns, since growers gain a more competitive position in the market. In general, from a grower's point of view, it is almost impossible to influence the volume flexibility of the products, because demand changes much faster than the duration of the production cycle. However, having all records about the plant's lifetime (e.g. watering, temperature in the glasshouse, light) may allow growers to adjust the volume of their products to a certain extent, by comparing these records against each other over a number of years. A similar explanation can be given for the positive effect of this requirement on the appearance of the product in the supermarket, where having good records about seeds/plants used (e.g. quality, purity, pest resistance) may provide insight into the final product's appearance in the supermarket. This requirement has a positive perceived impact on lead time, because records may allow growers/breeders to gain information about the reasons for differences in the length of the production process over years (e.g. input of temperature in the glasshouse) and to act upon it at an early stage. This requirement has a positive perceived impact on product safety as well, since records contain all information about seed/plant treatments.

The part-worths for *product recall and control of non-conforming products* have a negative sign for impact on production costs for wholesalers and retailers, suggesting that this requirement involves the incurring of costs. However, these are not major costs, since several respondents mentioned that product recalls do not happen very often in tomato chains.

Management commitment toward food safety is perceived to have a slightly negative impact on production costs of wholesalers and retailers since it involves additional costs with respect to food safety controls.

A record of residue analysis and chemical use has a positive perceived impact on product safety for all chain members. An interesting result is obtained from the breeder concerning the perceived positive impact of this requirement on the appearance of the product in the supermarket. The argument presented was that keeping records of residue analysis and chemical use allows the optimization of the amount of the chemical use and the timing.

Worker health, safety and welfare is perceived to have a slightly positive impact on production costs of the growers. According to growers, this requirement itself probably costs money, but it has a very positive effect, because it increases the productivity of employees in the long run.

Hazard analysis is perceived to have a negative impact on the costs for breeder, a slightly negative impact for retailers, and no impact for costs of growers and wholesalers' costs. The explanation for this could be that the breeder is the crucial point for providing safe/hazardless raw material (seeds) for the rest of the chain. Therefore, they spend more on having a good system of control over hazards.

Traceability has a negative perceived impact on production costs of wholesalers and a slightly negative impact on costs of retailers. This may be explained by the fact that wholesalers play an extremely important role in the traceability. Wholesalers receive

product batches from growers with the grower's number in each batch. However, many products are repackaged to make them attractive for retailers (e.g. red, green and yellow paprika in one package, or paprika and eggplant in one package). These mixed products should be recoded, which costs time and extra labor. Traceability has a slightly negative perceived impact on mix and volume flexibility of wholesalers and retailers. This can be explained by the fact that wholesalers and retailers are limited in their options for increasing their product volume due to traceability requirements. In the case of mix flexibility, the higher the variety of products, the more additional traceability systems should be applied, since more different products need to be traceable. This requirement appeared to have a slightly negative perceived impact on the lead time of the wholesalers and retailers, which might be explained by the fact that stamping all batches costs time and increases the lead time.
To compare the perceptions of respondents from different supply chain links, a Mann-Whitney U test was performed to detect differences between groups. This test was chosen because it can be used with ordinal data and does not assume a normal distribution [15]. Given the small number of respondents, we defined two groups of respondents: growers are considered as one group, and wholesalers plus retailers are considered as the second group. The null hypothesis (no difference) was rejected for the impact of several requirements on several performance indicators. A significant difference was found for the impact of all five requirements on production costs at 5% critical level ("Keeping records of varieties and rootstocks" and "Product recall and control of non-conforming products" could not be tested because they are relevant only to one of the groups). A significant difference was found for the impact of management commitment toward food safety on volume flexibility ($p<0.10$), on lead time, and product safety ($p<0.05$). The impact of traceability on volume flexibility, mix flexibility and product appearance in the supermarket is found to be significantly different between the groups ($p<0.05$)

3.2 Contribution of supply chain members to different performance indicators

In the second part of the questionnaire, respondents were asked to assess the contribution of each supply chain member to the chain performance indicators. For that purpose, the respondents were asked to divide 100 percentage points between supply chain members for each chain performance indicator, given the chain member's contribution to the performance indicator. Table (iii) presents the mean results of perceptions about the four supply chain links, normalized by the number of respondents in each link.

Performance Indicators	**Breeder %**		**Grower %**		**Wholesaler %**		**Retailer %**		**Total %**
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Chain Production Costs	8.0	(2.1)	47.3	(11.5)	13.4	(4.7)	31.5	(13.1)	100
Chain Volume Flexibility	10.7	(13.0)	35.1	(7.3)	24.6	(15.8)	29.6	(13.2)	100
Chain Mix Flexibility	13.4	(9.6)	29.5	(8.2)	21.5	(12.6)	35.7	(17.1)	100
Chain lead time	10.4	(8.7)	31.5	(4.9)	28.4	(5.8)	29.7	(13.2)	100
Chain Product Safety	8.5	(5.8)	47.9	(27.5)	17.0	(8.8)	26.9	(22.9)	100
Appearance in the supermarket	7.1	(3.5)	28.2	(16.6)	19.1	(10.3)	45.7	(26.8)	100

Table (iii) Contribution of chain members to whole supply chain performance

From Table (iii) it becomes clear that the perceptions of the respondents about the contribution of different links to the whole chain performance are very diverse (given the large standard deviations between and within groups). The results in Table (iii) show that growers are perceived to have the highest contribution to chain production costs (47.3%), chain volume flexibility (35.1%), and chain product safety (47.9%). Retailers are perceived to have the highest contribution to chain mix flexibility (35.7%) and to the appearance of the product in the supermarket (45.7%). According to respondents, the breeder has the smallest contribution to the whole chain performance.

3.3 Results for the whole supply chain

Now that we have available the perceived impacts of QAS requirements on performance indicators from the supply chain members, we can aggregate these results into the perceived chain impact on the performance categories: efficiency, flexibility, responsiveness and product quality. To do this we use the average weights obtained from supply chain members about their contribution to a whole supply chain performance (see Table (iii)). Obtained part-worths from Table (ii) were multiplied by these weights and, using an additive model, were aggregated into a chain impact for each performance category. Flexibility consists of volume flexibility and mix flexibility, and product quality consists of product safety and the appearance of the products in the supermarket. In order to aggregate these indicators into these categories, the average importance weights of these indicators for measuring these categories, obtained from respondents, are used. The results of the aggregated impact of QAS requirements on performance categories are presented in Table (iv).

With the results on the impact of QAS requirements on each performance category now available, we can aggregate them into the impact on the whole performance. To achieve this, category weights are applied. These weights are obtained from respondents, given their assessments about the importance of each category for measuring the whole performance of the chain.

The aggregated results show that QAS requirements in general have a small impact on the performance categories. The requirement for records of varieties and rootstocks has a slightly positive impact on efficiency. However, the other six requirements have a slightly negative impact, meaning that they slightly decrease the efficiency of the entire supply chain. All requirements have a slightly positive impact on product quality. Flexibility and responsiveness are slightly affected by QAS requirements. The results of the perceived impact of QAS requirements on the performance of the chain revealed that each requirement separately has a slightly positive impact on the whole performance.

All QAS requirements have a positive impact on the overall performance of the chain. The mean of all QAS requirements has a slightly positive impact (0.57) on the overall performance of the chain, suggesting that QAS might be useful to implement. Note that the numbers given in Table (iv) are on a scale between -5 and 5, which are the extremely negative and extremely positive points, respectively. The outcome of a small impact might be also a result of the disagreement of the supply chain members about the impact of QAS requirements on their performance (negative and positive answers cancel each other out during the aggregation process, revealing a small impact).

The performance measurement model used in this study allows supply chain members to see the impact of QAS requirements on the different aspects of the whole performance (efficiency, flexibility, responsiveness, and food quality). This allows the decision makers to make tradeoffs between different aspects of the performance. For instance, although management commitments toward food safety slightly decreases efficiency (-0.27), flexibility (-0.15) and responsiveness (-0.38) for the whole chain, it increases the food quality for the whole chain (1.52). And given that supply chain members weigh the food quality as the most important aspect of the performance (43 %), we may conclude that this requirement has a positive impact on the whole performance (0.51).

QAS Requirements	Efficiency	Flexibility	Responsive-ness	Product Quality	Whole Chain Impact
Category weights	*22%*	*24%*	*11%*	*43%*	*100%*
Records of varieties & rootstocks	1.43	0.75	0.2	1.18	1.02
Product recall & control of non-conforming products	-0.61	-0.27	-0.69	0.73	0.03
Management commitment towards food safety	-0.27	-0.15	-0.38	1.52	0.51
Records of residue analysis and chemical use	-0.26	0.08	-0.2	1.87	0.73
Worker health, safety and welfare	0.12	-0.24	-0.08	1.33	0.64
Hazard Analysis	-0.58	-0.09	-0.59	1.27	0.32
Traceability	-0.79	-0.3	0	1.79	0.69
Mean of all QAS requirements					*0.57*
*Results are presented on a scale of -5 (very negative) to +5 (very positive impact)					

Table (iv) Aggregated results of the perceived impact of QAS requirements on the performance of supply chain using average weights

4. Conclusions

This study provides insights into the performance of a complete supply chain, from different supply chain members' points of view, which is an approach rarely taken in empirical research. The contribution of this study is in the application of a method that enables researchers to study performance measurement in a broader context than the traditional context of a single firm.

The performance measurement model developed in this study allows supply chain members to develop a clear view of the impact of QAS requirements. Also, the model makes it possible to make tradeoffs between issues such as production costs and food quality, within the own firm as well as throughout the chain.

Results revealed that supply chain members do not have a clear view of the whole chain nor about the contribution of each supply chain member to the whole supply chain performance. Sharing information within and between chain members is very important in the chain, because supply chain partners can work in tight coordination to optimize the chain-wide performance.

When interpreting the results of this research, caution is needed since this research is a case study with a small sample size, which attempts to show an application of the method to understand the perceptions of the chain members about the impact of QAS requirements on the performance of the whole chain.

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