Measuring the impact of crises in the horticultural sector: The case of Spain

Pérez-Mesa, Juan Carlos and Sanchez-Fernández, Raquel and Serrano-Arcos, Mar

Universidad de Almería, Universidad de Almería, Universidad de Almería

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Juan Carlos Pérez Mesa
Departamento de Economía y Empresa
Universidad de Almería
Tlf.: +34 950 214702
e-mail: juancarl@ual.es

Mª Mar Serrano Arcos
Departamento de Economía y Empresa
Universidad de Almería
Tlf.: +34 950 214035
e-mail: msa159@inlumine.ual.es

Raquel Sanchez Fernández
Departamento de Economía y Empresa
Universidad de Almería
Tlf.: +34 950 214035
e-mail: rasanche@ual.es

Abstract

Purpose: The following research has been conducted with the purpose of reviewing the literature on image crises in the food industry as well as providing a diachronic analysis to distinguish between the varying types of crises that played a critical role in the horticultural sector in recent decades, focusing on the particular case of Spain as the largest horticultural exporter in Europe. This research also analyses the economic impact of these crises upon demand.

Design/methodology/approach: An empirical analysis has been conducted using inverse demand models to determine the prospective impact on demand of the image crises in the main European destination markets.

Findings: The empirical analysis reveals an immediate impact upon demand (imports) in the short term. Sector crises invariably have one or many 'explosion' points when they reach the public sphere. These events reduce demand among European consumers, ultimately leading to a decrease in imported goods. The tested models revealed considerably significant losses that subsequently reduce annual exports by more than 3%. The analysis also reveals strong effects of complementarity and substitution among the various products that comprise the horticultural supply.

Research limitations/implications: This study has not taken into account several movements that have also affected the horticultural sector, such as 'anti-consumption' and boycotts. Empirical results reveal a strong impact of image crises on demand (imports) in the short term. Consequently, there is an evident need to undertake actions, managed from the supply origin, that reach the consumer and effectively re-establish the prestige of the Spanish production system.

Practical implications: This paper highlights the importance of the mass media in consumer attitudes and perceptions, and the need to create channels of direct communication to break the information asymmetry between production and consumption areas.

Originality/value: This paper sheds new light on the literature of image crises. The findings of this research have contributed to greater knowledge of how image crises influence demand. From the point of view of management, these results can have practical implications for the highly competitive sector of horticultural production.

Keywords

Image; crisis; demand; exportation; horticultural; Spain.

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1. Introduction

The horticultural sector in southeast Spain has existed for over half a century and it is characterized by its strong export orientation. The importance of this sector is reflected by its export sales figures: 6.032 million euros per year, with a 23% total increase since 2013 (ICEX, 2017). At present, 75% of all production is destined for export: 33% to Germany, 16% to France, 12% to the United Kingdom, and 11% to the Netherlands (just 3% is exported outside the European Union). As a percentage of total production, a mere 25% remains in Spain. In respect to the distribution channel, the main customers are the biggest European distribution chains (e.g., Aldi, Edeka, Tesco, Carrefour, and Lidl, among others), accounting for 70% of Spanish producer sales (Pérez-Mesa and Galdeano-Gómez, 2015). These retailers demand high production quality standards, together with encouraging social responsibility and environmentally friendly practices. These can nevertheless, be distorted by the influence of negative campaigns related to production quality, one such case being the outbreak of *Escherichia Coli* identified by Germany and erroneously attributed to the Spanish cucumbers; or the circulation of news stories concerning unethical management within the sector. For example, erroneous news stories about inhumane working conditions for immigrants, or environmental degradation through the excessive use of fertilisers and pesticides. This, combined with the growth of environmental awareness and concern about food safety by end consumers, may gradually erode the image and reputation of the Spanish horticultural sector. This phenomenon has been reflected in the decreased consumption of affected products.

The impact of an image crisis upon demand has become an increasingly relevant issue within business management, but the number of studies to have analysed this phenomenon in particular sectors, is very low. Examples of such studies would include the transport sector (Efthymiou and Antoniou, 2017) and the financial sector (Akhter *et al*., 2017). Among the literature, work has been done to better understand how image crises have affected the tourism sector (Avraham, 2018; Avraham and Ketter, 2017; Hudson, 2016; Ketter, 2016; Song *et al*., 2011). However, very little is known about the impact of image crises within the food sector. Some researchers have investigated changes in consumer demand before and after a food safety event and have demonstrated that food safety information has a statistically significant effect upon consumer demand, though the effect is often marginal and short-term (Grunert, 2005; Headey, 2011; Piggott and Marsh, 2004; Shimshack, 2007). With regard to the horticultural sector, the use of a conceptual framework in order to recognise the origin and scope of these crises has not been carried out in previous research until now. This research has studied different image crises as well as their impacts upon the final demand of horticultural food products. Following Hu and Baldin (2018), the economic impact analyses in the agribusiness sector are scarce and difficult to measure. Thus, this research aims to analyse image crises in the horticultural sector and their impact on demand, given the lack of previous studies on this topic.

This study aims at analysing the impact upon demand of image crises in the horticultural sector, exploring the particular case of Spain, the largest horticultural exporter in Europe. For this purpose, this research provides a conceptual delimitation and a classification to analyse the notion of 'image crisis' in the horticultural industry and a diachronic analysis to identify the different type of crises suffered by the sector. Subsequently, an empirical analysis has been conducted using inverse demand models to determine the prospective impact on demand of these image crises in the main destination markets. After a review of the results, this paper concludes with some limitations and future research directions.

2. Image crisis in the food industry: conceptual delimitation, typology and effects

According to Van Asselt *et al*. (2017), the term 'crisis' is defined as "*an urgent, dynamic situation that is rapidly changing with unpredictable outcomes, it is poorly understood and has an impact on society and politics*". Crises are deemed to be negative changes in the security, economic, political, social and environmental affairs, especially when they occur unexpectedly and with hardly any warning (Çesmeci *et al*., 2013). Generally, a crisis event involves uncertainty about what occurred, its reasons, and what might occur later (Broekema *et al*., 2018). Some of the most common consequences of crises are the decrease in sales and market shares and the widespread negative publicity (Vassilikopoulou *et al*., 2009).

In the food industry sector, the *Codex Alimentarius* describes the term 'food crisis' as "a situation, whether accidental or intentional, that is identified by a competent authority as constituting a serious and as yet uncontrolled foodborne risk to public health that requires urgent action" (FAO/WHO, 2013). It is noteworthy that a food event can be classified as an 'accident' or an 'incident', which, in turn, can evolve from a minor incident to a major crisis at any moment (Chammem *et al*., 2018). Incidents can result in serious health risks and a decrease in the well-being of consumers, and may lead to widespread consumer concerns. It may also generate a disruption of national and international trade, as was demonstrated by the serious outbreak with the *Escherichia coli* bacteria in Germany in 2011 (Van Asselt *et al*., 2017). While a food safety incident is an unintentional event and harmful, food fraud is an intentional event for economic interest (Chammem *et al*., 2018). The shortage of specific information as well as the exposure of mass media coverage can cause the consumer's risk perceptions to be intensified and, consequently, may lead to a lowered demand for the affected food products (Frewer *et al*., 2002; Verbeke, 2005). Therefore, food crises can trigger strong consumer reactions, with significant effects on food export markets, as well as having serious political implications (Swinnen *et al*., 2005). At times, a crisis may also involve an entire category of products, such as the 'mad-cow' disease crisis (Van Heerde *et al*., 2007).

Within the ambit of food crises, it is important to define a 'food safety crisis', as being that which frequently affects a wide variety of food products (Van Asselt *et al*., 2017). 'Food safety concern' is defined as "*the degree of consumers' anxiety regarding the quality of processed foods, food additives, and pesticide residues that could jeopardize their physical health*" (Hsu *et al*., 2016, p. 202). Some of the impacts that food safety issues can have on consumers' demand of the related food can be grave. However, associations have no knowledge about the strength and the endurance of their influence on consumers' food demand. In addition, their own-effects on demand for contaminating food products may set off potential cross-effects, which in turn, may affect the demand for other products' categories (Chen *et al*., 2015). Consumer awareness of food safety information and the analysis of food demand are closely related (Obayelu *et al*., 2014). In recent years, consumers have become increasingly concerned about the risks to health posed by food consumption (Röhr *et al*., 2005). It has become increasingly challenging for the general public to assess food safety risks, which is now commonly recognised as a credence attribute (Lobb *et al*., 2007). Thus, consumers have to trust in producers, retailers, regulators, and even the media, to ensure potential health impacts are minimised (Lobb *et al*., 2007).

Besides the food safety crisis, image crises in the food industry are also caused by problems in the environment, the social welfare and the economic viability. In particular, the Spanish horticultural sector has been affected by recurring crises arising from two main sources. Firstly, the ineffective management of problems common to this sector, such as: i) the excessive use of fertilisers and pesticides, resulting in low-quality production and consumption (Wainwright *et al*., 2014); ii) the environmental degradation (Grindlay *et al*., 2011; Juntti and Downward, 2017); and iii) the bad social conditions for immigrant workers (Medland, 2016; Pumares and Jolivet, 2014). Secondly, erroneous accusations spread through the mass media blaming food safety practises for environmental and social risks, originated both in Spain and in other countries. Moreover, an image crisis has the power to compromise the economic viability of companies and sectors, thereby adversely affecting future economic sustainability. Such crises may be the result of temporary or structural changes (e.g., a decrease in price or demand, increased competition, or overproduction). This study examines three sources that can lead to an image crisis: food safety, environmental and social crisis, and on the economic impact on exportation and demand (Figure 1). All of these crises can affect demand both before and after information dissemination whether true or false, through the mass media. Both cases are considered to be image crises in this paper.

Figure 1. Image crises in the Spanish horticultural sector: Origin and consequences

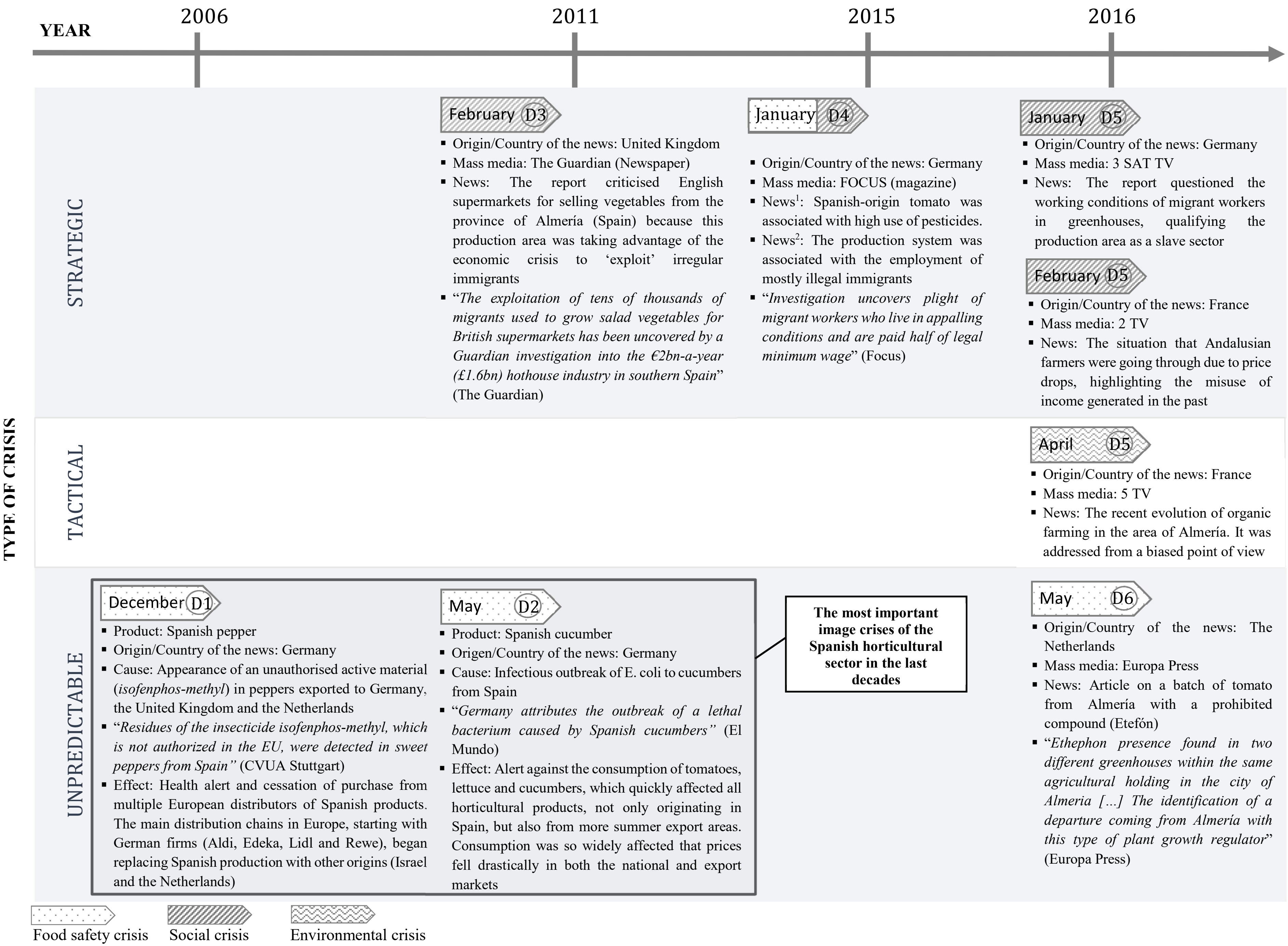
Source: Own elaboration.

3. Proposal for the classification of horticultural sector crises: the case of Spain

A country's image in the horticultural sector can be damaged by minor incidents and major crises. In order to identify the incidents and crises affecting this sector, it is necessary to know the origin and scope of each crisis. Therefore, we identify the following typology: 1) *strategic crisis*, which is slow, chronic, progressive and is detectable by indicators; 2) *tactic crisis,* which is progressive but faster than the previous one and; 3) *unpredictable crisis*, which happens due to an identified but unsolved problem that gives no prior indications until it actually occurs.

Following the previous typology, and considering the conceptual framework proposed in Figure 1, Figure 2 provides a chronological analysis of the main news and/or events that have affected the Spanish horticultural sector in recent years. Through negative communication campaigns within the mass media and a widespread diffusion among consumers using social media, some of them resulted in crises and others were dismissed as fake news. In particular, the most important image crises in recent decades are highlighted and explained in the Figure. All these crises have heightened the sense of risk perceived by the consumer and consequently, have adversely affected the image and reputation of the sector in Spain as well as other countries in the European Union.

Figure 2. Diachronic analysis of image crises in the Spanish horticultural sector



Note: D1-D6 will be Dummy variables introduced in the inverse demand model in order to know its impact (see model [1] in page 6).

4. Analysis of crises impact on exports

4.1. Methodology

After conceptualising, classifying and reviewing the main Spanish horticultural sector crises, an inverse demand model was chosen to estimate the effect of the various crises the sector has endured. This type of model is commonly used in the analysis of agricultural product consumption (Tomek and Kaiser, 2014). The prices of such products, especially fresh produce, quite often depend on the conditions of the supply (endogenous prices). Production is not very flexible in the short term, it is highly seasonal, and requires fast commercialization. Therefore, prices are adjusted in order that the available supply may be consumed. Moreover, specific characteristics of commercialisation (e.g., concentration of production companies or distributers) also has a bearing on prices depending on the existence, or not, of supply (Galdeano, 2005). In light of these features, inverse demand proves to be the most suitable analysis method. The precise moment when the crises occurred was introduced using dummy variables.

The data sample consists of monthly export tons and revenues (Euros). They were collected from the database ESTACOM provided by the Spanish Institute for Foreign Trade (ICEX, 2017). In particular, we used data of Spanish horticultural products exported to EU-27: tomato, pepper, and cucumber and other vegetables (by subtracting the sum of products used from total exports -code TARIC 07-). The tomato, pepper and cucumber are the 3 most exported vegetables from Spain. They represent 16%, 12% and 9% of the total Spanish vegetable exports (in tons, 2016).

In regards to the estimation, an analysis of each product was first conducted to identify any significant effects resulting from specific crises in the Spanish horticultural sector. Next, the same procedure was carried out for all exported vegetables as a whole. It was determined there was no need to draft an itemized list of the crises' countries of origin simply because the effects of such incidents spread rapidly throughout the EU, owing to the fact that most customers are large multinational companies operating throughout Europe. Seemingly, Unrelated Regressions (SUR) were used for the estimation of the models, yet the results obtained were similar to those of the individual estimation using Ordinary Least Squares (OLS). The system of equations for each product is defined as follows:

$$M_{i_t} = \alpha_i + \sum_i \beta_i q_{i_t} + \sum_k \theta_k D_{k_t} + \varepsilon_{i_t} \qquad [1]$$

Where:

- M_i is the monthly revenue (Mill. €) as a consequence of the exportation of i products to the EU. In the present case, i=1 for tomato, i=2 for pepper, i=3 for cucumber, i=4 for other products. The series begins in January 2006 and ends in August 2017 (140 pieces of data in total) (ICEX, 2017).

- q_i is the amount (in tons) of product i exported to the EU (ICEX, 2017). The purpose of this variable is to measure not only the impact of the supply of the product in question on generated income, but also the degree of complementarity of all other horticultural products by including the exported amounts of each product separately.

- D_k is a dummy variable with a value of 1 in the months affected by crisis k. 5 points in time were selected (see Figure 2): D1=December 2006 (crisis *isofenphos-methyl* in pepper); D2=May 2011 (pepper crisis); D3=February 2011 (report of illegal workers); D4=January 2015 (report of excessive pesticide use); D5= January-February-April 2016 (reports of illegal workers, poor management by growers, and false organic production); D6=May 2016 (pepper with chemical residue).

Initially, a preliminary version of the model included the term $\sum_k b_{k_{i_t}} D_{k_t}$ to test the influence of the various crises on the relationship between supply and revenue. However, it was later excluded as no significant term was found in any of the cases, demonstrating that revenue adjustment in crisis situations takes place through reductions in purchases, not decreases in prices.

Later, an analysis was conducted to determine the general effects on total exports using the following model:

$$M_t = \alpha_1 + \beta_2 q_t + \sum_k \theta_3 D_{k_t} + \varepsilon_{i_t} \qquad [2]$$

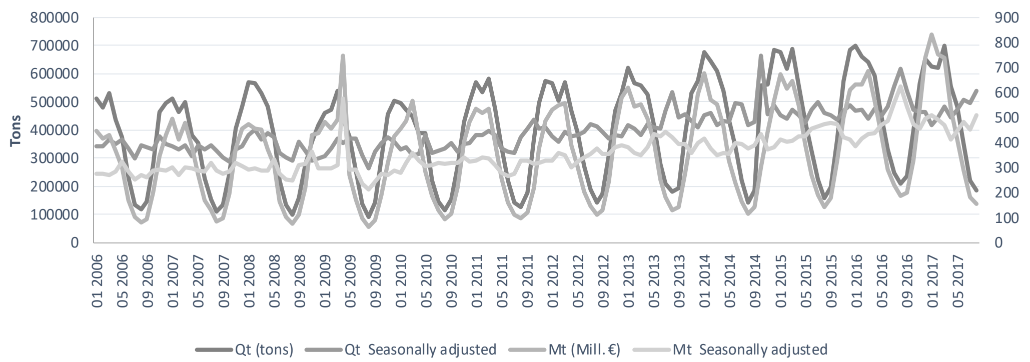
As only the moment when each crisis began was known, we proceeded to repeatedly increase the number of affected months using the following algorithm for each equation (vegetable).

1. All k crises are introduced, affecting only the starting month, i.e., a single value 1 is introduced within each D_k.

2. For the variables D_k with p <10%, more months are introduced (values 1) until D_k ceases to be significant (p>10%) or reduce the overall significance of the model measured by R^2 adjusted or the Akaike criterion (AIC). This procedure served to determine the definitive duration of each crisis.

Prior to undertaking the estimation, we proceeded to deseasonalize the series using a multiplicative model (Figure 3). Next, the presence of unit roots was tested by means of the Augmented Dickey-Fuller Test (ADF), accepting the existence of stationarity I(0) as long as the tests were independently conducted for both trend and term stationarity. The existence of a deterministic trend was detected, which can be eliminated using anomalous variables (Flynn et al., 2010; Van Beers and Van der Panne, 2011) defined as: $\overline{M_{\iota t}} = \frac{M_{it}}{M_{\iota a}}$ and $\overline{q_{\iota t}} = \frac{q_{it}}{q_{\iota a}}$; where $\overline{M_{\iota a}}$ and $\overline{q_{\iota a}}$ are the annual averages for revenue and tonnage. Thus, the stationarity I(0) calculated for the new variables was verified (Table 1). Finally, the variables were transformed into logarithms. The results of the estimations can be seen in Table 2.

Figure 3. Monthly horticultural exports of Spain to the EU-27



Source: Own elaboration.

(Insert Table 1 about here)

An alternate estimation was carried out using the classic Almost Ideal Demand System (AIDS) to verify whether its results coincided with those obtained in [1]. The static formulation of the linear form of inverse AIDS (IAIDS) is the following:

$$W_{i_t} = \alpha_i + \sum_j \beta_{ij} \log(q_{i_t}) + \gamma_i \log(Q_t) + \sum_k \theta_k D_{k_t} + \varepsilon_{i_t} \qquad [3]$$

Where:

— W_{i_t} is the resulting fraction after dividing the expenditure on imports corresponding to product i in period t by total spending for all horticultural products combined for the same period.

— Q_t is the index of quantities. In practice, Stone's price index is commonly used and, thus, $log(Q_t) = \sum_i W_{i_t}\, log(Q_{i_t})$.

The estimation of this model imposes the following theoretical restrictions: $\sum_i \alpha_i = 1, \sum_i \beta_{ij} = 0$, $\sum_i \gamma_i = 0$, and, by including the dummy variables that affect the intercept, $\sum_i \theta_i = 1$ (adding-up); $\sum_j \beta_{ij} = 0$ (homogeneity); $\beta_{ij} = \beta_{ji}$ (symmetry). This model makes it possible to interpret the consumption structure (in this case import-export) in terms of flexibilities. As this study does not seek to calculate the flexibilities themselves (or elasticities in traditional supply), the only calculations made, in view to conducting the subsequent interpretation, were those of:

— Scale flexibility, which shows the percentage of variation in the marginal value of the consumption of product i (standardized price) in response to a proportional increase in the supply of all goods. It is represented as: $f_i = \left(\frac{\gamma_i}{W_i}\right) - 1$.
— Compensated price flexibility, which reveals the percentage of change in the normalized price caused by a 1% variation in the supply of a given good: $f_{ij} = -\delta_{ij} + \left(\frac{\beta_{ij} + \gamma_i W_j}{W_i}\right)$ where δ_{ij} is the Kronecker delta [1 for i=j, 0 for $i \neq j$].

The equation [3] was estimated with level variables after verifying the results of the ADF tests (all the series were I(0) without lag) and using intercept and trend (Table 2). The ADF tests revealed strong stationarity. The results of the estimation, carried out using SUR, are displayed in the following table. Naturally, standard procedure dictates that one of the four equations must be omitted from the estimation to avoid singularity in the variance-covariance matrix of the error term; in this case, the equation corresponding to 'others' products was excluded. The parameters of the estimation were calculated using the estimations obtained for the remaining equations.

(Insert Table 2 about here)

4.2. Results

The results of the estimations (Table 3) confirm the significant impact (p<10%) of the main crises analysed, namely the *isofenphos methyl* crisis (D1) and the so-called 'cucumber crisis' or '*E-coli* crisis' (D2), for the horticultural export as a whole ("Total vegetables" column). Furthermore, the crisis related to reports of illegal workers, poor management by growers, and false organic production (D5) also shows a significant impact on exports (p<5%). Results also revealed that the influence of each crisis varied depending on the product (vegetables). More specifically, the *isofenphos methyl* crisis (D1) affected only the demand for pepper (p<5% and a negative coefficient) and had barely any repercussions on other products. However, it should be noted that this crisis eventually had a considerable impact on the Spanish distribution sector, mainly because it acted as a catalyst for the implementation of Integrated Pest Management (IPM). Other crises that appear to have an impact on the demand for vegetables were: D2, which mainly affected the demand for tomato, cucumber and other vegetables; D4, which affected the demand for tomato; D5, which had a highly detrimental impact on the demand for cucumber ($p<1\%$); and D6, which was harmful for the demand for tomato, cucumber and other vegetables. In general, all the crises had a negative effect on exports (see "Total vegetables" column), except for the reports of illegal workers, which occurred in 2011 (D3), as the coefficient was not negative.

In addition, although they were not the main objective of this work, some rather interesting results were obtained (Table 3). For example: i) the parallel presence of strong complementarity and substitution effects between various vegetables; and ii) the high price elasticities obtained from calculating the revenue-quantity elasticity (coefficients $log\ \overline{q_{it}}$), which were lower than 1 in all cases.

(Insert Table 3 about here)

Table 4 presents the estimated number of months of impact of the crises included in the model (calculated based on the optimization of R^2 adjustment in the 'Total Vegetables' model). It also displays the cost of losses as a result of decreases in exports to the EU. The crisis with the longest duration was D2 (pepper crisis; 8 months), revealing a calculated total impact on the sector of nearly 100 million € in 2011 (more than double the estimations provided at the time). However, D1 (crisis *isofenphos-methyl* in pepper) hardly had any economic effect, although, as mentioned earlier, it did mark a turning point in the production strategy of the sector. The impact of D5 (reports of illegal workers, poor management by growers, and false organic production) was also considerable (174 million €; 4 months); in this case the crisis was sparked by numerous reports of poor practices in the Spanish horticultural sector in 2015.

(Insert Table 4 about here)

The classic estimation of the IAIDS model (Table 5) confirms the results of model [1] and offers more information for interpreting data. The impact of crises D1, D2, D4, D5 and D6 is significant for some of the products analysed, mainly in tomato and pepper. It is worth noting that there is a logical explanation for the existence of positive coefficients in this case: the effect a crisis has on a given product may increase the relative percentage (W_i) of the rest. In more specific terms, D2 primarily affected, apart from cucumber, those products with the highest production at the outset of the crisis, namely tomato and pepper. The strong mutual influence between different productions is again confirmed, above all for tomato and pepper; where scale flexibility has a value higher than 1. This type of situation favours the expansion of crisis effects. The compensated price flexibilities reveal a more than proportionate sensitivity to the demanded supply, except for tomato, which makes sense if we consider that this product is where Spain has less international presence. In general, the results of the estimations (Tables 3 and 5) show quantifiable effects, of the analysed crises, on the Spanish exports of vegetables. There is also a contagious effect of the crises, regardless of the product where it originated, to the rest of the vegetables.

(Insert Table 5 about here)

4. Discussion and conclusions

The literature review has reflected that there are few studies that analyse possible interactions between image crises and their economic impact upon demand, especially in the horticultural sector. The main sources of the image crisis are food safety, environmental and social crises, as well as their possible economic impact on exportation and demand. These crises can intensify consumer perceptions of risk, which in turn may lead to a negative image and a damage of the reputation of a country or sector. A negative image can detrimentally influence a country's ability to enhance its international projection, its economic interests and the opinion of foreign populations toward the country.

The Spanish horticultural sector is regularly enduring image crises. The sector's own mistakes of the past and its failure to address existing problems have had repercussions, mainly in the form of negative news in both the national and international media. However, precisely as this research has indicated, some of the crises in the past were the result of unfounded accusations. These incidents stem from prior negative misconceptions and, in some cases, disinformation among consumers regarding efforts made by the Spanish horticultural production and marketing sector to improve the quality and safety of its supply chain. It has thus been confirmed that the published information that reaches consumers has been largely negative.

Most crises in the sector can be classified as strategic, in the sense that they take place gradually, chronically and progressively. This type of crisis is easily detectable by generic indicators, such as the number of inspections and labour reports of illegal immigrants, the percentage of un-recycled waste, and reductions in aquifer levels. It is vital that the sector identifies these indicators and systemically monitors them. Once that has been accomplished, the sector must then transfer this information to the end consumer to counteract negative news in the media, which is often unfounded. When a real and obvious problem has arisen in the sector, addressing the issue has proven difficult. Creative solutions often require the redesign of production and marketing systems, which in turn require the implementation of long-term measures. Only with governmental involvement and approval can these changes be affected. Thus, the search for solutions at a company level is all too often an impracticable option.

On numerous occasions, the failure to respond to unfounded accusations was the result of a widespread belief that promotional campaigns aimed at the end consumer were useless. The sector had traditionally viewed large European distributors as their main end-customer, and that these organizations would be responsible for informing consumers about the efforts made by suppliers to ensure product quality and safety (Pérez-Mesa and Galdeano, 2015). This has been proven to be false. The scarce response that has come from the sector in recent years has been coordinated through grower associations. More specifically, the recent creation of the interprofessional[1] greenhouse growers association HortiEspaña in 2017 opens a world of possibility for collaboration for all organizations with a common interest in the supply chain, by financing information campaigns that change consumer perceptions.

The empirical analysis carried out using inverse demand models reveals a strong impact on demand (imports) in the short term. Sector crises, whether they are caused by negative news events or internal errors, and regardless of whether they are short, medium or long term, always have one or various 'explosion' points when they reach the public. These events lower demand among European consumers, ultimately causing a decrease in imports. The tested models revealed rather considerable losses that reduce annual exports by more than 3%. The analysis also reveals strong effects of complementarity and substitution among the various products of the horticultural supply. Consequently, these characteristics inadvertently assist the impact of crises in spreading rapidly to other products unrelated to the original problem.

In sum, there is an evident need to undertake actions, managed from the supply origin, that reach the consumer and effectively re-establish the prestige of the Spanish production system. Such initiatives would break the information asymmetry that exists between production and consumption areas. All information campaigns should emphasize the measures implemented to

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[1] In Spain, an interprofessional association (or interbranch) is an organisation recognised by law, comprised of representative organisations responsible for the production and, where appropriate, the agri-food marketing and distribution of the sector or products included in the agri-food system. To be recognised as such, it must have a minimum representation of 51% in each branch of the above activities. An interprofessional association has regulatory capacity, which can be extended to the entire sector.

improve both social and environmental sustainability, and, in the case of the latter, the new integrated pest management systems used in the sector should be highlighted. The consumer's perception of the poor social conditions in the production area is a difficult matter to solve, mainly because these conditions are caused by general problems that are often exogenous to the system itself.

Several limitations of the present study should be mentioned. Firstly, the crisis classification provided does not reflect the strategies and actions needed to address each of them individually. For this reason future research could be carried out to proactively analyse, and ultimately identify, the main indicators that allow these crises to be detected and determine which strategies should be implemented to anticipate or combat them. These indicators and actions should concentrate mainly on predictable crises, that is, those identified in our study as strategic and tactical. Secondly, the empirical analysis has a short-term influence, which is why it would be necessary to develop accumulated effect methodologies in the medium and long term. Finally, this study has ignored some movements that have emerged which affect the horticultural sector, such as anti-consumption and boycotts. Future research could address these issues from the point of view of the end consumer and determine what impact they have on the sector itself.

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Table 1. Application of the Augmented Dickey-Fuller Test to the series

	Level		1st difference			Level		1st difference	
	Without trend	With trend	Without trend	With trend		Without trend	With trend	Without trend	With trend
q_t	-2.483*	-6.054	-11.298	-11.290	$\overline{q_t}$	-8.976	-8.935	-7.403	-7.346
M_t	-2.047*	-5.307	-9.552	-9.599	$\overline{M_t}$	-6.583	-6.561	-9.630	9.581
q_{1t}	-6.300	-6.455	-11.664	-11.368	$\overline{q_{1t}}$	-9.031	-9.102	-11.209	-11.221
M_{1t}	-5.854	-8.120	-12.211	-12.328	$\overline{M_{1t}}$	-9.686	-9.588	-8.672	-8.501
q_{2t}	-1.027*	-6.655	-9.426	-9.424	$\overline{q_{2t}}$	-8.697	-8.644	-8.688	-8.651
M_{2t}	-2.153*	-7.015	-11.643	-11.599	$\overline{M_{2t}}$	-8.579	-8.611	-16.531	-16.439
q_{3t}	-1.564*	-3.521	-9.441	-9.528	$\overline{q_{3t}}$	-5.052	-5.110	-9.095	-9.103
M_{3t}	-2.841*	-5.124	-13.342	-13.406	$\overline{M_{3t}}$	-8.142	-8.230	-7.557	-7.600
q_{4t}	-1.241*	-6.900	-12.380	-12.362	$\overline{q_{4t}}$	-9.031	-9.099	-9.011	-9.023
M_{4t}	-1.265*	-6.786	-10.670	-10.628	$\overline{M_{4t}}$	-6.587	-6.591	-6.562	-6.631

(*) Non-stationary series (p<5%)

Table 2. Application of the Augmented Dickey-Fuller to the series IAIDS

	Level		1st difference	
	Without trend	With trend	Without trend	With trend
$log(Q_t)$	-4.543	-8.967	-8.541	-8.620
W_{1t}	-7.521	-9.954	-9.840	-9.809
W_{2t}	-6.543	-7.652	-8.012	-8.442
W_{3t}	-7.378	-7.512	-7.743	-7.772
W_{4t}	-8.511	-8.430	-7.943	-7.891
$log(q_{1_t})$	-7.322	-7.466	-9.319	-9.278
$log(q_{2_t})$	-3.699	-7.985	-9.191	-9.264
$log(q_{3_t})$	-4.862	-7.443	-8.960	-8.871
$log(q_4)$	-1.408*	-7.012	-9.013	-8.990

(*) Non-stationary series (p<5%)

Table 3. Results of the estimation

	Tomato $log(M_{1t})$		Pepper $log(M_{2t})$		Cucumber $log(M_{3t})$		Others $log(M_{4t})$		Total Vegetables $log(M_t)$	
Intercept	0.0014		-0.0029		0.0032		0.0000		0.0033	
D1	0.0748		-0.1043	**	0.0538		-0.0095		-0.0137	*
D2	-0.0246	**	-0.0256		-0.0147	*	-0.0158	*	-0.0170	*
D3	0.0676	*	0.0795	*	-0.0324		0.0237		0.0214	
D4	-0.0149	*	0.0369		-0.0581		-0.0219		-0.0284	
D5	-0.0317		0.0147		-0.2082	***	-0.0728		-0.0420	**
D6	-0.0167	**	-0.0155		-0.1124	*	-0.0248	*	-0.0234	
$log(\overline{q}_t)$									0.4346	***
$log(\overline{q_{1t}})$	0.3787	**	-0.0730		0.0640		-0.2913	**		
$log(\overline{q_{2t}})$	-0.0137		0.4289	***	-0.1258	*	0.1751	*		
$log(\overline{q_{3t}})$	0.1135	**	0.0995	*	0.8873	***	0.0163			
$log(\overline{q_{4t}})$	-0.0588		0.0620		-0.6340	***	0.3542	**		
R2 Adj.	0.573		0.424		0.669		0.305		0.453	
ADF(1)	-10.390		-10.102		-9.487		-9.520		-7.878	
ADF(2)	-10.401		-10.065		9.730		-9.519		-7.852	
F	12.619	***	7.210	***	28.204	***	4.340		8.413	***
D-W	1.744		1.707		1.574		1.592		1.426	

(***)=p<1%; (**)=p<5%; (*)=p<10%

ADF(1) without lags =test with intercept; ADF(2) without lags =test with intercept and trend

Table 4. Economic estimation of impact of crises analysed

Crisis	Duration months (a)	Year of crisis	% Deviation over monthly average (b)	Average monthly exports (Mill. €) (c)	Total impact (Mill. €) (a x b x c)	% total annual imports
D1	4	0.97	-3%*	208	-25.84	-1.04%
D2	8	0.96	-4%*	319	-97.97	-2.56%
D3	1	1.05	5%	319	16.11	0.42%
D4	1	0.94	-6%	434	-27.47	-0.53%
D5	4	0.90	-10%**	434	-173.60	-3.33%
D6	1	0.95	-5%	437	-22.92	-0.44%

(**)=p<5% and (*)=p<10%

Current prices according to values calculated for D_i (Table 3 "Total Vegetables")

Table 5. Results of estimation with inverse AIDS model

	Tomato (W_{1t})		Pepper (W_{2t})		Cucumber (W_{3t})		Others (W_{4t})	
Intercept	0.6964	***	-0.0878		0.0849		1.0029	-
D1	0.0166	***	-0.0128	**	0.0054		0.0074	-
D2	-0.0139	***	0.0122	***	-0.0071	*	-0.0088	-
D3	0.0043		0.0054		-0.0099		0.0002	-
D4	-0.0093	**	0.0046		-0.0027		0.0067	-
D5	-0.0196	***	0.0165	**	-0.0084		0.0115	-
D6	-0.0058		0.0058		0.0018		-0.0018	-
$log(Q_t)$	-0.0601	***	-0.0671	***	-0.0740		0.2012	-
$log(q_{1_t})$	0.0411	***	0.0328	***	0.0012		-0.0751	-
$log(q_{2_t})$	0.0328	***	-0.0052	***	-0.1111	*	0.0835	-
$log(q_{3_t})$	0.0012		-0.1111	*	0.0039	***	0.1060	-
$log(q_4)$	-0.0751	**	0.0835	***	0.1060	***	-0.1144	-
R2 Adj.	0.6126		0.5590		0.5979		-	
ADF(a)	-8.441		-9.156		-7.524		-	
ADF(b)	-8.412		-9.149		-7.521		-	
D-W	1.4189		1.5333		1.4584		-	
f_i	-1.286		-1.447		-0.260		-0.162	
f_{ii}	-0.864		-1.102		-1.035		-1.275	

(***)=p<1%; (**)=p<5%; (*)=p<10% (-)=Non-estimable

ADF(a) without lags =test with intercept; ADF(b) without lags =test with intercept an