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The Effects of 6 February 2023 Earthquakes on the Production and Marketing Process of Firms in the Agriculture and Food Sector: The Case of Malatya Province, Türkiye

Bahar Aydın Can [1,*], Serpil Gerdan [2] and Ramazan Aslan [3]

[1] Department of Crop and Animal Production, Izmit Vocational School of Higher Education, Kocaeli University, 41001 Kocaeli, Türkiye
[2] Department of Property Protection and Security, Izmit Vocational School of Higher Education, Kocaeli University, 41001 Kocaeli, Türkiye; sgerdan@kocaeli.edu.tr
[3] Department of Emergency Aid and Disaster Management, Faculty of Health Sciences, Ardahan University, 75000 Ardahan, Türkiye; ramazanaslan@ardahan.edu.tr
* Correspondence: baharcan@kocaeli.edu.tr

Abstract: Ensuring sustainability in the production and marketing of agricultural and food products after natural disasters is of critical importance to maintain beneficial nutrition for society. Examining the effects of earthquakes on the agricultural and food sectors is important in terms of drawing attention to the possible risks they may pose to societies that have not experienced large-scale earthquakes. This study examines firms in the agriculture and food sectors of Malatya province that were affected by the devastating earthquakes centered in Kahramanmaraş on 6 February 2023. This study aimed to determine the effects of earthquakes on firms in the agriculture and food sectors, the factors affecting firms' production and marketing processes, and the priority issues for them. Data obtained from 44 firms registered in the agricultural and food sectors of the Organized Industrial Zone of Malatya province were used. This study reports their general structure and frequency distributions by firm characteristics. In addition, statistical analysis methods, such as the chi-squared test, *t*-test, and factor analysis, were used for data evaluation. The results showed that 79.5% of firms export and make a significant contribution to Türkiye's agricultural and food product trade. The primary factors influencing firms, based on their size, included workforce availability, raw material supply, transportation logistics, and financial assistance. Firms' earthquake insurance, providing earthquake training for their employees, and constructing durable buildings were the most important factors in ensuring sustainability in production and marketing. These results further show that firms in the agriculture and food sectors in Malatya province were greatly affected economically by the earthquakes. Important lessons emerged as a result of these earthquakes experienced in Türkiye. The economic disruption following earthquakes may be overcome with less damage by constructing disaster-resistant buildings, instilling awareness of living with earthquakes in society, and creating safe production environments. This field study will guide sector stakeholders in building a resilient supply, production, and marketing network in preparation for future earthquakes.

Keywords: agriculture and food sectors; earthquakes; earthquake effects; 6 February 2023; Malatya

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1. Introduction

Earthquakes are natural phenomena caused by the sudden release of energy from the Earth's crust, which creates seismic waves [1]. These events can have profound and diverse impacts on the environment and human society, including agriculture, infrastructure, and the economy. Secondary impacts such as tsunamis, fires, landslides, and surface liquefaction significantly contribute to economic losses and fatalities associated with earthquakes. These impacts can sometimes be up to 40% of the total losses [2].

Soil losses and animal deaths after natural disasters negatively affect agricultural production. In addition, damage to companies in the sector that meet food needs negatively affects sustainability in production and marketing and recovery from the natural disaster. In this respect, ensuring sustainability in the agricultural and food sectors after earthquakes plays an important role in recovery. In addition, ensuring sustainability in the production and marketing of agricultural and food products after disasters is also important for the protection of natural resources and ensuring food safety.

Problems caused by earthquakes, such as food shortages and landslides, seriously affect daily life. Disasters disrupt the normal functioning of people, communities, and institutions, causing death, injury, economic damage, environmental destruction, fear, and panic [3]. People rely on the environment for food, shelter, energy, medicine, and income, especially during emergencies [4]. Earthquakes destroy buildings, bridges, railways, and infrastructure and cause major fires [5]. The effects of the earthquake, tsunami, and Fukushima nuclear accident in Japan in March 2011 were analyzed. It was shown that the country's agriculture and food sectors were significantly affected, including farms, agricultural resources, the food industry, and markets [6]. In a similar study in Japan, access to food for the elderly and disabled after earthquakes was examined. This study concluded that emergency food supplies need to be immediately revised for elderly individuals [7]. The Hsinchey earthquake also caused further economic impacts in Northern Taiwan in the manufacturing, food services and leisure, storage and retail trade, and public and construction sectors [8]. Research has shown that post-disaster fatalities are generally associated with access to food and clean water, shelter, emergency rescue, and emergency logistics [9].

Türkiye is a high-risk country in terms of earthquakes because of the many seismically active faults. Data from the Disaster and Emergency Management Presidency (AFAD) in 2023 reported that of the 5233 natural events in Türkiye requiring a response, 39% were caused by floods, 34% by forest fires, and 16% by earthquakes of magnitude 4 Mw and above. One of the most severe earthquake events in recent years was the couplet occurring on 6 February 2023, centered in Kahramanmaraş. On the same day, earthquakes measuring 7.8 Mw in Pazarcık district of Kahramanmaraş and 7.7 Mw in the Elbistan district caused major damage across 11 provinces, including Adana, Adıyaman, Diyarbakır, Gaziantep, Hatay, Kahramanmaraş, Kilis, Malatya, Osmaniye, Sanlıurfa, and Elazığ. These earthquakes were recorded as the second and third largest earthquakes in Türkiye [10,11]. This event caused extensive damage, resulting in extensive loss of life, large numbers of injuries, and significant challenges to disaster response and management [12–14]. According to official figures, more than 31,643 deaths, 80,278 injuries, and the collapse of 6444 buildings were reported in one week [15].

Disasters are so damaging to the functioning of daily life in cities that the damage can only be overcome through the efforts of victims [16]. Conducting field studies after an earthquake is similar to evaluating the results of a large experimental study conducted in an earthquake laboratory [17]. In the report of the Presidency's Strategy and Budget Directorate, a damage assessment was carried out covering the 11 provinces affected by the earthquake. The total cost of the earthquake to affect the Turkish economy was USD 103.6 billion. This represents approximately 9% of Türkiye's national income in 2023. The cost of the earthquake to the agricultural sector was USD 0.7 billion [18]. The region affected by the earthquake contributes a 9% share to Türkiye's exports. Thus, the impact of this event had a not insignificant negative impact on the country's economy [19].

Kahramanmaraş (359,329 hectares), Malatya (270,853 hectares), and Hatay (241,083 hectares) are the three provinces with the most agricultural area among the provinces most damaged by the 6 February 2023 earthquakes [20]. Since most of the firms in Hatay and Kahramanmaraş provinces could not be reached and the firms that were reached did not accept to participate in the survey, the survey was conducted in Malatya province. The total damage to the national economy of Malatya province, which was selected as the research area, was estimated to be approximately USD 1.5 million [21]. There was damage to the

functioning of the food system through direct damage to agricultural land and products, as well as other infrastructure that supports agricultural production [22]. The damage incurred in the agriculture and food sectors can have a ripple effect by affecting other sectors. For example, 75% of the 1% increase in job postings in the construction sector during the 2011 Great East Japan Earthquake occurred in the public sector, indicating that earthquakes had a significant impact on the labor market after the earthquake [5]. Earthquakes can cause significant damage to all aspects of the agricultural industry and pose challenges to restoration and recovery efforts. Even though there are usually no significant human losses in rural areas compared to cities during earthquakes, many farm families and even agricultural food business leaders suffer losses in terms of both human and physical and psychological disabilities [23]. Disasters can disrupt food industries, affecting production, processing, and distribution. Long-term impacts on the agricultural sector can include changes in agricultural output, income, and the overall farm economy [24,25].

After the 6 February 2023 earthquakes, some cultivated areas were destroyed by successive floods or converted into container sites, and some people engaged in agriculture died. This has affected the food industry and small businesses that produce and deliver natural products to all parts of the country [26]. Urban areas have a low level of resistance to the effects of large-scale disasters [27,28].

In a related study, Kircberger (2017) argued that in the impact of the Indonesian earthquake on the labor market, a shift occurred between sectors after the earthquake, with agricultural workers moving to the construction sector [29]. In a similar study, Mehrengen (2012) reported that labor supply decreased because of increased outmigration after the earthquake [30]. Earthquakes in low-income countries lead to higher wage increases in the agricultural sector as rice prices rise and labor supply shifts downward [29,31]. Dolu and İkizler (2020) reported similar findings from Türkiye. After the 2020 Elazığ earthquake, the labor market, which was based in agriculture, and unemployed workers in the region turned to the construction sector [32].

In a study examining the effects of the February earthquakes on agricultural production, it was reported that the earthquake zone, which was extensive, affecting 11 provinces, constituted 16.9% of the agricultural land in Türkiye and had a significant impact on agricultural production [33]. It is important to research how to address the problems that arise after an earthquake and create a systematic approach by analyzing the aftereffects and thus creating road maps for recovery [26].

After earthquakes, significant population decline in rural areas and the associated sustainable resource management are primary challenges [34]. Therefore, for developing countries, it is important to maintain sustainable development by identifying factors affecting sustainability in the agricultural and food sectors before and after earthquakes. In order for countries to overcome the time-consuming recovery process after disasters with less societal damage, there is a need to investigate these effects. Disaster preparedness also needs to be strengthened to ensure sustainable development. Therefore, comprehensive research conducted at the sectoral level in the post-disaster decision-making process will make a significant contribution to policymakers.

This study primarily contributes by providing insight into how earthquakes impact the agriculture and food sectors, supporting the creation of effective strategies to maintain continuity in agricultural production and food supply chains. Furthermore, analyzing these sectoral impacts aids in developing economic models to strengthen resilience against such crises.

When studies that may be related to the subject in Türkiye and the world are examined, there are studies on the effects of earthquakes on social media use [3,35–37], the labor market and employment [5,32,38], agriculture–food sector and food security [6,25,39–41], the regional economy [8,42], the supply chain in different sectors [43], farmers' poverty [31,44], the environment [4,45], and foreign trade [46–48]. The number of studies on the effects of earthquakes on the agriculture and food sectors is limited to the 6 February 2023 earth-

quakes [20,33,48–51]. However, no detailed study has examined the effects of the 6 February 2023 earthquakes on firms in the agriculture and food sectors.

This research is important in determining the effects of earthquakes on the post-earthquake effects of firms affected by earthquakes and in determining the measures and policies that can be taken in the agriculture and food sectors in the face of possible earthquakes.

The aim of this research was to investigate the impact of the 6 February 2023 earthquakes on firms operating in the agriculture and food sectors of Malatya Province, the factors affecting the production and marketing processes of firms affected by the earthquakes, and the priority issues facing firms thus affected. This study identified problems, and solutions are proposed to mitigate the negative effects of earthquakes in the agriculture and food sectors. Therefore, answers to the following research questions were sought.

1. Do earthquakes affect firms economically and physically?
2. Do time zones matter in the continuity of raw material supply-production-marketing chains of firms in earthquakes?
3. Are there any changes in the production capacity of firms by sector after the earthquakes?
4. Is there a relationship between the export status of firms and the impact of earthquakes on their supply chains?
5. What are the factors that affect companies the most after earthquakes, according to firm size?
6. What are the factors affecting the production and marketing processes of firms after earthquakes?

2. Materials and Methods

Malatya Province ranks second with 270,853 hectares in terms of the total agricultural area among the provinces affected by the 6 February 2023 earthquakes [18]. It also plays an important role in the marketing of agricultural products both domestically and internationally. To reach firms operating in the agriculture and food sectors, interviews were conducted with firms registered in Organized Industrial Zones. Malatya province was preferred because of the high number of firms in the agricultural and food sectors in the Organized Industrial Zone, the majority of firms that we could interview after the earthquake, and its large agricultural area.

The survey was conducted in May and June of 2024. Face-to-face interviews and a survey were conducted using the complete count method with a total of 44 firms that registered in the Malatya Organized Industrial Zone and which accepted to be interviewed.

This study was found ethically appropriate with the decision of the Kocaeli University Social and Human Research Ethics Committee dated 23 February 2024 and numbered 20189260-200-556496. During the survey studies, the aims of this study and how they can benefit from the results were explained to each firm. Informed consent was obtained from all participants involved in this study. Before collecting data, the questionnaires were piloted on a firm sample. The research questionnaire was performed with transparency and objectivity. The survey was conducted with firms inside their offices in the Organized Industrial Zone.

The survey consisted of 43 questions. The survey used in this research consists of 3 parts. In the first part, there were 13 questions about firms' general characteristics. In the second part, there were 11 questions to measure firms' attitudes and opinions about the effects of the earthquake on them. In the third part, there were 19 questions about the factors affecting the production and marketing processes of firms affected by the earthquakes.

SPSS, version 22.0, was used for statistical analysis (IBM Inc., Armork, NY, USA). The general structure of firms was investigated using frequency distributions. The questionnaire part of the research used a 5-point Likert scale to determine the perspectives and attitudes of firms (1 = strongly disagree and 5 = strongly agree).

In addition, the relationship between firms' general characteristics and opinions about the effects of the earthquake on the agriculture and food sectors was analyzed through

a chi-square test. Prior to the use of statistical tests, the data were analyzed after being subjected to the one-sample Kolmogorov-Smirnov test to see whether or not they exhibited a normal distribution. To analyze the factors affecting the agriculture-food sectors in the earthquake, an independent sample t-test was performed. In addition, factor analysis was conducted to examine the elements influencing firms' production and marketing processes during the earthquake. Factor analysis is a statistical method designed to evaluate complex datasets. While many statistical techniques focus on the relationship between independent and dependent variables, factor analysis takes a different approach. It explores patterns among multiple dependent variables and uncovers the underlying independent factors that shape them, even though these independent variables are not directly measured [52].

3. Results

3.1. General Characteristics of Firms

In terms of gender, 36 (81.8%) out of the 44 firm officials surveyed were male, and the reminder was female. Their average age was 41.70 years. Among the officials, the largest grouping were business owners (40.9%). The education level of the interviewed officials was 36.5% middle school and 29.5% high school graduates.

The distribution of firms' activities is shown in Table 1. The largest sector was dried fruit and vegetables, followed by cereals. In addition, among the firms examined, 13 firms had agricultural engineers and 30 had food engineers. The sector with the highest number of food engineers and agricultural engineers was the dried fruit and vegetable sector. A total of 77.3% of firms have a partnership structure at the limited liability firm level. In terms of years of business, 56.8% of firms had more than 20 years of experience. The average number of business years was 23.5 years. A total of 18.2% of firms employed less than 11 workers, 50% employed between 11 and 50 workers, and 31.8% employed more than 50 workers. Thus, most of the firms in the Organized Industrial Zone were small or medium-sized. Regarding foreign trade, 79.5% of firms export and 34.1% import. Details of the firms' general characteristics are provided in Table 1.

Table 1. General characteristics of firms.

	n	%		*n*	%
Field of activity					
Dried fruits and vegetables	12	27.3	Operation shape		
Fresh fruits and vegetables	6	13.6	Buying–selling	2	4.5
Cereals	9	20.5	Buying–processing–selling	7	15.9
Milk and dairy products	5	11.4	Buying–processing–packacing–selling	22	50.0
Egg producing	5	11.4	Producing–selling	5	11.4
Feed	3	6.8	Producing–processing–selling	3	6.8
Confectionery	4	9.1	Procuding–processing–packacing–selling	5	11.4
The type of business			Number of workers		
Production	11	25.0	<11 persons	8	18.2
Trade	7	15.9	11–50 persons	22	50.2
Production–Service	7	15.9	>50 persons	14	31.8
Production–Trade	19	43.1			
Legal structure			Number of administrative–technical personnel		
Private company	4	9.1	<6 persons	28	63.6
Limited company	34	77.3	6–10 persons	10	22.8
Incorporated company	6	13.6	>10 persons	6	13.6
Years of trading			Export situation		
<11 years	28	63.6	Yes	35	79.5
11–20 years	10	22.8	No	9	20.5
>20 years	6	13.6	Import situation		
			Yes	15	34.1
			No	29	65.9

3.2. The State of Firms' Affected by Earthquakes

The analyzed firms operate in six different sectors: dried fruits and vegetables (12 firms), fresh fruits and vegetables (6 firms), cereals (9 firms), milk and dairy products (5 firms), feed (3 firms), and confectionery (4 firms). The degree of firms physically affected by earthquakes is shown in Figure 1. Among the firms that were very affected, egg production (20.0%), fresh fruit and vegetable (16.7%), and dry fruit and vegetable (8.3%) sectors constituted the largest shares. The feed (66.7%) and dried fruit and vegetables (41.7%) sectors were identified as physically affected by the earthquakes. The most important export items in Malatya are dried apricots and agricultural products. When the 2023 export figures for agricultural products were evaluated, there was an overall decrease of 50.6% in Malatya province in February 2023—the month of the earthquake—compared with February of the previous year. [46]. There were delays in production and delivery due to the physical damage caused by the earthquake to firms exporting dried apricots, a major sector in Malatya. The finding that the dried fruit and vegetable sector suffered significant physical damage compared to other sectors supports the effect on the dried fruit sector leading to a decrease in exports.

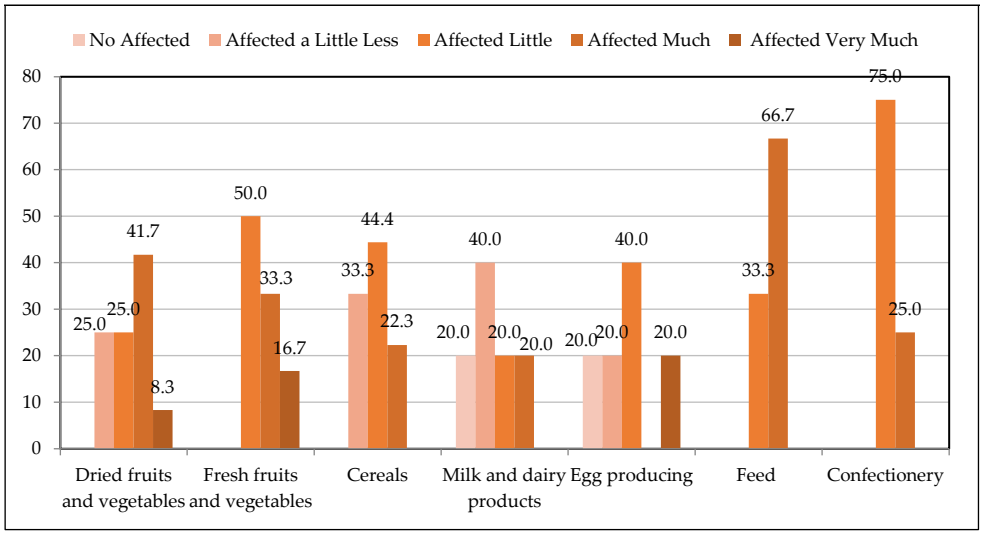


Figure 1. Extent of physical impact on firms by earthquakes (% responses).

As seen in Figure 2, firms were asked about the extent to which they were economically affected by the earthquakes. The confectionery sector (75%) has the highest rate among the firms that stated that they were affected economically by earthquakes. The feed (66.7%), cereals (66.7%), and dried fruits and vegetables (54.5%) sectors were the other sectors that were significantly economically affected. Studies on the effects of natural disasters on economies have shown that they have negative effects in most countries. Ates (2023) examined the impact of the Kahramanmaraş earthquakes on foreign trade. It was reported that the share of the 11 provinces affected by the earthquake in Türkiye's total exports was 9.14% in 2021, and this share decreased to 7.67% in 2023 [47]. One of the factors most affected was the supply of labor. The cost of labor, which is critical in the value chain, increased due to population migration. Temporary workers coming from outside the region either did not come or demanded very high wages due to the difficult living conditions [53]. Altun (2018) reported that 98% of industrial organizations in Türkiye are located in regions with high earthquake risk. It was also explained that the effects of earthquakes are not only physical but also economic in nature and negatively affect life [54]. This clearly results in a negative economic impact on firms in the region. Similarly, studies examining the economic impacts of the 2015 Nepal earthquake reported that the agricultural sector, which accounts for one-third of the country's GDP, suffered a total loss of USD 255 million [55], and Nepal's exports to China decreased by 26% [56].

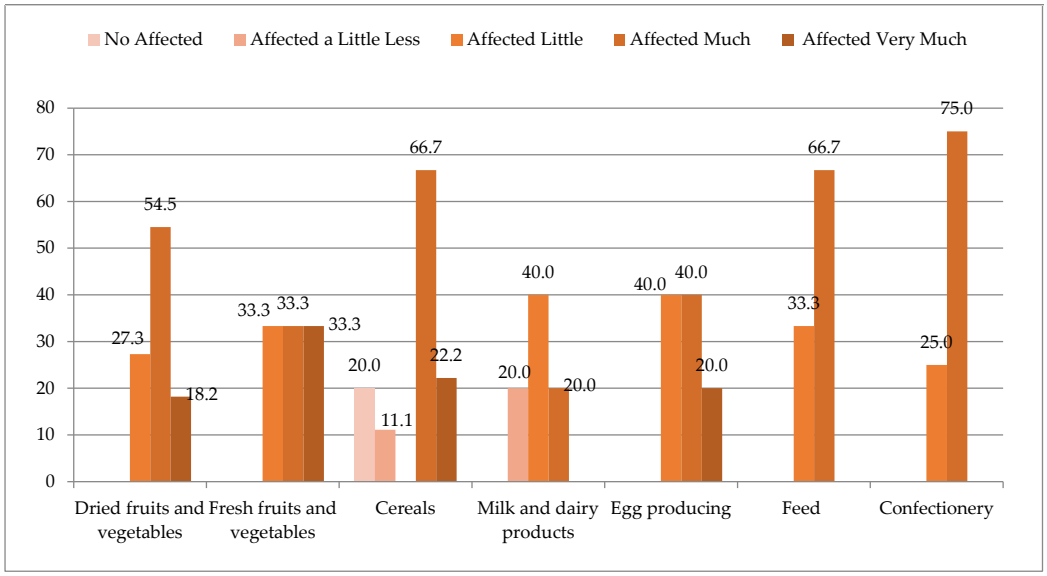


Figure 2. Extent of economic impact on firms by earthquakes (% responses).

Table 2 shows the importance of the different time periods for firms to maintain their continuity in the raw material–production–marketing chain after earthquakes. The average response to time slice "Seventh day after the Earthquake" was the highest, at 4.48, followed by "The first 24 h of an earthquake" (4.45) and "First month after the earthquake" (4.01), respectively. The average scores were close to 4 or above. The 7th day after the earthquake marked the period when the scale of the problem was fully realized. In a sense, it represents a transition from shock to awareness [53]. For this reason, most of the analyzed firms emphasized that the critical period ends after the seventh day. This is the period when firms seek the elements necessary to ensure the continuity of their activities after recovering from the initial shock of the earthquake, and the impact on firms was significant.

Table 2. Importance of time for continuity of the raw material–production–marketing chain during an earthquake.

Time Period of Earthquake		**Opinions ***						
		1	**2**	**3**	**4**	**5**	**Average**	**S.D**
The first 24 h	*n*	4	1	-	5	34		
	%	9.1	2.3	-	11.4	77.3	4.45	1.228
7th day	*n*	1	3	2	6	32	4.48	1.023
	%	2.3	6.8	4.5	13.6	72.7		
1st month	*n*	-	2	5	15	22	4.29	0.851
	%	-	4.5	11.4	34.1	50.0		
3rd month	*n*	1	1	7	21	14	4.04	0.888
	%	2.3	2.3	15.9	47.7	31.8		
6th month	*n*	1	2	10	17	14	3.91	1.052
	%	2.3	4.5	22.7	38.6	31.8		
1st year	*n*	1	2	12	14	15	3.90	1.007
	%	2.3	4.5	27.3	31.8	34.1		

Note: Five-point Likert scale where * 1 = strongly disagree and * 5 = strongly agree.

The findings regarding firms' changing opinions about production capacities after the earthquake by sector are shown in Table 3. Among those who believe that production capacity had decreased after the earthquake, the feed sector had the largest share, at 100%. The dried fruit and vegetable sector (75.0%) was the sector with the highest "unchanged"

rate. However, the relationship between firm sectors and changes in production capacities after the earthquake was not statistically significant ($p > 0.05$).

Table 3. Relationship between firms' sectors and post-earthquake production capacity status.

Sectors		Post-Earthquake Production Capacity						
		Increased	**Decreased**	**Unchanged**	**Total**	**χ2**	**sd**	***p* ***
Dried fruits and vegetables	*n*	-	3	9	12	16.194	12	0.182
	%	-	25.0	75.0	27.3			
Fresh fruits and vegetables	*n*	-	3	3	6			
	%	-	50.0	50.0	13.6			
Cereals	*n*	-	3	6	9			
	%	-	33.3	66.7	20.5			
Milk and dairy products	*n*	1	1	3	5			
	%	20.0	20.0	60.0	11.4			
Egg producing	*n*	-	3	2	5			
	%	-	60.0	40.0	11.4			
Feed	*n*	-	3	-	3			
	%	-	100.0	-	6.8			
Confectionery	*n*	1	2	1	4			
	%	25.0	50.0	25.0	9.1			
Total	*n*	2	18	24	44			
	%	4.5	40.9	54.5	100.0			

* statistically not significant at the 0.05 level.

Table 4 shows the relationship between firms' export status and their impact on the agriculture-food supply chain. As seen in Table 4, firms that export were more affected by the agriculture-food supply chain. The sector most affected by these disruptions is the dried fruit and vegetable sector, accounting for 91.7%.

Table 4. Relationship between firms' export status and impact on the agriculture–food supply chain.

Opinions		Export Status					
		Yes	**No**	**Total**	**χ2**	**sd**	***p* ***
Never	*n*	-	2	2	12.041	4	0.017
	%	-	22.2	4.5			
Very little	*n*	3	-	3			
	%	8.6	-	6.8			
Few	*n*	9	-	9			
	%	25.7	-	20.5			
Much	*n*	20	5	25			
	%	57.1	55.6	56.8			
Very much	*n*	3	2	5			
	%	8.6	22.2	11.4			

* statistically significant at the 0.05 level.

Of the analyzed firms, 63.6% had earthquake insurance, whereas 36.4% did not. The results of the chi-square test show that firms' earthquake insurance status and production cost increase were not significantly related ($p > 0.05$) (Table 5). In fact, 81.2% of firms with earthquake insurance and 87.6% of those without earthquake insurance stated that their production costs increased or partially increased after the earthquake. The devastation of the 6 February 2023 earthquakes was widespread and severe, leaving firms in a difficult

situation regarding raw material, transportation, logistics, and labor supply after the earthquake. Thus, regardless, earthquake insurance firms were economically affected. This suggests that this type of business insurance may require revision in order to be more effective in a country that is prone to large earthquakes, as Türkiye is.

Table 5. Relationship between firms' earthquake insurance status and increased production cost.

Earthquake Insurance		Increase in Production Costs After the Earthquake						
Status		**Increased**	**Partially Increased**	**Not Increased**	**Total**	**χ2**	**sd**	***p* ***
Yes	*n*	17	6	5	28			
	%	60.7	20.5	17.9	63.6			
No	*n*	11	3	2	16	0.329	2	0.851
	%	68.8	18.8	12.5	36.4			
Total	*n*	28	9	7	44			
	%	63.6	20.5	15.9	100.0			

* statistically not significant at the 0.05 level.

Table 6 shows the relationship between firms' earthquake insurance status and contractual production status. More than half (52.3%) of the analyzed firms were engaged in contracted production. The sectors with the highest levels of contracted production were milk and dairy products (10 firms) and cereals (7 firms). The relationship between firms' earthquake insurance status and contractual production status was significant ($p < 0.05$) (Table 6). Moreover, 71.4% of the firms engaged in contracted production had earthquake insurance. Firms stated that they have earthquake insurance to minimize the business damage from natural disasters that may occur during the contracted production period.

Table 6. Relationship between firms' earthquake insurance and contractual production status.

Earthquake Insurance		Contractual Production Status					
Status		**Yes**	**No**	**Total**	**χ2**	**sd**	***p* ***
Yes	*n*	20	8	28			
	%	71.4	28.6	63.6			
No	*n*	3	13	16	11.325	1	0.001
	%	18.8	81.3	36.4			
Total	*n*	23	21	44			
	%	52.3	47.7	100.0			

* statistically significant at the 0.01 level.

3.3. Opinions on Factors Affecting Firms During Earthquakes

Firm participants were also asked about the factors affecting the agricultural and food sectors after the earthquake in Türkiye. A *t*-test was performed for the number of workers in the firms, the results of which are given in Table 7. While evaluating the number of workers of the firms, they were divided into two groups: 30 workers and fewer (Group I) and 31 workers and more (Group II). The most influential factors in the agriculture and food sectors were the electricity supply for Group I and transportation and logistics for Group II. The results of the t-test regarding the factors affecting the agriculture and food sectors after the earthquakes revealed that the factors of raw material supply ($p < 0.01$), labor supply ($p < 0.01$), transportation and logistics ($p < 0.05$), financial support ($p < 0.05$), firms should not be located in the city center ($p < 0.01$), and misuse of agricultural land after the earthquake ($p < 0.05$) were significant. Ketboga (2023) stated that the earthquake caused problems in recruiting personnel for production enterprises in Malatya province and led to a doubling or tripling of wages [46]. Damage to transportation infrastructure

after an earthquake will likely disrupt the movement of goods and people, as well as cause heavy financial losses for the transportation sector. Direct infrastructure damage, loss of output and income, and increased reconstruction costs can further exacerbate economic losses [57].

Table 7. Analysis of factors affecting food and agriculture sectors during the February 6 earthquakes by firm size.

Factors	Number of Workers	N	Average	S.D.	*t*	*p* *
Raw material supply	≤30 workers	16	4.06	1.436	−3.127	0.003 *
	≥31 workers	28	4.93	0.262		
Labor supply	≤30 workers	16	4.44	1.031	−2.914	0.006 *
	≥31 workers	28	5.00	0.000		
Transportation and logistics	≤30 workers	16	4.50	1.033	−2331	0.025 **
	≥31 workers	28	4.96	0.189		
Financial support	≤30 workers	16	4.56	1.033	−2.266	0.029 **
	≥31 workers	28	5.00	0.000		
Electricity supply	≤30 workers	16	4.62	1.025	−1.418	0.164
	≥31 workers	28	4.93	0.378		
Clean water supply	≤30 workers	16	4.56	1.031	−1.795	0.080
	≥31 workers	28	4.93	0.262		
Effective role of institutions	≤30 workers	16	4.37	1.088	−1.551	0.128
	≥31 workers	28	4.75	0.518		
Create earthquake preparedness awareness	≤30 workers	16	4.50	1.265	−1.410	0.166
	≥31 workers	28	4.86	0.356		
Firms should not be located in the city center	≤30 workers	16	3.62	1.586	−3.217	0.002 *
	≥31 workers	28	4.68	0.548		
Misuse of agricultural land after an earthquake	≤30 workers	16	3.87	1.544	−2.052	0.046 **
	≥31 workers	28	4.61	0.832		

Note: Five-point Likert scale where 1 = strongly disagree and 5 = strongly agree. *, ** statistically significant at the levels of 0.01 and 0.05, respectively.

The surveyed firms were also asked about their thoughts on the agriculture–food sectors. Of all firms, 63.6% believe that earthquakes affected the agriculture and food sectors "a lot" and "very much". Firms were asked how much the earthquakes affected agricultural lands in the region, and 77.3% answered "not at all" or "very little". In addition, 75% of the firms answered "no" to the question, "Are there any farmers in the agricultural sector who stop producing?". Regarding the location of the Organized Industrial Zone, 88.6% of the firms stated that they believe that the zone was established in the right place.

Of the firms, 52.5% agreed with the statement, "I don't think earthquakes create awareness in the formation of agricultural policies". Firms that expressed this opinion stated that they had been economically affected by the earthquake. In addition, the high inflation rates that we have experienced in Türkiye in recent years have also contributed to this sentiment.

Factor analysis was employed to identify the factors influencing production and marketing processes following earthquakes. This analysis is a widely used multi-variate statistical analysis technique that transforms and simplifies complex interrelated variables by consolidating them into a few independent factors [58]. To assess the feasibility of conducting factor analysis, the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity were used. A KMO value above 0.5 indicates the dataset's suitability for factor analysis [50]. Here, the KMO value was 0.821, with Bartlett's test yielding a significance level of $p \leq 0.01$. The factor analysis identified three significant factors with eigenvalues above 1 (refer to Table 8). The eigenvalue represents the extent to which a factor explains the

variance across variables, with higher values indicating more explanatory power. Factors with lower eigenvalues were considered less impactful and were thus excluded [59].

Table 8. Factor analysis results.

Statements	Factor	Eigenvalue	Variance	Cumulative Variance
Firms must have insurance against earthquakes.	1	7.432	49.547	49.547
Firm employees should receive earthquake training to move in the correct direction during an earthquake.	2	2.986	19.905	69.453
Building earthquake-resistant buildings is effective in overcoming earthquakes with less damage.	3	1.596	10.642	80.095
Alternative roads for road transportation during earthquakes should be included in city and regional planning.	4	0.680	4.532	84.627
Power outages during earthquakes significantly affect the firm's continuity in production.	5	0.493	3.284	87.911
Damage to raw materials stored in the warehouse during an earthquake disrupts production.	6	0.435	2.902	90.813
The loss of life of employees or their relatives in an earthquake causes disruptions to the workflow.	7	0.324	2.159	92.972
Damage to tools and equipment during an earthquake negatively affects production flow.	8	0.242	1.615	94.587
Damage to highways during an earthquake prevented the marketing of the products.	9	0.209	1.394	95.981
Earthquakes negatively affect exports in the marketing of products.	10	0.180	1.197	97.178
The problems experienced with diesel and fuel oil supply during the earthquake negatively affected transportation.	11	0.156	1.038	98.216
The government provides sufficient support to firms during earthquakes.	12	0.120	0.799	99.015
Banks provide convenience to firms in paying their debts.	13	0.098	0.650	99.665
Delays in debris removal after an earthquake negatively affect the continuity of firms' activities.	14	0.031	0.208	99.873
After the earthquake, support for feed, fertilizer, seed, etc. was provided to agricultural production firms in a timely and sufficient manner.	15	0.019	0.127	100.00
Kaiser-Meyer-Olkin measure of sampling adequacy			0.821	
Bartlett's test of sphericity		chi-square	666.115	
		df	105	
		p	0.000	

Factors 1, 2, and 3 explained 49.55%, 19.90%, and 10.64% of the variance, respectively, and thus accounted for 80.09% of the total variance. According to the rotation results of the factor analysis, Factor 1 ("earthquake preparedness") included firms' opinions about earthquake insurance, earthquake education, construction of durable buildings, and alternative highways. Factor 2 ("sustainability in production and marketing") covered firms' opinions on building, equipment, road damage, loss of life, power outages, fuel supply, and export issues. Factor 3 ("supports") covered firms' opinions on government support, ease of dept payments by banks, debris removal process, and support for agricultural enterprises' production (see Table 9). The reliability level was considered sufficient because the Cronbach's alpha coefficient was greater than 0.70 in all scales except for a small difference in the risk-taking attitude scale [60].

Table 9. Rotation results of the factor analysis.

Statements	Earthquake Preparedness	Sustainability in Production and Marketing	Supports
	(Factor 1)	(Factor 2)	(Factor 3)
Firms must have insurance against earthquakes.	0.920		
Firm employees should receive earthquake training to move in the correct direction during an earthquake.	0.916		
Building earthquake-resistant buildings is effective in overcoming earthquakes with less damage.	0.906		
Alternative roads for road transportation during earthquakes should be included in city and regional planning.	0.733		
Power outages during earthquakes significantly affect the firm's continuity in production.		0.619	
Damage to raw materials stored in warehouses during earthquakes disrupts production.		0.823	
The loss of life of employees or their relatives during an earthquake causes disruptions to the workflow.		0.845	
Damage to tools and equipment during earthquakes negatively affects production flows.		0.873	
Damage to highways during an earthquake prevented the marketing of the products.		0.875	
Earthquakes negatively affect exports in the marketing of products.		0.825	
Problems experienced in diesel and fuel oil supply during the earthquake negatively affected transportation.		0.885	
The government provides sufficient support to firms during earthquakes.			0.886
Banks provide convenience to firms in paying their debt.			0.883
Delays in debris removal after an earthquake negatively affect the continuity of firms' activities.			0.716
After the earthquake, support for feed, fertilizer, seed, etc. was provided to agricultural production firms in a timely and sufficient manner.			0.874
Eigenvalue	7432	49,547	49,547
Variance	2986	19,905	69,453
Cumulative variance	1596	10,642	80,095
Croncbach's alphas	0.944	0.949	0.886

4. Discussion

In the region where the earthquakes occurred, centered on Kahramanmaraş, the predominant production activities were in the service, industry, and agriculture sectors. The earthquakes had a significant impact on all these key sectors, including the agricultural sector, which supplies Türkiye with agricultural raw materials and food products and generates significant export income. Determining the effects of the earthquake on firms operating in the agricultural and food sectors is important for ensuring agricultural sustainability, national food security, and much-needed export revenue.

In this study, the impact of the devastating earthquakes of 6 February 2023, on firms in the agriculture and food sectors and factors affecting production and marketing processes were examined. The majority of the firms participating in the survey operated in the dried fruits and vegetables or cereals sectors. Nearly 70% of the firms are small or medium-sized. 79.5% of the analyzed firms export and make a significant contribution to the country's agricultural and food product trade. Due to the damage to Iskenderun Port during the earthquakes and the fire that broke out, full containers and many products were

damaged or had to be kept waiting, causing spoilage of agricultural and food products [46]. This resulted in economic losses, especially for exporting and importing firms. In studies examining the effects of these earthquakes on foreign trade, transport infrastructure damage caused disruptions to both export and import trade [48,61]. Miya Kawa et al. examined the impact of the earthquakes in Hansnin-Awaji (Kolze) in 1995 on exporting firms [62]. After the earthquake, firms exporting goods by sea were financially affected by the earthquake because they exported more goods. In a similar study, El Hadri et al. examined the impact of natural disasters and found that countries that export agricultural products have greater negative impacts [63].

The results showed that most participating firms operating in the agriculture and food sectors were economically affected. The chaos and lack of infrastructure after the earthquakes made it difficult to store and transport agricultural and food products, damaging the distribution channels of agricultural and food products. It also made it harder for consumers to access food products and caused prices to rise. Farmers and business owners in the agricultural and food sectors, as well as ready-made feed production facilities, reported experiencing economic difficulties due to declining incomes. There were serious losses in goods and services for businesses selling agricultural pesticides, fertilizers, seeds, and agricultural equipment in the earthquake region. In another study examining the effects of earthquakes, it was reported that in the food sector, some flour, pasta, oil, and feed factories in the earthquake zone had buildings and machinery damaged by the earthquake and were out of production [22].

Many companies in the present study were physically affected by the earthquakes. The firms most affected were from the egg production, fresh fruit and vegetable, and dried fruit and vegetable sectors. Akdemir and Ok (2023) stated in their study that the biggest disruption to agricultural activities was in the supply of pesticides and fertilizers due to destruction of the city-center storage warehouses during the February 6th earthquakes. They found that disruptions in feed transportation caused a 20% loss in productivity [33].

According to firms, several post-event time periods were critical for the continuity of the raw material supply-production-marketing chain. In particular, the first week after the earthquake was the most important period reported by the participants, because by the end of the first week, the extent of the problem was felt the most. Oğuz and Gülçubuk (2023) found that the agriculture and food value chain, except for animal husbandry, almost collapsed in this time period after the February 6th earthquakes [53].

The sector reporting the greatest decrease in production capacity was the feed sector. This may have been due to the damage to feed warehouses in the regions affected by the earthquakes.

Exporting firms were more affected by earthquakes in the supply chain. Puzzello and Raschky (2014) also examined how natural disasters affect foreign trade through the global value chain. These authors suggested that natural disasters cause supply problems and therefore foreign trade decreases. [64]. The 6 February 2023 earthquakes also caused logistics problems, particularly through damaged or closed roads, which caused delays in logistics activities, causing the supply chain to deteriorate [46].

According to the size of the firms examined, the factors most affected in the agriculture and food sectors were labor force, raw material supply, transportation logistics, and financial support. Firms reported labor supply difficulties due to population migration away from the affected areas. For this reason, labor supply after earthquakes is an important factor in ensuring agricultural and food sector firms' production continuity. Ates (2023) reported losses of trained personnel engaged in agricultural production [47]. In a study examining the effects of the earthquake felt in Elazığ and Malatya in 2020, it was reported that the region's labor market was based on agriculture, and the construction sector was an option for those who became unemployed after the earthquake, and the number of people changing jobs increased [32]. Kirchberger (2017), in his study investigating the short-term impact of the 2006 earthquake in Indonesia, stated that there was an increase in wages for agricultural workers [29]. The high wage demand resulting from labor migration

after earthquakes reduced firms' profits [5]. The results of previous studies are similar to the results of the present research and highlight the importance of labor supply for food production and food security after an earthquake.

The most influential factors affecting the production and marketing process after earthquakes of the firms were "earthquake preparedness" (earthquake insurance, earthquake education, construction of durable buildings, alternative highways, etc.) and "sustainability in production and marketing" (building, equipment, and road damage, loss of life, power outages, fuel supply, export issues, etc.). Findings regarding the factors affecting the production and marketing processes of firms reflect the opinions of "company officials". Most of the firms examined had earthquake insurance, and having earthquake insurance helped to mitigate their losses. Thus, it was determined that firms attach importance to earthquake insurance and disaster training. In his study, Yorukbulut (2023) stated that earthquake insurance in Kırıkkale raised awareness about having earthquake insurance after the February 6th earthquakes [65]. The results of the present study demonstrate that being prepared for an earthquake is important for sustainability in production and marketing during the post-earthquake period in the agriculture and food sectors. Another study highlighted that improving disaster preparedness training and planning was critical for understanding the impact of previous experience on disaster preparedness [66]. Disaster preparedness knowledge can be acquired through education [67]. Our findings are generally in line with those of other similar studies.

There is another important issue observed as a result of the face-to-face surveys conducted with the firms in this research. Although more than a year had passed since the earthquakes, most interviewees were unhappy, unmotivated, and hopeless. The physical and economic losses caused by THE 2023 earthquakes on firms, the loss of life and property experienced by those in their immediate surroundings, and the images they were exposed to during the removal of demolitions and debris during the recovery process in the city have had a negative impact on people. A few other studies have also found this. Studies have shown that there are long-term effects on the well-being and mental health of victims and evacuees 12–24 months after the disaster and that they may experience symptoms of burnout [68,69].

Our results show that the agriculture and food sectors are likely to be severely affected by earthquakes and other natural disasters. Earthquakes are inevitable in Türkiye due to the very active seismicity in the country. Therefore, to ensure continuity in the agricultural production and marketing process, firm owners and employees' awareness of earthquake preparedness and recovery can make a significant contribution. In this context, raising awareness about earthquakes among firms and citizens and providing timely and adequate post-earthquake support will ensure that the negative effects that may occur on sectors after an earthquake are overcome with less negative impact.

The fact that firms operating in the agricultural and food sectors in other provinces affected by the earthquake did not want to participate in the survey limited the scope of the research. Further research, to be conducted after the firms in the other provinces affected by the earthquakes have completed their recovery process, may increase the relevance of findings of the present study.

5. Conclusions

Disasters have far-reaching economic consequences when disrupting supply chains, transportation, and other vital services. In particular, after earthquakes of great magnitude, economic processes that require long-term recovery may be interrupted.

The results of the present study showed that the February 2023 earthquakes greatly affected firms in the agricultural and food sectors economically. Among the factors affecting the production and marketing processes of the companies after the earthquakes, the most important factors are being prepared for earthquakes, sustainability in production and marketing, and external support. Therefore, planning emergency preparation before the inevitable earthquake will help to minimize the impact. Official institutions and organiza-

tions should make training about pre-disaster preparations mandatory for companies and conduct inspections to ensure compliance. Creating disaster preparation plans for other possible disasters will help to coordinate the process.

The two major earthquakes on 6 February 2023, caused significant destruction in Malatya province, as in the other ten affected provinces, and the city's commercial activities almost came to a standstill. In earthquakes, transportation, energy, communication, agricultural production, and city infrastructure were damaged, and the destruction of industrial facilities and commercial units negatively affected production and supply chains. The region makes a significant contribution to the Turkish economy in the agricultural and food sectors. Following the earthquakes, significant disruption to agricultural and food production was observed.

The Ministry of Agriculture and Forestry provided support to reduce the economic damage experienced after the earthquakes. For livestock farmers in the provinces affected by the earthquakes, the same number of animals were given free of charge to replace animals that perished. Farmers were provided with fuel and fertilizer support, and the application period for projects to be carried out for rural economic investments was extended. The support provided to farmers provided short-term relief. However, long-term support is needed for producers to recover physically and economically in the region.

Since the ability of those working in the agricultural sector to continue production individually after a natural disaster decreases, "Contract Farming" practices, especially in animal husbandry, should be encouraged.

Special incentives and tax exemptions should be provided for medium- and large-scale investments in agriculture and food sectors in the 11 disaster-prone provinces.

The solutions that firms expected the most from the research were postponement of public bank debts for producers and firms; increased support for firms that supply products to the agricultural and food sectors; a ban on using agricultural lands for other purposes after the earthquake; protection of water and soil resources; and reviewing the durability of structures such as buildings, barns, warehouses, and silos.

Preparing for natural disasters before they occur will help reduce the damage imposed. In addition, to prevent workforce loss after natural disasters, it is important to transform affected areas into livable areas within a very short period. Therefore, a pre-established coordination plan after earthquakes would contribute to continuity of production and marketing processes in these sectors.

This research suggests that the effects of the February 2023 earthquakes on agriculture and food sectors had a significant impact on society and the country's economy. This situation heightened awareness among policymakers about ensuring sustainability in production and marketing for the food security of society after earthquakes. Thus, one aim should be to create disaster-resistant structures by learning permanent lessons from earthquakes, instilling awareness of living with earthquakes in society, creating a safe living and production environment, eliminating deficiencies in infrastructure and superstructure, improving deficiencies in agricultural and food systems as soon as possible, and transforming the regions where earthquakes have occurred and will occur again into safe and sustainable areas. It is hoped that the findings of the present study may form the basis for new research topics to expand our understanding of potential earthquake risks and their impacts on other sectors.

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