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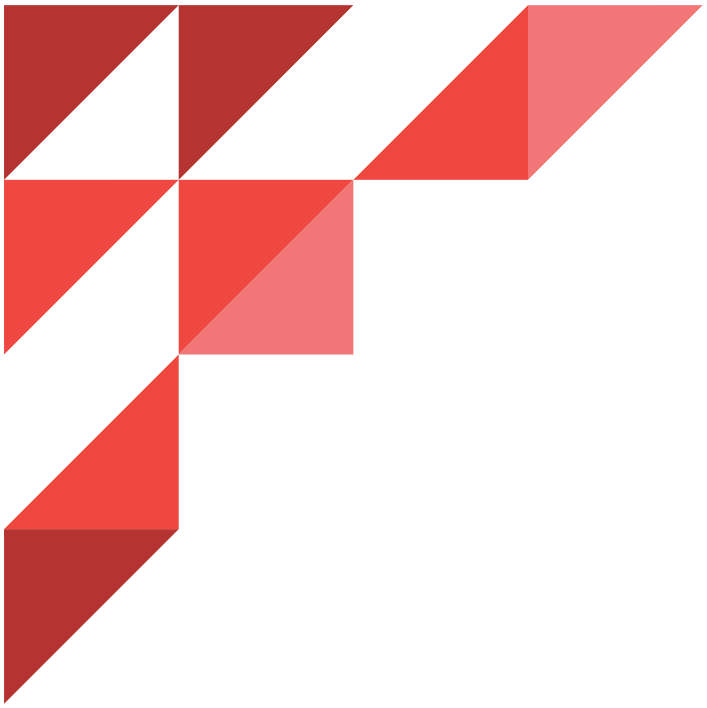
Supply Chain Resilience After the February 6 Earthquakes Report



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BUSINESS FOR GOALS

Supply Chain Resilience After the February 6 Earthquakes Report

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Executive Summary

The Report on the "Supply Chain Resilience After the February 6 Earthquakes" examines the effects of earthquakes on the supply chain and post-earthquake conditions. It highlights key findings and recommends strategies to increase supply chain resilience for economic recovery.

Businesses not only suffer physical damage in earthquakes, but also have to contend with ongoing infrastructure challenges and high reconstruction costs in the wake of the earthquake.

The report emphasizes the importance of providing reliable housing, personnel, access to finance, coordination and resolving existing structural problems, which play a key role in increasing the resilience of the supply chain. The main focuses for strengthening the post-disaster supply chain and promoting economic recovery are:

- Solving housing problems reliably,
- Eliminating labor shortage,
- Diversifying and facilitating sources of access to finance,
- Ensuring stakeholder coordination,
- Elimination of structural problems,
- Planning for the supply chain.

These priorities stand out as key components to strengthen supply chain resilience.
During the post-disaster recovery process, many companies based their competitive strategies on the product quality and prices of their primary competitors. Instead of developing innovative products, they reduced prices and took their competitors' products as a reference instead of the standard product quality in their own industry.

Although supply chain stakeholders maintain a strong level of trust, inadequate communication has revealed a lack of rapid, efficient and transparent exchange of information in emergencies and risky conditions.

The earthquake caused an increase in the supply chain costs of businesses, reduced existing supply sources and extended travel times. While price increases are a common response from businesses, the adoption of alternative methods such as creating new demand or different transportation methods is unfortunately rare. The report emphasizes that restructuring costs are very high and points out that most businesses will not be able to get rid of these costs in the long term because they do not have certificates that comply with international quality standards.

The report provides indispensable guidance and a comprehensive roadmap to identify key strategies and steps to improve supply chain management in post-disaster conditions. It includes quick recommendations for infrastructure, housing, coordination, financial support, risk planning, cost management and resolving infrastructure issues.

Introduction

This report includes research findings on the supply chain resilience and economic recovery processes of businesses after the Kahramanmaraş Earthquakes that took place on February 6, 2023. Based on the assumption that supply chain resilience plays a critical role in ensuring economic recovery for businesses in the aftermath of the disaster, the report includes the challenges, strategies and recommendations faced by businesses affected by the earthquake. The report is based on document analysis, survey work and one-on-one interviews. Post-disaster supply chain resilience and economic recovery processes of businesses are analyzed through a survey conducted with 105 businesses, in-depth interviews with 20 senior managers and a focus group study. While the report emphasizes the importance of forward-looking proactive measures and collaborations, it will make a significant contribution to the preparation of businesses and their stakeholders in the supply chain network for future disasters. By implementing these recommendations, stakeholders can strengthen supply chains and contribute to the long-term resilience and sustainable economic growth of the disaster-affected region.

Post-disaster conditions often result in damage to infrastructure, disruption of transportation networks, and obstruction of the movement of goods. To alleviate this challenge, organizations need to invest in creating resilient infrastructure and alternative routes. First of all, one of the most important challenges encountered in post-disaster conditions is the inadequacy of critical infrastructures such as transportation networks, production facilities and distribution centers. In such cases, supply chain resilience is vital to overcome infrastructure disruptions.

Reference: SBB Post-Earthquake Evaluation Report, 2023.

Supply chain resilience for the economic recovery in the aftermath of the disaster is critical to minimizing the impact of disasters and facilitating recovery and revival processes. The report describes key elements, risk management strategies, technological advances, collaboration mechanisms and best practices for stronger post-disaster supply chain management and economic recovery. Understanding and applying the findings from this report can significantly improve our ability to overcome challenges resulting from disasters, protect livelihoods, and promote sustainable economic development in the affected areas.

With the application of advanced logistics strategies and innovative technologies, emphasis can be placed on combining existing resources with temporary ones to bridge gaps, renew infrastructure, and distribute resources efficiently across affected areas. Additionally, effective collaboration between all supply chain stakeholders is crucial for resilience in post-disaster conditions. Close coordination between suppliers, manufacturers, distributors and rescue organizations helps expedite response and recovery efforts. Building strong relationships through information sharing, joint planning and resource pooling can result in a coordinated, efficient supply chain response.

The human aspect of supply chain resilience in post-disaster conditions must also be considered. This includes providing immediate and adequate support to the affected communities, prioritizing the delivery of essential goods, and ensuring ethical practices throughout the supply chain. Addressing social, environmental and economic concerns in disaster recovery operations helps create sustainable supply chains that are resilient to future disruptions. This report develops a collective understanding of supply chain resilience that encompasses its multidimensional nature. Examining dimensions such as supply chain robustness, resilience, agility and adaptability of businesses will create opportunities for post-disaster economic recovery.

Technical and Economic Resilience

Resilience is examined in four different dimensions (Bruneau et al. 2003): technical, economic, organizational and social.

- Technical resilience relates to the ability of physical assets to survive disaster.
- Economic resilience is called the capacity to eliminate economic damages and losses caused by disasters.
- Organizational resilience describes the resilience of businesses and other institutions to respond to disasters and maintain their existence.
- Social resilience, on the other hand, refers to the effort to reduce the negative social consequences of disasters.

These dimensions are interconnected, for example, technical and organizational dimensions are associated with the resilience of infrastructures such as search and rescue, energy, water and sanitation, while social and economic dimensions can be associated with the resilience of society as a whole (Bruneau et al.). 2003).

Since this report is based on research on supply chain and economic recovery, it focuses on the technical (supply chain) and economic (recovery) dimensions of resilience.

Technical resilience relates to physical mechanisms such as logistics, transportation, and physical damage within the supply chain network measured by factors such as damaged roads, transportation to demand points, and logistics infrastructure.

Within the scope of economic resilience, the elements considered are substitution of inputs, price mechanisms, market mechanisms for reallocation of scarce resources, etc. In measuring resilience in terms of supply chain (technical) and economic recovery (economic), material and physical loss or damage, loss of output or employment levels were considered.

Therefore, the intertwining of both supply chain (technical) and economic recovery (economic) processes may further complicate resilience factors at business, sector and national economy-based levels. For example, while the behavior of business owners can be complicated by public policy decisions, the process becomes even more difficult to manage when the different behaviors of supply chain stakeholders are added. Physical damage causes business interruptions; It causes disruption and losses in the supply chain. These losses are experienced until the economic recovery is ensured.

To simplify the analysis of this process, this report considers the concept of resilience as measures necessary to prevent business interruptions due to physical damage and losses in the aftermath of the disaster (Kajitani and Tatano, 2009). In this report, the conditions of resilience in a serious crisis are discussed. Factors such as stocks, capacity, input substitution, existing contracts and market dynamics cannot be calculated at the time of crisis, because security, shelter, nutrition and psycho-social conditions come to the fore at such times. This report examines resilience in crisis conditions. It mentions the resilience under conditions not even taken into account in pre-disaster scenarios. Examples of these conditions include: inadequate housing and nutrition conditions, complete reshaping of production processes, the regulatory protocols between customers who have lost their suppliers and suppliers who have lost their customers.

Under these emergency conditions, standard distinctions in the literature may be deemed to have disappeared; For example, there is no distinction between customer side and supply side during the data collection process of this report. Both sides' question sets are intertwined; for example, disruptions in the supply of inputs (amount and timing), fixed capital stock being affected by power outages, supply disruption, system redundancy, etc. For example, businesses may import raw materials other than infrastructural, physical and structural elements due to business interruptions. However, this input substitution may increase costs. Factories cannot be easily relocated, but they can be relocated if the equipment is not damaged.

The report also takes into account the key role of the public in supply chain resilience and economic recovery. However, it is envisaged that public influence through cash or in-kind aid can increase resilience and recovery. However, the deterrent effects of public aid on resilience have not been taken into account.

Supply Chain Resilience and the Impact of Disasters

Supply chains operate within complex networks of interconnected organizations. In disasters, supply chains are a process that includes both economic and humanitarian aid operations. The resilience of this chain reflects a business's capacity to respond to, recover from disaster and revive.

In the disaster response process, the humanitarian aid supply chain comes into play first. However, the economic supply chain becomes effective in order to ensure economic recovery in post-disaster periods.

The humanitarian aid supply chain ensures that aid is delivered to the right places quickly and completely in case of disaster. Humanitarian aid supply chains that emerge during disaster response processes are complex processes involving many factors such as search and rescue, shelter and nutrition.

An economic supply chain ensures the efficient movement of products and services. It makes a critical contribution to the uninterrupted operations of businesses and the continuity of global economies.

However, natural or man-made disasters can seriously impact supply chain resilience. For example, the February 6 earthquakes had a high-risk and low-probability impact, breaking the resilience of both humanitarian aid and economic supply chains.

This report provides recommendations by analyzing the situation for economic recovery and strengthening the supply chain after earthquakes.

The Importance of the Provinces Affected by the Earthquake in the National Economy

The table below shows employment data in the earthquake-affected provinces by 2021. Some summary information that can be extracted from the table may be:

- Approximately 13.3% of the total employment in Türkiye is located in the earthquake-affected regions.
- In total, it is the province with the highest employment in the region (712 thousand people).
- Adana, Gaziantep and Hatay have a significant share in total employment.
- While the province with the highest share of provincial employment in the total is Gaziantep (2.5%), the province with the lowest share is Kilis (0.1%).

Table 1: Activities with the Highest Share in the Private Sector in Employment in the Earthquake-affected Regions (2021)

Province	Total Employment	Registered Employment	Share of the Province in the Disaster Area (%)	Share of the Provincial Employment in the Total Number (%)
Adana	690	425	18	2,4
Adıyaman	122	81	3,2	0,4
Diyarbakır	446	248	11,6	1,5
Gaziantep	712	471	18,5	2,5
Hatay	477	296	12,4	1,7
Kahramanmaraş	338	210	8,8	1,2
Kilis	38	25	1	0,1
Malatya	257	149	6,7	0,9
Osmaniye	142	88	3,7	0,5
Şanlıurfa	407	227	10,6	1,4
Bölge Toplamı	3.841	2.344	100	13,3
Türkiye	28.797	20.441	-	100

Reference: SBB Calculations Based on TURKSTAT Household Labor Force Survey.

When looking at the product and sector distribution in the region, Gaziantep manufacturing, agriculture, food, textile and steel sectors come to the fore.

Table 2: Activities Share of provinces in total country exports by product or sector (2022)

Province	Product or Sector	Percentage Share
Gaziantep	Carpet	60,6
Gaziantep	Cereals, Pulses, Oil Seeds and Products	31,7
Gaziantep	Fruit and Vegetable Products	17,4
Gaziantep	Textile and Raw Materials	16,8
Hatay	Fresh Fruits and Vegetables	15,6

Province	Product or Sector	Percentage Share
Malatya	Dried Fruit and Products	15,5
Gaziantep	Leather and leather products	9,9
Gaziantep	Dried Fruit and Products	9,5
Hatay	Steel	9,1
Kahramanmaraş	Textile and Raw Materials	8,5
Gaziantep	Furniture, Paper and Forest Products	7,2
Gaziantep	Air-conditioning Industry	6
Adana	Textile and Raw Materials	5,9
Adana	Aquaculture and Animal Products	5,1
Adana	Fresh Fruits and Vegetables	4,9
Gaziantep	Chemical Substances and Products	4,7
Adana	Cereals, Pulses, Oil Seeds and Products	3,8
Adana	Chemical Substances and Products	2,6
Gaziantep	Machinery and Parts	2,3
Hatay	Mining Products	2,1
Adana	Automotive Industry	2

Reference: TİM, 2022.

According to the data of the Ministry of Environment, Urbanization and Climate Change, a total of 1,929,313 buildings are damaged throughout the region. The reason for expressing this data collectively is that earthquake victims found the determination of low, medium and high damage categories unclear. Earthquake victims stated that this categorization used to determine the degree of damage led to subjective interpretations and expressed the problems experienced in determining the damage status of buildings after the earthquake.

Organized Industrial Zones (OIZ) have a critical role in terms of supply chain resilience. In particular, the earthquake effects of the OIZs in the region and the examination of the activity areas in these regions reveal that the supply chain has suffered serious damage. These damages refer to disruptions and negative impacts on the functioning of the supply chain. If the damages in the first week of the earthquake are as in the table below, it is obvious that the damage afterward is much deeper.

Rapid damage assessment studies were carried out on a sector basis in the acute period after the earthquake. For example, in the agricultural sector, it has been reported that animal farms, product warehouses, TIGEM (General Directorate of Agricultural Enterprises) facilities, fishing shelters, food control laboratories, sugar factories, flood control facilities, irrigation facilities, water boreholes, DSI facilities, GDF (General Directorate of Forestry) facilities were damaged. Looking at this sector-specific example, it is clear that supply chain elements are interconnected and damage at any point affects other points.

Table 3: Damages Detected in OIZs in the First Week of the Earthquake

Region Name	Activity Status	Extent of Destruction in the Nearest District or Center (Satellite)	The Extent of Destruction in OIZs	Number of Companies by Sectors
Adıyaman Besni OIZ	Partially in Service - Organizational structuring is ongoing	Moderate destruction	Probably Minor Damage	9 Wholesale Trade, 7 Textile, 3 Retail Trade, 3 Food, 2 Chemistry, 2 Agriculture and Animal, 1 Electricity and Gas, 1 Metal, 1 Food and Beverage, 1 Rubber and Plastic and 1 Education
Adıyaman Gölbaşı OIZ	In service	Severe Destruction	Possibly Medium Damage	5 Metal, 4 Wholesale Trade, 2 Textile, 2 Food, 1 Furniture, 1 Agriculture and Animal
Adıyaman Kahta OIZ	In service	Severe Destruction	Probably Minor Damage	34 Textile, 14 Food, 4 Wood, 2 Nonmetal, 1 Machinery and Equipment and 1 Furniture
Adıyaman OIZ	In service	Severe Destruction	Probably Minor Damage	56 Textile, 53 Food, 17 Furniture, 15 Metal, 15 Rubber and Plastic, 5 Electronics, 5 Metal, 4 Paper, 3 Chemistry, 2 Wood, 2 Machinery and Equipment, 2 Agriculture and Animal, 1 Recycling, 1 Wholesale Trade, 1 Mining support activities, 1 Transportation Vehicles and 1 construction
Gaziantep Islahiye OIZ	In service	Severe Destruction	Possibly Severe Damage	6 Food and 2 Textile
K.maraş Elbistan OIZ	In service	Severe Destruction	Possibly Medium Damage	8 Construction, 4 Wood, 3 Metal, 3 Textile, 3 Wholesale Trade, 3 Retail Trade, 2 Food, 2 Rubber and Plastic, 1 Exterior, 1 Office Management, 1 Machinery and Equipment, 1 Metal and 1 Furniture
K.maraş Erkenez OIZ	Partially in Service - Organizational structuring is ongoing	Severe Destruction	Possibly Severe Damage	Partially In Service (many factories nearby)
K.maraş Türkoğlu OIZ	In service	Severe Destruction	Possibly Severe Damage	12 Textile, 4 Metal, 3 Food, 2 Wholesale Trade, 2 Machinery and Equipment, 1 Electricity and Gas, 1 Furniture, 1 Education and 1 Chemistry
K.maraş Türkoğlu-2 OIZ	Partially in Service - Organizational structuring is ongoing	Severe Destruction	Possibly Medium Damage	Partially In Service (many factories nearby)
Malatya II. OIZ	In service	Severe Destruction	Probably Minor Damage	48 Wholesale Trade, 37 Textile, 16 Metal, 14 Food, 13 Rubber and Plastic, 13 Retail Trade, 7 Machinery and Equipment, 5 Metal, 4 Petroleum, 4 Transportation Vehicles, 3 Leather, 3 Paper, 3 Construction, 2 Recycling, 2 Management, 1 Health, 1 Architecture and engineering, 1 Exterior structures, 1 Furniture, 1 Chemistry, 1 Financial services, 1 Agricultural and Animal, 1 Education, 1 Other professional activities, 1 Electronics and 1 Computer programming

Reference: TÜRKONFED Durum Raporu. (2023).

Effect of Earthquakes on Supply Chain

The February 6 earthquakes caused extraordinary conditions in the supply chain. Significant effects on the supply and demand sides will be felt even more in the medium and long term. Earthquakes caused population mobility and migration throughout the country. An increase was observed in rental and housing prices. The break in the region's supply chain in sectors such as agriculture, textile and iron and steel has caused upward pressure on prices (SBB Post-Earthquake Assessment Report, 2023, p. 122). Disruption of price stability is a key indicator of a fragile supply chain and delays post-disaster economic recovery.

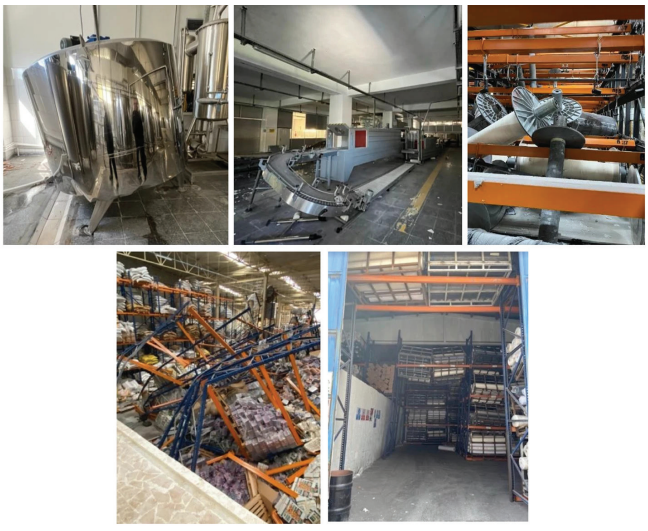
When company scales and damage status are examined:

- The total number of large-scale companies destroyed or severely damaged is 894,575.
- The total number of small-scale firms destroyed or severely damaged is 618,596.
- The total number of micro-sized companies destroyed or severely damaged is 687,026.
- The total number of medium-sized companies destroyed or severely damaged is 596,920.

Table 4: Number of Damaged Buildings

Company Sizes/ Damage Status	Destroyed	Severely Damaged	Medium Damaged	Slightly Damaged
Large	33,375	861,200	531,593	4,324,883
Small	157,672	460,924	334,015	1,950,626
Micro	251,904	435,122	320,049	1,496,309
Medium	93,800	503,120	407,940	3,594,387

Reference: SBB, 2023



Reference: Sagbas et al, 2023.

While the cost of the destruction caused by the February 2023 earthquakes in physical assets resulted in a decrease in the capital stock, it created serious costs, including emergency expenses, cash aid, infrastructure damage and debris removal expenses.

Added by the insurance sector losses, tradesmen's income losses and macroeconomic effects, the total damage, cost and loss caused by the earthquake is calculated as 103.6 billion dollars, constituting 9% of the total GNP. Out of which, 11.8 billion dollars represents the private sector damage estimate and 12.9 billion dollars is the public sector damage estimat, and the damage estimate is 56.9 billion dollars for houses that will be urgently demolished, are ruined, heavy and moderately damaged.

According to the data of public institutions and organizations, a significant part of the damage consists of public service buildings and the equipment in these buildings. In addition, infrastructure assets are also included in this damage. A significant portion of the damage to privately owned basic infrastructure and distribution facilities consists of damage to electricity distribution facilities and fiber/copper networks. Demolitions in sheepfolds and barns is also a significant damage item. The private sector damage item includes damage to the manufacturing industry, energy, communications, tourism, health, education sectors, small tradesmen and places of worship.

Field Study: Method

Method

This study used multiple data collection methods to understand and analyze the situation of businesses affected by the earthquake. The key components of the study are:

Survey Study

- Field work covers between 2 June and 29 July. It includes a survey conducted with 105 different businesses. The surveys are designed to collect comprehensive information about the post-earthquake situation of businesses, their level of exposure, and the recovery processes. Quantitative data analysis was carried out by percentage weighting of raw data.
- While some indicators cover all businesses participating in the survey (105), some indicators are reduced to only businesses that participated in the survey and were directly affected by the earthquake (67). For this distinction, the expressions **"Businesses participated in the survey" and "Businesses damaged by the earthquake"** were used.

In-depth Interviews

- Additionally, as part of the study, in-depth interviews were conducted with 20 senior managers. These interviews focused on the internal dynamics, decision processes and strategic reactions of businesses.

Focus Group Work

- Another element of the study is a focus group study. This group work is based on sharing knowledge and experience with business owners and managers during the earthquake response and post-earthquake process.

The data obtained through these methods were used to analyze the situation of businesses affected by the earthquake, evaluate their exposure and understand the recovery processes.

Field Study: Results

According to the survey data, the sectoral distribution of the companies participating in the survey is as follows: The rate of businesses operating in the service sector was determined as 34%, in the packaging sector 2%, in the retail sector 20%, in the health sector 5%, in the technology sector 1% and in the production/manufacturing sector 37%. These data clearly show the distribution of participating businesses across various sectors. 67 (61%) of the 105 businesses that participated in the survey were physically affected by the earthquake. The survey results clearly show the effects of earthquakes on the supply chain processes of businesses and especially highlight the negative effects of serious damage to infrastructure on the supply chain.

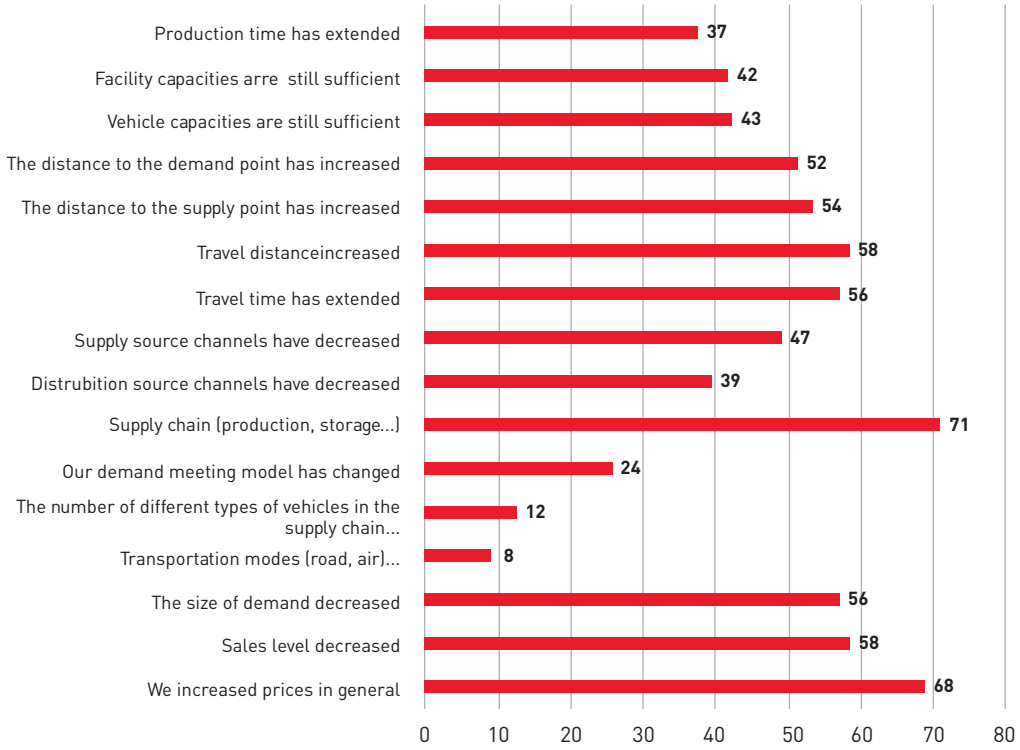
62% of the businesses participating in the survey physically felt the effects of the earthquake

- 67 businesses that stated that they suffered physical damage from the earthquake expressed the reconstruction cost as 8 billion TL, on the basis of the period in which the survey took place. 89% of these businesses damaged by the earthquake had machinery/equipment damage, while the damage rate was 100% in 34%; In 20% of cases, 75-90% damage to machinery/equipment was stated.
- Due to the impact of the earthquake, 63% of businesses experienced basic infrastructure problems such as water, electricity and gas. Additionally, the severity of damage to the infrastructure of 50% of these businesses varies between 90% and 100%.

» This situation reveals the effects of the earthquake on the supply chain, as well as its serious damage to the activities and operational processes of businesses. Particularly serious damage to infrastructure problems has greatly affected production capacity and caused businesses to have difficulty in maintaining their ordinary operations. This situation has revealed that businesses need support in crisis management, emergency planning and infrastructure security.

The answers given to the questions asked to understand the effects of earthquakes on the supply chain in the businesses participating in the survey are as follows:

Figure 1: Supply Chain Fragility Indicators (%, Businesses participated in the survey n=105)



According to the survey results, only 43% of the participants stated that their current vehicle capacity is sufficient. This rate was determined as 21% in businesses physically affected by the earthquake.

» This data shows that the majority of businesses experienced a decrease in vehicle capacity following the disaster. This situation reveals that the transportation capacity in the supply chain is insufficient to meet the needs under current conditions. This capacity decrease, especially in logistics processes, shows that disruptions in transportation processes, one of the basic elements of the supply chain, are increasing.

» This situation shows that disruptions in processes such as material supply, storage, distribution and delivery to the customer negatively affect the operational efficiency of businesses and emphasizes the general break in the supply chain. In this context, it is clearly seen that businesses need support to strengthen their logistics operations and increase their transportation capacity.

According to the survey results, 37% of the businesses participated in the survey stated that they experienced an increase in production times. This rate reached 46% in businesses physically affected by the earthquake.

» The increase in production time is an important indicator that indicates disruptions in the supply chain and delays in the production process. This situation shows that disruptions in material supply, logistics, production planning or operational processes within the supply chain affect the production process of the business and prevent the normal flow of the process.

» This situation, which shows that disruptions or deficiencies in supply networks negatively affect the production line or cycle of the business, emphasizes that disruptions at any point in the supply chain may prevent the production of the final product on time and at the desired quality. In this context, increases in production time indicate that the critical points in supply chain management should be improved and that businesses are not resistant to the crisis situations.

The prolongation of production time is an indication that the break in the supply chain delays the production time.

» The rate of those who stated that the production time was extended in businesses that were physically damaged in the earthquake was determined as 46%. This shows that the increase in the production times of businesses damaged after the earthquake is more evident. On the other hand, this means that the general impact of the earthquake on production activities was felt at different levels in the production processes of businesses and that the damaged businesses take more restoration and improvement efforts.

According to the survey results, it was determined that the facility capacities of 42% of the businesses participating in the survey were still sufficient. Unfortunately, this rate is only 19% in businesses physically affected by the earthquake.

» This situation generally shows that the majority of businesses have insufficient facility capacities and are having difficulty meeting demand in the current situation. This inadequacy in facility capacities can be considered as a result of restrictions in supply chain processes such as production, storage or distribution and the inability of businesses to meet current demand.

» The ability of businesses to meet production demand is weak, and this negatively affects their operational effectiveness and the satisfaction of supply chain stakeholders. In this context, it indicates that businesses need support to expand their facility capacity, optimize production processes or make supply chain management more efficient.

Survey results showed that 52% of the businesses participated in the survey were physically affected by the earthquake, while 61% experienced an increase in distance to demand points after the disaster.

» The small difference between these two groups indicates that the supply chain is affected regionally and multiple times. This situation indicates that businesses have difficulties in their logistics processes.

» The increase in distance has negatively affected the efficiency of transportation, storage and distribution processes in the supply chain, causing them to spend more operational resources and time. This shows that businesses are trying to maintain their relationships with demand centers by allocating more time and more resources.

According to survey data, the rate of businesses stating that there was an increase in the distance to supply points was recorded as 54%. This rate was 66% in companies physically affected by the earthquake.

» The increase in this distance due to the impact of the disaster more clearly reveals the difficulties faced by businesses in supply chain management. This increase has a direct impact on the structuring of supply networks, material supply and logistics processes, negatively affecting businesses' access to supply sources and efficiency. Therefore, it appears that the increase in distance in the supply chain seriously affects the operational processes of businesses.

According to the survey data, the rate of businesses stating that there was an increase in travel distance was 58%, while, similarly, the rate of businesses affected by the earthquake was 66%.

» Conditions arising from the impact of the disaster have led to increased travel distances in logistics operations. This increase indicates a significant increase in the distance traveled in the procurement, storage, distribution and delivery processes of materials, products or services.

» This situation caused businesses to reconsider their logistics planning and transportation strategies and increased their operational costs.

According to the survey results, the rate of businesses stating that there was an increase in travel time was recorded as 56%.

» The increase in time spent in transportation processes due to the impact of the disaster has negatively affected the operational efficiency of businesses. This increase in time indicates that transportation processes within the supply chain take longer, and this may cause businesses to spend more resources, revise their operational plans, and cause delays in delivery processes.

» In this context, it is important for businesses to review their transportation strategies and develop new operational approaches to increase their efficiency.

According to survey data, the rate of businesses stating that there is a decrease in supply source channels is recorded as 47%.

» Survey results show that the restrictions imposed by the disaster create significant obstacles for businesses to access supply sources. These restrictions have negatively affected the material supply processes in the supply chain, causing difficulties in accessing certain resources and causing businesses to seek alternative supply channels. Businesses may need to diversify their supply networks under these conditions.

» In this process, businesses may need support (financing, training, technical, infrastructure, manpower, etc.) to make their supply chain processes more resilient and adaptable.

According to survey data, the rate of businesses stating that there is a decrease in distribution source channels is 39%; The rate of businesses affected by the earthquake was recorded as 52%.

» Restrictions in this distribution network due to the effects of the disaster caused businesses to experience serious difficulties in delivering their products to their target points.

» These restrictions reduced the efficiency of distribution networks, causing delays in delivery processes and negatively affecting the capacity of businesses to meet customer expectations. This situation highlights the need for businesses to review their distribution strategies, work on alternative transportation methods and make their logistics networks more flexible and durable.

According to the survey results, the rate of businesses stating that supply chain costs (production, storage, distribution, transportation and demand management) has increased was recorded as 71%.

» It is emphasized that in the aftermath of the disaster, costs increase, especially in production, storage, distribution, transportation and demand management processes. These cost increases are directly related to operational and logistical difficulties experienced at various stages within the supply chain.

» For example, factors such as restrictions in material supply processes, increase in demand for storage areas, and increase in transportation and distribution costs raise the general costs of businesses. This situation reveals the need of businesses for support to develop cost-oriented strategies, increase operational efficiency and manage supply chain processes more effectively.

According to survey data, the rate of businesses stating that the size of demand has decreased is 56%; The rate of businesses affected by the earthquake was 75%.

» This situation shows that there is a significant change in demand management processes within the supply chain. The decrease in demand is generally caused by factors such as decreases in demand in post-disaster market conditions, consumers becoming victims of earthquake, whether directly or indirectly, and the general economic uncertainties. This situation has disrupted the inventory management, production planning and logistics operations of businesses.

» In particular, this decrease in demand requires more precise demand forecasting and flexibility in supply chain processes and highlights the need for financing for businesses' capacity to adapt to these new dynamics.

According to survey data, the rate of businesses stating that their sales level has decreased is 58%; The rate of businesses affected by the earthquake was 70%.

» This shows that sales and marketing operations within the supply chain were seriously affected by the disaster. With regard to this decrease in sales, the general suggestion is to create substitute markets in order to maintain the competitiveness of post-disaster businesses and to maintain their presence in the market, and to carry out this process by a platform consisting of public and private sector representatives and making transparent decisions.

» This platform, which includes public institutions, organizations and businesses, whether affected and unaffected by the disaster, may provide substitute support to those affected by the disaster.

78% of the businesses participated in the survey do not have an internationally recognized quality certificate.

» In these conditions where restructuring costs are so high, lack of standardization in production poses additional risks.

57 of 105 businesses experienced sales losses, and a total sales loss of 1,516,258,250 TL was reported.

» While there was an increase in the number of employees in 58 of 105 businesses, there was no change in 42; There was a decrease in 5 of them. Considering that the survey was conducted between June 2 and July 29, it can be concluded that this cost stated between these dates is even higher today.

There is no promising picture in the measures taken to increase the resilience of the supply chain.

» When asked about changing demand response modes, which is a strategy to strengthen the supply chain, it was stated that only 24% of businesses made changes. This situation reveals that alternative demand meeting methods are not adopted by the majority.

» In other words, only a small portion of businesses have taken steps to implement different demand meeting models that will strengthen the supply chain. This situation shows that businesses do not know that they need to make changes in their current processes and that they are not aware of the transition to alternative methods.

Changing transportation modes is another strategy for strengthening the supply chain, but this strategy was implemented by only 8% of the businesses participated in the survey.

» The vast majority of businesses did not take steps to change transportation modes in their supply chains or did not adopt this strategy. This situation shows that businesses are dependent on existing transportation methods or face obstacles in transitioning to alternative methods. It reveals the need to support businesses in adopting and implementing strategies such as changing transportation modes to increase the robustness of the supply chain.

Unfortunately, the only prominent factor to deal with supply chain fragility has been price increases. Among the businesses participated in the survey, the rate of businesses stating that they increased the prices is 68%.

» This situation shows that businesses make changes in their pricing strategies to eliminate the fragility in the supply chain or increase prices in order to balance demand and supply. The high-rate price increase strategy of the businesses can often be considered a reflection of efforts to offset or minimize the effects of supply chain fragility.

However, according to the survey results, in general, the rate of the businesses that increase prices is higher than the businesses physically affected by the earthquake.

» This situation also raises the ethical concerns of businesses. Among businesses affected by the earthquake, this rate was 58%, which is 10 points lower than the rate of 68% of general businesses. While this situation shows that businesses that suffered physical damage in the earthquake are limited in making commercial decisions because they have difficulties in conducting operations, it also emphasizes the necessity of making such decisions within the framework of ethical and social values in disaster situations.

This table shows the fragility in the supply chain in detail by comparing different fragility indicators and their proportions between overall participant businesses and the businesses physically affected by the earthquake. When the indicator differences are filtered between +10 and –10, the indicators showing that the supply chain is collectively affected after the earthquakes are colored. Accordingly, the following is valid for all businesses whether physically affected or not affected by the earthquake:

» Prices have increased,
» Costs have increased,
» Travel time has extended,
» Travel distance has increased,
» Production time has extended.
» The number of different types of vehicles in the supply chain has increased,
» Transportation modes have changed,
» The demand meeting model has changed,
» Supply source channels have decreased,
» The distance to the demand point has increased,

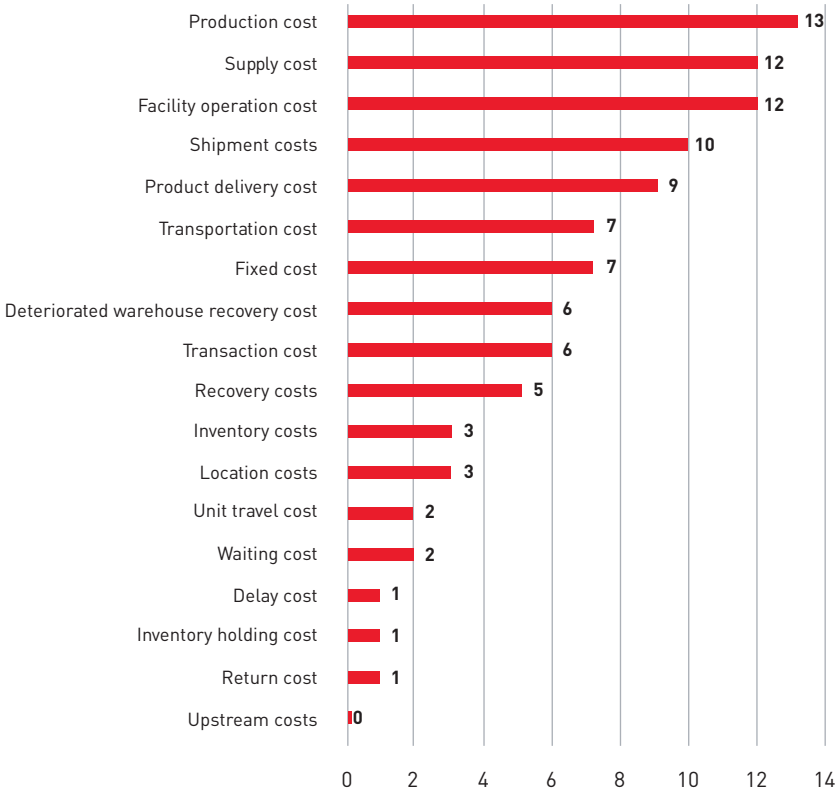
The fragility indicators mentioned in the table can form a basis for strategic planning and improvement steps for supply chain management.

Table 5: Difference Between Those Who Suffered Physical Damage from the Earthquake and Those Who Didn't (%)

Supply Chain Fragility Indicators	Difference
Facility capacities are still sufficient.	-23
Vehicle capacities are still sufficient.	-22
We increased prices in general.	-9
The number of different types of vehicles (such as trucks, vans and helicopters) in the supply chain has increased.	-2
Supply chain (production, storage, distribution, transportation and demand management) costs have increased.	-1
Transportation modes (road, air) have changed.	0
Our demand meeting model has changed.	3
Travel time has extended.	5
Supply source channels have decreased.	7
Travel distance increased.	8
The distance to the demand point has increased.	9
Production time has extended.	9
The distance to the supply point has increased.	11
Sales level decreased.	12
Distribution source channels have decreased.	13
The size of demand decreased.	18

The table below lists the various costs associated with different elements of the supply chain or logistics. The costs that have increased the most are as follows: Production costs at 13%; supply costs at 12%; operating costs, again at 12%; transportation costs at 10%; delivery costs at 9%; transportation costs at 7%; Fixed costs at 7%; Deteriorated warehouse recovery cost at 6%; transaction costs at 6%; Recovery costs at 5%. This analysis supports the view that the damage is based on the loss of production machinery, equipment, buildings and people. This data determines the costs of various elements in the supply chain directly related to the damages experienced. Production costs showed the highest increase associated with damage to machines, equipment or buildings in production, which are one of the basic elements of supply chain processes. Likewise, supply costs and operating costs have increased significantly, affecting the functioning of the supply chain and causing costs to increase. This analysis reveals in detail the cost increases that occur in case of damage to different elements in the supply chain and the effects of this situation on supply chain management and operations.

Figure 2: Supply chain costs that increased the most after earthquakes (%)



Among the 105 companies that participated in the survey, 54% of these companies used their own resources in the post-earthquake recovery process. While 24% preferred bank loans, only 21% benefited from public support or incentives. That is, the majority of companies participated in the survey preferred to use their own capital during the recovery process. This situation shows that businesses focus on the recovery process by using their own resources or financial power, prefer bank loans less and use public supports less.

Figure 3: Resources in the post-earthquake recovery process

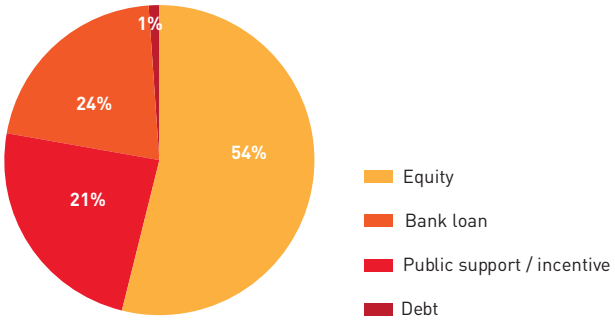


Table 6: The businesses participated in the survey reported manpower needs for the following occupational groups.

Construction Sector	Food Industry	Service Industry	Technical and Manufacturing Sector	Design and Technology Sector
Concrete worker	Baklava master	Waiter	Packaging machine operator	Designer
Mason	Baker master	Courier	Blacksmith	Technical personnel
Construction worker	Kitchen personnel	Grocery store worker	Warehouse personnel	Warehouse personnel
Civil engineer	Rolling pin Master	Advertiser	Computer-literate support staff	Computer-literate support staff
Building contractor	Water seller	Sales staff	Electrician	
Construction foreman		Driver	Engine repair master	Engine repair master
Patern maker			Automobile electrical journeyman and apprentice	Automobile electrical journeyman and apprentice
Welder			Technical personnel	Technical personnel
Machine technician			Plumber	Plumber
Machine operator			Foreman	
Installation master				
Construction team				

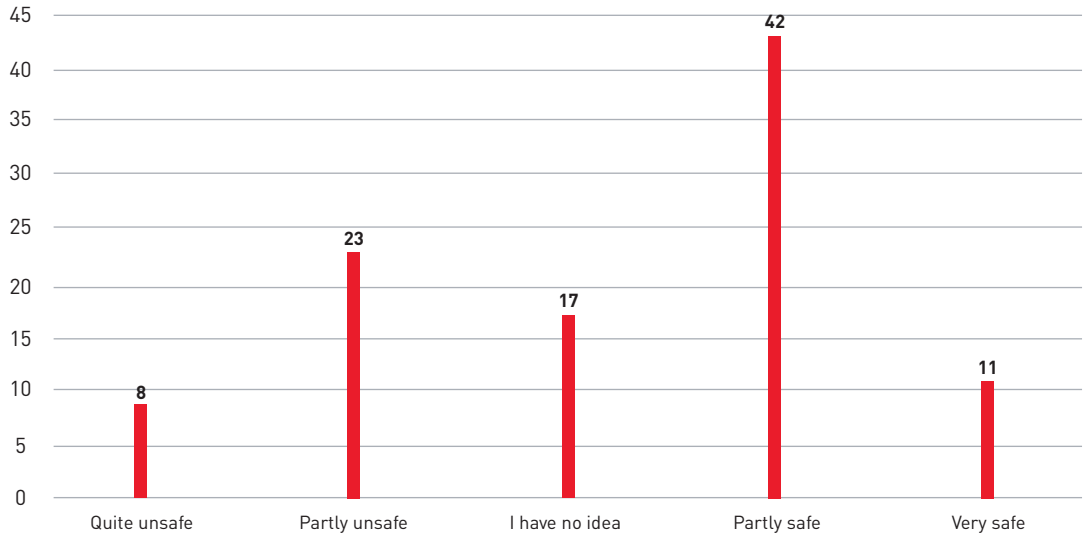
Table 7: The equipment and material needs of the businesses participated in the survey are stated as follows.

Construction and Building Materials	Food and Store Arrangement	Electricity and Installation	Repair and Hand Tools	Furniture and Home Decoration
Tool bag	Binding stand	PC	Screwdriver set	Chair
Workbench	Nuts showcase	Additional monitor	Blades	Armchair
Jack	Jar	Shelf	Board holder	Table
Pipe	Shelf	Lamp	Tweezers	Cabinet
Concrete	Table	Pipe	Opening-closing apparatus	Showcase
Cement	Chair	Cable	Repair pad	Decoration
Iron	Cabinet		Aligner	Aligner
Mold	Pastry supplies		Bonding Agent	Bonding Agent
Lighting	Kitchenware		Tape	
Cash desk	Sellable product stocks		Bistoury	
	Sellable glassware products			
	Jars			

Table 8: The businesses participated in the survey stated that they needed the following machines

Construction and Building Materials	Food and Restaurant Businesses	Photography and Printing Industry	Industry and Production	
Concrete mixing and pouring vehicle	Furnace	Cameras	Production machines	Cleaning and Hygiene:
Crane	Dough kneading machine	Cameras	Filling machine	Cleaning machines
Truck	Mixer	Computer	Packaging machine	Chemicals
Water reservoir	Refrigerated cabinets	Printer	Label machine	Dentistry and Health:
Depot	Doner kebab machine	Printing machine	Generator	Dentistry machines and equipment
Grader	Coffee machine	Lenses	Electrical and plumbing machines	Infrared
Bulldozer	Refrigerator	Laminating machine	Vacuum machine	Stretcher
Forklift	Cash desk	Bookbinder	Power source	
	Coffee grinder		Technical and Repair:	
	Printing machines		Welding machine	
	Cutting machine		Sawmill	
	Mincing machine		Ribbon machines	
	Balance		Screwing machines	
	Grinder		Jack	
	Heated tank		Lift	
			Nut gun	
			Accumulator test machine	
			Air machine	
			Compressor machine	
			Soldering machine	
			Electrical and plumbing machines	

Figure 4: How would you define your relationship of trust with your supply chain during post-disaster recovery? (%)

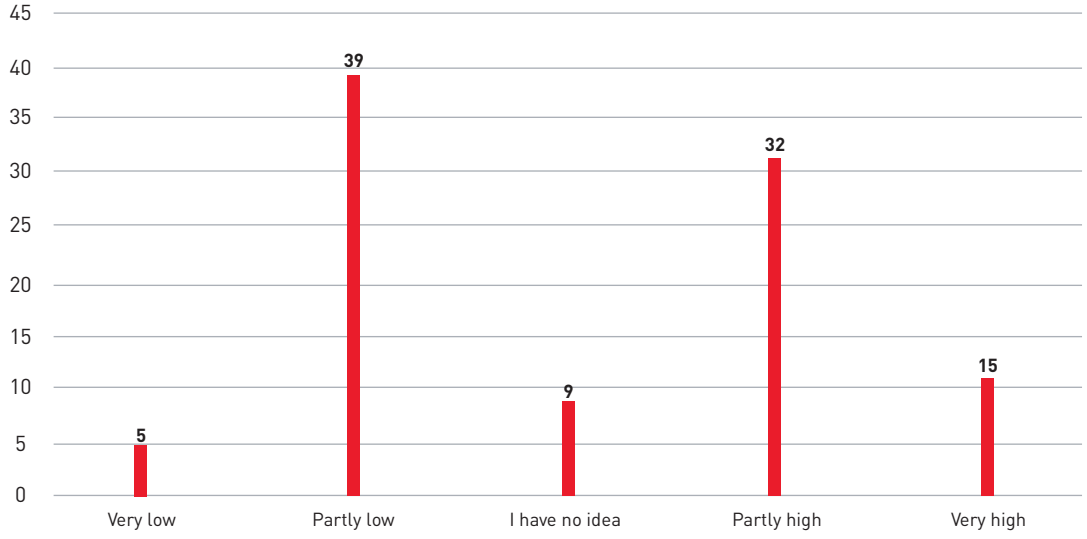


According to the survey results, the trust rate among supply chain stakeholders was determined as 53%. This rate shows that despite the vulnerabilities in the supply chain process, a majority of survey participants trust each other. This shows that there is a kind of solidarity and cooperation in the relationships between businesses, despite the difficulties and uncertainties in the supply chain.

The supply chain communication level of the companies participated in the survey was determined to be low in 44% and high in 47%. This data shows that communication in the supply chain is sometimes below expectations, but in some cases it is quite effective. A high level of communication indicates that information flow and collaboration between stakeholders is robust, indicating that communication is maintained despite vulnerabilities in the supply chain. However, low levels of communication sometimes indicate a lack of information sharing, which can negatively impact the efficiency and resilience of the supply chain.

In summary, high levels of trust and communication indicate that supply chain stakeholders continue to believe in and cooperate with each other, while low levels of communication indicate deficiencies in some areas. These situations highlight the importance of trust and cooperation between stakeholders, despite the existence of supply chain fragility.

Figure 5: How would you describe your level of communication with your supply chain during post-disaster recovery? (%)



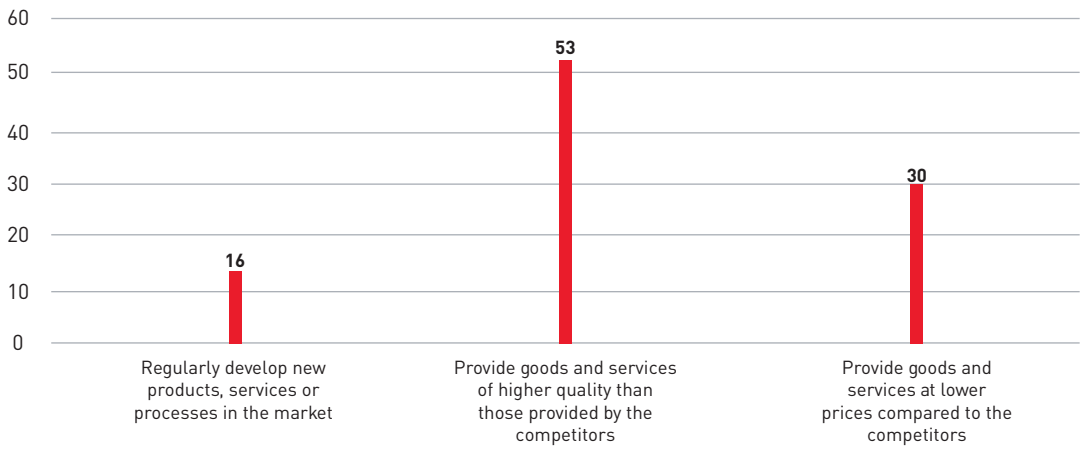
When the businesses participated in the survey were asked about the factors most important to their business's competitive success, different priorities attracted the attention:

» For 16% of businesses, the priority is to develop new products, services or processes in the market.
» For 53%, the priority is to provide better quality products or services than their competitors;
» 30% prefer to offer products or services at lower prices than their competitors.

From a supply chain resilience perspective, it shows that businesses cannot establish a certain standard for competition in times of risk and crisis. Accordingly, supply chain stakeholders do not follow a specific model or standard to maintain their competitive position to ensure resilience.

Within the framework of supply chain resilience, creating scenarios in terms of competition may be an important step when conducting emergency and risk assessments. Because competition stands out as an important factor that determines what position the supply chain stakeholders will take in times of crisis or risk and what kind of competitive strategy they can follow in this situation. It should be explained that these scenarios can guide businesses in determining their competitive positions in emergency planning in terms of supply chain resilience.

Figure 6: The first important factor for the competitive success of the business (%)



Qualitative Findings

The results of the qualitative research conducted between February and August 2023 revealed six main themes in terms of recovering the resilience of supply chains in the aftermath of the earthquakes. These themes include issues that stand out in certain areas and require particular attention in the recovery of the supply chain.

The first theme concerns the need for housing.

» Housing needs in the aftermath of the earthquakes include employee housing, which can impact continuity of operations in the supply chain. The availability and security of housing after earthquakes is of vital importance for the population that stayed in the region or temporarily migrated.

» The distance and accessibility of residences to business areas, especially their functionality to business areas such as Organized Industrial Zones (OIZs), are of great importance. This affects the local labor force's access to housing and workplaces. Therefore, housing availability and distance between workplaces emerge as a key barrier that can affect the productivity of the workforce in the region and hence the smooth functioning of the supply chain.
» Transition from temporary housing to permanent housing should be made, but when doing this, the seismic structure of the region should be taken into consideration.
» Convenient and effective access of the workforce to residences and workplaces is a critical element for the recovery of the region and the efficiency of the supply chain. One participant stated:

Unless the industrial facilities here are rebuilt, it will be in vain to build houses.

» Among the main reasons why factories cannot operate are the lack of supply and financing, as well as the inability to meet the housing needs of the workforce that will work in medium and large-scale businesses in the region. Businesses are looking for solutions such as containers to solve this problem, but have difficulty accessing sufficient shelter space.

The second theme emphasizes the need for staff and offices.

» The needs in personnel and offices after the earthquake may affect the process of restructuring the operations of businesses.
» Maintaining an uninterrupted workforce is vital for supply chain operations in the short and medium term. Especially in the aftermath of the earthquake, it is a critical issue for businesses to maintain their activities and ensure the continuity of the supply chain.
» The transition between earthquake response and recovery phases must be rapid and efficient. This includes ensuring businesses keep their employees safe, as well as maintaining access to healthcare and means of livelihood.
» It is required to take the necessary steps to ensure the safety and well-being of employees. Additionally, rebuilding the basic infrastructure for businesses to continue their operations is important to strengthen the functioning of the supply chain. One business owner stated that,

Staff shortages continue as there are relocations. Sustainability of the sector can be ensured if well-organized buildings are provided as the offices were destroyed.

The earthquake also caused a significant population migration in Adıyaman; Those who left the region after burying their relatives moved to various cities in Türkiye and enrolled their children in new schools. However, organizing and gathering workers has been challenging as there is a shortage of containers or tents and many people are hesitant to return to the region.

» In particular, access to healthcare and protection of means of livelihood are of critical importance to minimize the effects of the earthquake.
» The goal in this process is to increase the general resilience of society and ensure business continuity along with the safety of employees. In this way, the sustainability and efficiency of supply chain operations can be kept at the highest level during the post-earthquake recovery process.

The third theme is the need for financing.

» Earthquakes can increase businesses' need for financial resources, which is an important factor for restoring and improving the supply chain.
» Financing difficulties in the aftermath of the earthquakes severely hampered the resilience of the supply chain. In the opinion of one business owner,

The earthquake also disrupted the financial flow chain in the region. Many companies used to have business ties with neighboring businesses, relying on checks for transactions. The postponement of these controls due to the earthquake made it difficult to restore the financing system. The damage caused by the delay in check payments was especially great in places such as Adana, where companies have checks from Gaziantep or Mersin.

- Reconstructing damaged infrastructure, repairing service roads, and providing emergency assistance has placed a significant financial burden on affected areas. Therefore, it is necessary to establish facilitated financial assistance mechanisms, strengthen insurance frameworks and engage the government, private sector and international organizations to effectively support the recovery process.
- The cessation of production along with the financial devastation suffered by companies created serious operational difficulties. Considering that the insurance rate is low, the damage has reached high levels. At this point, it is emphasized that public banks' postponement of loan receivables is a mitigating factor.
- It was stated that the expectation of the Credit Guarantee Fund in the industry was high, but the size of such fund was too low to meet the expectations.
- For the recovery of the industry; It was requested that banks facilitate access to finance, assist with mortgages, increase loans based on guarantee and increase their limits. It was suggested to develop funds not only for the industry but also for employees. It was proposed to distribute government incentives and taxation to the disaster area with positive discrimination principles. It was stated that there is need to incentives such as energy, insurance premium payments, employment, low-term loans, etc.

The fourth theme is coordination and existing structural problems.

- Lack of coordination and existing structural problems in the aftermath of the earthquakes point to difficulties in restoring the supply chain.
- It has been stated that there is a fundamental difficulty in this process due to the lack of coordination in the earthquake response and recovery processes. In particular, the lack of effective cooperation and coordination between different institutions, non-governmental organizations, local governments and other stakeholders has slowed down the infrastructure recovery process. This deficiency causes delays in taking the necessary measures for the reconstruction of damaged areas, the establishment of safe infrastructure and post-disaster recovery.
- These coordination issues also impact supply chain resilience and economic recovery.
- The participants states that,

A number of platforms are mentioned. There is a need for cross-platform coordination? It needs to be consolidated by highlighting some names. We are pressed for time. Municipalities and non-governmental organizations need to be strengthened.

But we are still at the first stage. My father is a businessman; He can take a shower once a month. These are things that people can only endure with different motivation.

The fifth theme is structural problems.

- The economic crisis and the centralized institutional structure reduced the flexibility in post-earthquake recovery processes.

No solution has been found for these issues for 90 days. The incentives given to an entrepreneur whose current business is moderately damaged or severely damaged do not contribute much concretely. Qualified personnel are also lacking. Naturally, there will be no investment from here.

- In addition, geopolitical crises reduced the purchasing power of companies selling in the region, causing a decrease in exports.
- Differences between regions have been emphasized, therefore locally appropriate intervention and solution mechanisms should be developed.

The province with the most problems in settlements is Hatay, but the province with the most damaged industry is Kahramanmaraş. If there is a step by step recovery, it will be motivation. But no step has been taken for this.

The sixth theme relates to supply chain planning.

- After earthquakes, it may be required to replan and improve the supply chain. This theme highlights the need for a well-organized planning in the structural and operational aspects of the supply chain.

» Due to sectoral differences, some sectors or destinations are positioned as backward on the resilience scale and others as advanced. However, turning this positive situation into an opportunity is only possible with supply chain resilience planning. According to one participant,

Despite the difficulties experienced, there was an increase in demand in some sectors, such as the plastics industry, due to the ongoing construction and infrastructure projects in the aftermath of the earthquake. This has led to the release of safety stocks in these sectors to meet increasing demand. Adequate planning is of great importance to meet this intense demand and prevent possible damages that may arise from imports. It is important to determine current and future production needs for each sector and ensure that current production capacity can meet these needs. Incentives should be provided to increase the capacity of domestic producers, taking into account employment and financing problems.

» The disruption at one point of the supply chain after the disaster also affected the distant link of the chain. There are physical difficulties in the operational context, not in demand.

Many companies cannot carry out their office activities because their offices are destroyed. There is a container logistics village project. Along with customs, logistics companies also have difficulties in planning and shipment. We are also discussing the financing and planning problems of these projects with the Ministry of Trade in order to solve the office and service shortage. Hatay and Mersin are provinces with an international transportation structure, and we are trying to solve their problems with container city clusters there.

» Breaks in the raw material side, which is the very beginning of the supply chain, create risks in the short and medium term.

Our producers importing raw materials were affected. Raw materials burned in the fire that broke out in Iskenderun port. Even though they transported insured products, their raw materials were burned. An economic loss was experienced in this sense. Due to the fire in Iskenderun port, businesses suffered great losses. This further complicated the financial situation as many companies were left without any means of transportation or storage. Some businesses have resorted to blocking the payment system on their own to protect their interests.

» Damage to the borrowing and financing link in the supply chain has also led to breaks in the supply chain.

One of the most important problems that arose was the problem of debt collections. Many debts had to be written off, increasing financial distress. The cost of textile production in the country has increased due to damage to machines and difficulties in finding spare parts. This situation has led to the need for innovative solutions in companies' own R&D departments. Spare parts shortage has become a major problem disrupting production.

» There were also problems in accessing loans at the financing point, weakening the supply chain resilience.

Another issue was the credit conditions under which the sector operated. During this difficult period, loan maturities had to be shortened, but unfortunately, not much progress was made in this regard. For example, companies in Maraş sell their products to Denizli, Bursa and other cities. Because payments were often received after products had been delivered, there were limited alternatives for prioritizing payments, causing further financial hardship.

» Based on this example, it can be said that a single center alone will not be sufficient to make the supply chain more resilient. A supply chain plan needs to be made for the temporary substitution of the final destination with more resilient cities or centres. However, an important issue here is the protection of small businesses and the temporary substitution of destination shifts in a way that does not upset the balance in the region.

With the right support, initiatives and planning, sectors can recover and regain strength. Efforts should be made to protect and support small and medium-sized enterprises, to protect the clustering effect of industries in certain regions, and to provide incentives to domestic producers to meet the increasing demand.

» It is of great importance to encourage imports in order to facilitate exports and support producers in the earthquake-affected region.

These six themes detail different areas and important issues in the recovery of supply chains after earthquakes and indicate priorities for businesses to pay attention to.

Overcoming Challenges in the Post-Crisis Supply Chain and Economic Recovery Process: Recommendations

Post-disaster conditions that disrupt supply chains and delay economic recovery greatly impact the resilience of businesses. Some of the main challenges are:

» **Loss of life:** Increased loss of life depending on the extent of the disaster delays both psychological, social and economic recovery and affects business continuity and employment.

» **Infrastructure Damage:** Disasters disrupt the flow of goods by causing serious damage to infrastructures such as roads, ports and warehouses. This prevents materials from being transported in a timely and efficient manner, leading to delays and disruptions in the supply chain.

» **Communication Interruption:** Disasters cause widespread communication disruptions, including power outages and damage to communication networks. This makes it difficult for supply chain stakeholders to coordinate and share critical information, slowing the recovery process and reducing resilience.

» **Resource Scarcity:** Post-disaster conditions cause shortages of basic resources such as fuel, electricity and water. The lack of these resources negatively impacts the ability to run warehouses, transportation, and other supply chain operations, making rapid recovery difficult.

» **Damaged Suppliers:** Disasters disrupt the operations of suppliers and manufacturers. It can lead to unavailability of critical components and raw materials. It extends delivery times and makes it difficult to meet customer demands.

» **Increasing Demand:** Following a disaster, there is an increase in demand for essential products and materials. This increase in demand puts pressure on the supply chain to quickly restart operations. Problems arise with production capacity and inventory management.

» **Lack of Visibility:** Disasters create uncertainties, making it difficult to accurately track inventory, shipping, and overall operations. Making the right decisions becomes difficult.

» **Human Resources Management:** Post-disaster conditions disrupt workforce availability and preparedness. Employees experience family losses, psychological difficulties, and physical damage and loss. They may have to relocate. A labor shortage occurs.

» **Financial restrictions:** Implementing resilience strategies often requires significant investments, which can be challenging for small and medium-sized businesses (SMEs) or companies with limited resources.

» **Lack of coordination and information sharing:** Inadequate collaboration and communication between supply chain participants hinders rapid exchange of critical information and coordination in post-disaster conditions.

» **Complex regulatory environment:** Implementing various regulations and compliance requirements during a crisis delays recovery efforts, underscoring the importance of predetermined emergency plans and protocols.

Proactive measures should be taken to ensure continued supply of essential goods and services in times of crisis.

- Damage to manufacturing facilities, diminished resources, and increased demand uncertainty following a disaster further exacerbate the challenges faced by supply chains.
- Demand forecasting techniques may be applied.
- Strategic inventory may be created.
- Resilient supply chain networks may be established.
- Stock levels may be maintained by diversifying suppliers.
- By incorporating redundancy into the system, supply chain resilience may be significantly increased.

Disaster funds should be monitored regularly for economic recovery after the disaster.

- It is necessary to create emergency funds, diversify public incentives and provide access to external financing.
- Insurance coverage against disasters reduces financial risks.

Disasters not only affect physical infrastructure, but also leave significant psychological and emotional impacts on affected communities.

- Recovery efforts must prioritize the well-being of individuals and communities and promote social resilience.
- By harnessing the power of community participation, promoting social networks and integrating local knowledge, supply chains can contribute to the harmonious and sustainable rebuilding of communities.

Timely and accurate information sharing among stakeholders is crucial to managing a coherent recovery effort.

- Disruption of communication channels during disaster response and after the disaster prevents the effective flow of information throughout the supply chain.
- Timely and accurate information sharing should be ensured among stakeholders.
- Investment should be made in technology-enabled communication platforms.
- Standardized reporting systems should be used.

The Importance of Preparations Before Disasters: Recommendations

In multiple disasters, including earthquakes, fires, floods and epidemics, vulnerabilities cause breaks in the supply chain. Supply chain resilience can only be strengthened by businesses preparing before disaster. The primary steps for this may be:

Businesses should have risk management strategies.

- With recovery strategies and scenario analyzes determined before the disaster, companies can quickly adapt to possible risks.
- In order to deal with unexpected events, it is necessary to conduct proactive planning and risk assessment and develop real-time response mechanisms.

Emergency plans should be developed.

- A comprehensive risk assessment should be conducted to identify vulnerabilities and potential disruptions in the emergency environment.
- Risks should be effectively identified and prioritized
- Suppliers should be diversified and alternative distribution channels should be created.

Stakeholder coordination should be ensured.

» A digital platform should be developed among stakeholders before a disaster so that the factors that cause supply chain resilience can be quickly identified.
» It should be ensured that all stakeholders in the supply chain network are in cooperation and coordination.
» Emergency plans should be developed and term sheets for collaboration with key stakeholders should be made available before the disaster.

It is more difficult for SMEs to achieve resilience.

» Strategies such as quickly switching suppliers, rerouting shipments, or changing production processes may be considered.

Technological resources should be ready and up to date.

» In terms of resilience, taking advantage of technological developments may be an option, but the data sources of these technologies, their last update dates and their continuity should be ensured.
» With software programs, the current status analysis of the supply chain network can be made transparently visible.
» Real-time data viewing and monitoring under emergency conditions streamlines decision-making processes and reduces disruptions.

The soundness of the physical infrastructure should be monitored from a technical and legal perspective.

» Manufacturing sectors, in particular, are highly dependent on physical infrastructure such as factories, production lines and warehouses.
» Damage to these facilities after a disaster significantly disrupts the supply chain. Periodic observation, maintenance and reinforcement of these facilities are required.

Adjustments may be made in inventory management.

» Manufacturing sectors typically maintain higher levels of inventory, including raw materials and finished goods, to support production.
» It can act as a buffer to existing inventory in the recovery of the supply chain.

Redundancy is key to supply chain recovery.

» Industries with higher inventory levels or redundancy in their supply chains recover more easily.

For example, food retail chains maintain stock buffers that can help them recover quickly after an outage. However, the safety of these stocks should be ensured against multiple disasters, such as floods or fire after an earthquake.

» Alternative suppliers and production facilities should be determined to ensure **redundancy and diversification.**
» In case of outages, they may be enabled to switch suppliers or production locations.
» Maintaining a spare inventory and strategically storing goods in multiple geographic locations replaces interrupted supply routes.

Time management is vital for some industries.

» For sectors with low tolerance for disruptions in time management, such as the pharmaceutical industry, the post-disaster period requires faster response and prioritization of resources.
» For sectors that can compensate for initial delays (production, delivery, etc.), such as manufacturing sectors, insurance and financial support mechanisms should be put into effect as soon as possible and continued until recovery occurs.

Sectors with complex supply chain structures are more fragile.

» For example, the automotive industry is dependent on a large number of suppliers, making it more difficult to recover quickly after an outage.
» Industries concentrated in a particular region should be identified and prioritized.

Industries that foster strong relationships with their suppliers generally have higher resilience.

- » Close collaboration and communication with suppliers enables rapid response and recovery strategies after a disaster.
- » A resilient supply chain relies on effective collaboration between all stakeholders, including suppliers, manufacturers, distributors and customers.
- » Sharing real-time information to improve decision-making processes increases the ability to recover efficiently.

Industries facing stringent regulatory requirements may face greater challenges in improving their supply chains.

- » Financial resources should be created for businesses so that they can invest in emergency plans and risk mitigation strategies.

Post-Disaster Supply Chain Resilience: Recommendations

Sector differences should be taken into account.

- » To increase the resilience of the supply chain after disasters, each sector needs to evaluate its unique characteristics, vulnerabilities and recovery options and develop alternative scenarios and plans.
- » For example, while industrial and production-oriented damage may be seen in some cities, housing and settlement-oriented damage may be greater in other cities.

To effectively build resilience, the supply chain network needs to be intervened holistically.

- » First of all, strengthening the infrastructure,
- » Meeting the need for safe housing,
- » Diversfying the suppliers
- » Coordination with civil society,
- » Collaboration, information sharing and coordination between stakeholders in the supply chain should be transparent and inclusive. In this way, it can encourage coordinated efforts towards resilience on a common platform.
- » Local communities and non-governmental organizations are the cornerstones of the recovery and preparation process. It is essential to include them in the decision-making process.
- » Community-led initiatives, training programs, and capacity-building efforts can increase preparedness, reduce vulnerabilities, and foster a sense of collective responsibility for supply chain resilience. A more holistic and sustainable recovery can be achieved through the participation of all stakeholders, including businesses, government and individuals.

It is necessary to create dynamic scenarios.

- » Supply chain strategies normally prioritize efficiency, such as cost reduction and lean operations, etc. However, in acute post-disaster conditions, disaster response capacity is more important.
- » It is necessary to develop crisis-oriented supply chain strategies
- » It is necessary to establish a coordination chain focused on resilience rather than solely on efficiency, integrate risk management techniques and adapt to dynamic scenarios.
- » For example, it may include maintaining stocks of critical materials, establishing alternative delivery routes, and using adaptive technologies.
- » As stated in the report, unfortunately, the differentiation in transportation and logistics and the lack of alternative modes being put into effect show that the supply chain is not adapted to risks.

States need to establish robust regulatory frameworks that encourage proactive measures for resilience.

- Companies can only implement contingency plans if the public and governments create robust regulatory frameworks that encourage proactive measures for resilience.
- Guidelines for supply chain risk management should be established, roles and responsibilities should be defined, and public-private data sharing should be facilitated.
- For example, cooperation in data sharing with the public is recommended in the insurance sector. It is important to integrate insurance companies into the public database and obtain square meter data of residences through this system (TSB, 2023).
- Additionally, it is necessary to create an enabling environment that includes transparent communication channels and regular simulations and exercises.
- Cooperation, trust and efficient coordination of resources should be encouraged during post-disaster recovery.
- Software and algorithms need to be developed and integrated into systems so that many post-disaster intervention and initiative mechanisms act in integrity rather than fragmentedly on a single platform.

Positive discrimination mechanisms can spread to the grassroots.

- A resilient supply chain not only facilitates the flow of goods but also catalyzes the revival of economic activities in disaster-affected areas.
- By prioritizing the early restoration and rehabilitation of supply chains, damaged businesses can continue their operations.
- Strategic interventions such as fiscal stimulus, tax relief and access to capital can further accelerate the economic recovery process.

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