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The Effect of Natural Disaster on Regional Economic Growth: Evidence from an Earthquake in İzmir/Türkiye[1]

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Abstract

This study examines the economic impact of the Aegean Sea Earthquake, which struck İzmir, Türkiye, on October 30, 2020, focusing on how it affected local businesses and financial resilience. Using a combination of survey data and regression analysis, the study investigates the operational disruptions experienced by companies of varied sizes and sectors. Findings show that while large firms displayed resilience, small businesses suffered significant operational and financial setbacks, prolonging the economic recovery process. The results underscore the importance of developing robust crisis management strategies and fostering economic structures that are more resilient to both natural disasters and global crises. The study concludes with recommendations for policymakers and business leaders to enhance financial resilience to future shocks.
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1. Introduction

Natural disasters, particularly large-scale events such as earthquakes, have extensive effects on economic development (Shabnam, 2014; Klomp, 2016; Fabian et al., 2019). These disasters can significantly slow economic growth in the short term by halting economic activities, reducing incomes, and negatively affecting businesses. However, economic development involves more than just growth; it is a long-term process aimed at enhancing social welfare, improving living standards, and strengthening infrastructure Therefore, natural disasters threaten sustainability by disrupting short-term economic growth and undermining long-term development processes. In this context, the role of businesses in the economic system becomes especially clear, as natural disasters directly affect business operations, income streams, and overall sustainability. Natural disasters and unexpected events have profound, long-lasting effects on businesses. Large-scale disasters, such as earthquakes, adversely affect business operations, revenues, and service delivery, putting long-term sustainability at risk. These situations lead to periods of uncertainty and challenge for business owners and managers, evaluating their crisis management skills (Karunasena & Amaratunga, 2014; Sarmiento et al., 2015). The Aegean Sea Earthquake, which struck the Izmir region in 2020, had a significant impact on both the local economy and

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labor market. As seen in Izmir, the prolonged recovery process for small businesses caused a temporary disruption in economic development. This example proves that large-scale natural disasters have similar effects on economic development processes worldwide. Many countries, including Türkiye in the aftermath of the Izmir earthquake, have recognized the importance of learning from such crises and building more resilient economic structures.

The main challenges businesses face after an earthquake include the loss of customers, reduced income, production stoppages, and workforce losses. Small businesses were hit harder by the crisis and took longer to recover, while larger businesses showed greater resilience and actively contributed to regional development (Chang & Falit-Baiamonte, 2003; Webb, 2002). This study aims to evaluate the effects of the Aegean Sea Earthquake, which struck Izmir on October 30, 2020, on businesses and assess their preparedness for such unexpected events. The primary aim is to contribute to the development of more effective strategies for future disasters by analyzing the crisis management approaches and financial resilience of businesses of varied sizes. The analysis, considering factors such as the demographic characteristics of business owners and managers, business types, and the sectors they run in, provides a solid foundation for understanding the earthquake's impact on businesses (Corey & Deitch, 2011; Liu, Xu & Han, 2013). While the stagnation of production and trade slows overall economic development, it is notable that larger businesses tend to be more resilient to crises and recover more quickly. This highlights the importance of large companies as fundamental drivers of economic development. These businesses not only recovered swiftly but also continued to create employment and contribute to economic growth. Additionally, factors such as labor market flexibility and labor mobility played crucial roles in accelerating post-crisis recovery. In regions like Izmir, where the industry and service sectors are strong, reintegrating the workforce into the economy significantly accelerated regional development. In this context, we emphasize the need to update and prepare crisis management strategies for sustainable development. As shown in the Izmir example, developing resilient infrastructure and policies against natural disasters is critical for enhancing the sustainability of regional development. In addition, this study examines how unexpected global events such as pandemics increase the effects of earthquakes and how businesses try to cope with such crises. The study aims to evaluate the effectiveness of businesses' responses to such events by examining the differences between the pre-period and post-periods of business performance. The pandemic worsened the impact of the earthquake, highlighting that many businesses were unprepared for service interruptions. This finding underscores the need for businesses to update their crisis management strategies and be better prepared for future uncertainties. The combined effects of the pandemic and the earthquake have exposed the fragility of economic development and emphasized the importance of building more resilient economic structures for long-term, sustainable growth. In this study, we will summarize the current knowledge on the regional economic impacts of natural disasters through a literature review, present findings on labor market changes following the 2020 Aegean Sea Earthquake in the Izmir region, and evaluate the labor market's recovery process based on these findings. Additionally, we will explore how the pandemic intensified the effects of the earthquake and discuss the strategies businesses developed to respond to these crises.

2. Literature

Firms, as fundamental components of the economy, can incur significant economic losses during unexpected events such as natural disasters. In earthquake-prone regions, these disasters have serious economic consequences, often severely affecting the regional economy. However, studies examining the economic effects of earthquakes on firms are limited in the literature. Recent academic studies highlight the significant economic impact of earthquakes on small businesses, particularly in developing countries and earthquake-prone regions. These businesses often struggle with longer recovery times due to limited financial and technical resources. For example, the 2023 Turkish earthquakes caused massive damage, with the World Bank estimating a loss of over $34 billion, disproportionately affecting small and micro-enterprises that lack the infrastructure for rapid recovery (World Bank, 2023) . Small businesses in Albania similarly experienced severe disruptions following a recent earthquake, with losses in inventory, infrastructure, and customers. The United Nations Development Programme (UNDP) launched the "In Motion" recovery program to stabilize these businesses by offering support in infrastructure repair, business skill training, and reestablishing market activities. This program has shown promising results in assisting businesses to recover from both direct and indirect losses, highlighting the importance of targeted interventions in supporting small business resilience (UNDP, 2024) . Research on earthquakes and firms globally shows that businesses are highly vulnerable to such disasters (Kaushalya, Karunasena & Amaratunga, 2014; Orhan, 2016; Sarmiento et al., 2015). The literature highlights that firm size is a key factor in how quickly a business can recover from the impact of an earthquake. Larger firms, with their greater financial and technical resources, are generally able to recover

more swiftly (Chang & Falit-Baiamonte, 2003; LeSage, Pace, Lam, Campanella, & Liu, 2011; Tierney, 1997; Webb, 2002). This aligns with Schumacher and Strobl's (2011) findings, which suggest that more developed regions with stronger infrastructure tend to suffer less severe economic losses in the aftermath of a natural disaster, facilitating a quicker recovery. In contrast, small businesses, with limited resources, face greater challenges in mitigating the economic risks posed by earthquakes (Corey & Deitch, 2011; Chhibber & Laajaj, 2013). Earlier studies in developed countries have shown that over one-third of small businesses do not reopen after a disaster, and more than a quarter close within two years (Tierney & Webb, 2001). Similarly, Liu, Xu, and Han (2013) reported that following the 2008 earthquake in Wuhan, China, a sizable part of small and medium-sized businesses were unable to resume operations, with full recovery taking at least 36 months. Research in developing countries has shown comparable results: around two-thirds of small businesses in Sri Lanka (Robinson & Jarvey, 2008) and Indonesia (Pribadi, 2005) experienced lower incomes after the disaster compared to pre-event levels. A study examining sectoral differences analyzed the long-term economic recovery of 232 firms after the 1999 Adapazarı earthquake. The findings showed that firms in the finance, insurance, and real estate sectors recovered more quickly than those in other industries (Orhan, 2016). These findings are consistent with Chhibber and Laajaj's (2013) study, which emphasizes the importance of sectoral resilience, noting that sectors more aligned with the region's development strategies and financial structures tend to exhibit greater capacity for recovery. Furthermore, Schumacher and Strobl (2011) highlight that well-established sector, which often benefit from previous experiences with disasters, tend to exhibit stronger recovery mechanisms. This reinforces the importance of a sector's adaptability and its capacity to integrate crisis management practices into its operational strategies. This study will examine the effects of recent devastating earthquakes in Türkiye on local economic development to assess their socioeconomic impact. A survey focusing on the October 30, 2020, Aegean Sea Earthquake will be conducted in Izmir to evaluate the operational changes in firm activities, and these effects will be analyzed in detail.

3. Method

This study aims to understand the effects of the October 30, 2020, Aegean Sea Earthquake on companies running in Izmir and to analyze how such natural disasters influence business activities. A comprehensive survey and multivariate regression analysis were conducted to assess the short- and long-term impacts of the earthquake on company operations.

3.1 Survey Design and Implementation Process

The survey in this study evaluates changes in business activity after the earthquake and assesses the expected impact of future earthquakes by focusing on the sectoral distribution, size, and other descriptive statistics of the companies. The survey includes three sections and a total of thirty-three questions. The first section gathers descriptive information about the sector and size of the companies. The second section has questions about the extent to which activities changed after the earthquake. The third section features questions that predict how future earthquakes may affect the companies' operations.

We sent the online survey to all companies running in Izmir with the support of the Izmir Development Agency. However, due to insufficient responses from the online surveys, we also conducted face-to-face surveys with the agency's support. In total, 128 companies took part in the survey, and the analysis collected the obtained data. The study aimed to provide reliable results with a 5 percent margin of error.

In this study, the sample selection was based on the sectoral distribution of companies registered with the İzmir Chamber of Commerce. The table below compares the sectoral distribution of firms registered with the İzmir Chamber of Commerce to that of the survey sample:

Table 1: Sectoral Distribution Comparison of İzmir Chamber of Commerce Registered Companies and Survey Sample

Sector	Number of Companies Registered with the İzmir Chamber of Commerce	Percentage of Total (%)	Number of Firms in the Survey Sample	Sample Percentage (%)
Trade	30	46.5	65	50.8
Services	15	23.2	32	25
Manufacturing /Production	10	15.5	20	15.6
Agriculture-Livestock	5	7.8	7	5.5
Tourism	4,521	7	4	3.1
Total	64,521	100	128	100

The table shows that the survey sample largely reflects the sectoral distribution of companies registered with the İzmir Chamber of Commerce. Particularly in the trade and services sectors, the sample percentages align closely with the population percentages. Given that the trade sector constitutes the largest share in the Chamber's records, it is also predominantly represented in the survey. This alignment enhances the representativeness of the survey results.

3.2 Data Collection and Analysis Methods

The analysis of this study employed the multivariate regression model. This models the relationship between multiple dependent variables and one or more independent variables, effectively deriving meaningful results from complex data sets.

In our study, the multivariate regression examines 4 dependent variables (Y_1,Y_2,Y_3 and Y_4) and their relationships with a set of 9 independent variables (X_1,X_2, …, X_9). The equations can be written as:

$$Y_1 = \beta_{10} + \beta_{11}X_1 + \beta_{12}X_2 + \cdots + \beta_{19}X_9 + \epsilon_1$$
$$Y_2 = \beta_{20} + \beta_{21}X_1 + \beta_{22}X_2 + \cdots + \beta_{29}X_9 + \epsilon_2$$

And so on, for Y_3 and Y_4. Each dependent variable is modeled as a linear combination of the independent variables, with distinct coefficients for each dependent variable. In this study, dependent variables included the number of customers, income status, production level, number of employees, and demand for intermediate goods seen in businesses after the earthquake. Researchers associated these dependent variables with independent variables such as the age, gender, and education level of the company owner, the owner's sector knowledge, the age of the company and its building, the number of employees, employee experience, and the ability to work remotely. The regression analyses revealed that the significance tests for all models yielded results at a significance level of 1 percent. Additionally, the error terms related to the periodic model results showed periodic relationships for all models. This finding shows that it is proper to evaluate different periods within the same model. Detailed reports and estimates about the analysis results appear in the appendix.

4. Results

4.1 Number of Customers of Businesses

The analysis shows that sectoral effects significantly influenced changes in the number of customers for companies after the earthquake. The tourism sector, being the most vulnerable, experienced the largest decline in customer numbers. Businesses in this sector, including hotels, travel agencies, and tour operators, saw a sharp drop in visitors due to the immediate disruptions caused by the earthquake. The combination of damaged infrastructure canceled travel plans, and a loss of consumer confidence in the safety of the region resulted in a significant reduction in customer numbers. The tourism sector's reliance on physical presence, along with the global perception of the region as being affected by natural disasters, compounded the challenges of recovery. Additionally, an increase in the age of the company positively affects customer retention due to earthquake effects. This finding shows that more established and long-standing companies tend to be more resilient during crises and are better at minimizing customer loss.

Table 2. Periodic Impact of Earthquake on Change in Number of Customers

Equation	Obs	Parms	RMSE	"R-sq"	F	P>F
number~r_1_2	128	9	1.432609	0.7277	35.33958	0.0000
num~r_1_week	128	9	1.157774	0.8946	112.2755	0.0000
nu~r_1_month	128	9	.9054094	0.9446	225.4637	0.0000
nu~r_6_month	128	9	.8252854	0.9570	294.4518	0.0000

	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
number_of_customer_1_2						
age	-.0469935	.1131809	-0.42	0.679	-.271103	.1771159
gender	-.420726	.282919	-1.49	0.140	-.9809338	.1394818
sector	.5299644	.2347142	2.26	0.026	.0652068	.994722
firm_age	.3139153	.2392663	1.31	0.192	-.1598559	.7876864
building_age	.0552484	.0790352	0.70	0.486	-.1012492	.211746
education	.3999955	.2176161	1.84	0.069	-.030906	.8308971
number_of_workers	.0926077	.4260752	0.22	0.828	-.7510639	.9362792
experience_of_the_workers	.1144028	.1916328	0.60	0.552	-.2650494	.4938549
remote	-.1959018	.2620463	-0.75	0.456	-.7147796	.322976
number_of_customer_1_week						
age	.0261661	.091468	0.29	0.775	-.1549497	.2072819
gender	-.0548676	.2286432	-0.24	0.811	-.5076039	.3978687
sector	1.052026	.1896861	5.55	0.000	.6764283	1.427623
firm_age	.3733581	.1933649	1.93	0.056	-.0095238	.75624
building_age	.0599173	.0638729	0.94	0.350	-.0665575	.186392
education	.017893	.1758681	0.10	0.919	-.3303434	.3661294
number_of_workers	.4393613	.344336	1.28	0.204	-.2424584	1.121181
experience_of_the_workers	.1081395	.1548696	0.70	0.486	-.1985177	.4147967
remote	.2673486	.2117747	1.26	0.209	-.1519866	.6866837

number_of_customer_1_month						
age	.0331724	.0715304	0.46	0.644	-.1084648	.1748097
gender	.1113867	.1788049	0.62	0.535	-.2426649	.4654383
sector	1.395552	.1483395	9.41	0.000	1.101825	1.689279
firm_age	.2580458	.1512164	1.71	0.091	-.0413778	.5574694
building_age	.0112196	.0499503	0.22	0.823	-.087687	.1101261
education	-.0951805	.1375335	-0.69	0.490	-.3675105	.1771495
number_of_workers	.4353862	.2692798	1.62	0.109	-.0978146	.968587
experience_of_the_workers	.1710075	.121112	1.41	0.161	-.0688065	.4108214
remote	.2094193	.1656134	1.26	0.209	-.1185117	.5373503
number_of_customer_6_month						
age	-.0264369	.0652003	-0.41	0.686	-.15554	.1026662
gender	.1057784	.1629816	0.65	0.518	-.2169415	.4284983
sector	1.441496	.1352122	10.66	0.000	1.173763	1.70923
firm_age	.3705793	.1378346	2.69	0.008	.0976531	.6435056
building_age	.0231718	.0455299	0.51	0.612	-.0669821	.1133256
education	-.0906897	.1253625	-0.72	0.471	-.3389199	.1575405
number_of_workers	.592587	.2454499	2.41	0.017	.1065717	1.078602
experience_of_the_workers	.1454048	.1103943	1.32	0.190	-.0731868	.3639965
remote	.1709118	.1509575	1.13	0.260	-.1279991	.4698226

The research findings highlight that factors such as company experience and customer loyalty play a critical role in maintaining or regaining customer numbers after natural disasters. In sectors that directly interact with customers, like the service industry, the experience and reputation associated with a company's age enhance customer loyalty and result in less loss during crises. Consequently, developing and implementing crisis management strategies can help companies increase their resilience against unexpected events such as natural disasters. Factors such as experience, sectoral knowledge, and customer loyalty are crucial in reducing the impact of crises on companies, and effectively managing these factors can shape their long-term success.

4.2 Income Status of Businesses

The analysis revealed that sectoral effects played a decisive role in influencing the changes in company income during the period following the earthquake. Companies operating in certain sectors, such as manufacturing and services, experienced different levels of impact due to their distinct operational structures, supply chains, and customer bases. For instance, businesses in sectors that rely heavily on physical infrastructure or face-to-face interactions were more vulnerable to the immediate disruptions caused by the earthquake, while those in digital or service-based sectors showed a more rapid recovery. The extent of sector-specific resilience was further shaped by factors like the flexibility of business models, the availability of alternative work arrangements, and the ability to quickly adapt to new market conditions. Additionally, the increase in company age positively affected the effects of the earthquake on income. This finding shows that well-established and long-term companies tend to be more resilient during crises and excel at minimizing income loss. The research results reveal that a company's experience, reputation, and financial resilience play vital roles in supporting or increasing income after natural disasters. In sectors with direct customer interaction, such as the service industry, a company's age and experience enable a faster income recovery. As a company ages, strengthened customer loyalty and a solid market position allow it to manage financial losses more effectively during crises.

Table 3. Periodic Effect of Earthquake on Change in Income

Equation	Obs	Parms	RMSE	"R-sq"	F	P>F
revenue_1_2	128	9	1.374173	0.7686	43.91169	0.0000
revenue_1_~k	128	9	1.095155	0.9066	128.3344	0.0000
revenue_1_~h	128	9	.9015295	0.9451	227.6593	0.0000
revenue_6_~h	128	9	.777944	0.9619	333.9559	0.0000

	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
revenue_1_2						
age	-.0330422	.1085642	-0.30	0.761	-.2480102	.1819259
gender	-.5373346	.2713788	-1.98	0.050	-1.074692	.0000225
sector	.4073677	.2251403	1.81	0.073	-.0384325	.853168
firm_age	.4425118	.2295067	1.93	0.056	-.0119344	.8969579
building_age	.0509142	.0758114	0.67	0.503	-.0991999	.2010283
education	.3977662	.2087395	1.91	0.059	-.015559	.8110913

number_of_workers	.7267221	.4086957	1.78	0.078	-.0825362	1.53598
experience_of_the_workers	.1377753	.1838162	0.75	0.455	-.2261991	.5017497
remote	.1000426	.2513575	0.40	0.691	-.3976702	.5977555
revenue_1_week						
age	-.0102247	.0865209	-0.12	0.906	-.1815447	.1610952
gender	-.1918211	.2162768	-0.89	0.377	-.6200707	.2364285
sector	1.099307	.1794268	6.13	0.000	.7440237	1.45459
firm_age	.3910651	.1829066	2.14	0.035	.0288918	.7532385
building_age	.0584439	.0604183	0.97	0.335	-.0611903	.1780781
education	-.1097137	.1663561	-0.66	0.511	-.4391155	.219688
number_of_workers	.6295249	.3257123	1.93	0.056	-.015418	1.274468
experience_of_the_workers	.1618011	.1464933	1.10	0.272	-.1282703	.4518724
remote	.4445789	.2003207	2.22	0.028	.0479239	.8412339
revenue_1_month						
age	.0064751	.0712238	0.09	0.928	-.1345552	.1475055
gender	.0017205	.1780387	0.01	0.992	-.3508139	.3542549
sector	1.412755	.1477038	9.56	0.000	1.120287	1.705224
firm_age	.26218	.1505684	1.74	0.084	-.0359606	.5603205
building_age	.0011083	.0497362	0.02	0.982	-.0973744	.099591
education	-.1161618	.1369441	-0.85	0.398	-.3873248	.1550012
number_of_workers	.5528742	.2681258	2.06	0.041	.0219583	1.08379
experience_of_the_workers	.2038228	.1205931	1.69	0.094	-.0349634	.4426091
remote	.3094426	.1649037	1.88	0.063	-.0170832	.6359683
revenue_6_month						
age	-.0304561	.0614602	-0.50	0.621	-.1521534	.0912412
gender	.0530364	.1536324	0.35	0.731	-.2511711	.3572439
sector	1.460722	.127456	11.46	0.000	1.208347	1.713098
firm_age	.3548607	.1299279	2.73	0.007	.0975905	.6121309
building_age	.0292387	.0429182	0.68	0.497	-.0557436	.114221
education	-.1144665	.1181712	-0.97	0.335	-.3484573	.1195243
number_of_workers	.6510338	.23137	2.81	0.006	.192898	1.10917
experience_of_the_workers	.1534974	.1040617	1.48	0.143	-.0525551	.3595498
remote	.2232356	.142298	1.57	0.119	-.0585287	.5049998

Moreover, a high number of employees positively affects company income after the earthquake. More employees increase the company's operational ability, enabling quicker and more effective responses in times of crisis. This ability helps keep uninterrupted productivity and customer service, minimizing revenue loss. Large-scale companies can use their employees' skills and participation in crisis management processes to sustain their activities. Interestingly, the education of the company owner significantly affects revenue changes within 1-2 days after the earthquake. However, this effect diminishes over time. The findings reveal that highly educated owners can minimize revenue loss by making quick and effective decisions during crises. On the other hand, the decline of this effect in the long term suggests that crisis management relies on more than just owner education; other factors also play a role. These include company age, experience, reputation, and financial resilience. Well-established companies can recover their revenues more quickly due to their industry reputation and customer loyalty. The research findings emphasize the importance of sustainable strategies and operational resilience for long-term success, as well as the ability to cope with short-term effects during crisis periods. Although owner education initially influences income changes, over time, the firm's overall resilience and crisis management strategies become more significant.

4.3 Production Status of Enterprises

The analysis shows that sectoral effects played a key role in changing the production levels of firms after the earthquake. Additionally, increasing the age of the firm positively affects changes in production levels due to earthquake effects. This finding reveals that well-established firms with long operating histories tend to be more resilient during crises and excel at minimizing production losses. The research results show that a firm's experience, production process efficiency, and sectoral knowledge are critical for keeping or increasing production levels during crises such as natural disasters. The experience and operational efficiencies of firms in the production sector, gained through age, play a significant role in minimizing production fluctuations during crisis periods.

Table 4. Periodic Effect of Earthquake on Change in Production

Equation	Obs	Parms	RMSE	"R-sq"	F	P>F
production~2	128	9	1.445103	0.7894	49.56076	0.0000
production~k	128	9	1.127573	0.9067	128.4391	0.0000
prod~1_month	128	9	.9645104	0.9384	201.5279	0.0000
prod~6_month	128	9	.8676135	0.9527	266.3441	0.0000

	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
production_1_2						
age	.0259572	.114168	0.23	0.821	-.2001068	.2520212
gender	-.5744241	.2853864	-2.01	0.046	-1.139518	-.0093305
sector	1.118506	.2367612	4.72	0.000	.6496956	1.587317
firm_age	.3336607	.241353	1.38	0.169	-.1442424	.8115638
building_age	.0486637	.0797245	0.61	0.543	-.1091988	.2065262
education	.2645846	.219514	1.21	0.230	-.1700749	.6992442
number_of_workers	-.1337238	.4297912	-0.31	0.756	-.9847533	.7173057
experience_of_the_workers	-.1513595	.1933041	-0.78	0.435	-.534121	.231402
remote	-.0371753	.2643317	-0.14	0.888	-.5605784	.4862278
production_1_week						
age	.0225798	.089082	0.25	0.800	-.1538115	.1989711
gender	-.1454126	.2226789	-0.65	0.515	-.5863391	.2955139
sector	1.22447	.1847381	6.63	0.000	.8586699	1.59027
firm_age	.3026391	.1883209	1.61	0.111	-.0702551	.6755333
building_age	.064619	.0622068	1.04	0.301	-.0585566	.1877946
education	-.1246038	.1712805	-0.73	0.468	-.4637563	.2145487
number_of_workers	.5352061	.3353539	1.60	0.113	-.1288281	1.19924
experience_of_the_workers	.1441285	.1508297	0.96	0.341	-.1545294	.4427864
remote	.3557529	.2062505	1.72	0.087	-.0526437	.7641494
production_1_month						
age	.0410909	.0761995	0.54	0.591	-.1097918	.1919736
gender	.01995	.1904765	0.10	0.917	-.3572125	.3971125
sector	1.489847	.1580224	9.43	0.000	1.176947	1.802747
firm_age	.2457421	.1610871	1.53	0.130	-.0732265	.5647107
building_age	.0212982	.0532108	0.40	0.690	-.0840646	.1266609
education	-.2157063	.146511	-1.47	0.144	-.5058127	.0744002
number_of_workers	.5855967	.2868571	2.04	0.043	.0175909	1.153602
experience_of_the_workers	.1466607	.1290177	1.14	0.258	-.1088073	.4021286
remote	.3570239	.1764239	2.02	0.045	.0076871	.7063608
production_6_month						
age	.0085841	.0685444	0.13	0.901	-.1271406	.1443088
gender	-.0653578	.1713408	-0.38	0.704	-.4046297	.2739141
sector	1.489263	.1421471	10.48	0.000	1.207797	1.770728
firm_age	.3384627	.144904	2.34	0.021	.0515384	.6253871
building_age	.0307322	.0478651	0.64	0.522	-.0640456	.1255099
education	-.1525068	.1317922	-1.16	0.250	-.4134685	.1084549
number_of_workers	.6388152	.2580388	2.48	0.015	.1278725	1.149758
experience_of_the_workers	.1327016	.1160563	1.14	0.255	-.0971014	.3625047
remote	.2546455	.1586999	1.60	0.111	-.0595962	.5688872

As a result, effectively implementing crisis management strategies can help businesses enhance their resilience against unexpected events like natural disasters. The combination of experience, sectoral knowledge, and operational efficiency is crucial for reducing the impact of crises on businesses. Thoughtful management of these factors plays a significant role in shaping the long-term production success of companies.

4.4 Number of Employees of Businesses

According to the analysis, only sectoral factors decisively influenced changes in the number of employees at the company. While the company's suitability for remote work positively affected employee numbers in the first week after the earthquake, this effect did not continue significantly in later periods. The findings show that the sector in which the company runs plays a critical role in figuring out changes in the number of employees. Specifically, labor demand in the sector during crises and the company's position within that sector are key factors influencing employee numbers.

Table 5. Periodic Effect of Earthquake on Change in Number of Employees

Equation	Obs	Parms	RMSE	"R-sq"	F	P>F
number~s_1_2	128	9	1.644386	0.7869	48.82565	0.0000
num~s_1_week	128	9	1.002395	0.9366	195.2228	0.0000
nu~s_1_month	128	9	.913928	0.9486	244.1813	0.0000
nu~s_6_month	128	9	.9156259	0.9488	245.083	0.0000

	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
number_of_workers_1_2						
age	-.0441755	.129912	-0.34	0.734	-.3014142	.2130632
gender	-.0786638	.3247418	-0.24	0.809	-.7216851	.5643575
sector	1.26495	.2694112	4.70	0.000	.7314885	1.798411
firm_age	.0459296	.2746362	0.17	0.867	-.4978775	.5897367
building_age	.1933029	.0907187	2.13	0.035	.0136708	.3729349
education	-.0925998	.2497854	-0.37	0.712	-.5871999	.4020003
number_of_workers	.0822226	.4890604	0.17	0.867	-.8861659	1.050611
experience_of_the_workers	.0147458	.2199612	0.07	0.947	-.4207994	.450291
remote	.2001257	.3007836	0.67	0.507	-.3954559	.7957073
number_of_workers_1_week						
age	.0144255	.0791925	0.18	0.856	-.1423836	.1712345
gender	.0664445	.1979581	0.34	0.738	-.3255323	.4584212
sector	1.556303	.1642292	9.48	0.000	1.231113	1.881494
firm_age	.2722626	.1674143	1.63	0.107	-.0592345	.6037597
building_age	.0809517	.0553008	1.46	0.146	-.0285495	.1904529
education	-.2743165	.1522657	-1.80	0.074	-.5758178	.0271847
number_of_workers	.5440344	.2981243	1.82	0.071	-.0462815	1.13435
experience_of_the_workers	.065993	.1340853	0.49	0.624	-.1995092	.3314952
remote	.3797442	.1833535	2.07	0.041	.016686	.7428023
number_of_workers_1_month						
age	.0236295	.0722034	0.33	0.744	-.1193404	.1665993
gender	.1765141	.1804872	0.98	0.330	-.1808686	.5338968
sector	1.423118	.1497352	9.50	0.000	1.126628	1.719609
firm_age	.3433939	.1526392	2.25	0.026	.0411531	.6456347
building_age	.0913016	.0504202	1.81	0.073	-.0085355	.1911387
education	-.1422627	.1388274	-1.02	0.308	-.4171549	.1326295
number_of_workers	.5968775	.2718133	2.20	0.030	.0586601	1.135095
experience_of_the_workers	.0582278	.1222515	0.48	0.635	-.1838424	.3002981
remote	.2597829	.1671716	1.55	0.123	-.0712335	.5907993
number_of_workers_6_month						
age	.0203207	.0723375	0.28	0.779	-.1229147	.1635562
gender	.1647792	.1808225	0.91	0.364	-.1932675	.5228258
sector	1.404356	.1500133	9.36	0.000	1.107315	1.701397
firm_age	.3651045	.1529227	2.39	0.019	.0623022	.6679068
building_age	.0885114	.0505139	1.75	0.082	-.0115112	.188534
education	-.118684	.1390854	-0.85	0.395	-.3940869	.1567189
number_of_workers	.6511886	.2723183	2.39	0.018	.1119712	1.190406
experience_of_the_workers	.0605748	.1224787	0.49	0.622	-.1819452	.3030948
remote	.2320231	.1674821	1.39	0.169	-.0996082	.5636544

The limited effectiveness of remote work only in the early days of the crisis highlights the need for the company to review its crisis management strategies. Continuously and effectively offering remote work options during crisis management can help companies mitigate the impact of crises and keep stable employee numbers. As a result, sectoral dynamics and the company's crisis management strategies significantly influence changes in employee numbers. Careful management of these factors is crucial for shaping the company's long-term success.

4.5 Intermediate Goods Demand of Businesses

According to the analysis, changes in the demand for intermediate goods at the company depend on factors, including the sector, the age of the company, the age of the business building, the number of employees, and the ability to work remotely. In particular, the general demand dynamics and competitive conditions of the sector play a determining role in the demand for intermediate goods. As the company's age increases, its experience and reputation can positively influence this demand.

Table 6. Periodic Effect of Earthquake on Intermediate Goods Demand Change

Equation	Obs	Parms	RMSE	"R-sq"	F	P>F
input_dema~2	128	9	1.037005	0.9220	156.3303	0.0000
input_dema~k	128	9	.8127693	0.9563	289.0311	0.0000
inpu~1_month	128	9	.6948112	0.9699	426.6075	0.0000
inpu~6_month	128	9	.6684116	0.9726	469.7462	0.0000

	Coefficient	Std. err.	t	P>|t|	[95% conf.	interval]
input_demand_1_2						
age	-.0567499	.0819269	-0.69	0.490	-.2189733	.1054735
gender	.067769	.2047931	0.33	0.741	-.3377419	.4732798
sector	1.399645	.1698997	8.24	0.000	1.063227	1.736064
firm_age	.0178293	.1731948	0.10	0.918	-.3251137	.3607723
building_age	.1770138	.0572103	3.09	0.002	.0637318	.2902958
education	-.1249885	.1575231	-0.79	0.429	-.4369	.1869229
number_of_workers	.2388662	.3084179	0.77	0.440	-.3718321	.8495645
experience_of_the_workers	.1512931	.1387149	1.09	0.278	-.1233763	.4259626
remote	-.2799067	.1896843	-1.48	0.143	-.6555005	.095687
input_demand_1_week						
age	-.0202936	.0642115	-0.32	0.753	-.1474387	.1068516
gender	.1440406	.1605099	0.90	0.371	-.173785	.4618661
sector	1.382719	.1331616	10.38	0.000	1.119046	1.646393
firm_age	.1798651	.1357442	1.33	0.188	-.0889219	.4486522
building_age	.1309019	.0448394	2.92	0.004	.0421153	.2196885
education	-.0844126	.1234612	-0.68	0.495	-.3288781	.160053
number_of_workers	.6014915	.2417275	2.49	0.014	.122847	1.080136
experience_of_the_workers	.1149854	.10872	1.06	0.292	-.1002911	.330262
remote	.1503794	.1486681	1.01	0.314	-.1439982	.444757
input_demand_1_month						
age	.0133138	.0548924	0.24	0.809	-.0953787	.1220062
gender	.2259514	.1372149	1.65	0.102	-.0457478	.4976506
sector	1.412507	.1138357	12.41	0.000	1.187101	1.637913
firm_age	.2697033	.1160435	2.32	0.022	.0399256	.499481
building_age	.0736182	.0383319	1.92	0.057	-.0022827	.1495191
education	.0032728	.1055432	0.03	0.975	-.2057132	.2122588
number_of_workers	.5576929	.2066453	2.70	0.008	.1485145	.9668712
experience_of_the_workers	.0917062	.0929414	0.99	0.326	-.092327	.2757395
remote	.1766504	.1270917	1.39	0.167	-.0750039	.4283047
input_demand_6_month						
age	.0163615	.0528067	0.31	0.757	-.0882012	.1209241
gender	.2311204	.1320014	1.75	0.083	-.0302555	.4924963
sector	1.370936	.1095105	12.52	0.000	1.154094	1.587777
firm_age	.3247534	.1116344	2.91	0.004	.1037062	.5458006
building_age	.0776254	.0368754	2.11	0.037	.0046083	.1506424
education	.0334398	.101533	0.33	0.742	-.1676058	.2344853
number_of_workers	.5901395	.1987937	2.97	0.004	.196508	.9837709
experience_of_the_workers	.0787349	.08941	0.88	0.380	-.0983059	.2557758
remote	.1368494	.1222628	1.12	0.265	-.1052432	.378942

Interestingly, the analysis shows that the age of the company's building positively affects the demand for intermediate goods. This finding shows that an older building or one with a long history contributes to more reliable and sustainable production processes, enhancing the supply of intermediate goods. Additionally, the number of employees and the ability to work remotely significantly affect the demand for intermediate goods. Maintaining flexibility in employee numbers and enabling remote work during crisis periods can positively influence the company's operational continuity and demand management.

5. Conclusion and Recommendations

We analyzed the economic impact of the Aegean Sea Earthquake, which struck İzmir, Türkiye, on October 30, 2020, by exploring its effects on local businesses, their recovery processes, and overall financial resilience in the region. The findings reveal that businesses are still insufficiently prepared for natural disasters like earthquakes. Additionally, recent unexpected events, such as pandemics, have intensified their impacts on businesses and underscored the urgent need for effective emergency management

strategies. These crises yield varying results based on the experience and knowledge of the companies involved. The research shows that experienced and well-established companies exhibit greater resilience during crises due to their institutional knowledge and effective crisis management strategies. These companies succeed in minimizing customer loss, protecting their income, ensuring production continuity, and managing their workforce effectively. Therefore, crisis management processes play a critical role in figuring out the long-term success of businesses. To enhance preparedness against crises, business owners and managers should take several initiative-taking steps. First, they should regularly attend crisis management training to improve their ability to respond effectively to crises and bolster their businesses' ability to cope. Additionally, companies need to develop alternative business continuity strategies to keep operations and ensure consistent customer service. Diversifying suppliers and accessing different supply sources can also minimize disruptions in the supply chain. Public-private partnerships offer another avenue for effective crisis preparedness. Collaborating with local governments and other organizations enables businesses to create joint crisis plans and respond in a coordinated manner. Furthermore, developing sustainability plans and using information and communication technologies can enhance resilience during crises. State-supported crisis management training and consultancy services can equip business owners and managers with the skills to make effective decisions during crises and ensure operational continuity. Organizing training on crisis communication and post-crisis recovery strategies can also prepare businesses for these processes. This policy proposal can succeed through cooperation between the state and the private sector, empowering businesses to respond more effectively to crises and sustain their long-term success. Ultimately, businesses must prepare for and respond effectively to natural disasters and crises. This study provides a foundation for guiding businesses in this regard and developing crisis management strategies. However, each business needs to adapt its preparedness plans and strategies to its specific circumstances. Future research that delves deeper into diverse types of crises and how businesses across different industries respond could further enhance crisis management strategies. The limitations of this study should be acknowledged. While the findings provide valuable insights into the economic impact of natural disasters on local businesses, the scope of the research was confined to businesses in İzmir, Türkiye. Therefore, the results may not be universally applicable to other regions or industries without further investigation. Additionally, the study primarily relied on survey data, which may have been influenced by response biases or limitations in sample representation. Future research could expand the sample size and include diverse geographical locations and industries to further validate the findings and improve the generalizability of the results. In terms of future academic implications, this study highlights the need for further research on the intersection of crisis management and business resilience, particularly in the context of natural disasters and other unexpected global events. Future studies could explore the role of technology and innovation in crisis preparedness, as well as the impact of digital transformation on business recovery. Overall, the findings of this study are largely consistent with the existing literature, supporting the robustness of the results and demonstrating their alignment with previously established patterns and theories. This consistency not only reinforces the validity of the current analysis but also highlights its contribution to the broader understanding of the topic by offering additional insights and empirical evidence within the context studied.

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APPENDIX

SURVEY FORM

DATE:

This survey form was prepared for a research conducted on behalf of TÜBİTAK at the Department of Economics, Faculty of Economics and Administrative Sciences, Bakırçay University. The study aims to examine the extent to which the earthquake affected the performance of businesses and to determine the changes in the labor market, which is the final result of business performance. This scientific research has no administrative or political aspect.
Please do not write your name, surname or anything indicating your identity on the survey form.
There are 28 questions in this survey. Try to answer the questions with as many single options as possible.
In cases where you can give more than one answer, please do not exceed 3 options. Answering the questions completely, realistically and sincerely will contribute to the achievement of the purpose of this research.
Answer the questions by placing an X in the spaces in parentheses. Example: (X)
If the sections allocated for the answer are not sufficient and/or if there are no answers suitable for you, you can also use the empty sections of the survey form for the answer.
Thank you in advance for your valuable help and contributions with your answers to the questions.

Best regards

Assistant Professor Aslı DOLU — Project Executive

Dr. Hüseyin İKİZLER — Researcher

QUESTIONS

Part-1 Descriptive Statistics
1. What is your age?
l.( ) 15-20 between ages 2.( ) 21-30 between ages 3.( ) 31-40 between ages 4.( ) 41-50 between ages
5.( ) 51-60 between ages 6.( ) 60-65 between ages 7.( ) 65 Ages and above
2. What is the gender of the business owner/partners? (If there are partners, more than one mark can be made.)
1.( ) Female 2.( ) Male 3.( ) I Don't Want To Specify
3. Which industry do you think the business serves the most?
1.( ) Agriculture-Animal Husbandry 2.( ) Trade 3.( ) Services
4.( ) Manufacturing-Production 5.( ) Tourism 6.( ) Transportation
4. The first two numbers of your business's Nace Code, which indicates your field of activity in the Izmir Chamber of Commerce membership information system? (01-99)
.....
5. What is the status of your business?
1.( ) Individual Company 2.( ) Limited Company 3.( ) Joint Stock Company 4.( ) Collective Company
6. How many years has the business been in business?
1.( ) Less than 3 years 2.( ) 3-5 years 3.( ) More than 5 years
7. Graduation of the business owner/partners? (In case of partners, more than one can be marked.)
1.( ) University and above 2.( ) Secondary/High School Graduate 3.( ) Primary School Graduate and below
8. Number of people working in the business?
1.( ) Less than 10 2.( ) Between 10-49 3.( ) 50 and above
9. What is the average working time of employees in the company?
1.( ) Less than 6 months 2.( ) Between 6-12 months 3.( ) Between 2-3 years 4.( ) 3 years and above
Part-2 Earthquake Impact on Company Activities
10. Did you experience an earthquake while your company was still operating?

1.( ) Yes 2.( ) No (Please go to Question 17.)

In the table below, for each column (period information), select only one of the options for the relevant variables. For example, the survey can be answered by placing an X to indicate the option that the number of customers decreased by 40%-60% during the earthquake. Then, information on how activities changed in other periods can be entered for the same question.

Change in Company Activities	**Before the Earthquake**	**During an Earthquake**	**1 Week Later**	**After 1 Month**	**After 6 months**
11. Number of Customers?					
No customers came.					
It decreased by 60%-80%.					
It decreased by 40%-60%.					
Decreased by less than 40%.					
There was almost no change.					
12. Company Revenue?					
No income was generated.					
It decreased by 60%-80%.					
It decreased by 40%-60%.					
Decreased by less than 40%.					
There was almost no change.					
13. Company Production (Service delivery)?					
No production/service was performed.					
It decreased by 60%-80%.					
It decreased by 40%-60%.					
Decreased by less than 40%.					
There was almost no change.					
14. Number of Company Employees?					
The employees did not come.					
It decreased by 60%-80%.					
It decreased by 40%-60%.					
Decreased by less than 40%.					
There was almost no change.					
15. How long has the company been in operation?					
There was no change in the duration					

It decreased by 60%-80%.					
It decreased by 40%-60%.					
Decreased by less than 40%.					
There was almost no change.					

16. Will there be a change in your business's turnover during the outage? Can you estimate this change as a percentage of your usual turnover for a week?

.....

Part-3 Expectations Regarding Earthquake

17. What could be the impact on your business's revenue during an outage?

1.( ) Production cut 2.( ) Sales cut 3.( ) Penalties for non-compliance with contracts
4.( ) Increase in production costs 5.( ) Other effects on revenues

18. How long would you postpone your business investment decisions after the outage?

1.( ) I will not change the investment decision. 2.( ) I will postpone it for 1-3 months. 3.( ) I will postpone it for 3-6 months.
4.( ) I will postpone it for 6 months. 5.( ) I will cancel the investment decision.

19. What could be the impact on your business's operations during an outage?

1.( ) Disruption in company organization 2.( ) Workers' stress 3.( ) Decrease in the number of customers
4.( ) Endangerment of employees or customers 5.( ) Partial closure 6.( ) Damage to the company's reputation
7.( ) Order delay 8.( ) Other operational effects

20. Once operational, how long will your operations continue to be affected?

1.( ) 0 days 2.( ) A few days 3.( ) 1-2 weeks 4.( ) 2-4 weeks 5.( ) > 1 months

21. Over the course of a full year, what consequences could the outage have on your activity level?

1.( ) No effect 2.( ) Decrease in activity 3.( ) Increase in activity

22. Is your business dependent on municipal services (drinking water/electricity), ignoring the substitute solutions you have at your disposal (e.g. water tanks) to protect yourself against the risk of service interruptions?

1.( ) Yes, for production 2.( ) Yes, for sale 3.( ) Yes, for the supply chain
4.( ) Yes, for well-being at work 5.( ) Yes, for other reasons

23. How do you reduce the number of employees if there is a decrease in your activities after you are operational after the outage?

1.( ) I do not change the number of employees 2.( ) Paid Leave 3.( ) Unpaid leave 4.( ) Termination of employment contract

24. Do you believe that the business building is solid?

1.( ) Yes 2.( ) No

25. Do you expect a devastating earthquake in the next 30 years?

1.( ) Not possible 2.( ) Low probability 3.( ) Possible Possible 4.( ) Most likely

26. Do you expect a devastating earthquake in the next 10 years?

1.( ) Not possible 2.( ) Low probability 3.( ) Possible Possible 4.( ) Most likely

27. Do you expect a devastating earthquake next year?

1.( ) Not possible 2.( ) Low probability 3.( ) Possible Possible 4.( ) Most likely

28. How much damage do you think the business will suffer after a potentially devastating earthquake?

1.( ) Invulnerable 2.( ) Minor damage 3.( ) Moderate damage 4.( ) Serious damage

Demographic Information and Business Characteristics

In this section, information will be provided about the profile of business owners and officers (job description, age, gender, graduation status, etc.) and the characteristics of the business such as its sector, status, service period, and age of the building, because of the survey conducted on the companies.

	Company owner	Middle manager	Top manager	Total
21-30 years old	4.7	2.3	3.1	10.2

31-40 years old	18.0	5.5	1.6	25.0
41-50 years old	29.7	1.6	6.3	37.5
51-60 years old	16.4	0.8	1.6	18.8
60-65 years old	0.8	0.0	0.0	0.8
61-64 years old	4.7	0.0	0.0	4.7
65 years old and above	3.1	0.0	0.0	3.1
Total	77.3	10.2	12.5	100.0

	Male	Female	Total
Primary school graduate and below	**8.6**	**3.1**	**11.7**
Company owner	7.8	2.3	10.2
Senior manager	0.8	0.8	1.6
Senior/secondary school graduate	**39.1**	**18.8**	**57.8**
Company owner	29.7	14.1	43.8
Middle manager	6.3	1.6	7.8
Senior manager	3.1	3.1	6.3
University and above	**21.9**	**8.6**	**30.5**
Company owner	18.0	5.5	23.4
Middle manager	0.8	1.6	2.3
Senior manager	3.1	1.6	4.7
Total	69.5	30.5	100.0

	Incorporated company	Limited company	Sole Proprietorship	Total
Agriculture-Animal Husbandry	0.0	0.0	0.8	0.8
Manufacturing-Production	0.8	3.9	7.0	11.7
Services	1.6	5.5	12.5	19.5
Trade	0.8	7.8	58.6	67.2
Tourism	0.0	0.8	0.0	0.8
Total	3.1	18.0	78.9	100.0

Building Age\Business Activity Period	Less than 3 years	3-5 years	More than 5 years	Total
5-10	0.8	3.9	2.3	7.0
11-15	1.6	2.3	4.7	8.6
16-20	0.0	3.9	8.6	12.5
21-25	0.8	0.0	10.9	11.7
26-30	0.0	2.3	10.2	12.5
31 and above	3.9	6.3	37.5	47.7
Total	7.0	18.8	74.2	100.0

Average Working Time \ Company Size	Less than 10	Between 10-49	50+	Total
Less than 6 months	1.6	0.0	0.0	1.6
6-12 months	14.1	1.6	0.0	15.6
2-3 years	24.2	0.8	0.0	25.0
3 years and above	51.6	5.5	0.8	57.8
Total	91.4	7.8	0.8	100.0

Suitable for Remote Work\Company Operation Period	Less than 3 years	Between 3-5 years	More than 5 years	Total
Yes	0.8	0.0	6.3	7.0
No	6.3	16.4	66.4	89.1
Partially	0.0	2.3	1.6	3.9
Total	7.0	18.8	74.2	100.0