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Economic Effects of Earthquakes 1999 Marmara/Türkiye Earthquake Case

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ABSTRACT

Frequent earthquakes are a reality of Türkiye. It is crucial to be prepared for these earthquakes, take the necessary measures before the earthquake, and recover the losses quickly when an earthquake occurs. In this study, the literature about the economic effects of earthquakes is examined and the impact of earthquake on the Kocaeli province, the epicenter of the 1999 Marmara Earthquake, is analyzed. As an important indicator of economic activity level, the effects of the earthquake on the city's exports were examined with panel data regression covering the years 1996-2021 and 163 countries. The results of the regressions show that despite the large magnitude of the earthquake and the heavy losses, the economy of Kocaeli province recovered rapidly and returned to its export performance rapidly, even surpassing its previous performance in a short time.

Keywords: Türkiye, Earthquake, Kocaeli, Panel Data, Exports.

JEL Classification Codes: Q54, C33, O50

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INTRODUCTION

Many regions of Türkiye are placed on fault lines and earthquakes are frequent. Earthquakes cannot be prevented and predicted; it is necessary to take extensive measures in advance to minimize the possible damages. In the aftermath of the earthquakes, the most important issue is the rapid assessment of damage and the compensation of the losses.

In this study, the literature about earthquake's economic effects are examined and the impact on the Kocaeli province of Türkiye, the epicenter of the 1999 Marmara Earthquake, was analyzed.

The Marmara earthquake occurred on 17 August 1999 at 03:02, and its epicenter was Kocaeli/Gölcük/Türkiye. Its size was measured at 7.8 Mw (moment magnitude) It is one of the biggest earthquakes in the history of Türkiye, felt in a wide area as far as Ankara and in the whole Marmara Region. 18,373 people died and 48,901 people were injured due to the earthquake (SBB, 2023). Since the earthquake region is one of the most important industrial regions of the country, the economic losses caused by it were also very high. 285,211 houses and 42,902 workplaces were damaged in the earthquake (SBB,2023).

This article examines the effects of the earthquake on exports of Kocaeli city, an important indicator of the level of economic activity. For this purpose, two-panel data models were estimated; in the first cross sections are the countries Kocaeli City exports to between 1996-2021, and in the second cross sections are the sectoral exports of Kocaeli City in the same period. These regressions enable us to comment on both the market structure of the exports of the city and the sectoral composition of the export basket. To our knowledge, there are no econometric studies examining the effects of the 1999 earthquake on exports of Kocaeli city.

The results of our analysis show that despite the magnitude of the earthquake and the heavy losses, the economy of Kocaeli province recovered rapidly and returned to its export performance rapidly, even surpassing its former performance in a short time.

In the second part of the article, the literature on analysis methods of natural disasters, the studies on Türkiye's earthquakes, and the studies on policy suggestions for before and after earthquakes were examined. In the third part method of analysis, the data and results of the gravity regressions, and in the fourth part data, method, and results of sectoral panel data analysis were explained. The fifth part was devoted to evaluation and discussions. In the sixth part, concluding remarks were made.

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LITERATURE SURVEY

There are many factors to consider when examining the economic effects of earthquakes. Buildings, workplaces, machinery equipment, stocks of raw materials and finished goods, loss of labor and working days, and destruction of infrastructure are calculated as direct effects, while employment losses, migration, changes in business methods, environmental damage of cities affected by the earthquake, connections with cities, input-output relations are calculated as second-degree losses. The effects of the post-earthquake recovery process must also be taken into account. The data used in the analysis must be healthy and reliable. Likewise, the advantages and disadvantages of the analysis methods used should be considered.

Methods of Analysis

Basically, 4 analysis methods are used to analyze the economic effects of earthquakes and other disasters:

Econometric models: In the regression models in the literature, the effects of the disaster are estimated with the disaster dummy variables, usually by establishing export panel equations (where cross sections are countries) of the affected region. Gravity models are frequently used for this purpose (Oh and Reuveny 2010, Hadri, Mirza and Rabaud 2018, Dadakas ve Tatsi 2021). The studies show that disaster has negative effects on exports and imports. Hadri, Mirza, and Rabaud (2019) found that the effects were similar for low-income, high-income, large, or small countries, while Oh and Reuveny (2010) found that negative effects were stronger in small countries and countries with autocratic rule. Hayahsi (2012) estimated the log-linear panel model using risk and vulnerability factors as explanatory variables; used the model to estimate the economic damage of the March 2011 North East Haponia Tsunami and earthquake, showing that the actual damage could be twice as much as the government's estimate. Dadakas ve Tatsi (2021) examine the global agricultural trade impact of the 2011 triple disasters in Japan, earthquake, tsunami, and nuclear accident in Fukushima employing the panel gravity model. The authors find that the disasters had negative effects on both exports and imports and these effects were extended up to 2014.

In addition, difference in differences models are also widely used models. Jalan (2022) examines the effects of the 2004 Indonesian tsunami on tourism and GDP using a panel difference in differences model. The analysis results show that the tsunami did not affect the GDP growth rate of the countries exposed to the tsunami, but after the disaster tourists visiting these countries increased (which can be explained by the possibility of disaster tourism, dark tourism, and blue tourism) and this led to a rise in tourism revenues. Ayumu (2015) examined the effects of the earthquake in Hanshin-Awaji on the growth of factories in Kobe employing the difference in differences method. Pagliacci and Russo (2019) examined the effects of the Emilia-Romagna earthquake that took place in 2012 in Italy using the difference in differences method. The authors concluded that some Regions and some Municipalities within it performed better.

The disadvantage of econometric models is that it takes years to form the time series after the disaster. Although econometric models have predictive capacity, they are also criticized for needing large data sets and not being able to distinguish between direct and secondary effects (Rose and Guha, 2004; Aloughareh, Ashtiany, and Nasserasadi, 2016).

This study also employed econometric techniques of gravity analysis and sectoral panel export analysis. A frequently cited disadvantage of econometric models is that it takes years to form the time series after the disaster is not a problem for this study. Since in this article the effects of the earthquake on exports of Kocaeli after 26 years were examined, there is enough data to constitute a big enough panel for analysis. Also, the criticism for econometric models about not being able to distinguish between direct and secondary effects is not a problem for our purposes since the aim of the study is to observe the total direct and secondary effects of the disaster on the exports of the city, without concentrating on which part are due to direct and which part are due to secondary effects.

Input-output models are important in terms of revealing intersectoral links such as raw material-final product and imported input. Some studies integrate input-output models with engineering models and transportation networks (Sohn, Hewings, Kim, Lee, Jung 2004; Cho, Gordon, Moore, Richardson, Shinozuka and Chang, 2001). The disadvantage of input-output models is that up-to-date data is often not available, since data collection takes a long time. In addition, input-output analyses are criticized for being rigid against input and import substitutions, uncertain resource constraints, unresponsive to price changes (Rose and Guha, 2004), and therefore overestimating economic effects (Aloughareh et al., 2016).

General equilibrium models (CGE): General equilibrium models eliminate many of the disadvantages of input-output models by being sensitive to price changes, considering input and import substitutions, and taking into account supply constraints (Aloughareh et al., 2016). However, CGE models are generally amenable to long-term analysis, and the flexible adjustment feature often underestimates economic effects; it also needs a lot of data, and that much data is often not available (Aloughareh et al., 2016). Selçuk and Yeldan (2001) analyze the effects of the 1999 Marmara earthquake on the Turkish economy using the CGE method. Xie, Rose, Shantong, Jianwu, Ning, Tariq (2018) examine the effects of dynamic economic resilience factors on the recovery efforts after the 2008 Wenchuan earthquake with the CGE method.

The social accounting matrix (SAM) is mostly used to measure secondary effects. These are the methods generally used by researchers interested in regional sciences and socio-economics (Cole; 1998, 2004; Aloughareh et al., 2016).

Studies Examining Earthquakes in Türkiye

There are few studies examining the effects of earthquakes in Türkiye. Selçuk and Yeldan (2001) examined the GDP impacts of the 1999 Marmara earthquake with a general equilibrium model, in which the neoclassical growth theory formed the analytical basis of the intertemporal dynamics. They estimated the possible GDP impacts of various policy scenarios. The results of the analysis show that the initial GDP effects of the earthquake will vary between 4.5% contraction and 0.8% growth in GDP, depending on the results of government policies. The authors' policy recommendation from the results is that the government should compensate for the capital losses of the sectors with a negative indirect tax (a subsidy funded by foreign aid). On the other hand, financing the increase in government expenditures caused by the earthquake by imposing additional indirect taxes is not recommended as it will cause production losses.

Durukal and Erdik (2008) make a comprehensive analysis of the effects of the 1999 Marmara earthquake on the Kocaeli city. The authors examined the physically damaged industrial facilities and job losses in the region in detail and conducted surveys and damage assessments. In the article, the effects of the earthquake on the industrial sectors due to the interruption of buildings, machinery and equipment, stocks, and production were estimated. Kocaeli is a city where Türkiye's heavy industry facilities are densely located; 15.3% of Turkey's manufacturing industry production is carried out in the city. There are many factories and production facilities in petrochemicals, automobiles, motor vehicles and railway vehicles, base metals, synthetic yarn, paint, rubber, paper, iron-steel, pharmacy, sugar, cement, and energy. 345 out of 1062 members of the Kocaeli Chamber of Industry report that they have been damaged by the earthquake. Durukal and Erdik (2008) present a detailed balance sheet of the loss.

Özceylan and Coşkun (2012) analyzed the 2011 Van earthquake within the framework of the concept of vulnerability. The vulnerability index is calculated using various socio-economic indicators like migration from the countryside, urbanization, construction permits, healthiness of growth, the age structure of the population, average household size, adequacy level of health services, level of national income per capita, adequacy of accommodation alternatives (Özceylan and Coşkun, 2012).

Immediately after the Marmara earthquake, the World Bank (1999) evaluated the earthquake's economic effects and the costs of rebuilding with a team of experts and academicians and made policy recommendations for the prevention of future disasters. WB estimates 3-6.5 billion dollars (1.5%-3.3% of GDP) loss of wealth due to the devastation in the earthquake, and 0.6%-1% of GDP was projected to shrink due to the indirect consequences of the earthquake (1.2-2 billion dollars). The Bank estimated that at least some of this GDP loss would be offset by production elsewhere in the country, and rebuilding activities in 2000 to push GDP one percentage point above previous estimates. WB predicted that the current account deficit would increase by 1.5% ($3 billion) of GDP in the 1999-2000 period, above the baseline estimate, largely due to the increase in construction activities (World Bank, 1999). The government's post-earthquake policies were praised for giving confidence to the markets, signaling that fiscal and monetary discipline would not be abandoned.

OECD (2000) provides detailed information on the effects of the 1999 Marmara earthquake in many areas. The earthquake region is the heart of Turkish industry and if we include Istanbul, one-third of Türkiye's GDP is produced in this region. The region's income per capita is almost twice the Turkish average; although only 4% of Turkey's population lives in the area, its contribution to budget revenues is 16%. The report states that large-scale migration movements started after the earthquake. SMEs provided shelter, health support, etc. to their employees in order not to lose their qualified personnel and this has been a working solution in many workplaces. It is observed that workshops and other micro-enterprises with up to 10 employees are among the sectors most affected by the earthquake. Many of them lost their workplaces on the ground floors of the buildings, their working capital disappeared; and family members, many of whom were employees, died. OECD (2000) predicted that 20-50% of all employment would be completely lost as a result of the earthquake. The report estimates that the negative effect of the earthquake on GDP will be around 2-2.5% in 1999, but GDP will rise 1.5% above the baseline estimate in 2000 due to reconstruction activities.

Aktürk and Albeni (2002) examined the economic effects of the 1999 Marmara earthquake. The following information, quoted by the author from TURKSTAT, is important: "Out of 889 workplaces whose production capacity was affected in the manufacturing industry, 364 reached their normal production capacity in 16 days, while 521 reached their normal production capacity in an average of 18 weeks" (Aktürk and Albeni, 2002, 7). Again, the following summary information given by the authors can give an idea about the budgetary effects of the earthquake: "The total loss of resources or income transferred by the public sector to the earthquake zone in 1999 is 1774 million dollars (1 percent of GNP); For the year 2000, it is 3796 million dollars (1.7 percent) (Aktürk and Albeni, 2002, 7).

When after data was observed, it is seen that GNP of Türkiye declined by 6,1% in 1999 and recovered in 2000 by a growth rate of 6,3%. So, downturn was bigger that what many studies expected but next year economy was quickly recovered.

DPT (1999) analyzed the various dimensions of the damage with the first data obtained in the first months immediately following the earthquake. In their damage/loss analysis, in addition to the damaged buildings, machinery equipment, finished goods, and raw material stocks, the losses caused by stopping production for a certain period were also tried to be estimated.

Şahin (2020) examines the legal and administrative infrastructure of disaster management in Türkiye. It evaluates the responsible institutions in this field, the legislation, and the strategy documents created.

There are no econometric studies examining Türkiye cases of how earthquakes affect the economics of the disaster region and how they recover after the disaster. This article aims to fill in this gap. Although 26 years passed since the Marmara Earthquake it is worth studying since "the Marmara earthquake is considered one of the largest earthquakes of the last century in terms of magnitude, the extent of the affected area, and material losses" (SBB, 2023, 23). The earthquake hit cities that are the industrial heart of the country. Türkiye is a country on many fault lines; earthquakes occur frequently. Examining the effects of past earthquakes and the recovery process of the economy of the affected regions after the earthquake would help policymakers make plans to ensure the country's resilience to disasters. In Türkiye, two even bigger earthquakes of magnitude 7.7 M_w and 7.6 M_w occurred in 6th February 2023 and 20th February 2023 in Kahramanmaraş (in fact, the biggest earthquakes in the history of Türkiye Republic), which should also be studied from many perspectives. However, since it occurred a very short time ago, there is not enough data to study after effects econometrically.

Studies on Policy Suggestions for before-Earthquake and after-Earthquake

Earthquakes cannot be predicted or prevented. Taking precautionary measures before the disaster and after an earthquake occurs to ensure quick recovery requires sound policies. There is a large interdisciplinary literature on the subject.

Dalziel and Saunders (2012) state that when assessing whether regional economic strategies need to be changed after the earthquake, two issues need to be considered: i) did the earthquake change the key strengths and opportunities that are the main drivers of economic development of the region?, ii) will short-term effects of the earthquake, including the transition path of adoption in the process, have long-term effects on the development of the region (hysteria effect)? (Dalziel and Saunders, 2012, 119)

The concept of vulnerability/resilient city emerges as an important concept in the formulation of policies before and after earthquakes.

Ergünay (2009) defines vulnerability as follows:

> It is defined as "the probable measure of damage or harm that a community, structure or service may suffer when danger occurs". In other words, vulnerability can also be defined as "the measure of physical, social, environmental or economic losses and damages that an element or group of elements exposed to danger (such as human, structure, life, socio-economic order) may experience in case of danger"... Mathematically; we can also express disaster risk as Risk = Danger x Assets x Vulnerability." (Ergunay, 2009, 5-6).

Vulnerability/resilient city concepts have come to the agenda of Türkiye and the world, especially in recent years.

> "In the "Making Cities Resilient: My City is Getting Ready" campaign, launched in 2010 by the United Nations International Strategy for Disaster Risk Reduction, the resilient city was defined as "a transparent local government with public contributing to planning, providing adequate infrastructure, have the ability to reduce disaster risks through planning, took steps to predict disaster and protect their assets, minimizing physical and social losses in extraordinary conditions, have the ability to self-regulate before, during and after a disaster, quickly repair basic services after disaster, and a system that can continue its social, institutional and economic activities" (quoted from UNISDR, 2010: 14; Hayrullahoğlu et al., 2018).

Weichselgartner (2001) says that vulnerability includes the ancient characteristics of society; these are mainly preparedness and preventive measures, post-disaster actions, and recovery capacity.

Hayashi (2012) used three variables as an indicator of vulnerability in his regression analysis: i) private capital stock and social capital per capita, ii) the proportion of the region's population aged 15 years and younger (assuming that recovery will be faster in regions with younger populations), iii) The ratio of post-disaster rescue and rehabilitation expenditures to public total investments in the region. The author also draws attention to the importance of the savings rate per household, the unemployment rate, the share of forest and flood control investments in total public investments, and population density.

The variables frequently used in the calculation of vulnerability to disasters in the vulnerability literature include population density, migration rate, average household size, public awareness, safety and health conditions, social equality, population below the poverty line, home ownership, average housing value, average rent, unemployment, female employment rate (Özceylan and Coşkun, 2012).

One of the main elements of a city to be a disaster-resistant city is to return the city to its normal life as quickly as possible after the disaster; for this, the infrastructure of the city should be prepared for disasters; damage to the infrastructure deepens the disaster damage experienced by the city and leads to the cessation of life in the city (Hayrullahoglu, Aliefendioğlu and Tanrıvermiş, 2018). Great importance should be given to the soundness of transportation networks before the earthquake, and the maintenance of main arteries, public transportation networks, bridges, and viaducts should be done periodically (Hayrullahoğlu et al., 2018). The city's drinking and utility water, sanitary installation, energy, communication, and transportation infrastructure should be sound, the buildings should be suitable for earthquakes, public buildings should be kept safe and able to serve in the event of an earthquake, as they will be used as assembly and service areas during and after the earthquake; special attention should be given to health and education structures, military structures and parks with large areas (Hayrullahoğlu et al., 2018).

Durukal and Erdik (2008) draw attention to the necessity of paying special attention to the dangers of the spread of substances harmful to human health, which may cause environmental pollution. The spread of chemicals and other harmful substances emitted from various production facilities after a disaster, out of control, can become another disaster by causing environmental pollution, fires, and damage to human health.

Hayrullahoglu et al. (2018) within the framework of the resilient city approach draw attention to the importance of the state's cooperation and harmony with non-governmental organizations, academia, the private sector, and the public; ensuring inter-institutional coordination, and clearly defining everyone's duty. Peker and Orhan (2020) emphasize that the inclusion of climate and earthquake components in local-scale urban planning as well as national and regional plans and policies has become a necessity.

OECD (2000) states that for safe houses there is a need for a well-established insurance system and for insurance premiums to be adjusted according to risk.

Padli, Habibullah, and Baharom (2010) display that the national income of the country has a significant impact on the economic effects of natural disasters; citizens of rich countries are better prepared for disasters; therefore, the impact of disasters is also smaller. Similarly, Felbermayr and Gröschl (2014) show that the negative effects of natural disasters on GDP are strong and state that poorer countries are more affected by geographical disasters.

Jalan (2022) argues that the growth effects can even be positive in the long run if restructuring after a natural disaster is done by establishing a better capital stock and adopting newer technologies. Hallegatte and

Dumas (2009) state that the "productivity effect" may occur due to the rapid loss of capital stock because of a natural disaster; technological change will not be able to turn a disaster into a positive event, but the quality of post-disaster reconstruction can reduce the cost of the disaster. Cuaresma, Hlouskova, and Obersteiner (2008) examine the long-term effects of replenishing the post-disaster capital stock and conclude that only developed countries can benefit from it. Cheng and Zang (2020) state that economically stronger countries suffer less from disasters and recover faster after disasters.

Peker and Orhan (2020) draw attention to the importance of the city's growth in harmony with its geography:

> The natural resources in the geography where the city is located should be determined as the thresholds of the carrying capacity and development boundaries of the city. In terms of climate crisis, protection of water and soil resources, and in terms of earthquake risk, defining the habitability limits in areas with suitable ground conditions gain importance… Creating air corridors in the city with open and green space systems, increasing water absorption surfaces, providing thermal comfort with microclimatic effect, constituting pharynx areas, increasing surface permeability is possible. On the other hand, these areas can take on roles such as creating assembly areas during an earthquake, gathering together in an emergency, distributing aid and ensuring the flow of information." (Peker and Orhan, 2020, 7).

Peker and Orhan (2020) propose the establishment and dissemination of renewable energy systems that can produce energy independently of the urban infrastructure network as a policy proposal that will increase the resilience of cities in the face of earthquake risks. This will enable the city to benefit from clean energy and will be able to respond to emergency energy needs immediately after the disaster, as it will be independent of power units that are interrupted in disaster situations.

Essentially, environmental policies and disaster management policies should go hand in hand. Policies for one area will often give support to the other. For example, creating green areas in the city, making bicycle paths, making clean energy investments, and avoiding narrow streets and high-rise apartments in the city will help alleviate environmental problems and reduce the damage caused by earthquakes (Peker and Orhan, 2020).

GRAVITY EQUATION FOR THE EXPORTS OF KOCAELI

Literature on Gravity Equations

In this study, panel data analysis for the exports of Kocaeli province, the epicenter of the 1999 Marmara Earthquake, on the basis of countries, between the years 1996-2021 is performed. The gravity model was used in the analyses.

Gravity models are inspired by Newton's universal gravitation law. The law says that the attraction between two masses is directly proportional to the weights of the masses and inversely proportional to the square of the distance between them. This has been applied to trade movements between countries; trade between two countries is expected to be directly proportional to the economic size of the countries (to represent the mass; measured usually by national income) and inversely correlated with the distance between the countries. The theory, which was first put forward by Tinbergen (1962) and Poyhonen (1963), has been widely used since then to measure the effects of trade flows and trade agreements between countries. Over time, the theoretical bases of the models were proven and the gravity equations were extended to include populations of each trading partner, tariffs, prices, institutional factors like economic freedom level and trade restrictiveness of the partners, dummy variables for the effects of geographical, cultural and institutional factors like common border, language or religion on trade. For a comprehensive review of the gravity literature, Head and Mayer (2013) can be seen.

Almost all of the gravity export models in the literature use the national income (or per capita income) of the two countries, their populations, the distance between them, and price indicators (real exchange rate, import/export unit prices, CPI, etc.) as independent variables of the export gravity regression (Westerlund and Wilhelmsson, 2011; Nardis, 2008; Rojid, 2006; Harb, 2007; Kien, 2009; Bhattacharya and Wolde, 2010; Abiad et al., 2011; Tumbarello, 2007; Bussiere et al., 2008; Ekanayake and Ledgerwood, 2009, Tamaş ve Miron, 2021). The difference in GDP per capita of the two countries (Trotignon, 2010, Saputra, 2019), trend and cyclical parts of GDP (Abiad et al., 2011), domestic demand (Abiad et al., 2011), relative GDPs of trading partners and relative factor densities (measured by the difference in national income per capita) (Egger, 2002; Zarzoso and Lehmann, 2003, McPherson and Trumbull, 2008) are among the other independent variables used. National incomes of both exporting and importing countries are positively affecting exports in nearly all studies, as expected. Greater national income usually means greater production capacity and more variety of the goods produced (from the perspective of the exporting country) and greater purchasing power (from the perspective of the importing country) thus having a positive effect on exports.

Distance is expected to reduce foreign trade by increasing transportation costs. Since data on direct transportation costs are not generally available, distance is used as an approximate indicator in many studies. However, distance is not an adequate indicator as it does not take into account border trade between countries, difficulties arising from the country's transportation infrastructure or geographical shapes (mountains, access to seas, etc.), and bureaucratic costs related to transportation. Abiad et al. (2011) and Bhattacharya and Wolde (2010) defined a dummy variable that indicates whether a country is landlocked or not, and take into consideration the disadvantaged position of landlocked countries in terms of transportation. Zarzoso and Lehmann (2003) added the public infrastructure investments to the model by measuring them with the public capital stock and road network.

Endoh (1999) pioneered the approach of using dummy variables to see the trade creation and trade diversion effects of free trade agreements and trade blocks and then this approach also followed by many studies like Rojid (2006), Kien (2009), Tumbarello (2007), Bhattacharya and Wolde (2010), Horsewood and Voicu (2012), Soeng and Cuyvers (2018), Khati and Kim (2023), Islam et al. (2024).

Among the other dummy variables used to represent cultural, geographical, and political affinities between countries, the most frequently used ones are common language and common border (Abiad et al., 2011; Tumbarello, 2007; Rojid, 2006; Kien, 2009; Bhattacharya and Wolde, 2010; Bussiere. et al., 2008; Trotignon, 2010; Ekanayake and Ledgerwood, 2009, Kamel 2021, Tamaş & Miron, 2021, Islam et al. 2024). There are studies that include the common currency in the model as a dummy variable (Nardis et al., 2008; Abiad et al., 2011; Trotignon, 2010). These variables are expected to affect the trade between countries positively by decreasing social distances, easing communication, and doing business between the countries.

In gravity models economic crisis periods are also usually represented by dummy variables and their coefficients measure how much trade was affected by these crises (Kamel, 2021, Neyaptı et al. 2007, Akkemik and Göksal 2010). Kamel (2021) in her study examining trade relations among the Middle East North African countries by gravity model, defines a dummy variable taking the value of 1 for the Arab Spring period for affected countries in MENA, to account for the effects on trade of this political and social turbulence period. She also defines dummy variables for wars and conflict periods in the MENA region. Hadri, Mirza, Rabaud (2019) use gravity equation to estimate effect of disasters on exports of the countries, including in the equation variables indicating intensity of four types of disasters (floods, storms, earthquakes, extreme temperatures) experienced by various countries in various times. Dadakas and Tatsi (2021) explore the effect of global agricultural trade impact of the 2011 triple disaster in Japan (earthquake, tsunami, and nuclear accident in Fukushima) by employing a panel gravity model and defining dummy variables for the disaster periods.

In this study, with a similar approach, the earthquake was represented by using dummy variables. Earthquakes are also a kind of crisis to the production and export structure of the region; it is an unexpected adverse shock affecting factories, suppliers, and employees.

There are many studies examining Türkiye's export and import data with gravity models. Lehman, Herzer, Martinez-Zarzoso, and Vollmer (2007) make panel data analysis of sectoral exports from Türkiye to European Union countries between 1988-2002. Neyapti, Taşkın, Üngör (2007) estimated the import and export equations of Türkiye's 150 trading partner countries using panel data between 1980 and 2001. Adam and Moutos (2008) measured the effects of the Türkiye -EU Customs Union on both Türkiye and EU-15 countries in the gravity equation involving OECD countries. The data set covers the years 1988-2004. Akkemik and Göksal (2010) examined Türkiye's exports to 110 countries between the years 1990-2006. In addition to the classical gravity variables, the authors also added China's exports in each market as a variable to measure whether Türkiye's export markets were adversely affected by China's exports. Suvankulov and Güç (2012) examined the exports of China, Russia, Iran, India, and Türkiye to Central Asian countries with a panel data set containing 165 countries and the years 1996-2009. Bayar (2014) analyzed Türkiye's exports to developed countries and Middle East and North African countries between 1993 and 2012 with two separate panel data gravity models and analyzed both the differences between estimation methods and regions. Bilgin, Gözgör, and Demir (2018) analyze the determinants of exports of Türkiye to 43 member countries of the Islamic Development Bank for 1996 –

2015, using the panel gravity method. The authors also try to measure the effect of political risks, in addition to classical gravity variables. Akçay and Saygılı (2019), for 1996-2015 estimated the panel gravity model of Türkiye's exports and examined the effects of regional economic organizations on exports.

This is the first study in the literature using gravity model in analyzing the effects of a disaster in Türkiye.

Zero Problem and Estimation of Gravity Models

In the estimation of many gravity models, there is "zero problem"; that is presence of zero trade flows between some countries in some periods. Gravity equations are usually estimated in logarithmic form since in logarithmic form heteroscedasticity problem is decreased. Also, since estimated coefficients give elasticities; interpretation gets simpler. But the logarithm of zero is undefined; so, in gravity models where there exist zero trade flows, logarithmic transformation cannot be used. Some economists tried to deal with this problem by excluding zero trade flows or adding a very small number to zero observations or using a Tobit estimator but these methods can cause biases in estimations since usually "zero observations" are not distributed randomly. They usually correlate with dependent and explanatory variables of the gravity model, for example, national income, distance, or various types of trade costs. Moreover, as Silva Santos and Tenreyro (2006) indicated, even in the case of the non-existence of "zero observations", if the gravity model was estimated in logarithmic form, the dependent variable estimated is not the trade, it is the logarithm of trade; because as Jensen's inequality says ($E(\ln y) \neq \ln E(y)$), estimation becomes biased. Also, even without any zeros in the data, the OLS estimator of the model in logarithmic form is inconsistent since the error term's logarithm will depend on the data's higher moments, like the variance of it and if heteroscedasticity exists, the explanatory variables and the expected value of the error (in logarithm) can be correlated (Silva Santos and Tenreyro 2006). To account for these problems, various estimation methods were developed (For a survey of the methods used, see Bacchetta et al. 2012, Shepherd 2016, Bayar 2018).

Heckman (1979) is the leading study on the problem. Heckman (1979) emphasizes "sample selection bias"; when a sample is selected if there are omitted observations if they are non-random and if they are correlated with the error term or the regressors; estimations must account for this correlation, otherwise, coefficients will be biased. If zero observations were simply removed from the data, an important variable of "the probability to be included in the sample" (that is, in a gravity model, the probability that there is positive trade relation between the countries), is omitted and this causes omitted variable bias. In a gravity model, if zero observations were omitted, the dependent variable ceases to be "bilateral trade"; it becomes "bilateral trade given that a trade relationship exists". Heckman (1979) suggested a two-equation estimation model as a solution to these problems. In the first equation, the probit model of being included in the sample (in gravity models probability of having a positive trade relation) was estimated. After that, probabilities estimated from this equation were used as independent variable in the main equation (in gravity, trade equation) thus probability of being included in the sample is accounted for and omitted variable bias was prevented. Those two equations can be estimated simultaneously employing maximum likelihood methods or a two-step estimation procedure can be used.

Silva Santos and ve Tenreyro (2006) show that if the model is estimated in multiplicative form, it is possible that both zero observations can be included and biases are avoided. Since data is in multiplicative form, non-linear estimation techniques need to be used. Authors show that the use of Poisson Pseudo Maximum Likelihood gives the best unbiased results; even if there is heteroscedasticity and even if data is not Poisson distributed. Also, the inclusion of importer and exporter fixed effects is possible in this method. Another benefit of the Poisson Pseudo Maximum Likelihood method is that although in the Poisson regression, the dependent variable is specified in its levels (instead of in logarithms, due to the existence of zero observations in gravity models), coefficients of the independent variables entering into the equation in logarithms can still be interpreted as elasticities (Shepherd 2016). Silva Santos and ve Tenreyro (2009) also wrote the code of PPML estimator for the econometrics package Stata (name of the command is ppml) in an effort to handle convergence problems appearing in the Poisson estimation (if the regressand variable has many zeros, has too large values, or if the independent variables have different scales, include many dummy variables or there is high collinearity among them).

Shepherd (2016) makes a comparison between Poisson and Heckman estimation methods. Poisson method deals effectively with heteroscedasticity but the Heckman model cannot. Fixed effects Poisson models have desirable statistical properties while in the Heckman model fixed effects cause incidental parameters problems, thus bias and inconsistency, in the

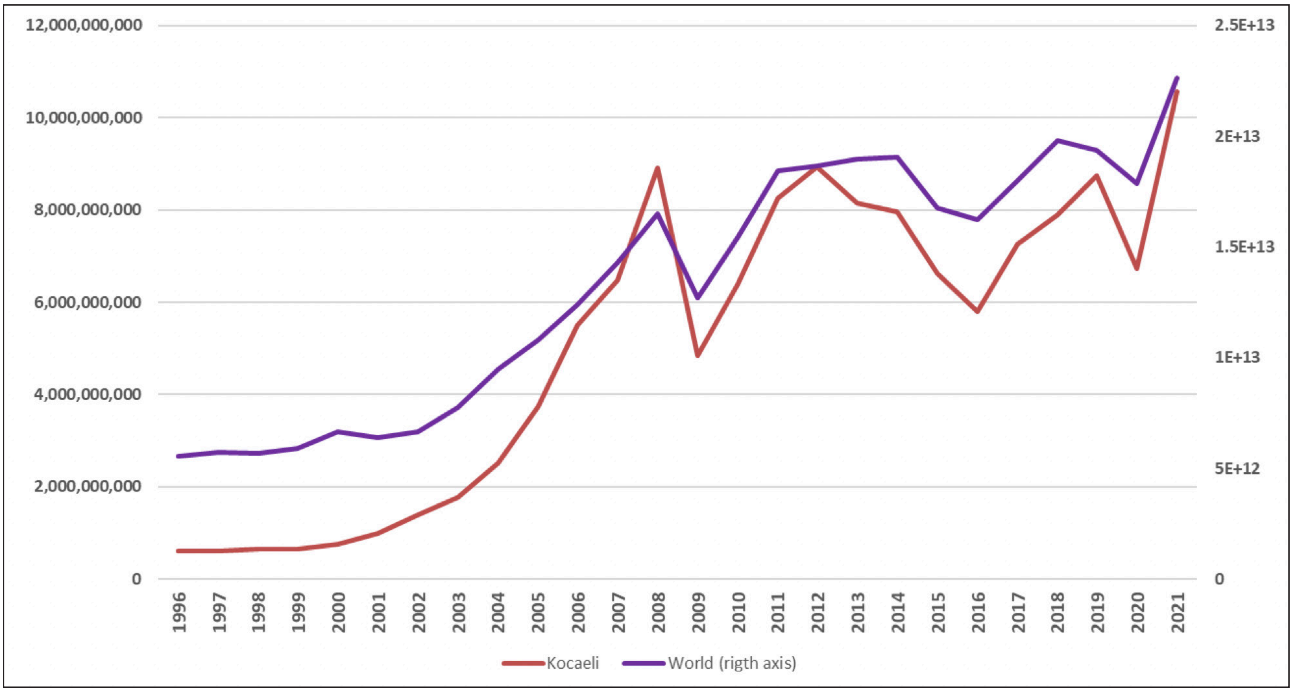

Figure 1: Kocaeli's Exports and World Imports
Source: TURKSTAT and World Trade Organization

probit selection equation. Although Heckman's model allows for a separate data generating process for non-zero and zero observations, Poisson's assumption is that all data are drawn from the same observation (Shepherd, 2016). Heckman model retains another advantage of including in the model explicitly the information the zero observations have. Overall, Shepherd (2016) concludes that in gravity models, Poisson is more commonly used as a workhorse estimator; mostly since even under relatively weak assumptions it produces consistent estimates, deals effectively with heteroscedasticity, consistent in the existence of fixed effects (which may be included in the form of dummy variables), includes zero observations naturally and without any additions to the basic model.

In this article also PPML model is used to estimate the gravity equation of exports of Kocaeli City. Estimations were done also using fixed effects and random effects OLS, Hausmann-Taylor, and Heckman models but the main results do not differ much[1].

Data

Kocaeli's exports increased from 616.7 million dollars in 1996 to 12.5 billion dollars in 2022. Figure 1 shows Kocaeli's exports (current dollars) and world imports (second axis, current million dollars). The export of the province shows an increasing trend above the rate of increase of world imports. During the crisis years of world trade, the export of the city is also decreasing. While the share of Kocaeli in world imports was around 0.01% in 1996, it increased to 0.047% in 2022. From the visual inspection of Figure 1, it is seen that the exports of the province continued to increase from 1999 to 2000, and even increased the rate of increase in the following years post-earthquake.

Figure 2 shows the shares of the top 10 countries which Kocaeli exports the most. The Netherlands has the highest share of Kocaeli's exports with 12.7%. It is followed by the Republic of South Africa with a share of 11.1% and the USA with a share of 10%.

The panel gravity model of Kocaeli city was estimated using export data of Kocaeli to 163 countries whose statistics are available between 1996-2021. Yearly data were used due to data availability problems. One of the most important variables of gravity analysis is the national income of trade partners and national income data is not available for many countries at higher frequency than annual (quarterly or monthly). Also, the reason for not going to years before 1996 is due to data availability reasons; difficulty of obtaining a consistent time series of the variables before 1996 for many countries. However, these data limitations do not affect the main purposes of the analyses adversely, 26 years and 163 cross-sections give enough degrees of freedom for reliable analysis.

1 Results can be requested from the author.

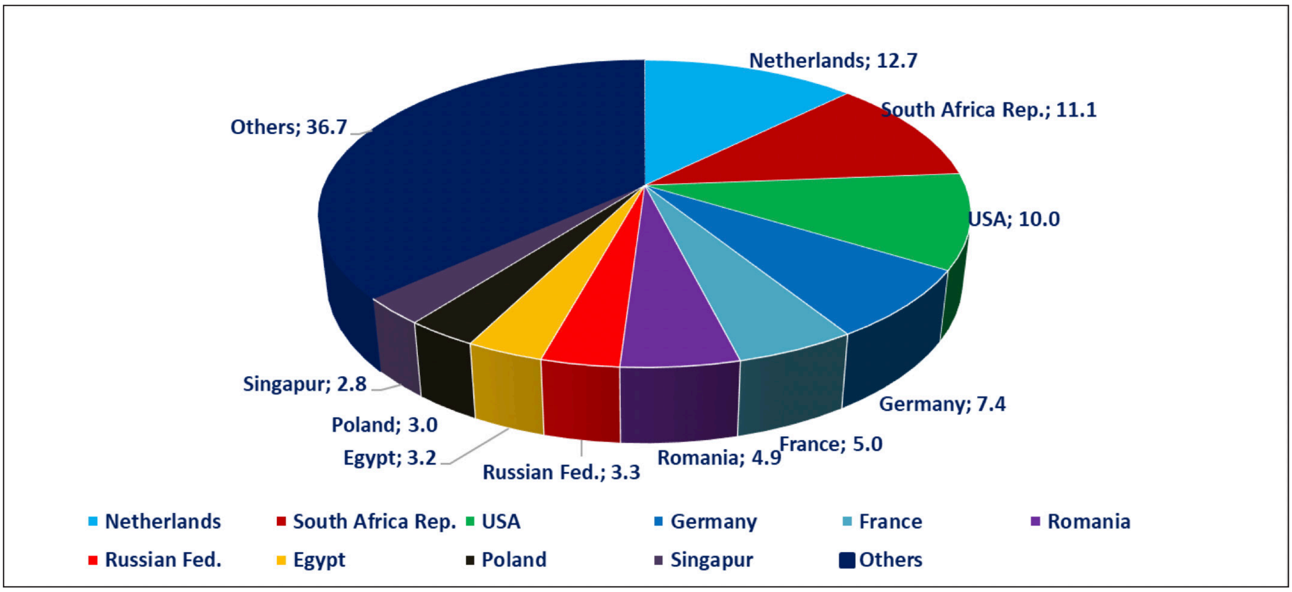

Figure 2: First 10 Countries in Exports of Kocaeli (2022)

Source : TURKSTAT

$$\mathrm{RealExp}_{\mathrm{it}} = \beta_0 + \beta_1 \mathrm{lnGDP\_TradePartner}_{\mathrm{it}} + \beta_2 \,\mathrm{lnDistance}_{\mathrm{it}}$$
$$\beta_3 \,\mathrm{lnKocaeliRGDP}_{\mathrm{it}} + \beta_4 \mathrm{Dummy\_CU}_{\mathrm{it}} + \beta_5 \mathrm{Dummy\_Border}_i$$
$$\beta_6 \mathrm{Dummy\_FTA}_{\mathrm{it}} + \beta_7 \mathrm{lnTR\_Rexch}_t + \beta_8 \,\mathrm{DummyEQ}_i + \beta_9 \,\mathrm{Trend}_t$$

RealExp is exports of Kocaeli in current dollar value, deflated by the export unit price index; taken from TURKSTAT (Turkish Statistical Institute). lnGDP_TradePartner is the real GDP of trade partners of Kocaeli (in constant 2015 dollars) and taken from the World Bank database; in logarithmic form. Ln_distance is the log of distance; taken from CEPII, Mayer, and Zignano (2011); calculated using longitudes and latitudes of the most important cities/agglomerations (population-wise) of the countries. In Türkiye this city is İstanbul. Since İstanbul is very near to Kocaeli city, this works as a good proxy for the distance between Kocaeli and its trade partners. As an indicator of the level of economic activity in the City, the real GDP of the city was included; again TURKSTAT data. Türkiye entered into customs union (CU) with EU countries in 1996; so, in the regression, a dummy variable showing whether the trade partner is a customs union member or not was included to see whether Kocaeli exports more to CU member countries. Türkiye has several free trade agreements and so a dummy variable for FTA was included to represent these. A list of countries and entering into force dates of FTAs were obtained from the Türkiye Ministry of Trade web page.

In Türkiye exports have an increasing trend; so, a trend variable was also included to account for it. Border dummies were defined for neighbors of Türkiye (Syria, Iran, Iraq, Azerbaijan, Georgia, Bulgaria, and Greece) to see whether Kocaeli has more intense trade relationships with border neighbors of Türkiye. The real exchange rate of Türkiye is from calculations of the Türkiye Republic Central Bank. Real exchange rate calculations of the Central Bank are based on trade shares of 36 countries comprising 80% Türkiye's total trade in the period 2006-2008. The series takes 2003 as the base year. The rise in the series of real exchange rates shows the appreciation of the Turkish lira. CU dummy is later eliminated from the regression since its coefficient is statistically insignificant. To check for the effects of the 1999 Marmara Earthquake a dummy variable taking values of 0 up to 1999 and 1 beginning from 2000 was defined (DummyEQ).

Gravity Regression Results

The resulting PPML estimation of the equation is given in Table 1:

Coefficients of the variables in logarithms are interpreted as elasticities as mentioned before. Thus, results show that as the GDP of the city increases by 1%, exports of the city increase by 0.71%. The GDP of trade partners is also another important factor in exports of the city, as expected. As the GDP of trade partners increases by 1%, exports of the city increase by 0.65%. Again in line with the expectations, Kocaeli exports less to more distant countries; as distance increases by 1%, Kocaeli's exports decrease by around the same percentage. Kocaeli exports more to border neighbors of Türkiye and to the countries that have free trade agreements with Türkiye. The positive trend of exports is seen from the significantly positive coefficient of the trend variable.

Table 1: PPML Estimation Results

Number of Observations: 3874 *Pseudo log-likelihood: -6.501e+08* *R-squared: .44466965*						
Vari.	***Coeff.***	***Robust St. Err.***	***z***	***P>|z|***	***[95% Confidence- Interval]***	
ln_GDP_TradePartner	0.653	0.025	25.76	0.000	0.604	0.701
ln_Distance	-1.018	0.040	-25.24	0.000	-1.097	-0.939
ln_KocaeliGDP	0.714	0.401	1.78	0.075	-0.072	1.492
Dummy_Border	0.385	0.123	3.12	0.002	0.143	0.626
Dummy_FTA	0.462	0.185	2.49	0.013	0.098	0.825
ln_TR_Rexch	1.794	0.436	4.12	0.000	0.940	2.649
Dummy_EQ	0.577	0.167	3.46	0.001	0.250	0.904
Trend	0.0492	0.020	2.43	0.015	0.005	0.089
Constant	-19.860	8.630	-2.3	0.021	-36.774	-2.946

The coefficient of the earthquake dummy is surprisingly positive and significant. Indicating that the City recovered very quickly after the earthquake and in time even increased its export performance. The real exchange rate's coefficient is also significantly positive; meaning that when there is appreciation in the real exchange rate, exports of the city increase. This can be thought of as counter-intuitive but this is in line with what is observed in Türkiye's total exports also.

Even though studies examining exports of Türkiye covering the period up to the onset of the 2000s frequently find a negative relationship between appreciation of the real exchange rate and Turkish exports, the research covering the period after the 2000s detect either no relationship or even some find a positive relationship (for references of these studies see; Bayar, Ünal, and Tokpunar (2015)). This is largely due to that Türkiye transformed its production and export structure significantly from low technology, low value-added sectors like textile and garments to medium technology sectors of automotive and machinery. This process caused prices to cease to be the main source of competition, rather quality, design, and after-sales services became the main competitive advantage of Türkiye. Thus, the importance of the real exchange rate decreased to a great extent.

SECTORAL PANEL DATA ANALYSIS

Data and Methodology

The first regression aimed to observe country dynamics of exports of Kocaeli. Another important dimension of the exports of the City is its sectoral composition. To observe the sectoral dynamics behind Kocaeli's export performance, in this section the sectoral panel equation was estimated. Exports of the sectors constitute cross sections and 1996-2021 period constitutes the time series (in years). When a disaster occurs, usually different sectors are affected in divergent ways and to different degrees. Sectoral panel data analysis enables one to see how each sectors was affected in which ways and to which degree. This in turns facilitates policy makes in formulation policies according to distinct needs of the sectors.

For the sector classification, the classification system of the World Trade Organization (WTO) was used. WTO forms the main sectors by aggregating on the basis of SITC Rev3.; i) Food, ii) Agricultural Raw Materials, iii) Mining Products, iv) Iron and steel, v) Chemicals, vi) Office and telecommunication equipment, vii) Automotive products, viii) Textiles, ix) Clothing[2].

Regression equation can be represented as:

$$\mathrm{lnExp_{it}} = \beta_0 + \beta_1 \mathrm{ln\_\ WImp_{it}} + \beta_3 \mathrm{lnKocaeliRGDP}_t$$

$$\beta_4 \mathrm{ln\_TR\_Rexch}_t + \beta_5 \mathrm{ln\_TR\_ExpPrice}_t + \beta_7 \mathrm{DummyEQ}_i$$

The export variable (lnExp) is the dollar value of Kocaeli's exports on the basis of years and sectors, and it is TURKSTAT data. Wimp is world imports in each sector in current dollars; taken from World Trade Organization statistics. The real GDP of Kocaeli province is TURKSTAT data. DummyEQ variable is a dummy taking a zero value up to and including the earthquake year 1999 and

2 SITC equivalent of each sector can be obtained from the author.

taking the value of 1 beginning from the year 2000 and afterward up to the year 2021.

Since there are no zero observations, thus no "zero problem" in the sector equation, all variables are included in the equation in logarithmic form and the coefficients indicate the elasticities. In the estimation, one of the second-generation panel estimation techniques, the Augmented Mean Group method, which takes into consideration the cross-section dependencies and parameter differences between the cross sections was used.

Panels are composed of both cross-sections and time series; so time series characteristics of the system need to be taken into consideration. If the variables entering the equation are not stationary, the existence of the cointegration among the variables should be searched for as in time series analysis. Otherwise, a "spurious regression" problem can occur.

In testing stationarity characteristics of the series, in early times, first-generation unit root tests were formulated and the presence of cointegrating relationships among the variables entering the regression was searched using again first generation cointegration tests.

First-generation unit root tests and cointegration tests do not take into consideration cross-sectional dependencies and parameter heterogeneities. However, in most panels considerable dependencies among cross-sections exist. For example in a panel estimation of sectoral production in years, sectors will be affected by events common to them (perhaps to differing degrees) like problems in the domestic economy or conditions in world markets. All these create dependencies between cross-sections and if not accounted for, will cause biased estimation. Similarly, in most panels, coefficients will be different for each cross section and an estimation method forcing for all cross sections a single coefficient will cause bias.

To deal with cross-sectional dependencies and parameter heterogeneities, second-generation tests of panel unit root and second-generation tests of cointegration were developed. Also, second-generation panel estimation models accounting for parameter heterogeneities and cross-sectional dependencies were formulated. Refer to Eberhardt (2009) for a comprehensive panel estimation methods review and related references in historical order.

Here, the existence of cross-sectional dependencies in the model was tested by the cross-section dependence (CD) test formulated by Pesaran (2004). The test is based on the mean of pairwise correlation coefficients of ordinary least squares residuals of separate cross-sectional regressions. The null hypothesis is "cross sections are independent". The test was shown to have desirable properties even in small N and small T samples and give good results even in cases where residuals are not distributed normally and some of the variables are not strictly exogenous but weakly exogenous.

$$CD = \sqrt{\frac{2T}{N(N-1)}\left(\sum_{i=1}^{N-1}\sum_{j=i+1}^{N}\widehat{\rho_{ij}}\right)\widetilde{asy}N\left(0,1\right)} \text{ where i, j=1,2,…..,N} \quad (1)$$

Where $\hat{\rho}_{ij}$ is the sample estimate of pair-wise correlations of the residuals obtained from OLS.

Test results given in Table 2 indicate the presence of cross-sectional dependencies in both cross-sectionally and time-variant variables, exports of Kocaeli, and world imports for each sector. So, second-generation tests of unit root and second-generation tests of cointegration and second generation estimation methods were used.

Table 2: Cross Sectional Dependency Tests

	lnExp	***lnWexp***
Pesaran (2004) CD Test Stat.	2.355	22.26
P-value	0.009	0.000

To test unit root in variables that vary in both cross sections and time, that is sectoral exports of Kocaeli (lnExp) and world imports in each sector (lnWexp), a simple, intuitive and commonly used test was employed, Cross-Sectionally Augmented Dickey-Fuller test (CADF) of Peseran (2007). The test also has the advantage that it has desirable properties even in small samples and where N and T are close to each other (Peseran, 2007). Peseran (2007) estimated the model in equation (2) for each cross-section:

$$\Delta y_{it} = a_i + b_i y_{i,t-1} + c_i \overline{y_{t-1}} + d_i \Delta \overline{y_t} + e_{it} \quad (2)$$

The test's null hypothesis is non-stationarity, $H_0=b_i=0$. If the null hypothesis was rejected, this means that there is no unit root, and the series is stationary. The test accounts for cross-sectional dependencies by including in the estimation differences and lagged values of cross-sectional averages at each period. Parameter heterogeneities also were taken into account by estimating the equation for every cross-section separately. Then, for the panel as a whole, the tests were obtained by averaging t-statistics from estimating every cross-sectional regression:

$$CIPS\left(N,T\right) = t - bar = N^{-1}\sum_{i=1}^{N} t_i(N,T) \quad (3)$$

Where $t_i(N,T)$ is the t-ratio of the coefficient of $y_{i,t-1}$ from the estimation of equation (2) for cross-section i.

The results of the CIPS test are given in Table 3. Test results show that both variables are stationary at the first difference, integrated to order one, I(1) series (lnExp is significant at 5% level, lnWexp significant between 5%-10% level).

In the regression equation estimated, there is one variable that is cross sectionally invariant; the real GDP of Kocaeli, so stationarity properties of this variable were tested using time series stationarity tests. To test the stationarity characteristics of the series, the Ng-Perron test (Ng and Perron, 2001) was employed. The test shows that the GDP of Kocaeli is stationary in the first difference, I(1) variable (Table 4).

To test for whether a cointegration relationship exists among the variables, a second-generation test of cointegration that takes into consideration cross-sectional dependendencies and heterogeneities in the parameters was used; Westerlund's (2008) Durbin-Hausman cointegration test. Moreover, the test has the advantage that it can be used even if the variables are integrated to different orders. At the first stage of calculation of the test, the first candidate cointegration relation was estimated and the residuals were obtained. Afterward, common factors were decomposed using principal components methods (to deal with cross-sectional dependencies). Then, the remaining error terms (after eliminating the common factors) were tested for stationarity. If the error terms were found to be stationary, this indicates that there is a cointegration relationship among the variables.

Westerlund offers two tests; namely, Durbin-Hausman panel and Durbin-Hausman group tests. The null hypothesis in both tests is "no cointegration". Durbin-Hausman panel test, examines the whole panel for the existence of the cointegrating relationship, assuming that the autoregressive parameter is the same for all sectors; thus, rejecting the null hypothesis means that there is a cointegrating relationship among the variables for the panel as a whole. On the other hand, the Durbin-Hausman group test permits different coefficients among sectors. The null hypothesis is again "cointegration does not exist". The alternative is the existence of a cointegration relationship in one or more of the cross sections. Thus, rejecting the null hypothesis indicates that there is a

Table 3: CIPS Unit Root Tests

	lnExp	**d_lnExp**	**lnWexp**	**d_lnWexp**
Pesaran (2007) CIPS Test Stat.	-2.1352	-3.9085	-1.7492	-3.2943
Critical Value at 5%*	-3.36	-3.36	-3.36	-3.36
Critical Value at 10%*	-2.97	-2.97	-2.97	-2.97

*for N=10 ve T=30 (model with intercept)

Table 4: Ng-Perron Tests

ln_KocaeliRGDP		MZa	MZt	MSB	MPT
Ng-Perron test stat.		0.65626	0.33189	0.50574	21.523
Asymptotic critical values*:	1%	-13.8	-2.58	0.174	1.78
	5%	-8.1	-1.98	0.233	3.17
	10%	-5.7	-1.62	0.275	4.45
d(ln_KocaeliRGDP)		***MZa***	***MZt***	***MSB***	***MPT***
Ng-Perron test stat.		-10.278	-2.2031	0.21435	2.62455
Asymptotic critical values*:	1%	-13.8	-2.58	0.174	1.78
	5%	-8.1	-1.98	0.233	3.17
	10%	-5.7	-1.62	0.275	4.45

cointegration relationship in at least one of the cross sections. Table 4 shows Durbin-Hausman cointegration test results between lnExp, lnWexp, and lnRGDP. Durbin-Hausman panel test rejects “no cointegration” null hypothesis at less than 1% level. Durbin-Hausman group test cannot reject the “no cointegration” null hypothesis at the 10% level, but the test statistic is very near to the critical value at the 10% level.

Table-5: Durbin-Hausman Panel Cointegration Test

Durbin-Hausman Panel Test Stat.	2.837
Durbin-Hausman Group Test Stat.	1.221
Critical Values: 10%=1.28---5%=1.645---1%=2.333	

The Durbin-Hausman cointegration test gives the best results when we exclude other variables, real exchange rate, export prices, and the dummy for the earthquake. In fact, also when we do AMG regression, the coefficients of these variables turn out to be statistically insignificant. So, the model below was estimated:

$$lnExp_{it} = \beta_0 + \beta_1 lnWimp_{it} + \beta_2 lnKocaeliRGDP_t$$

To estimate the model, again a second-generation estimation methodology was used; which takes into consideration parameter heterogeneities and cross-sectional dependencies. The augmented mean group model was first formulated by Eberhardt and Bond (2009) and then improved by Eberhardt and Teal (2011). The method also has the advantage that variables having different integration degrees can be estimated in the same model. The model was represented as:

$$\begin{aligned} & y_{it} = \beta_i' x_{it} + u_{it} \qquad u_{it} = \alpha_i + \lambda_i' f_t + \varepsilon_{it} \\ & x_{mit} = \pi_{mi} + \delta'_{mi} g_{mt} + \rho_{1mi} f_{1mt} + \dots + \rho_{nmi} f_{nmt} + v_{mit} \\ & m = 1, \dots k \quad and \quad f_{mt} \subset f_t \\ & f_t = \phi' f_{t-1} + \varepsilon_t \quad and \quad g_t = \kappa' g_{t-1} + \varepsilon_t \end{aligned} \tag{4}$$

Here, x_{it} represents the vector of the observed variables. f_t represents factors affecting all cross sections. Sector-specific factor loadings are represented by λ_i and enable us to take into account common factors affecting different cross sections in different ways. The second equation is estimated to account for unobservables f_t and g_t on observed variables. In this way, the authors include dependencies between cross-sections in both unobservable and observable variables.

Eberhardt and Bond (2009) and Eberhardt and Teal (2011) estimate the model in two stages:

$$\begin{aligned} & \Delta y_{it} = b' \Delta x_{it} + \textstyle\sum_{t=2}^{T} c_t \Delta D_t + e_{it} \\ & \qquad \Rightarrow \hat{c}_t = \hat{\mu}_t^{\bullet} \end{aligned} \tag{5}$$

In the first phase, the model is estimated in first differences. Also, time dummies were included in the first differences. The main motivation behind estimating the model is preventing non-stationary variables and unobservable variables from biasing the results. Then, the second stage regression was estimated; in this regression time dummies’ coefficients obtained from the first stage regression were employed among independent variables. Second-stage regression was also formulated such that parameter heterogeneity between the cross-sections was allowed. Afterward, the coefficients of the panel as a whole were obtained by averaging each cross-section’s coefficients (Eberhardt and Bond, 2009; Eberhardt and Teal, 2011).

$$\begin{aligned} & y_{it} = a_i + b_i' x_{it} + c_i t + d_i \hat{\mu}_t^{\bullet} + e_{it} \\ & \hat{b}_{AMG} = N^{-1} \sum_i \hat{b}_i \end{aligned} \tag{6}$$

Regression Results

Earthquake dummy variable, real exchange rates, export price index, and coefficients were excluded from the equation as they were statistically insignificant. The panel equation on the basis of sectors also confirms our observation that the exports of the city of Kocaeli were not adversely affected by the earthquake. Again, it is seen that exchange rate and price variables do not have an important role in the exports of the city.

In the AMG equation, the coefficient of world imports from the average coefficients is positive and insignificant (table 6). However, the variable was not excluded from the equation since the cointegration test Westerlund (2008) indicates that there is a cointegration relationship and the coefficient of the Wimp variable is statistically significant in some sectors. Since the Augmented Mean Group method also estimates the sectoral coefficients separately, it allows us to comment on how the exports of the sectors are affected by the world imports in that sector and the GDP of the City and the differences between sectoral effects.

Table 7 shows the coefficients and p-values of ln_Wipm and ln_KocaeliRGDP for each cross-section. World imports are a positive and significant factor affecting sectoral exports of Kocaeli in 5 sectors; the highest coefficient is in chemicals, with an elasticity of 1.6%. As world chemicals imports increase by 1%, Kocaeli’s chemicals exports increase by 1.6%. Similarly, the automotive sector has also had good performance; as world automotive imports increase by 1%, Kocaeli’s automotive exports increase by

Table 6: Regression Results

Number of Observations: 234 Wald chi2(2) = 58.02 Prob > chi2 = 0.0000						
Variable	***Coefficient***	***Standard. Error***	***z***	***P>|z|***	***[95% Confidence- Interval]***	
ln_Wimp	0.312	0.397	0.79	0.431	-0.466	1.090
ln_KocaeliRGDP	2.325	0.573	4.06	0.000	1.201	3.448
__00000R_c	1.1425	0.340	3.36	0.001	0.471	1.809
Constant	-33.777	8.224	-4.11	0.000	-49.893	-17.659
Variable __00000R_c refers to the common dynamic process. Root Mean Squared Error (sigma): 0.4236						

Table 7: Coefficients of ln_Wipm and ln_KocaeliRGDP in Individual Sector Regressions

	ln_Wimp	***P-value***	***ln_KocaeliRGDP***	***P-value***
Food	1.206	0.034	0.485	0.546
Agricultural Raw Mat.	-0.525	0.683	2.383	0.068
Mining Products	0.950	0.000	0.937	0.014
Iron and Steel	-0.714	0.229	4.485	0.000
Chemicals	1.604	0.000	0.945	0.046
Office and telecom equip.	-0.962	0.472	5.233	0.002
Automotive	1.377	0.105	2.633	0.005
Textiles	1.293	0.070	0.711	0.260
Clothing	-1.419	0.247	3.108	0.028

1.38% (at a 10% significance level). Thus, Kocaeli increases its share in world markets in these sectors in response to market expansion. Similarly, the textiles sector's response to a 1% increase in world textile imports is 1.29% and the food sector's response to a 1% increase in world food imports is 1.2%; both sectors increase their exports more than an increase in world imports in their respective sectors; which means Kocaeli can increase its share in world markets in these sectors also. The mining sector has elasticity near to 1, a 1% increase in world chemicals imports increases Kocaeli's mining exports by 0.95%; that is, the city can more or less protect its market share. In other sectors, the coefficients of world imports are not significant.

Kocaeli's real GDP, as a supply-side determinant of exports, turns out to be a significant factor affecting sectoral exports of the city, in all sectors except the food and textiles sectors. Coefficients of the variable can be ranked from highest to lowest as; office and telecommunication equipment, iron and steel, clothing, automotive, agricultural raw materials, chemicals, and mining products. In all these sectors, except chemicals and mining products, elasticities are above 1, suggesting that, as Kocaeli city's real GDP increases by 1 percent, exports of these sectors increase more than in proportion.

EVALUATION AND DISCUSSIONS

Türkiye is an earthquake country. Protecting from the harmful effects of earthquakes, taking the necessary precautions before the earthquake, eliminating the damage after the earthquake, and returning to economic life quickly are the issues that should be given great importance for Türkiye.

In this study, the literature about the economic effects of earthquakes is summarized and the effects of the 1999 Marmara earthquake, which is one of the biggest earthquakes in Türkiye history, on the exports of Kocaeli province, which is the epicenter, were examined with the panel gravity model and sectoral panel model.

The model results show that the GDP of the trading partner, which is one of the classical gravity variables, and the GDP of Türkiye, which is also among the classical gravity variables, are the variables that affect bilateral exports of Kocaeli positively. In line with the research in the literature, distance affects exports of the City negatively. Again in line with the expectations of gravity models, Kocaeli exports more to Turkey's border neighbors and countries having Free Trade Agreements with Türkiye. It is observed that after the 1999 Marmara earthquake, the exports of the City recovered rapidly and even improved its former performance in the following years.

Results of sectoral panel analysis show that real GDP of Kocaeli and the world imports (in some sectors) are the most important factors affecting sectoral exports of the City. In line with panel gravity results, it seems that the earthquake did not affect the export performance of the City negatively. In 5 of 9 sectors examined, the City increases its share in world markets in response to the widening World market in these sectors.

Many factors could have contributed to this quick recovery from the devastating earthquake; which should be explored in detail in further studies. Our initial observations suggests that one of the important reasons may be that there was great solidarity from the whole nation, from every region of Türkiye to help the disaster region. Kolukırık and Tuna (2009) reviewed newspapers of that days and put light on the economic and social environment after the disaster. There are many news about how big cooperation and solidarity experienced in the region, both by the inhabitants of the region and volunteers from all regions of Türkiye. This should have big impact on the quick recovery of the region. As OECD (2020) mentions, SMEs in the region provided shelter, health support, etc. to their employees in order not to lose their qualified personnel. Also, increased government expenditures to the region may have helped quick recovery. In the second part of 1999 1.4 billion dollars were expended for the region (0.8% of GNP) from government budget, and in 2000 budgetary expenditures to the region increased and appeared at 1.2 billion dollars (Aktürk and Albeni, 2002).

As mentioned in literature survey part, Dalziel and Saunders (2012) state the two dimensions to evaluate for policy formulation : did the earthquake change the key strengths and opportunities that are the main drivers of economic development of the region and will short-term effects of the earthquake, including the transition path of adoption in the process, have long-term effects on the development of the region (hysteria effect)? (Dalziel and Saunders, 2012, 119). In the these dimensions findings of this study makes us to think that earthquake did not change main strengths, opportunities and drivers of economic development as we observe from increasing export performance of the City and adverse effects of the disaster did not persit in the long term. In fact, at that time the region had a strong industrial base and high income level; and this was not changed even in the short-term; suggesting that the vulnerability of the region is low.

CONCLUDING REMARKS

As an important extention area of this study, causes of resilience and quick recovery of Kocaeli from the devastating earthquake should be analysed. Searching for strengths of the City that enabled it to recover quickly from a big disaster contain information that can be helpful for both Türkiye and other countries in being prepared for the disasters and in recovering from it quickly whenever it occurs.

As another expansion area of the study, the reasons behind the export performance of Kocaeli province can be examined with micro data on firm basis. Due to the fact that firm-based data are more accessible, especially in recent years, and the important role of microanalysis in revealing the dynamics behind macroeconomic results, microanalysis become widespread in the literature recently. How producers and exporters in Kocaeli coped with the consequences of the earthquake and even increased export performance in the following years can be an example for firms in other cities of Türkiye and other countries affected by earthquakes.

Türkiye experienced two even bigger earthquakes in 6^{th} February 2023 and 20^{th} February 2023. Epicenter of the first was Pazarcık district of Kahramanmaraş City and magnitude was 7.7 M_w. The second had center in Elbistan district of Kahramanmaraş and magnitude was 7.6 M_w Due to this disaster 48, 448 people died, 3.3 million people have been displaced; it cost Turkish economy around 103,6 billion dollars or, around 9% of GDP of Türkiye (SBB, 2023). From the disaster 11 provinces and more than 14 million people were affected (SBB, 2023). Further studies should focus on this disaster and ways to quick rehabilitation of the 11 provinces adversely affected from the event. Experiences of Kocaeli earthquake can provide useful information for the policies aiming quick recovery of the business activity in the region.

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