

REGIONAL RESILIENCE IN TURKIYE'S MANUFACTURING INDUSTRY: AN APPLICATION ON LEVEL 2 REGIONS

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Abstract

Regional resilience is an essential concept for identifying the problems regions face in the development process, and determining the level of regional resilience provides critical contributions to policy-making aimed at increasing societies' resilience to shocks. The economic shocks experienced in Türkiye in recent years have made it even more essential to analyze regional resilience levels. The manufacturing industry plays a vital role in Türkiye's economy, which is characterized by significant sectoral diversity. In this framework, this research aims to analyze the resilience of the manufacturing industry to economic shocks in Türkiye's NUTS Level 2 regions. Within the scope of the study, regional resilience is revealed through the sensitivity index calculated using data from 2013 to 2023. In the analysis process, 2009-based Gross Domestic Product (chained volume, thousand ₺) data for the manufacturing industry sector are used. The findings of this study reveal that the resilience levels of regions in the manufacturing industry in Türkiye differ significantly from each other. Moreover, the recovery rates of regions against economic shocks are found to vary significantly.

Keywords: Regional resilience, Manufacturing industry, Türkiye

JEL Classification: O14, R11, R58

TÜRKİYE İMALAT SANAYİNDE BÖLGESEL DİRENÇ: DÜZEY 2 BÖLGELERİ ÜZERİNE BİR UYGULAMA

Öz

Bölgesel dirençlilik, bölgelerin kalkınma sürecinde karşılaştığı sorunları belirlemek için önemli bir kavramdır ve bölgesel direnç düzeyinin tespiti, toplumların şoklara karşı dayanıklılığını artırmaya yönelik politika oluşturma süreçlerine kritik katkılar sağlamaktadır. Son yıllarda Türkiye'de yaşanan ekonomik şoklar bölgesel dirençlilik seviyelerinin analiz edilmesini daha da önemli hale getirmiştir. İmalat sanayi, önemli bir sektörel çeşitliliğe sahip Türkiye ekonomisinde hayati bir rol oynamaktadır. Bu çerçevede, bu araştırma Türkiye'nin İBSS Düzey 2 bölgelerinde imalat sanayinin ekonomik şoklara karşı gösterdiği dirençliliği analiz etmeyi amaçlamaktadır. Çalışma kapsamında, bölgesel dirençlilik 2013-2023 dönemi verileri kullanılarak hesaplanan duyarlılık endeksi aracılığıyla ortaya konulmuştur. Analiz sürecinde, imalat sanayi sektörüne ilişkin 2009 bazlı Gayri Safi Yurt İçi Hasıla (zincirlenmiş hacim, bin ₺) verisi kullanılmıştır. Bu araştırmanın bulguları, Türkiye'de imalat sanayisinde bölgelerin dirençlilik düzeylerinin birbirinden önemli ölçüde farklılık gösterdiğini ortaya koymaktadır. Ayrıca, bölgelerin ekonomik şoklara karşı toparlanma hızlarının da belirgin biçimde farklılaştığı saptanmıştır.

Anahtar kelimeler: Bölgesel dirençlilik, İmalat sanayi, Türkiye

JEL Sınıflaması: O14, R11, R58

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1. Introduction

Issues such as the regional consequences of national shocks and the factors that determine regional resilience to shocks are of interest to academics and researchers in regional science (Chen & Groenewold, 2022). Economic resilience is a concept that refers to natural and adaptive responses to disasters, enabling individuals and communities to avoid certain potential losses. It can occur at the market, household, firm, or macroeconomic level (Rose, 2004: 307). This concept is increasingly used in economic geography to analyze how quickly systems recover from shocks, and there is a growing body of literature on regional resilience in this field (Gong et al., 2020: 497). At the regional level, economic resilience is an economy's ability to withstand and recover quickly from shocks. Measuring economic resilience is critical to understanding the factors that affect it (Ringwood et al., 2019).

Regional resilience is a complex process comprising distinct stages. Regional resilience is significantly influenced not only by the nature, duration, and scale of the shock, but also by factors like regional economic structures, past experiences, and government policies at different spatial scales (Gong et al., 2020: 500). However, as Boschma (2015) points out, it is not possible to fully and comprehensively explain the factors that make a region resilient. Moreover, the resilience of regions is deeply embedded in historical legacies, as reflected in industrial, network, and institutional structures. This legacy shapes regional resilience by presenting limitations and opportunities (Boschma, 2015: 743). These factors show that regional resilience changes over time and is a dynamic process. This dynamic structure is an essential motivation for research on measuring regional resilience and identifying the factors that affect it.

This paper, which examines regional resilience in Türkiye's manufacturing industry across the Nomenclature of Territorial Units for Statistics (NUTS) Level 2 regions, is essential for several reasons. First, the increasing frequency of recessionary shocks and differences in regional growth trajectories during both recession and recovery periods have heightened scholarly focus on resilience concepts in recent years (Eraydın, 2016: 600). On the other hand, the COVID-19 pandemic caused fluctuations in regional economies around the world (Zárate-Mirón & Moreno-Serrano, 2024: 133) and had significant effects on Türkiye's economy, just as it did on a global scale. In addition, when factors such as the Russia-Ukraine War's effects on foreign trade, the February 6, 2023, earthquake termed the 'Disaster of the Century', and exchange rate shocks are considered, there have been significant events in recent years that have affected Türkiye's economic structure and regional resilience levels. These developments make measuring regional resilience in Türkiye both critical and meaningful.

This study focuses on the manufacturing industry to identify regional resilience, significantly contributing to Türkiye's economic and trade growth. According to the International Standard Industrial Classification (ISIC, Rev.4), export data within the scope of the General Trade System (TurkStat, 2025a) show that in January 2025, Türkiye's total exports reached 21,165,091.923 thousand USD, while the manufacturing sector's exports reached 19,757,991.936 thousand USD. Considering that the share of the manufacturing industry in exports by economic activities was 93.35% in January 2025, it can be argued that manufacturing has an essential place in Türkiye's foreign trade. Moreover, it is well known that the number of enterprises and employees in Türkiye's manufacturing industry is increasing annually. Data on the manufacturing industry shared by TurkStat (2025b) highlights that in the period 2013-2023, the number of enterprises in this sector increased from 365,723 to 461,644, while the total number of employees increased from 3,642,332 to 5,051,468. These figures demonstrate that the manufacturing industry is a key sector of the Turkish economy. However, despite its importance, regional resilience in the Turkish manufacturing industry has rarely been analyzed. In this study, regional resilience in the manufacturing industry is analyzed, and the findings are evaluated in light of key impact factors (such as the pandemic and earthquakes). From this perspective, this study is expected to make a significant contribution to the literature.

The growth in the manufacturing sector in Türkiye is remarkable, not only in terms of exports and employment but also in terms of labor productivity. The manufacturing industry has higher labor productivity than the agriculture and services sectors. Taymaz & Suiçmez (2005: 19) emphasize that this sector also plays a key role in developing and diffusing new technologies to other industries. TurkStat (2025b) data show that the total production value of the manufacturing industry in 2023 is 15,512,721,307,719 ₺. However, when the technology level is analyzed, only 3.67% (569,790,159,530 ₺) of this amount is high technology, and 26.6% (4,131,121,764,639 ₺) is medium-high technology. These statistics show that Türkiye's manufacturing industry needs to be strengthened, and in this context, this sector is considered in the regional resilience assessment in this study. In this study, the literature review follows the introductory section. The third section outlines the research methodology, and the fourth section presents the findings and discussion. The study concludes with a results and recommendations section.

2. Literature Review

Many researchers have argued that economic resilience should be formalized in the literature. This has deepened the debate on its definition and measurement methods (Ringwood et al.

2019: 381). Related to these debates, regional resilience has also been addressed in different ways in the literature and has been the subject of numerous studies. While a considerable number of studies have addressed regional resilience (Zhang et al., 2025; Giannakis et al., 2024; Perobelli et al., 2024; Zárate-Mirón & Moreno-Serrano, 2024; Kitsos et al., 2023; Chen & Groenewold, 2022; He et al., 2022; Yetişen & Dulupçu, 2021; Gong et al., 2020; Ringwood et al., 2019; Eraydın, 2016; Han & Goetz, 2015; Kumral et al., 2012), a few of them provide valuable implications specifically for the manufacturing sector (Perobelli et al., 2024; Kitsos et al., 2023; Ringwood et al., 2019). On the other hand, some studies directly focus on the manufacturing industry. While some manufacturing-oriented studies (Bostan & Karadağ, 2022) examine the sector in a broader context through comparative analyses, others (Di Tommaso et al., 2023; Zhang et al., 2023) directly investigate the resilience of this sector. Recent research on regional resilience and the manufacturing industry is presented in Table 1.

Table 1. Studies on regional resilience and the manufacturing industry

Author	Period	Research Focus	Method	Findings
Zhang et al. (2025)	China; 2000-2022	Estimation of regional economic resilience	Entropy method, spatial Durbin model & kernel density estimation	Economic resilience has generally improved. However, regional disparities persist.
Giannakis et al. (2024)	EU NUTS-2 Regions; 2008–2016	Regional economic resilience & sectoral interconnectedness	Spatial regression analysis	Intersectoral linkages are essential factors in explaining regions' resilience to external shocks.
Perobelli et al. (2024)	Brazil; 2010-2018	Economic resilience analysis & sectoral composition	Input-output analysis	Sectors with weaker resilience capacity have a higher share of value-added.
Zárate-Mirón & Moreno-Serrano (2024)	United States; 2005-2015	Regional resilience & cluster composition	Regression models	Regions characterized by strong clusters and high innovation show less vulnerability.
Di Tommaso et al. (2023)	United States; Post 2008	Industry resilience	Composite indicators	Sectors react heterogeneously to shocks.
Kitsos et al. (2023)	EU and UK NUTS-2 Regions; 2008–11	Regional economic resistance & industrial embeddedness	Input-output tables & fixed-effects and quantile regressions	Regional embeddedness is important for the resilience of manufacturing, financial, and commercial services at the industry level.
Zhang et al. (2023)	China; 2011-2020	Determining the resilience of the manufacturing industry chain	TOPSIS method	The resilience of manufacturing industry chains exhibits significant

Bostan & Karadağ (2022)	Türkiye; 2009-2016	Overview and comparison with selected world countries	Comparative analysis	spatial and temporal divergence. Domestic firms are mainly concentrated in low and medium-low technology-intensive industries.
Chen & Groenewold (2022)	China's 30 provinces; 1978-2018	An empirical analysis of resilience	VAR model, calculating resilience indices	Provinces close to the coast with a new industrial structure are found to be less resilient.
He et al. (2022)	243 cities in China; 2004-2018	Industrial diversification & regional economic resilience	OLS method	Industrial diversification contributes to regional economic resilience.
Yetişen & Dulupçu (2021)	NUTS-2 Regions of Türkiye; 2009-2019	Resilience analysis	Sensitivity index	The recovery speed of regions in the face of a shock is different.
Gong et al. (2020)	China; 2019-2020	Regional resilience and the COVID-19 crisis	Analysis of resilience	A complex combination of the characteristics of the COVID-19 crisis, government support, institutional experience, and industrial structures can potentially influence regions' recovery and resilience rates.
Ringwood et al. (2019)	United States; 1990-2015	Measuring regional economic resilience	A quantitative method	Among manufacturing-dependent districts, metro districts are the most resilient.
Eraydın (2016)	NUTS-2 Regions of Türkiye	Measuring regional resilience	Discriminant function analysis	There are various fields where interventions and support are required to strengthen regional resilience.
Han & Goetz (2015)	United States; 2007-2009	Analyzing the economic resilience of counties	The measure of economic resilience	Counties adjacent to metro areas experience more severe shocks than nonadjacent counties.
Östh et al. (2015)	Sweden; 1990-2010	Spatial economic resilience	Local Moran's I	There is a positive and significant correlation between proxies of resilience and accessibility.
Kumral et al. (2012)	NUTS-2 Regions of Türkiye; 1987-2001	Resilience analysis	Sensitivity index	Sensitivity to shocks is markedly different across regions.

Table 1 shows that regional resilience has been analyzed based on various countries and regions, and that many studies address this issue in general. However, some studies also focus directly on the manufacturing industry. In addition to the studies in Table 1, it should be noted that issues such as digitalization, structural transformation, growth, employment, wage inequality, and

regional diversification in the Turkish manufacturing industry are also frequently addressed in the literature (Karkın, 2024; Kıyak, 2023; Taştan & Akar, 2013; Cinemre, 2012; Tuncer & Altıok, 2012). Nevertheless, given that regional resilience is a dynamic process, there is a need for current and comprehensive studies examining regional resilience in the Turkish manufacturing industry. In this respect, this study is anticipated to contribute to the literature.

3. Methodology

3.1. The aim and scope of the research

The primary objective of this research is to calculate regional resilience in the manufacturing industry in Türkiye. The study covers the 2013-2023 period and focuses on Level 2 regions in Türkiye according to the NUTS. These regions are listed in Table 2 below.

Table 2. Study area

Code	Level 2 (26 subregions)	Code	Level 2 (26 subregions)	Code	Level 2 (26 subregions)
TR62	Adana subregion	TR63	Hatay subregion	TR83	Samsun subregion
TR51	Ankara subregion	TR82	Kastamonu subregion	TR21	Tekirdağ subregion
TR61	Antalya subregion	TR72	Kayseri subregion	TR90	Trabzon subregion
TR32	Aydın subregion	TR42	Kocaeli subregion	TRB2	Van subregion
TRA2	Ağrı subregion	TR52	Konya subregion	TR81	Zonguldak subregion
TR22	Balıkesir subregion	TR71	Kırıkkale subregion	TR10	İstanbul subregion
TR41	Bursa subregion	TRB1	Malatya subregion	TR31	İzmir subregion
TRA1	Erzurum subregion	TR33	Manisa subregion	TRC2	Şanlıurfa subregion
TRC1	Gaziantep subregion	TRC3	Mardin subregion		

In this study, the 2013-2023 period is preferred for the following reasons: (i) the availability of data on Türkiye's NUTS-2 regions as of the analysis period, (ii) the occurrence of major shocks during this period that directly affected regional resilience, such as the pandemic, global supply chain crises, and the the 6 February 2023 earthquake, and (iii) the desire to compare the index results over ten years.

3.2. Analysis Method and Data Set

Regional resilience can be measured in various ways in the literature. As Table 1 reveals, econometric models such as the VAR model, the OLS method, and regression analysis (Zárate-Mirón & Moreno-Serrano, 2024; Kitsos et al., 2023; Chen & Groenewold, 2022; He et al., 2022) are widely used in the regional resilience measurement. In addition, spatial analyses (Zhang et al., 2025; Giannakis et al., 2024; Östh et al., 2015) and multi-criteria analyses (Zhang et al., 2023) are among the methods frequently used to measure and assess regional resilience.

Index-based methods (Yetişen & Dulupçu, 2021; Kumral et al., 2012) are also often preferred. This study adopts index-based methods because they provide a comprehensive framework for analyzing regional resilience. Within the scope of this study, regional resilience levels in Türkiye's manufacturing industry are measured for NUTS-2 regions. Although there are many methods for estimating regional resilience, according to Martin (2012: 16), one of the simplest ways to measure regional resilience is to calculate the ratio of the decline in employment or output in a region to the corresponding decline in the country as a whole, and this can be shown as in equation 1.

$$\Delta E_r/E_r = \beta_r(\Delta E_N/E_N) \text{ or } \beta_r = (\Delta E_r/E_r)/(\Delta E_N/E_N) \quad (1)$$

Where $\Delta E/E$ is the percentage change in employment, and β_r is the sensitivity index (Martin, 2012: 16). In this study, an output-based measurement is made based on the index Martin (2012) expressed in equation 1 to determine regional resilience. In other words, the index is defined as the ratio of the percentage change in regional output (Q_r) to the percentage change in national output (Q_N), and this can be shown as follows:

$$\beta_r = (\Delta Q_r/Q_r)/(\Delta Q_N/Q_N) \quad (2)$$

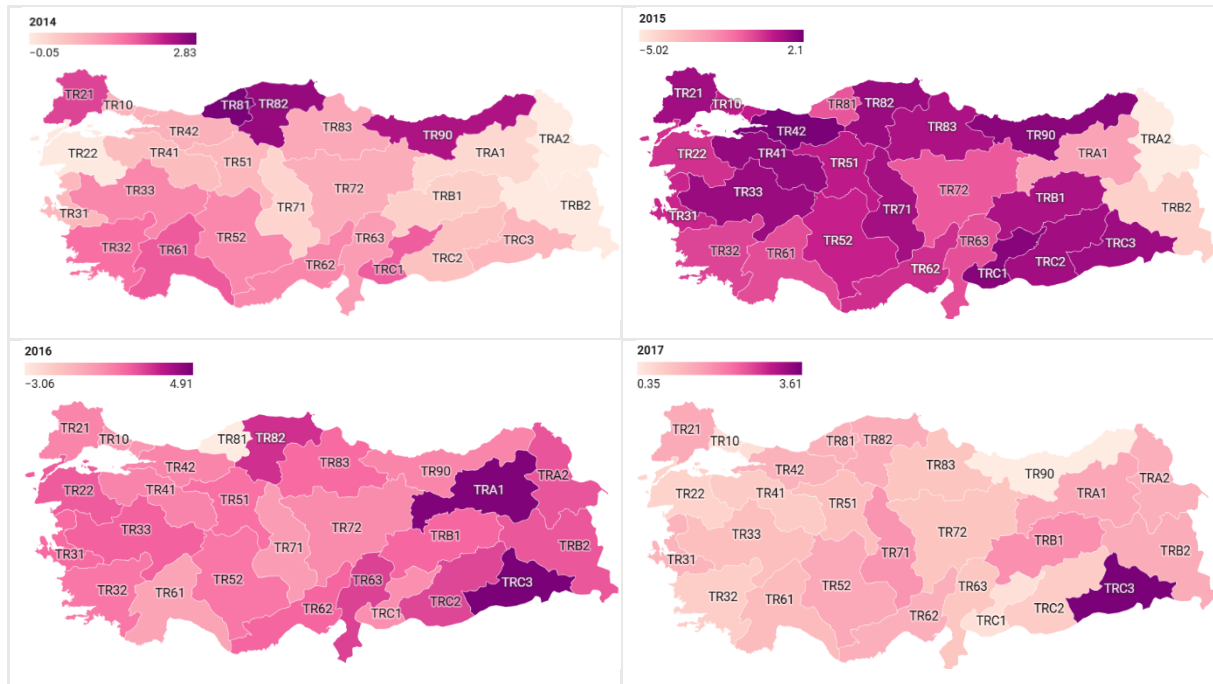
GDP data is frequently used as an output indicator in measuring regional resilience. In this axis, in the study, we have meticulously collected and used the 2009-based Gross Domestic Product (chained volume, thousand ₺) data for the manufacturing industry sector under Section C, according to Activity A10 (NACE Rev. 2) for NUTS-2 (26 regions). The relevant data are obtained from the Turkish Statistical Institute's Regional Accounts database (TurkStat, 2025c). The interpretation of the index is as follows: If this index has a value less than one, the region has a high (relative) resilience (low sensitivity) to a recession shock. Conversely, if a region has a value greater than one, it has a low (relative) resilience (high sensitivity) (Martin, 2012: 16). A negative value of this index means that while there is a contraction at the national level, there is no contraction at the regional level (Kumral et al., 2012).

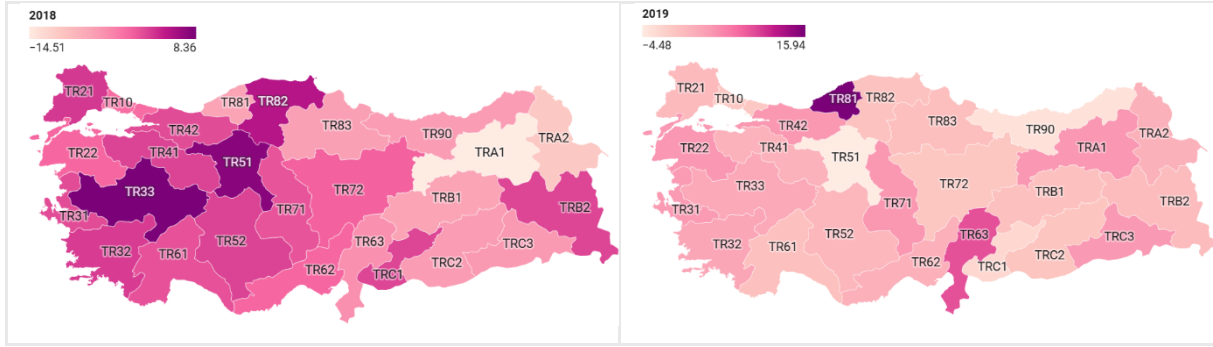
4. Findings and Discussion

In this study analyzing regional resilience in the manufacturing industry in Türkiye, the results of the sensitivity index for the 2013-2023 period are presented in APP-1. In this section, the index values are evaluated and interpreted in two periods, pre-2020 and post-2020, with the pandemic as the breakpoint, to analyze the research findings more clearly and to see the periodic differences more prominently.

The pre-2020 index findings are presented visually in Figure 1. These findings reveal that some regions in Türkiye have shown resilience during national contraction periods. According to the index findings, in Türkiye, three regions in 2014, seven in 2015, two in 2016, thirteen in 2018, and nine in 2019 had negative sensitivity index values. This situation shows that these regions did not experience a contraction at the regional level, whereas Türkiye did at the national level. In 2017, no region exhibited a negative sensitivity index value. In 2014, the TRA1 region showed the highest resilience (low sensitivity) to recession shocks, followed by TR71, TRB1, TRC2, TR41, TR31, TR51, TRC3, TR10, TR42, TR72, and TR83. Moreover, seven regions in 2015, eight in 2016, and eight in 2017 had high resilience (low sensitivity). The TR71 and TR61 regions in 2018, and the TR83, TRB2, and TR21 regions in 2019, stood out as regions with high resilience (low sensitivity). Furthermore, the findings reveal that eleven regions in 2014 exhibited low resilience (high sensitivity) to recession shocks. In 2014, the three regions with the lowest resilience (high sensitivity) were TR81, TR82, and TR90, respectively, while in 2015, they were TR42, TRC1, and TR90. The regions with the lowest resilience were TRC3, TRA1, and TR82 in 2016; TRC3, TRB1, and TR71 in 2017; TR33, TR51, and TR82 in 2018; and TR81, TR63, and TR22 in 2019 (Figure 1).

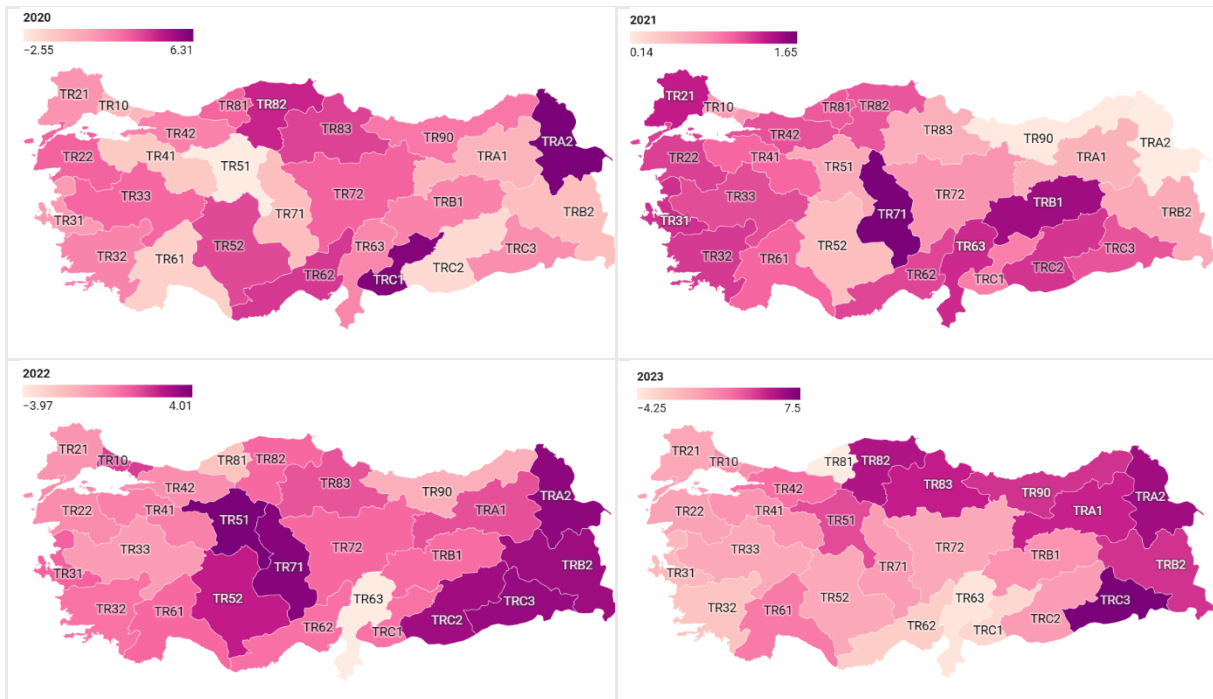
Figure 1. Pre-2020 regional resilience in the manufacturing industry: A visual representation of the data





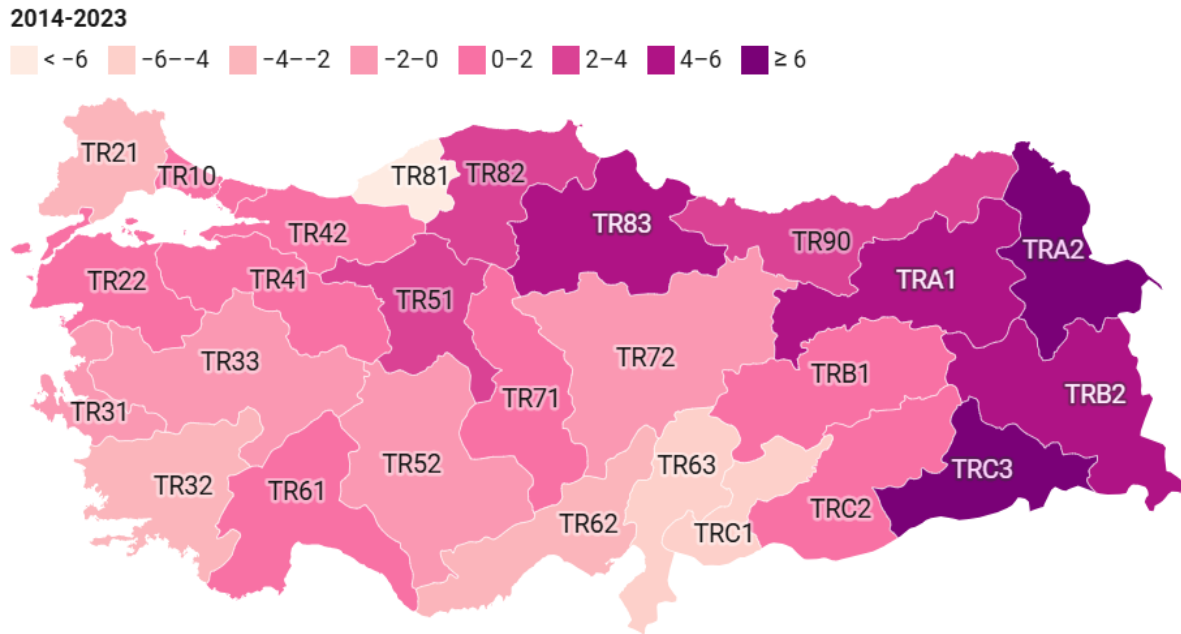
Post-2020 index findings also show that while Türkiye has a national contraction, some regions remain outside this trend. Seven regions in 2020, seven in 2022, and ten in 2023 did not experience a contraction. In 2021, no region had a negative value in the sensitivity index. In 2020, only the TRA1 region appeared to have demonstrated high resilience (low sensitivity). In 2021, it was determined that ten regions showed high resilience. In addition, nine regions in 2022 and four in 2023 stood out as highly resilient. On the other hand, in 2020, eighteen regions exhibited low resilience (high sensitivity), with TRA2, TRC1, and TR82 ranking as the top three regions. In 2021, although sixteen regions showed low resilience, TR71, TRB1, and TR21 were the most prominent. In 2022 and 2023, the number of regions showing low resistance was 10 and 12, respectively. The regions leading in low resilience were TR51, TR71, and TRA2 in 2022, and TRC3, TRA2, and TR82 in 2023 (Figure 2).

Figure 2. Post-2020 regional resilience in the manufacturing industry: A visual representation of the data



When the change in regional rankings according to the sensitivity index values from 2014 to 2023 is analyzed, it is noteworthy that the TR81 region, which had the lowest resilience (high sensitivity) in 2014, has been the most prominent in terms of index value change. On the other hand, it is observed that TR82 and TR90 regions, which come after the TR81 region in the ranking with their high value in the sensitivity index in 2014, have exhibited a considerable increase in resistance in 2023. The change in the rankings of the regions according to the sensitivity index values reveals that the index values for TR81, TR63, TRC1, TR62, TR32, TR21, TR31, TR33, TR52, and TR72 have decreased. In contrast, the index value of the other regions has increased. The regions with decreasing index values in this period are the regions that did not experience contraction in 2023. Regarding the increase in the sensitivity index from 2014 to 2023, the TRC3, TRA2, TRA1, TRB2, and TR83 regions rank among the top five, respectively. These regions rank high on the sensitivity index in 2023 and stand out as having the lowest levels of regional resilience (Figure 3).

Figure 3. Change in Index Value (2014-2023)



As Figure 3 highlights, the findings of this research show that in the change of regional resilience level for the period 2014-2023, the regions mainly located in eastern Türkiye stand out at the low resilience level (high sensitivity). When comparing regional resilience data in the manufacturing industry before and after 2020 (Figures 1 and 2), it is observed that despite fluctuations in the index, this trend has become more pronounced in 2022-2023. These findings are consistent with the research findings of Küçükiremitçi (2023), which evaluates the manufacturing industry and its sub-sectors for the 2015-2020 period. In the mentioned study, it

is emphasized that the regions with the lowest number of manufacturing industry establishments in Türkiye are TRA2, TRB2, and TRC3 regions, which are composed of Eastern and Southeastern provinces, and that TRA2, TRB2, and TRA1 regions rank last in manufacturing industry sales. In addition, it is stated that size and specialization are more prominent in developed localities in the manufacturing industry (Küçükiremitçi, 2023: 45-54). Therefore, the findings of this study on regional resilience levels are consistent with the results of the previously mentioned research.

This study's findings that there are differences between regions in terms of regional resilience in the manufacturing industry are consistent with the research findings of Zhang et al. (2023) focusing on China, Ringwood et al. (2019) focusing on the United States, Bostan & Karadağ (2022), and Eraydın (2016) focusing on Türkiye. In addition, it can be stated that the findings of this study are consistent with the research findings of Di Tommaso et al. (2023), which focus on industrial resilience and emphasize the different levels of resilience across sectors.

Although regional resilience is a multidimensional concept influenced by many factors, it can be observed that certain developments play a significant role in the resilience of regions in some years. In this context, it is possible to interpret this study's results based on the prominent developments in Türkiye. As is known, the coup attempt in Türkiye on July 15, 2016, had economic and social effects and negatively affected growth, as emphasized in scientific studies and policy documents (Gülcan et al., 2020; Republic of Türkiye Ministry of Science, Industry and Technology, 2018). Several measures were taken during this process, and financial support was provided in response to the internal and external shocks encountered in 2016 (Republic of Türkiye Ministry of Finance, 2018). According to the findings of this study, while two regions had negative index values in 2016, no region had a negative index value in 2017, and eighteen regions exhibited low (relative) resilience. The absence of any area with a negative index value in 2017 indicates that no region could diverge positively despite the national contraction. In light of this information, it can be argued that the manufacturing industry (particularly in the context of regional resilience) did not recover immediately but experienced a delayed recovery process.

On the other hand, the global COVID-19 pandemic, which caused uncertainties and fluctuations in the economy, has also been a significant development affecting the period covered by this research. In the findings of this research, the fact that only one region (TRA1 region) had high resilience (low sensitivity) in 2020 reveals the depth of the impact of the pandemic on the manufacturing industry. This situation proves that the effects of the national-level contraction

were also felt at the regional level. As also discussed in the study by Küçükkiremitçi (2023), a decline was recorded in the main indicators of the manufacturing industry in 2020 (such as capacity utilization rate, R&D expenditures, exports, productivity per employee (2015=100), production value) compared to 2019 (Küçükkiremitçi, 2023: 2). This situation not only reflects the negative impact of the COVID-19 pandemic on the manufacturing industry but also supports the negative trends observed in this research.

According to the index results of this research, the fact that ten regions exhibited high resilience in 2021 indicated that recovery had begun following the economic shock caused by the COVID-19 pandemic. However, the absence of any region with a negative index value in the same year indicated no region diverged positively despite the national-level contraction. The survey results of the Business for Goals Platform (TÜRKONFED, UNDP & TÜSİAD, 2020; 2021) emphasized that the change in the level of impact of the crisis varied across sectors, with the manufacturing industry being affected more negatively than the average, and also showed that the severity of the crisis impact decreased in regions where the industrial sector was more developed. In this context, it could be said that the findings of this study are consistent with the said study.

Finally, the two major earthquakes in Türkiye on February 6, 2023, constitute a significant event that affected 2023. Therefore, it is essential to consider this when interpreting regional resilience. In reports revealing the earthquake's impact (SBB, 2023), regarding evaluations specific to the manufacturing industry, it is mentioned that the share of 11 earthquake-affected provinces in 2022 exports was 8.6%, and that the earthquake did not cause significant damage to planned industrial areas in the region. However, it is stated that production disruptions are expected in some facilities due to infrastructure damage or a lack of labor force, and it is emphasized that the most critical impact of the earthquake on manufacturing industry workplaces is the loss of the skilled labor force (SBB, 2023: 95-96). According to the findings of this study, considering that the number of regions with high regional resilience decreased and the number of regions with high sensitivity increased in 2023 compared to the previous year, it is possible to say that there is a negative trend in regional resilience levels. However, it would be more appropriate to comprehensively interpret the impact of national shocks in 2023 by incorporating current data post-2023 and examining the lagged period.

5. Results and Recommendations

Economic resilience plays a vital role in achieving growth and development goals. As He et al. (2022) emphasized, reinforcing economic resilience is the key to sustainable economic growth in various regions (He et al., 2022: 1). This situation supports growth and development. The effectiveness and success of regional development policies are directly associated with the capacity to withstand economic shocks. Regions that are resilient in the face of shocks and capable of rapid recovery provide significant advantages in achieving economic growth and development goals. For this reason, designing effective growth and development policies and establishing strong foundations for regional development requires understanding regional resilience. This study aims to analyze regional resilience in Türkiye's manufacturing industry. Accordingly, this study focuses on NUTS-2 regions and calculates the sensitivity index based on the 2013-2023 period. As a result of the research, it has been found that the resilience levels of regions in Türkiye's manufacturing industry differ significantly. In addition, it has been determined that recovery rates across regions following economic shocks also vary considerably.

The findings of this study require multidimensional policy recommendations to strengthen the manufacturing industry in Türkiye. In this regard, it is crucial to plan and implement incentive mechanisms that support local economic development, while accounting for regional differences in resilience. In addition, as emphasized by Zhang et al. (2025: 26), improving the quality of education, expanding vocational training opportunities, and strengthening the labor force's skills are essential for enhancing economic resilience. Moreover, as Zárate-Mirón & Moreno-Serrano (2024: 133) argue, it is crucial to consider the level of innovation in the region to strengthen regional resilience. In this context, updating vocational training programs, increasing R&D investments, accelerating technological transformation, and enhancing cooperation in the manufacturing industry will significantly boost regional resilience by raising productivity and competitiveness.

As stated in a report published by The Economic Policy Research Foundation of Türkiye [TEPAV], conducting efforts to increase the scale of firms and in the process improving the investment environment and quality infrastructure are among the determining factors in strengthening regional resilience in the manufacturing industry (TEPAV, 2007: 48). On the other hand, in recent years, artificial intelligence technologies and applications have been rapidly spreading worldwide, and modern manufacturers are making significant investments in artificial intelligence solutions as part of their digital transformation journeys. In this process, artificial intelligence improves industrial organizations' efficiency, quality, and productivity and

rapidly transforms the manufacturing industry (Soldatos, 2024). In this axis, considering technological revolutions and the rapid development of artificial intelligence, incentive programs to support innovative products and processes in the manufacturing industry can be implemented, and efforts to improve the digital infrastructure of regions can be strengthened.

This study analyzes regional resilience in the manufacturing industry using the sensitivity index for 2013-2023 in Türkiye's NUTS-2 regions. In future studies, regional resilience can be analyzed across sectors (automotive, construction, etc.), and new indices can be developed by incorporating institutional and social dimensions into the measurement process. Moreover, the links between regional resilience and various factors (for example, sector clusters, R&D expenditures, and digitalization) can also be examined using econometric analyses.

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APP-1. Sensitivity index results

	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
TR10	0.81	0.76	0.36	0.55	-1.05	-0.77	-0.12	0.78	1.82	1.27
TR21	1.99	1.36	0.91	1.45	2.37	0.82	1.39	1.36	-0.47	-0.05
TR22	-0.02	0.37	2.02	0.76	-0.73	4.36	2.90	1.22	-0.17	0.24
TR31	0.72	0.56	1.66	1.29	1.17	4.07	1.18	1.29	0.96	-1.06
TR32	1.61	0.01	1.31	0.86	2.18	2.99	1.92	1.25	0.54	-1.84
TR33	1.37	1.50	1.86	1.10	8.36	2.64	2.79	1.17	-0.68	-0.14
TR41	0.65	1.61	0.96	0.90	1.73	1.63	-0.95	1.05	0.14	0.95
TR42	0.83	2.10	0.91	1.31	1.19	4.21	1.99	1.15	-0.26	2.51
TR51	0.72	0.80	1.51	1.11	7.42	-4.48	-2.55	0.66	4.01	3.82
TR52	1.36	0.64	1.32	1.49	1.73	1.13	3.59	0.50	2.46	-0.13
TR61	1.79	-0.17	-0.08	1.16	0.80	-0.01	-1.27	1.06	0.81	2.10
TR62	1.38	0.41	1.79	1.38	-0.74	1.93	4.01	1.20	0.60	-2.39
TR63	1.13	-0.20	2.63	0.99	-4.01	9.21	1.80	1.31	-3.97	-3.80
TR71	0.29	1.29	0.19	1.78	0.63	4.24	-0.48	1.65	3.74	0.57
TR72	0.89	-0.42	0.75	1.01	-0.39	-0.51	2.91	0.80	0.82	-0.17
TR81	2.83	-0.33	-3.06	1.35	-5.95	15.94	2.86	1.11	-2.27	-4.25
TR82	2.61	1.48	3.00	1.42	4.73	-0.11	4.44	1.13	0.81	5.77
TR83	0.96	1.14	1.68	1.00	-5.48	0.31	3.74	0.62	1.31	5.17
TR90	2.43	1.77	0.91	0.35	-5.14	-3.42	2.32	0.16	-1.44	4.62
TRA1	0.24	-2.30	4.76	1.52	-14.51	4.35	0.04	0.59	1.40	5.07
TRA2	-0.05	-5.02	2.20	1.38	-10.32	1.73	6.31	0.14	3.57	6.32
TRB1	0.38	1.17	1.75	1.85	-5.96	-0.01	1.94	1.50	0.71	1.05
TRB2	-0.04	-3.99	2.13	1.43	1.55	0.60	-0.49	0.66	3.24	4.61
TRC1	1.78	1.86	0.62	0.54	1.58	-2.36	6.07	0.93	0.56	-2.93
TRC2	0.58	1.34	2.52	0.89	-5.05	-0.40	-1.73	1.27	3.22	0.60
TRC3	0.75	1.43	4.91	3.61	-4.79	4.14	1.59	1.14	3.37	7.50