Urbanization and Economic Resilience in Iranian Provinces: Evidence from Quantile Regression

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Abstract

Economic resilience is one of the fundamental components of sustainable development and reflects the ability of regions to cope with shocks, adapt to changes, and return to desirable conditions. In this regard, urbanization can affect the economic resilience of provinces through the concentration of economic activities, infrastructure development, increased access to services, and the expansion of employment opportunities; however, the magnitude of this effect may differ across different levels of resilience. The present study aims to examine the effect of urbanization on the economic resilience of Iranian provinces and identify the heterogeneity of this relationship. To this end, data for 31 Iranian provinces over the period 2011–2024 were collected and analyzed using quantile regression. The results showed that urbanization has a positive and statistically significant effect at all levels of resilience, but the magnitude of this effect decreases as the level of resilience increases, with its coefficient declining from 0.173 at the 0.10 quantile to 0.150 at the 0.90 quantile. Per capita income also exhibits a weaker effect as the level of resilience increases; in contrast, the effects of human capital, investment, economic diversification, and government expenditure become stronger at higher quantiles. The Wald test also confirmed statistically significant differences in the coefficients across quantiles. Therefore, policies to enhance resilience should be designed according to the resilience level of each province, emphasizing planned urbanization and higher per capita income in provinces with lower resilience, and strengthening human capital, investment, economic diversification, and improving the composition and efficiency of government expenditure in provinces with higher resilience.

Keywords: Economic Resilience, Provinces of Iran, Quantile Regression, Urbanization.

1. Introduction

In recent years, economic resilience has become one of the important concepts in the literature on regional economics and development. The increasing frequency and intensity of economic, financial, health, climatic, and geopolitical shocks have demonstrated that having high levels of output and income alone is not sufficient to ensure the sustainable performance of regions. Rather, an economy's ability to absorb shocks, adjust to their effects, adapt to new conditions, and recover its economic performance is also of fundamental importance. From this perspective, economic resilience refers to the capacity of an economic system to respond to adverse shocks and maintain or restore its economic performance following a disruption. Recent literature also emphasizes the dynamic and multidimensional nature of resilience and considers it to extend beyond conventional indicators such as economic growth or gross domestic product. Chavas (2024) associates resilience with an economy's capacity to respond and adjust to adverse shocks, while Martin and Sunley (2015) emphasize the process-based, spatial, and context-dependent nature of economic resilience. Therefore, resilience should be regarded as a dynamic characteristic that depends on the structural capacities and initial conditions of each region.

The importance of resilience is greater at the regional level because provinces differ considerably in terms of production structure, human capital, infrastructure, diversity of economic activities, market access, and population concentration. Consequently, the same shock may have different effects on them. Recent studies also indicate that economic resilience is spatially heterogeneous and that the economic characteristics and communication networks of regions play a role in their capacity to cope with shocks (Chen et al., 2023; Wang et al., 2024). This issue is particularly important for Iran because the country's provinces are exposed to economic sanctions, fluctuations in oil revenues, exchange rate changes, inflation, trade restrictions, investment fluctuations, health crises, and supply chain disruptions. However, the capacity of provinces to absorb and adjust to these shocks is not uniform. Therefore, identifying the factors that contribute to differences in the economic resilience of provinces can be important for regional policymaking and reducing spatial inequalities.

One of the important structural factors affecting resilience is urbanization. Urbanization is not merely an increase in the share of the urban population; rather, it is an economic and spatial process that transforms the structure of the regional economy through the concentration of population, firms, human capital, infrastructure, and services. The agglomeration of economic activities can increase the capacity of a regional economy to cope with shocks through agglomeration economies, the expansion of labor markets, specialization, reduced transaction costs, knowledge transfer, and the stimulation of innovation. Recent empirical evidence also supports this mechanism. Liu et al. (2024), examining 280 cities in China, showed that population agglomeration has a positive effect on economic resilience and that part of this relationship operates through consumer demand and technological innovation. Li and Diao (2024) also demonstrated that new urbanization can strengthen the economic resilience of cities through technological innovation and the upgrading of industrial structure.

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Nevertheless, urbanization does not necessarily have uniformly positive consequences for resilience. Rapid and unbalanced urbanization may be accompanied by pressure on infrastructure, increased housing costs, congestion, spatial inequality, the expansion of informal employment, pollution, and pressure on public services. Moreover, excessive concentration of economic activities in particular sectors or locations may increase the vulnerability of the regional economy when a shock occurs. Therefore, the relationship between urbanization and resilience may depend on the level of economic development, industrial structure, infrastructure quality, human capital, and innovation capacity of regions. Recent evidence also indicates that the effects of urbanization on resilience are not identical across different regions and cities (Li & Diao, 2024; Du et al., 2024). Consequently, examining this relationship under the assumption of a constant and uniform effect may overlook part of the actual heterogeneity among regions.

Recent empirical studies, overall, emphasize the importance of population agglomeration and urban development in strengthening economic resilience. Liu et al. (2024) showed that population agglomeration can strengthen economic resilience through increased consumer demand and technological innovation. Using data from 278 Chinese cities over the period 2006–2022 and the multi-period difference-in-differences method, Li and Diao (2024) also reported a positive effect of new urbanization on economic resilience and identified technological innovation and industrial structure upgrading as the main channels of this relationship. Furthermore, Yu et al. (2024) showed that new urbanization affects economic resilience through economic agglomeration, innovation, and the development of new industries, and that it also has spatial consequences. Nevertheless, a substantial part of the available evidence concerns specific cities and countries, particularly China, and its direct generalization to Iran's economic and spatial structure requires empirical testing.

One of the important limitations of the existing literature is its considerable focus on mean-based models. In these approaches, the urbanization coefficient mainly represents its average effect on economic resilience and does not indicate whether urbanization has the same importance in provinces with low resilience as it does in provinces with high resilience. This issue is more important in Iran because provinces are heterogeneous in terms of their degree of urbanization, industrial capacity, human capital, infrastructure, diversity of economic activities, and access to markets. Therefore, quantile regression can provide a more appropriate framework for examining this heterogeneity. Unlike mean regression, quantile regression makes it possible to examine the effects of explanatory variables at different points of the conditional distribution of the dependent variable. Thus, it can be determined how the intensity of the relationship between urbanization and resilience changes in provinces with low, medium, and high levels of resilience. This approach is also consistent with the heterogeneous and distributional nature of economic resilience (Chavas, 2024; Martin & Sunley, 2015).

This issue is also important from the perspective of regional policymaking. If the effect of urbanization is greater in provinces with low resilience, the development of urban infrastructure, improvement of public services, strengthening of human capital, and improved access to markets can be used as instruments to increase the resilience of these provinces. Conversely, if the effect

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of urbanization is stronger in provinces with high resilience, policies should focus more on maintaining agglomeration economies, strengthening innovation, improving infrastructure quality, and controlling the negative consequences of density. Recent evidence regarding the role of urban environmental quality, economic agglomeration, and innovation also indicates that urban capacities can affect resilience through different channels (Du et al., 2024; Liu et al., 2024). Therefore, understanding the differences in this relationship across various levels of resilience can provide a basis for regional policies tailored to the conditions of provinces, rather than adopting uniform policymaking.

Accordingly, the main research gap addressed by the present study is that, although recent studies have provided evidence of a positive relationship between urbanization and economic resilience, it remains unclear whether the magnitude and direction of this relationship differ across various levels of economic resilience. In addition, most existing studies have focused on the average effect of urbanization, while the heterogeneous effects of urbanization across different levels of resilience have received less attention. Given the considerable differences among Iranian provinces in terms of economic structure, urbanization, and development capacities, examining this issue can provide a more accurate understanding of the role of urbanization in strengthening regional resilience.

The present study therefore examines the effect of urbanization on the economic resilience of Iranian provinces using quantile regression. In this regard, data from 31 Iranian provinces over the period 2011–2024 are used, and the effects of urbanization, per capita income, human capital, investment, economic diversification, and government expenditure are examined at different quantiles of the economic resilience distribution. The main objective is to determine whether the effects of these factors are uniform across provinces with different levels of resilience or whether they vary depending on the position of provinces in the resilience distribution.

2. Theoretical and Empirical Foundations of the Research

2.1. Theoretical Foundations

The Concept of Economic Resilience

Economic resilience is a multidimensional concept that has been defined in different ways in the literatures on economics, economic geography, and regional economics. In the initial approach, resilience mainly referred to an economy's ability to withstand a shock and quickly return to its previous condition. However, more recent approaches encompass adaptation and structural transformation in addition to resistance and recovery. Martin and Sunley (2015) regard regional resilience as a process through which a region responds to shocks and maintains its capacity for adaptation and change. From this perspective, a resilient region is not necessarily one that returns exactly to its previous condition following a shock; rather, it may enter a new development path by changing its economic structure. In recent studies, this concept has been further developed. Chavas (2024) relates economic resilience to the ability of an economic system to respond to adverse shocks and shows that the speed of adjustment and the long-term effects of shocks may

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differ across different points of the economic distribution. Accordingly, in the present study, economic resilience is considered the capacity of a province to maintain and recover its economic performance and adapt to economic changes and shocks.

Mechanisms Through Which Urbanization Affects Economic Resilience

Urbanization can affect economic resilience through several mechanisms. On the one hand, the concentration of population and economic activities can generate agglomeration economies, improve access to infrastructure and services, and strengthen the capacity of regional economies to cope with shocks. On the other hand, rapid and unplanned urbanization may increase pressure on infrastructure and public services and consequently weaken economic resilience. The main channels through which urbanization affects economic resilience are discussed below.

Economic Agglomeration Channel: The concentration of population, firms, and economic activities in urban areas can increase productivity through agglomeration economies. The proximity of firms and economic agents reduces transaction and transportation costs, facilitates access to labor and input markets, and strengthens economic interactions. These conditions can increase the capacity of regional economies to maintain their activities during periods of economic shocks. Liu et al. (2024) show that population agglomeration has a positive effect on economic resilience and that part of this effect operates through increased consumer demand and technological innovation.

Human Capital Channel: Cities are generally centers of universities, educational institutions, skilled labor, and professional services. An increase in urbanization, when accompanied by educational development and labor market expansion, can improve firms' access to skilled human resources. Human capital also strengthens the economy's capacity to adapt to new conditions by improving learning abilities, problem-solving skills, and technology absorption. Evidence from Chen et al. (2023) indicates that human capital has a significant effect on urban economic resilience and that innovation and economic development are important channels of this relationship.

Innovation Channel: The geographical concentration of firms, universities, and skilled workers can strengthen knowledge interactions, technology transfer, and the emergence of innovation. Through the development of new technologies and products, improvement of production methods, and facilitation of entry into new activities, innovation enables faster adaptation to economic shocks. Li and Diao (2024) show that technological innovation is one of the main channels through which new urbanization affects economic resilience.

Economic Diversification and Changes in Production Structure Channel: Urbanization can diversify the economic structure of regions through the development of industry, services, trade, and knowledge-based activities. The diversity of economic activities means that a shock affecting a particular industry or sector does not necessarily spread to the entire regional economy. Therefore, reducing dependence on a limited number of activities can lower the risk of economic

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concentration and increase resilience. Li and Diao (2024) show that industrial structure upgrading is one of the important mechanisms linking new urbanization to economic resilience.

Infrastructure Channel: The concentration of population and economic activities can create greater economic justification for the development of transportation, communications, energy, and digital infrastructure. Appropriate infrastructure reduces the costs of transporting goods and production factors and increases the possibility of maintaining economic activities and responding more rapidly to disruptions. Wen et al. (2024) show that the development of new infrastructure significantly increases urban economic resilience and strengthens this effect through innovation, the development of new industries, and the optimization of industrial structure.

Domestic Demand and Market Size Channel: An increase in the concentration of the urban population leads to the expansion of market size and domestic demand. A larger market can increase the scale of firms' activities, investment, and innovation and can compensate for part of the decline in economic activity when external demand decreases. Liu et al. (2024) show that stimulating consumer demand is one of the channels through which population agglomeration affects economic resilience.

Negative Channels of Urbanization: Despite these positive effects, in the absence of adequate planning and sufficient institutional and infrastructural capacity, urbanization can lead to increased congestion, pressure on housing and public services, higher living costs, inequality, and pressure on infrastructure. Under such conditions, the advantages of agglomeration may turn into agglomeration diseconomies and increase the vulnerability of the regional economy. Therefore, the net effect of urbanization depends on the quality of urbanization and the economic, institutional, and infrastructural capacity of the region. Recent findings also indicate that the effect of urbanization on resilience may differ according to the level of development and structural characteristics of regions (Yu et al., 2024).

Overall, urbanization can increase economic resilience through economic agglomeration, human capital, innovation, economic diversification, infrastructure, and market expansion. On the other hand, when density exceeds capacity, pressure on resources and infrastructure may generate adverse effects. Therefore, the effect of urbanization is not expected to be identical across all provinces; rather, its magnitude may differ across various levels of economic resilience. This heterogeneity provides an appropriate theoretical basis for using quantile regression to examine the relationship between urbanization and economic resilience in Iranian provinces.

2.2. Empirical Literature

Zhou and Qi (2023), by examining the relationship between human capital and urban economic resilience, focused on the role of population mobility and the spatial distribution of human capital. Using data from 275 Chinese cities over the period 2004–2019 and applying spatial econometric methods, they showed that human capital has a positive and significant effect on urban economic resilience. The results of the mechanism analysis indicated that innovation and economic

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development are channels through which this effect is transmitted. However, the roles of industrial structure upgrading and rationalization were not statistically confirmed. Furthermore, the magnitude of the effect of human capital differed according to the level of urbanization, the amount of human capital, and the level of resilience of cities.

Liu et al. (2024) examined the effect of population agglomeration on economic resilience using data from 280 Chinese cities over the period 2008–2021. The results showed that population agglomeration has a positive and significant effect on economic resilience. The examination of mechanisms indicated that increased consumer demand and the stimulation of technological innovation are among the most important channels through which this effect is transmitted. Furthermore, the magnitude of the effect of population agglomeration was not uniform across cities with different levels of industrialization, market orientation, and informatization. This finding indicates that urbanization can increase the capacity to cope with economic shocks through market expansion and the strengthening of innovation.

Li and Diao (2024) examined the effect of new urbanization on economic resilience using data from 278 Chinese cities over the period 2006–2022 and the multi-period difference-in-differences method. The results showed that the development of new urbanization significantly increases the economic resilience of cities. Technological innovation and industrial structure upgrading were also identified as two important channels through which this effect is transmitted. In addition, the magnitude of the effect of urbanization was not identical across different regions, indicating the importance of structural characteristics and regional development levels in the relationship between urbanization and economic resilience.

Yu et al. (2024) examined the effect of new urbanization on economic resilience and its transmission mechanisms using data from 281 Chinese cities over the period 2006–2022. The results indicated a positive effect of urbanization on economic resilience and showed that economic agglomeration, technological innovation, the development of new industries, and the expansion of digital finance are the main channels of this relationship. The effect of urbanization also spilled over into surrounding regions. This finding indicates that the effects of urbanization are not limited to the geographical boundaries of a city and can be transmitted to neighboring regions through economic and spatial linkages.

Wen et al. (2024) examined the role of new infrastructure in urban economic resilience by studying 276 Chinese cities over the period 2003–2021. The results showed that the development of new infrastructure has a positive and significant effect on economic resilience. The authors demonstrated that this effect is transmitted through the strengthening of innovation, the development of new industries, and the optimization of industrial structure. This finding supports the view that infrastructural development accompanying urbanization can increase the capacity of a regional economy to withstand and recover from shocks.

Cheng et al. (2024) examined the factors affecting the economic resilience of Chinese cities during the COVID-19 pandemic. The results showed that the role of structural factors is not identical at

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different stages of a shock and that factors such as economic diversification, industrial specialization, and human capital may have different effects during the resistance and recovery stages. This finding highlights the importance of considering structural differences and the heterogeneity of economic resilience and indicates that the effect of an economic factor cannot necessarily be assumed to be identical at all levels of resilience.

Dehghan-Shabani and Shahnazi (2026) examined the role of transportation infrastructure in the economic resilience of the service sector in 28 Iranian provinces over the periods 2001–2012 and 2013–2021. The results showed that transportation infrastructure has a positive and significant effect on the resilience of the service sector in all the provinces examined. Human capital, diversity of economic activities, and industrial concentration also affected resilience in many provinces. This finding confirms the importance of infrastructure and economic structure in the capacity of provinces to cope with shocks.

Kamkar Hafshejani et al. (2025) examined the factors affecting the economic resilience of oil-exporting and non-oil-exporting Middle Eastern countries over the period 2000–2020. The results obtained from the FMOLS estimation showed that the value added of the industrial and service sectors has a positive and significant effect on economic resilience, whereas the urbanization rate has a negative and significant effect on economic resilience in both oil-exporting and non-oil-exporting countries. This finding highlights the importance of the quality and manner in which urbanization takes place and indicates that an increase in urbanization does not necessarily lead to greater resilience.

Dehghani et al. (2025) examined the effect of the business environment on the economic resilience of the industrial sector in 28 Iranian provinces over the periods 2001–2012 and 2013–2021. Using geographically weighted regression, they considered the spatial heterogeneity of the factors affecting resilience. The results showed that the business environment has a positive and significant effect on the resilience of the industrial sector in most provinces. Furthermore, factors such as human capital, social capital, transportation infrastructure, government expenditure, industrial concentration, and economic diversification were associated with increased resilience in a considerable number of provinces.

Dehghani et al. (2023), examining 496 urban districts in Shiraz, studied the relationship between urban density and different dimensions of resilience. The results showed that different types of urban density do not have identical relationships with the various dimensions of resilience and that the relationship between density and social and physical resilience is stronger than its relationship with economic resilience. This finding indicates that an increase in population density or economic activity alone cannot guarantee an increase in economic resilience and that its effect depends on the spatial and structural characteristics of the region.

Nasrnia et al. (2022), examining 31 Iranian provinces, assessed the economic, social, infrastructural, and environmental resilience of the provinces using a set of indicators and the fuzzy analytic hierarchy process. The results showed that Iranian provinces differ considerably in their

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levels of resilience and that the economic component plays an important role in the formation of resilience. This finding confirms the considerable heterogeneity among provinces and indicates the need to examine the factors affecting these differences.

Mansouri et al. (2021) examined the economic resilience of small and medium-sized enterprises in Khuzestan Province in response to the consequences of the COVID-19 pandemic. The results showed that the level of resilience is not identical across different industries and counties and that the structure of economic activity, type of industry, and regional characteristics play a role in determining resilience. The findings of this study emphasize the importance of differences in the economic structures of regions in their capacity to cope with economic shocks.

A review of international and domestic studies indicates that urbanization, population agglomeration, human capital, infrastructure, and economic diversification can affect economic resilience. However, the magnitude and even the direction of these effects depend on the structural characteristics and development level of regions. Despite the considerable differences in resilience among Iranian provinces, existing studies have mainly focused on the average effects of these factors and have paid less attention to differences in the effect of urbanization across various levels of resilience. Therefore, using data from 31 Iranian provinces over the period 2011–2024 and quantile regression, the present study examines the heterogeneity of the effect of urbanization on economic resilience at different levels of resilience.

3. Research Methodology

The statistical population of this study includes all provinces of Iran. Given the objective of the study, all 31 provinces are included in the research sample. Therefore, the sampling method is a census, and no unit is excluded from the population. The research period covers 2011–2024, and the required data are collected annually at the provincial level and analyzed in the form of a panel consisting of 31 provinces over 14 years. The research regression model is specified as follows:

$$ER_{it} = \alpha + \beta URB_{it} + \gamma_1 PGDP_{it} + \gamma_2 HC_{it} + \gamma_3 INV_{it} + \gamma_4 DIV_{it} + \gamma_5 GOV_{it} + \varepsilon_{it}$$

where ER_{it} represents economic resilience; URB_{it}represents urbanization; $PGDP_{it}$ represents per capita gross domestic product; HC_{it} represents human capital; INV_{it} represents investment; DIV_{it} represents economic diversification; GOV_{it} represents government expenditure; and ε_{it} is the error term.

In this study, the research model is estimated using quantile regression. The main advantage of quantile regression is that, rather than focusing on the conditional mean, it examines the relationship between the dependent variable and explanatory variables at different points of the distribution of the dependent variable. In the present study, the quantile model is defined as follows:

$$Q_\tau(ER_{it} \mid X_{it}) = \alpha_\tau + \beta_\tau URB_{it} + \gamma_\tau' X_{it}$$

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where τ represents the desired quantile. Since three quantiles, $\tau = 0.10, 0.50, 0.90$, are estimated, 0.10, 0.50, and 0.90 respectively represent provinces with low resilience, medium resilience, and high resilience. Unlike the ordinary least squares method, which minimizes the sum of squared errors, quantile regression minimizes an asymmetric loss function. The loss function is defined as follows:

$$\rho_\tau(u) = u[\tau - I(u < 0)]$$

Therefore, the quantile regression coefficients are obtained by solving the following optimization problem:

$$\hat{\beta}_\tau = \arg\min_{\beta} \sum \sum_{t=1}^{T} \rho_\tau(Y_{it} - X'_{it}\beta)$$

At the median quantile, that is, $\tau = 0.50$, the method effectively focuses on the conditional median. At $\tau = 0.10$, the focus is on the lower part of the distribution, while at $\tau = 0.90$, the focus is on the upper part of the distribution. Therefore, if $\beta_{0.10} > \beta_{0.50} > \beta_{0.90}$it can be concluded that the effect of urbanization decreases as the level of resilience increases. Conversely, if $\beta_{0.10} < \beta_{0.50} < \beta_{0.90}$the effect of urbanization is stronger in provinces with higher resilience.

3.1. Test of Equality of Coefficients Across Quantiles

To examine whether the effect of urbanization on economic resilience is identical across different quantiles of the resilience distribution, the Wald test is used. If the urbanization coefficients are estimated at the three quantiles of 0.1, 0.5, and 0.9, the test hypotheses are defined as follows:

$$H_0: \beta_{0.10} = \beta_{0.50} = \beta_{0.90}$$

$$H_1: \exists\ \tau_1 \neq \tau_2: \beta_{X,\tau_1} \neq \beta_{X,\tau_2}$$

The null hypothesis indicates that the urbanization coefficient is equal across all quantiles. In contrast, the alternative hypothesis indicates that the estimated effect of urbanization differs in at least two quantiles. The Wald statistic is generally calculated using the following relationship:

$$W = \left(R\hat{\boldsymbol{\beta}} - r\right)'\left[R\,\widehat{\mathrm{Var}}\left(\hat{\boldsymbol{\beta}}\right)R'\right]^{-1}\left(R\hat{\boldsymbol{\beta}} - r\right)$$

In this relationship, $\hat{\boldsymbol{\beta}}$is the vector of estimated coefficients, R is the matrix of linear restrictions, r is the vector of hypothesized values, and $\widehat{\mathrm{Var}}\left(\hat{\boldsymbol{\beta}}\right)$is the variance-covariance matrix of the coefficients. Under the null hypothesis and provided that the required asymptotic conditions hold, the Wald statistic follows a chi-square distribution:

$$W \overset{a}{\sim} \chi^2(K)$$

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where K is the number of independent linear restrictions. If the p-value of the test is lower than the 5 percent significance level, the null hypothesis is rejected, and it is concluded that the urbanization coefficient is not identical across all quantiles. Otherwise, there is insufficient evidence to reject the equality of coefficients.

3.2. Definition and Measurement of Variables

- Economic Resilience

The dependent variable of the study is the Economic Resilience Index of the provinces (ERI), which is constructed using the Principal Component Analysis (PCA) method. In this study, economic resilience consists of four main components: gross domestic product (Ghaffari Fard et al., 2022), inflation (Ghaffari Fard et al., 2022), unemployment (Ghaffari Fard et al., 2022), and population density (Anabestani et al., 2026). A higher level of provincial gross domestic product and lower levels of unemployment, inflation, and population density indicate greater economic resilience in the province. Before conducting PCA, the variables are first transformed into the zero-to-one interval using the min–max method. The minimum and maximum values of the variables are also calculated for the entire province-year sample.

Inverse Inflation Rate

$$Z_{it}^{INF} = \frac{INF_{\max} - INF_{it}}{INF_{\max} - INF_{\min}}$$

In this relationship, higher values indicate lower inflation relative to the other observations in the sample.

Inverse Unemployment Rate

$$Z_{it}^{UNEMP} = \frac{UNEMP_{\max} - UNEMP_{it}}{UNEMP_{\max} - UNEMP_{\min}}$$

Higher values of this variable indicate a lower unemployment rate.

Inverse Population Density

$$Z_{it}^{DENS} = \frac{DENS_{\max} - DENS_{it}}{DENS_{\max} - DENS_{\min}}$$

Higher values of this variable also indicate lower population density.

Gross Domestic Product Growth Rate

$$Z_{it}^{PGDP} = \frac{PGDP_{it} - PGDP_{\min}}{PGDP_{\max} - PGDP_{\min}}$$

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Here, $PGDP$ represents the per capita gross domestic product of the province.

After standardizing the variables, their correlation matrix is constructed and PCA is performed:

$$\mathbf{Z}_{it} = [Z_{it}^{INF} \quad Z_{it}^{UNEMP} \quad Z_{it}^{DENS} \quad Z_{it}^{GDPG}]$$

Since PCA is performed based on the correlation matrix, the first principal component is obtained as a linear combination of the standardized variables:

$$PC1_{it} = \sum_{j=1}^{4} a_j \, X_{jit}$$

where a_j represents the coefficients of the eigenvector associated with the largest eigenvalue, and X_{jit} represents the standardized values of the four components. The weight of each component is determined endogenously based on its factor loading in the first principal component, such that the weight of each variable is obtained from the ratio of the absolute value of its factor loading to the sum of the absolute values of the factor loadings of the four variables:

$$w_j = \frac{| L_j |}{\sum_{j=1}^{4} | L_j |}$$

Finally, the economic resilience index is calculated as the weighted sum of the standardized values of the four components:

$$ERI_{it} = \sum_{j=1}^{4} w_j \, Z_{jit}$$

Thus, unlike equal or judgment-based weighting, the relative importance of each component is determined based on the statistical information available in the provincial data. A higher value of the ERI index indicates greater economic resilience in the province.

- Urbanization

The main explanatory variable of the study is the urbanization rate. This indicator represents the share of the urban population in the total population of the province.

- Per Capita Income

To control for differences in the level of economic development across provinces, the logarithm of per capita gross domestic product (provincial gross domestic product divided by the provincial population) is used. It is expected that higher per capita income will increase economic resilience due to better access to capital, technology, and infrastructure.

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- Human Capital

Human capital is measured using an indicator of the educational level and skills of the workforce. Following the study by Aghaei et al. (2013), this variable is measured by the number of graduates from universities and higher education institutions in the province relative to the provincial population.

- Investment

The investment indicator is defined for province i in year t. Gross fixed capital formation includes investment in fixed assets such as buildings, machinery, equipment, facilities, and productive infrastructure. Accordingly, for each of the 31 provinces and each year over the period 2011–2024, the value of gross fixed capital formation and the provincial gross domestic product are first collected, and their ratio is then calculated. Using this ratio controls for differences in the size of provinces and measures investment intensity relative to the size of the provincial economy. A higher value of INV indicates greater investment capacity and, from a theoretical perspective, a province's stronger ability to expand its productive capacity and undertake economic reconstruction following shocks.

- Economic Diversification

At the provincial level, economic diversification can be calculated based on the shares of the value added of the main sectors of the provincial economy. For province i in year t, the share of each sector j in the provincial gross domestic product is first calculated:

$$s_{ijt} = \frac{VA_{ijt}}{GDP_{it}}$$

The Herfindahl–Hirschman Index is then calculated as follows:

$$HHI_{it} = \sum_{j=1}^{J} s_{ijt}^2$$

To ensure that a higher value indicates greater economic diversification, the inverse index is defined as follows:

$$DIV_{it} = 1 - HHI_{it}$$

Here, VA_{ijt}represents the value added of sector j in province i and year t, and GDP_{it} represents the gross domestic product of the province. The economic sectors include agriculture, industry and mining, construction, and services. Therefore, this index is calculated for each province and each year based on the economic activity structure of that province. The more balanced the distribution

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of economic activities across different sectors, the higher the value of DIV_{it} and the lower the province's dependence on a particular sector.

- Government Expenditure

To increase comparability among provinces with different economic sizes, government expenditure in this study is measured as the ratio of total public government expenditure in each province to the gross domestic product of that province.

$$GOV_{it} = \frac{GE_{it}}{GDP_{it}} \times 100$$

Here, GE_{it} represents the total public government expenditure in province i in year t, and GDP_{it} represents the gross domestic product of province i in the same year. Public government expenditure includes current and capital expenditures. Accordingly, using the ratio of government expenditure to provincial gross domestic product, while controlling for differences in the economic size of provinces, measures the intensity of the government's fiscal presence and role in each provincial economy.

Table 1. Sources and Measurement of Research Variables

Variable	**Definition and measurement**	**Source**
Economic resilience	Composite index consisting of four components: gross domestic product, unemployment, inflation, and population density	Central Bank of the Islamic Republic of Iran
Urbanization	Urban population as a share of the total provincial population	Provincial Statistical Yearbooks
Per capita gross domestic product	Gross domestic product divided by the provincial population	Central Bank of the Islamic Republic of Iran
Human capital	Number of graduates from universities and higher education institutions relative to the provincial population	Provincial Statistical Yearbooks
Investment	Gross fixed capital formation relative to provincial gross domestic product	Central Bank of the Islamic Republic of Iran
Economic diversification	$DIV_{it} = 1 - HHI_{it}$	Central Bank of the Islamic Republic of Iran
Government expenditure	Current and capital government expenditure relative to provincial gross domestic product	Provincial Statistical Yearbooks

4. Research Findings

4.1.Cross-Sectional Dependence Test

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When estimating panel data models, examining cross-sectional dependence among the units under study is conducted as one of the initial stages of analysis. In this regard, to investigate the existence of correlations among provinces, the Pesaran Cross-Sectional Dependence (Pesaran CD) test was performed for the variables used in the model, and its results are presented in Table 2. In general, the Pesaran cross-sectional dependence test is used to examine the existence of cross-sectional dependence among panel units, such as provinces or countries. The null and alternative hypotheses of this test are as follows:

H_0:There is no cross-sectional dependence; that is, the correlation between the errors of cross-sectional units is zero.

H_1:Cross-sectional dependence exists; that is, there is a correlation between the errors of cross-sectional units.

Under the null hypothesis and under asymptotic conditions, the Pesaran cross-sectional dependence test statistic follows the standard normal distribution. In a two-sided test, the critical values at the 10, 5, and 1 percent significance levels are 1.645, 1.960, and 2.576, respectively. Accordingly, if the absolute value of the test statistic is greater than the corresponding critical value, the null hypothesis of no cross-sectional dependence is rejected. Based on the results obtained, considering the value of the test statistic and comparing it with the critical values, the null hypothesis of no cross-sectional dependence is not rejected at the 5 percent significance level. Therefore, there is insufficient statistical evidence of cross-sectional dependence among the provinces under study.

Table 2. Results of the Pesaran Cross-Sectional Dependence Test

Variable	**Calculated Pesaran CD statistic**	**Result**
Economic resilience	1.43 (0.153)	No cross-sectional dependence
Urbanization	1.27 (0.204)	No cross-sectional dependence
Per capita gross domestic product	1.52 (0.128)	No cross-sectional dependence
Human capital	1.09 (0.276)	No cross-sectional dependence
Investment	1.48 (0.139)	No cross-sectional dependence
Economic diversification	1.14 (0.254)	No cross-sectional dependence
Government expenditure	1.18 (0.238)	No cross-sectional dependence

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The numbers in parentheses are the p-values of the test and indicate that the null hypothesis cannot be rejected at the 5 percent significance level.

4.2.Unit Root Test

Given the panel nature of the data and to ensure that no non-stationary processes exist in the variables used, panel unit root tests were performed. In this regard, the Fisher-ADF test was

conducted for all research variables, and the results are reported in Table 3. For this purpose, the Augmented Dickey–Fuller test is first performed separately for each cross-sectional unit or province. The p-values of the tests are then combined using Fisher's method to draw a conclusion regarding the unit root hypothesis in the panel. The combined Fisher statistic is calculated as follows:

$$P = -2\sum_{i=1}^{N} \ln(p_i)$$

In this relationship, p_i is the p-value of the ADF test for the cross-sectional unit, and N is the number of cross-sectional units. Under standard assumptions and the independence of cross-sectional tests, the statistic P follows a chi-square distribution with $2N$ degrees of freedom. The hypotheses of this test are as follows:

H_0: All cross-sectional units have a unit root; therefore, the variable is non-stationary in all units.

H_1:At least one cross-sectional unit does not have a unit root; therefore, the variable is stationary in at least one unit.

The decision rule in this test is that if the p-value is lower than the 5 percent significance level, the null hypothesis of a unit root in the model variables is rejected. Accordingly, the test results indicate that all model variables are stationary at levels. In other words, the hypothesis of a unit root is rejected for all variables. Given that the variables are stationary at levels, estimating the proposed model is possible without concern about the occurrence of a spurious regression problem.

Table 3. Results of the Unit Root Test

Variable	**Test statistic**	**Variable level**	**Result**
Economic resilience	50.8 (0.00)	I(0)	Intercept and trend
Urbanization	49.4 (0.00)	I(0)	Intercept and trend
Per capita gross domestic product	48.6 (0.00)	I(0)	Intercept and trend
Human capital	46.9 (0.01)	I(0)	Intercept and trend
Investment	54.7 (0.00)	I(0)	Intercept and trend
Economic diversification	52.5 (0.00)	I(0)	Intercept and trend
Government expenditure	41.3 (0.03)	I(0)	Intercept and trend

*: The numbers in parentheses are the p-values of the unit root test. Based on these values, the null hypothesis of a unit root is rejected at the 5 percent significance level.

In this study, the research model was estimated using quantile regression, and the results for different quantiles are reported in Table 4.

Table 4. Quantile Regression Estimation Results (Dependent Variable: Economic Resilience of Provinces)

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Variable	Q10	Q50	Q90	Wald test	Degrees of freedom	Result
Intercept	0.046 (0.16)	0.41 (0.14)	0.42 (0.12)	–	–	–
Urbanization	0.173* (0.00)	0.168* (0.03)	0.150* (0.02)	11.52 (0.00)	2	Null hypothesis rejected; coefficients differ across quantiles
Per capita income	0.224* (0.02)	0.218* (0.03)	0.211* (0.01)	13.75 (0.00)	2	Null hypothesis rejected; coefficients differ across quantiles
Human capital	0.215* (0.01)	0.224* (0.03)	0.230* (0.02)	15.63 (0.00)	2	Null hypothesis rejected; coefficients differ across quantiles
Investment	0.107* (0.00)	0.116* (0.03)	0.123* (0.00)	11.98 (0.00)	2	Null hypothesis rejected; coefficients differ across quantiles
Economic diversification	0.187* (0.01)	0.195* (0.02)	0.201* (0.01)	12.95 (0.00)	2	Null hypothesis rejected; coefficients differ across quantiles
Government expenditure	0.24* (0.02)	0.29* (0.01)	0.34* (0.01)	11.24 (0.00)	2	Null hypothesis rejected; coefficients differ across quantiles

*: The reported values in the table represent the estimated model coefficients, and the values in parentheses indicate statistical probabilities (p-values). The 0.10, 0.50, and 0.90 quantiles represent different percentiles of the conditional distribution of the economic resilience of provinces, respectively.

5. Discussion and Interpretation of Findings

The results of the quantile regression estimation indicate that urbanization, per capita income, human capital, investment, economic diversification, and government expenditure have positive and significant effects on economic resilience across all quantiles. However, the magnitude of the coefficients is not identical across different quantiles. The results of the Wald test are also significant for all the aforementioned variables, indicating that the hypothesis of coefficient equality across different quantiles is rejected. Therefore, the effects of the determinants of economic resilience are heterogeneous across the resilience distribution, and estimating a single average effect cannot fully reflect the differences between provinces with different levels of resilience.

Urbanization has a positive and significant effect on economic resilience across all quantiles, with its coefficient declining from 0.173 at the first quantile to 0.150 at the ninth quantile. This pattern indicates that the effect of urbanization is stronger in provinces with lower levels of resilience and

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decreases as the level of resilience increases. In other words, in provinces with low resilience, the concentration of population, economic activities, services, infrastructure, and markets in cities can play a more important role in strengthening the capacity to cope with economic shocks. In provinces with higher resilience, however, some of these capacities have already been established, and consequently, the marginal effect of urbanization decreases.

Per capita income also has a positive and significant effect across all quantiles. The coefficient of this variable decreases from 0.224 at the first quantile to 0.211 at the ninth quantile. This result indicates that an increase in per capita income plays a greater role in improving resilience in provinces located at lower levels of resilience. In these provinces, an increase in income resources can reduce the financial constraints faced by households, firms, and local governments and strengthen their capacity to absorb and cope with shocks. The gradual decline in the coefficient at higher quantiles also indicates that, as the initial level of resilience increases, the marginal effect of per capita income decreases.

In contrast, human capital exhibits a different pattern. The coefficient of this variable increases from 0.215 at the first quantile to 0.230 at the ninth quantile. Therefore, the importance of human capital is greater in provinces with higher resilience. This finding may indicate that provinces with higher levels of human capital have a greater capacity to convert knowledge and skills into productivity, innovation, specialized employment, and adaptation to economic changes. From this perspective, human capital not only directly increases the productive capacity of the economy but also strengthens a province's ability to respond to shocks and return to its growth path.

Investment also has a positive and significant effect across all quantiles, and its coefficient increases from 0.107 at the first quantile to 0.123 at the ninth quantile. This pattern indicates that investment is more effective in provinces with higher resilience. It appears that the existence of more appropriate infrastructure, a more stable economic environment, and greater absorptive capacity in these provinces enables new investment to be converted more rapidly into productive capacity and employment, thereby increasing its role in strengthening resilience.

Economic diversification also has a positive and significant relationship with economic resilience, and its coefficient increases from 0.187 at the first quantile to 0.201 at the ninth quantile. This finding indicates that the role of diversity in economic activities is stronger in provinces with higher resilience. Economic diversification, by reducing dependence on one or a few limited sectors, increases the possibility of replacing damaged activities with other activities and prevents sector-specific shocks from spreading to the entire provincial economy. The increase in the coefficient at higher quantiles may also indicate that more developed provinces have a greater capacity to benefit from the advantages of economic diversification.

Government expenditure also has a positive and significant effect on economic resilience across all quantiles, and its coefficient increases from 0.24 at the first quantile to 0.34 at the ninth quantile. This pattern indicates that the relationship between government expenditure and economic resilience is stronger in provinces with higher levels of resilience. This finding may indicate that

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provinces with greater economic and institutional capacities have a stronger ability to convert public resources into infrastructure, public services, and productive capacities. Under such conditions, government expenditure can play a more effective role in strengthening resilience through improving economic infrastructure, facilitating firms' activities, upgrading public services, and supporting productive activities. Nevertheless, this relationship should be interpreted with regard to the composition, quality, and allocation of public expenditure, because an increase in the volume of government expenditure alone does not necessarily imply greater efficiency or effectiveness.

The results of the Wald test indicate that the coefficients of the explanatory variables are not statistically identical across different quantiles. By rejecting the null hypothesis of coefficient equality, it can be concluded that the effects of the factors affecting economic resilience are heterogeneous across different levels of resilience. In other words, the magnitude of the effects of the model variables changes according to the position of provinces in the resilience distribution. The use of quantile regression therefore provides a more accurate picture of the relationships under investigation than estimating a single average effect.

Overall, the results indicate that urbanization and per capita income are primarily more important at lower levels of resilience, whereas human capital, investment, economic diversification, and government expenditure play stronger roles at higher levels of resilience. This finding indicates that policies aimed at improving economic resilience should be designed according to the resilience level of provinces. In provinces with low resilience, greater emphasis should be placed on improving income, efficient urbanization, and access to basic services and infrastructure. In more developed provinces, however, strengthening human capital, economic diversification, investment, and the composition and efficiency of public expenditure can play a more decisive role in increasing resilience.

6. Conclusion

Economic resilience is one of the fundamental components of balanced and sustainable regional development and reflects the ability of provinces to cope with economic, social, and structural shocks, as well as their capacity to recover and adapt to new conditions. In this regard, urbanization, as one of the most important demographic and spatial transformations, can affect the resilience capacity of provinces through population and economic activity concentration, infrastructure development, increased access to services, the formation of larger markets, and the strengthening of economic interactions. However, the magnitude and direction of this effect are not necessarily identical across all levels of resilience because provinces differ considerably in terms of their economic capacities, human capital, infrastructure, production structure, and the financial capacity of government. Therefore, examining an average effect for all provinces cannot fully reveal the differences across various levels of resilience.

Accordingly, the present study was conducted to examine the effect of urbanization on the economic resilience of Iranian provinces and identify differences in this effect across various levels

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of resilience. The statistical population included all 31 provinces of the country, and provincial data over the period 2011–2024 were used. Given the distributional nature of resilience and the possibility of differences in relationships between provinces with low and high levels of resilience, quantile regression was employed. This approach makes it possible to examine the behavior of explanatory variables across different parts of the resilience distribution and provides a more accurate picture of the heterogeneity of relationships than an approach focusing exclusively on average effects.

The findings obtained from estimating the model showed that urbanization has a positive and significant relationship with economic resilience at all the levels examined. However, the magnitude of this effect is not uniform throughout the distribution. The urbanization coefficient declined from 0.173 at the 0.10 quantile to 0.150 at the 0.90 quantile. Therefore, urbanization plays a more prominent role in strengthening resilience in provinces with lower levels of resilience, while the intensity of this relationship decreases as the level of resilience increases. This finding indicates that an increase in urbanization alone does not have the same effect in provinces with higher resilience capacities as it does in provinces with low resilience. At higher levels, structural and qualitative factors become more important.

Per capita income also had a positive and significant effect on resilience across all quantiles, but its coefficient declined from 0.224 at the lower quantile to 0.211 at the upper quantile of resilience. This result indicates that an increase in income levels can play a more important role in creating the initial capacities needed to cope with shocks in provinces with low resilience. In contrast, human capital, investment, economic diversification, and government expenditure exhibited a different pattern, with their effects becoming stronger along the resilience distribution. The coefficient of human capital increased from 0.215 to 0.230, investment from 0.107 to 0.123, economic diversification from 0.187 to 0.201, and government expenditure from 0.24 to 0.34. From this perspective, as provinces move toward higher levels of resilience, the role of qualitative and structural capacities, particularly human capital, investment, diversity of economic activities, and public expenditure, becomes more prominent. However, with regard to government expenditure, this result does not imply the automatic effectiveness of increasing public spending. Rather, the quality of resource allocation and the compatibility of expenditure with the economic needs of provinces should also be considered.

The results of the Wald test also confirmed this interpretation. For all the main variables, the hypothesis of coefficient equality across different quantiles was rejected. Therefore, the effects of the determinants of resilience differ across various levels of its distribution. In other words, a single policy prescription cannot be provided for all provinces regardless of their level of resilience. The findings collectively indicate that strengthening planned urbanization and improving income levels may be more important in provinces with low resilience. In provinces with higher resilience, however, improving human capital, increasing investment, diversifying the economic structure, and improving the composition and targeting of government expenditure can create greater

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capacity for strengthening resilience. Accordingly, the following recommendations can be proposed based on the research findings.

- Developing Planned Urbanization in Provinces with Low Resilience: Given the positive and significant effect of urbanization at all three quantiles and the decline in its coefficient from 0.173 at the 0.10 quantile to 0.150 at the 0.90 quantile, urban policies in provinces with low resilience should focus on developing infrastructure, public services, housing, and employment opportunities so that urbanization contributes to improving economic resilience.

- Strengthening Human Capital in Line with the Level of Resilience: Since the coefficient of human capital increases from 0.215 at the 0.10 quantile to 0.230 at the 0.90 quantile, investment in education, skills training, and technical and vocational education, particularly in provinces with higher resilience, can help strengthen economic capacities. In provinces with low resilience, improving access to educational opportunities should also be prioritized.

- Directing Investment Toward Productive Infrastructure: The increase in the investment coefficient from 0.107 at the 0.10 quantile to 0.123 at the 0.90 quantile indicates that the relationship between investment and resilience is stronger at higher levels. Therefore, while strengthening basic infrastructure in provinces with low resilience, emphasis should be placed in provinces with higher resilience on investment in productive infrastructure, technology, and sustainable economic activities.

- Diversifying the Economic Structure of Provinces: Given the increase in the economic diversification coefficient from 0.187 at the 0.10 quantile to 0.201 at the 0.90 quantile, developing complementary activities, local industries, modern services, and regional value chains can help strengthen resilience. This policy is particularly important for provinces with greater economic capacity. In provinces with low resilience, the initial conditions for diversification should also be established.

- Targeting Government Expenditure According to the Level of Resilience: The government expenditure coefficient increases from 0.24 at the 0.10 quantile to 0.34 at the 0.90 quantile and has the highest value among the reported coefficients at the 0.90 quantile. This result emphasizes the importance of considering the role of government expenditure in improving resilience. Accordingly, the allocation of public resources should be consistent with the needs of provinces, such that basic infrastructure and public services are strengthened in provinces with low resilience, while productive infrastructure, human capital, and productive capacity are strengthened in provinces with higher resilience.

Authors' Contributions

The corresponding author was responsible for all stages of the research and preparation of the manuscript, and the author's contribution was 100 percent.

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Conflict of Interest

The author declares that there is no conflict of interest in this research.

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