

Research Article

A Framework to Assess the Correlation between Transportation Infrastructure Access and Economics: Evidence from Iran

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One of the most important impacts of access to transportation infrastructure is the economic and social well-being of residents. However, it is important to know, how much of an impact it has? Which of the access routes—road, rail, or air—has more impact? What methods can be used to assess this effect? Does this effect vary from country to country? This study attempts to provide a framework to examine the correlation between the access of a country's cities (to various types of rail, air, and road transportation networks) and the economic and social parameters of its inhabitants. For this purpose, the connection of the city to the rail network was calculated by taking into account the distance in time between the city and the nearest station. A city's road access is calculated by finding the average road distance of a city to other cities in that country. A city's access to air traffic is calculated based on the weekly flights of that city's airport (if that city has an airport). To evaluate the performance of the proposed framework, a case study is conducted in Iran. The results of the case study show that the access of cities to transportation networks strongly influences economic development and population size in Iran. Pearson's correlation coefficients between transport infrastructure and economic growth and population size are 0.641 and 0.725, respectively. It was also found that among the transport networks, road transport is more correlated with economic development and unemployment rate of Iranian cities compared to other transport modes.

1. Introduction

Transportation is now a critical component of development that can contribute greatly to income distribution, reducing poverty and socioeconomic inequality, eliminating the effects of poverty and destitution, and narrowing the gap between urban and rural incomes. Better access to transportation infrastructure leads to a reduction in the final cost of goods, changes in land use, and subsequently more employment and income opportunities. Unlike other sectors of the economy, transportation has the flow of distribution in itself to some extent, being one of the constituent elements of the system of distribution of goods and people in different

regions [1]. The innovation of transport modes is closely linked to the development of the regional spatial structure [2].

The science of transportation economics is also concerned with the optimal use of transportation facilities to meet transportation needs at a particular time and place [3]. Policymakers typically worry about the effects of infrastructure allocation since such effects are not well known [4]. The fact that the influence of infrastructure differs from country to country is one of the key causes of the confusion surrounding this impact. Numerous studies have demonstrated that developing nations generally experience this impact more so than developed ones [5–7].

This study sought to develop a framework to examine the degree of correlation and impact of cities' access to transportation networks on economic growth, unemployment rates, and population to more accurately determine the intensity of the effects of these parameters on each other. It is important because it can help decision-makers understand the magnitude of the impact of transportation infrastructure investments on residents' economies [8]. In this study, all modes of transportation are considered, including access to cities via rail, road, and air networks. Previous studies usually consider only one of these transport infrastructures. In this study, Iran was examined as a case study.

2. The Theoretical Basis of Wider Economic Impacts

Transport and the economy are inextricably linked. Transport is usually described as being a derived demand from the demand for activities; transport is only useful as a way of bridging the spatial gap between locations, it has no value in its own right. This suggests that transport only responds to the needs of the wider economy. However, transport is also a substitutable input so that cheaper transport can be substituted for other more expensive inputs such as land leading to relocation and the potential for an increase in productivity. In this way, transport can be argued to be an engine of growth.

Here we see the potential problem of causality arising. In the aggregate, better transport and better economic performance are clearly associated, but which is the driving force is ambiguous. It is clear that without good transport economic performance may be constrained, but simply improving transport, without ensuring that other conditions for growth are met, is likely to be counter-productive. This is the problem with attempts to assess the role of transport in the type of aggregate growth models that follow the tradition.

The key to understanding the economic impact of transport is in understanding the role of accessibility. Changes in accessibility affect the generalized cost of transport. If transport costs are reduced industries become more competitive and hence improved transport contributes to productivity growth. But it may also lead to changes in the optimal location of activities thus leading to faster growth in employment in some areas and slower growth in others. This is the potential for an agglomeration effect. But conventional measures of continuous accessibility may be inadequate in identifying the way that HSR changes the potential for firms and individuals to connect with each other. HSR has an essentially discontinuous effect where some lose accessibility through the penalty of connecting to the new network and any associated reduction in service on classic rail lines.

Lower transport costs enable markets to expand in size thus resources are drawn into the larger market, which can continue to grow as the increasing returns cancel out the self-balancing mechanism that would apply in a perfectly competitive world. Backward and forward linkages in the local economy reinforce this process of cumulative causation. The circular process continues with increased market

size promoting further increasing returns, which in turn reduce costs and encourage the further inward movement of resources as real wages and profits increase. Firms in the core region can better overcome the transport costs and supply markets in the periphery more cheaply.

3. Review of Literature

Past research indicates that investment in transportation infrastructure can be significant for the economic development of the country. Accordingly, many countries consider transportation as their economic sector in budget planning [9]. Reference [10] analyzed the communications between transportation infrastructure, financial influence, and economic growth in the G-20 countries from 1961 to 2016. The purpose was to examine whether temporal causality is between the variables. Utilizing the panel vector error-correction model, they discovered the long-run and short-run connections between the variables. The research's most robust conclusion was that both financial penetration and transportation infrastructure stimulate economic growth in the long run. On the other hand, short-run results were non-uniform and depended on the specific measure of financial penetration and transportation infrastructure utilized.

3.1. Impact of Railroad Access on Economics. Reference [11] examined the effect of the high-speed railroad system in the northwest of Europe and the first high-speed railroad of England on the economic transformation of these regions. It was concluded that transport infrastructures affect the regional economy, though the transformative effect would not be possible without political interventions.

Another study in 2018 investigated the relationship between railroad access and the industrialization of cities in the Dallas region. They utilized the employment information of employers in 2014 to examine the results. The findings showed that the benefits obtained from railroad access created considerable demand in various industrial segments, including production, knowledge, and services [12].

Reference [13] examined the effect of railroad access on the population of various regions of California State. This study dealt with investigating the population of cities in this state between 1950 and 2010. It found that people have mostly chosen regions with access to the railroad system for living. As this access increased in a region, gradually, the population of that region also increased.

In a study performed in 2018, the effect of railroad access was examined on the economic development of cities in China. High-speed rail (HSR) improved access across China by 12.11% from 2009 to 2013. This research observed that the cities of the wealthy eastern region with access to HSR experienced a considerable increase in fixed-income investment, which can stimulate future economic development. It also showed that extensive studies with a relatively large population used HSR more for attracting investments [14].

Reference [15] examined the effect of increasing the speed of trains and employing high-speed trains on their productivity. Based on this study, an increase in the speed of trains would lead to their increased operational costs. Nevertheless, their productivity would grow to such an extent that it compensates for the increased operational costs and contributes to their enhanced productivity with a nonlinear curve. Hence, even increasing the speed of trains would influence the economy of the affected regions [16].

Reference [17] researched the effect of creating railroad on increasing the land value in the west of Mississippi in the 1800s in the US. They found that railroads caused a 20% increase in the price of agricultural lands in this region. The most crucial reason was facilitated transport of loads and goods through this region.

3.2. Impact of Transportation Network Investment on Economics. For example, in a study by Button and Regini [18], it was observed that in February 2009, the USA, while suffering extensive economic problems, allocated 46.7 billion dollars to its transport infrastructure; the central part of this budget was spent on constructing highways and railroads (27.5 billion dollars for bridges and freeways, 8.4 million dollars for transit, 8 million dollars for the rapid railroad system, 1.3 billion dollars for the railroad, 1.5 million dollars for international road transport). After this investment, around 280,000 new jobs were created in this country, reducing the unemployment rate to a satisfying degree. It also significantly supported the economic development of the country and liberating itself from the economic crisis it had been facing [18].

Reference [1] appraised the impact of access to transportation networks on localized economic outcomes in China over twenty years of rapid income growth. It addressed the endogenous placement of networks because these networks lead to connect historical towns. Their results reveal that proximity to transportation networks has a reasonably sized positive causal impact on per capita GDP levels across areas but no effect on GDP growth. They present a simple theoretical framework with empirically testable predictions to expound their results. They clarify that their results are consistent with factor mobility playing an essential role in determining the economic benefits of infrastructure development.

Andersson [19] conducted general research about the effect of investment in transportation on the economic development of different countries. He concluded that the effect of these investments has been generally positive [19]. Hall [20] researched the efficiency and utility of transport investments in the USA, India, and Spain. It was observed that this utility depends on the country's economic development; the more developed countries changed into developed and were negatively affected, while less-developed countries were better in efficiency utility and efficiency development of the system [20]. Kotavaara et al. [6] examined the relationship between

access to roads and railroads transport system and population changes of regions between 1970 and 2007 in Finland. The analyses were performed in urban regions and regions with numerous buildings. They obtained access to these regions to the transport system. The results showed that access to railroad transport was effective in increasing the regional population in the 1970s. Also, in 2000–2007, access to the railroad transport influenced the population growth, which coincided with the period considerable investments were spent on long trip transport; in those years, the economy of the country also had an ascending trend [6].

In a research performed in 2011, after investigating studies conducted in various countries and reviewing 55 past studies, it was found that 43 cases of transport investments had a positive effect on the economic development of those countries, while the other 12 cases were either neutral or had an adverse effect on the economic developing of the country [18]. Studies also show that investment in the transport system infrastructure in medium-income developed countries (India and China) had a more positive effect on economic development.

Easterly and Rebelo [21] researched the relationship between fiscal policy, degree of development, and growth rate variables. They obtained a constant relationship between investment in transport as well as communication and economic development. The econometric models of this research covered 1970–1988. Specifically, it captured the observations related to general investments, including 36 countries in the 1960s, 108 countries in the 1970s, and 119 countries in the 1980s. These two researchers first regressed the annual growth rate on the general investments and status variables. The general investments included household and urban infrastructure, communication and transportation, industry, and mines, while the status variables included level of income, political instability, and the ratio of government consumption to gross domestic product. Regarding transportation and communication, they concluded that investment in the transport sector is continuously and positively associated with economic development, showing correlation coefficients of 0.59–0.66 [21].

3.3. Research Gap. Accordingly, in some studies in the past, the economic impacts of conducting transportation infrastructure are assessed. These studies found that investment in transportation infrastructure impacts economic growth, but this impact is different from country to country. In each of the studies, usually, just one of the transportation infrastructures (including road, railroad, and air) has been considered and not all simultaneously. Also, a comprehensive framework is not presented in them. This research has attempted to develop a framework that involves all types of transportation networks (including road, rail, and air). Additionally, this framework can be used for different countries that decision-makers with using it be able to forecast the influence of conducting and operation of these infrastructures on economic and social parameters of the studied country.

4. Methodology

The research method consists of 5 steps, which are explained as follows.

Step 1. Selecting studied cities in the country.

To start the research, first, a statistical sample should be chosen from the country's cities. The criteria of this selection were as follows: (i) the cities should be scattered throughout the country and not densified in just one zone so that the entire country would be investigated and the selected sample represents the entire country; (ii) the cities should be at least 2-3 hours apart from each other so that the residents of the selected cities could not commute to another city for income generation or employment [22]. In this way, two cities that have very close relations and economic effects on each other would not be included in the statistical sample concurrently [23] not all of the chosen cities should have railroad stations or airports so that a broad set of different conditions could be obtained. This would, in turn, help in more precise capturing of the correlation between access and economic development.

Step 2. Collecting the social and economic parameters of cities.

At this stage, the statistical information of cities, including average household income, unemployment rate, and population of the selected cities, should be taken from the statistics organization. In this study, the average annual income of each household in cities is considered representative of that city's economic development [24]. The average income of the studied cities is taken from statistics organizations.

Step 3. Calculating the road access of selected cities.

In order to calculate the road access of each city, Relation (1) has been used [6]:

$$A_n = \frac{(\sum_{n=1}^n (P_{n+1}/d_{n,n+1}) + (P_n/R_n))}{Z}, \quad (1)$$

where A_n is the road access of city n , P_n is the population of city n , Z is the number of the studied cities, $d_{n,n+1}$ is the temporal distance of city n and $n+1$ (min), and R_n is the time required for traversing the radial distance of the city (city center to the terminal border of the city).

Regarding calculating the distance of cities based on the minute, first, the optimal road path of each city from the all other cities should be identified. Then, based on the allowable speed of vehicles in each of the road paths, the temporal distance of each city from other selected cities should be calculated.

Step 4. Calculating air access of the selected cities.

In order to calculate the air access of each of the selected cities, the number of flights of the desired city is in the iterative program (for example, number of flights in a week if the program of flights repeats weekly).

Step 5. Calculating the rail access of selected cities.

In order to calculate the railroad access of the selected cities, the method introduced by Ossi et al. in a research in [6] has been used:

$$RA_n = \left(\frac{1}{d_n} \right), \quad (2)$$

where RA_n is the rail access of city n and d_n is the temporal distance of city n to closest railroad station (min), ($0 < RA_n < 1$).

Step 6. Calculating the correlation of each of the access types of cities with the average income of the selected cities.

At this stage, it is possible to calculate the correlation of the extent of railroad, road, and air access of every selected city with the average income of each of these cities. The equations and materials are presented in Table 1.

The methodology is presented as a framework in Figure 1.

5. Case Study

5.1. Selecting the Statistical Population. The selection of the candidate cities has been made based on the procedure explained in step one of the methodology. After performing the investigations, 75 cities have been chosen from the entire country, whose names and the provinces in which these cities are located plus the average household income per year are presented in Table 2. The location of these cities across the country is also shown in Figure 2. As shown in the figure, these cities have been scattered throughout the country and chosen at a suitable distance. The statistical sample covers around 33% of the Iranian population and can be a comprehensive statistical population. It is worth mentioning that most of the central part of Iran is uninhabited deserts [25]. For this reason, as shown in Figure 2, the central part of the country has fewer cities to choose from. The average annual income (Statistics organizations had not calculated the average income of households in small cities. To solve this problem, occupations the people of these cities deal with and the average income gained from these occupations (available in the statistics organization) were used to calculate the average income of a household in that city.) of each household in the studied cities, their unemployment rate, and population are presented in Table 2. These parameters are also shown in Figures 3 to 5, respectively. For ease of analysis, the amount of these parameters figures is classified into six categories. The first category depicts the lowest average income, unemployment rate, and population in Figures 3 to 5, and the last category, depict by larger circles, represents the highest value of these parameters. (The access of the selected cities to the rail, road, and air networks is shown in Figures 6 to 8, respectively. This information is presented in Table 3 too.)

5.2. Calculating the Access of Selected Cities to the Road Transport Network. In order to calculate the road access of each of the selected cities, first, the temporal distance of each of the 75 cities from the other 74 cities (which to some extent represent the entire country) has been calculated. Then, the

TABLE 1: The equations to calculate access of cities to rail, road, and air networks.

Transportation mode	Equation to calculate access	Parameters
Road access	$(\sum_{n=1}^n (P_{n+1}/d_{n,n+1}) + (P_n/R_n))/Z$	P_n = population of city n , Z = number of the studied cities in the case study, $d_{n,n+1}$ = temporal distance of city n and $n + 1$ (min), R_n = the time required for traversing the radial distance of the city (city center to the terminal border of the city).
Rail access	$(1 [zwnj] / d_n)$	d_n = temporal distance of city to closest railroad station (min),
Air access	Weekly flights of the airport in that city	—

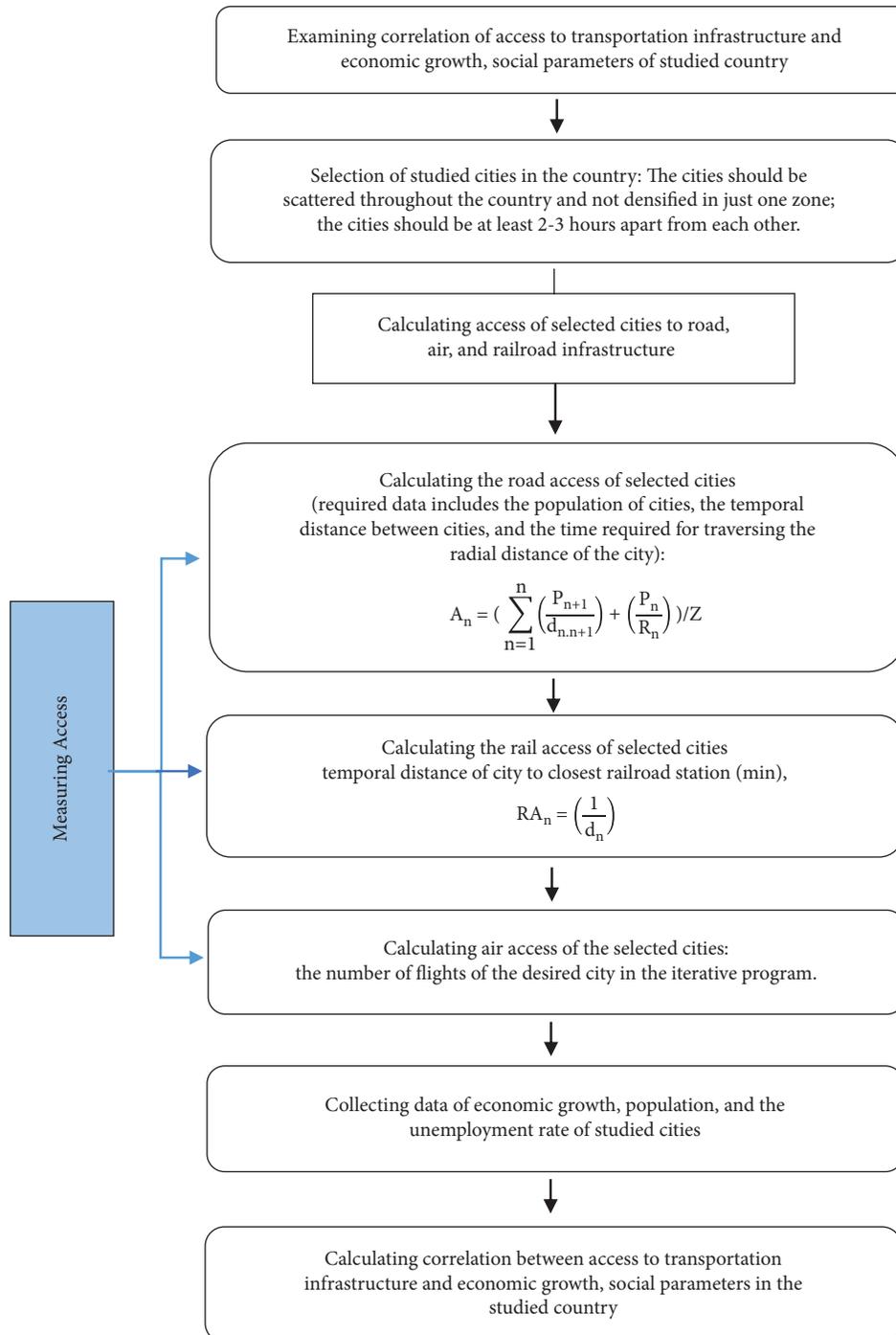


FIGURE 1: Flowchart of methodology.

TABLE 2: The selected cities plus the average annual income of each household (Rials), population, and unemployment rate in these cities.

City name	Population	Income	Unemployment rate
Jafarabad	7706	6,975,342	15.5
Ardebil	482632	10,975,647	12.5
Tabriz	1494998	11,245,564	9.3
Oromieh	667499	9,345,475	9
Zanjan	386851	9,376,654	12.7
Ghazvin	381598	11,664,932	10.8
Sanandaj	373987	7,954,473	14.1
Hamedan	525794	10,893,251	11.5
Tehran	8154051	14,256,470	9.5
Ghom	1074036	11,875,290	10.1
Kermanshah	851405	10,132,965	15.2
Arak	484212	8,952,231	8.9
Ilam	172213	10,356,275	12.6
Khoramabad	348216	8,153,499	11.6
Dezful	248380	9,738,876	15
Dehlaran	30989	7,903,363	12.4
Ahvaz	1112021	9,565,838	11.5
Masjedsoleiman	103369	8,132,265	18.4
Abadan	212744	8,959,706	11.5
Omidieh	60461	7,134,924	16.1
Khansar	19875	7,243,983	14.8
Kashan	275325	9,192,300	8
Dogonbadan	91739	9,647,891	11.1
Khormoj	34944	8,337,992	12
Shiraz	1460665	12,491,834	9.5
Lamerd	25131	8,466,527	12.1
Darab	61672	9,064,252	8.9
Damavand	37315	9,975,367	7.5
Sari	296417	12,768,954	10.5
Amol	219915	12,843,571	9.1
Gorgan	329596	10,993,415	12
Noshahr	43378	11,251,577	13
Roodsar	37579	8,580,093	10.4
Semnan	153680	9,329,809	7
Damghan	58770	8,853,534	9.2
Minoodasht	28478	8,692,075	11
Maravetapeh	7906	7,792,075	14.3
Zahedan	560725	9,284,926	11.1
Bojnord	199791	9,320,621	11.1
Dargaz	37054	8,685,762	8.5
Sabzevar	231557	8,305,554	10.5
Neishabor	239185	10,586,085	10.2
Chenaran	48567	7,685,762	12
Mashhad	2749374	12,388,344	10.3
Kalat	7532	7,896,915	16
Bordscan	26107	7,255,708	10.9
Torbat heidarie	91285	9,301,067	10.3
Torbat jam	94758	8,942,604	16
Khaf	28444	8,562,521	15.5
Gonabad	36367	8,028,566	5
Tabas	35150	8,417,075	10.7
Jandagh	4472	7,297,368	13
Ghaen	40226	7,935,453	13.4
Birjand	178020	8,516,320	11
Nahbandan	18827	6,195,897	13.6
Bandan	21859	6,367,110	15.1
Zabol	137722	7,918,724	11.5
Khash	54105	6,196,763	16
Saravan	115896	5,864,712	18.2
Zaboli	10112	4,757,494	18.5

TABLE 2: Continued.

City name	Population	Income	Unemployment rate
Iranshahr	119635	7,149,275	13.5
Chabahar	85633	8,829,646	12
Bam	107131	8,732,926	11.4
Jiroft	111034	7,304,736	14
Kerman	534441	8,248,194	11.4
Minab	63229	7,441,789	12.3
Bandarabas	435751	9,622,338	9.3
Sirjan	185623	8,033,593	12.5
Shahrekord	159775	9,061,822	16.7
Yasoj	108505	10,997,210	10.9
Sfahan	1756126	10,794,924	11.6
Ardestan	15701	8,084,597	11.9
Shahreza	123767	7,181,739	12.5
Abade	55758	8,452,397	10.1
Marvdasht	85248	7,762,773	15.1

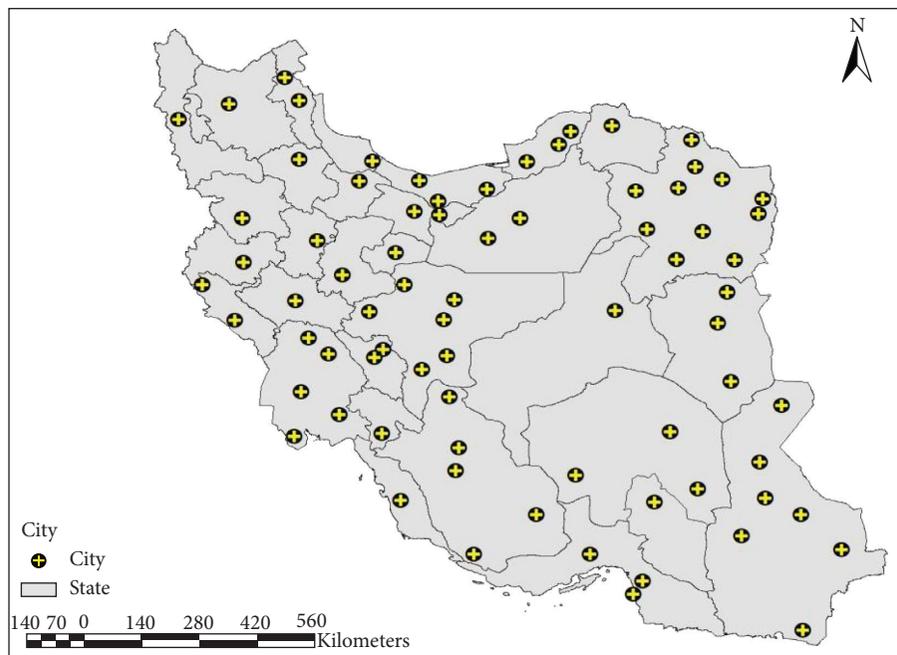


FIGURE 2: Location of the studied cities.

population and area of each of these cities have been taken from the statistics and geographic organization. Using relation (1), the extent of road access of each city has been calculated, as presented in Table 2.

5.3. *Calculating the Access of Selected Cities to the Rail Transport Network.* The next step is to calculate the rail access of the studied cities. For this purpose, the method presented in the fifth step of the methodology has been used, and its results are reported in Table 2.

5.4. *Calculating the Access of Selected Cities to the Air Transport Network.* The air access of the selected cities has been calculated using the method presented in the fourth step of the methodology, with its results presented in Table 2.

The total access of the studied cities is also shown in Figure 9. For ease of analysis, the accesses are divided into six categories; the first category indicates the lowest access rate, and the last represents the highest access rate.

5.5. *Calculating the Total Access of Cities to the Transport Networks (Road, Rail, and Air).* After obtaining cities' access to road, rail, air transport networks, the relation of total access to transport networks with economic development can be obtained. For this purpose, first, the extent of access of each city to the overall road, rail, and air transport should be obtained. Regarding the procedure, first using Relation (3), cities' access to each type of transport network should be obtained. Then, by summing up them together for each city, the extent of access to all transport networks can be obtained.

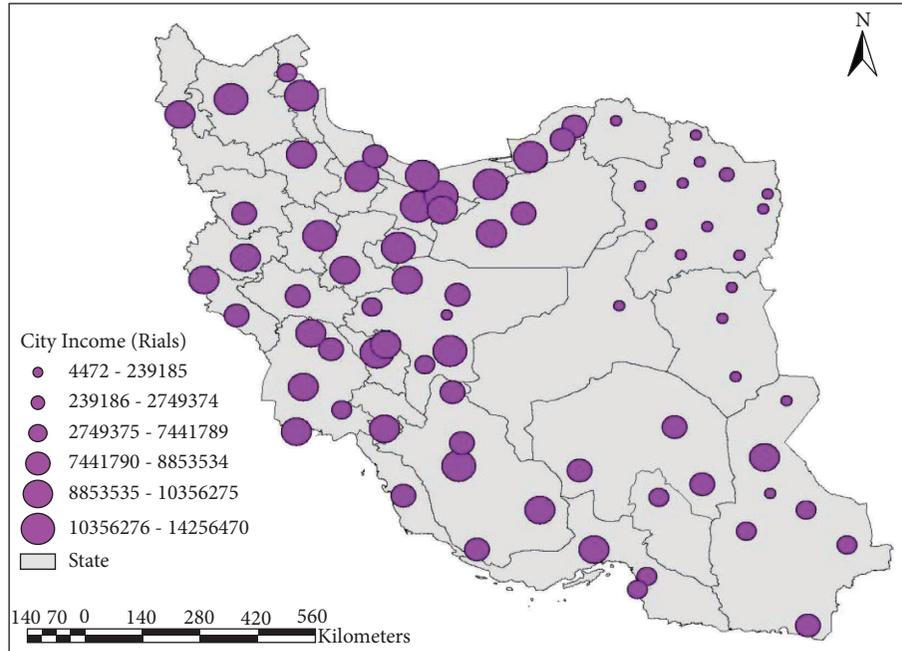


FIGURE 3: The average annual income of each household in the studied cities (Rials).

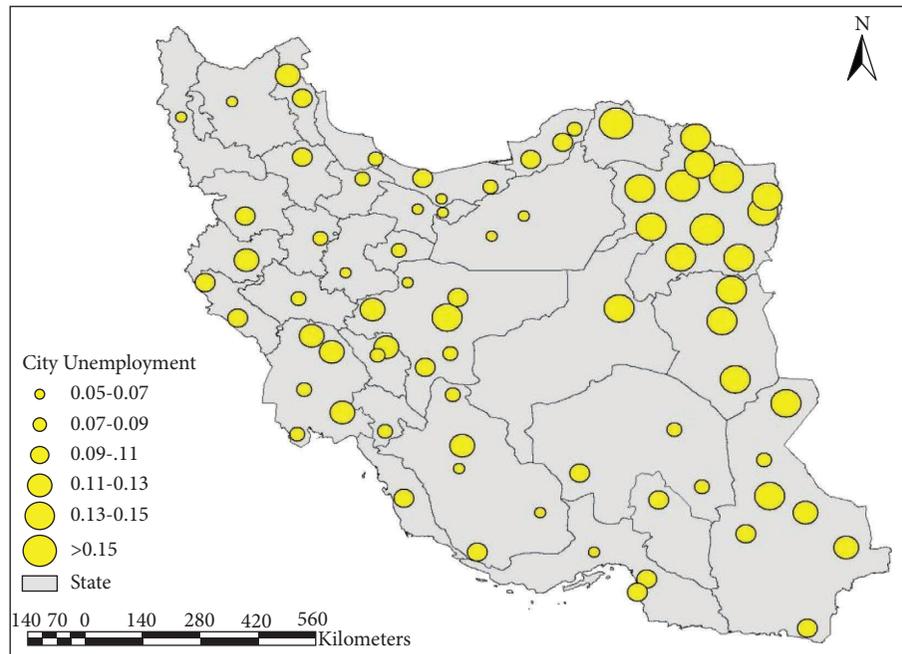


FIGURE 4: The unemployment rate of the studied cities.

$$Acc_i = \sum_{k=1}^3 \left(\frac{x_i^k - \min \{x_j^k\}}{\max \{x_j^k\} - \min \{x_j^k\}} \right), \quad (3)$$

where x_i^k is the access of city i to transport mode k and Acc_i is the general access of city i to the transport networks.

The total access of the selected cities to transportation networks is calculated and presented in Table 4.

6. Analysis of Correlation between Economic Growth, Population, and Access of Cities

After calculating the rail, road, and air access and calculating the total access of the studied cities, the correlation between these parameters and average household income, unemployment rate, and population of cities can be obtained [26]. For this purpose, SPSS software has been used with its results presented in Table 5.

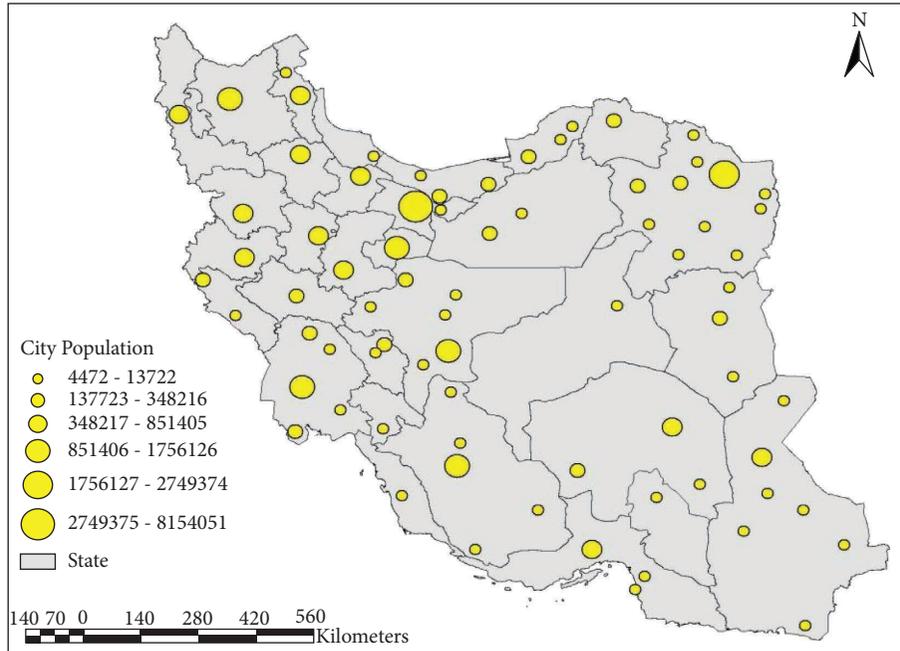


FIGURE 5: The population of the studied cities.

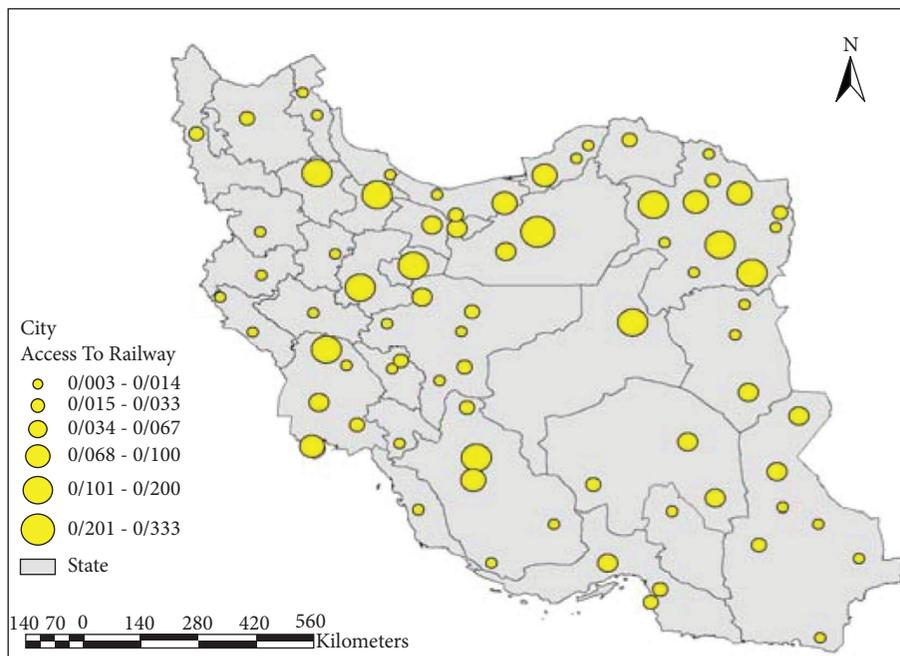


FIGURE 6: The rail access of the studied cities.

Based on the results obtained from analyzing the relationship of total access of cities (considering road, rail, and air access) with the parameters of average income, population, and the unemployment rate of those cities, it is found that since the sig value in them is less than 0.05; thus the relationship is significant (Sig parameter is a criterion for determining the significance level of the obtained results [27]. If the significance level is very low, then the correlation is considerable, and the two variables are linearly dependent.

On the other hand, if this value is relatively large, then the correlation is not significant, and the two variables are not linearly interdependent [28]). Secondly, the correlation of total access to cities has been more significant with their population (0.725) than with the average income or unemployment rate. The 0.725 value is reasonably high for the Pearson correlation coefficient, suggesting a close relationship between cities' access and population. The Pearson correlation coefficient for the average income and total

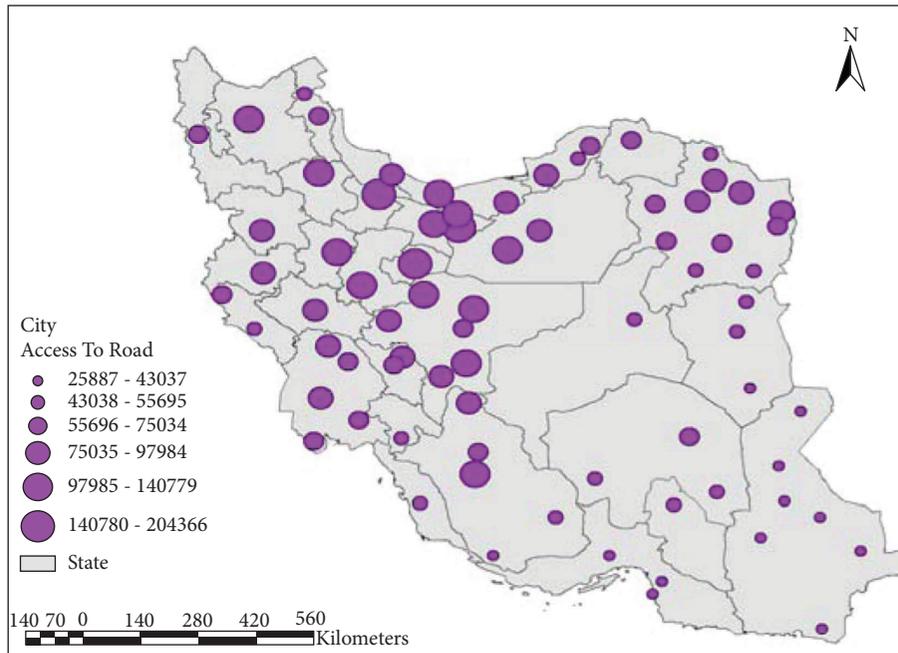


FIGURE 7: The road access of the studied cities.

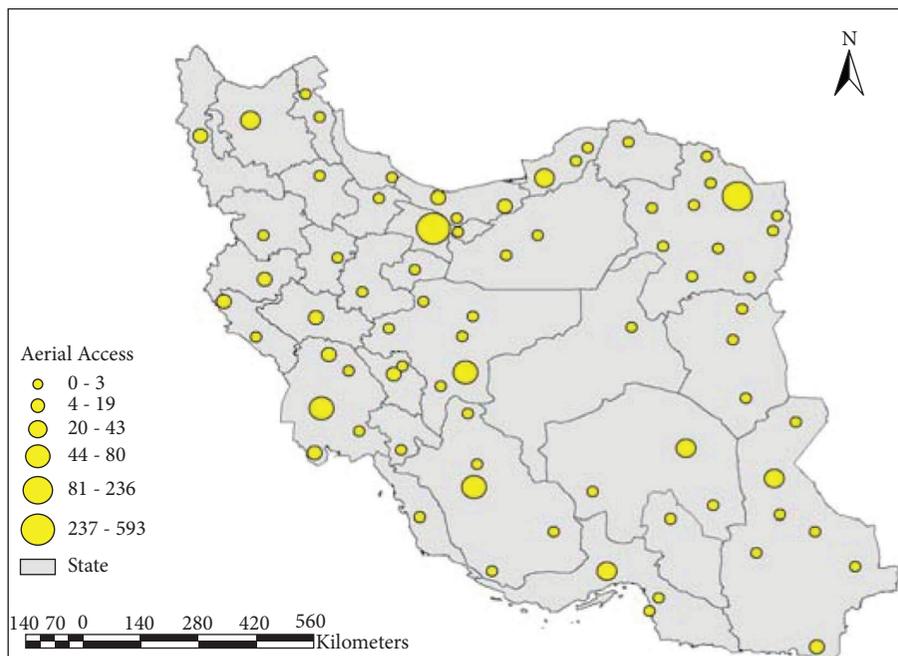


FIGURE 8: Aerial access of the studied cities.

access has been 0.641, indicating that the total access of cities has a significant correlation with their average income. The Pearson correlation coefficient between the unemployment rate of cities and their total access has been -0.483 , which is not very high yet non-negligible, indicating a relative correlation between access of cities and the unemployment rate in them.

According to the results in Table 6, it is observed that since sig value with regards to the population and rail

access is very high, hence these two parameters do not have any significant relationship with each other. The Pearson correlation coefficient of rail access with average income and unemployment rate is 0.271 and -0.360 , respectively, which are not large values and only indicate the relative correlation of these two parameters.

Based on the results in Table 6 and the low value of sig parameter, it can be concluded that the correlation between road access and the three parameters of average income,

TABLE 3: The access of each studied city to the road, rail, and air transport.

City name	Road access	Rail access	Air access
Jafarabad	49267	0.004	0
Ardebil	64413	0.009	0
Tabriz	116797	0.033	32
Oromieh	59570	0.015	16
Zanjan	107832	0.2	0
Ghazvin	156629	0.143	0
Sanandaj	79334	0.005	6
Hamedan	107994	0.009	0
Tehran	124129	0.067	593
Ghom	176683	0.2	0
Kermanshah	91522	0.005	19
Arak	128932	0.2	0
Ilam	65690	0.004	11
Khoramabad	92436	0.011	12
Dezful	77060	0.2	9
Dehlaran	53982	0.008	0
Ahvaz	77688	0.043	80
Masjedsoleiman	64038	0.009	0
Abadan	67992	0.1	13
Omidieh	64228	0.019	0
Khansar	96165	0.011	0
Kashan	140779	0.067	0
Dogonbadan	52724	0.005	0
Khormoj	46926	0.004	0
Shiraz	113789	0.1	64
Lamerd	37102	0.003	0
Darab	49478	0.005	0
Damavand	204366	0.05	0
Sari	97508	0.083	10
Amol	112467	0.02	0
Gorgan	81950	0.1	22
Noshahr	106578	0.009	9
Roodsar	80962	0.007	0
Semnan	108156	0.067	0
Damghan	89432	0.333	0
Minoodasht	65982	0.012	0
Maravetapeh	51881	0.006	0
Zahedan	38503	0.05	23
Bojnord	59056	0.016	6
Dargaz	51370	0.014	0
Sabzevar	75034	0.143	11
Neishabor	83533	0.1	0
Chenaran	94520	0.023	0
Mashhad	78980	0.083	236
Kalat	85066	0.018	0
Bordscan	59805	0.011	0
Torbat heidarie	68186	0.2	0
Torbat jam	70650	0.008	0
Khaf	50358	0.2	0
Gonabad	54042	0.005	0
Tabas	50288	0.2	0
Jandagh	60619	0.005	0
Ghaen	47681	0.008	0
Birjand	55695	0.005	6
Nahbandan	37621	0.06	0
Bandan	32131	0.013	0
Zabol	35194	0.04	3
Khash	33984	0.007	0
Saravan	29440	0.009	0

TABLE 3: Continued.

City name	Road access	Rail access	Air access
Zaboli	32261	0.009	0
Iranshahr	34470	0.02	0
Chabahar	25887	0.009	6
Bam	46864	0.05	0
Jiroft	45744	0.013	0
Kerman	58915	0.05	23
Minab	42419	0.015	0
Bandarabas	43037	0.05	43
Sirjan	54794	0.03	2
Shahrekord	97984	0.024	0
Yasoj	64697	0.006	8
Sfahan	109504	0.02	60
Ardestan	110214	0.028	0
Shahreza	97256	0.007	0
Abade	83366	0.022	0
Marvdasht	60578	0.2	0

population, and the unemployment rate of cities is significant, with the correlation coefficients of 0.578, 0.299, and -0.535 , respectively. This shows a relatively good correlation between road access and average income as well as the unemployment rate.

Based on Table 6, the unemployment rate did not significantly affect air access because of the enormous sig value. However, the Pearson correlation between average income and air access and the population was 0.441 and 0.887, respectively, which is a good correlation.

7. Discussion and Conclusion

7.1. Economic Studies. Reference [29] Politicians are bitterly separated on many matters of public policy. Yet, they agree that spending on transportation programs creates jobs and thus constitutes a path out of the nation’s long and deep recession. Infrastructure investments are prescribed to stimulate the economy in the short term by creating construction employment, and to foster longer-term economic growth by making the transportation system more efficient and reliable. Democrats and Republicans, liberals and conservatives, and rural and urban officials seek funding for roads and transit projects in their districts, repeatedly asserting that these expenditures will create jobs. Managers vigorously sought to create jobs through transportation spending in the recent economic stimulus package. Reference [30] examined the historical impact of railroads on the U.S. economy, with a focus on quantifying the aggregate impact on the agricultural sector in 1890. Expansion of the railroad network may have affected all counties directly or indirectly an econometric challenge that arises in many empirical settings. Reference [7] examined the effect of transportation (road and rail) infrastructure on economic growth in India over the period 1970–2010. Using Vector Error-Correction Model (VECM), the paper finds bidirectional causality between road transportation and economic growth [5]. Previous work on transportation investments has focused on average impacts in high- and middle-income countries. This paper estimated average and heterogeneous

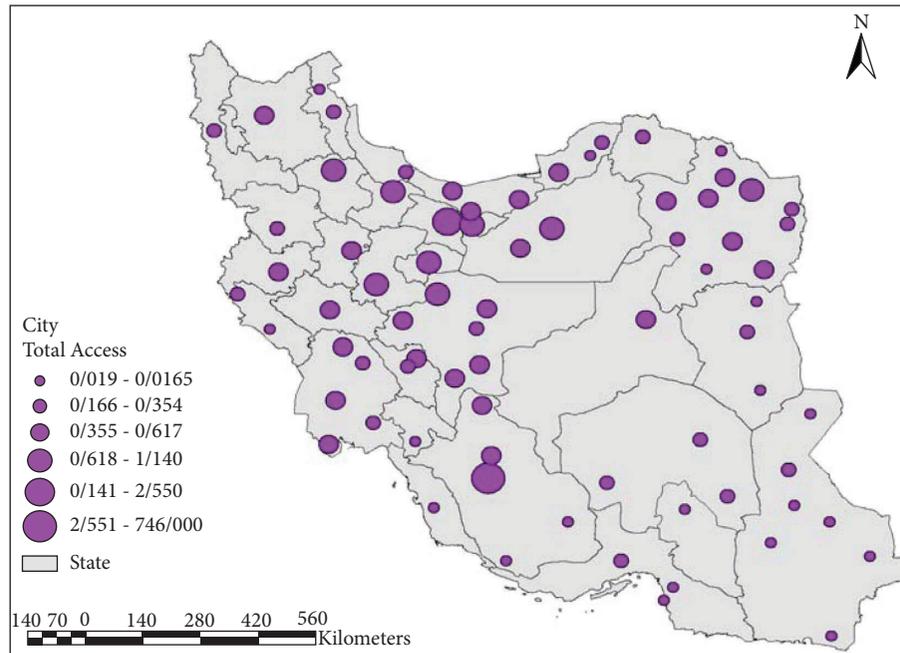


FIGURE 9: Total access of the studied cities to transportation networks.

effects in a poor continent, Africa, using roads and cities data spanning 50 years in 39 countries. The results suggest that this elasticity is stronger for small and remote cities, and weaker in politically favored and agriculturally suitable areas. In summary, past studies in economics have shown that transportation infrastructure access has a considerable impact on cities' economic growth, and this effect is different in various countries.

7.2. Transportation Studies. Many studies tried to find the relationship between region access to network access and economic growth [3]. The theoretical model of the new economic geography is that it does not have an analytical solution. Numerical simulations can show the range of possible outcomes, but this is less satisfactory as a decision-making model to build into an appraisal framework or to estimate impacts ex-post. Reference [31] provided the link between the theoretical model and its potential use in an extended analysis framework. This was used in an empirical study by [32] and is the approach now adopted by the UK Department for Transport (2014) in its appraisal methodology WebTAG.

Various parameters were surveyed in cities, and in different studies [33] used employment rate [13], examined the population of cities [18], assessed the producing jobs, and some other parameters such as GPD, average income.

Most of these studies considered rail access as the influential parameter, but some of them regarded it as other transportation networks too. Some of them provide frameworks, but most of them use the usual frameworks that were provided before.

7.3. Innovation. This study also considers all transportation networks once separately and once together. Employment rate and average income of cities were also considered. This

study used methods for calculating urban access to transportation networks that have been presented and used in previous studies. Finally, based on the fact that improving access to transport networks has a different impact in different countries, a framework is created that can be used in all countries to assess the correlation between improving access to transport networks in these countries and regions and their economic growth.

This study used the framework presented and found a significant relationship between access to cities' transportation networks and their average income (in Iran as a case study). Nevertheless, these networks should be considered together and not separately.

7.4. Limitations. The most important limitation of this study was access to information on jobs and the average income of cities in detail, especially the smaller towns.

7.5. Recommendations for Future Research. As this research covered the correlation between employment and economic growth with transportation network access generally, the future research can assess the kinds of the jobs produced by improving Transportation access in cities. Also, a cost-benefit study can be done before and after improving transportation infrastructure access in cities.

7.6. Conclusion. The construction of transport networks and improving access to different regions of a country have an impact on the economic and social parameters of those regions. The extent of this effect varies from country to country. This study has attempted to provide a comprehensive framework for assessing the impact of improved access to various types of transportation networks on

TABLE 4: The extent of access of each city to the overall road, rail, and air transport networks.

City name	Total access *
Jafarabad	0.132
Ardebil	0.225
Tabriz	0.608
Oromieh	0.234
Zanjan	0.754
Ghazvin	0.942
Sanandaj	0.313
Hamedan	0.469
Tehran	2.550
Ghom	1.140
Kermanshah	0.403
Arak	0.873
Ilam	0.243
Khoramabad	0.405
Dezful	0.597
Dehlaran	0.165
Ahvaz	0.485
Masjedsoleiman	0.223
Abadan	0.403
Lamerd	0.063
Darab	0.135
Damavand	1.070
Sari	0.538
Amol	0.511
Gorgan	0.497
Noshahr	0.476
Roodsar	0.315
Semnan	0.557
Damghan	0.851
Minoodasht	0.238
Maravetapeh	0.150
Bojnord	0.215
Dargaz	0.159
Sabzevar	0.504
Neishabor	0.468
Chenaran	0.415
Mashhad	0.815
Kalat	0.354
Jandagh	0.198
Ghaen	0.130
Birjand	0.180
Nahbandan	0.151
Bandan	0.050
Zabol	0.113
Zahedan	0.180
Khash	0.051
Saravan	0.029
Zaboli	0.045
Iranshahr	0.074
Chabahar	0.019
Bam	0.188
Jiroft	0.126
Kerman	0.294
Minab	0.111
Bandarabas	0.239
Sirjan	0.206
Shahrekord	0.435
Omidieh	0.239
Khansar	0.406

TABLE 4: Continued.

City name	Total access *
Kashan	0.740
Dogonbadan	0.153
Khormoj	0.119
Shiraz	0.746
Bordscan	0.202
Torbat heidarie	0.532
Torbat jam	0.258
Khaf	0.432
Gonabad	0.161
Tabas	0.432
Yasoj	0.235
Sfahan	0.595
Ardestan	0.510
Shahreza	0.428
Abadeh	0.617
Marvdasht	0.490

* overall road, rail, and air transport networks.

economic growth, unemployment rates, and population growth. This approach enables decision-makers to consider the economic effects to some extent before selecting whether to construct transportation networks and, if necessary, to alter their choice of network type or location.

This study provides a framework for determining the relationship between economic and social factors and urban access to transportation infrastructure. The formulas suggested to calculate a city's accessibility to air, land, and rail transportation are shown in Table 1. These equations are all based on the history of relevant research.

To evaluate the performance of the proposed framework, a case study was conducted in Iran. For this purpose, 75 cities were selected from all over Iran. About one-third of Iran's population lives in these cities. The study only covered cities that are at least 2-3 hours apart. As a result, the inhabitants of the chosen cities are unable to work and earn a living in the next city. The cities were scattered all over the country; therefore, the whole country was investigated. The connectivity of each city by road, rail, and air was determined after the cities had been chosen. The statistical organization then took the average income, population, and unemployment rate of these cities. Finally, SPSS software was used to calculate the correlation between these values. Finally, with Pearson correlation coefficients of 0.725 and 0.641, respectively, it was discovered that there is a significant association between urban population growth, urban economic development, and urban access to transportation networks. Additionally, each individual transportation network, including rail, air, and road, was assessed to determine the association between average income, unemployment rate, and population of cities. However, the value was significantly less than what the whole access would have produced. Additionally, road transportation had a more significant impact on the unemployment rate and average income of Iranian cities compared to other forms of access to the transportation network.

The suggested structure is applicable to all nations. In order to prioritize one sort of network access over all other types of road, air, and rail connectivity for various sections of the country under study, it can also assist decision-makers.

TABLE 5: SPSS analysis on the correlation of the general access of cities with their average income, population, and the unemployment rate.

		Income	Population	Unemployment rate
Total access *	Pearson correlation	0.641	0.725	-0.483
	Sig. (2-Tailed)	0.000	0.000	0.000
	N	75	75	75

* overall road, rail, and air transport networks.

TABLE 6: SPSS analysis on the correlation of rail, air and road access of cities with their average income, population, and the unemployment rate.

		Income	Population	Unemployment rate
Rail access	Pearson correlation	0.271	0.52	-0.36
	Sig. (2-Tailed)	0.19	0.657	0.002
Road access	Pearson correlation	0.578	0.299	-0.535
	Sig. (2-Tailed)	0.000	0.009	0.000
Air access	Pearson correlation	0.441	0.887	-0.149
	Sig. (2-Tailed)	0.000	0.000	0.203
	N	75	75	75

Data Availability

Data are available on request.

Disclosure

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Conflicts of Interest

The authors declare that they have no conflicts of interest.

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