Evaluating the Impact of Access to Rail Transport System on Social Welfare: Case Study of Iran

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Abstract

Today, transportation is considered one of the most effective factors affecting the economic development of cities. It is because greater access to cities to transportation results in reduced finished cost of the goods consumed by people in these regions, land-use changes, and enhanced employment and income generation for them. All these suggest enhanced welfare of the residents and economic development of regions. In many studies, the relationship between rail access and economic development has been investigated, in most of which only the general relationship between these two parameters has been confirmed. However, the existence of a mathematical relationship between railway access of cities and their economic development has not been explored. In this paper, 75 cities have been investigated from all around Iran to model the relationship between these two parameters. These cities account for 33% of the entire population of the country. The selection criteria for cities was a temporal distance of at least 2-3 hours from each other (so that the residents of these cities would not be able to work in any other chosen cities); the cities were scattered throughout the country so that the entire country would be studied. After selecting the cities, railway access of each city was calculated, followed by the average income of the people in that city. Eventually, the relationship between these two parameters was calculated by SPSS, and then the excellent relationship between the parameter of access and economic development was obtained. It was found that access can significantly affect the economic development of different regions. After assessing the relationships obtained, it was found that these relations can predict by at least up to 69% the average income of other cities not used in the modeling.

Keywords: rail transportation, economic development, modeling, access.

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1. Introduction

Today, transportation is known as a key for development, which can play an effective role in income distribution, reducing poverty and socioeconomic inequality, as well as eliminating the effects of poverty and insolvency, and reducing the income gap between urban and rural communities. Unlike other economic sectors, transportation has the distribution flow inside it to some extent, as it is itself a factor or one of the main constituents of the commodity as well as passenger distribution system across

regions(A Deljouei, SMM Sadeghi, E Abdi, M Bernhardt-Romermann, 2016). The effect of transportation on the economy of regions is so large that the science of transportation economics has been created. This science applies the best method of utilizing transportation facilities to respond to the needs or demand of transportation at specific times and places. Policymakers are typically concerned about the distributional effects of infrastructure, which are by no means obvious(Banerjee et al., 2020).

In this research, attempts have been made to model a relationship between the access to railway transportation systems and the economic development of different regions. Through that, one can determine to what extent changes in access of regions to this transportation system would affect the economic development of those regions. This research has considered Iran as a case study.

2. Literature review

Among transportation networks, special attention is paid to railway transportation, as it has advantages over other modes of transport(Fereshteh Faghihinejad, 2013). These advantages include 1. Reducing fuel consumption: studies performed in Iran have shown that railway transportation consumes around 1/10 of the fuel used by road transportation (Razazi.gh, 2013), 2. Being economical: railway transport has the capacity of mass load transportation, 3. Environmental protection: in studies conducted on the level of pollutants emitted to the air resulting from combustion of truck and locomotive engines have shown that locomotives are the least air pollutant mode in ground transportation, 4- increasing safety: according to statistics (Razazi.gh, 2013), railway transportation has always had minimum accidents compared to other transportation systems.

Considering the importance of railway transportation on economic development, some studies have been conducted in this regard. Nevertheless, most of them have tested the effect of access to railway transportation system on the economic development of cities and countries and its association with its positive or negative effects and economic return, and less has dealt with calculating the relationship between them(Fereshteh Faghihinejad, 2018).

In a study performed in 2018, the effect of railway access was investigated on the population of different regions in California state. This study examines the population of cities in this state within 1950-2010, and found that people have chosen mostly the regions with access to the railway system for their life, and with increase in the railway access of a region, the population of that region found an ascending trend gradually (Talebian et al., 2018).

A study in 2018 examined the effect of railway access on the economic development of cities in China. High-speed rail (HSR) from 2009 to 2013 improved the level of access at the national level of China by 12.11%. In this research, it was found that the cities of the wealthy Eastern region and with access to HSR have experienced a considerable increase in investment of fixed assets, which can stimulate the future economic development. It also showed that large cities with a relatively huge population use HSR more in absorbing investment (Diao, 2018).

In a study performed in 2012, the effects of increasing the speed of trains and use of high-speed trains were investigated on their productivity. Based on this study, the increase in the speed of trains leads to their elevated operational cost, but their productivity would grow so much that not only the increased operational cost would be compensated, but it would also result in enhanced productivity with a

nonlinear curve. Thus, even the increase in the speed of train would influence the economy of affected regions (Kanafani et al., 2012).

In another study in 2018, the effect of high-speed railway system in the northwest of Europe and the first high-speed rail line of England was tested on the economic development of these regions. It was concluded that transport infrastructures would affect the economy of the region, but any transforming effect would not be possible without political interventions (Vickerman, 2018).

Decker and Felin (2007) studied the effect of creating railway on increasing the land value in the west of Mississippi in the 1800s in the US. They observed that railways caused 20% increase in the value of agricultural lands in this region. The most important reason for that was facilitated displacement of loads and products through this region (Decker & Flynn, 2007). Anderson [2008] conducted a general research regarding the effect of investment in transportation on the economic development of different countries. They concluded that the effect of these investments has been generally positive (Andersson & Andersson, 2008). Hall (2007) researched the efficiency and utility of transportation investments in the US, India, and Spain. They found that this utility depends on the level of economy development of the country; more developed countries changed into developed countries and were negatively affected, while less-developed countries were better in efficiency utility and developing the system efficiency (Holl, 2007). In the study by Ketavara et al., attempts were made to obtain a relationship between access to road and railway transportation system and population changes of regions between 1970 and 2007 in Finland. The analyses were performed in the urban regions and the regions with many buildings. The researchers obtained the access of these regions to the transport system. The results indicated that access to railway transport in the 1970s has been influential in increasing the population of the region. Similarly, in 2000-2007, access to railway transport was effective in increasing the population, which coincided with substantial investments in transportation for long distances, as well as with the economic growth of this country (Kotavaara et al., 2011)Another study in 2018 investigated the relationship between railway access and industrialization of cities in Dallas region. They used the employment information obtained from employers in 2014 to investigate the results. They found that the advantages obtained from railway access have created considerable demand in different industry sectors including manufacturing industries, knowledge, and services (Yu et al., 2018).

Based on different studies, it is found that investment in transportation infrastructure can be a very effective factor for economic development of the country. For this reason, many countries consider transportation as an economic sector in their budget planning(Faghihinejad, 2022). For example, in a study by Kens-Button and Aura Regini in 2011, it was found that in February 2009, USA, while suffering many economic problems, allocated 48.1 billion dollars to its transportation infrastructure when planning their budgets. Most of this sum was dedicated to building highways and railways. After these investments, around 280,000 jobs were created in this country and reduced unemployment rate by a suitable rate. In addition, it significantly helped the economic development of the country and surviving the economic crisis it was coping with (Button, 2011).

3. Research methodology

The first step for analyzing the relationship between the two parameters of economic development and railway access is obtaining the required data. These data include the average income of cities and their railway access, with the method of achieving them explained further.

Overall, 75 cities were chosen from all cities throughout Iran. These cities claim 33% of the Iran's population. When choosing the cities, attempts were made to choose the cities scattered throughout the entire country and not condensed in a specific part. In this way, the entire country would be investigated and the selected sample would represent the entire country. Secondly, the cities had at least 2-3 hours of distance from each other, so that the residents of any city would not be able to travel to another chosen city for income generation or employment. In this way, two cities with very close economic relations and impacts would not be included in the statistical sample studied(Delfani et al., 2021). The location of the chosen cities is shown in Fig. 1. Also, the names and average household income of these cities are reported in Table 1.

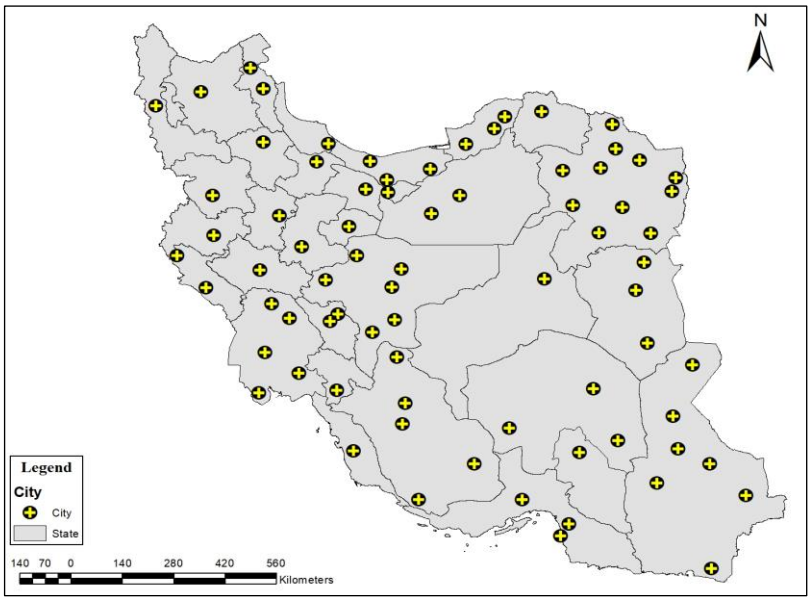


Fig. 1. The location of the studied cities in Iran

The average household income in the studied cities was taken from the statistics organization of Iran. For the small cities whose average income had not been calculated by the statistics organization, their average income was calculated based on the occupations the people of these cities dealt with as well as the average income gained from these occupations (which were available in the statistics organization) (*The results of household expenditure and income statistics*, 2017).

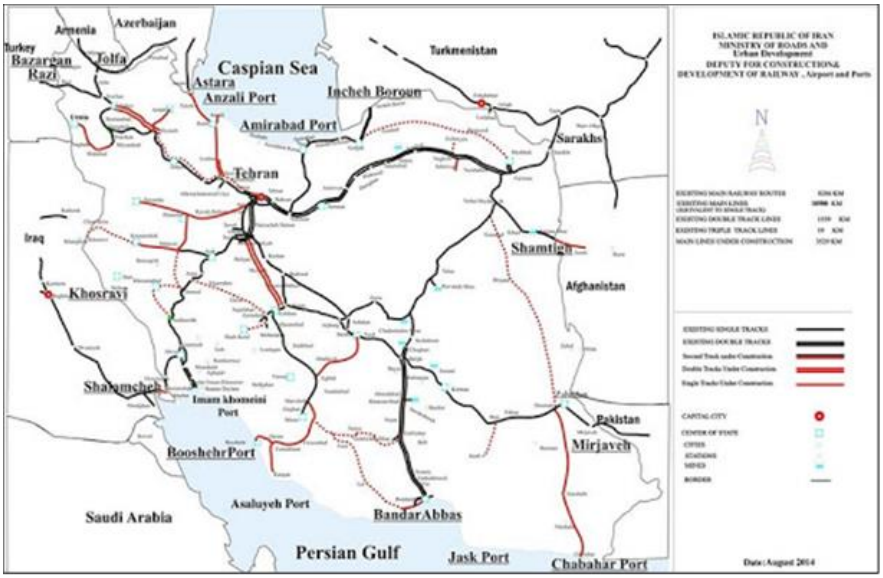
Table 2. The average household income in the studied cities in 2017(*The results of household expenditure and income statistics*, 2017)

Name of cities	income	Name of cities	incom	Name of cities	incom
Jafar Abad	6,975,342	Marvdasht	9,192,300	Tabas	8,942,604
Ardabil	10,975,647	Lamerd	9,647,891	Jandagh	8,562,521
Tabriz	11,245,564	Darab	8,337,992	Ghaen	8,028,566
Oromieh	9,345,475	Damavand	12,491,834	Birjand	8,417,075
Zanjan	9,376,645	Sari	8,466,527	Nahbandan	7,297,368
Ghazvin	11,664,932	Amol	9,064,252	Bandan	7,935,453
Sanandaj	7,954,473	Gorgan	9,975,367	Zabol	8,516,320
Hamedan	10,893,251	Noshahr	12,768,954	Zahedan	6,195,897
Tehran	14,256,470	Rodsar	12,843,571	Khash	6,367,110
Ghom	11,875,290	Semnan	10,993,415	Saravan	7,918,724
Kermanshah	10,132,965	Damghan	11,251,577	Zaboli	9,284,926
Arak	8,952,231	Miodasht	8,580,093	Iranshahr	6,196,763
Ilam	10,356,275	Marave Tapeh	9,329,809	Chabahar	5,864,712
Koram Abad	8,153,499	Bojnord	8,853,534	Bam	4,757,494
Dezfol	9,738,876	Dargaz	8,692,075	Jiroft	7,149,275
Dehlaran	7,903,363	Sabzevar	7,792,075	Kerman	8,829,646
Ahvaz	9,565,838	Neishabor	9,320,621	Minab	8,732,926
Masjed soleiman	8,132,265	Chenaran	8,685,762	Bandar Abas	7,304,736
Abadan	8,959,706	Mashhad	8,305,554	Sirjan	8,248,194
Omidieh	7,134,924	Kalat	10,586,085	Shahr kord	7,441,789
Khansar	7,243,983	Bord Skan	7,685,344	Yasoj	9,622,338
Kashan	8,084,597	Torbat Heidarieh	12,388,344	Isfahan	8,033,593
Dogonbadan	7,181,739	Torbat Jam	7,896,915	Ardestan	9,061,822
Khormoj	8,452,397	Khaf	7,255,708	Shahr Reza	10,997,210
Shiraz	7,762,773	Gonabad	9,301,067	Abadeh	10,794,924

3.1. Calculating the access of the selected cities to the railway transport system

The next step is to calculate the railway access of the studied cities. To this end, the inverse temporal distance of each of the studied cities with the closest railway station was considered as railway access of that city. This method has been used by Ketavara e tal. (2011) to calculate railway access (Kotavaara et al., 2011). In order to compute the railway access of each of the chosen cities, first the temporal distance of each of the cities until the closest railway station was calculated based on minutes. Then, the inverse of this temporal distance was considered as railway access of that city. Fig. 2 displays the available and under construction railway lines as well as those with permission of construction in 2017.

Fig. 2. The available and under construction railway lines as well as those with construction permission in 2017



4. Modeling the relationship between access to railway transport system and economic development

After introducing the data related to access to the railway transportation system and average income of cities into SPSS, some results of the model between them were found. Table 3 summarizes these modelings. Also, Fig. 3 depicts the diagram of different types of models between these two parameters(Hariri-Ardebili et al., 2021).

Table 3. Summary of the modeling performed for the relationship between railway access and average income of cities along with the parameters of these models

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.400	49.287	1	74	.000	64176129.439	29.122		
Logarithmic	.824	34.549	1	74	.000	-2113256.034	2.407E6		
Inverse	.448	59.95	1	74	.000	55884.751	-1.439E11		
Quadratic	.601	54.885	2	74	.000	1.819E8	67.234	-5.866E8	
Cubic	.743	69.368	3	74	.000	3.462E8	49.012	-2.456E9	4.554E9
Compound	.377	44.747	1	74	.000	2.292E47	1.000		
Power	.889	59.784	1	74	.000	-3.842	.271		
S	.507	76.047	1	74	.000	0.104	-1.660E4		
Growth	.377	44.747	1	74	.000	109.051	3.211E-6		
Exponential	.377	44.747	1	74	.000	109.051	3.211E-6		
Logistic	.377	44.747	1	74	.000	4.364E-48	1.000		

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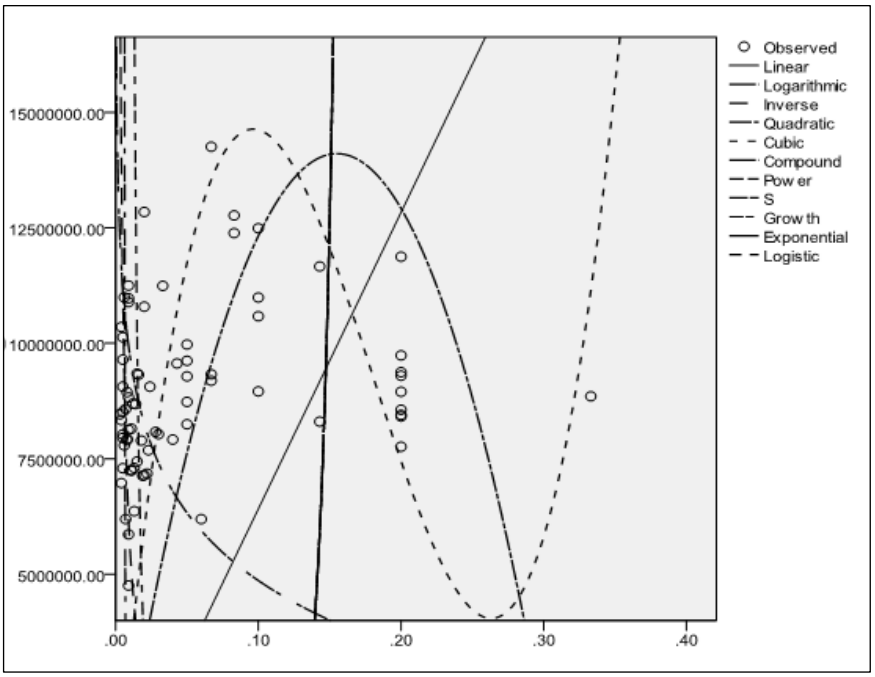

Fig. 3. The graphs of all modelings performed

In all of the models presented, confidence interval is 95%. The models whose sig. value is less than 0.05 will be acceptable. From among the models with these conditions, their relationships with a higher coefficient of determination and F coefficient will have better fit (Gujarati, 2009). Thus, the logarithmic and power model with higher F coefficient and coefficient of determination would be more suitable than other models.

The **power curve regression model** is according to Relation 1. By incorporating the numbers obtained in Table 4, Relation 2 is achieved revealing the relationship between railway access and average income of cities.

$$y = ax^b \quad (1)$$

$$\mathrm{GNI} = \mathrm{RailAcc}^{-3.842} \quad (2)$$

Where:

GNI = economic development (average income of cities)

RailAcc = acts railway access of cities

According to Table 5, the determination coefficient of this relation is 0.889 and its F is 594.784.

The logarithmic model will be as Relation 3. By embedding the values obtained in Table 5, Relation 4 is obtained, indicating the relationship between railway access of cities and their average income.

$$y = bLnx \quad (3)$$

$$\mathrm{GNI} = -2113256.034 * \mathrm{LnRailAcc} \quad (4)$$

Where:

GNI = economic development (average income of cities)

RailAcc = railway access of cities

The determination coefficient of this relation according to Table 3 is 0.824 and its F is 346.549.

5. Investigating the obtained results

In order to investigate the accuracy of the results obtained using the method applied in this paper, first based on around 70% of the data obtained about the average income and railway access of the countries cities, a model was developed. Then, using the 30% remaining data, the developed model was assessed. For this purpose, first using the data of 55 cities of the country, a model would be developed and using the data of 20 remaining cities, prediction of the developed model would be evaluated. Table 4 summarizes of the modeling performed for the 55 cities.

Table 4. Summary of the modeling performed for the relationship between railway access and average income of 70% of cities and the parameters of these models

Equation	Model summary					Parameter Estimates		
	R Square	F	df1	df2	Sig.	b1	b2	b3
Linear	0.421	39.272	1	54	0.000	59431837.831		
Logarithmic	0.805	222.564	1	54	0.000	-2202054.658		
Inverse	0.410	37.522	1	54	0.000	5269913		
Quadratic	0.597	39.206	2	53	0.000	1.666E8	-5214E8	
Cubic	0.746	59.959	3	52	0.000	3.544E8	-2.511E9	4.641E9
Compound	0.411	37.663	1	54	0.000	1.334E43		
Power	0.864	34.799	1	54	0.000	-3.859		
S	0.473	48.419	1	54	0.000	0.096		
Growth	0.411	37.663	1	54	0.000	99.299		
Exponential	0.411	37.633	1	54	0.000	99.299		
Logistic	0.411	37.633	1	54	0.000	7.497E-44		

Based on Table 5, logarithmic and power models, with the maximum F value and determination coefficient, are the best fit for this relationship. Relations 5 and 6 represent the logarithmic and power models.

$$\mathrm{GNI} = \mathrm{RailAcc}^{-3.859} \quad (5)$$

$$\mathrm{GNI} = -2202054.658 * \mathrm{LnRailAcc} \quad (6)$$

After developing the models, now it should be determined to what extent the relations found are able to predict the average income of 20 other cities. After incorporating the level of railway access of the intended cities in Relation 5 and 6, it was found that the logarithmic model offers a better prediction

about the average income of cities. The average income for the 20 remaining cities predicted by logarithmic relation is presented in Table 5.

Table 5. The average income predicted for each household of the 20 cities not used in the logarithmic model related to railway access and economic development

Name of City	Average city income predicted through the obtained models	Average city income in actuality	Deviation percentage from the actuality	Name of City	Average city income predicted through the obtained models	Average city income in actuality	Deviation percentage from the actuality
Nahbandan	6,195,284	6,195,897	0	Chabahar	10,372,846	8,829,646	17
Birjand	11,667,185	8,516,320	36	Bam	6.596,766	8,732,926	-24
Ghaen	10,632,846	7,935,453	33	Jiroft	9,563,096	7,304,736	30
Bandan	9,563,096	6,367,110	50	Kerman	6,596,766	8,248,194	-20
Zabol	7,088,141	7,918,724	-10	Minab	9,247,980	7,441,789	24
Zahedan	6,596,766	9,284,926	-28	Bandarabas	6,596,766	9,622,338	-31
Khash	10,926,254	6,196,763	76	Sirjan	7,721,632	8,033,593	-3
Saravan	10,372,846	5,864,712	76	Shahrekord	8,213,703	9,061,822	-9
Zaboli	10,372,846	4,757,494	118	Yasooj	11,265,703	10,997,210	2
Iranshahr	8,614,489	7,149,275	20	Sfahan	8,614,489	10,794,924	-20

Based on the information presented in Table 5, it is found that the prediction accuracy of the logarithmic model is 69%. Note that the maximum prediction deviation between the average incomes and the real values is related to cities on borders, which are close to neighboring countries. Indeed, because of proximity to these cities and their financial markets, they can be active there as well and even use their railway transport for displacement in the neighboring city. Therefore, external factors will also affect their average income. In these cities, the job of many people is smuggling gasoline, food, live poultry, and others to neighboring countries. Naturally, no precise information was available about the income obtained from these activities. Further, the cities whose average income is largely different from the mean average income, such as Seravan and Zaboli cities, did not have suitable prediction for average income.

Since in the modeling with 55 cities, the accuracy of results is 69%, hence the results obtained from modeling 75 cities of Iran should have an accuracy of at least 69%. Nevertheless, it is clear that because of a larger statistical population, it will definitely have greater accuracy of results.

6. Conclusion

In this research, attempts were made to model the relationship between access of cities to the railway transport system and their economic development based on railway access data of 75 cities of Iran and the average household income in them. The obtained results also showed acceptable relationships between these parameters. It was found that access can considerably influence the economic development of Iran cities. In addition to confirming the positive effect of railway access for cities on their economic development(Sobhan Nazari, Fereshteh Faghihinejad, 2012), This research also helps approximate the effect of investment in this area on the economic development of these cities. As regional and urban designers do not pay due attention to the effect of their plans in goal setting and general plans of the country (Taylor & Schweitzer, 2005), these relations can be helpful.

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