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Locating Transportation Logistics Centers and Their Dynamic Synergy for Equilibrium Economic Behavior

Qiaoyun Guo [1] and Abdol Aziz Shahraki [2,*]

[1] Marxism College, Jingchu University of Technology, Jingmen 448000, China; qiaoyun_guo@outlook.com
[2] Royal Institute of Technology, School of Architecture and Built Environment, 100 44 Stockholm, Sweden
* Correspondence: sharaki@kth.se

Abstract: Locating transportation logistics centers (TLCs) is significant in organizing and easing the shipment of commodities. By choosing the right place and building a brand TLC, various producers and trade companies will benefit from its services. This paper applies the Euclidean theorem and graph theory to select an optimal place. Because the price of transportation services is an important challenge, this article shows ways to reduce it for the companies that are customers of the TLC. This study hypothesizes that a TLC network standardizes and improves services and reduces prices and after the building of Iranshahr's TLC, our aim is to synergize and connect it with a network of TLCs. Case studies were carried out on the building of a network of TLCs with four nodes in Coburg, Ashgabat, Iranshahr, and Chabahar. The novelty of this research is in the method used, which studies TLCs in two statuses—separately and with a network. The research includes, simultaneously, TLCs in both developed and developing economies with various socioeconomic formations. The paper analyses, methodologically, the economic behavior of the TLCs in the two situations using a mathematical model. The model uses two Lagrange target functions to prove that the network decreases prices while improving presented services. We found that multimodal cargo transportation by one TLC within a network of TLCs decreases the costs of transportation services and that the TLC network improved economies of scale through knowledge, technology, and experience synergy. The outcomes and model of this study will assist transportation planners and engineers in building and managing a TLC and including it in a network.

Keywords: sustainable transportation services; transportation logistics center; network modeling; cargo intermodal transport cost; graph theory; equilibrium economic behavior

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1. Introduction

Transportation logistics centers (TLCs) are an important part of modern urban systems and play a key role in managing services in a wide chain of logistics, supplying, storing, distributing, and transporting cargo to various destinations. A network of TLCs uses multimodal transportation and grows the economy of scale in the nodes. Considering the importance of TLCs, finding suitable locations to plan, design, and build them and manage their services is important in urban and regional development planning. The location of a TLC is an important decision that affects the efficiency of transportation services and their prices. Nevertheless, creating a network of TLCs is a creative strategy that generates more urban and regional economic growth compared with the function of one TLC separately [1]. TLCs supply varied services, such as storage, transportation of goods, handling, and quality control of services. Therefore, building TLCs can increase urban and regional development, particularly in developing countries. Global experience shows that the TLCs included in networks supply better transportation services and exhibit remarkable economic outcomes in both advanced and developing countries [2]. This paper addresses the problem of the high prices of transportation services provided by TLCs. A major challenge is the high prices of services in TLCs. After finding an optimal location for a TLC, this paper investigates the following questions:

i. Does the synergy of transportation logistics centers lead to lower prices of transportation services in Iranshahr?
ii. Is synergy between the services of Iranshahr's transportation logistics center and transportation logistics centers in Coburg, Ashgabat, and Chabahar necessary?

This study aimed to ensure sustainable transportation services for producers, industries, and businesses in Iranshahr through its transportation logistics center and to connect it to the global network of transportation logistics centers. The goal was also to support development of the micro, meso, and macroeconomics in the city through the improvement of transportation services, gaining the trust of customers, and increasing commercial services. Transportation economic behavior concerns prices that pay for different transported cargos in nodes that have surplus supply and demand. Experience shows that TLCs located in both advanced and underdeveloped socioeconomic areas may impose various strategic goals concerning economic equilibrium behaviors. Although Iranshahr is a developing city, it has transport exchanges with Coburg, which is a developed city. Therefore, we analyzed transportation prices both in Iranshahr and Coburg. We also analyzed TLCs in two situations—separately and in a network of TLCs—to prove the usefulness of the TLC networks.

Recognizing the importance of the location of the transportation logistics center, we hypothesized that a network of transportation logistics centers improves the quality and quantity of transportation services and reduces their prices.

Methodologically, this study had two parts: theoretical and practical. The required data were collected in the four nodes of Coburg in Germany, Ashgabat in Turkmenistan, and Iranshar and Chabahar in Iran, with reference to their activities and local conditions. Data were gathered and graphed and classical location theories were applied. The major research method to reach the stated goal and answer the above questions was to analyze the economic behavior of TLCs in two situations—separately and with a network. We analyzed the economic behavior of TLCs both in separate situations and when included in a network of TLCs using a mathematical model. The model proved the validity of the hypothesis related to the possibility of reducing the price of transportation and increasing the quality of services by integrating the TLCs into a network. As an innovation, this paper analyzed two types of economic behavior of TLCs:

- The economic behavior of TLCs in a separate situation;
- The economic behavior of TLCs in a dynamic synergy when included in a network.

The novel and distinctive features of this study, compared to published works, are in its research method, which highlights the importance of networking with TLCs. This research is an innovative work because its methods consider two statuses for the TLCs—separately and with a network. Furthermore, the TLCs were analyzed in both developed and developing economies with various socioeconomic structures. We hypothesized that a network of TLCs reduces transportation prices more than a separate TLC and creates economic prosperity in the developing nodes. Despite the necessity of synergy in the services of TLCs by networks, adequate research has not been conducted on it. Therefore, this paper addresses networking with TLCs to fill that gap.

The results of this practical research article will help those who plan and manage TLCs to provide efficient services with lower prices to their applicants. The model used in this paper will particularly assist planners and engineers in the synergic status of TLCs, which, to date, has not been adequately studied.

This paper is structured in five parts. Following this introduction, Section 2 reviews the literature concerning the optimal location and operation of the TLCs. Section 3 is devoted to case studies, and Section 4 presents methods applied in the study. Section 5 details and discusses the findings of the study, and finally, Section 6 details its conclusions.

2. Literature Review

This section explores various opinions on choosing the location of TLCs, networking with TLCs, analyzing the economic behavior of TLCs, and management of TLCs. Cities that, due to their geographic location, production potential and capacities, and knowledge and human resources, produce surplus agricultural, livestock, or artificial goods need to find new bazaars. After the increase in production, they require services to transport the goods to consumption destinations. This phenomenon that has occurred throughout history, but with particular characteristics in every era [3].

A TLC, especially if it is integrated into a network of TLCs, positively impacts the socio-economic development of the region. For this reason, China has great expectations for socioeconomic prosperity in the ports of the Yangtze River Economic Belt [4]. The prices of transportation services are a major challenge in urban and regional economic enterprises. The freight transport price is about 28% of the total good delivery cost average [5]. Transportation prices are high in the production process, and scholars have always planned to decrease the costs [6,7]. American state and local governments spend billions on transportation costs. Despite massive investments in transportation infrastructure, traffic congestion remains a major societal and public policy problem [8].

The business sector in the United States alone spent over USD 1.45 trillion on transportation in 2018 and this is the largest overhead for most businesses [9]. Regions can start overcoming the transportation cost challenge by selecting optimal locations for TLCs and building networks to minimize transportation prices [10]. Optimization is possible through site analysis to determine whether a candidate place is suitable to supply standard transportation services for economic enterprises and companies [11,12]. Choosing the right place and building a brand TLC reduces the prices of transportation services and increases the number of happy customers. The question is whether the site in question is suitable for TLC activities as a regional node in the network of TLCs aimed at reducing transportation prices. In addition to the, so far, classic locating theories, digitalization assists the selection of a pertinent node for a TLC [13]. The complexity of relationships in the chain of production, warehousing, marketing, and safe and fast transportation of goods to destinations necessitates the services of TLCs. Such centers should organize, manage, and optimize all the complex relationships of cargo delivery, storage, marketing, and transportation. Scholars have declared that decisions on distribution management are of importance in international marketing. International distribution management includes international channel and sale management through the international distribution of transportation services [14]. Planning a network of TLCs that includes many multimodal TLCs is necessary to enhance trade and economic growth [15,16]. Preferably, a TLC should have a multimodal transportation infrastructure and exchange knowledge and technologies with other TLCs in the network [17]. Enhancing technological flexibility and, consequently, improving the performance of digital manufacturing is a newly applied technique in selecting a node place for a TLC network. Besides, a consolidated production distribution toward the destination nodes strategy is employed to allocate and deliver tasks to manufacturing resources at minimum costs [18]. Furthermore, the development of TLC networks using new technologies such as applications of smart logistics based on the Internet of Things (IoT) is in progress [19]. The planning and development of TLCs must account for several factors such as the availability of suitable land and the abundant production of various products. Usually, the TLC is located where all activities related to transportation services take place. The TLC distributes goods to national and international destinations. A TLC must be equipped with the infrastructure and machinery to conduct the abovementioned tasks [20,21]. TLCs have evolved since the last century, and their potential supports the realization of sustainable urban economic development. Researchers have answered the question of whether TLCs are suitable and practical for creating a sustainable urban environment. In answering this question, they have also considered the specific situations and needs of cities and have found that, above all, the attitudes and participation of individual stakeholders, especially enterprises using urban logistic services, should be considered [22–24]. The need to concentrate the services of TLCs in the form of networks in developing cities has increased significantly in recent years. This need originates from recent social, economic, and technological advances [25]. In parallel, aspiring green agendas in conjunction with tremendous economic pressures are resulting in increased attention being paid to the environment and to technological innovations for improving existing TLC systems [26]. A network of TLCs connects different modes of cargo transportation, storage and distribution of goods, marketing, and management of transportation services. Furthermore, it improves the economy of scale in cargo transportation operations. The network should also be a platform for providing value-added logistic services. The goal of a TLC network is to support the local requirements of the flow of goods in national and transnational exchange networks by creating clean, safe, and cheap combined and multimodal transportation [27]. TLCs not only act as connecting links of different modes of transportation but also appear as links with trade, which shows their importance [28–30]. Figure 1 shows the functions of a generic network of TLCs.

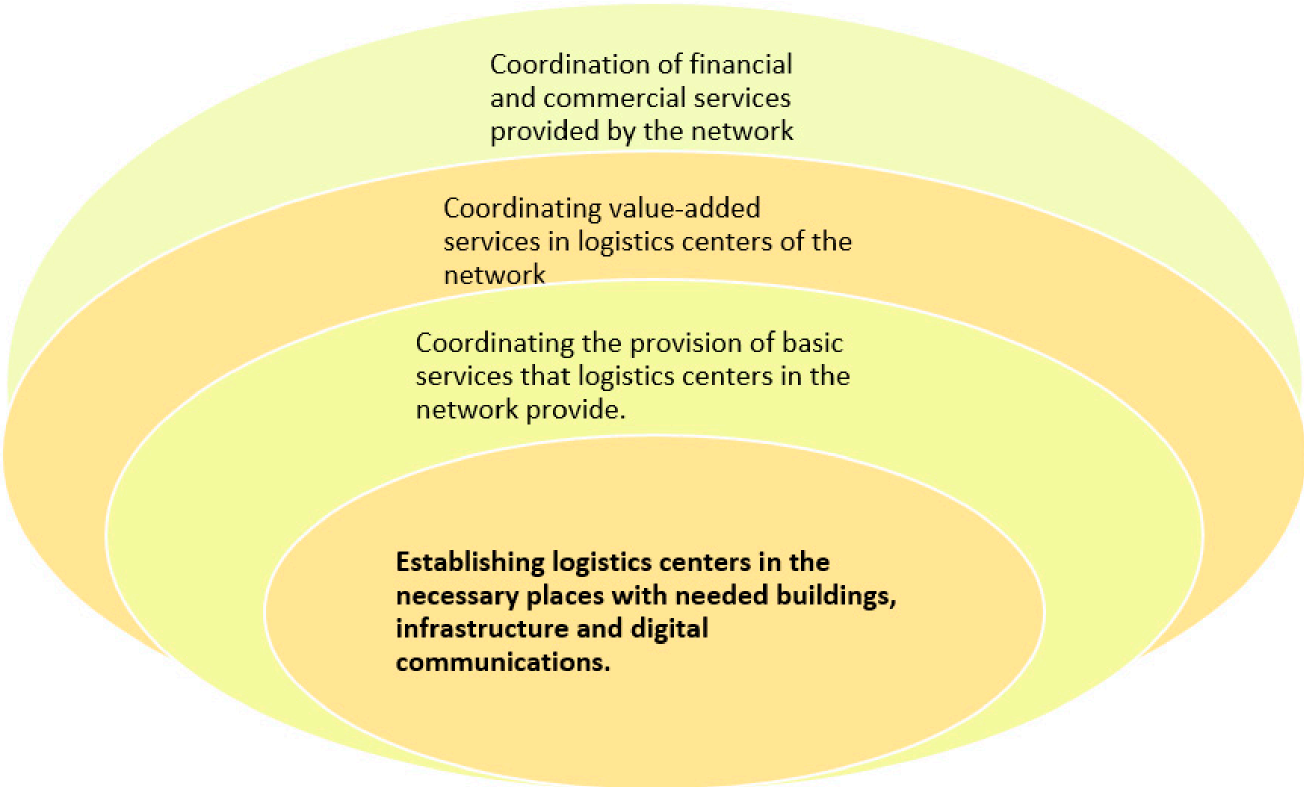


Figure 1. Diagram of the relationship between common TLC services and infrastructure facilities in a network of TLCs.

Figure 1 illustrates four levels of general services expected from a network of TLCs. The foundation step is establishing TLCs in the necessary places with needed buildings, infrastructure, and digital communications. The second level is coordinating the provision of basic services that TLCs provide in the network. This level of services in the network encompasses multimodal transportation, unloading and loading of cargo, moving goods, changing fleets, managing warehouses, and storing and distributing cargo. The third level of services is coordinating value-added services in the network of TLCs, including setting common standards for consolidation of small cargo; packing, unloading, and loading; and clearance of goods. Finally, the network coordinates financial and commercial services provided by the TLCs, such as banking, insurance, and pricing services. The following findings were made:

1. When production is greater than local consumption and surplus, communities try to export their products to far and near markets;
2. Global experience has shown that a TLC in a suitable place will lead to the development of production and trade in the city or region;

3. Location theories and scholars' opinions have shown that the right place to build a TLC is one with diverse production potential and multimodal transportation infrastructure and machines;
4. A TLC provides a set of services such as storage, packaging, transportation, insurance, and reliable delivery of cargo to customers;
5. Synergy and integration of TLCs in a network lead to efficiency and cheaper prices of transportation services compared with each TLC separately.

These findings are considered in the next sections of the study.

3. Case Studies and Data Collection

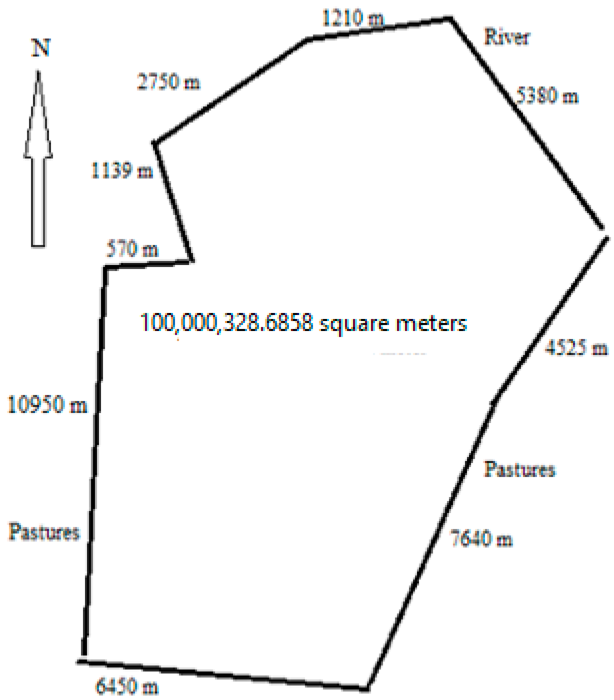
Field studies were undertaken to collect the necessary data for planning and building a logistic center in Iranshahr. We collected data related to Iranshahr to show the production potential, transportation infrastructure, and location of the city. We examined the data and checked whether the site is suitable for building a logistic center. Because this study hypothesized that a logistics center has more effective economic behavior when cooperating with a network of logistics centers, we also studied three logistics centers: Ashgabat, Chabahar, and Coburg. Iranshahr, with an area of 20,131 square kilometers, includes four cities, three districts, and seven villages and has a population of 219,503 according to the census of 2015 [31]. One of the demographic characteristics of Iranshahr is the youth of its population, which supports the potential for the efficient and sustainable functioning of a TLC in this city. Iranshahr is almost in the center of the Sistan Baluchistan province and at the intersection of the south–north and east–west highways, with the possibility of connecting with the Gulf of Oman. It is a neighbor of Pakistani Baluchistan and is also linked with the Kerman province of Iran through Bam. The main axes of the communication of Iranshahr are listed in Table 1.

Table 1. The major accessibility of Iranshahr to its north, south, west, and east regions.

Line	Origin of Road	Destination of Road	Distance/km	Function of the Road
1	Iranshahr	Bam	380	Connects Iranshahr to Kerman province
2	Iranshahr	Bandar Abbas	539	Connects Iranshahr to Hormozgan province and the Persian Gulf
3	Iranshahr	Khash	149	Connects Iranshar to Zahedan
4	Iranshahr	Sarbaz	108	Connects Iranshahr to the Gulf of Oman
5	Iranshahr	Nikshahr	169	Connects Iranshahr to the Gulf of Oman
6	Iranshahr	Saravan	227	Connects Iranshahr to Pakistan
Total			1622 km	

Source: [32].

In Table 1, the first road passes from Bazman with its amazing mountain groves and mines, and ends on the Bam–Kerman Road in its west. Road 2, Iranshahr–Bampur–Dalgan–Bandar Abbas passes from the agricultural plains of Bazman and Dalgan and goes to the important harbor of Bandar Abbas in Iran, connecting Iranshahr to the Persian Gulf. The Iranshahr–Kash road passes through the beautiful Damen landscapes, and Taftan volcanic mountains, and ends at Zahedan, connecting Iranshahr to Afghanistan. Road 4, Iranshahr–Sarbaz, travels along the Sarbaz River with its amazing landscapes, passes many towns and villages with various productions, and ends in Chabahar. This is the second connection between the cities and villages of the western shores of the Gulf of Oman and Iranshahr. The fifth road, the Iranshahr–Nikshahr road passes through the wonderful green mountainous Tang Sarhe and ends in Chabahar. This is the second connection between the cities and villages of the western shores of the Gulf of Oman and Iranshahr. The Iranshahr–Saravan Road is an important road that passes through various landscapes including deserts, mountains, farms, groves, and green areas, and arrives at Pakistan's trading border cities. These roads support the communication of surrounding communities with Iranshahr and increase the transportation of cargo and trade. The prime location of Iranshahr regarding its major corridors, as mentioned in Table 1, is pertinent to building a logistical center. Iranshahr has great potential in the livestock, agricultural, horticultural, mining, industrial, scientific, and service fields. It has fertile agricultural lands, vast plains, natural energy, and human resources capable of producing various products. Iranshahr produces tons of agricultural products; the total agricultural production of Iranshahr in 2016 was 497,650.74 tons [32]. For this reason, Iranshahr has surplus production that should be transported to national and international markets. Additionally, 10 important mines are being exploited in the city, producing a large volume of cargo for the Iranshahr TLC by many related enterprises and companies. Paying attention to indicators such as the existence of a dynamic workforce and educational centers and proximity to production centers, one site was selected for a TLC. The government owns the land and it is in the vicinity of the railway station. The site is located on the fourth kilometer of the Iranshahr–Sarbaz–Chabahar highway. Based on technical analysis, the soil of the site is suitable for the construction of strong foundations for multimodal transportation infrastructures, warehouses, offices, and machinery installation. The site is close to a train station and has access to land, air, water, and rail transportation infrastructure. Figure 2 is a sketch and surveying results of this site.



Area=10000328.6858 m^2
Perimeter=40614 m

Point 1	X=260094.6339	Y=2983677.6939
Point 2	X=263626.0000	Y=2991064.0000
Point 3	X=264149.0000	Y=2991041.0000
Point 4	X=265070.0000	Y=2993246.0000
Point 5	X=266508.0000	Y=2995052.0000
Point 6	X=271741.0000	Y=2997060.0000
Point 7	X=272407.0000	Y=2994860.0000
Point 8	X=272385.0000	Y=2991745.0000
Point 9	X=271433.8461	Y=2988551.9587
Point 10	X=271433.8461	Y=2988551.9587
Point 11	X=266429.0978	Y=2982645.0498

Figure 2. A sketch of the site considered for the TLC in Iranshahr and surveying calculations. Source: [32].

Figure 2 shows a site with an area of approximately 1000 hectares and a perimeter of almost 41 km. In the figure, there is also a table of land surveying that calculates the height of 11 points of the site. As the table shows, the topography of the site has a gentle south-north slope but is almost flat.

Iranshahr should exchange cargo transportation services with the city of Ashgabat. Ashgabat, with 902,000 inhabitants, is home to Turkmenistan's TLC [33]. The shareholders of the TLC are Turkmen Railways, Turkmen Motor Transport, Turkmen Communications, Turkmenistan Airlines, Turkmen Sea and River Lines agencies, the State Insurance Agency of Turkmenistan, and the Turkmen Logistics Association Economic Society. The center is a logistic solution provider for the delivery of transportation services. The services include the transit, import, and export of cargo from the consignor to the consignee by one or several types of transportation multimodal services. Based on the cooperation achieved with the freight forwarding companies in the Baltic states, Iran, Afghanistan, China, and several countries in Europe and Asia, the TLC offers good performance of transport services for the carriage of goods at the lowest prices and in the shortest time. In this situation, the Turkmenistan TLC in Ashgabat benefits from its position for regional transfers from Central Asia to Iran and the Caucasus, and to Turkey. At the same time, transcontinental transit from China to the Caucasus works in cases of a substantial decrease in transport of either of its competitors. The war in Ukraine is a motivating factor for increasing volumes of cargo for transportation [34,35]. The Iranshahr TLC needs to transport cargo as imports and exports with Coburg. Coburg, with 42,000 people, has an advanced TLC. Coburg TLC's customers are from communities representing a variety of sectors, from e-commerce and manufacturing to pharma and third-party logistics services, and from dozens of countries [36]. The center serves both small and large businesses. Its services include total logistic management, air and ocean freight forwarding, and inland ground and rail services. It fulfills import/export services, warehousing and distribution, global trade services, logistics, and technological solutions. Interestingly, Coburg's TLC supports the sustainable energy infrastructure transition globally. It has launched many initiatives to help pursue renewable energy development, including onsite solar, in its global logistics real-estate portfolio. These initiatives are coupled with battery storage and depot charging for electric vehicles [37].

Chabahar, with 291,910 people, is a harbor on the Gulf of Oman and the Indian Ocean [38]. It is a place that connects the international transportation corridor of Chabahar–Iranshahr–Khash–Zahedan–Milak to Afghanistan and Ashgabat. From 2012 to 2015, Chabahar's share of cargo transportation increased due to the transportation services provided by the corridor, which is a section of the major Euro–Asia corridor [39]. The Chabahar–Milak corridor is 820 km long, and is the shortest route between the Middle East and Central Asia due to its proximity to Central Asian countries and access to the and seas. The Chabahar origin station consists of two ports: Kalantari and Beheshti. The development of Chabahar and the increase in its loading capacity of up to 8.5 million tons show the importance of the Chabahar–Zahedan–Milk railroad line [39]. The cities of Iranshahr, Zahedan, and Zabol on the route of this railway line have diverse and significant agricultural, horticultural, livestock, industrial, and mining production. In the train stations of these cities, strategic transportation services help the economic development and income of households. Chabahar is now a strategic center for international transportation. In the development programs of the southern Baluchistan region of Iran, Iranshahr is the center of the support and development of this region [40,41]. When a network of the four TLCs, based on the calculations in the next part of this article was designed, it showed that Iranshahr is also a suitable place in terms of distance index.

Due to numerous requests from the owners of farms, gardens, groves, industries, and mines in Iranshahr, the planning and construction of a TLC are now being discussed. This paper plans a TLC according to the relevant academic standards and principles. It considered indices such as production potential, sustainable socioeconomic development trends, access to multimodal transportation infrastructure, and proximity to production centers and mines. The suitability of the site's soil for constructing the required buildings and facilities and its proximity to the other three nodes have also been noted.

4. Methods Applied

Both the theoretical justification and investigational facts presented in Sections 2 and 3 were used to plan a TLC in Iranshahr and to connect it to a network of TLCs. The chosen

TLCs in this case study were located in four mismatched locations. This mismatch is associated with various socioeconomic formations of the cities with these TLCs as nodes. Figure 3, which compares the gross domestic production (GDP) of the four communities, reveals huge differences in economic development.

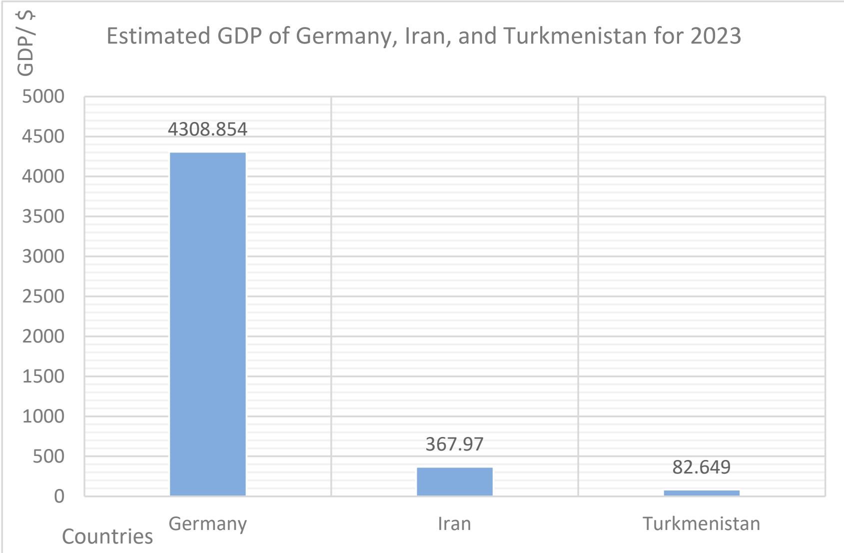


Figure 3. Comparison of GDP in countries with Coburg, Ashgabat, Iranshahr, and Chabahar TLCs. Source: [42].

Figure 3 shows that the GDP of Germany is almost 12 and 110 times that of Iran and Turkmenistan, respectively. Despite the huge differences in the socioeconomic development of the communities, they should exchange transportation services.

Methodologically, this study considered four TLCs—in Coburg, Ashgabat, Iranshar, and Chabahar—to analyze the economic behavior of TLCs in transportation price changes. The economic equilibrium behavior of TLCs in the network is illustrated in Figure 4. The graph in Figure 4 takes four nodes—1, 2, 3, and 4—as a subnetwork within the global network of TLCs.

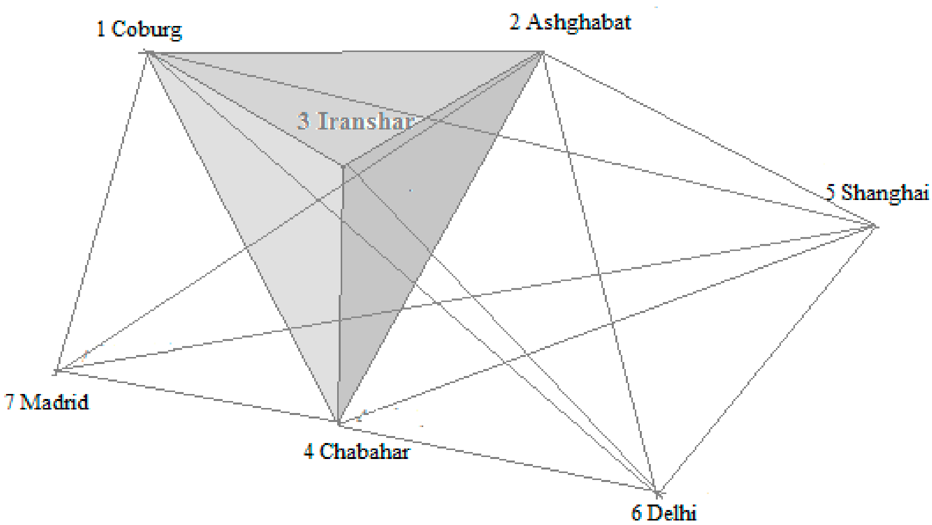


Figure 4. TLC of Iranshahr as a synergetic node in a network composed of TLCs in Coburg, Ashgabat, Iranshahr, and Chabahar. Source: The graph was supplied by the authors.

To prove the suitability of Iranshahr in terms of being closer to the other three nodes, this study uses the Euclidean theorem. The Euclidean theorem indicates that the distance between any two nodes, like α (Coburg) and β (Iranshahr) or γ (Ashgabat) and β on the real line, is the absolute value of the numerical difference of their coordinates:

$$d(\alpha,\ \beta) = |\alpha - \beta| \rightarrow d(\alpha,\ \beta) = \sqrt{(\alpha -\ \beta)^2}. \quad (1)$$

In the Euclidean plane α and β have Cartesian coordinates, and the distance between two points is given by:

$$d(\alpha,\ \beta) = |\alpha - \beta| \rightarrow d(\alpha,\ \beta) = \sqrt{(\beta_1 - \alpha_1)^2 + (\beta_2 - \alpha_2)^2 + \ldots + (\beta_n - \alpha_n)^2} \quad (2)$$

Simulating calculations in the distances between nodes in the graph with Equation (2) gives the results in Table 2.

Table 2. Distance between Iranshahr and Coburg, Iranshahr and Ashgabat, Chabahar and Coburg, and Chabahar and Ashgabat.

Name of the Origin Node	Name of the Destination Node	Distance between the Two Nodes/Kilometers
Iranshahr	Coburg	≅5953
Chabahar	Coburg	≅6247
Iranshar	Ashgabat	≅1537
Chabahar	Ashgabat	≅1846

Source: [43].

Table 2 shows that the distance between Iranshahr and Coburg (5953 km) is shorter than the distance between Coburg and Chabahar (6247 km). Similarly, the distance between Iranshahr and Ashgabat (1537 km) is shorter than that between Ashgabat and Chabahar (1846 km). Therefore, according to Equations (1) and (2), in terms of distance from other TLCs, Iranshahr is a suitable place for a TLC. This study hypothesized that a network of transportation logistics centers improves the quality and quantity of transportation services and decreases their prices.

Here, this study built a mathematical model to minimize transportation prices in TLCs. For this purpose, it should show the different economic behavior of nodes when influenced by changes in transportation prices. Figure 4 illustrates that Iranshahr proved to be a more suitable place and thus had better accessibility. First, the focus is to model the economic behavior in terms of transportation prices in Iranshahr's TLC.

4.1. The Economic Behavior of TLCs in Iranshahr and Coburg When Working Separately

Here, we begin by introducing the following two variables:

$$Tp_i^c = Transportation\ price\ of\ cargo\ c\ (c = 1, \ldots\ m)\ in\ excess\ supply\ node\ i\ of\ the\ finite\ transportation\ network\ (j = 1, \ldots, n)$$

where, in the case of Iranshahr, i denotes Iranshahr's TLC and c represents every agricultural, mineral, or other good to be transported to destinations and

$$\gamma_{ij}^c = Additional\ transport\ costs\ from\ excess\ supply\ node\ i\ to\ demand\ node\ j$$

where γ_{ij}^c is overhead costs such as insurance when cargo is delivered to destination j.

Next, we describe the relationship between the introduced variables at a given demand and supply transportation price. Generally, the following conditions exist for every pair of nodes, i.e., i (Iranshahr) and j (Coburg).

$$Tp_j^c - Tp_i^c \leq Tp_{ij}^c;\ for\ \{j = 1, \ldots, n\};\ \{i = 1, \ldots, n\};\ \{c = 1, \ldots, m\}\ . \quad (3)$$

Associated with this set of equilibrium conditions, we describe the following minimization Lagrange target equation.

$$Minimize\ Tp = \sum_{ijc}\left[Tp_j^c - \gamma_{ij}^c\right]X_{ij}^c; \tag{4}$$

where X_{ij}^c presents predetermined transportation nodes.

Subject to conditions of

$$\sum_j X_{ij}^c \leq \overline{X}_i^c;\ [i = 1, \ldots,\ n.\ c = 1, \ldots,\ m];\ X_{ij}^c \geq 0 \tag{5}$$

To include the minimization conditions mentioned above, we write the following Lagrange target equation.

$$Minimize\ Tp = \sum_{ijc}\left[Tp_j^c - \gamma_{ij}^c\right]X_{ij}^c - \sum_{ic} Tp_i^c\left[\sum_j X_{ij}^c - X_i^c\ \right]; \tag{6}$$

subject to the following conditions:

$$Tp_j^c - Tp_i^c\ \leq \gamma_{ij}^c;\ \{i = 1, \ldots n; j = 1, \ldots,\ n; c = 1, \ldots,\} \tag{7}$$

$$\left(\ Tp_j^c - Tp_i^c - \gamma_{ij}^c\right)X_{ij}^c = 0;\ X_{ij}^c \geq 0 \tag{8}$$

The transportation prices to deliver cargo are Lagrange parameters. With Equation (6), the economic behavior of the TLC in Iranshahr would be characterized by adapting the *Tp* to a particular destination node. In our calculations, this study considers Coburg's destination. It solves target Equation (6) with MAT-LAB 7.7 R2008b software to find the minimum Tp when Iranshahr's TLC transports a 50 ton cargo to Coburg's TLC. Consider $50 \times 5953 = 297,650$ Ton. km. The Tp in target Equation (6) is USD 0.09 per Ton. km. Thus, in the case of Iranshahr's TLC, we calculated $Minimum\ Tp = 0.09$ USD per Ton. km.

This study also simulated target Equation (6) with particular data in Coburg's TLC. In this case, it solved the equation for transporting a 50-ton cargo from Coburg's TLC to the Iranshahr destination. We consider again $50 \times 5953 = 297,650$ Ton. km. The Tp suggested by target Equation (6) is USD 0.15 per Ton. km.

Thus, in the Coburg case (TLC in an advanced and developed socioeconomic node) the $Minimum\ Tp =$ USD 0.15 per Ton. km has been calculated.

4.2. The Economic Behavior of TLCs in Iranshahr and Coburg When They Are in the TLC Network

Let us to develop a model for synergy and collaboration of TLCs in Iranshahr and Coburg when they are included in the network presented in Figure 4. To illustrate the complications in the behavior of TLCs in the network scope, we introduce a nonlinear equation to determine *Tp* with the following conditions:

$$Tp = Tp\left(X_{11}^1, \ldots,\ X_{ij}^c, \ldots,\ X_{nn}^m\right) \tag{9}$$

respecting the following two conditions:

$$\frac{\delta^2 Tp}{\delta X_{ij}^b \delta X_{ij}^c} \leq 0 \tag{10}$$

where δTp denotes changes in transportation costs and δX_{ij}^b and δX_{ij}^c show the increasing economy of scale in nodes *b* and *c*, i.e., Iranshahr and Coburg, when they are included in the TLCs' network presented by the graph in Figure 4.

$$\frac{\delta Tp}{\delta X_{ij}^b} < 0\ for\ 0 \leq X_{ij}^b \tag{11}$$

These conditions imply increasing returns with increase in scale in the transportation of any freight. They also imply the advantages of the joint transportation of different cargos by the network of TLCs in terms of the minimization of transportation costs. In fact, the conditions indicate economic behavior changes in the TLCs. Now, we write a minimizing target function for the TLCs included in the network as follows:

$$Minimizing = \sum_{ijc} Tp_j^c X_{ij}^c - Tp\left(X_{11}^1, \ldots,\ X_{ij}^c,\ \ldots,\ X_{nn}^m\right) - \sum_{ic} Tp_i^c \left[\sum_j X_{ij}^c - \overline{X}_i^c\right] \quad (12)$$

The TLCs in Coburg and Iranshahr provide different service-level prices associated with time, delay, and guaranteed quality.

The presented model is now sufficiently robust to calculate the transportation prices in every node included in the network. First, it minimizes the Tp when Iranshahr's TLC sends 50 tones cargo to the TLC in Coburg. The model minimizes the target Function (12) with MAT-LAB software and obtain $Tp = USD$ 0.075 per Ton. km. Similarly, it calculates the minimum $Tp =$ USD 0.125 Ton. km, when Iranshahr's TLC transports 50 tons of cargo to the TLC in Coburg.

Target Equation (6) can be simulated in particular situations of every TLC, for example, Coburg, Iranshahr, Chabahar, and Ashgabat to minimize the transportation prices of cargo when every TLC works separately. Additionally, target Equation (12) is applicable in every TLC to minimize the transportation prices when TLCs collaborate through a network of TLCs.

5. Findings and Discussion

The selection of the right location is an important step in the process of planning and building a logistic center. Therefore, the general and specific indicators of each region should be kept in mind at the same time as the location of the site. In the special case of Iranshahr, the network of transportation roads, railway transportation lines, air transportation, proximity to Oman sea ports, multimodal transportation infrastructure, proximity to production and industrial centers, proximity to mines, suitable geographical location, and natural and human resources have been considered. The potential of different services, tourist activities, and scientific work also influences the site selection of advanced TLCs. Furthermore, as Figure 1 illustrates, a TLC in Iranshahr will create added value with functions such as packaging and insurance and timely delivery of goods, which will increase productivity in the region.

It was found that Iranshahr's TLC, which is planned in a suitable place, will lead to the economic development of the region. The adequacy of all required factors in Iranshahr through the local cognition and case studies has been confirmed. This study shows that cities with agricultural, animal husbandry, industrial, mining, artistic and cultural production potential should export their goods to consumer markets. The total land transportation lines of Iranshahr have a length of 1622 km and connect it to all commercial and production poles around the city—to the east, west, north, and south. The Euclidean theorem, proven geometrically and computationally with the help of Equations (1) and (2), showed that Iranshahr has a shorter distance to the other nodes of graph 4. For example, the distance between Iranshahr and Coburg is 5953 km, which is less than the distance between Chabahar and Coburg, of 6247 km. The site which was shown in Figure 1 has been selected in accordance with the mentioned indicators. The site has an area of approximately 1000 hectares with a suitable soil for foundations to construct buildings, infrastructure, and facilities. The proximity of the site to the train station, airport, and river is another advantage. These points guarantee the TLC in Iranshahr will provide sustainable services. The economic analyses calculated the prices of transportation services of TLCs in Iranshahr and Coburg by minimizing the objective through Equation (6). The prices were USD 0.09 per Ton. Km and USD 0.15 per Ton.km, assuming that the TCLs provide services separately. If the TLCs in Iranshahr and Coburg are included in the network of TLCs shown in the graph of Figure 4, the prices are different. In this case, our analysis with minimization of target Equation (12) showed that the prices are USD 0.075 per Ton. km and USD 0.124 per Ton. km, respectively, for Iranshahr's TLC and Coburg's TLC. Figure 5 compares the transportation prices of the TLCs in two situations—separately and within a network of the TLCs.

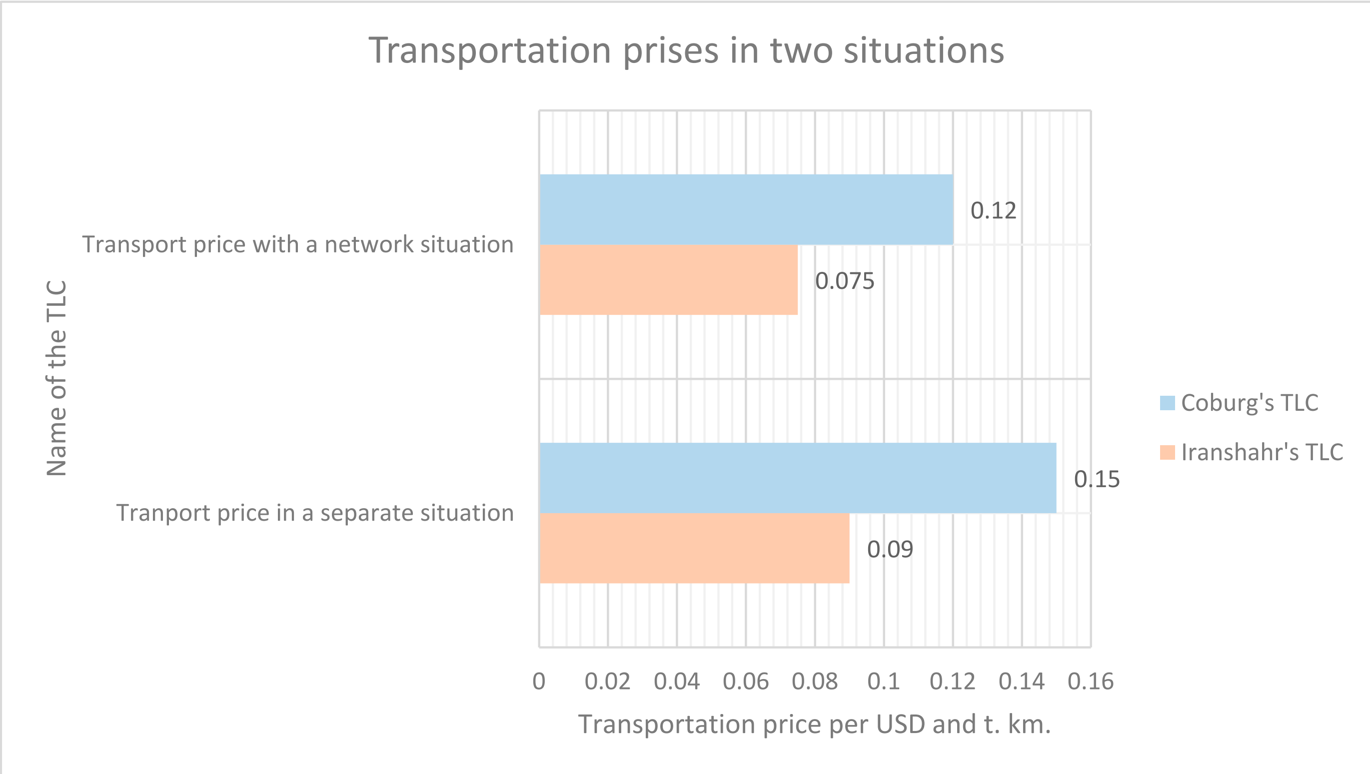


Figure 5. Transportation prices of TLCs of Iranshahr and Coburg per USD and Ton. Kilometer in two situations. Source: The figure was supplied by the authors.

Figure 5 clearly shows that the network introduced in the graph 4 reduced the price of transportation prices. This reduction is from USD 0.15 to USD 0.12 per t. km in Coburg's TLC and from USD 0.09 to UAS 0.075 per t. km in Iranshahr's TLC.

The production relationships and the socioeconomic formation of a society influence the economic behavior of the TLC. For this reason, we studied the economic behavior of TLCs in two developing and developed economies. The higher transportation prices in Coburg, shown in Figure 5, are associated with its socioeconomics in terms of higher wages of the workforce, modern technologies, and more qualified services compared with Iranshahr. In Coburg, with an advanced socioeconomics, economic enterprises and companies behave according to market rules. In advanced TLCs, the price of transportation between origins and destinations does not exceed a given margin. In this way, TLC services optimize transportation prices.

The reason for the reduction is the scientific and technological cooperation and coordination in cargo management and reliable delivery of cargo to customers. This success brings satisfaction to the producers and business enterprises of partner TLCs, and as a result will lead to a regional and urban economic boom in Iranshahr.

To compare prices of Iranshahr's TLC and global average prices, we researched the price of a 22 ton cargo that was transported from Pavlodar in Kazakhstan to Berlin in Germany. It was USD 0.72 per t. km [44]. It was foundhIranshahr's prices were lower compared with other developing regions. The comparison found that when the Iranshahr's logistics center is connected to a network of logistics centers, it will have better efficiency for transporting cargo. One of these efficiencies is the reduction in transportation prices through the transfer of experiences and technology and coordination between the TLCs of the network. The analysis proved that the construction of the infrastructure of Iranshahr's TLC and connecting it to the network of TLCs, multimodal transportation services of goods, warehousing, and cargo distribution are possible at lower prices. The purpose of planning and building TLCs with combined and multimodal cargo transportation terminals is to improve cargo transportation through the modernization of infrastructure. Modernization is possible through collaboration and synergy with advanced TLCs such as Coburg' TLC. The synergy of the TLCs would integrate the transportation process, application of information systems, and documentation of cargo transportation.

In this study, target Equation (6) described the optimum transportation prices of TLCs in developing regions such as Iranshahr, Chabahar, and Ashgabat nodes. The interpretation of this mathematical formula in the presented model is that the TLC agglomerates all scattered economic activities. The TLC of Iranshahr gathers all decentralized flows of production plants and farms under the umbrella of the TLC. TLCs in developing regions gather different and scattered products in one center for fast and safe transportation with a lower price compared with the market. When we simulated target Equation (6) with data from Iranshahr, it was found that the minimum transportation price was USD 0.09 per t. km. This price is less than what we observe in Iranshahr now. Iranshahr's TLC is a historical evolutionary movement in regions with pre-capitalist socioeconomic formation. The TLC supports the development of societies toward industrial and commercial capitalism and, as a result, to more advanced stages of socioeconomic evolution. Additionally, target Equation (12) describes the minimum transportation prices by TLCs, when they are with a network of the TLCs in advanced regions such as the Coburg node. The interpretation of target Equation (12) is that the transportation prices in both developed and developing TLCs decline when they are in a synergic state. It was that an isolated TLC is an example of static synergies. However, synergies may be dynamic in the sense that a merging of TLCs creates capacity to increase the rate of services to all TLCs. TLCs in advanced regions are the natural result of the historical evolution of per-capitalist socioeconomic formations to industrial and advanced capitalism. International advanced TLCs are a means of export and commerce growth. In developing regions, TLCs have the task of towing backward economies toward greater concentration, organization, and productivity. Therefore, Iranshahr's TLC, in a developing region, will first be established. Then, it requires regulations for the accumulation and organization of producers for the export needs of surplus goods. Finally, it requires synergy with the TLCs in developed regions to sustainably conduct its transportation services.

6. Conclusions

This paper addressed the location of a transportation logistics center (TLC) and its synergy with a network of transportation logistics centers (TLCs). While planning and management of a TLC is a recent regional planning development tool, its synergy with a network has not yet been adequately studied. This paper fills this gap by confirming the suitability of the Iranshahr's TLC site with the Euclidean theorem and analyzing its economic behavior within a network. This paper aimed to select a suitable site to plan and build a TLC in Iranshahr and to connect it to a network of TLCs in Coburg, Ashgabat, Chabahar, and Iranshahr. Therefore, it studied the economic behavior of TLCs in both developed and developing nodes. The site in Figure 2 with an approximate 1000-hectare area, 1622 km of roads, a railway station, airways, and river have a shorter distance to the surrounding economic hubs. Methodologically, this paper outlines an innovative mathematical model that analyzed TLCs in two statuses: separately and synergic. Target Equation (6) modeled the behavior of prices in a separate TLC such as Iranshahr's. However, target Equation (12) modeled the economic behavior of the TLC network. The model showed the link between reduction in the prices of transportation services provided by the TLC and synergy in the network of TLCs. Calculations and simulations of the model showed that the network reduced transportation prices. The reductions were from USD

0.09 to USD 0.075 and from USD 0.15 to USD 0.124, respectively, in Iranshahr and Coburg. The above calculated reductions in the transportation prices proved the influence of a dynamically synergistic mode of TLCs in a network. Therefore, this research exhibited positive consequences in reducing prices and providing equilibrium economic behavior for TLCs and their sustainable services. The outcomes of this study will assist managers of transportation services, economic departments of production enterprises, analysts, and engineers. The methods applied in this research are useful in careful planning and practices for the transportation of goods with prices as low as possible. Future research concerning TLCs in the transportation industry will involve building models for synergy in TLC networks with detailed analysis of their economic behavior.

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