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# Predicting the competitive position of extended gates: the case of inland customs zones

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The extended gate concept aims to reduce the pressure on international ports by postponing administrative processes from these border gates to inland terminals. At present, this approach is used mainly in the container transport industry in European and Asian ports. In this paper we study an extended gate concept, where inland customs services are made available from all entry points of a country. Our aim is to predict the portion of the current flow through border gates that is diverted to these inland customs zones. We propose a time-series gravity models to predict these changes and estimate the parameters of this model using publicly available data for different cargo groups. The focus of our application is Iran, a nation with a large and emerging economy, where goods currently enter through 26 main border gates. In addition to this flow diversion model we explain how flow matrices can be synthesized from the available transport statistics. Our calculations indicate that transportation cost, travel time and customs tariff discounts are the most important for the choice of customs zone. The attractiveness of extended gates increases as the direct cost of transportation between the border gate and destination province rises. Extended customs zones in Iran would have an average share of import flows in 2025 of around 13% and attract a volume of 8.4 million metric tons of goods.

Highlights

- We study the potential of extended gates to attract flows from existing border customs.
- We use a time series gravity type model that can be estimated on publicly available data.
- We demonstrate the model with an application to the large and emerging economy of Iran.
- Our calculations indicate an expected share of inland customs zones of 13% in 2025.

***Keywords***: *Extended Gate, Customs Zone, Dryports, Time-Series Freight Model.*

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# 1. Introduction

The organization of hinterland connections of maritime ports is currently attracting great interest as a means to improve the competitiveness of ports and countries' ability to support international trade. New logistics systems have started to develop in the hinterland, that make use of different modes of transport, transshipment terminals, border control services and commercial, value added services such as warehousing and container storage.

In the freight and logistics business, many stakeholders have an interest in a strongly performing transportation networks. Cargo owners want to receive their goods within a reasonable timeframe and at reasonable cost. Terminal operators want a timely transfer and connection to inland transport modes. Freight forwarders want to optimize transportation chains, and maritime carriers prefer shorter stop times at ports. Transportation time and cost are important factors for all these stakeholders. Despite advanced information technologies and infrastructures, ports and border gate services for cargo are often unable to meet demand, particularly at peak times. Delays may occur due to congestion at seaports, transport connections and customs points. Extended gates can play a role in reducing delays in the port by postponing the receipt of goods until inland terminals in the terminal. The extended gate concept aims to reduce this pressure on ports by shifting processes from seaport terminals to inland terminals, also called dryports, or the final destination. At present, this approach is used mainly in the container transport industry. Despite the fact that the success of extended customs zones to attract flows is vital for the continued attractiveness of border terminals, we have not found any references to studies devoted to estimating their potential to attract flows. Rather we want to fill the gap of modeling potential cargo attractiveness to an extended gate from all gates of the country, including sea, river, road and rail gates.

In order to fill this gap in the literature, we propose a modelling approach to allow such estimations to be made. We focus on an open extended gate concept, where customs services in an inland region are made available for all goods from all entry points of a country, for both sea and land gates. In this concept, the use of customs services will partially transfer from border regions to the extended gate regions. Our aim is to predict the portion of the current flow through border gates that is diverted to these inland customs zones. It is not a trivial question which part of all the flows entering border gates will use the different inland gates. A quantitative demand model based approach is needed to calculate this split. Our initial assumption is that the split will depend on the logistics performance characteristics of the alternatives. Such a prediction of cargo attraction potential is important because it determines the economic performance of the supply chain and the use of the network of transport corridors and hubs. The cargo flows could change in the network and the share of modes could shift. Also it could have financial implications especially when the private sector wants to invest.

The paper is built up as follows. With the aim to position our study in the body of research on the topic, we review the literature around extended gates and the modelling of these flows in Section 2. In Section 3, we describe the model developed and elaborate on the data needed for its estimation and application. Section 4 introduces the case study for Iran, including the preparation of the data for the model and the results of the estimation and application. Section 5 concludes the paper with a summary of our main findings and recommendations for researchers and practitioners.

# 2. Literature review

Many studies have focused on hinterlands and connections to them as a competitive feature of ports. Containerization provides easier transportation of goods between modes and container ports to remain competitive to increase their productivity and hinterland accessibility. These challenges have given rise to novel ideas such as satellite terminals. As a response to the congested situation at several container terminals on the Hamburg-Le Havre port range in 2004/2005, these terminals started to ship goods directly into their hinterland instead of waiting for containers to be picked up by truck, rail or barge. In other words, the container terminal operators were able to move the containers to secondary hinterland locations without owner involvement.

Van Klink and Van den Berg, 1998, McCalla, 1999, Heaver et al., 2000 and 2001, Notteboom, 2002, and Notteboom and Rodrigue, 2008 are among those to have looked at hinterland connections using dry ports or inland terminals. Bichou & Gray, 2004, Notteboom, 2006, Parola & Sciomachen, 2009, and Notteboom and Rodrigue (2005, 2007 and 2009), all study the importance of inland gates in supply chains and the evolution of terminalization. In studies about connecting ports or border gates to inland terminals, the term "dry port" is more familiar than "extended gate". In fact, however, a dry port is simply a basic extended-gate concept – one based on the idea that not all industrial and value-added activities need necessarily be undertaken in the vicinity of seaports. The role of dry ports in sea-hinterland connections in goods transportation was surveyed by Van Klink (1998) and Roso et al. (2009). A dry port is a physical site located away from traditionally used land, air, and coastal borders. The vision is to facilitate and process international trade through strategic investment in multimodal transportation assets and promote value-added services as goods move through the supply chain. While ports provide technical services to destinations overseas, a dry port (sometimes "inland port") is an inland intermodal terminal that is directly connected to a seaport by road or rail; operating as a center for the transshipment of sea cargo to inland destinations. Roso et al. worked on the dry port concept in their studies published in 2002 and 2009. They state that "a dry port is an inland intermodal terminal directly connected to seaport(s) with high capacity transport mean(s), where customers can leave/pick up their standardized units as if directly to a seaport". In other words, the dry port concept involves rather more than a rail shuttle connection between a seaport and a hinterland. In fact, dry ports have the ability to provide secure hinterland markets, raised throughput, and improved service quality.

Despite numerous theoretical studies of the concept, in reality dryports rarely work as intended. Veenstra et al. explain that, with only a few exceptions, most are simply extensions of seaports providing them with an unlocked hinterland. At present the more substantial definition of a dry port provided by Leveque and Roso, 2002 is not satisfied in practice. The notion of extended gateways was introduced in scientific studies by Van Breedam and Vannieuwenhuyse, 2006. In their definition, "The gateway is extended with prime locations embedded in its integrated and multimodal hinterland network. With fast, frequent, reliable and efficient multimodal connections with the gateway, these hinterland locations have the same opportunities for logistics activities as the original prime locations in the gateway." Rodrigue and Notteboom, 2009 believe that extended gates raise benefits by reducing containers' dwell times at seaports. They consider an inland or satellite terminal as an extended gate and state that "it commonly takes the form of a satellite terminal when in proximity to a port terminal or an inland port (terminal) when linked to long distance corridors". Van Lier et al., 2011 explain the concept of the extended gateway and understand that transshipment from one mode to another acts a bottleneck in combining transport modes within a journey. They also propose a four-phase methodology to lower the threshold to such a multimodal approach. Veenstra et al., 2012 rework the Leveque/Roso definition of a dry port to describe an extended gate, as follows: "An extended gate is an inland intermodal terminal directly connected to seaport terminal(s) with high capacity transport mean(s), where customers can leave or pick up their standardized units as if directly with a seaport, and where the seaport terminal can choose to control the flow of containers to and from the inland terminal."

In fact, the central idea in the extended gate concept is that the release point of goods is shifted from the seaport terminal to an inland terminal, or even the eventual destination. This brings customs and commercial release closer to the customer, thus decreasing waiting times, smoothing peaks and enhancing forecasting ability. Clients can collect their goods closer to the inland destination. As dwell times at deep-sea terminals are shorter, operators feel less pressure and so are able to better plan their utilization of rail and barge shuttles. This means more use of railroads and waterways, and consequently reduces air pollution and road congestion. The extended gate concept is used mainly in the port container terminals industry. However, it is also extendable to other transportation modes.

To the best of our knowledge, there are no studies in the literature to predict flows through an open extended gate system for several ports, that are based on an empirically validated model of transport demand. Garcia-Alonso et al. (2009), De Langen et al. (2012), Zhang et al. (2015) and Halim et al. (2016) develop freight demand models for ports with hinterland transport, but do not include choice of extended gates.

We continue this paper by explaining the methodology, describing the case study and discussing the model results.

## 3. Modelling approach

An extended gate is linked usually to one or two terminals or gates. Here we allow all extended gates to serve all regions and be connected to all border gates. In the version we propose, customs procedures are also moved partially or completely to the extended-gate platform. This could also provide multimodal transportation services. Our concept is intended not only for seaport connections; it could be used to tackle congestion and delay issues at any border gate. For this reason, accessibility to facilities could be studied and evaluated independently in each case. For efficient performance, it is better that an extended-gate terminal be accessible by different modes of transportation. We assume that cargo owners, forwarders, carriers, and other decision-makers are able to choose either a border gate or the extended gate as their point of delivery. Consequently, a portion of the direct flow of goods between border gates and final destinations would be diverted by way of the extended gate.

The notation for flows that takes into account the split between the original route – through the border zone – and the new route through the extended gate; is provided by Equation (1) and Figure 1. Origin and destination can be hinterland regions or customs gates.

$$V_{ij}^{n(1)} = V_{ij}^{\mathrm{n(2)}} + V_{ij}^{\mathrm{kn(2)}} \tag{1}$$

Where:

$V_{ij}^{n(1)}$ = the direct flow between customs gate i and province j before split in year n (tons)

$V_{ij}^{\mathrm{n(2)}}$ = the direct flow between customs gate i and province j after split, Route 1 (tons)

$V_{ij}^{\mathrm{kn(2)}}$ = the flow between customs gate i and province j through extended gate k after split, Route 2 (tons)

The trade origin- destination flows are figured out based on production and attraction measures along with transport resistance or transport cost in the distribution module of a freight transport system. The modelling approach employed is the gravity model. The traditional gravity model was developed to describe trade of factory to consumers (Tinbergen 1962, Poyhonen 1963, Linnemann 1966). Most of the freight studies done by the gravity model use cross-section data. First studies which used time series are Ghosh (1976) and Natale et al. (2015). Matyas (1997) assessed panel data gravity model form an economic point of view. Hummels and Levinsohn

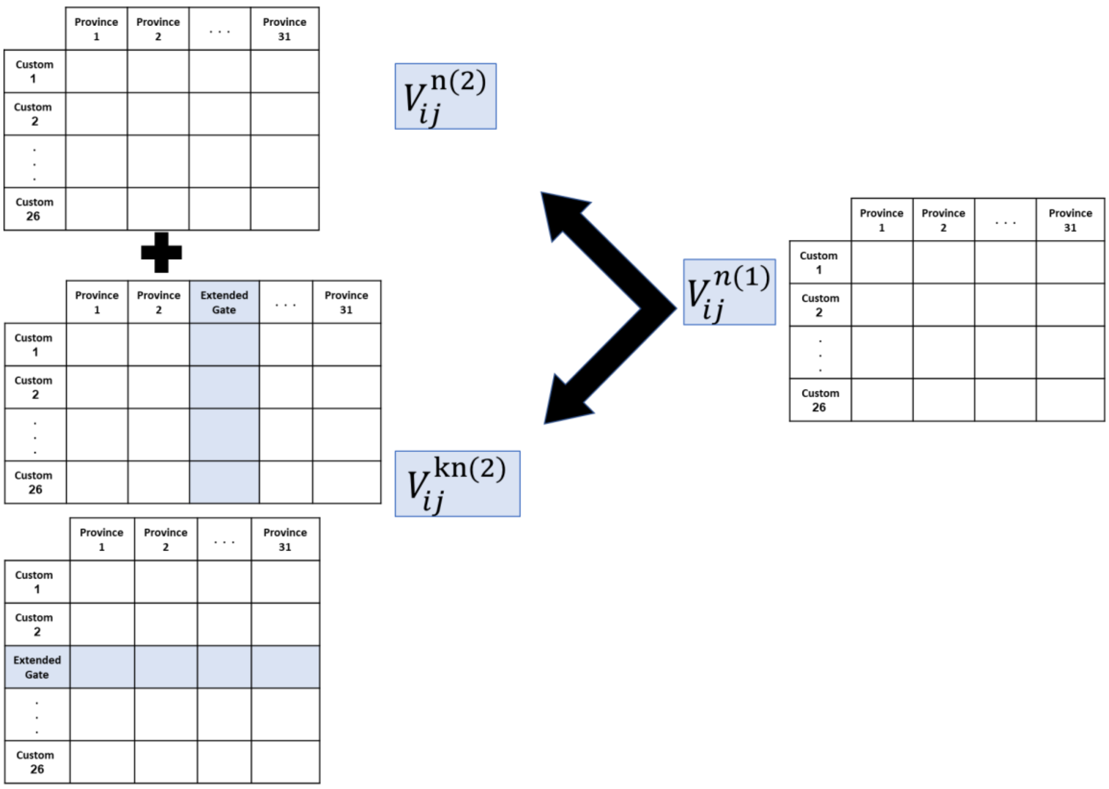


*Figure 1. Flow split between origin and destination via extended gate*

(1995) were of the first people who used panel country-pair data techniques rather than exporter-importer impacts. Gravity models mostly contain variables such as border tariffs, in order to cover barriers on the other side of the borders [Shepherd, 2013]. A large part of the literature about gravity model aims at aggregated trade flow information and doesn't consider differences between different commodities and region pairs in terms of the effect of transport costs on trade patterns and volumes. We refer to Tavasszy, (1994), (1998), Deardorff (1998), Kepaptsoglou, et al. (2010) for more details about static gravity model formulations. Bougheas et al, (1999) used simple time series gravity estimations to model country exports. Baltagi, et al. (2003) studied interaction impacts in gravity models considering importer, exporter, and time. This was shown using an unbalanced panel of bilateral trade between the triad (EU15, the USA, and Japan) and 57 most important trading partners of them during 1986–1997. Chakravarty and Chakrabarty (2014) applied a time series gravity model to study Indo-ASEAN trade during 1971-2010. Kurtovic, S. and Talovic, S. (2015) worked on the impact of the trade liberalization by the European Union (EU) and its effect on decreasing trade deficit in Bosnia and Herzegovina (B&H) using a dynamic economical gravity model with time series data of 2005 to 2013. Natale. Et al. (2015) estimated seafood exports during 1990–2010, using a time series gravity model.

We chose to develop a time series model. Independent variables to allow predictions were chosen based on the availability and accessibility of the data. Next, a derivation of the gravity model, with the functional pattern shown in Equations (2) was developed. An appropriate functional pattern was used for each class of goods. After calibration, equation (2) is used to predict direct flow between each customs gate-province pair. Equation (3) is used to predict the flow between them through the extended gate.

$$Log(S_{\mathrm{ij}}^{\mathrm{n}}) = b_0 + b_1 Log(S_{\mathrm{ij}}^{\mathrm{n-1}}) + b_2 D_{ij}^{n} + b_3 T_{ij}^{n} + b_4 C_{ij}^{n} + b_5 Irrtariff_j \quad (2)$$

$$S_{\mathrm{ij}}^{\mathrm{kn}} = b_0 + b_1 S_{\mathrm{ij}}^{\mathrm{kn-1}} + b_2 D_{ij}^{kn} + b_3 T_{ij}^{kn} + b_4 C_{ij}^{kn} + b_5 Irrtariff_k \quad (3)$$

$$S_{\mathrm{ij}}^{\mathrm{n}} = \frac{V_{\mathrm{ij}}^{\mathrm{n}}}{\sum_{l=1}^{26} V_{\mathrm{lj}}^{\mathrm{n}}} \quad (4)$$

$$S_{\mathrm{ij}}^{\mathrm{kn}} = \frac{V_{\mathrm{ij}}^{\mathrm{kn}}}{V_{\mathrm{ij}}^{\mathrm{kn}} + V_{\mathrm{ij}}^{\mathrm{n}}} \quad (5)$$

$$\sum_{i=1}^{26} S_{\mathrm{ij}}^{\mathrm{n}} = 1 \quad (6)$$

$$\sum_{i=1}^{26} \sum_{j=1}^{31} V_{\mathrm{ij}}^{\mathrm{n}} = V_{\mathrm{c}}^{\mathrm{n}} \quad (7)$$

$$\sum_{i=1}^{26} V_{\mathrm{ij}}^{\mathrm{n}} + \sum_{i=1}^{26} V_{\mathrm{ij}}^{\mathrm{kn}} = V_{\mathrm{j}}^{\mathrm{n}} \quad (8)$$

Where:

$V_{\mathrm{c}}^{\mathrm{n}}$=foreign exchanges of country in year n (tons)

$V_{\mathrm{j}}^{\mathrm{n}}$= foreign exchanges of province j in year n (tons)

$V_{\mathrm{ij}}^{\mathrm{n}}$ = direct foreign exchanges of province j via customs gate I in year n (tons)

$V_{\mathrm{ij}}^{\mathrm{kn}}$ = foreign exchanges of province j via customs gate I through extended gate k in year n (tons)

$S_{\mathrm{ij}}^{\mathrm{n}}$ = share of customs gate i of foreign exchanges of province j in year n (%)

$S_{\mathrm{ij}}^{\mathrm{n-1}}$ = share of customs gate i of foreign exchanges of province j in year n-1 (%)

$S_{\mathrm{ij}}^{\mathrm{kn}}$= share of extended gate k of foreign exchanges of province j via customs gate i in year n (%)

$S_{\mathrm{ij}}^{\mathrm{kn-1}}$= share of extended gate k of foreign exchanges of province j via customs gate i in year n-1 (%)

$D_{ij}^{n}$= ground direct distance between customs i and province j in year n (km)

$D_{ij}^{kn}$= ground distance between customs gate i and province j through extended gate k in year n (km)

$T_{ij}^{n}$ = direct travel time between customs gate i and province j in year n (hour)

$T_{ij}^{kn}$= travel time between customs gate i and province j through extended gate k in year n (hour)

$C_{ij}^{n}$ = direct transportation cost between customs gate i and province j by 10 Tons trucks in year n (rials)

$C_{ij}^{kn}$= transportation cost between customs gate i and province j through extended gate k in year n (rials)

$Irrtariff_j^n$ = irrevocable part of tariff customs gate j= 1- trading profit discount in tariff of customs j in year n (%)

$Irrtariff_k^n$= irrevocable part of tariff extended gate k= 1- trading profit discount in tariff of extended gate k in year n (%)

To calculate the share of inland customs zones, after estimation of coefficients, the model is applied on an extended set of alternatives, that now include the extended gates as additional customs points.

Certain special issues need to be considered in the demand modeling. For example, generating an origin-destination (OD) matrix is not always possible due to lack of continuous cargo tracing. Cargo throughputs may be recorded by different organizations and the coding may be inconsistent between databases. Thus, we faced the additional challenge of creating an OD matrix for flow synthesis. Below we explain a specific application of our modelling method for Iran, where we also solved the problem of O/D synthesis.

# 4. Application

Iran, as the place of the case study, is a country of 1.648 million km² with a population of 79 million [SCI, 2016]. The population distribution is shown in Figure 2. Since the production and attraction of goods is directly related to population, a large number of goods are sent from boundaries to inland parts of the country. Iran had 31 provinces and 138 active customs points in the period of study, including 63 (45%) border customs, of which 53 are used for exporting and 58 for importing [IRICA, 2011]. A large proportion of goods trading is done in ports, especially in the south, due to access to the high seas. Due to the long distance between these ports and the northern region, which accounts for a considerable share of the population, having a logistics terminal or distribution center in a central part of the country, such as the extended gate studied in this paper, could be helpful. Predicting attractable cargo is important in the planning of extended gate. Cargo amounts and categories are used for designing infrastructures and components as well as the road and rail network connected to it. The extended gate studied here has not yet been built and it will be the first one in Iran. The main goal of this paper is to predict the amount of attractable cargo based on the most effective parameters. The first aim of this extended gate is to support Rajaei Port, the biggest port in Iran. However, due to its location, as shown in Figure 2 and 3, it will also be able to attract goods from other import/export portals. Hence, the extended gate could attract goods at two levels: first, as a supporter of Rajaei Port; second, by attracting goods and freight from other country portals. The research methodology attempts to predict attractable goods at all two levels.

Four databases were used to develop the origin-destination matrix:

1. Customs of Iran database: which includes the amount of goods traded through the country's customs [IRICA, 2012].
2. Road Maintenance and Transportation Organization of Iran database (road database): which includes amount, kinds, origin, and destination of goods transported by the national road network [RMTO, 2012].
3. Railways of Islamic Republic of Iran database (railway database): which includes amount, kinds, origin, and destination of goods transported by the national railway network [RAI, 2012].
4. Ports and Maritime Organization of Iran (ports database): which includes throughput data of national ports [PMO, 2012].

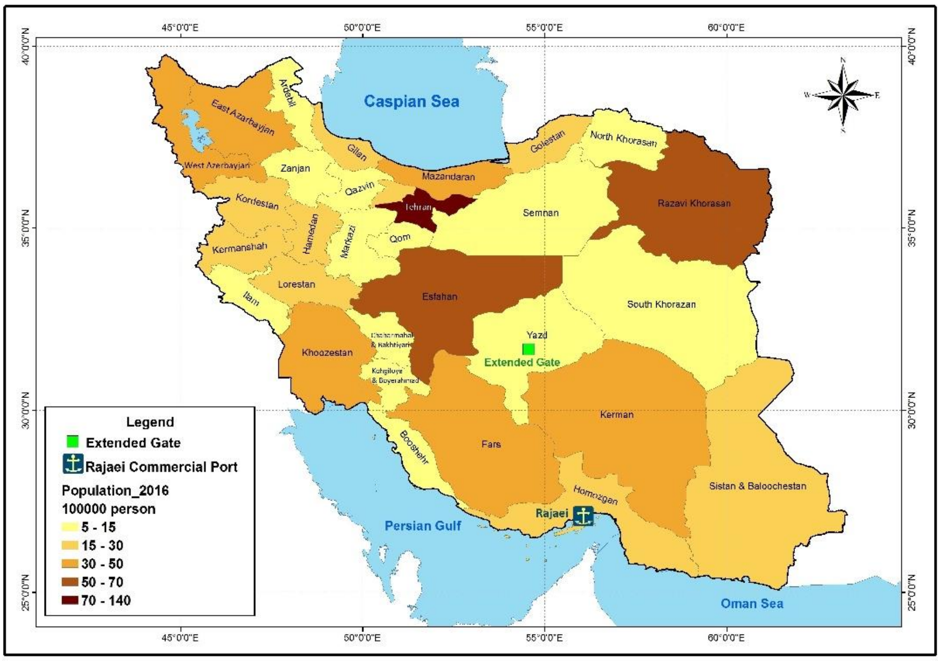


*Figure 2. Population distribution in Iran's provinces*

Since the goods do not have the same unique code in each database, it is not possible to track them from one to the other. Thus, we assigned a unique code to each customs administration, each kind of good, and each inland point of the country and created a uniform database using these codes. A matrix of transported goods between customs and inland production/attraction centers was developed for model calibration by first gathering data on all goods traded through border customs over a period of 11 years (2001-2011). Subsequently, three other databases were used to determine the distribution plan for the goods through inland centers. In other words, matrix rows were first created based on the total amount of goods exchanged in customs, and then each row was distributed across 31 provinces (matrix columns) based on the road and railway databases. Transit freights were then taken into account based on the port databases and the rows that included a marine customs administration were modified.

Data was collected from a total of 138 customs administrations for 2001-2011, and then the non-border customs were eliminated and each province's share of each customs point was calculated. Based on the Pareto principle, the customs administrations that included 80% of imports/exports from each province were chosen. Thus, during the modeling, the customs points that play an important role for one province, despite their low share of total national exchange of goods, were not eliminated. In total, 26 of 63 customs administrations were selected.

All of the steps mentioned above were repeated for each of the nine classes of goods and, eventually, 26 x 31 calculation matrices for 2010 and 2011 were created. Customs gate included land customs and port customs in Figure 3.

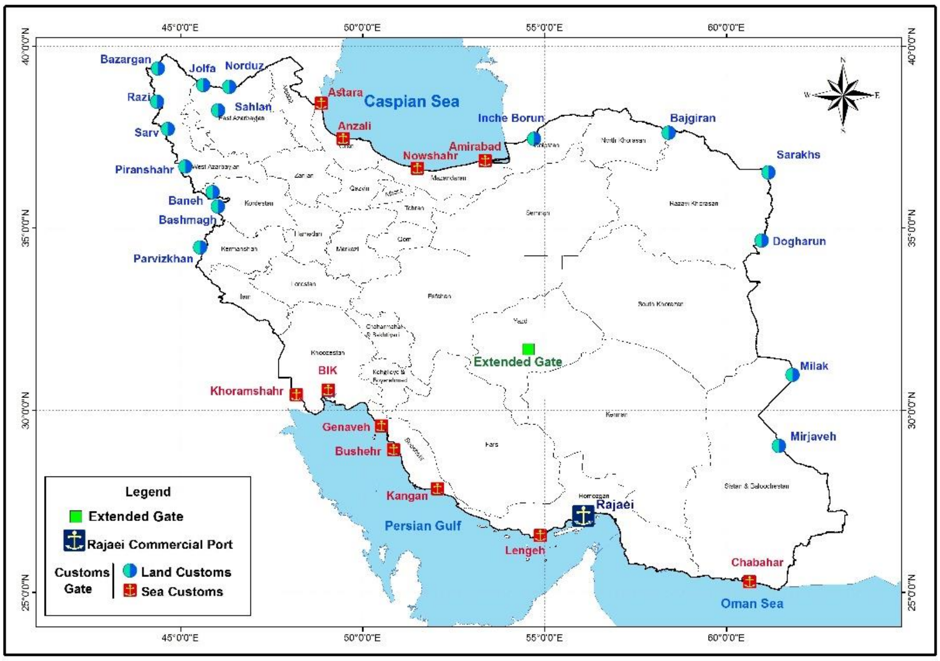


*Figure 3. Extended gate, seaports and customs points considered in this study*

The four databases used have different cargo classifications. The international cargo coding systems did not have the best fit with the datasets used in our study. Hence, we made a nine-group classification based on the road database for all databases, presented in Table 1. The road database was chosen because most of the information used for modeling was derived from the structure of this database and the share of road transportation is much greater than for rail.

**Table 1. Cargo Classification**

| Cargo Group Number | Cargo Group |
|---|---|
| 1 | Agricultural, livestock, food cargo |
| 2 | Metallic cargo |
| 3 | Mineral and constructional cargo |
| 4 | Light industry products |
| 5 | Machinery and spare parts |
| 6 | Chemical cargo |
| 7 | Paper and wood |
| 8 | Leather, textiles, and clothing |
| 9 | Different types of wastage and scrap |

The independent variables of distance, cost, and time of road and rail transportation was calculated for each matrix component. The independent variables were:

- Transportation cost ($C_{ij}^{n}, C_{ij}^{kn}$) [RMTO, Report 2012]: without the extended gate, cargo passes directly from customs to provinces. With the addition of the extended gate, this direct trip is divided into two sections. The cost components considered in the model were:

$C_{kj}^{n}$: Goods transportation costs between origin/destination city and extended gate

$C_{ik}^{n}$: Goods transportation costs between extended gate and customs

$C_{ij}^{n}$: Goods transportation costs between origin/destination city and customs

$C_{ij}^{kn}=C_{ik}^{n}+C_{ik}^{n}$

Figure 4 illustrates an example situation where the origin/destination city is Tehran and the customs point is Rajaei port.

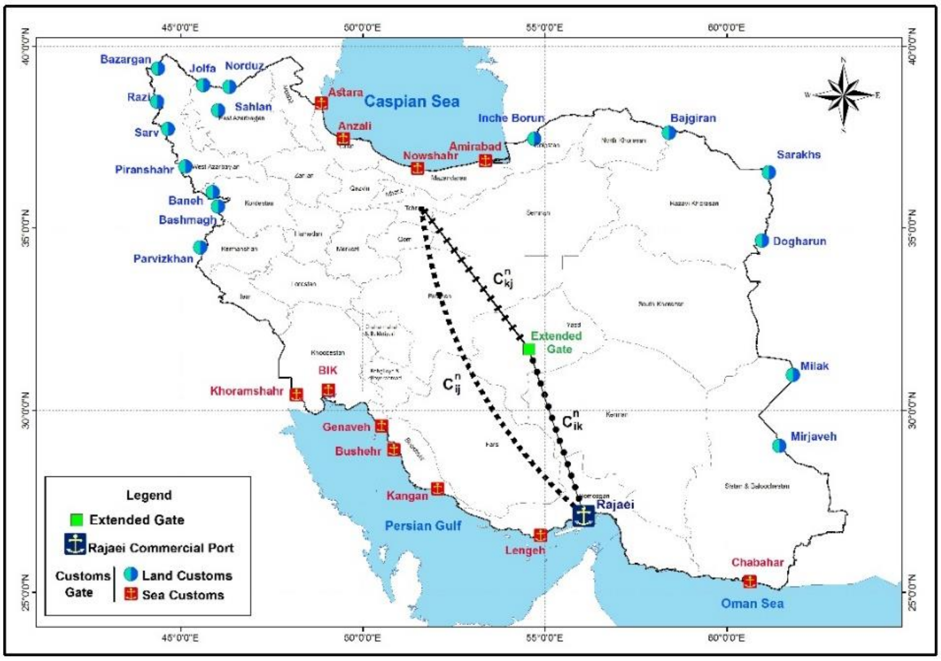


*Figure 4. Sample of direct/via extended gate transportation costs components*

- Transportation time ($T_{ij}^{n}$, $T_{ij}^{kn}$) and distance ($D_{ij}^{n}$, $D_{ij}^{kn}$) [Gitashenasi, 2014]: time and distance were calculated based on the road and rail network for two cases of direct transportation between the city and customs point and for transportation via the extended gate. The trip time was calculated using a toolkit which computes it separately for passenger car and cargo vehicles according to the average speeds observed during the previous year. Distance was calculated according to the shortest authorized path.
- Trading profit discount in customs ($Irrtariff_j$, $Irrtariff_k$) [IRICA, 2012]: entry fees, taxes, and charges paid to customs administrations. Effective parameters on these costs were:

1. Exporting value (goods expense in origin), that is, real trading value
2. Other added values such as transportation, insurance, etc.
3. Goods amount (weight/number)
4. Time entering country
5. An 8-digit code for each kind of good identified
6. Tariff rate for each kind of good
7. Discounts
8. Tariff suggestions from other countries based on agreements
9. Damage to the cargo before entering customs

Some discounts are offered in order to encourage transportation companies to use a specific customs point because in some services are related to demand. If cargo arrive to the port, some services like truck will be provided. Road transportation companies prefer to serve in the gates or customs by higher chance of cargo absorbing. The relevant data was gathered and considered as a percentage in the model.

Statistical descriptions of the independent variables are shown in Table 2. The minimum travel time was 25 minutes, the maximum 28 hours, and each trip was completed in an average time of 12.5 hours at average speed. The maximum discount in the customs tariff rate was 25%. The nearest city to the customs administration was 5 km and the farthest was 2606 km. Due to the extended gate's location, the average value of $C_{kj}^{n}$ was 35% lower than $C_{ik}^{n}$. Costs were calculated based on Iranian rials. Conversion was not done because of the exchange rate fluctuations and different rates of the Official (Government) Base and the Market Base. As this difference could affect the reliability of the data, model, and results, the calibration process was done using rials [CBI, 2016].

**Table 2. Statistical descriptions of the independent variables**

| Descriptive Parameter | Independent Variable | | | | | |
|---|---|---|---|---|---|---|
| | $T_{ij}^{n}$ (Minutes) | $Irrtariff_j$ | $C_{kj}^{n}$ (Thousand rials) | $C_{ik}^{n}$ (Thousand rials) | $C_{ij}^{n}$ (Thousand rials) | $D_{ij}^{n}$ (Km) |
| Mean | 742.5484 | 0.946154 | 2.83E+03 | 4.31E+03 | 4.07E+03 | 1051.186 |
| Median | 723.5 | 1 | 2829 | 4295 | 3681 | 1038 |
| Maximum | 1676 | 1 | 5385 | 5630 | 13019 | 2606 |
| Minimum | 25 | 0.75 | 949 | 3355 | 633 | 5 |
| Std. Dev. | 347.9195 | 0.085452 | 1140.926 | 681.8146 | 2165.718 | 505.5605 |
| Skewness | 0.173491 | -1.130785 | 0.555508 | 0.278483 | 1.199883 | 0.157291 |
| Kurtosis | 2.265805 | 2.568227 | 2.60636 | 2.016925 | 4.756074 | 2.370517 |
| Observations | 806 | 806 | 806 | 806 | 806 | 806 |

The current and future demand for border exchange, including importing, exporting, and transiting, should first be studied to estimate the potential demand for the extended gate. Thus, the relevant data was gathered from the annual database of national border customs.

The data for 2001-2011, based on rials and dollars [IRICA, 2012] value, shown in Table 3 demonstrates 15% growth. At the same time, the dollar-based growth rate was 13%. The dollar-based growth rate is more reliable due to fewer fluctuations. The lowest growth rate is for 2011, at -1%. There is another negative growth rate for 2010 related to the dollar-based exchange value. A negative rate was only observed in those two years, which could be due to sanctions.

**Table 3. Total country cargo throughput**

| Year | Sum of Country's Exports and Imports | | | Growth rate (%) | | |
|---|---|---|---|---|---|---|
| | Weight | Value-Million rials | Value-Million Dollars | Weight | Value-rials | Value-dollars |
| 2001 | 31,687,769 | 138,347,774 | 34,334 | - | - | - |
| 2002 | 31,535,394 | 209,267,069 | 35,637 | 0 | 51 | 4 |
| 2003 | 36,078,019 | 257,953,597 | 42,065 | 14 | 23 | 18 |
| 2004 | 49,926,001 | 300,802,700 | 35,389 | 38 | 17 | -16 |
| 2005 | 60,448,473 | 448,229,354 | 49,722 | 21 | 49 | 41 |
| 2006 | 71,257,578 | 503,065,587 | 54,720 | 18 | 12 | 10 |
| 2007 | 73,813,740 | 592,120,251 | 63,751 | 4 | 18 | 17 |
| 2008 | 77,400,848 | 708,331,487 | 74,376 | 5 | 20 | 17 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 2009 | 77,178,322 | 765,264,110 | 99,422 | 0 | 8 | 34 |
| 2010 | 105,543,790 | 938,935,906 | 91,001 | 37 | 23 | -8 |
| 2011 | 104,807,781 | 1,044,826,346 | 95,627 | -1 | 11 | 5 |
| Average | | | | 14 | 23 | 12 |

The average growth rate of goods carried nationwide in the period 2001-2011 was 9% [Notteboom, 2002], 5% in more recent years and 1% in 2011. Over the 10 years included, the amount of carried goods in the country, based on border exchange figures, had the lowest growth in 2011. The statistics show a high correlation between the amount of goods carried on national roads and exchanged on borders. Port throughput studies indicate an expected doubling of flows between 2012 and 2014. These studies predict that total border exchange would rise from 109 million tons in 2012 to more than 230 million tons in 2025 [SPI, 2015].

The predictions are used as input in this paper to estimate the amount of cargo attractable to the extended gate. After creating data matrices, the models were developed using Eviews 9.0 software for each goods class individually. The model coefficients and goodness-of-fit parameters are shown in appendices A and B respectively, for each class of goods.

To generalize the results to the whole population and ensure the best estimation, classic Gauss-Markov theorems should be confirmed [Gujarati, 2004]. Given these assumptions, OLS is the Best Linear Unbiased Estimator (BLUE). This means that out of all possible linear unbiased estimators, OLS gives the most precise estimates of parameters [Gujarati, 2004]. Here, we first describe initial estimation problems and then the solutions. The Gauss-Markov theorems concern the set of error random variables, $\varepsilon_i$ [Wooldridge, 2011]:

- They have a mean zero of: $E[\varepsilon_i] = 0$
- As are shown in Table A2, they all have approximately a mean zero.
- The error terms are homoscedastic; that is, all have the same finite variance: $Var(\varepsilon_i)=\sigma^2$. This means that the error terms all have the same variance and are not correlated with each other.

This assumption is tested in Eviews software by Breusch-Pagan and white tests. As seen in Table A2, the null hypothesis is rejected in all classes of goods except Class 9. Error term variance is not constant in the models of classes 1 to 8 and the models suffer from heteroscedasticity.

- Distinct error terms are uncorrelated: $\mathrm{Cov}(\varepsilon_i, \varepsilon_j) = 0, i \neq j$

While the Durbin-Watson test would usually be used, here it was not possible due to the lag variable. Therefore, the Breusch-Godfrey test was used. The autocorrelation test for first- and second-order correlation was also done and the results are shown in Table A2. First-order autocorrelation did not occur in the models for classes 3, 4, and 5 with a 95% confidence level, or in models 2 and 6 with a 90% confidence level. Goods classes 1, 7, 8, and 9 suffered from first-order autocorrelation, while second-order autocorrelation did not occur in models for classes 2, 3, and 4 with a 90% confidence level.

- The error terms are distributed normally: $U_i \sim (N, \sigma^2)$

The Jarque-Bera test is a goodness-of-fit test of whether sample data have the skewness and kurtosis matching a normal distribution. Test results are also shown in Table A2. This hypothesis is rejected in all goods classes.

- The model must be linear in the parameters. The dependent variable should be a linear combination of the explanatory variables.

As seen in the model equation, this hypothesis is confirmed.

- The sample should be variate. The independent variables cannot all have the same value that have not. Such perfect multicollinearity is not permitted.
- The number of observations cannot be smaller than the number of explanatory variables in the model.

Comparing the sample size of 806 with the maximum number of independent variables in the models, this criterion is fulfilled.

Estimators designed for dealing with bias problems might be used to solve variable variance in models. However, here, robust standard error and white estimators could not be used due to autocorrelation. The usual prescription for such cases is to respecify the model, choosing alternate predictors to minimize nonspherical characteristics in the residuals. Predictors are often selected on the basis of theory, policy, or available data, and alternatives may be limited. More lagged predictors, used to account for autocorrelations, introduce additional problems. In this instance, the best approach is to use heteroscedasticity-and-autocorrelation-consistent (HAC) estimates of OLS standard errors. OLS coefficient estimates will be unchanged, but tests of their significance become more reliable. An advantage of HAC estimators is that they do not require detailed knowledge of the nature of the heteroscedasticity or autocorrelation in the innovations to compute consistent estimates of the standard errors. HAC estimates using the quadratic spectral (QS) kernel achieve an optimal rate of consistency [Andrews, 1991]. The results of using the HAC estimator are shown in Table 4. Goodness-of-fit and Gauss-Markov test results are shown in Table 5.

With the exception of Class 9, the explanatory level of all models was more than 73%. The model for Class 9 has an explanatory level of 66% because this group does not always exhibit similar behaviour. The average error is near zero in all models but does not follow a normal distribution. The hypotheses are asymptotically valid [Wooldridge, 2011], which allows the analysis of the results even if the sample size is not sufficiently large.

In autoregressive models, some of the effective parameters that are not quantitative (such as the trust of a goods owner in a specific custom point or route) or do not have sufficient data (such as services available in all portals) can be modelled. These variables could be partly covered by the customs share of the last year's exchange between the origin-destination and the constant value of the model. Another advantage of $S_{ij_{n-1}}$ lagged variables is the ability to consider newly built ports by giving this variable a value of zero. Thus, the effect of being relatively unknown in the initial years could be consider in the models.

The customs share of the last year's exchange was the most effective parameter in all the models. The positive coefficient of $C_{ij}^n$ (cost from origin to destination) means that the desirability of using the extended gate increases as this cost rises. Travel time between the extended gate and each i or j and the customs irrevocable tariff rate coefficients were negative, meaning that increasing travel time or tariffs reduces extended gate desirability. Some goods classes, such as the agricultural, livestock, and food class, are less sensitive to cost variables because it is more important to provide them on time and continuously. Travel time was used as a proxy variable because $C_{kj}^n$ and $C_{ik}^n$ were correlated with $C_{ij}^n$. In Iran, transportation cost is not only just dependent on distance but also on market competition, fleet capacity, route security, and appropriate truck type. Thus, this parameter is statistically significant in some models. The extended gate share decreases with increasing travel time (distance) between the extended gate and point i or j. Due to the fluctuation of this variable in some goods classes, its logarithmic form was used. The customs irrevocable tariff rate was statistically significant in many classes, having a negative coefficient. Thus, most goods classes are affected by discounts and this could be used to attract cargo to the extended gate in the very early years of its activity.

**Table 4. Model's calibration results and coefficient of HAC regressors**

| Cargo Group Number | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cargo Group | | Agricultural , livestock, food cargo | Metallic cargo | Mineral and construction cargo | Light industry products | Machinery and spare parts | Chemical cargo | Paper and wood | Leather, textiles, and clothing | Different types of wastage and scrap |
| Dependent Variable | | $S_{ij}^{n}$-CG1 | $S_{ij}^{n}$-CG2 | Log($S_{ij}^{n}$-CG3) | Log($S_{ij}^{n}$-CG4) | Log($S_{ij}^{n}$-CG5) | Log($S_{ij}^{n}$-CG6) | Log($S_{ij}^{n}$-CG7) | Log($S_{ij}^{n}$-CG8) | Log($S_{ij}^{n}$-CG9) |
| Constant | Coeff | 0.066 | 0.031 | -0.411605 | 0.709 | -0.736 | | -0.744 | -0.646 | 0.521 |
| | Sig. | 0.006 | 0.019 | 0 | 0.125 | 0.000 | | 0.000 | 0.000 | 0.094 |
| $S_{ij}^{n-1}$ | Coeff | 0.880 | 0.895 | | | | | | | |
| | Sig. | 0.000 | 0.000 | | | | | | | |
| Log ($S_{ij}^{n-1}$) | Coeff | | | 0.871562 | 0.894 | 0.830 | 0.833 | 0.849 | 0.843 | 0.788 |
| | Sig. | | | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| $C_{ij}^{n}$ | Coeff | 0.0015 | | | | 0.043 | 0.055 | 0.023 | 0.138 | 0.064 |
| | Sig. | 0.056 | | | | 0.095 | 0.026 | 0.087 | 0.001 | 0.052 |
| D1 | Coeff | | | -0.317301 | -0.097 | | | | | |
| | Sig. | | | 0.0041 | 0.027 | | | | | |
| D1*$C_{ij}^{n}$ | Coeff | | 0.0004 | | | | | | | |
| | Sig. | | 0.073 | | | | | | | |
| $T_{ij}^{n}$ | Coeff | | -1.34E-05 | -4.00E-05 | | -4.30E-05 | | | | |
| | Sig. | | 0.015 | 0.0214 | | 0.014 | | | | |
| $1/T_{ij}^{n}$ | Coeff | | | | | | | 5.256 | | |
| | Sig. | | | | | | | 0.034 | | |
| LOG ($T_{ij}^{n}$) | Coeff | -0.008 | | | | | -0.168 | | | -0.280 |
| | Sig. | 0.013 | | | | | 0.000 | | | 0.009 |
| Tariff rate | Coeff | -0.014 | -0.019 | | -0.021 | | | | | |
| | Sig. | 0.098 | 0.090 | | 0.037 | | | | | |
| | Sig. | | | | | | | | | |
| Log ($Irrtariff_j$) | Coeff | | | | | -1.704 | -0.588 | | | -0.821 |
| | Sig. | | | | | 0.000 | 0.102 | | | 0.100 |
| Log ($D_{ij}^{n}$) | Coeff | | | | -0.083 | | | | | |
| | Sig. | | | | 0.067 | | | | | |

**Table 5. Goodness-of-fit parameters of model calibrated by HAC estimators and Gauss-Markov test results**

| Cargo Group | Agricultural, livestock, food cargo | Metallic cargo | Mineral and construction cargo | Light industry products | Machinery and spare parts | Chemical cargo | Paper and wood | Leather, textiles, and clothing | Different types of wastage and scrap |
|---|---|---|---|---|---|---|---|---|---|
| Cargo Group Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
| Included observations | 806 | 806 | 633 | 754 | 740 | 621 | 587 | 541 | 590 |
| R Square | 0.866724 | 0.876381 | 0.834002 | 0.796791 | 0.768242 | 0.799617 | 0.779591 | 0.732353 | 0.663405 |
| Adjusted R Square | 0.866058 | 0.875764 | 0.83321 | 0.795704 | 0.766981 | 0.798643 | 0.778454 | 0.730858 | 0.661103 |
| F Test | 1300.647 | 1419.651 | 1053.397 | 733.2338 | 609.1022 | - | 686.1798 | 489.7915 | 288.2483 |
| F Test.Sig | 0 | 0 | 0 | 0 | 0 | - | 0 | 0 | 0 |
| Wald F-statistic | 170.0238 | 197.5729 | 1113.515 | 703.4992 | 547.4462 | - | 534.5766 | 506.9799 | 299.5843 |
| Prob (Wald F-statistic) | 0 | 0 | 0 | 0 | 0 | - | 0 | 0 | 0 |
| Error Mean | -6.03E-20 | -1.07E-17 | 4.81E-16 | 6.79E-16 | 1.14E-15 | -0.002017 | 9.23E-17 | 4.40E-16 | -2.18E-15 |
| Error Std. Deviation | 0.03437 | 0.037656 | 0.920428 | 0.862291 | 0.908277 | 1.073685 | 0.950697 | 1.054441 | 1.1667 |
| Error Normal Distribution (Jarque-Bera) | 87680.71 | 12874.92 | 145.5095 | 344.6786 | 85.05896 | 87.27802 | 141.9418 | 35.26335 | 55.48792 |
| Error Normal Distribution (Jarque-Bera-Probability) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

The dummy variable for D1 is one if the sum of $C_{kj}^{n}$ and $C_{ik}^{n}$ is more than 1.2 times $C_{ij}^{n}$, and is zero otherwise. When $C_{kj}^{n}$+$C_{ik}^{n}$ is more than 1.2 times $C_{ij}^{n}$, the extended gate share in the goods classes of Light industry products and Mineral and construction cargo is reduced by 0.096% and 0.31%, respectively. A one million rials rise of $C_{ij}^{n}$ in Classes 5, 6, 7, 9, 1, and 8 causes a 4.3%, 5.5%, 2.3%, 6.4%, 0.15%, and 13.8% rise in extended gate share, respectively.

The goods class of Light industry products is highly sensitive to the irrevocable tariff rate, with a one-unit change causing a 2.1% change in the extended gate share of this class. In other words, applying discounts in this class could affect the attractable cargo level significantly. A similar change in the irrevocable tariff rate causes a 0.58% to 1.9% change in the extended gate share of other classes. A one hour increase in travel time causes a 0.26% and 0.24% reduction in the extended gate share for classes 3 and 5, respectively. This impact is lower in other classes.

The model output calculates the extended gate and other gates' share of each province's total foreign trade, including exports and imports. The model output of each year was considered as an input for the next year's model. Thus, the final estimation for 2025 was done step by step. The lagged variable of extended gate share was given a value of zero in the model for first year.

If there are no changes to the attributes and all else remains the same as current circumstances, the shares of each customs point in 2025 would be as reported in Figure 5. This figure shows the share of each province's import and export flows which could be redirected to the extended gate route for each cargo class in 2025.

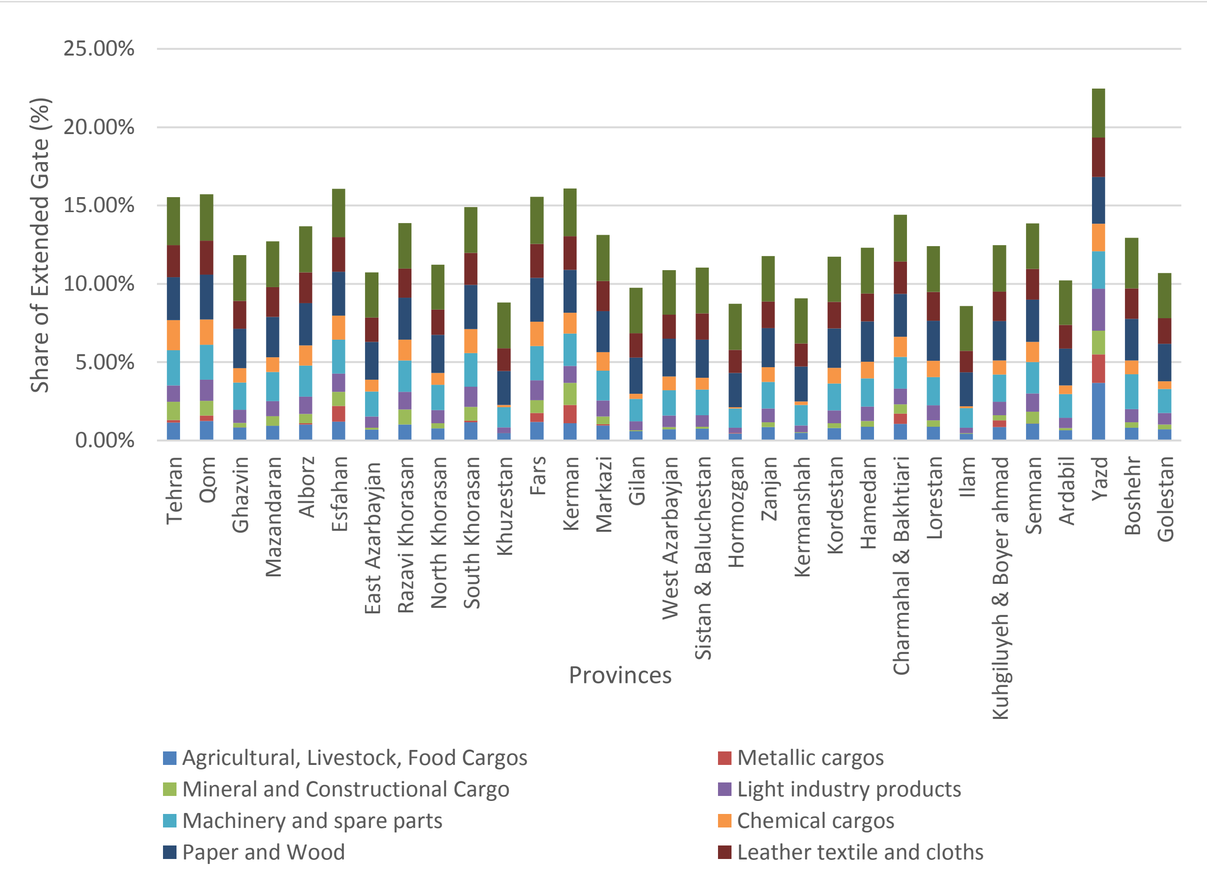


*Figure 5. Share of extended gate from the total provincial imports and exports in 2015 (Ceteris Paribus)*

The average import/export redirection for each province to the extended gate was calculated to be 12.68%, with a maximum of 22.5% for Yazd and a minimum of 8.59% for Ilam province, while for the capital, Tehran, it was 16%.

The share of province-gate cargo demand for the extended gate for each cargo class can be predicted based on the results. For instance, appendix C shows the sea extended gate's share of cargo Class 5 (Machinery and spare parts) for each province-gate pair. In addition, it shows the percentage of total cargo Class 5 flow between each province-gate pair that would be redirected to the extended gate route.

The maximum share of the extended gate in this cargo class is between Amir Abad gate (located north of the extended gate) and Yazd province (where the extended gate is located), at 2.8%, and then between Rajaei gate (located south of the extended gate) and Tehran province (located north of the extended gate), at 2.0%. The latter path is shown in Figure 4.

After calculating the shares for each goods class, the amount of cargo from each class attractable to the extended gate could be estimated. These amounts are shown in Table 6. The extended gate could attract 8.49 million tons of cargo annually in 2025.

**Table 6. Prediction of attractable cargo amount to the extended gate in each cargo class**

| Cargo Group | Cargo Group Number | Attractable Cargo Amount |
|---|---|---|
| Agricultural, livestock, food cargo | CG1 | 1,404,205 |
| Metallic cargo | CG2 | 1,202,244 |
| Mineral and construction cargo | CG3 | 2,968,765 |
| Light industry products | CG4 | 566,792 |
| Machinery and spare parts | CG5 | 531,707 |
| Chemical cargo | CG6 | 1,510,701 |
| Paper and wood | CG7 | 14,993 |
| Leather, textiles, and clothing | CG8 | 164,054 |
| Different types of wastage and scrap | CG9 | 125,751 |
| Total | | 8,489,212 |

Mineral and construction cargo has the highest share of goods attracted due to the relatively small distance between the extended gate and the main iron ore mines in the country. This is followed by Agricultural, livestock, food cargo, and Chemical cargo.

## 5. Conclusions

An important aim of this paper was to determine the effective parameters for the prediction of cargo attraction to an extended gate in a developing country such as Iran. The primary variables, such as cost and time, appear to have a significant effect on cargo attraction, as well as the added value of services. On this basis, we predicted the amount of cargo attractable by 2025, studying the affordable services in extended gates and logistics terminals in Iran. We found that having a customs administration in such places affects their performance. Therefore, we hypothesized that the most effective parameters for predicting cargo attraction to an extended gate were the presence of a customs administration, the transportation costs, and travel time and distance. These assumptions were examined during the study. The models also took into consideration the parameters of obscurity, familiarity, and reputation because it is known that customers generally like to use tried and tested routes and services, where they are familiar with the processes.

We used four different databases to specify whole cargo trips and create an origin-destination matrix because there is currently no continuous cargo tracking between origin and destination in Iran. The customs database was used to determine portal cargo exchange and three other databases were used to determine the distribution pattern of these cargos and the independent variables of cost, distance, and travel time. Ultimately, nine matrices for nine different goods classes were created.

Linear and exponential models were developed and estimated by OLS method. Goodness-of-fit and Gauss-Markov theorems were used to test for the generalizability of the models. HAC estimators were also used for estimation due to the rejection of some hypotheses. R-squared was more than 83% for the first three goods classes and more than 73% for classes 4, 5, 6, 7, and 8. Class 9, Different types of wastage and scrap, exhibited no specific behavior pattern, hence, its R-squared was 66%. Generally, the model estimations were acceptable.

The results confirm the primary hypotheses, with cost, travel time, and the customs irrevocable tariff rate statistically significant in most of the models. The cost of direct transportation between the main point of origin and destination ($C_{ij}^{n}$) was considered in the models, with the results revealing that, as costs increase, the extended gate share of these cargos will rise. Some of the goods classes were sensitive to cost when the sum of $C_{kj}^{n}$ and $C_{ik}^{n}$ was more than 1.2 times $C_{ij}^{n}$.

A negative coefficient for travel time (also representing distance) means that an increasing distance between origin and destination will lead to a decrease in the extended gate share of cargo because cargo owners and shippers prefer to use closer customs points if they do not need to import or export their goods via a seaport. Goods classes 3 and 5 were more sensitive to travel time.

A negative coefficient for the customs irrevocable tariff rate in the models means that a decrease in discounts causes a reduction in the extended gate's share of transported cargos. The changes vary from 0.58% to 1.2% for a one-unit drop in the irrevocable tariff rate in different goods classes. The statistical significance of travel time is higher compared with costs in the class of Agricultural, livestock, food cargo due to the importance of these goods and the necessity for on-time delivery to consumption markets.

Lagged variables helped us to consider the effect of hidden parameters and also take into account the fact that the extended gate does not yet exist. In other words, lagged variables helped us to determine the effect of relative obscurity, lack of familiarity, and reputation on using a specific customs administration without the extended gate. Thus, we could predict the extended gate's performance in the very first years of its activity.

Yazd province had the greatest estimated cargo redirection to the extended gate (22.5%) and the class of Agricultural, livestock, food cargo constituted the highest share (3.68%) of this. Based on our estimates, the extended gate will be able to attract 16% of the cargo for Tehran province from the direct path. Cargo redirection to the extended gate was estimated to be more than 15% for six provinces but less for the other 25 provinces. The extended gate's cargo flow share in most of the province-gate pairs was positive and could be due to discounts which are applied to the tariffs with the aim of encouraging the market. In fact, these discounts could decrease clearance and transportation costs and attract cargo from much province-gate trade.

Our predictions are that 35% of the amount of cargo attractable to the extended gate in 2025 will belong to the Mineral and construction cargo class. Chemical cargo will make up 18% of the total share, Agricultural, livestock, food cargo 17%, and Metallic cargo 14% of the attractable cargo. Paper and wood cargo will account for the smallest share, at 0.2%. Some cargo groups are more sensitive to effective variables like cost and travel time so providing smooth and economical transportation facilities could be a productive solution to absorbing those groups of cargos. As the lag variable of extended gate's share is significant in most models, marketing, demand and supply study could derive a specific gate for cargo flow.

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# Appendix A: Model's calibration results and coefficient of regressors

| Cargo Group Number | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|---|
| Cargo Group | | Agricultural, livestock, food cargo | Metallic cargo | Mineral and construction cargo | Light industry products | Machinery and spare parts | Chemical cargo | Paper and wood | Leather, textiles, and clothing | Different types of wastage and scrap |
| Dependent Variable | | $S_{ij}^{n}$-CG1 | $S_{ij}^{n}$-CG2 | Log($S_{ij}^{n}$-CG3) | Log($S_{ij}^{n}$-CG4) | Log($S_{ij}^{n}$-CG5) | Log($S_{ij}^{n}$-CG6) | Log($S_{ij}^{n}$-CG7) | Log($S_{ij}^{n}$-CG8) | Log($S_{ij}^{n}$-CG9) |
| Constant | Coeff | 0.00707 | 0.01104 | -0.37955 | -0.42005 | -0.73334 | -0.29641 | -0.69725 | -0.64621 | -1.30862 |
| | Sig. | 0.02360 | 0.00130 | 0.00020 | 0.00000 | 0.00000 | 0.05717 | 0.00000 | 0.00000 | 0.07860 |
| $S_{ij}^{n-1}$ | Coeff | 0.88441 | 0.89547 | | | | | | | |
| | Sig. | 0.00000 | 0.00000 | | | | | | | |
| Log ($S_{ij}^{n-1}$) | Coeff | | | 0.87950 | 0.89670 | 0.83131 | 0.83365 | 0.84727 | 0.84298 | 0.78916 |
| | Sig. | | | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |
| $C_{ij}^{n}$ | Coeff | 0.00000 | 0.00000 | | | 0.00004 | 0.00005 | 0.00005 | 0.00014 | |
| | Sig. | 0.16190 | 0.07876 | | | 0.08970 | 0.11770 | 0.09203 | 0.00020 | |
| LOG ($C_{ij}^{n}$) | Coeff | | | | | | | | | 0.30279 |
| | Sig. | | | | | | | | | 0.04120 |
| $T_{ij}^{n}$ | Coeff | -0.000001 | | | -0.000019 | | | -0.000020 | -0.000088 | |
| | Sig. | 0.04550 | | | 0.04520 | | | 0.03122 | 0.00010 | |
| LOG ($T_{ij}^{n}$) | Coeff | | | | | | -0.011544 | | | -0.33882 |
| | Sig. | | | | | | 0.02264 | | | 0.00710 |
| $1/Irrtariff_j$ | Coeff | | 0.01657 | | | | | | | |
| | Sig. | | 0.09913 | | | | | | | |
| Log ($Irrtariff_j$) | Coeff | -0.01063 | | | -0.63258 | -1.65237 | -0.56330 | | | -0.78296 |
| | Sig. | 0.40720 | | | 0.05610 | 0.00000 | 0.07211 | | | 0.11580 |
| $D_{ij}^{n}$ | Coeff | | -0.00001 | -0.00032 | | -0.00029 | | | | |
| | Sig. | | 0.03670 | 0.00030 | | 0.00550 | | | | |

## Appendix B: Model's goodness-of-fit parameters and Gauss-Markov test results

| Cargo Group Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Cargo Group | Agricultural, livestock, food cargo | Metallic cargo | Mineral and construction cargo | Light industry products | Machinery and spare parts | Chemica l cargo | Paper and wood | Leather, textiles, and clothing | Different types of wastage and scrap |
| Included observations | 806 | 806 | 633 | 754 | 740 | 621 | 587 | 541 | 590 |
| R Square | 0.865845 | 0.876255 | 0.830835 | 0.796609 | 0.7683 | 0.799721 | 0.779664 | 0.732353 | 0.663405 |
| Adjusted R Square | 0.865175 | 0.875637 | 0.830298 | 0.795795 | 0.767039 | 0.798421 | 0.77853 | 0.730858 | 0.661103 |
| F Test | 1292.426 | 1417.998 | 1547.084 | 979.157 | 609.3019 | 614.9289 | 687.651 | 489.7915 | 288.2483 |
| F Test.Sig | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Error Mean | 4.22E-18 | -2.04E-17 | 7.22E-16 | -1.31E-15 | 4.50E-16 | 2.03E-15 | 3.49E-16 | 4.40E-16 | -2.18E-15 |
| Error Std. Deviation | 0.034464 | 0.037675 | 0.929166 | 0.862701 | 0.908163 | 1.073408 | 0.949741 | 1.054441 | 1.1667 |
| Breusch-Pagan-Godfrey (F-statistic) | 29.54485 | 89.07966 | 6.020408 | 9.33359 | 10.13881 | 5.587894 | 12.13076 | 2.657654 | 3.524675 |
| Breusch-Pagan-Godfrey (Prob. F) | 0 | 0 | 0.0026 | 0 | 0 | 0.0002 | 0 | 0.0477 | 0.0074 |
| White (F-statistic) | 12.5358 | 45.43328 | 3.725839 | 3.955724 | 3.530176 | 2.228439 | 7.076758 | 1.621332 | 1.747687 |
| White (Prob. F) | 0 | 0 | 0.0025 | 0.0001 | 0 | 0.0061 | 0 | 0.1059 | 0.0432 |
| Breusch-Godfrey LM Test-1 Lag Include (F-statistic) | 1.152622 | 3.123438 | 6.900406 | 10.84996 | 5.303506 | 2.76402 | 0.841273 | 0.54438 | 0.755325 |
| Breusch-Godfrey LM Test-1 Lag Include (Prob. F) | 0.2833 | 0.0776 | 0.0088 | 0.001 | 0.0216 | 0.0969 | 0.3594 | 0.4609 | 0.3852 |
| Breusch-Godfrey LM Test-2 Lag Include (F-statistic) | 0.582035 | 1.579101 | 5.024446 | 13.12484 | 0.0062 | 1.656381 | 1.005889 | 0.744011 | 0.001164 |
| Breusch-Godfrey LM Test-2 Lag Include (Prob. F) | 0.559 | 0.2068 | 0.0068 | 0 | 0.0061 | 0.1917 | 0.3664 | 0.4757 | 0.9988 |
| Error Normal Distribution (Jarque-Bera) | 88229.14 | 13089.22 | 137.2632 | 343.1561 | 95.98641 | 84.80808 | 135.331 | 35.26335 | 55.48792 |
| Error Normal Distribution (Jarque-Bera-Probability) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

## Appendix C: Share of sea extended gate from total provincial imports and exports of cargo Class 5 separately, via each custom point in 2015 (Ceteris Paribus)