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Modeling the Social and Economic Impacts of Mongolia's Dry Port and Its Results

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Abstract

Mongolia is a landlocked country with limited infrastructure and high dependence on the Xingang Tianjin port in China for imports. This research examines the potential impacts of establishing a dry port in Zamyn-Uud, Mongolia, utilizing a system dynamics modeling approach via Vensim software. The study evaluates transportation time, costs, inflation, and logistics performance index improvements, revealing that the establishment of the dry port can reduce transportation costs and delays significantly while enhancing economic growth. The findings offer actionable insights for policymakers and stakeholders in addressing logistical inefficiencies and fostering sustainable development in landlocked regions.

Keywords

System Dynamics, Vensim, Causal Loop Diagram, Container Shipping, Border Crossing, Terminal, Logistics, And Transportation

1. Introduction

Mongolia, a landlocked nation between Russia and China, relies heavily on the Xingang Tianjin port for over 34% of its imports [1]. Limited infrastructure and reliance on a single port contribute to elevated costs and delays, particularly during peak seasons. This logistical bottleneck hinders economic growth and raises consumer prices.

The concept of dry ports, dating back to the 1960s, has gained increasing academic and practical significance. Studies by Notteboom and Rodrigue (1990s), Roso, and Khaslavskaya have underscored the importance of dry ports in improving efficiency, reducing costs, and mitigating the challenges faced by landlocked countries.

For instance, Mongolia depends on Russian and Chinese seaports [2] while Laos and African nations face similar dependencies [3]. Limited seaport options increase costs, affecting consumer prices [4].

This study compares dry port challenges in Xingan and Mongolia to recommend tailored strategies and resource allocation for improved performance. Insights from this analysis can guide other regions reliant on dry ports for economic growth.

This section reviews literature on dry port operations in coastal and landlocked regions, identifying key requirements for efficiency. These include hinterland connectivity, border transaction management, seaport-dry port integration, economic corridor development, and supportive policies and regulations.

Mongolia's accession to the United Nations Intergovernmental Agreement on Dry Ports in 2016 marked a strategic step toward addressing these challenges. However, a comprehensive analysis of the potential impacts of a dry port in Mongolia remains unexplored.

This study employs system dynamics modeling to evaluate the social and economic impacts of establishing a dry port in Zamyn-Uud. By incorporating over 900 variables, the model provides a holistic view of the benefits, challenges, and implications of this infrastructure development.

1.1. Dry Ports in Mongolia

The United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP) adopted the Intergovernmental Agreement on Dry Ports on May 1, 2013, which Mongolia ratified on February 5, 2016. Currently, 16 countries have joined this agreement. UNESCAP is responsible for providing support related to the standardization of dry port operations, offering advice on intergovernmental agreements, and establishing structural organization, conditions, and operational standards.

Mongolia has 46 border crossing points established through agreements with neighboring countries and government resolutions. As a landlocked country with extreme weather conditions, Mongolia has a small population, a relatively small market, and is surrounded by major powers—China and Russia. The country's transportation and logistics infrastructure remains underdeveloped. To reach seaports, Mongolia must transport cargo 3800 km by land through Russia to the Vladivostok port or 1870 km to China's Tianjin port.

The most commonly used and nearest seaport for Mongolia is Xingang port in Tianjin, China, which frequently experiences cargo congestion and delays. Slow transit through Chinese territory, customs bottlenecks, and border crossing challenges further escalate transportation expenses.

Currently, Mongolia lacks dry ports or terminals meeting international standards. If the Government of Mongolia can secure international financial and developmental support while engaging with the private sector, it would become feasible to establish dry ports. This initiative requires developing legal and regulatory frameworks for port operations, obtaining support from international organizations for construction, and establishing both soft and hard infrastructure.

The development of dry ports in Mongolia is expected to generate substantial economic benefits. Presently, containers arriving at Xingang port are exempt from rental fees for only the first five days. Beyond this period, rental fees accrue until empty containers are returned to the port. For imports transported from Xingang port via rail and road through the Erenhot-Zamyn-Uud border crossing to Ulaanbaatar, rental fees accumulate until the containers are returned to Xingang port.

Mongolia has already joined agreements and conventions related to dry port development and has announced plans to establish dry ports in Zamyn Uud, Ulaanbaatar, Sainshand, Altanbulag, and Choibalsan. By implementing these projects, Mongolia aims to transform its transport and logistics landscape, enhancing trade efficiency and reducing costs while fostering economic growth.

1.2. The Current Flow of Imported Goods through the Zamyn Uud Port

Zamin-Uud Port is the largest and most significant border port in Mongolia, featuring both road and railway crossings with continuous operations. It borders the Chinese city of Ereen and serves as the primary port for imported goods into Mongolia (Table 1).

Table 1. Imports from China via Zamyn Uud port and total container volume passing through various destinations. 2018-2023 [5].

Year	Number of containers (TEU) arriving at Xingang and Lianyungang ports		Number of containers arriving from China (TEU)		Transit (TEU)	Total number of containers (TEU)
	Railway	Highway	Railway	Highway	Railway	
2018	61,658	22,640	10,450	5200	95,868	195,816
2019	67,834	19,920	8,350	3430	166,202	265,736
2020	63,964	20,340	9492	4068	211,992	309,856
2021	63,056	12,600	6840	2560	261,692	346,748
2022	91,988	13,790	5518	3680	276,928	391,904
2023	76,546	19,280	6440	3200	349,816	455,282

2. Research Methodology

System dynamic modeling is a software-based design for complex real-life problems that enables pre-calculation of results through experiments and simulations. In life or in reality, high-risk scenarios involving financial loss can be analyzed by conducting multiple test simulations using Vensim software. By comparing the pros and cons, this approach facilitates making the most profitable choice [6].

Currently, there are three types of modeling methods: system dynamics (SD), discrete event modeling, and agent-based (AB) modeling methods. The first two are based on J. Forrester's work from the 1950s and J. Gordon's top-down method from the 1960s. In contrast, the AB method is designed in a bottom-up manner, focusing on the behavior of the individual being modeled. Recently, the AB method has gained widespread use [7].

System dynamics modeling, pioneered by J. Forrester, provides a robust framework for analyzing complex, dynamic systems. This study utilizes Vensim software to simulate the impacts of a dry port on Mongolia's logistics and economy. Key variables include transportation costs, time, import demand, population growth, and foreign trade conditions [8] [9].

Figure 1 illustrates the overall process of rail transport costs, rail revenue, and the net profit from rail transport. This diagram is based on research paper [10], with the main differences detailed in terms of shipping revenue, shipping costs, and net shipping revenue. Research paper [10] estimates distribution costs, transportation costs, route lengths, and transportation-related greenhouse gas emissions. For our purposes, we can calculate the transportation costs of imported goods across three categories: normal period, delay period, and dry port period.

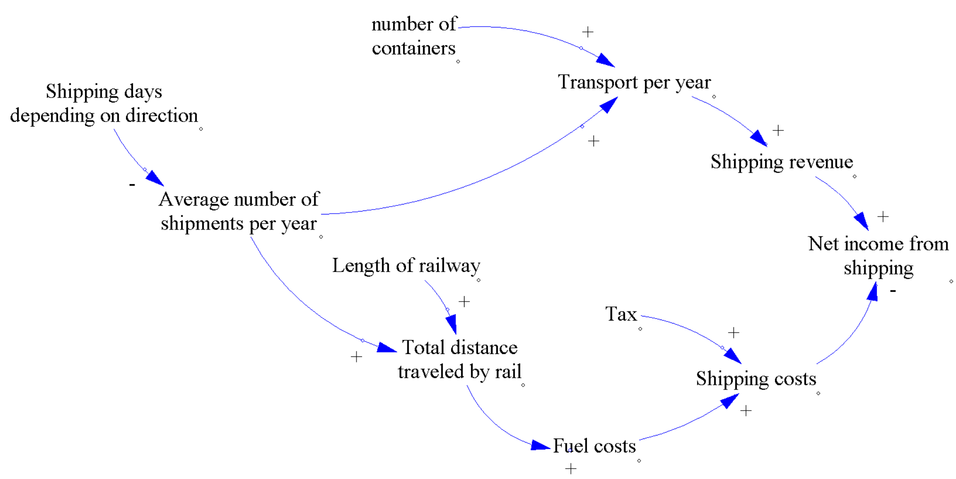

Figure 1. Rail transport loop diagram.

Figure 2 illustrates the distance from Xingang Port to the Ulaanbaatar AB-TEMA Terminal and further to the warehouse, as well as the return journey of empty containers from the warehouse back to Xingang Port. Based on the diagrams above, a system dynamics model was developed.

Figure 2. Transportation process from Xingang Port to Ulaanbaatar warehouse.

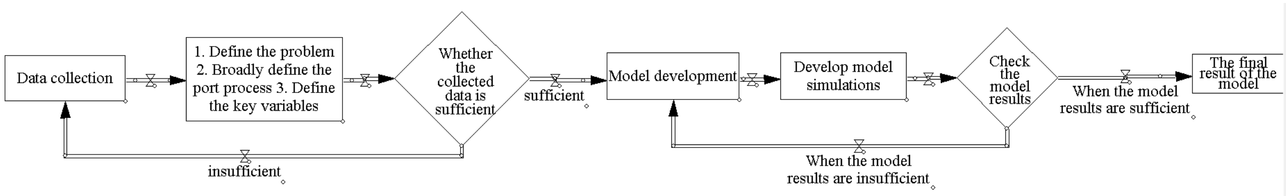

Figure 3. Model development scheme.

Inspired by Tom Fiddaman's beer distribution game model [11], a dynamic model of the flow system for goods and products imported from China was developed by modifying the dry port on the Roads. The Beer Game serves as an application of SD modeling and simulation techniques, widely utilized in management education to tackle dynamic issues such as inventory flow, risk, and lead time in supply chain management (**Figure 3**).

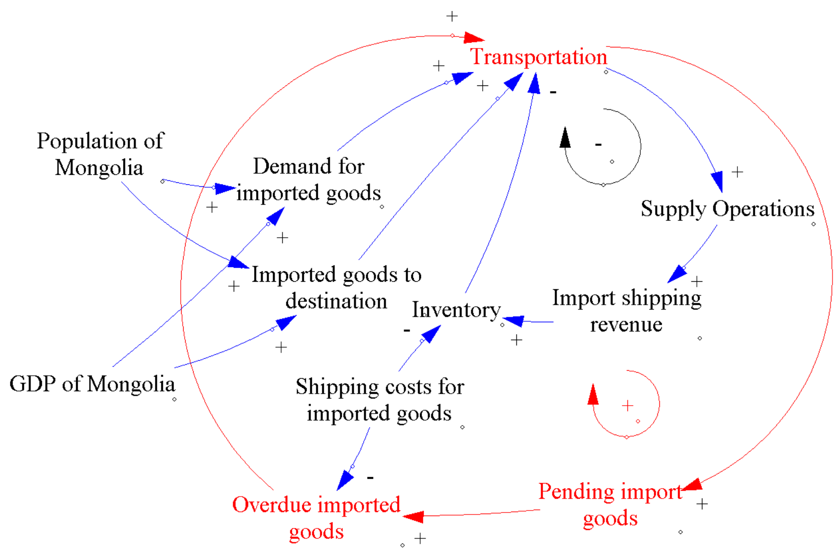

Figure 4. Supply and demand diagram for imported goods 1.

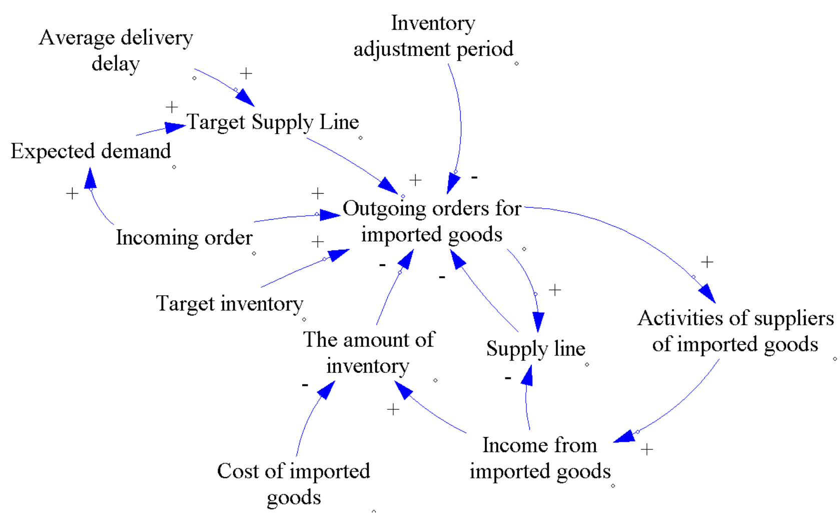

Figure 5. Supply and demand diagram for imported goods 2.

As illustrated in Figure 4 and Figure 5, if the transportation costs for imported goods and products from China are high, the physical volume of transportation will decline. Conversely, it is anticipated that shipments will rise when the shipping costs for returned goods and imported items are low.

The cost is calculated using the following formula.

$$L(t) = \int_0^t Ll\mathrm{d}t + L(0) \quad (1)$$

Here the following variables were calculated.

$$\text{Total fuel consumption} = \int_{2014}^{2030} \text{fuel consumption } \mathrm{d}t + \text{Fuel consumption}(2014) \quad (2)$$

$$\text{Toll} = \int_{2014}^{2030} \text{toll surcharge } \mathrm{d}t + \text{toll charge}(2014) \quad (3)$$

$$\text{Fuel price} = \int_{2014}^{2030} \text{fuel surplus } \mathrm{d}t + \text{fuel price}(2014) \quad (4)$$

The model simulates the flow of imported goods from Xingang Tianjin port to Ulaanbaatar via Zamyn-Uud. It incorporates three transportation scenarios: normal, delayed, and post-dry port establishment. Each scenario evaluates costs, time, and environmental impacts. Assumptions and parameters are detailed in Table 3.

Here, t is the period 2014-2030 in the system dynamic model. Looking at the general equations in the model:

Table 2. System dynamics model parameters (from model).

Parameter	The formula	Unit
1. Loaded in the same direction	1. even direction load[normal] = RANDOM 0 1() * 2 + 5	days
	1. even direction load[when delayed] = RANDOM 0 1() * 23 + 7	days
	1. Loaded in the same direction [when the dry port was established] = RANDOM 0 1() * 2 + 3	days
2. With an odd direction load	2. odd direction load[normal time] = RANDOM 0 1() * 27 + 3	days
	2. odd direction loaded [when delayed] = RANDOM 0 1() * 46 + 14	days
	2. with cargo in an odd direction [when the dry port was established] = RANDOM 0 1() * 11 + 3	days
Total annual transportation costs	taxes + fuel costs	sum/year
Number of days in a year	365	days
Road charges	∫ toll surcharge dt + 2000.0	fuel/km
toll surcharge	Toll* toll increase percentage/100	fuel/km
Cost of empty truck from Road Gate to Xingang	Cost of empty truck from Road Gate to Xingang [normal time, twenty feet] = 1200	dollars
	Cost of empty truck from Road Gate to Xingang [delayed, twenty feet] = 1500	dollars
	Cost of empty truck from Road Gate to Xingang [dry dock time, twenty feet] = 1000	dollars
	Cost of empty truck from Road Gate to Xingang [normal time, forty feet] = 1600	dollars
	Cost of empty truck from Road Gate to Xingang [delayed, forty feet] = 1850	dollars
	Cost of empty truck from Road Gate to Xingang [dry dock time, forty feet] = 1400	dollars

Continued

Fuel consumption per kilometer	Fuel consumption per km [twenty feet] = 28/100	l/km
	Fuel consumption per kilometer [forty feet] = 38/100	l/km
Fuel prices	∫ fuel increment dt + 1790.0	tank/l
Fuel consumption	Fuel consumption for total rail travel * km	l
Total cost of carriage by rail	(Empty rail cost from Zamin Uud to Xingang + Port cost at Xingang Port when loaded + Trailer rental at Xingang Port when loaded + Loaded rail cost from Xingang to Zamin Uud) * dollar rate + Zamin Uud Port loaded rail cost + Railway cost from Zamin Uud to UB in loaded time + Cost in loaded time from UB ABTEMA to warehouse + Cost in empty time from UB ABTEMA to warehouse + Ulaanbaatar ABTEMA Terminal to Zamin Uud empty time railway cost + Ulaanbaatar ABTEMA Terminal loaded railway cost.	the grove

Table 2 presents the numerical values and formulas for the general variables in the system dynamics model, with detailed formulas for some variables provided below.

Import goods demand = IF THEN ELSE(Time < Import demand start time, Import demand constant rate, delay1 (Initial import demand + STEP(Import demand step, Order step time) + Import demand shock, Integer constraint))

Total transportation time = (Zamin Uud port railway loaded time[normal time] + Zamyn Uud to UB railway loaded time[normal time] + Xingang port loaded time[normal time] + "Xingang to Zamyn Uud railway" cargo transportation time[normal time] + Ulaanbaatar ABTEMA Terminal railway cargo time[normal time] + UB ABTEMA to warehouse time with cargo[normal time] + "Truck transportation time from Xingang to Zamyn-Uud[normal time, twenty feet] + Truck load time at Road Gate[twenty feet] + Truck time from Road Gate to UB[normal time, twenty feet])*0.6 + (Zamyn Uud rail load time[when delayed] + Railway loading time from Zamin-Uud to UB[when delayed] + Loading time at Xingang port[when delayed] + "Railway loading time from Xingang to Zamin-Uud"[when delayed] + Ulaanbaatar ABTEMA Terminal railway loaded time[when delayed] + time with cargo from UB ABTEMA to warehouse[when delayed] + "Truck transportation time from Xingang to Zamin-Uud"[when delayed, twenty feet] + time when truck loaded at Zamin Uud port[when delayed, twenty feet] + Loading time of the truck from Road Gate to UB[when delayed, twenty feet]) * 0.4

Loads of roads = Loads going to the entrance of the road/(Time of the railway at the entrance of the road [during normal] * 0.7 + Time of the railway at the entrance of the road [during the delay] * 0.3) – Loads going to UB + Other imports from China by rail.

3. Dynamic Modeling of Zamyn Uud Dry Port System

The future demand for imported goods arriving from China through Zamyn Uud port is contingent upon the population growth of Mongolia, as well as economic activity and consumption patterns. As the population and economy expand, production and consumption rise, leading to an increased demand for imported goods. It is anticipated that the supply of imported goods from China will elevate the daily rental costs of containers at Xingang Port due to time delays linked to the inspection capacity of the Zamin-Uud border port, which would subsequently raise transportation costs and consumer goods prices. One potential solution to this issue is the establishment of the Zamin-Uud dry port. The volume of goods imported from the PRC arriving at Zamyn-Uud port is measured in tons, TEU, ton-kilometers, and average transit time from various locations in China and Xingang port to Zamyn-Uud port, Ulaanbaatar city ABTEMA Terminal, and subsequent warehouse due dates are defined (Figure 6).

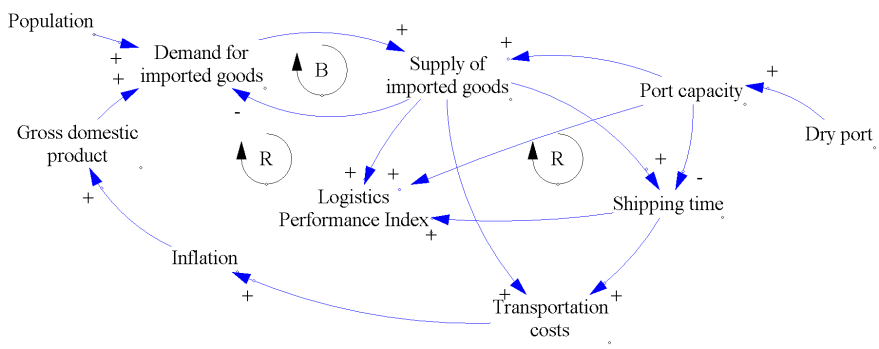

Figure 6. Mongolia's import transport loop diagram.

The aim of our research is to assess how the speed of imported goods and products flowing from China will increase with the establishment of a dry port at the Zamyn Uud border port. We will also examine its impact on the logistics performance index and foreign trade terms index, as well as the reduction in transportation costs and its effect on inflation. The calculations will be based on these factors. The flow of inventory was conducted from Xingan port and other urban areas of China towards Ereen City, following the route Ereen Road—Ulaanbaatar ABTEMA Terminal—to the consignee's warehouse (Figure 7, Figure 8).

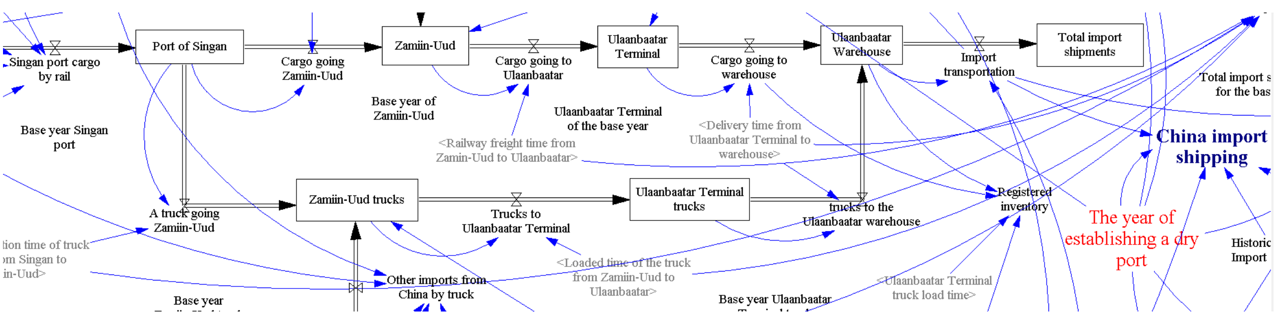

Figure 7. Xingang port and model of imported goods arriving via roads (from model).

The modeling of demand for imported goods, port capacity, and time delays is structured as follows, inspired by the beer distribution game (Figure 9).

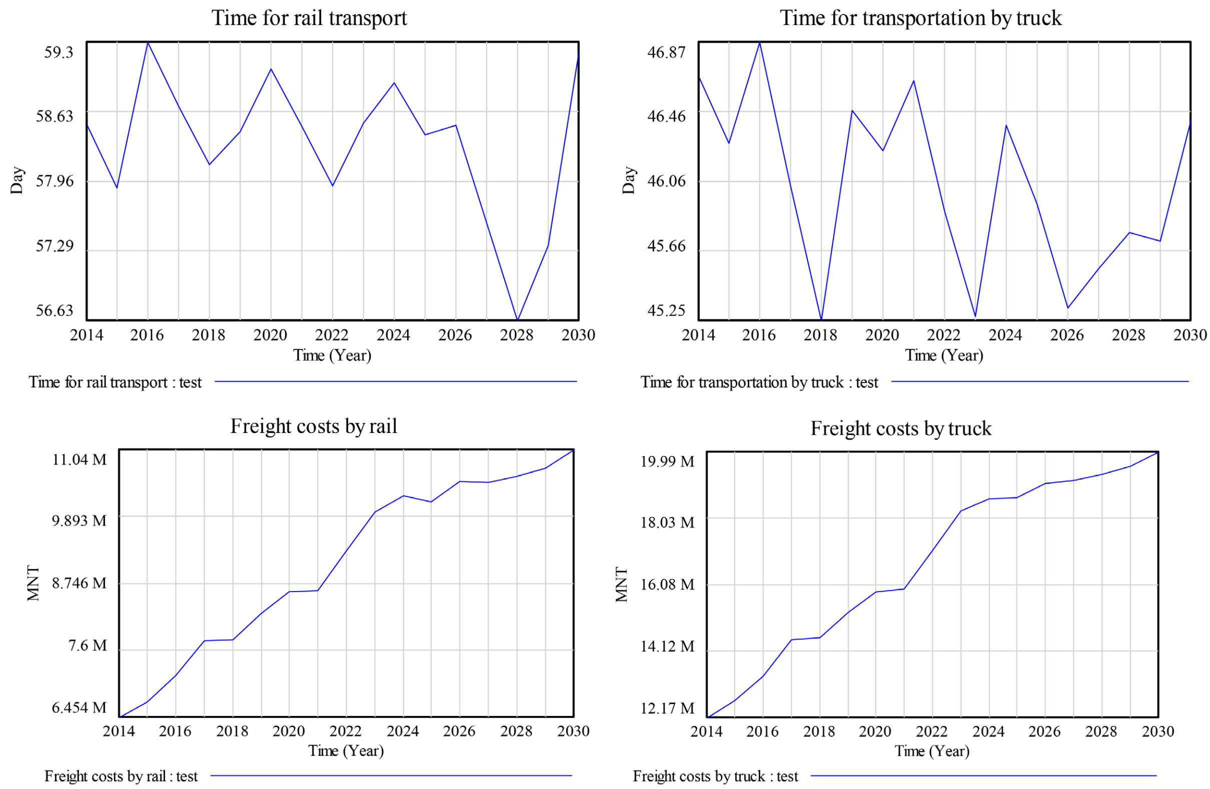

Figure 8. Truck and rail transportation costs and times.

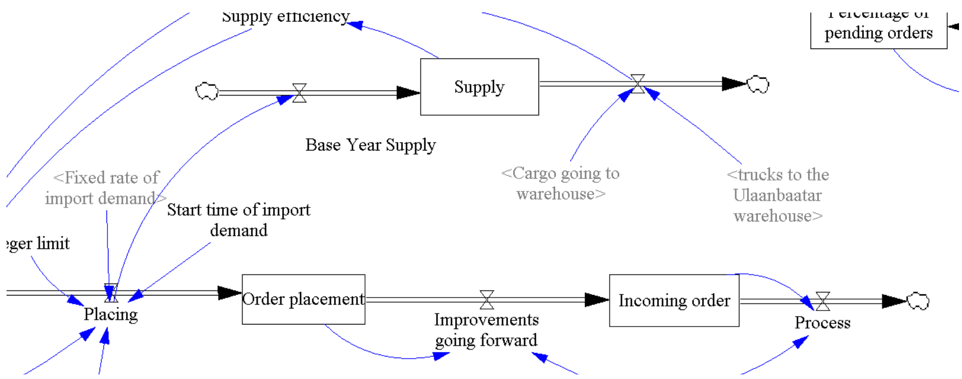

Figure 9. Demand and Supply patterns for imported goods (from model).

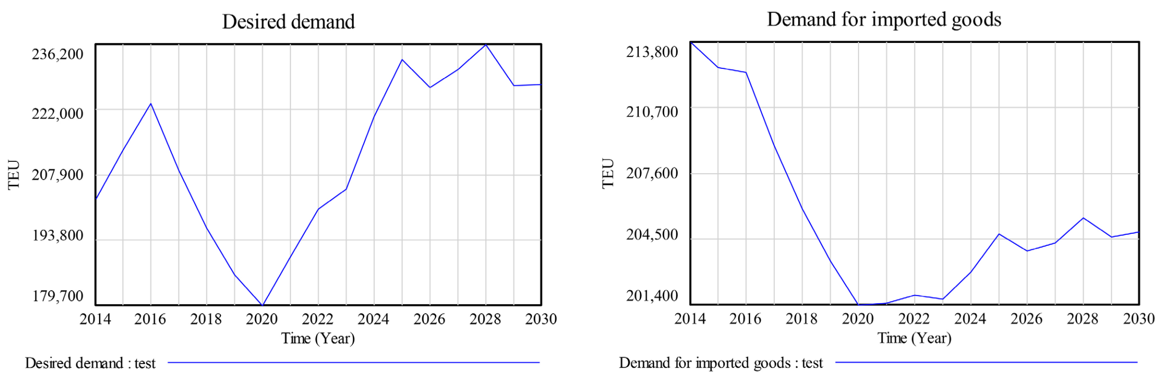

Figure 10. Demand and desired demand for imported goods entering road-gates.

Data were sourced from the National Statistics Committee, previous studies, and international reports. Limitations, such as reliance on projections and external factors, are acknowledged. Scenario analysis addresses uncertainties by simulating variations in key input assumptions (**Figure 10**).

4. Results from Simulations

We have demonstrated how the following indicators will influence the main outcomes upon the establishment of a dry port. These include:

- Shipping time and cost of imported goods;
- Mongolia Logistics Performance Index;
- Consumer goods prices or inflation;
- Production in Mongolia's transport industry.

4.1. Shipping Time and Cost of Imported Goods

The construction of the dry port is anticipated to reduce rail freight and road transportation times by 54% and 52%, respectively. Additionally railway and road transport costs are expected to decrease by 24% and 25%, respectively (**Figure 11**).

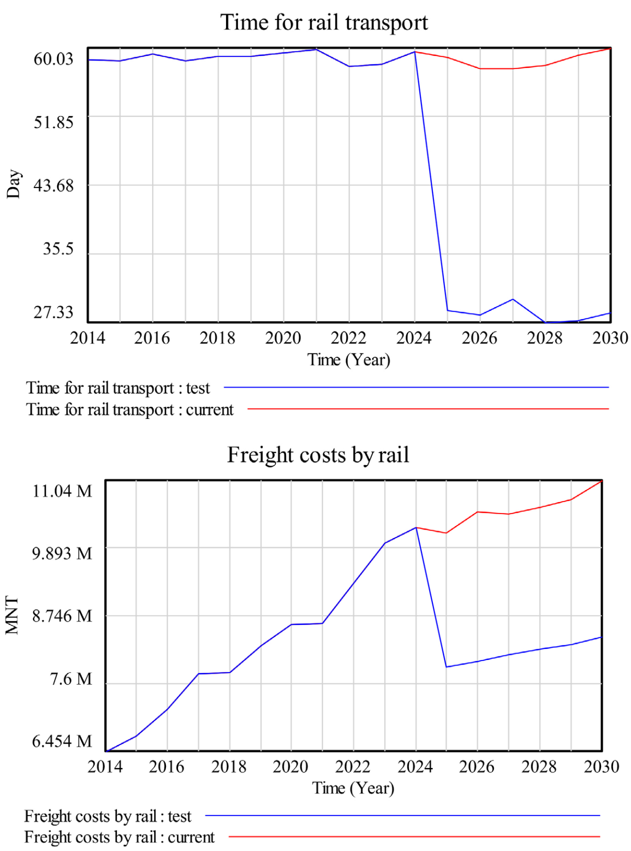

Figure 11. Rail and truck transportation times and costs at dry ports.

If you examine the route from Singan Port to the Ulaanbaatar receiving warehouse, truck transportation averages 101 days during delays, while rail transportation takes 121 days. Under normal conditions, truck transport averages 22 days, and rail transport takes 30 days. When a dry port is established, truck transportation averages 10 days. In 20 days, rail transport will take 27 days. This results in a cost of 300 billion MNT for Mongolia annually (Figure 12).

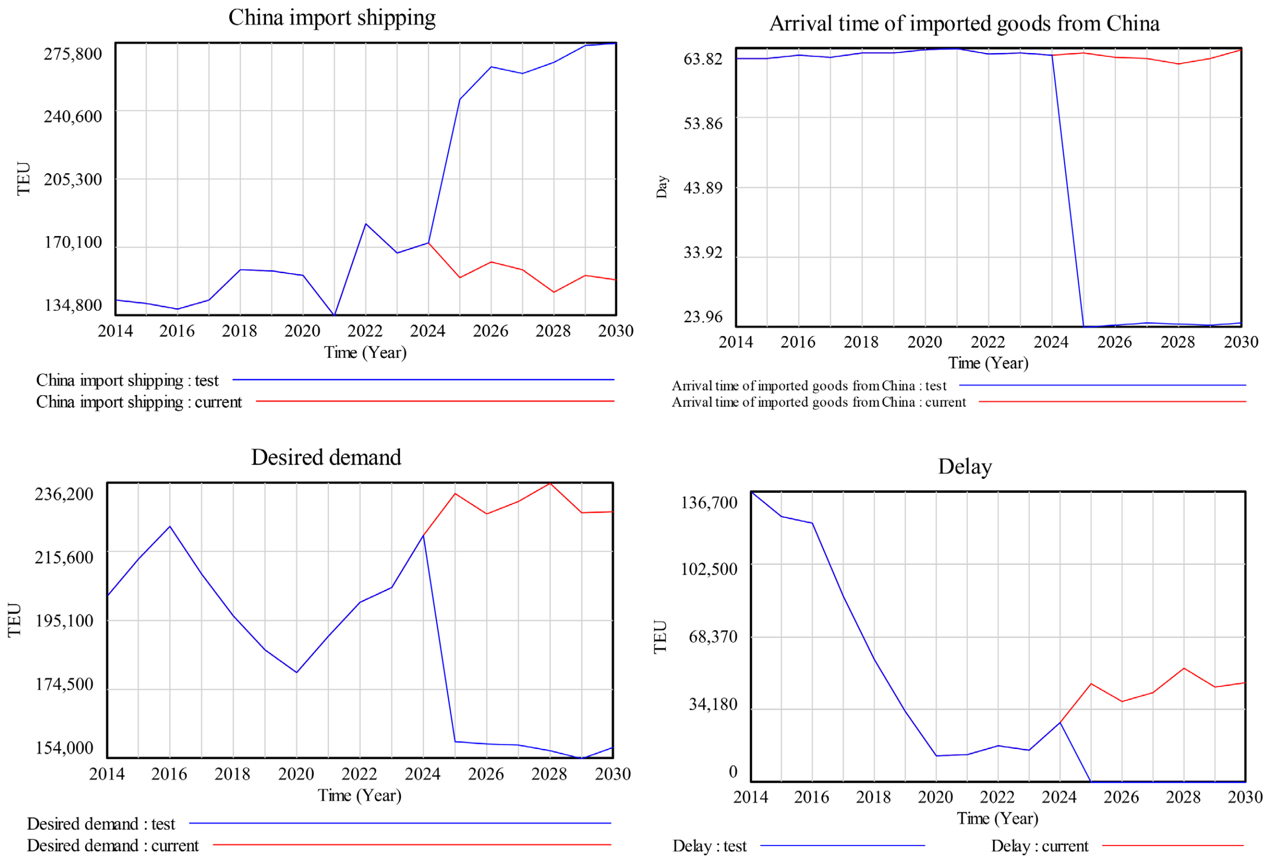

Figure 12. Import cargo volume, transportation time, demand, and goods delay from China upon the establishment of a dry port.

With the establishment of a dry port in Zamyn-Uud, the volume of imported goods from China can increase by 85%. By 2030, China's imported goods are projected to double, increasing by 100%. Consequently, by 2030, the transportation time for imported goods from China is expected to reduce from 62 days to 24 days, while demand and time delays will decrease by 36% and 30%, respectively.

The main results are presented in the following Tables 3-11.

Table 3. Port costs and delays. Xingang Port /PRC/ /Loaded containers/.

Container type	Spend during normal shipping			To be spent during shipping delays			In the case of establishing a dry port		
	Time /day/	Cost /USD/		Time /day/	Cost /USD/		Time /day/	Cost /USD/	
		Port expenses	Container rental		Port expenses	Container rental		Port expenses	Container rental
20 feet	5 - 7	30 - 40	20 - 30	75 - 90	200 - 360	600 - 720	4 - 5	20 - 30	15 - 20
40 feet	5 - 7	70 - 80	40 - 50	75 - 90	400 - 600	950 - 1250	4 - 5	40 - 60	40 - 50

Table 4. From Xingang port /PRC/ - ZamynUud Port /Mongolia/Loaded Containers/.

Container type	When shipping is normal transportation fee				When shipping is delayed transportation fee				Shipping charges in case of established dry port			
	Time /Day/		Cost /USD/		Time /Day/		Cost /USD/		Time /Day/		Cost /USD/	
	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car
20 feet	5 - 7	3 - 4	1000	1750	6 - 8	3 - 4	1100	3000	5 - 7	3 - 4	1000	1800
40 feet	5 - 7	3 - 4	1600	2200	6 - 8	3 - 4	1800	3400	5 - 7	3 - 4	1400	2200

Table 5. Road port costs /Loaded container/.

Container type	When shipping is normal Port charges				When shipping is delayed Port charges				Port costs in the case of establishing a dry port			
	Time /Day/		Transfer + Others /Zero/		Time /Day/		Transfer + Other /Zero/		Time /Day/		Transfer + Other /Zero/	
	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car
20 feet	1 - 2	1 - 2	50,000	10,000	5 - 10	2 - 3	50,000	10,000	1 - 2	1 - 2	30,000	5000
40 feet	1 - 2	1 - 2	100,000	10,000	5 - 10	2 - 3	100,000	10,000	1 - 2	1 - 2	70 000	5000

Table 6. From road entrance - Ulaanbaatar /Loaded Containers/.

Container type	When shipping is normal transportation fee				When shipping is delayed transportation fee				Shipping charges in case of established dry port			
	Time /Day/		Cost /zero/		Time /Day/		Cost /zero/		Time /Day/		Cost /zero/	
	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car
20 feet	3 - 4	1 - 2	1,105,000	4,000,000	4 - 7	2 - 3	1,108,800	4,360,000	2 - 3	1 - 2	1,150,000	3,000,000
40 feet	3 - 4	1 - 2	2,430,000	4,000,000	4 - 7	2 - 3	2,430,000	4,360,000	2 - 3	1 - 2	2,400,000	3,300,000

Table 7. Ulaanbaatar ABTEMA. Terminal costs /Loaded containers/.

Container type	When shipping is normal Terminal costs				When shipping is delayed Terminal costs				Terminal costs in case of established dry port			
	Time /Day/		Delivery + Others /Zero/		Time /Day/		Delivery + Other /Zero/		Time /Day/		Delivery + Other /None/	
	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car
20 feet	1 - 2	1 - 2	250,000	25,000	2 - 7	1 - 2	550,000	50,000	1 - 2	1 - 2	200,000	25,000
40 feet	1 - 2	1 - 2	350,000	50,000	2 - 7	1 - 2	700,000	70 000	1 - 2	1 - 2	300,000	25,000

Table 8. Minion Pro Capt.

Container type	When shipping is normal transportation fee		When shipping is delayed transportation fee		Shipping charges in case of established dry port	
	Time /Day/	Cost /zero/	Time /Day/	Cost /zero/	Time /Day/	Cost /zero/
		Car		Car		Car
20 feet	1 - 2	100,000	1 - 2	180,000	1 - 2	100,000
40 feet	1 - 2	200,000	1 - 2	350,000	1 - 2	200,000

Table 9. Costs from consignee's warehouse to ABTEMA Terminal /Empty container/.

Container type	When shipping is normal transportation fee		When shipping is delayed transportation fee		Shipping charges in case of established dry port	
	Time /Day/	Cost /zero/	Time /Day/	Cost /zero/	Time /Day/	Cost /zero/
		Car		Car		Car
20 feet	1 - 2	50,000	1 - 2	100,000	1 - 2	50,000
40 feet	1 - 2	100,000	1 - 2	200,000	1 - 2	150,000

Table 10. Costs from Ulaanbaatar ABTEMA Terminal to Zamyn Uud /Empty containers/.

Container type	When shipping is normal transportation fee				When shipping is delayed transportation fee				Shipping charges in case of establishment of dry port			
	Time /Day/		Cost /zero/		Time /Day/		Cost /zero/		Time /Day/		Cost /zero/	
	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car
20 feet	3 - 4	1 - 2	745,000	800,000	4 - 7	2 - 3	745,000	1,400,000	2 - 3	1 - 2	450,000	700,000
40 feet	3 - 4	1 - 2	940,000	800,000	4 - 7	2 - 3	940,000	1,400,000	2 - 3	1 - 2	600,000	800,000

Table 11. Road entrance /Mongolia/ - Singan /PRC/ /Empty containers/.

Container type	When shipping is normal transportation fee				When shipping is delayed transportation fee				Shipping charges in case of established dry port			
	Time /Day/		Cost/USD		Time /Day/		Cost/USD		Time /Day/		Cost/USD	
	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car	Railway	Auto car
20 feet	5 - 7	3 - 4	800	1200	6 - 8	3 - 4	900	1500	5 - 7	3 - 4	600	1000
40 feet	5 - 7	3 - 4	1300	1600	6 - 8	3 - 4	1400	1850	5 - 7	3 - 4	1100	1400

4.2. Mongolia Logistics Performance Index

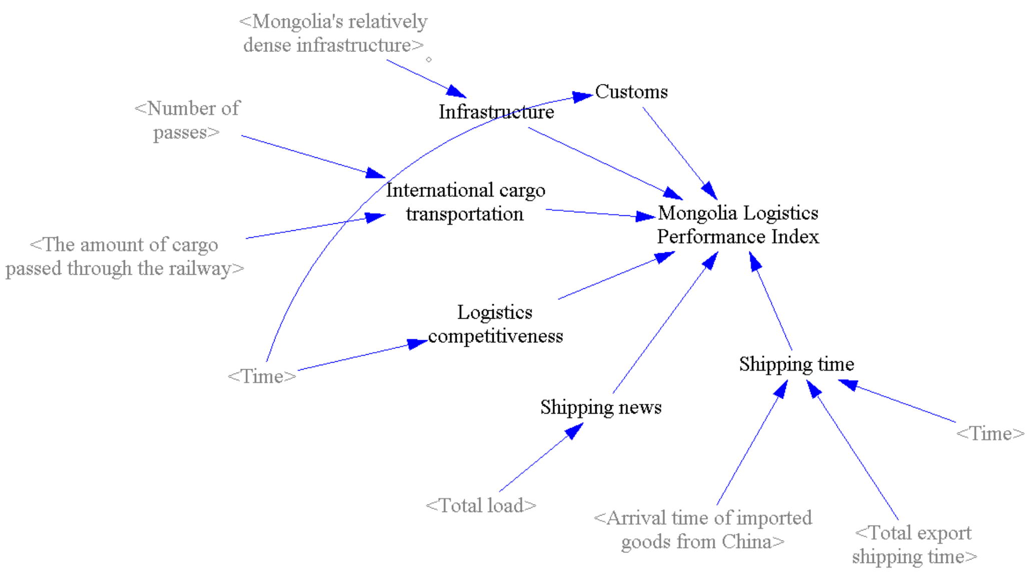

Figure 13. Logistics performance index model (from model).

According to the 2018 Logistics Performance Index, Mongolia ranked 129th out of 167 countries regarding logistics performance. In 2023, our northern neighbor, Russia, placed 88th [12], while our southern neighbor, China, secured 19th place. Analyzing Mongolia's logistics performance reveals a score of 2.5 out of 5 for the efficiency of border customs clearance organization, 2.3 points for the quality of trade and transport infrastructure, and 2.3 points for the quality and competitiveness of logistics services. The frequency of cargo delivery and delivery time received a score of 2.4, while price competition and transport organization simplification scored 2.3. The control and regulation of cargo circulation earned a score of 2.7 (**Figure 13**, **Figure 14**).

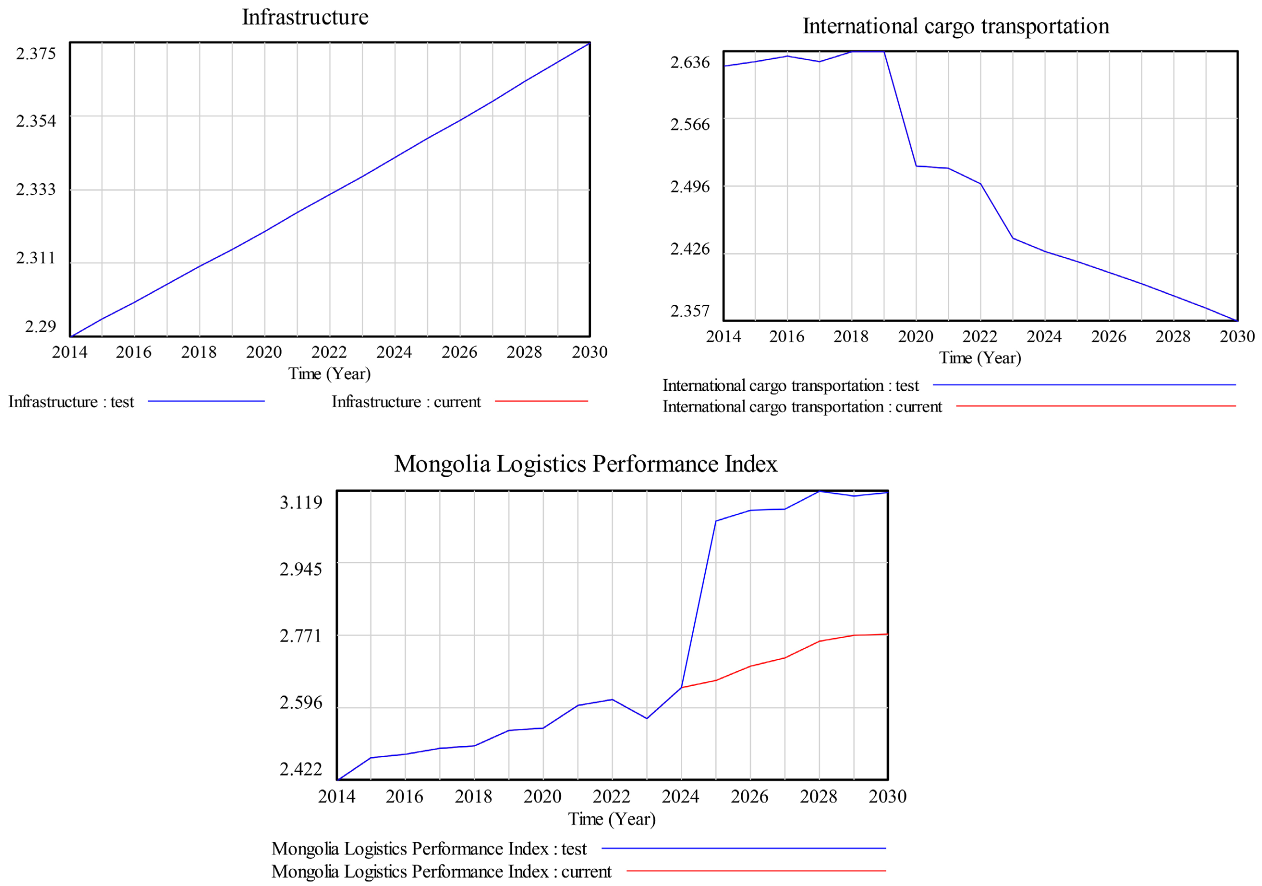

Figure 14. Logistics performance index of Mongolia in dry port area.

Mongolia's logistics performance index is projected to increase by 6% with the establishment of a dry port in Zamyn-Uud.

4.3. Consumer Goods Prices or Inflation

In our model, we have selected the relative price variable to illustrate inflation or the changes and increases in the prices of goods in Mongolia. This variable encompasses three types of prices: agriculture, manufacturing, and trade services. Consumer prices, or market prices, are influenced by producer prices, import prices, and indirect taxes.

As domestic demand for goods and services rises, their prices will also increase, leading to a rise in relative prices. Conversely, relative prices may decrease when the supply of imported goods increases and transportation costs decline (Figure 15, Figure 16).

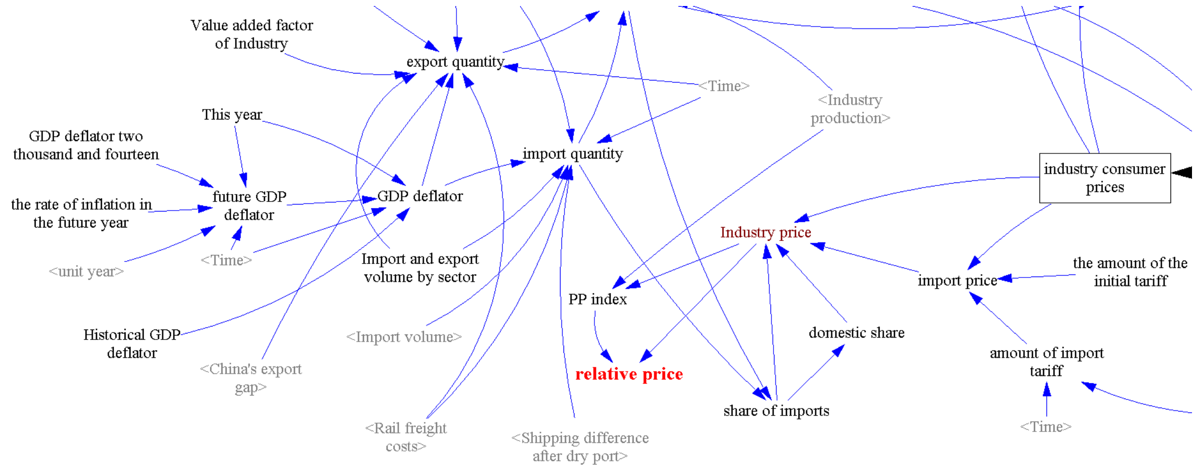

Figure 15. Relative price sector (from model).

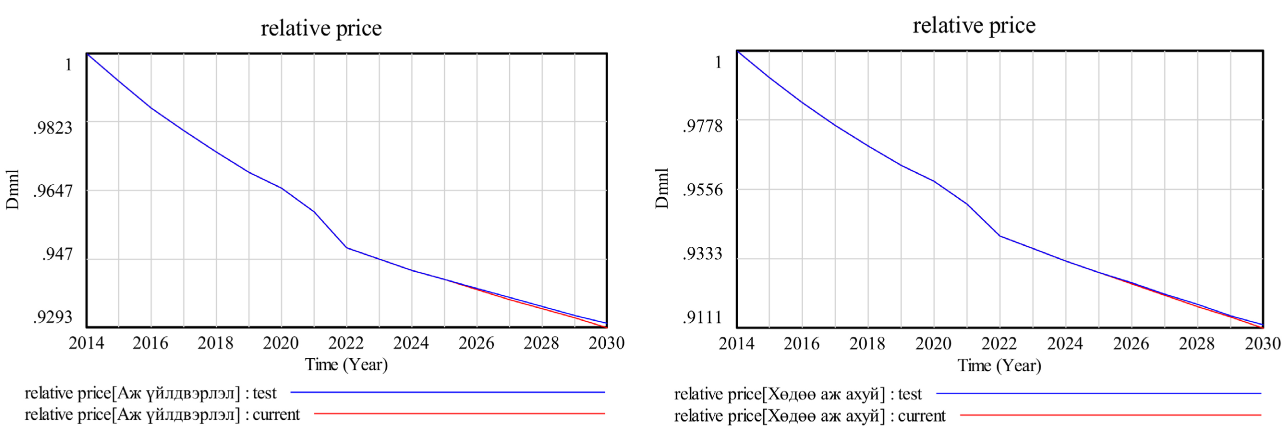

Figure 16. Relative prices of the industry and agriculture sectors after the establishment of the dry port.

When the dry port is constructed in Zamyn-Uud in 2024, Mongolia's inflation is projected to decrease by 0.1 points.

4.4. Mongolia's Transport Industry Production

The production volume of Mongolia's transport sector has been projected until 2030, based on indicators such as population growth, foreign trade conditions, and the expansion of economic sectors. The amount of cargo and the number of trips were analyzed and modeled separately for rail transport, road transport, and air transport (Figure 17, Figure 18).

Once the dry port is established in Zamyn-Uud, the production of the transport sector is anticipated to rise by 1.6%.

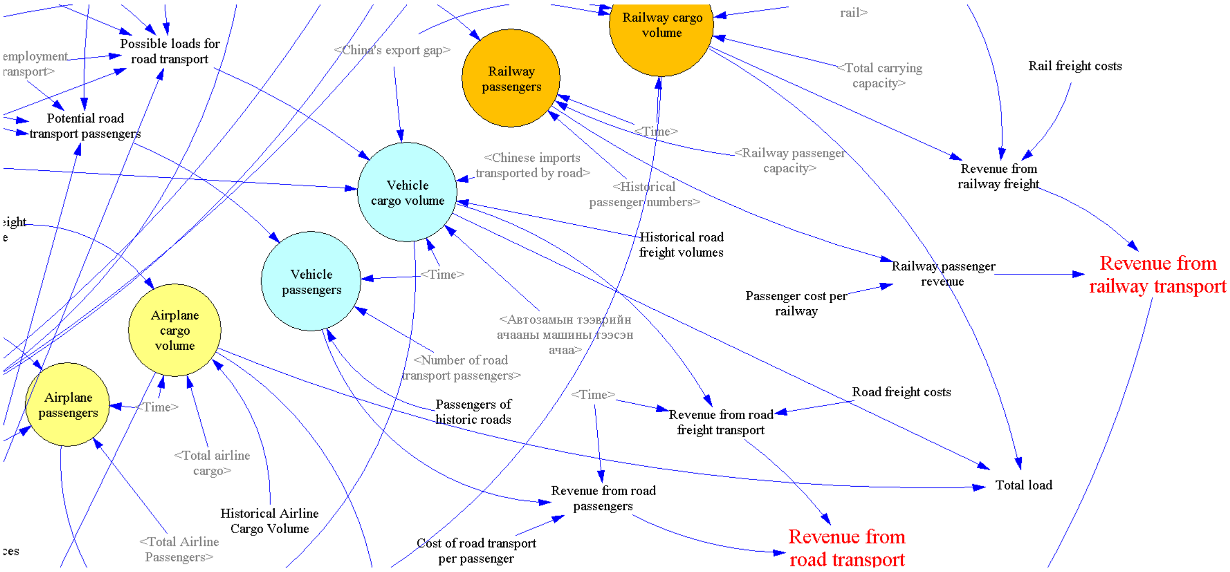

Figure 17. Production model of transport sector (from model).

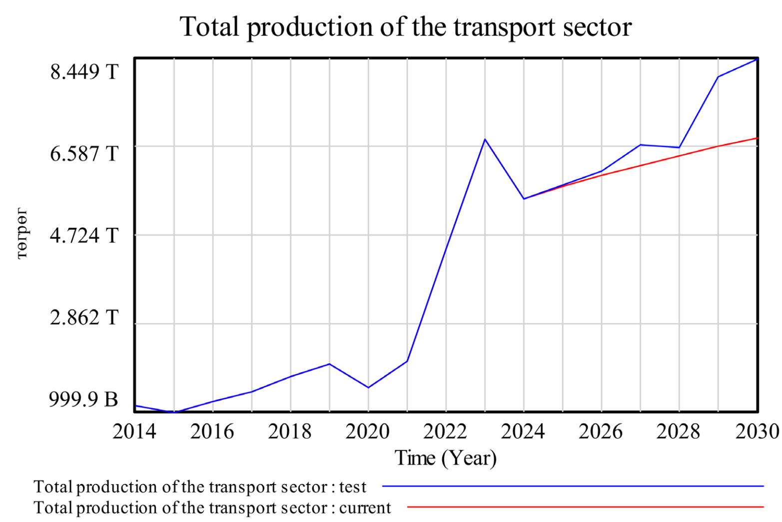

Figure 18. Production of the transport sector after the establishment of a dry port.

4.5. Discussion

Justification of Projections

The substantial reductions in transportation time and costs are supported by historical data and case studies from similar dry port implementations in other landlocked countries. For example, the Almaty dry port in Kazakhstan yielded comparable improvements in efficiency and cost savings.

Challenges and Limitations

Potential challenges include:

- **High Initial Costs:** Infrastructure development requires significant investment.
- **Operational Complexities:** Coordination among stakeholders and training of personnel are critical.

- **Shifting Bottlenecks:** Congestion may shift to other parts of the supply chain.

Mitigation strategies include phased implementation, public-private partnerships, and capacity-building initiatives.

Future Research

Future studies could explore:

- Comparative analyses with other landlocked nations.
- Long-term economic and environmental impacts.
- Integration of advanced technologies in logistics operations.

5. Conclusions

As of today, over 5500 containers are delayed at Xingang port in Tianjin, with shipping times reaching 180 days. This prolongation increases the transportation and logistics costs borne by imported goods, consequently raising their prices and adversely affecting the population's income.

International experience highlights the significance of dry ports in addressing this issue for landlocked Mongolia. Mongolia has joined the agreement and convention for establishing dry ports and has announced the creation of dry ports in Zamyn Uud, Ulaanbaatar, Sainshand, Altanbulag, and Choibalsan. Utilizing regional and spatial planning alongside new economic theory, a dynamic model of the Zamyn Uud Dry Port system was developed, incorporating over 900 variables. The results were validated across four production areas.

If the test results are aggregated, by 2030, transportation time is projected to decrease by 52% - 54%, averaging 20 days for truck transport and 27 days for rail transport.

In terms of costs, savings of 550,000 MNT per 20-ton container and 1.4 million MNT per 40-ton container are anticipated, leading to an annual reduction of 300 billion MNT in transportation costs for Mongolia.

By 2030, China's imports are expected to double, with the time for transporting imported goods decreasing from 62 days to 24 days, and transportation delays reducing by 30% - 36%.

Additionally, by 2030, Mongolia's logistics performance index is projected to rise by 6%, inflation is expected to decrease by 0.1 points, and production in the transport sector is anticipated to grow by 1.6%.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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