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Does Cross-Border Logistics Performance Contribute to Export Competitiveness? Evidence from China Based on the Iceberg Transport Cost Model

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Abstract: This paper investigates the economic relationship between logistics performance and export competitiveness based on the iceberg transport cost model and conducts further empirical analysis according to China's LPI. It finds that the higher the efficiency of logistics and transport, the lower the transportation costs coefficient per unit distance; when logistics and transportation costs decrease, foreign demand for domestic goods increases, as does the export value expressed in domestic prices. Additionally, Spearman's rank correlation method is used to analyze the relationship between logistics performance index and export level, indicating that logistics performance index has a positive rank correlation with the export level at a significant level of 1%. Moreover, a case study on China' LPI supports the conclusion derived from the theoretical analysis, and conducive countermeasures are put forward. This research confirms the positive correlation between logistics performance and export competitiveness and proposes specific solutions to enhancing the logistics capabilities of other developing countries.

Keywords: cross-border logistics; logistics performance index; export competitiveness; iceberg transport cost; rank correlation

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1. Introduction

As international logistics performance (LP) can significantly contribute to the development of a country's bilateral trade, understanding the relationship between LP and export competitiveness (EC) is of great importance. Initially, logistics mainly concentrated on analyzing the supply chain to optimize the flow of components needed for the production process. With the subsequent globalization and modernization of markets, the concept of logistics has acquired a broader function, including spatial and temporal relationships. Langley et al. (2008) [1], Mangan et al. (2008) [2], Rushton et al. (2006) [3]; CILT (2012) [4] explored the definition of "logistics" and argued that logistics can be considered as a complete system that includes information, storage, packaging, and transport to meet the requirements of quality, time, and cost. Moreover, performance is essential for competitiveness. Consequently, the LP and the competitiveness of a country are highly interrelated (Arvis et al., 2018) [5]. Therefore, LP is currently referred to as an organization, a supply chain, or a supply chain network (Beamon & Balick, 2008) [6]. In this paper, LP refers to time, cost, and complexity in accomplishing import and export activities from the perspective of a supply chain. The Logistics Performance Index (LPI) was published by the World Bank every two years since 2007 and contains cost, time, and reliability dimensions (Hotrawaisaya et al., 2014) [7]. It can be used to measure the performance of

logistics operations between supply-chain partners, including on-time delivery, delivery time, error-free delivery, scheduled delivery, order fulfillment rate, damaged order, rush order delivery, on-time demand, size, short transit times, availability of cargo space, and condition of vehicles and containers (Lai et al., 2002 [8]; Lu, 2003 [9]; Simatupang and Sridharan, 2002 [10]; Vieira et al., 2015 [11]). Although many previous studies showed strong correlation between improved LP and cross-border trade, there are few studies that analyze the effects of LP on the EC based on the iceberg transport cost model and the relationship between the LPI and Export Level (EXP) of a country. China, as one of the leading export and import countries in scale, has attached great importance to the construction of a cross-border logistics system. In past decades, although several bonded zones and free trade zones were established along the coast and inland and strong support was provided in both institutional and financial resources, China's LP level is still relatively low and needs to be improved urgently. However, there is little published data on how to boost a country's EC by improving its LPI according to China's specific phenomena. Therefore, in this study there are two primary objectives: (1) to investigate the economic relationship between logistics performance and export competitiveness based on the iceberg transport cost model and conduct further empirical analysis according to China's LPI; and (2) to conduct a case study on China's LPI based on the conclusion derived from the theoretical analysis in order to reveal the potential reasons for China's situation. In particular, we aim to propose reasonable and practical solutions to these problems in China's logistics.

This paper is structured as follows. In the second section, we briefly review the related research literature focusing on the iceberg transport cost model, the impact of logistics effectiveness on trade, the efficiency of customs and border management clearance, and the competence and quality of logistics services. In the third section, theoretical analysis concerning logistics efficiency and export price and LP and export value is conducted. Furthermore, Spearman's rank correlation method is used to analyze the relationship between logistics performance index and export level. This process can best address the first research objective and generate significant theoretical results. In the fourth section, the LPI of China is selected as the empirical object, and a regression analysis is performed according to the above model. Several important empirical findings emerge from the Chinese case study. Moreover, several problems and implications about the case are discussed in section five. Finally, our conclusions are presented.

2. Literature Review

2.1. Research on the Iceberg Transport Cost Model

The iceberg transport cost model has its origins in the ice trade of the 19th century. Before artificial refrigeration and ice production widely spread in the early 20th century, natural ice was an important traded natural resource in almost all parts of the world. For most of history, the ice cream trade was very localized. The situation changed in 1806 when Frederic Tudor shipped 130 tons of natural ice from Boston to the Caribbean island of Martinique [12]. In 1833, the Tudors sent an experimental cargo to Calcutta, and after its success this long-lasting ice trade route extended to Indonesia, Brazil, the Philippines, China, Australia, and even Peru and San Francisco [13]. Other companies, attracted by the extremely high profitability of the industry, quickly entered the market, further expanding the ice cream business in Boston [14]. Figure 1 shows the increase and decrease of Boston's tropical ice exports. The peak of the industry was around 1860. The gradual emergence of artificial ice production and refrigeration results in its eventual decline.

Figure 1. Boston's Global Ice Trade. Source: Herold (2011. p. 168) [15].

The costs of transporting icebergs are one of the crucial components of current models of trade and economic geography, originally proposed by Samuelson in 1952 [16]. The concept is quite simple in nature: as a result of shipping, parts of the goods evaporate or are lost as they move away from one area to another. Hence the name "Iceberg"; like an ice cube, part of the output melts as it moves, so for one freight unit to reach its destination more than one freight unit must be sent. These transport costs mean that they are on the one hand expressed in terms of goods transported; on the other hand, they are independent of the rest of the economy because they are most often an exogenous constant which does not vary with the spatial distribution of economic activity. Krugman (1981, 1991, 1992 [17–19]) improved Samuelson's contribution by introducing a distance factor in the transport cost and by modifying the "iceberg transport cost" model. González-Val and Pueyo (2017) [20] and Sedgley and Elmslie (2018) [21] hold the view that the iceberg transport costs can also be used in different ways to formalize various economic models.

McCann (2005) [22] compares the main different aspects between the iceberg method and certain stylized facts. He also focuses on the analysis of three main criticisms. In line with this criticism, several alternatives have been put forward to handle the transport process and its impact on the distribution in space of diverse economic activities. One way to develop new, more comprehensive transportation is to consider introducing additional charges. Ottaviano et al. (2002) [23] (using additional valuation-based trade costs) and Irarrizabal et al. (2015) [24] formalize a model that includes additional costs during transport and conclude after estimating them that their magnitude is non-zero and of great importance for both theoretical models and empirical estimates.

Forslid and Okubo (2015, 2016) [25,26] adopted another formalization of trade cost that copes directly with the introduction of economies of scale. Although it focuses on the iceberg shipping method, previous work has defined shipping costs based on productive competence. Later work did something similar because it included trade costs based on the value of a firm's exports. Economies of scale in transport are so pervasive that ice (melted, which underlies the term "cost of the iceberg") is also subject to them (Bosker and Buringh, 2020 [27]).

It is important to point out that iceberg costs are so widely used because they are an easy way to introduce the friction necessary to create space in economic relations between remote regions. They make it possible to formalize models with transport costs without explicitly considering the transport sector, since it is often integrated into the cost function of a typical company [28]. In this way, the introduction of space into trade through transport

costs and their impact on prices, export volumes and profits are developed in a manageable way, thus reducing the level of complexity that can stem from the endogenous transport sector. Consequently, the iceberg method has become an important tool for analyzing the impact of space on economic activity and the location of trade.

2.2. Research on the Influence of LP on International Transactions

Although it is difficult to define and measure logistics performance, previous studies have looked at the influence of LP on transactions. A robust statistical relationship between transport costs and international trade flows was found by Limao and Venables (2001) [29]. They showed that cutting transport costs by fifty percent can increase the transactions amount five-fold. Wilson et al. (2005) [30] evaluated the severity equation of the impact of customs environment, port efficiency, regulatory environment service, and sector infrastructure on trade volume. The relationship between import and export time, international trade, and logistics services was analyzed by Nordas et al. (2006) [31]. Furthermore, the consequence of time lags on trade and the influence of facilitation and other trade-related restrictions on export competitiveness were also assessed by Iwanow & Kirkpatrick (2009) [32]. They define three composite factors, namely trade facilitation, regulation, and business regulation, and show that the above three aspects are very important key points of the export competitiveness of a country. In addition, LP is also an important component of international trade between importing and exporting countries, and excellent logistics performance can mitigate the negative influence of distance (Behar & Manners, 2008 [33]).

Guner and Coskun (2012) [34] analyze the relationship between logistics development and other economic and social factors (measured by GPI), focusing on 26 OECD member countries. Hausmann et al. (2013) [35] summarized the factors that have effects on direct trade transaction costs, which include fees, time, and variability. All of them lead to obvious direct or indirect costs that harm the EC levels of related countries. Furthermore, four composite indicators concerning facilitation of trade from a wide range of key indicators were proposed by Portugal-Perez and Wilson (2012) [36]. Behar et al. (2013) [37] observe the evidence that exporters' LP can enhance exports.

Overall, the literature argues that the costs of trade and logistics efficiency are of great importance in trade volumes between different countries. However, the relationship between logistics sector size and LP is not monotonous (Rantasila and Ojala 2012). Likewise, logistical disadvantages and advantages develop with income levels. For example, the duration of export studies in low-income countries is twice as long as in developed countries (Arvis et al. 2016) [38]. Therefore, lower-middle-income and poor countries need to pay more attention on promoting their logistics efficiency by improving infrastructure, customs operations, and the quality of logistics services. In addition, developed countries are concerned about bottlenecks in logistics, skills development and training, and international connectivity. Reis et al. (2020) [39] were the first to take into account the six dimensions of the LPI for importing and exporting economies, showing that the dimensions of the LPI do not affect each other to the same extent.

In terms of the Chinese literature, Yan Borui and Li Qian (2021) [40] examined in detail the development status of logistics performance in RECP countries using data from the Regional Comprehensive Economic Partnership (RECP) countries' logistics performance index. Tao Zhang and Qiao Sen (2020) [41], Liang Ye and Cui Jie (2019) [42], and Lu Hua et al. (2020) [43] used the Silk Road countries' logistics performance index as an entry point to verify the impact of logistics performance on China's trade level with countries along the Belt and Road. Unfortunately, previous scholars have used the logistics performance index as a single indicator, i.e., the value of a single overall logistics performance index as the research variable, without considering the dimensions of logistics performance in terms of infrastructure and services.

2.3. Research on the Customs Clearance Efficiency

Customs clearance efficiency means the effectiveness of customs clearance steps in relation to the simplicity, speed, and predictability of customs agencies. Poor customs performance is often the result of customs control procedures, including cumbersome documentation, duplication of inspections by different agencies, and the insufficiency of cross-border coordination and clearance. Cumbersome customs procedures are said to be the main obstacle to trade (Hummels et al., 2009 [44]). There is ample evidence that the improvement of the customs clearance process can significantly reduce the time it takes for goods to clear customs. Restrictions in the logistics sector are another major obstacle to cross-border trade. Hollweg and Wong (2009) [45] showed there is a negative correlation between the customs factor of the LPI and foreign customs restrictions. As for the research approaches, Aalok Kumar and Ramesh Anbanandam (2022) [46] developed an environmental and social sustainability framework based on an integrated multicriterion decisionmaking (MCDM) method. It has two sustainability enablers, nine dimensions, and 63 sustainability attributes, which are validated based on the case of the Indian freight industry. Aysu Goçer et al. (2022) [47] put forth a methodological framework to recommend logistics policies of the development of the LPI score of Turkey via both qualitative and quantitative methods in an uncertain business background.

2.4. Research on the Logistics Services

Logistics services mainly include different aspects of quality-of-service management and deals with meeting customer needs. It is related to the properties of the product and to operational constraints on reliability and flexibility of the logistics system as well. If a country intends to fulfill the goal of logistics excellence, it requires continuous promotion in service responsiveness and reliability support capabilities through continuous funds in logistics operations. It is undeniable that the quality of logistics services can be considered a key point in promoting international commercial transport. LPI results show that service quality is the driver of LP in developing and developed economies (Arvis et al., 2016) [38]. It is estimated that every 22–25% increase in exports of developing countries is attributed to a 10% growth in an exporter's LPI capability score (Turkson 2011) [13].

Based on the LPI, Li Yan et al. (2019) [48] conducted a comparative analysis of the logistics performance levels of 12 countries belonging to the world's top 500 logistics enterprises to find out their common advantage points. In this way, the main factors that restrict China's logistics performance index are compared and analyzed, and targeted reform and development suggestions are put forward to provide scientific reference for China's logistics development decisions.

3. Conceptual Model

The iceberg model can be expressed mathematically as follows: when 1 unit of goods is transported from a domestic producer, only part T can reach foreign consumers, and the $(1 - T)$ part is consumed during transportation. When the producer achieves equilibrium in the sales of goods at home and abroad, the income obtained must be equal, so:

$$Ph = Pf * T \quad (1)$$

In Formula (1), Ph is the domestic price of a certain commodity, Pf is the foreign price of this commodity, and T represents the transportation efficiency. The higher the efficiency, the lower the transportation cost $(1 - T)$. Thus, Formula (1) shows that the income Ph obtained by the manufacturer from selling 1 unit of goods in the domestic market is equal to the income received from the transportation of 1 unit of goods to foreign countries. However, Samuelson's "Iceberg Transportation Cost" did not consider the impact of distance on transportation costs, so it was criticized by some scholars. Almost 30 years afterward, Krugman (1981, 1991, 1992) [17–19] improved on Samuelson's contribution, introducing

the distance factor into the transportation cost and revising the "iceberg transportation cost" as:

$$V_{\mathrm{d}} = e^{-TD} \tag{2}$$

In Formula (2), V_{d} represents the number of items transported from the place of production to the final destination of consumption, D represents the distance traveled, and T represents the melting coefficient of the iceberg per unit distance. Taking the derivative of V_{d} to the transport distance D, we can get: $\partial V_{\mathrm{d}}/\partial D = e^{-TD} * (-T) = V_{\mathrm{d}} * (-T)$, and then divide by V_{d} to get:

$$\frac{\partial V_{\mathrm{d}}/\partial D}{V_{\mathrm{d}}} = -T \tag{3}$$

Formula (3) shows that the economic meaning of the parameter T is the ratio of the consumption of each unit of the commodity per unit of distance when the unit of commodity transported arrives at the place of consumption. Therefore, $(1 - T)$ is the remaining ratio. Although the definition here is contrary to Samuelson's definition of T, the essential meaning is the same. The relationship between the "iceberg transportation cost" and distance measured by physical objects is shown in Figure 2. The distance between the horizontal line represented by $V_{\mathrm{d}} = 1$ and the curve represented by $V_{\mathrm{d}} = e^{-TD}$ represents the consumption within a certain transportation distance. The sum of the quantity of products, that is, the total transportation cost expressed as follows:

$$TTC = 1 - V_{\mathrm{d}} = 1 - e^{-TD} \tag{4}$$

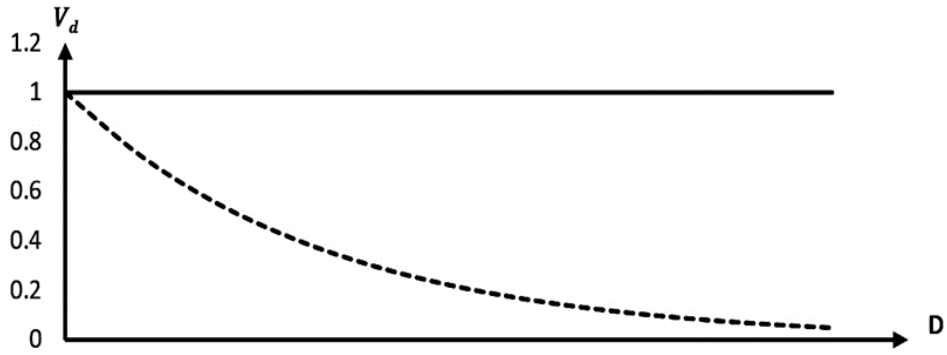

Figure 2. Relationship between "Iceberg Transportation Cost" and Distance.

3.1. Logistics Efficiency and Export Prices

When the producer reaches equilibrium in the domestic and foreign sales of goods, the income obtained must be equal, and the logistics and transportation costs will eventually be passed on to the consumers. Therefore, there is $Ph = Pf * e^{-TD}$, and both sides of the formula are multiplied by e^{TD}. It can be seen that the price of export products abroad is:

$$Pf = Ph * e^{TD} \tag{5}$$

In Formula (5), $e^{TD} > 1$, so $Pf = Ph * e^{TD} > Ph$, that is, the price paid by foreign consumers will inevitably be greater than the domestic sales price, and the extra part is the total transportation cost. Therefore, the total transportation cost expressed in the currency for transporting a unit of goods abroad within a certain transportation distance is:

$$TTC = Pf - Ph = Ph * \left(e^{TD} - 1\right) = Pf * \left(1 - e^{-TD}\right) \tag{6}$$

In Formula (6), the "$Ph * \left(e^{TD} - 1\right)$" after the second equal sign is the unit commodity transportation cost expressed by the domestic commodity price, and the "$Pf * \left(1 - e^{-TD}\right)$" after the third equal sign is the unit transportation cost of goods expressed in foreign

commodity prices. The higher the efficiency of logistics transportation, the smaller the coefficient of transportation cost per unit distance, the smaller the total transportation cost, and the lower the sales price of domestic products in foreign markets.

3.2. LP and Export Value

Generally, the domestic price Ph is determined by the equilibrium of supply and demand in the domestic market, and the distance D is controlled by natural factors and cannot be changed artificially. Therefore, the only measures left to the government to improve the competitiveness of domestic commodity trade are to improve logistics efficiency and reduce transportation cost T. The first derivative of Pf with respect to the transportation cost T is:

$$\partial Pf/\partial T = Ph * e^{TD} * D \tag{7}$$

In Formula (7), Ph, e^{TD}, and D are all greater than zero, so $\partial Pf/\partial T > 0$, that is, the higher the logistics transportation cost, the higher the price of domestic products exported to foreign markets and the lower the competitiveness. Therefore, when the cost of logistics and transportation decreases, the price of domestic products exported to foreign markets decreases and competitiveness increases. Figure 3 shows the relationship between logistics efficiency and export volume. For foreign consumers, the demand is inversely proportional to the price. It can be assumed that the demand function is $Q = a - b * Pf$ and that a and b are constants greater than zero. Bringing the export price $Pf = Ph * e^{TD}$ into the demand function:

$$Q = a - b * Ph * e^{TD} \tag{8}$$

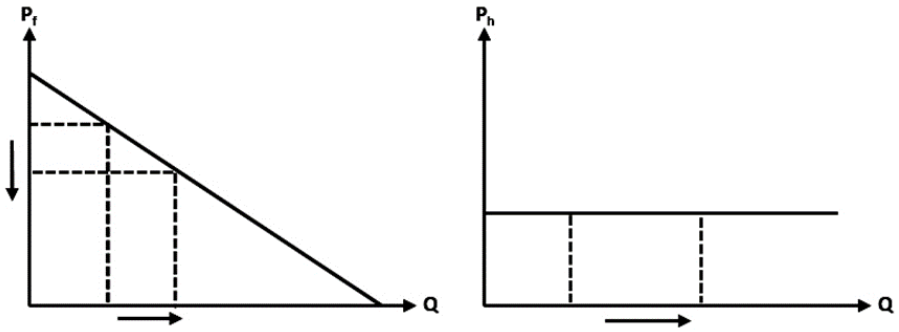

Figure 3. The relationship between cross-border logistics efficiency and EC.

The first derivative of Q with respect to the transportation cost T is:

$$\partial Q/\partial T = -b * Ph * e^{TD} * D = -b * \partial Pf/\partial T \tag{9}$$

Because $\partial Pf/\partial T > 0$, $\partial Q/\partial T < 0$, which means that when logistics efficiency is improved and transportation costs are reduced, foreign consumers' demand for domestic products will increase. The export value expressed in foreign prices (export) is:

$$Ef = Q * Pf \tag{10}$$

When the logistics and transportation cost T decreases, the price Pf of domestic products exported to foreign markets decreases, and the demand Q of domestic products by foreign consumers increases. Therefore, it is impossible to determine whether the export value expressed in foreign prices will increase. The export value expressed in domestic prices (export) is:

$$Eh = Q * Ph \tag{11}$$

When the logistics transportation cost T decreases, the domestic price Ph is determined by the equilibrium of supply and demand in the domestic market and is not affected by the

efficiency of logistics. The demand for domestic goods Q by foreign consumers increases, so the export value expressed in domestic prices will increase.

4. Empirical Analysis and Results

4.1. International Logistics Index (LPI)

The LPI was first proposed by the World Bank in 2007. It is a benchmark test to measure the performance of a country's logistics supply chain based on a questionnaire for freight forwarders and express carriers in countries around the world every two years since 2010. LPI comprehensively describes the LP of the surveyed countries and objectively reflects the specific reasons for the problems of a country's LP. It has been used by the World Bank and other international organizations to promote trade facilitation reforms in developing countries. LPI consists of International LPI and Domestic LPI and the two aspects concerning different survey objects and contents. The LPI mentioned in this paper refers to the international one.

The latest World Bank data about LPI has updated to 2018. It ranks countries on six dimensions of trade, including customs performance, infrastructure quality, timeliness of shipments, etc. The data used in the ranking come from a survey of logistics professionals who are asked questions about the foreign countries in which they operate. The components analyzed in the International LPI were chosen based on recent theoretical and empirical research and on the practical experience of logistics professionals involved in international freight forwarding. The specific indicators are described in Table 1.

Table 1. LPI sub-indicators and their meanings.

LPI Sub-Indicators	Description
Customs	Efficiency of customs clearance processes for customs control agencies, such as speed, simplicity, and predictability of procedures
Infrastructure	Quality of transport and logistics IT infrastructure
International shipments	Convenience and affordability of international transportation
Logistics service quality and competence	Competitiveness and quality of logistics services
Tracking & tracing	The ability to track and trace the shipment of goods
Timeliness	The rate of arrival of goods in a given or expected time period

Note: The data come from the World Bank. https://lpi.worldbank.org/ (accessed on 5 August 2022).

The LPI uses standard statistical techniques to aggregate the data into a single indicator that can be used for cross-country comparisons. The indicator ranges from 1 to 5; the higher the score, the better the performance. Table 2 shows the LPI scores of the top 10 countries in the world (see S1 in Supplementary Materials for full data) and that of China from 2012 to 2018. As can be seen, most countries with high LPI are in Europe, while Japan and Singapore are the only two Asian countries among the top 10. In terms of the rank, Germany occupies the first in the recent three surveys, with the scores of 4.12, 4.23, and 4.20, respectively. By contrast, the rank of Singapore declined gradually from 1 in 2012 (4.13) to 7 in 2018 (4.00). As for the performance of China, it almost remains stable, ranking 26th in the world during the period from 2012 to 2018, with a slight decrease in 2014 (28) and 2016 (27).

When it comes to the average annual growth rate, it can be used to assess the development trend and outlook of a country's LP level. According to Table 3, among the top 10 LPI countries in 2018, Sweden (1.70%), Germany (1.39%), and Austria (1.19%) ranked top three in terms of average annual growth, while Singapore (−1.06%), Finland (−0.66%), and Denmark (−0.25%) experienced negative growth. Although China's LPI only ranked 26th in 2018, its average annual growth rate (0.85%) ranked 5th among the top ten countries, indicating that China's cross-border logistics have developed rapidly in the past few years.

Table 2. LPI ranks and scores of top 10 countries and China.

Country	2018		2016		2014		2012	
	Rank	Score	Rank	Score	Rank	Score	Rank	Score
Germany	1	4.20	1	4.23	1	4.12	4	4.03
Sweden	2	4.05	3	4.20	6	3.96	13	3.85
Belgium	3	4.04	6	4.11	3	4.04	7	3.98
Austria	4	4.03	7	4.10	22	3.65	11	3.89
Japan	5	4.03	12	3.97	10	3.91	8	3.93
Netherlands	6	4.02	4	4.19	2	4.05	5	4.02
Singapore	7	4.00	5	4.14	5	4.00	1	4.13
Denmark	8	3.99	17	3.82	17	3.78	6	4.02
United Kingdom	9	3.99	8	4.07	4	4.01	10	3.90
Finland	10	3.97	15	3.92	24	3.62	3	4.05
China	26	3.61	27	3.66	28	3.53	26	3.52

Note: The data come from the World Bank. https://lpi.worldbank.org/ (accessed on 10 August 2022).

Table 3. LPI and average annual growth rate of top 10 countries and China.

Countries	2018	2016	2014	2012	Average Annual Growth Rate/%
Germany	4.20	4.23	4.12	4.03	1.39
Sweden	4.05	4.20	3.96	3.85	1.70
Belgium	4.04	4.11	4.04	3.98	0.50
Austria	4.03	4.10	3.65	3.89	1.19
Japan	4.03	3.97	3.91	3.93	0.84
Netherlands	4.02	4.19	4.05	4.02	0.00
Singapore	4.00	4.14	4.00	4.13	−1.06
Denmark	3.99	3.82	3.78	4.02	−0.25
United Kingdom	3.99	4.07	4.01	3.90	0.76
Finland	3.97	3.92	3.62	4.05	−0.66
China	3.61	3.66	3.53	3.52	0.85

Note: Average annual growth rate = $\sqrt[3]{\frac{LPI2018}{LPI2012}} - 1$; data calculated based on the LPI released by the World Bank from 2012 to 2018. https://lpi.worldbank.org/ (accessed on 5 September 2022).

4.2. Analysis Methods and Results

Theoretical analysis shows that the export value Eh expressed in domestic prices is derived from the transportation cost T, and there is $\partial Eh/\partial T = Ph * \partial Q/\partial T = -bPh * \partial Pf/\partial T = -bPh2D * e^{TD}$. The expression of $\partial Eh/\partial T$ contains the variable T, so it is not a constant. Therefore, the relationship between the transportation cost T and the export value Eh is not a simple linear relationship, so the linear correlation method cannot be used for empirical research. However, $\partial Eh/\partial T < 0$ is certain, that is, when the logistics transportation cost T drops, the export value expressed in domestic prices will increase. In other words, the higher the value of the LPI, the lower the logistics transportation cost T and the higher the export level (EXP). Therefore, Spearman rank correlation can be used to test the relationship between the LPI and the EXP of a certain period.

Spearman rank correlation, named after Charles Spearman, is a method for studying the relationship between two variables based on rank information. It is based on the difference between two pairs of ranks and is also known as one of the "Coefficient of rank correlation". In practical applications, when the raw information obtained has no specific data representation and can only be used to describe a certain phenomenon in terms of rank, the coefficient of rank correlation can be used to analyze the correlation between phenomena.

The calculating procedures are as follows: (1) suppose two random variables are X and Y (which can also be regarded as two sets), both of which have n elements; (2) the i ($1 \leq i \leq n$) values taken by the two random variables are denoted by Xi and Yi, respectively; (3) sort X and Y (both in ascending or descending order) to obtain two sets x and y, where elements xi and yi are the ranks of Xi in X and Yi in Y, respectively; (4) the elements in the set x and y are correspondingly subtracted to obtain a ranking difference set d, where $di = xi - yi$ ($1 \leq i \leq n$). The Spearman rank correlation coefficient between the random variables X and Y can be calculated from x, y or d, which is shown below:

$$r_s = 1 - \frac{6\sum d_i^2}{n(n^2 - 1)} = 1 - \frac{6\sum (x_1 - y_1)^2}{n(n^2 - 1)} \quad (12)$$

The coefficient of rank is the same as the correlation coefficient r_s, taking values between -1 and $+1$. $r_s > 0$ indicates positive correlation of X and Y; $r_s < 0$ shows negative correlation; $r_s = 0$ means no correlation. The difference from the normal correlation coefficient is that the rank correlation coefficient is calculated on the basis of rank rather than specific values, which is more applicable to reflect the correlation of serial variables.

Here, we use Formula (12) to test the correlation between LPI and EXP of 160 countries around world in 2018. The calculation process of the rank correlation coefficient is shown in Table 4 (part of the data is selected; see S2 in Supplementary Materials for full data). The LPI is queried from the international LPI released by the World Bank. The EXP listed in the table uses the ratio of the exports of goods and services of a country to its GDP in 2018, which would make the result more objective due to the different sizes of countries. The exports of goods and services represent the value of all goods and other market services provided to the rest of the world. They include the value of merchandise, freight, insurance, transport, travel, royalties, license fees, and other services but exclude compensation of employees and investment income (formerly called factor services) and transfer payments.

Table 4. Procedures for calculating the coefficient of rank correlation of LPI and EXP in 2018.

Code Name	LPI	EXP	Rank of LPI (lpi_i)	Rank of EXP (exp_i)	$(lpi_i - exp_i)^2$
German	4.2	47.3	1	40	1521
Sweden	4.05	45.7	2	42	1600
Belgium	4.04	29.1	3	88	7225
Austria	4.03	55.4	4	31	729
Japan	4.03	18.3	5	121	13,456
Netherlands	4.02	84.7	6	10	16
Singapore	4	176.3	7	3	16
Denmark	3.99	56.6	8	29	441
United Kingdom	3.99	30.5	9	84	5625
Finland	3.97	38.5	10	63	2809
United Arab Emirates	3.96	93	11	8	9
Hong Kong SAR, China	3.92	188.3	12	2	100
Switzerland	3.9	66.2	13	21	64
United States	3.89	12.3	14	136	14884
New Zealand	3.88	27.9	15	94	6241
France	3.84	31.7	16	77	3721
Spain	3.83	35.2	17	70	2809
Australia	3.75	21.9	18	111	8649
Italy	3.74	31.4	19	80	3721
Canada	3.73	32.3	20	75	3025

Table 4. *Cont.*

Code Name	LPI	EXP	Rank of LPI (lpi_i)	Rank of EXP (exp_i)	$(lpi_i - exp_i)^2$
Norway	3.7	38	21	64	1849
Czech Republic	3.68	77	22	13	81
Portugal	3.64	43.4	23	44	441
Luxembourg	3.63	196.4	24	1	529
Korea, Rep.	3.61	41.7	25	50	625
China	3.61	19.1	26	117	8281
...					
Libya	2.11	39.6	154	56	98
Haiti	2.09	NA	155	NA	0
Sierra Leone	2.08	17.5	156	123	33
Niger	2.07	11.8	157	126	31
Burundi	2.06	5.7	158	142	16
Angola	2.05	40.8	159	54	105
Afghanistan	1.95	NA	NA	NA	0

Note: 17 countries whose export data of 2018 are not available from the World Bank are excluded when calculating $(lpi_i - exp_i)^2$. Data come from World Bank national accounts data and OECD National Accounts data files. https://data.worldbank.org/country. https://data.worldbank.org/indicator/NE.EXP.GNFS.ZS?view=chart (accessed on 8 September 2022).

Specific calculating processes are as follows: first, rank the LPI and EXP of each country according to their scores. Then, set the ranks of LPI and EXP as lpi and $expi$, respectively. Finally, bring lpi and exp into the Formula (12):

$$r_s = 1 - \frac{6\sum(lpi_i - exp_i)^2}{n(n^2 - 1)} \tag{13}$$

As mentioned above regarding the correlation coefficient, if $r_s > 0$, the rank variable lpi and exp are positively correlated; if $r_s < 0$, the rank variable lpi and exp are negatively correlated; if $r_s = 0$, the rank variable lpi and exp are not correlated.

Here are the general steps of null hypothesis testing: first, put forth the hypothesis. According to the theoretical derivation result in Section 3, LPI are positively correlated with EXP, so the following hypothesis tests can be put forward:

$$H_0 : r_s > 0 ; H_1 : r_s \leq 0 \tag{14}$$

Second, give a significant level. In this case, we set $\alpha = 0.01$ as the significant level.

Third, choose the testing method. If the sample size is greater than 30 and the data shows a normal distribution, the Z-Score Test is applied. As the sample size in this case is 143 (160 − 17), it is far greater than 30, and when $n > 10$, the correlation coefficient r_s approximately obeys the normal distribution $N(0, \frac{1}{n-1})$, so the Z-Score Test is used to test the hypothesis (14). The Z-Score is the non-standard normal distribution normalized by x that is $Z = \frac{x-\mu}{\sigma}$. The Z value statistic for the above hypothesis test is $Z = \frac{r_s - 0}{\sqrt{1/(n-1)}}$. If $Z > Z\alpha$, then the null hypothesis H_0 cannot be rejected. It indicates that the LPI is positively correlated with the EXP, showing the improvement of a country's logistics efficiency will enhance its EC. If $Z < Z\alpha$, reject the hypothesis H_0, which means the LPI is not positively correlated with the EXP. Therefore, developing logistics efficiency cannot improve EC. According to Table 4, there are 143 valid samples in this case, and $\sum(lpi_i - exp_i)^2 = 335595$, so $r_s = 1 - \frac{6 * 335595}{143(143^2 - 1)} = 0.3114$, $Z = \frac{0.3114 - 0}{\sqrt{1/(143 - 1)}} = 3.72$. Given the significance level $\alpha = 0.01$, queried from the Standard Normal Distribution table with common values, $Z_{0.01} = 2.32$, so $Z > Z_{0.01}$, the null hypothesis H_0 cannot be rejected, that is, the conclusion is that the LPI is significantly positively correlated with the EXP, and improving a country's logistics efficiency can boost its EC.

5. A Case Study of China

5.1. LPI of China

As a major export country, China attaches great importance on the construction of cross-border LP and has gained great achievements. In order to enhance the competitiveness of international trade, China established 15 free trade zones and 18 pilot free trade zones by 2019. In the 2018 International LPI Survey conducted by the World Bank and Turku School of Economics and Business Administration, China's comprehensive LPI scored 3.61 points, ranking 26th in the world, while its export values accounted for 19.10% of GDP in the same period, ranking 117th among the 160 countries. It is evident that the construction of China's cross-border logistics system is relatively ahead of its export level.

Table 5 shows the gap between China's LP sub-item scores in 2018 and the top 10 countries in the world. Germany is the country with the highest comprehensive index of global LP, and it ranks first in terms of customs clearance efficiency, infrastructure, and logistics quality and competence. Belgium is dominant in international shipments and timeliness, while Finland is the leader in tracking and tracing. In comparison, the scores of China's infrastructures and difficulty of arranging freight are higher than the comprehensive scores, and the scores are lower than the comprehensive scores in terms of customs clearance efficiency, logistics quality, cargo tracking ability, and timeliness. China has strong "hard power" in international logistics, but lacks "soft power", especially in terms of customs clearance efficiency [49], which is significantly lower than the overall score. Evidently, China should pay more attention to developing the "soft power" of its cross-border logistics capabilities in terms of cargo clearance and logistics services to reduce international logistics and transportation costs and enhance EC.

Table 5. Comparison of LP scores of 2018 between China and the top 10 countries.

Country	Customs		Infrastructure		International Shipments		Logistics Quality and Competence		Tracking and Tracing		Timeliness	
	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank	Score	Rank
China	3.29	31	3.75	20	3.54	18	3.59	27	3.65	27	3.84	27
Germany	4.09	1	4.37	1	3.86	4	4.31	1	4.24	2	4.39	3
Sweden	4.05	2	4.24	3	3.92	2	3.98	10	3.88	17	4.28	7
Belgium	3.66	14	3.98	14	3.99	1	4.13	2	4.05	9	4.41	1
Austria	3.71	12	4.18	5	3.88	3	4.08	6	4.09	7	4.25	12
Japan	3.99	3	4.25	2	3.59	14	4.09	4	4.05	10	4.25	10
Netherlands	3.92	5	4.21	4	3.68	11	4.09	5	4.02	11	4.25	11
Singapore	3.89	6	4.06	6	3.58	15	4.1	3	4.08	8	4.32	6
Denmark	3.92	4	3.96	17	3.53	19	4.01	9	4.18	3	4.41	2
UK	3.77	11	4.03	8	3.67	13	4.05	7	4.11	4	4.33	5
Finland	3.82	8	4	11	3.56	16	3.89	15	4.32	1	4.28	8
Japan	3.99	3	4.25	2	3.59	14	4.09	4	4.05	10	4.25	10

Note: the data come from the World Bank. https://lpi.worldbank.org/ (accessed on 5 August 2022).

Despite its relatively lower rank compared to the leading ones, China's LPI is generally higher than the global average, and its ranking continues to improve between 2012 and 2018. As shown in Table 6, China's logistics performance values of 3.52, 3.53, 3.66, and 3.61 in 2012, 2014, 2016, and 2018, respectively, are significantly higher than the global average of each year. The gap in LPI between China and the top 10 developed countries continues to narrow, with the gap decreasing from −0.48 in 2012 to −0.43 in 2018. It is predicted that the level of logistics performance of China would continue to rise. It is evident that the increase in LPI would stimulate the EC of China.

Table 6. Comparison of China's LPI indicators with the world average between 2012 and 2018.

Year	China	Top 10	Bottom 10	Average (Global)	Gap between China and the World Average	Gap between China and the Top 10 Average
2012	3.52	4.00	2.00	2.87	0.65	−0.48
2014	3.53	3.99	2.06	2.89	0.64	−0.46
2016	3.66	4.13	1.91	2.88	0.78	−0.47
2018	3.61	4.04	2.08	2.87	0.74	−0.43

Note: Averages calculated based on the LPI released by the World Bank from 2012 to 2018. https://lpi.worldbank.org/ (accessed on 5 September 2022).

5.2. Problems and Solutions to the Case

Although the strong development of transportation and logistics infrastructure has made a significant contribution to the improvement of the LPI of China in recent years, the ranking of China's LPI has been in a lingering stage since 2012, and the massive investment in transportation and logistics infrastructure has not been fully transformed into higher logistics transportation service quality. In order to progress from a logistics country of large scale to one of high quality, there are still some problems for China that need to be overcome urgently, which are discussed below.

Firstly, it is essential to continue to strengthen the construction of logistics infrastructure and focus on the improvement of the comprehensive transportation system in order to lay a solid foundation for improving the LPI. Secondly, it is also necessary to focus on the improvement of soft power such as the quality of logistics services and brand image, especially the quality of key logistics service providers. Cultivation and improvement of core competitiveness are necessary to support core logistics enterprises to go international. Thirdly, it is necessary to actively optimize customs and border management processes to shorten the time and cost of international logistics transactions. Fourthly, it is necessary to optimize the logistics business environment and promote the competitiveness of the industry with a benign market operation mechanism. The fifth suggestion is to speed up the improvement of the level of regional trade facilitation to realize the efficient flow of goods and the extensive sharing of information. Finally, it is of crucial importance to accelerate the application of green and smart logistics technology to ensure accurate tracking of goods and timeliness of services.

Another notable issue is the scarcity of logistics talent. At present, logistics professionals have been listed as one of the 12 types of talents in short supply in China, with a gap of more than 600,000. According to the "Long-term Plan for the Development of the Logistics Industry (2014–2020)", the number of logistics practitioners in China is growing at an average annual rate of 6.2%, and the demand for logistics jobs will increase by about 1.8 million people each year. Although there are more than 2000 colleges and universities offering logistics majors in China, plus third-party training institutions and public training bases, to supply hundreds of thousands of professionals each year, the number of professionals still cannot meet the demand. Currently, the demand for logistics talent ranges from high-end logistics planning and design personnel to middle-level logistics management, so there is an overall shortage of personnel and grassroots management and operation personnel, as well as high-, medium-, and low-end talent, in the logistics industry.

The following aspects should also be taken into consideration. First, the unbalanced economic development and different industrial structures in various regions of China have caused regional differences in the level of logistics development. Second, the geographical advantages and characteristics of regions are different, resulting in significant differences in the types and positions of demand for logistics employees, which further exacerbates the demand for logistics talent. Third, the hierarchical structure of logistics talent does not meet the needs of industry development. From the perspective of talent demand, logistics companies have the largest demand for primary positions, such as front-line

skilled personnel, accounting for 69% of the total demand, but the talent training structure of colleges and universities is the opposite.

In addition to the employment problems, as the main body of the logistics market, logistics enterprises should take more responsibility in improving China's LP. It may be a good method to introduce the performance evaluation mechanism of logistics enterprises. Enterprise LP evaluation refers to the application of specific enterprise LP evaluation indicators. By comparing these indicators with unified logistics evaluation standards, corresponding evaluation models, and evaluation calculation methods, logistics enterprises can achieve lower enterprise logistics costs and more objective, fair, and accurate judgments of effectiveness (output and benefit). Research on the performance evaluation of logistics enterprises can further enrich the theory of performance evaluation, and at the same time, performance evaluation is the premise and foundation of performance management.

The purpose of LP evaluation research is to find the weak links of logistics operation through performance evaluation to better achieve logistics goals through continuous improvement. Some suggestions should be put forward to improve LP evaluation:

(1) Excellent LP is based on the effectiveness of the cycle of measurement-assessment-plan-improvement. Therefore, to establish an effective LP management system, it is necessary to ensure an effective supervision and communication system.
(2) Integrate logistics functions, including internal and external integration, to improve LP. Empirical studies have found that logistics integration is significantly correlated with LP improvement. Successful intralogistics integration generally consists of the following important factors: senior management support, company-wide commitment/attitude change, communication and training within the portfolio, practical planning, good information acquisition, system design to support customer service, ease of use, system flexibility, cost–benefit ratio, etc.; the purpose of the integration with the outside is to implement supply-chain management and establish a real-time, interactive, and shared integrated information platform.
(3) Strengthen customer relationship management and knowledge management. Through relationship management and knowledge management, logistics enterprises can obtain and share information and knowledge as well as customer perception, which helps them find the gap between enterprise performance and customer perception to narrow the gap and improve LP.
(4) Establish strategic partnerships with suppliers and third-party logistics providers to help them improve LP. In cross-border trades, LP not only depends on domestic logistics enterprises but is also directly related to the performance of overseas logistics enterprises. Since the LP level of some developing countries is relatively backward, Chinese logistics enterprises should actively cooperate with suppliers and third-party logistics enterprises in other countries to promote each other while developing themselves and to realize the overall LP enhancement.

6. Discussion and Implications

The contribution of logistics performance to export competence cannot be ignored. There is a lack of a unified framework discussed in the literature that can test the correlation between the logistics performance index and the export level. To fill this research gap, the present study put forth a conceptual model based on the "iceberg transportation cost" theory of Samuelson and Krugman. The study finds that the higher the logistics transportation performance, the smaller the transportation cost coefficient per unit distance, and the smaller the total transportation cost, the lower the selling price of domestic products in foreign markets. When the logistics and transportation costs decrease, the demand for domestic products Q by foreign consumers will increase, and the export value expressed in domestic prices will rise. With reference to the comprehensive international LPI released by the World Bank, using Spearman's rank correlation, this study also verified that at a significant level of 1%, the LPI has a positive rank correlation with the EXP. Therefore, improving LP can significantly increase EC.

In addition to the theoretical contribution of the research, a case study on China was fully discussed in Section 5. Although China has become one of the strong logistics countries in scale, there is still a long way to go to become one of major countries in quality, especially in terms of customs clearance efficiency. Furthermore, according to the research results, some suggestions to improve China's LP level are put forward: from the perspective of the LPI index, China should improve the comprehensive strength of cross-border logistics in terms of cargo clearance and logistics services, so as to reduce the cost of international logistics transportation and improve EC; from the perspective of logistics talent demand, it is urgent to cultivate qualified and high-quality front-line logistics operators to make up for the manpower gap; from the perspective of the development of logistics enterprises, it is crucial to introduce the LP evaluation mechanism so as to find the weak links in logistics operations and then better achieve the goal of improving LP through continuous promotion. The above problems and recommendations concerning China's case would also be useful for other countries in a similar situation.

The findings of the research may spur public and private agencies that have direct or indirect influence over LP to focus attention on altering the most relevant aspects of LP to improve their country's export ability in today's global economy. Moreover, as our logistics metrics are directly related to operational performance, countries can use these metrics to target actions to improve and monitor the progress of their logistics.

7. Conclusions

Based on the "iceberg transportation cost" theory of Samuelson and Krugman, this paper studies the economic relationship between logistics transportation performance and EC. The proposed framework in the case study could be used as a benchmark for promoting the EC level by improving the LP of a country, specifically for other developing countries. This paper firstly put forward conceptual models based on the 'iceberg transport cost' theory. Theoretical analysis concerning logistics efficiency and export price and LP and export value is conducted in Section 3. The results show that the improvements in LPI can boost EC and expand the value of exports in terms of domestic prices. In addition, Spearman's rank correlation was used to test the rank correlation between a country's international LPI and its level of exports, which verified the contribution of LPI to EC. Then, there is also a case study on China's LPI to support the conclusion derived from the theoretical analysis. At the same time, countermeasures for the Chinese case are proposed in the discussion section. Overall, it is evident that the theoretical approach and the validation method can be applied to test the relationship between LPI and EC in other countries. Moreover, the proposed suggestions for the Chinese case could be a reference for other countries, especially developing ones.

This study still has some limitations. Firstly, the content analysis could be expanded to involve a greater number of countries, and the analysis could focus on characteristics of the case country, such as infrastructure, timeliness, or customs clearance. Another limitation is that the data selected in the study belong to 2018 since there has been no updated information by the World Bank due to the COVID-19 pandemic. Further research can pay more attention to the application of this model and empirical method to other countries and regions, especially with regard to specific index comparisons. Furthermore, new characteristics of the relationship between the LPI and EXP in the context of the global pandemic would also be worth studying to make more contributions to export competence development by improving the quality of logistics performance of different countries and areas.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su15010490/s1, S1: LPI scores of countries in the world 2012–2018; S2: Procedures for calculating the coefficient of rank correlation of LPI and EXP in 2018.

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References

1. Langley, C.J.; Coyle, J.J.; Gibson, B.J.; Novack, R.A. *Managing Supply Chains, a Logistics Approach*; Thomson South-Western: Mason, OH, USA, 2008.
2. Mangan, J.; Lalwani, C.; Butcher, T. *Global Logistics and Supply Chain Management*, 2nd ed.; John Wiley & Sons: New York, NY, USA, 2008.
3. Rushton, A.; Croucher, P.; Baker, P. *The Handbook of Logistics and Distribution Management*; Kogan Page: London, UK, 2006. [CrossRef]
4. CILT. Available online: http://www.ciltuk.org.uk/pages/royalcharter (accessed on 2 August 2012).
5. Arvis, J.F.; Ojala, L.; Wiederer, C.; Shepherd, B.; Raj, A.; Dairabayeva, K.; Kiiski, T. *Connecting to Compete 2018: Trade Logistics in the Global Economy*; World Bank: Washington, DC, USA, 2018. [CrossRef]
6. Balcik, B.; Beamon, B.M. Facility location in humanitarian relief. *Int. J. Logist. Res. Appl.* **2008**, *11*, 101–121. [CrossRef]
7. Hotrawaisaya, C.; Chandraprakaikul, W.; Suthikarnarunai, N. Performance improvement by logistics collaboration management model for orchid flower industry in Thailand. *Eng. Manag. Res.* **2014**, *3*, 52–68. [CrossRef]
8. Lai, K.; Ngai, E.W.T.; Cheng, T.C.E. Measures for evaluating supply chain performance in transport logistics. *Transp. Res. Part E* **2002**, *38*, 439–456. [CrossRef]
9. Lu, C. The impact of carrier service attributes on shipper-carrier partnering relationships: A shipper's perspective. *Transp. Res. Part E* **2003**, *39*, 399–415. [CrossRef]
10. Simatupang, T.M.; Sridharan, R. The collaborative supply chains. *Int. J. Logist. Manag.* **2002**, *13*, 15–30. [CrossRef]
11. Vieira, J.G.V.; Yoshizaki, H.T.; Ho, L.L. The effects of collaboration on LP and transaction costs. *Int. J. Bus. Sci. Appl. Manag.* **2015**, *10*, 1–14.
12. Baker Library. *Tudor Company Records*; Harvard Business School: Boston, MA, USA, 1752–1864.
13. Turkson, F.E. *Logistics and Bilateral Exports in Developing Countries: A Multiplicative Form Estimation of the Logistics Augmented Gravity Equation*; CREDIT Research Paper; University of Nottingham, CREDIT: Nottingham, UK, 2011; p. 11.
14. Wyeth, N. *The American Almanac and Repository of Useful Knowledge, for the Year 1849*; Metcalf and Company: Cambridge, UK, 1848; pp. 175–180.
15. Herold, M.W. Ice in the Tropics: The Export of 'Crystal Blocks of Yankee Coldness' to India and Brazil. *Revista Espaço Acadêmico* **2011**, *11*, 162–177.
16. Samuelson, P.A. The transfer problem and transport costs: The terms of trade when impediments are absent. *Econ. J.* **1952**, *62*, 278–304. [CrossRef]
17. Krugman, P. Intraindustry specialization and the gains from trade. *J. Political Econ.* **1981**, *89*, 959–973. [CrossRef]
18. Krugman, P. Increasing returns and economic geography. *J. Political Econ.* **1991**, *99*, 483–499. [CrossRef]
19. Krugman, P. *Geography and Trade*; MIT Press: Cambridge, MA, USA, 1992.
20. González-Val, R.; Pueyo, F. Trade liberalization and forest transition. *Int. J. Econ. Theory* **2017**, *13*, 269–287. [CrossRef]
21. Sedgley, N.; Elmslie, B. Discrimination, human capital, and life expectancy in a model of economic development. *Int. J. Econ. Theory* **2018**, *14*, 211–231. [CrossRef]
22. McCann, P. Transport costs and new economic geography. *J. Econ. Geogr.* **2005**, *3*, 305–318. [CrossRef]
23. Ottaviano, G.; Tabuchi, T.; Thisse, J.F. Agglomeration and trade revisited. *Int. Econ. Rev.* **2002**, *43*, 409–435. [CrossRef]
24. Irarrazabal, A.; Moxnes, A.; Opromolla, L.D. The tip of the iceberg: A quantitative framework for estimating trade costs. *Rev. Econ. Stat.* **2015**, *97*, 777–792. [CrossRef]
25. Forslid, R.; Okubo, T. Which firms are left in the periphery? Spatial sorting of heterogeneous firms with scale economies in transportation. *J. Reg. Sci.* **2015**, *55*, 51–65. [CrossRef]
26. Forslid, R.; Okubo, T. Big is beautiful when exporting. *Rev. Int. Econ.* **2016**, *24*, 330–343. [CrossRef]
27. Bosker, M.; Buringh, E. Ice(berg) transport costs. *Econ. J.* **2020**, *130*, 1262–1287. [CrossRef]
28. Miguel, P.A.; Fernando, S.G. Transport costs in new economic geography models: A more realistic approach. *Int. J. Econ. Theory* **2021**, *17*, 221–233. [CrossRef]

29. Limao, N.; Venables, A.J. Infrastructure, geographical disadvantage, transport costs and trade. *World Bank Econ. Rev.* **2001**, *15*, 451–479. [CrossRef]
30. Wilson, J.S.; Mann, C.L.; Otsuki, T. Assessing the benefits of trade facilitation: A global perspective. *World Econ.* **2005**, *28*, 841–871. [CrossRef]
31. Nordas, H.; Pinali, E.; Grosso, M. Logistics and time as a trade barrier. *OECD Trade Policy Work. Pap.* **2006**. [CrossRef]
32. Iwanow, T.; Kirkpatrick, C. Trade facilitation and manufactured exports: Is Africa different? *World Dev.* **2009**, *37*, 1039–1050. [CrossRef]
33. Behar, A.; Manners, P. *Logistics and Exports*; Department of Economics and CSAE Working Paper Series; CSAE: Oxford, UK, 2008.
34. Guner, S.; Coskun, E. Comparison of impacts of economic and social factors on countries LPs: A study with 26 OECD countries. *Res. Logist. Prod.* **2012**, *2*, 329–343.
35. Hausman, W.H.; Lee, H.L.; Subramanian, U. The impact of LP on trade. *Prod. Oper. Manag.* **2013**, *22*, 236–252. [CrossRef]
36. Portugal, P.; Wilson, J.S. Export performance and trade facilitation reform: Hard and soft infrastructure. *World Dev.* **2012**, *40*, 1295–1307. [CrossRef]
37. Behar, A.; Manners, P.; Nelson, B. Exports and international logistics. *Oxf. Bull. Econ. Stat.* **2013**, *75*, 855–886. [CrossRef]
38. Arvis, J.F.; Saslavsky, D.; Ojala, L.; Shepherd, B.; Busch, C.; Raj, A. Trade Logistics in the Global Economy: The Logistics Performance Index and Its Indicators. *World Bank Other Oper. Stud.* **2016**, *88*, 400. [CrossRef]
39. Reis, G.M.D.; Amorim, P.S.; Cabral, J.; Sarsfield Pereira Cabral, J.A.; Toloi, R.C. The impact of logistics performance on Argentina, Brazil, and the US soybean exports from 2012-2018: A gravity model approach. *Agriculture* **2020**, *10*, 338. [CrossRef]
40. Yan, B.; Li, Q. A Comparison of Logistics Development in RCEP Countries Based on Logistics Performance Index. *China Circ. Econ.* **2021**, *35*, 21–30.
41. Tao, Z.; Qiao, S. A Study on the Influencing Factors of International Trade in "One Belt, One Road": An Empirical Test of Trade Agreements and Logistics Performance. *Soc. Sci.* **2020**, *1*, 63–71.
42. Liang, Y.; Cui, J. The impact of logistics performance on China's trade potential under the "Belt and Road" initiative: An extended gravity model. *Bus. Econ. Res.* **2019**, *1*, 94–97.
43. Lu, H.; Wang, M.; Du, Z. A comparative analysis of logistics performance between China and Central and Eastern European countries along the Belt and Road. *China Circ. Econ.* **2020**, *34*, 55–65.
44. Hummels, D.; Lugovskyy, V.; Skiba, A. The trade reducing effects of market power in international shipping. *J. Dev. Econ.* **2009**, *89*, 84–97. [CrossRef]
45. Hollweg, C.; Wong, M.H. Measuring Regulatory Restrictions in Logistics Services. *Work. Pap.* **2009**. [CrossRef]
46. Kumar, A.; Anbanandam, R. Assessment of environmental and social sustainability performance of the freight transportation industry: An index-based approach. *Transp. Policy* **2022**, *124*, 43–60. [CrossRef]
47. Ger, A.; Zpeynirci, Z.; Semiz, M. Logistics performance index-driven policy development: An application to turkey. *Transp. Policy* **2022**, *124*, 20–32.
48. Li, Y.; Chen, X. Research on ways to improve China's logistics performance index in the context of the World Top 500. *Value Eng.* **2019**, *9*, 69–71.
49. Miao, H. The impact of "One Belt, One Road" international LP on Country's export trade. *Bus. Econ. Res.* **2019**, *5*, 133–136.