# Trade effects of liner shipping across world regions

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## Abstract

**Purpose** – Liner shipping plays a crucial role in facilitating the movement of manufactured goods around the world. While previous literature has shown that liner shipping is an important trade driver, potential differences across trade routes and world regions have not as yet been explored. This paper examines whether the impact of liner shipping on bilateral trade flows differs significantly across world regions, as well as exploring other geographical patterns.

**Design/methodology/approach** – Using state-of-the-art gravity modelling, this paper investigates the impact of the UNCTAD's Liner Shipping Bilateral Connectivity Index on bilateral trade in manufactured goods using a comprehensive database of disaggregated trade data for the period from 2006 to 2019.

**Findings** – The results show that the trade effect of liner shipping is greater in long-distance and interregional bilateral flows. For some regions, such as North America and Oceania, the effect is greater than the world average, while for others, such as Africa and South America, the effect is significantly smaller. The trade effects of liner shipping connectivity on the main east–west routes are average, but clear asymmetry emerges when analysing China's inward and outward trade flows separately.

**Originality/value** – The results of this paper show that the major east–west routes determine the baseline trade effects of liner shipping, demonstrate that some north–south trades such as those involving Oceania generate larger trade effects and confirm that the trade effects of liner shipping can be improved for some world regions such as South America and Africa.

**Keywords** Liner shipping, Maritime connectivity, World regions, East–west trades, North–south trades

**Paper type** Research paper

## 1. Introduction

As occurs with bulk commodities, most merchandise trade is transported by sea. However, manufactures are usually shipped in containers on regular liner services, and deeper integration of the world's economy through global supply chains has increased the importance of maritime connectivity. The quasi-natural experiment of the Suez Canal blockade in March 2021 demonstrated, more than any particular factor, the extent to which international trade and global sourcing depend on maritime trade and liner connectivity.

Around 80% of the value of world trade in manufactures is related to countries in Europe, East Asia and North America. In seaborne trade, the main east–west routes between these three world regions dominate maritime containerised trade with a share of 40% in 2021 (UNCTAD, 2022). Most shipping lines are concentrated in the Northern Hemisphere, while fewer shipping lines connect the southern and northern hemispheres. Overall, major east–west shipping routes constitute the backbone of global shipping networks, with links to secondary north–south ones (Notteboom *et al.*, 2022).

Trade benefits consumers and producers around the world, leads to higher productivity, stimulates competition, promotes innovation and thus fosters the growth and development of countries. With the increasing liberalisation of the world economy, promoted by the World Trade Organisation at the global level and by the signing of numerous preferential trade



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agreements at the regional level, the importance of trade costs and other factors affecting trade has been highlighted. Given the critical importance of maritime transport for global merchandise trade, the impact of maritime connectivity on trade flows has been also studied.

The UNCTAD has been producing the Liner Shipping Connectivity Index (LSCI) since 2004, using actual data from the deployment of the world's container shipping fleet (UNCTAD, 2017). While the LSCI is computed at the country level, the UNCTAD also elaborates a bilateral version of the LSCI, the Liner Shipping Bilateral Connectivity Index (LSBCI). These synthetic indexes can be used to analyse the importance of maritime connectivity as a trade driver. In this sense, recent literature has shown that improved liner shipping connectivity, as measured by the UNCTAD, promotes trade between countries (Fugazza and Hoffmann, 2017; Del Rosal and Moura, 2022). However, previous studies have focused on the average effects of maritime connectivity on trade flows across countries. Given the uneven global distribution of maritime trade flows (e.g. Xu *et al.*, 2015), with most shipping lines serving east–west trade, it is worth investigating whether the trade effects of maritime connectivity are the same for the main maritime routes as for secondary routes. Similarly, it is not known whether liner shipping connectivity has the same effect on deep-sea trade as on short-sea flows. It is also worth exploring how liner shipping connectivity affects China's trade with the rest of the world as China stands out as a major player in world maritime trade and is by far the best connected country in the global shipping network.

The research question of this paper is whether the impact of liner shipping connectivity on bilateral trade flows differs across trade routes and world regions. To investigate this question, a comprehensive database of disaggregated manufacturing data comprising 156 coastal countries for the period 2006 to 2019 and the UNCTAC's LSBCI are used in PPML estimation of a gravity model that allows the identification of differential trade effects of maritime connectivity across world regions and trade routes.

The empirical results of this paper confirm that liner shipping connectivity has an economically and statistically significant positive effect on bilateral trade flows. Main east–west routes determine the baseline trade effects of liner shipping connectivity. These trade effects are very similar among countries in the circum-equatorial trade routes, although the effects are greater for North America and they also show clear asymmetry when China's inward and outward trade flows are analysed separately. North–south trade routes are associated with less intense trade effects except in the case of Oceania, for which a larger effect of maritime connectivity is found.

This paper contributes to the literature by documenting a number of geographical patterns in the trade effects of maritime connectivity. The empirical evidence presented in this paper may be useful in informing policy initiatives taken by international institutions such as the UNCTAD that seek to increase the participation of remote and less developed countries in global trade networks. Finally, the article also opens up avenues for future research on a number of issues that are the subject of initial exploration here.

The rest of the paper is structured as follows: Section 2 reviews the literature on maritime connectivity and trade effects at the country level, Section 3 presents the methodology and data used for the analysis, Section 4 presents the empirical results, discussing the differential trade effects of liner shipping connectivity across world regions and other geographical patterns while Section 5 concludes, outlining some policy implications.

## 2. Literature review

The great advantage of ocean shipping has always been that no other mode of transport can compete in terms of cost over long distances and in large volumes. This advantage has traditionally been associated with bulk commodities, but containerisation and intermodal transport have extended it to general cargo. It is not surprising, therefore, that the first efforts to analyse the effects of maritime connectivity were focused on freight costs. One of the first attempts was carried out by Wilmsmeier *et al.* (2006), who showed the impact of port connectivity on international maritime transport costs. Wilmsmeier and Hoffman (2008) and Wilmsmeier and Martinez-Zarzoso (2010) found a significant cost-reducing effect of liner shipping connectivity on intra-Caribbean and intra-Latin American trade, respectively. Marquez-Ramos *et al.* (2011) documented the importance of maritime connectivity as a determinant of maritime freight rates and how these freight rates affect export flows. Cost-reducing effects of maritime connectivity were also found by Arvis *et al.* (2013) for agricultural and manufactured goods.

The latter paper used the UNCTAD's LSCI as a measure of maritime connectivity. The UNCTAD, the international institution most involved in the systematic analysis of maritime connectivity, has been elaborating the LCSI for coastal countries since 2004. The main objective of the LSCI is to measure the role of countries in the global shipping network. In its most recent version, the LSCI is computed at the country level using current data on the container shipping fleet deployment provided by MDS Transmodal. The UNCTAD also publishes the bilateral version of the LSCI, the LSBCI, which is computed for country pairs [1] (Fugazza *et al.*, 2013; UNCTAD, 2017). The methodology for computing the LSBCI is detailed in Fugazza and Hoffmann (2016). The LSBCI for a country pair A and B is computed using five components, including pure connectivity indicators such as the number of transhipments required to get from A to B, the number of direct connections common to both countries and the geometric mean of the number of direct connections of both countries, but also including intensity indicators such as the degree of competition in shipping services that connect both countries and the size of the largest vessel on the weakest route connecting countries A and B. The five components are normalised and simply averaged to compute the LSBCI, which varies between 0 and 1 and is symmetrical by nature.

Previous evidence has shown that improvements in maritime connectivity are associated with reductions in freight costs, so positive effects on trade volumes can be expected: "Improved liner shipping connectivity can help reduce trade costs and has a direct, positive bearing on trade volumes" (UNCTAD, 2017, p. 99). A number of papers have examined the impact of liner shipping connectivity on trade volumes. Fugazza and Hoffmann (2017) showed that maritime connectivity is an important determinant of trade flows. Using a gravity equation model, they found a positive and significant effect of the LSBCI on bilateral exports. In analysing the impact of the LSBCI and its components on South Africa's import and export trade flows, Hoffmann *et al.* (2020) found significant trade effects in liner shipping connectivity indicators. Lin *et al.* (2020) studied the spatial link between liner shipping connectivity at the country level and merchandise trade, founding that the LSCI has significant direct and spillover effects. Saeed *et al.* (2021) examined the relationships between trade flows, per capita income and maritime connectivity. Del Rosal and Moura (2022) confirmed that better liner shipping connectivity has trade enhancing effects, using finely measured data on seaborne containerised trade flows between EU trading countries and the rest of the world. The positive effects of maritime connectivity have also been confirmed for agricultural trade (Del Rosal, 2023). In general, previous studies on the trade effects of maritime connectivity have focused on identifying average effects at the country level, without analysing the differential effects that may exist, for example, between different maritime routes or between short-sea and deep-sea trade.

Recent data for the period 2019 to 2021 show that around 40% of global containerised trade is concentrated on the main east–west routes, i.e. connecting East Asia, Europe and North America ( UNCTAD, 2022). East–west routes also concentrate most shipping lines and vessels (Wang and Wang, 2011). These facts suggest a first hypothesis for the analysis of the geographical patterns of the trade effects of maritime connectivity, namely whether liner shipping connectivity has differential trade effects along major shipping routes. Recent data also reveal that intraregional trade flows account for more than 25% of global containerised trade (UNCTAD, 2022). Ducruet and Notteboom (2021) and Xu *et al.* (2015) underlined the intensity of intra-regional trade flows, especially in world regions with high internal connectivity such as Asia and Europe. It is also worth exploring whether the trade effects of maritime connectivity are significantly different for intraregional maritime traffic. A closely related hypothesis would be whether there are differential effects for short-sea trade flows. Conversely, it may be that some differential trade effects of liner shipping connectivity occur on long-distance routes. It has been argued that the traditional advantage of ocean shipping has been in long-distance transport of large amounts of freight and that containerisation has extended this advantage to breakbulk cargo (Rodrigue, 2020, chapter 5; Notteboom *et al.*, 2022, chapter 1).

East–west shipping routes therefore form the backbone of global shipping networks. Other routes connect to and complement the dominant circum-equatorial container trade, such as north–south secondary ones (Notteboom *et al.*, 2022). Few shipping lines connect the coasts of South America and Africa, while other regions of the global south, such as Oceania, have a significant number of shipping lines (Wang and Wang, 2011; Xu *et al.*, 2015). This raises the question of whether maritime connectivity has a significant differential effect for world regions served by nonmainline routes.

In terms of the volume of maritime trade, East Asia maintains a clearly dominant position in the global shipping network, driven by the rapid growth of traffic in East Asian ports and especially Chinese ports (Xu *et al.*, 2015). China's trade surge since the 1990s has made the country the factory of the world and the main player in global container trade. In 2021, China alone accounted for about 30% of global container trade by volume (UNCTAD, 2022). The rise of China is associated with structural trade imbalances, which have also led to chronic container imbalances (Theofanis and Boile, 2009). According to the database used in this paper, China's manufacturing trade surplus with the rest of the world grew from around \$600 billion to \$1,200 billion over the sample period. Unsurprisingly, China is also the country with by far the best maritime connectivity, and its lead is growing (UNCTAD, 2022). For all these reasons, China deserves special analysis and it is therefore worth exploring whether there are significant asymmetric effects of maritime connectivity in China's trade flows with the rest of the world. China's trade imbalances suggest that China's directional trade flows may be better analysed separately.

International databases on trade flows at the country level do not usually include any information on the mode of transport or whether the goods are containerised. To circumvent these difficulties, the usual strategy followed in the literature is to define a set of goods that are considered to be "highly containerisable," i.e. manufactured goods which are highly likely to be shipped in containers. This strategy was first proposed by Wilmsmeier *et al.* (2006) and subsequently used in other papers on the impact of maritime connectivity (e.g. Fugazza and Hoffmann, 2017; Hoffmann *et al.*, 2020; Saeed *et al.*, 2021). This paper proposes a different strategy. In the first step, disaggregated bilateral trade data are used to identify highly containerisable goods as those manufactured goods for which the effect of maritime connectivity is positive and significant. The set of highly containerisable goods is then pooled together in a second step to estimate the differential effects of maritime connectivity that may exist across trade routes and across world regions. The next section details the proposed methodology and describes the databases used in the estimations.

## 3. Methodology and data

The gravity equation is the most appropriate framework for analysing bilateral trade flows in value terms as it has a solid theoretical foundation that provides clear guidance for the empirical estimation. Therefore, a gravity model is proposed to obtain consistent estimates of the trade effects of maritime connectivity, here proxied by the UNCTAD's LSBCI.

Anderson and van Wincoop (2004) outlined a gravity model at the good/sector level, based on the assumptions that all goods are differentiated by country of origin and enter in a constant elasticity of substitution (CES) utility function. Solving the consumer's optimisation problem and imposing market clearance conditions, Anderson and van Wincoop (2004, pp. 707–708) arrive at the following structural gravity system for each good class $k$:

$$X_{ijkt} = \frac{Y_{ikt}E_{jkt}}{Y_{kt}}\left(\frac{t_{ijkt}}{\Pi_{ikt}P_{jkt}}\right)^{1-\sigma_k} \tag{1}$$

$$\Pi_{ikt}^{1-\sigma_k} = \sum_j \left(\frac{t_{ijkt}}{P_{jkt}}\right)^{1-\sigma_k}\frac{E_{jkt}}{Y_{kt}} \tag{2}$$

$$P_{jkt}^{1-\sigma_k} = \sum_i \left(\frac{t_{ijkt}}{\Pi_{ikt}}\right)^{1-\sigma_k}\frac{Y_{ikt}}{Y_{kt}} \tag{3}$$

where $X_{ijkt}$ is the value of the trade flow in good $k$ from exporter $i$ to importer $j$ in year $t$, $Y_{ikt}$ is the value of production in exporter $i$ for good $k$ in year $t$, $E_{jkt}$ is the expenditure in importer $j$ for good $k$ in year $t$, $Y_{kt}$ is world output for good $k$ in year $t$, $t_{ijkt}$ is the bilateral trade cost factor and $\sigma_k$ is the elasticity of substitution. The terms $\Pi_{ikt}$ and $P_{jkt}$ represent outward and inward multilateral resistance terms (MRT), respectively, key theoretical components of the structural gravity system.

Based on previous literature (Fugazza and Hoffmann, 2017; Del Rosal and Moura, 2022), the LSBCI is expected to reduce trade costs and to have a positive effect on bilateral trade flows. The bilateral trade cost factor is given by

$$t_{ijkt}^{1-\sigma_k} = \gamma^k \boldsymbol{G_{ijt}} + \beta^k LSBCI_{ijt} \tag{4}$$

where $\boldsymbol{G_{ijt}}$ is a vector of observable gravity variables that may influence trade costs such as distance, contiguity, trade policy variables, etc., and $LSBCI_{ijt}$ is the LSBCI between countries $i$ and $j$ in year $t$.

The estimation of the structural gravity model poses several challenges, as extensively discussed in Head and Mayer (2014) and Yotov *et al.* (2016). Three empirical issues are especially noteworthy. First, the MRTs are not directly observable but have to be controlled for in order to avoid obtaining biased estimates of the parameters of interest. The MRT can be accounted for by the inclusion of exporter-year and importer-year fixed effects, the solution widely used in the gravity literature. The inclusion of these sets of fixed effects will absorb the size variables ($E_{jkt}$, $Y_{ikt}$ and $Y_{kt}$) and any other potential regressor that varies at the country, year and country-year dimensions. Second, endogeneity concerns such as reverse causality may arise when estimating trade determinants using the gravity equation. The common practice to deal with endogeneity concerns is to include country-pair fixed effects. Previous literature has shown that this solution is able to account for the reverse causality between trade flows and liner shipping connectivity (Del Rosal and Moura, 2022). The inclusion of country-pair fixed effects also controls for other unknown time-invariant bilateral determinants of trade, although it also prevents the identification of variables that vary at the country-pair level such as distance between partners and other potential gravity variables of $\boldsymbol{G_{ijt}}$. Third, some functional form has to be assumed and a corresponding estimator applied. Since Santos Silva and Tenreyro (2006), it has become standard to express the gravity equation in exponential form and apply the Poisson pseudo maximum likelihood (PPML) estimator. With this specification $X_{ijkt}$ can include zero trade flows and the PPML estimator is robust to the presence of heteroskedasticity, i.e. the nonconstant variance of the error term associated with bilateral trade data.

With these considerations in mind, the first step in the empirical strategy is to estimate the following gravity equation for each class of manufacturing good $k$:

$$X_{ijkt} = \exp\left[\gamma_1 WTO_{ijt} + \gamma_2 PTA_{ijt} + \beta^k LSBCI_{ijt} + \delta_{ikt} + \theta_{jkt} + \pi_{ijk}\right] + \varepsilon_{ijkt} \quad (5)$$

where $WTO_{ijt}$ is an indicator variable that takes the value of 1 if countries $i$ and $j$ belong to the World Trade Organisation in year t and 0 otherwise, $PTA_{ijt}$ is a trade policy indicator variable that takes the value of 1 if countries $i$ and $j$ have a preferential trade agreement of any kind and 0 otherwise, $\delta_{ikt}$, $\theta_{jkt}$ and $\pi_{ijk}$ are the exporter-year, importer-year and country-pair fixed effects, respectively, and $\varepsilon_{ijkt}$ is the error term.

Estimates of $\beta^k$ are obtained after running the gravity regression for each class of manufacturing goods $k$. The first step in the empirical strategy is completed with the definition of a subsample of highly containerisable goods. In this paper, the highly containerisable goods are defined as those manufactured goods for which the LSBCI is economically and statistically significant. The second step in the proposed strategy is to investigate whether the LSBIC has different trade effects across trade routes and world regions. For this purpose, the following equation can be estimated, pooling all highly containerisable goods:

$$X_{ijkt} = \exp\left[\gamma_1 WTO_{ijt} + \gamma_2 PTA_{ijt} + \beta_1 LSBCI_{ijt} + \beta_2 LSBCI_{ijt} \times ROUTE_{ij} + \delta_{ikt} + \theta_{jkt} + \pi_{ijk}\right] + \varepsilon_{ijkt} \quad (6)$$

Note that, as long as Equation (6) is estimated with pooled data across highly containerisable goods, average effects across goods are revealed. Note also that the fixed effects also vary by good in Equation (6). The interaction term $LSBCI_{ijt} \times ROUTE_{ij}$ is included in Equation (6) to investigate the hypotheses outlined in Section 2. $ROUTE_{ij}$ is the treatment dummy with a generic label defining the route to be investigated. $ROUTE_{ij}$ takes the value 1 if countries $i$ and $j$ belong to the route of interest and 0 otherwise. Alternatively, $ROUTE_{ij}$ can be utilised to investigate possible differences in the effects of liner shipping connectivity for countries belonging to a particular world region. The coefficient $\beta_2$ therefore measures the differential trade effect of the LSBIC for trade flows between countries defined by $ROUTE_{ij}$, being $\beta_1 + \beta_2$ the total trade effect for these trade flows. For example, a positive and statistically significant estimate of $\beta_2$ would indicate that the LSBCI may have a larger trade effect on the route or the region defined by $ROUTE_{ij}$, measured by $\beta_1 + \beta_2$, compared to the effect on the rest of world trade, measured only by $\beta_1$. On the contrary, if the estimate of $\beta_2$ is insignificant, the trade effect is not statistically different from the world average effect.

Two main data sources are combined in the estimations [2]. First, bilateral merchandise trade data are taken from the International Trade and Production Database for Estimation (ITPD-E). The ITPD-E contains data on international and domestic trade in millions of current US dollars for 265 countries and 120 manufactured goods (see Borchert *et al.*, 2021, for further details). Data on ITPD-E manufactured goods are aggregated into the 22 divisions of the International Standard Industrial Classification (ISIC, rev. 3), the good level used in the estimations. LSBCI data for country pairs are provided by the UNCTAD (see footnote 1). The UNCTAD provides LSBCI quarterly data and annual averages are used. Note also that the LSBCI is not computed for a country with itself. Therefore, annual averages across partners are used for LSBCI intranational observations ($LSBCI_{iit}$). ITPD-E and LSBCI data are collected in a sample which comprises 156 coastal countries and 22 manufactured goods for the sample period 2006 to 2019, including zero and missing values. The countries in the sample are grouped into world regions according to the UNCTAD classification of countries by geographical region [3]. Table A1 in the Appendix shows the world region groupings with the 156 countries in the sample, while Table A2 summarises the trade data from the goods perspective. Finally, the data for the trade policy indicator variables are taken from Gurevich and Herman (2018).



## 4. Results

The results of estimating Equation (1) for the 22 ISIC manufactured goods are shown in Table 1. Note that regression results are displayed in rows and multiway clustered standard errors are not reported to save space. The WTO dummy coefficient estimates are mostly positive and statistically significant, and negative and not significant in other cases. Previous literature has found that WTO membership can have unexpected trade effects (e.g. Rose, 2004). The coefficient estimates of $PTA_{ijt}$ have the expected sign and are statistically significant in the majority of cases, implying that the existence of preferential trade agreements between country partners has a positive effect on bilateral trade. Regarding the variable of interest, the LSBCI has a positive and statistically significant effect with 8 out of 22 manufactured goods (shown in bold in Table 1), including food products, wearing apparel, publishing-related products, chemicals, rubber products, nonmetallic products, radio and television products and furniture and other manufacturing products. The regression results for other manufacturers show LSBCI to be positive but insignificant coefficient estimates,

| ISIC Rev.3 | | *WTOijt* | *PTAijt* | *LSBCIijt* | Observations |
|---|---|---|---|---|---|
| 15 | *Food products* | *−0.117* | *0.152**** | *1.303*** | *2,62,254* |
| 16 | Tobacco products | 0.701** | 0.298 | 4.067 | 1,22,675 |
| 17 | Manufacture of textiles | 0.305*** | 0.166*** | 0.272 | 2,45,194 |
| 18 | *Manufacture of wearing apparel* | *0.187**** | *0.158*** | *2.162**** | *2,44,477* |
| 19 | Manufacture of leather | 0.151** | 0.255*** | 0.816 | 2,22,146 |
| 20 | Manufacture of wood | 0.702*** | 0.127*** | 0.349 | 2,08,205 |
| 21 | Manufacture of paper | 0.281*** | −0.0262 | 0.143 | 2,09,029 |
| 22 | *Publishing and media products* | *−0.359* | *0.0264* | *5.163*** | *2,29,335* |
| 23 | Fuel products | −0.287 | 0.258*** | 0.754 | 1,77,773 |
| 24 | *Manufacture of chemical* | *0.0305* | *0.168**** | *2.136*** | *2,58,035* |
| 25 | *Manufacture of rubber and plastics products* | *0.547** | *0.105**** | *1.303**** | *2,52,727* |
| 26 | *Other nonmetallic mineral products* | *0.180*** | *0.0669* | *1.635**** | *2,24,841* |
| 27 | Manufacture of basic metals | 0.0176 | 0.335*** | 0.464 | 2,10,431 |
| 28 | Fabricated metal products | 0.0414 | 0.152*** | 0.758 | 2,53,130 |
| 29 | Machinery and equipment | 0.201** | 0.128*** | 0.780 | 2,64,682 |
| 30 | Office machinery | −0.0342 | 0.0784 | −2.387 | 2,24,873 |
| 31 | Electrical machinery | 0.200 | −0.0954 | −2.045 | 2,51,041 |
| 32 | *Communication equipment* | *−0.624** | *−0.0888* | *1.876*** | *2,38,143* |
| 33 | Medical and precision instruments | −0.275 | 0.0798*** | −0.868 | 2,39,463 |
| 34 | Motor vehicles | 0.429*** | 0.159*** | 0.746 | 2,40,180 |
| 35 | Other transport equipment | 0.631** | −0.00755 | 1.278 | 2,05,518 |
| 36 | *Manufacture of furniture and other manufacturing* | *0.0261* | *0.0965* | *2.972*** | *2,50,288* |

**Note(s):** The statistical inference is based on three-way standard errors clustered by exporter, importer and year, not shown to save space. *, ** and *** denote significance at the 10, 5 and 1 per cent levels respectively. Goods categories correspond to ISIC Rev. 3 divisions and are in italic when the LSBCI has a positive and statistically significant trade effect. See text for further details
**Source(s):** Author's work

**Table 1.**
Estimates by manufactured good

while three cases are negatively signed but also insignificant. An insignificant effect of liner shipping connectivity may be due to a number of reasons. Noncontainerised shipping in general cargo ships, roll-on/roll-off vessels, etc., is also important for trade in manufactures, as is the case of the automotive industry. From a methodological point of view, the lack of information on the mode of transport and whether the cargo is containerised or not may dilute the effect of liner shipping connectivity (Del Rosal and Moura, 2022). In any case, the set of 8 manufactured goods for which the LSBIC has a statistically significant effect forms the subsample of highly containerisable goods that is subsequently used to investigate the differential effects of liner shipping connectivity across trade routes and world regions.

A first set of geographical hypotheses is tested in Table 2 by estimating Equation (2) with pooled data across highly containerisable manufactured goods defined in Table 1. Column (1) reports the benchmark average effect of the LSBCI on world trade. The estimate of $\beta_1$ in Column (1) is positive, large and statistically significant at the 1% level. The LSBCI varies between 0 and 1, and the sample mean is approximately equal to 0.2. With the benchmark estimate of $\beta_1$ in Column (1), an 0.1 increase in the LSBCI generates an increase in bilateral trade of about 19.4%. This result is in the middle range of the readily comparable results of Fugazza and Hoffmann (2017) and Del Rosal and Moura (2022). The most directly comparable result from Fugazza and Hoffmann (2017) would give an equivalent trade effect of the LSBCI of around 31%. In Del Rosal and Moura (2022), a 0.1 increase in the LSBCI led to an increase in bilateral trade of around 5%. It is worth noting that Fugazza and Hoffmann (2017) admittedly did not control for reverse causality. As for Del Rosal and Moura (2022), they finely measured data on seaborne containerised trade, but their sample comprised only European import and export flows, i.e. it lacks global coverage.

Column (2) of Table 2 investigates LSBCI differential effects for circum-equatorial shipping routes. The interaction term $LSBCI_{ijt} \times EASTWEST_{ij}$ is included in Column (2), where $EASTWEST_{ij}$ is a dummy variable that takes the value of 1 if the exporter or the importer belongs to East Asia, Europe or North America and 0 otherwise. The $LSBCI_{ijt} \times EASTWEST_{ij}$ coefficient estimate is positive and large, pointing to a positive differential LSBCI trade effect for the major east–west shipping routes, but is not statistically different from zero. The estimates for $\beta_1$ in Column (2) are somewhat reduced compared to the

| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| $WTO_{ijt}$ | −0.0239* | −0.0422* | −0.0446 | −0.0731** | −0.0270** |
| | (0.0135) | (0.0219) | (0.0418) | (0.0360) | (0.0118) |
| $PTA_{ijt}$ | 0.0866* | 0.0802* | 0.0765* | 0.0754 | 0.0889* |
| | (0.0516) | (0.0480) | (0.0427) | (0.0468) | (0.0508) |
| $LSBCI_{ijt}$ | 1.942*** | 1.723*** | 2.395*** | 2.504*** | 1.845*** |
| | (0.474) | (0.490) | (0.624) | (0.608) | (0.483) |
| $LSBCI_{ijt}$ x $EASTWEST_{ij}$ | | 0.862 | | | |
| | | (0.890) | | | |
| $LSBCI_{ijt}$ x $SAMEREG_{ij}$ | | | −1.019 | | |
| | | | (0.887) | | |
| $LSBCI_{ijt}$ x $SHORTSEA_{ij}$ | | | | −1.132 | |
| | | | | (0.749) | |
| $LSBCI_{ijt}$ x $DEEPSEA_{ij}$ | | | | | 1.564*** |
| | | | | | (0.436) |
| Observations | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 |

**Note(s):** Four-way standard errors clustered by exporter, importer, good and year are in parenthesis. *, ** and *** denote significance at the 10, 5 and 1 per cent levels respectively. See text for further details
**Source(s):** Author's work

**Table 2.** Geographical patterns of the LSBCI trade effects

benchmark world effect of Column (1), pointing to somewhat lesser effect of the LSBCI for the reference trade flows in this regression (routes other than east–west ones). Given that circum-equatorial shipping routes concentrate the greater part of the shipping lines, vessels and vessel capacity, and a great part of global containerised trade, it can be said that the east–west routes predominantly determine the benchmark trade effect of liner shipping connectivity. Column (3) of Table 2 investigates the LSBCI impact on intraregional trade flows with the interaction term $LSBCI_{ijt} \times SAMEREG_{ij}$. The estimate of $\beta_2$ is negative but not statistically significant. Although the LSBCI trade effect for short-sea trade between partners belonging to the same world region suggests a lower intensity, it is not statistically different from the benchmark effect. Closely related issues are further investigated in the last two columns of Table 2. Columns (4) and (5) allow for differential effects for short-sea and deep-see trade, respectively. The LSBCI variable is interacted in Column (4) with $SHORTSEA_{ij}$, which takes the value of 1 if the distance between partners is below the 20th percentile of the distance sample distribution and 0 otherwise. As the differential effect examined in Column (4) is quite similar to that in Column (3), although less restrictive because the exporter and importer may be located in different regions, the result is also similar: The estimate of $\beta_2$ is negative but also statistically insignificant. However, a significant differential effect is found in Column (5) with deep-sea trade. The main regressor is interacted with $DEEPSEA_{ij}$, which takes the value of 1 if the distance between the exporter and the importer is above the 80th percentile of the distance sample distribution and 0 otherwise. The estimate of $\beta_2$ in Column (5) is large, positive and highly significant. Therefore, the estimated effect of the LSBCI over long distances is $1.845 + 1.564 = 3.409$ (standard error 0.598) or about 34% for a one-tenth increase in the LSBCI.

Taken together, the results from Columns (3)–(5) point to a larger trade effect of liner shipping in long-distance and intercontinental bilateral flows. This evidence is consistent with the idea of the advantage of container transport over long, deep-sea distances (Notteboom *et al.*, 2022, chapter 1). The increasing importance of cross-border supply chains would also be responsible for this greater trade effect over long distances: "The international division of production and trade liberalization, commonly referred to as globalization, incited a large number of parts and finished goods to be carried over long distances, which has supported growth in container shipping" (Rodrigue, 2020, p. 173).

The trade effects of liner shipping connectivity across world regions are examined in Table 3. The generic indicator variable $ROUTE_{ij}$ of Equation (2) is defined for the countries of the region in question, which act as trading partners with other countries in the world. For instance, $LSBCI_{ijt} \times AFRICA_{ij}$ in Column (1) interacts $LSBCI_{ijt}$ with the dummy variable $AFRICA_{ij}$, which takes the value of 1 for the export/import flows from/to an African country to/from another country in the rest of the world and 0 otherwise. The same logic is repeated with the interaction terms for the rest of the world regions considered in Table 3. The regression results in Table 3 show that for several regions, including Europe, Central America and the Caribbean and all Asian regions, the differential trade effect of the LSBCI is not statistically different from the world average effect. For North America, however, a positive and significant differential effect is observed. The estimate of $\beta_2$ is 1.957, being statistically significant at the 1% level, so the estimated effect of the LSBCI for North America is $1.574 + 1.957 = 3.531$ (standard error 0.612). Arguably, the case of North America may be positively influenced by the importance of transpacific routes. Vessel movement data for 2018 show the predominance of the Asia–North America routes (Ducruet and Notteboom, 2021).

The results of Table 3 concerning three south regions, namely Africa, South America and Oceania, are of special interest. The interaction term for Africa and South America is negative and statistically significant. The estimated trade effect of the LSBCI for Africa is

**Table 3.** LSBCI trade effects across world regions

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) |
|---|---|---|---|---|---|---|---|---|---|
| $WTO_{ijt}$ | −0.0252 | −0.0256 | −0.0242** | −0.0239 | −0.0203 | −0.0272 | −0.0222 | −0.0228 | −0.0229 |
| | (0.0206) | (0.0171) | (0.00945) | (0.0773) | (0.0144) | (0.0539) | (0.0471) | (0.0154) | (0.0146) |
| $PTA_{ijt}$ | 0.0866* | 0.0864* | 0.0802 | 0.0866 | 0.0880* | 0.0807** | 0.0863 | 0.0868* | 0.0840 |
| | (0.0519) | (0.0490) | (0.0547) | (0.0618) | (0.0524) | (0.0396) | (0.0535) | (0.0525) | (0.0514) |
| $LSBCI_{ijt}$ | 1.982*** | 1.929*** | 1.574*** | 1.942*** | 1.969*** | 1.734*** | 1.856*** | 1.887*** | 1.905*** |
| | (0.475) | (0.484) | (0.551) | (0.498) | (0.474) | (0.536) | (0.524) | (0.496) | (0.483) |
| $LSBCI_{ijt}$ x $AFRICA_{ij}$ | −1.015*** | | | | | | | | |
| | (0.331) | | | | | | | | |
| $LSBCI_{ijt}$ x $EUROPE_{ij}$ | | 0.0446 | | | | | | | |
| | | (0.704) | | | | | | | |
| $LSBCI_{ijt}$ x $NORTHAMERICA_{ij}$ | | | 1.957*** | | | | | | |
| | | | (0.737) | | | | | | |
| $LSBCI_{ijt}$ x $CENTRALAMERICA_{ij}$ | | | | −0.0588 | | | | | |
| | | | | (1.863) | | | | | |
| $LSBCI_{ijt}$ x $SOUTHAMERICA_{ij}$ | | | | | −0.939*** | | | | |
| | | | | | (0.180) | | | | |
| $LSBCI_{ijt}$ x $EASTASIA_{ij}$ | | | | | | 0.666 | | | |
| | | | | | | (1.053) | | | |
| $LSBCI_{ijt}$ x $SOUTHEASTASIA_{ij}$ | | | | | | | 0.505 | | |
| | | | | | | | (0.743) | | |
| $LSBCI_{ijt}$ x $WESTASIA_{ij}$ | | | | | | | | 0.808 | |
| | | | | | | | | (0.606) | |
| $LSBCI_{ijt}$ x $OCEANIA_{ij}$ | | | | | | | | | 3.516*** |
| | | | | | | | | | (0.635) |
| Observations | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1960100 | 1960100 | 1,960,100 |

**Note(s):** Four-way standard errors clustered by exporter, importer, good and year are in parenthesis. *, ** and *** denote significance at the 10, 5 and 1 per cent levels respectively. See text for further details
**Source(s):** Author's work

1.982 - 1.015 = 0.967 (standard error 0.535), i.e. a 0.1 increase in the LSBCI generates an increase in bilateral trade of around 10%. For South American countries, the estimated effect is practically the same (1.969–0.939 = 1.030, standard error 0.340). However, the LSBCI trade effect is larger for Oceania, with an estimate of $\beta_2$ equal to 3.516 and total effect of 1.905 + 3.516 = 5.421 (standard error 0.683), meaning that a 0.1 increase in the LSBCI is associated with an increase in bilateral trade of about 54%. Liner shipping connectivity generates positive trade effects along the north–south secondary routes connecting these three regions to the world's main centres, but the effect for Oceania is 5 times higher. In this case, geographic proximity to Asia is arguably an important, idiosyncratic factor. The link of Oceania with Asian transshipment hubs has long been emphasised (Trace, 2002). While "container shipping between Australasia and East Asia has become the busiest south to north shipping route in the world" (Xu *et al.*, 2015, p. 9), other south regions "are only distributed a few shipping lines and vessels such as the west and east coast of South America and the west and east coast of Africa, and these regions are inactive for the global shipping and trade" (Wang and Wang, 2011, p. 56). Container shipping in Africa has been slower to take off and is still a work in progress, with marked differences between countries (Guerrero *et al.*, 2022). South America has experienced a significant expansion of maritime traffic, with trade flows with Asia becoming increasingly important, but it must still be considered an emerging region in global container trade (Wilmsmeier and Monios, 2016). The contrasting cases of trade effects of liner shipping connectivity in Oceania and South America and Africa are worthy of in-depth study in future work.

The case of China is explored separately in Table 4, which studies the LSBCI trade effects between China and a number of world regions. Given China's large trade surplus, export and import flows are analysed separately. The most striking result of Table 4 is the significant asymmetric LSBCI effects seen between China and several other regions, namely Europe, North America and South America. The trade effects of liner shipping connectivity are larger for China's export flows to these regions. For example, the estimated LSBCI trade effect for China's export flows to North America is 1.859 + 1.695 = 3.554 (standard error 0.798), above the world benchmark effect. These LSBCI trade effects are less intense for China's import flows, although only the estimated effect for China's import flows from Europe (1.964 - 0.999 = 0.965, standard error 0.476) is statistically significant at the 5% level. The same pattern is observed for China's trade flows to Africa, although the differential effects are not statistically significant. Finally, there are no significative differential effects when China's trade with Oceania is analysed in the last two columns of Table 4.

The results for China in Table 4 resemble the well-known problem of the empty container movements. Chronic container imbalances have been associated with structural trade imbalances since the surge of trade in China and other Asian countries (Theofanis and Boile, 2009). The repositioning of empty containers constitutes a complex problem with consequences such as a negative economic impact on shipping companies and environmental impacts on society (Song and Dong, 2015). The novel results of Table 4 also show that unbalanced trade also leads to asymmetric trade effects of maritime connectivity. It appears that the LSBCI trade effects are larger for China's exports of manufactured goods to the America and Europe, while the effects are smaller for China's imports from the same regions. This is despite the fact that freight rates are asymmetrically affected by the cost of repositioning empty containers, with head haul freight rates (e.g. from China to the US) typically higher than back haul freight rates (US to China) (Theofanis and Boile, 2009). Methodologically, this issue reinforces the importance of controlling for reverse causation when studying the trade effects of liner shipping connectivity. But the bottom line of these results from this analysis is that the LSBCI may have asymmetric trade effects when trade imbalances are substantial, in which case directional trade effects need to be analysed.

**Table 4.** China's LSBCI trade effects

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|---|---|---|---|---|---|---|---|---|---|---|
| WTOijt | −0.0288* | −0.0155 | −0.0214* | −0.0299 | −0.0232* | −0.0242* | −0.0238* | −0.0241* | −0.0239* | −0.0238* |
| | (0.0157) | (0.0115) | (0.0118) | (0.0189) | (0.0134) | (0.0134) | (0.0130) | (0.0130) | (0.0134) | (0.0135) |
| $PTA_{ijt}$ | 0.0870* | 0.0865* | 0.0905* | 0.0890* | 0.0865* | 0.0869* | 0.0866* | 0.0866* | 0.0867* | 0.0866* |
| | (0.0525) | (0.0509) | (0.0466) | (0.0505) | (0.0517) | (0.0516) | (0.0519) | (0.0519) | (0.0518) | (0.0516) |
| $LSBCI_{ijt}$ | 1.898*** | 1.964*** | 1.859*** | 1.982*** | 1.931*** | 1.941*** | 1.937*** | 1.942*** | 1.942*** | 1.941*** |
| | (0.454) | (0.473) | (0.461) | (0.462) | (0.476) | (0.475) | (0.475) | (0.473) | (0.474) | (0.474) |
| $LSBCI_{ijt}$ x $CHINA\text{-}EUROPE_{ij}$ | 1.018** | | | | | | | | | |
| | (0.430) | | | | | | | | | |
| $LSBCI_{ijt}$ x $EUROPE\text{-}CHINA_{ij}$ | | −0.999** | | | | | | | | |
| | | (0.436) | | | | | | | | |
| $LSBCI_{ijt}$ x $CHINA\text{-}NORTHAM_{ij}$ | | | 1.695** | | | | | | | |
| | | | (0.664) | | | | | | | |
| $LSBCI_{ijt}$ x $NORTHAM\text{-}CHINA_{ij}$ | | | | −1.686*** | | | | | | |
| | | | | (0.574) | | | | | | |
| $LSBCI_{ijt}$ x $CHINA\text{-}SOUTHAM_{ij}$ | | | | | 2.150*** | | | | | |
| | | | | | (0.640) | | | | | |
| $LSBCI_{ijt}$ x $SOUTHAM\text{-}CHINA_{ij}$ | | | | | | −2.167*** | | | | |
| | | | | | | (0.640) | | | | |
| $LSBCI_{ijt}$ x $CHINA\text{-}AFRICA_{ij}$ | | | | | | | 1.292 | | | |
| | | | | | | | (1.771) | | | |
| $LSBCI_{ijt}$ x $AFRICA\text{-}CHINA_{ij}$ | | | | | | | | −1.264 | | |
| | | | | | | | | (1.883) | | |
| $LSBCI_{ijt}$ x $CHINA\text{-}OCEANIA_{ij}$ | | | | | | | | | −0.0252 | |
| | | | | | | | | | (0.578) | |
| $LSBCI_{ijt}$ x $OCEANIA\text{-}CHINA_{ij}$ | | | | | | | | | | 0.190 |
| | | | | | | | | | | (0.562) |
| Observations | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 | 1,960,100 |

**Note(s):** Four-way standard errors clustered by exporter, importer, good and year are in parenthesis. *, ** and *** denote significance at the 10, 5 and 1 per cent levels respectively. See text for further details
**Source(s):** Author's work

In sum, the results in Tables 2–4 show that the average world effect of the LSBCI on trade is economically and statistically significant, but there may be differential effects when some routes, interregional trade or directional trade flows are analysed. While this might be expected given the inequality in the global shipping network, it had not been documented before.

## 5. Conclusions

The majority of internationally traded manufactured goods are shipped by sea through regular maritime services. Not surprisingly, liner shipping connectivity is an important trade driver of this and better connectivity may be important for enhancing countries' international trade and improving their positioning in global value chains. Previous studies have already found evidence of positive and significant effects of bilateral liner shipping connectivity, although this literature has focused on average effects and has not analysed differential effects across trade routes and world regions. In this regard, this paper highlights several distinctive facts and geographical patterns in the trade-enhancing effects of maritime connectivity. First, these effects are economically and statistically significant for the main east–west trade routes, which set the world benchmark. Second, the effects are larger for long-distance deep-see trade. Third, secondary north–south routes connecting countries from southern regions such as South America and Africa may have smaller trade effects, although the empirical results show that Oceania is an exception. Fourth, China's manufacturing trade surplus is reflected in asymmetric LSBCI trade effects, which are larger and statistically significant for China's export flows to other world regions, including major markets such as Europe and North America.

Based on the findings of this paper, there are several avenues for future research. The identification of differential trade effects of liner shipping connectivity for more specific trade routes could be investigated. Similarly, the analysis could be extended by considering more defined word regions, such as maritime areas or maritime facades. Alternatively, the sectoral dimension could be important in the analysis of some routes. The relationship between trade imbalances and maritime connectivity and the impact on trade is also a promising area of research.

From a policy perspective, additional research is also needed to understand why the trade effects of maritime connectivity are greater on some secondary north–south routes than others. This may be important for intergovernmental institutions such as the UNCTAD, which have done the most to study and promote maritime connectivity. At the very least, the robust empirical results documented in this paper confirm that maritime connectivity as an important driver of trade. The evidence presented in the paper also suggests that the trade effects of the LSBCI may be greater over longer distances, reinforcing the importance of maritime connectivity in reducing the effects of remoteness and distance in small and remote island states (UNCTAD, 2017). Ultimately, maritime transport and connectivity will play an increasingly important role in a liberalised and integrated global economy.

### Notes

1. LSCI and LSBCI data and metadata are available at http://stats.unctad.org/maritime (accessed 31/8/2023). Since 2020, the indexes have been published quarterly. The LSCI is computed at both port and country levels, while the LSBCI is computed for country pairs. See also UNCTAD (2022).

2. All estimations are performed using the "ppmlhdfe" STATA command, which allows for fast estimation of PPML models with multiple high-dimensional fixed effects (Correia *et al.*, 2020). The standard errors are clustered on all possible dimensions of the data, namely exporter, importer and year in the estimations of Equation (5) and exporter, importer, good and year in the estimations of Equation (6). Multi-way clustering leads to more conservative inferences (Egger and Tarlea, 2015).

3. See https://unctadstat.unctad.org/en/classifications.html (accessed 31/8/2023). Note that the only departure from UNCTAD classification is Mexico, classified by the UNCTAD as a Central America country. This is quite disputable, at least since the creation of the North American Free Trade Agreement (NAFTA). Mexico is included here in the North America region.

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**Appendix**

The supplementary material for this article can be found online.

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