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## Article

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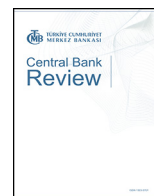
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# Logistics performance and export variety: Evidence from Turkey

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## ABSTRACT

This study examines the effects of logistics infrastructure on export variety, as measured by the extensive margin. Using finely disaggregated exports data for Turkey's trade with 174 countries over the period 2007–2017, we decompose gross export flows into the extensive and intensive margins of Turkish exports utilizing the method developed by Hummels and Klenow (2005). Gravity estimates suggest that logistics infrastructure positively influences export values and has a greater impact on the extensive margin than the intensive margin. Our empirical analysis further suggests that Turkish exporters are more sensitive to changes in local market logistics conditions than to those of their trade partners. These findings are robust to a variety of alternative measures and estimation methods.

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## 1. Introduction

Global trade has risen considerably over the last few decades, a change induced by the reduction and removal of trade barriers, improvements in transport and communications, and increase in cross-border production sharing. During the same period, many countries that have integrated successfully into the global economy have managed to expand the volume and diversity of their exports and achieve high, sustainable economic development (Wilson et al., 2005).

However, this process of integration seems to be proceeding more slowly for many other countries, particularly developing countries. The main reason is that most developing countries face logistics-based deficiencies in integrating with global production networks and delivering their products to world markets (Hausman et al., 2013; Martí et al., 2014; Yadav, 2014; Saslavsky and

Shepherd, 2014). The poor logistics infrastructure in developing countries increases the costs of and time required for trade, which hinders the efficient movement of products within global production networks (Martí et al., 2014; Gani, 2017). Therefore, effective logistics systems are increasingly a key component developing countries require to expand their exports, especially at a time when trade barriers are reduced as part of the process of globalization.

At the same time, many developing countries also seek to increase their exports by increasing the variety of products exported ("extensive margin," EM) rather than continuing their dependence on products that have been already exported ("intensive margin," IM). Exporting a new product/variety is particularly desirable for developing countries because it reduces dependence on traditional exports, which are more likely to experience declining trade terms in the long run. By exporting new varieties, countries may minimize conjectural fluctuations in export revenues, establish a more dynamic and reliable export sector and allow the country to compete more successfully in international markets (Lee and Kim, 2012; Beverelli et al., 2015).

Despite the significant benefits of exporting new varieties, little attention has been paid to the impacts of logistics infrastructure on

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export variety. Most empirical studies on the impacts of logistics infrastructure have primarily focused on exports, imports or total trade flows (Hummels, 1999; Sánchez et al., 2003; Jacks and Pendakur, 2010; Bernhofen et al., 2016). Some exceptions are Lee and Kim (2012), Persson (2013), Feenstra and Ma (2014), and Beverelli et al. (2015). In general, the latter studies conclude that the EM benefits more from better logistics performance than the IM.

Theoretically, Melitz (2003) predicts that a reduction in trade costs has heterogeneous effects on export margins. In particular, his model shows that a decline in variable trade costs raises the volume of exports by existing exporters (IM) but also allows less productive and smaller firms enter the export market (EM). On the other hand, a reduction in fixed trade costs will induce new firms to enter the export market (EM), but will not have any effect on the IM. To be best of our knowledge, this implication has not been tested before from a developing country perspective. Therefore, it is crucially important for the formulation and implementation of infrastructure and trade facilitation policies to determine if improvements in logistics raise exports through the creation of new or the trade of old products.

In light of this background, the present study examines the impact of improvements in logistics performance on product variety and makes several contributions to the literature. First, we decompose Turkey's exports to 174 countries over the period 2007–2017 into EM and IM, utilizing the methodology of Hummels and Klenow (2005). Second, we estimate the impact of logistics performance on exports using an augmented gravity model and determine whether this impact occurs mainly through the EM. Turkey's EM and IM and its logistics performance have been evaluated separately before (e.g., Türkcan and Pişkin, 2014; Ekmen-Özçelik and Erhat, 2014; Aldan and Çulha, 2016; Türkcan and Pişkin, 2016; Coşar and Demir, 2016), but none of these studies have examined the relationship between these factors. Last but not least, in contrast to previous studies, we consider four alternative proxies for logistics performance (logistics performance index, quality of transport infrastructure, liner shipping connectivity index and ease of trading across borders score), unlike previous studies that have used a single indicator.

Turkey is an appropriate choice for such an analysis not only because of the recent increases in its connections with global markets, but due to the diversification of its exports over our sample period. Geographical factors are also important when analyzing transport facilities, and Turkey has significant geographical advantages. It is geographically located as a central gateway to the European, Middle Eastern, North African and Central Asian markets. Turkey has also built up multi-modal (rail, road, air and sea) transport networks to facilitate internal and external trade in goods and services. Such improvements in the transport infrastructure reduce the import cost of raw materials and intermediate goods used in the production and exports of final goods and services. This is particularly important for Turkey because its export products require a high rate of imported inputs (Gündoğdu and Saracoğlu, 2016). Thus, a reduction in the cost of imported inputs linked to reduced transport costs is of vital importance if Turkey is to improve its export competitiveness in world markets and increase its integration within global production networks.

Our estimates indicate a statistically significant and positive effect of logistics performance on EM, and a negative yet insignificant effect on the IM. Our estimates also suggest that the positive effect of the exporter's Logistics Performance Index (LPI) score on export variables is partially cancelled out by trade with advanced countries that have better logistics infrastructure. In contrast, an improvement in logistics at home leads to a larger effect on export values and margins when Turkey trades with less-developed

countries.

The rest of the paper is organized as follows. Section 2 reviews the literature evaluating the link between the logistics sector and trade flows, as well as EMs and IMs. Section 3 describes the methodology used to measure EMs (export variety), IMs, and logistics performance, and also describes the data set. Section 4 describes the empirical model applied. Section 5 summarizes the results of the empirical analysis, while Section 6 presents the robustness checks of the analysis, and Section 7 concludes the paper.

## 2. Literature review

A better logistics system can substantially lower both variable and fixed trade costs. Variable costs (iceberg trade costs) vary with the amount exported, while sunk or fixed costs (such as loading and unloading at ports) do not (Lawless, 2010; Persson, 2013). Melitz (2003) provides a theoretical basis for modelling the effects of these trade costs on export margins. In his model, a firm's decision to export depends on its productivity and these two types of trade costs. Melitz's model predicts that a decline in variable trade costs have a positive effect on both EM and IM because productivity threshold for exports falls. However, a reduction in fixed trade costs will effectively boost the entrance of small and less productive firms into the export markets (EM), while it will not have any significant effect on IM. In related work, Chaney (2008) extended Melitz's model to address the sensitivity of EM and IM to trade barriers. In Chaney's model, the effect of a decline in trade costs on the EM and IM depends on the elasticity of substitution across varieties. Analysis of this model shows that the EM is sensitive to changes in trade barriers, while the IM is not.

While trade facilitation theory describes a clear relationship between logistics and trade flows, measurement of logistics performance is not straightforward because logistics includes multiple activities, such as shipping, intermodal transportation, storage, customs clearance, information and communication technology, etc.; hence, empirical studies must rely on proxy measures for logistics activities (Wilson et al., 2005; Portugal-Perez and Wilson, 2012). Numerous empirical studies have evaluated the effects of one or more activity of the logistics sector on trade flows. These studies can be classified into two broad categories based on the data and proxies they employ. The first category relies on bilateral aggregated trade data and utilizes various proxies for transport or logistics infrastructure.

The proxies used in the literature vary considerably. In earlier studies, the usual approach has been to focus only one aspect of the logistics performance, instead of considering all elements of logistics. Examples include Limao and Venables (2001) and Martínez-Zarzoso et al. (2003), who utilize their own transport infrastructure index as a proxy for trade facilitation. This index is based on several indicators obtained from World Development Indicators (WDI), such as lengths of road, paved roads, railways, and the number of telephone lines per person. Their results indicate significant gains from improved transport infrastructure in both exporting and importing countries. Reductions in shipping times have also been shown to have a positive impact on trade (Hummels, 2007).

Subsequent studies have sought to assess the impact of logistics performance by using different indicators in the analysis (e.g., Wilson et al., 2005; Portugal-Perez and Wilson, 2012; Hausman et al., 2013; Francois and Manchin, 2013; Yadav, 2014; Shepherd, 2016). Such approaches are intended to cover all aspects of the logistics and ensure the robustness of the results. These studies' indicators are mainly retrieved or constructed from multiple sources (e.g. Global Competitiveness Report, World Economic Forum, World Bank's Global Logistics Indicators Survey, World

Bank's Doing Business Database, OECD's Trade Facilitation Indicators, etc.). In general, most such studies suggest logistics performance has a strong effect on trade flows.

A number of studies have attempted to investigate the impact of maritime connectivity on trade costs and trade flows (e.g., Radelet and Sachs, 1998; Limao and Venables, 2001; Dollar et al., 2002; Fink et al., 2002; Hoffmann, 2002; Kumar and Hoffmann, 2002; Wang et al., 2002; Sánchez et al., 2003; Clark et al., 2004; Redding and Venables, 2004). In these studies, the variable of port efficiency is generally used as an indicator of logistics performance. Their results tend to confirm that an improvement in port efficiency significantly decreases shipping costs and increases bilateral trade volumes.

More recently, several studies, including those of Fugazza and Hoffmann (2017) and Hoffmann et al., 2019 measure the quality of maritime infrastructure using the Liner Shipping Connectivity Index (LSCI) developed by the United Nations Conference on Trade and Development (UNCTAD). Their results confirm a strong positive relationship between bilateral maritime liner shipping connectivity and trade flows. Some other studies have focused only on containerization and analyze the link between containerization and bilateral trade volumes. (e.g., Hummels, 2007; Notteboom and Rodrigue, 2008; Bernhofen et al., 2016). These studies highlight the role of containerization in declining transport costs and find that containerization has played an important role in bilateral trade volumes as well as the remarkable growth in world trade.

Finally, the Logistics Performance Index (LPI) developed by the World Bank has been used frequently in recent years as a proxy for logistics performance because it enables comparisons across countries (Arvis et al., 2012). Some recent studies utilizing the LPI include Bensassi et al. (2015), Güner and Çoskun, 2012, Martí et al. (2014), Puertas et al. (2014), Çelebi (2019), and Gani (2017), which examine the impact of logistics performance or trade facilitation on trade flows. The findings of these studies generally confirm the positive impact of logistics performance on trade flows. Moreover, their results indicate that the impact of LPI on trade flows varies considerably based on the exporter and importer countries' characteristics, such as market size, income, distance from trade partner, etc.

The second group of empirical studies decomposes trade flows into EMs and IMs and then evaluates the impact of logistics performance on these margins. Using EU data on imports from 118 developing countries, Dennis and Shepherd (2011) estimate the effects of trade facilitation on the range of products that a country exports. In doing so, they utilize various indicators from the World Bank's Doing Business database and find that, for 118 developing countries, a 1% fall in exporting costs increases export diversification by 0.4%. They also claim that exporting costs have stronger impact on poor developing countries. Likewise, Lee and Kim (2012) evaluate the impact of trade facilitation, proxied by the LPI indicator, on EM and IMs using the method of Hummels and Klenow (2005). Employing highly disaggregated data on imports to 26 EU countries from 150 developing and developed countries in 2007, they find that higher trade facilitation levels are positively associated with EMs, but not with IMs.

In the same vein, using the number of days needed to export from the World Bank's Doing Business database as a proxy, Persson (2013) analyzes the effects of trade facilitation on the EMs of both homogenous and differentiated products, in which the EM is calculated as the number of products exported. The evidence suggests a negative and statistically significant relationship between transaction costs and EMs of both types of goods, with a relatively larger effect on differentiated products. In particular, the results show that a 1% reduction in export transaction costs increases the number of differentiated exported products by 0.7%, while

increasing the number of homogeneous exported products by only 0.4%. In a follow-up study, Bourdet and Persson (2014) proxy trade facilitation with the total number of days required to clear all procedures for exporting and importing and estimate its effect on export volumes and the number of products exported (export diversification). They show that a simplification of export and import procedures has a strong negative impact on both export volumes and the number of products exported, based on data on EU imports from non-EU Mediterranean countries over the period 2006–2009.

Feenstra and Ma (2014) adapt the method of Hummels and Klenow (2005) to decompose exports into EMs and IMs and then determine the influence of port efficiency on export variety for a group of countries over the period 1988–2005. Their results reveal that the impact of the port efficiency on EMs is positive and statistically significant, while for IMs it is often not statistically significant and sometimes in the opposite direction. More recently, Beverelli et al. (2015) have used three types of EMs, namely the number of products by export destination, the number of export destinations by product, and Hummels and Klenow (2005) EMs as a measure of export diversification. Based on exports data for 133 countries in the year 2009, they find that trade facilitation, proxied by the OECD Trade Facilitation Indicators (TFIs), has a significantly positive impact on all three measures of export variety.

Finally, Zhang et al. (2019) explore the impacts of trade facilitation on export margins of China's forest product exports to 13 countries from 2007 to 2016. They adapt the calculation method of Bingzhan (2011), an extension of Hummels and Klenow (2005) method, in order to decompose export growth into EMs and IMs, with the latter further decomposed into price and quantity margins. In the analysis, they employ several indicators derived from the Global Competitiveness Report and the Global Corruption Perceptions Index Report, including port efficiency, customs environment, regulation environment, and finance and e-commerce. Surprisingly, their results show that trade facilitation has a significantly positive impact on quantity and price margins, but no significant impact on the EMs. They argue that there are limited opportunities for expanding the range of forestry export products because China already exports all forestry products.

An overview of the existing empirical studies on Turkey reveal two lines of research. The first concerns the contribution of each margin to Turkey's export growth, or factors influencing its export margins; the second involves the impact of logistics performance on trade. However, little of the empirical literature to date has focused on the influence of logistics performance on Turkey's export variety.

In the first line of research described above, Türkcan and Pişkin (2014) examine the EMs and IMs of Turkey's export growth, and further decompose the IM into its price and quantity compositions using the method proposed by Bingzhan (2011). Their results show that IM constitutes 99% of total export growth; 66% from quantity growth, and 33% from price growth. Similarly, Ekmekçi and Ertat (2014) conclude that the export growth of Turkey in the EU-15 market arises primarily from the IM, rather than the EM. In contrast, Aldan and Çulha (2016) reveal that EM plays an important role in Turkey's export growth, and that much of this growth is a result of expanding to new markets, rather than exporting new products. A study by Türkcan and Pişkin (2016) is closely related to the present paper; it investigates the effects of trade agreements (customs union and free trade agreement) on export margins of Turkey and finds that the effects of the trade agreements on the EM are negative, while the effects on the IM are positive.

The second line of research highlights the importance of logistics performance on Turkey's trade. For instance, Kuştepe et al. (2012) have investigated the effect of investment on highway



infrastructure on Turkey's trade over the period 1970–2005 and failed to obtain a long-run relationship between these two factors. Coşar and Demir (2016) also attempt to analyze the effects of internal transportation infrastructure of Turkey's provinces on their access to world markets. They conclude that an increase in Turkey's investment in the quality and capacity of road transportation infrastructure decreases transportation costs. Consequently, high-capacity expressways facilitate access to foreign markets for regions of Turkey remote from ports.

As shown in this section, there are only a few studies in the literature that examine the link between logistics performance and export variety. Moreover, to the best of our knowledge, no previous study has dealt with the role of transport infrastructure in Turkey on its export variety. This study aims to fill this gap in the literature by bringing these two lines of research together.

### 3. Data and some patterns

#### 3.1. Methodology of measuring export variety

The key step for our analysis is the choice of an appropriate method to calculate the export margins from among various established methods (Besedeš and Prusa, 2011). One commonly used method is the count method, which places equal weight on product categories and destination countries (e.g., Dennis and Shepherd, 2011; Persson, 2013; Beverelli et al., 2015). In the count method, bilateral EM refers to number of product categories that exported by a source country to a destination country. On the other hand, bilateral IM is defined as the value of the exports of common products that were exported by a source country to a destination country. The count method is easy to implement. However, it has one disadvantage: it gives equal weight (importance) to all observed product categories, leading to an underestimation or overestimation of the role of each margin in export growth (Lee and Kim, 2012).

The decomposition methodology developed by Hummels and Klenow (2005) is another commonly used method to investigate the impacts of logistic performance (or trade facilitation) on the EM and IM (e.g., Lee and Kim, 2012; Feenstra and Ma, 2014; Beverelli et al., 2015). The decomposition method overcomes the disadvantage of the count method by weighting each product by its overall importance as an export to a given country. Thus, the decomposition methodology prevents a category product from appearing important solely because a source country exports a lot of that product to a specific country.

For reasons already described above, the present paper employs the decomposition methodology developed by Hummels and Klenow (2005) to measure the EM and IM of Turkey. In this methodology, the bilateral EM of Turkey's exports to country  $m$  in period  $t$  ( $EM_{mt}$ ) is defined as

$$EM_{mt} = \frac{\sum_{i \in I_{mt}} p_{kmit} x_{kmit}}{\sum_{i \in I} p_{kmit} x_{kmit}} \quad (1)$$

where  $p_{kmit}$  and  $x_{kmit}$  denote the price (unit values) and quantity of exports of product  $i$  to country  $m$  in period  $t$ , respectively. The set  $I_{mt}$  encompasses observable categories in which Turkey has positive exports to country  $m$  in period  $t$ ;  $k$  is a reference country that has a positive exports to country  $m$  in period  $t$  in all  $I$  categories. Following the approach of Hummels and Klenow (2005), the rest of the world is used as the reference country ( $k$ ) in calculations. Thus, the EM can be interpreted as a weighted count of Turkey's  $i$  categories relative to the rest of the world's categories, with each category is weighted by its importance in the rest of the world's exports to importing country  $m$ . The value of  $EM_{mt}$  can fall between

zero and one.

Similarly, the bilateral IM is given by:

$$IM_{mt} = \frac{\sum_{i \in I_{mt}} p_{mit} x_{mit}}{\sum_{i \in I_{mt}} p_{kmit} x_{kmit}} \quad (2)$$

Hence,  $IM_{mt}$  represents Turkey's exports relative to  $k$ 's in those categories in which Turkey exports to country  $m$  in period  $t$  ( $I_{mt}$ ). Therefore, the IM compares the export flows from Turkey to country  $m$  in a common set of products. Like  $EM_{mt}$ , the value of  $IM_{mt}$  falls in the range from zero to one.

At the bilateral level, the EM, therefore, can be considered as the measure of product variety of Turkey's exports relative to the rest of the world's exported products. In contrast, the IM corresponds to Turkey's market share in the destination country. Accordingly, the EM will be large when Turkey exports many different products (varieties)  $i$  to country  $m$ , while the IM will be large when Turkey exports large amounts of a few products  $i$  to country  $m$ .

In addition, bilateral overall market share of Turkey's exports relative to the rest of the world's exports to country  $m$  in period  $t$  can be obtained as the product of the EM and IM:

$$OV_{mt} = EM_{mt} + IM_{mt} \quad (3)$$

In calculating export margins, we use the Base pour l'Analyse du Commerce International (BACI) database, an international trade database constructed by the Centre d'Études Prospectives et d'Informations Internationales (CEPII). The database contains detailed bilateral trade values (in thousands of U.S. dollars at current prices) and quantities of exports and imports using Harmonized System (HS, Revision 1996) six-digit product–country pair level data for more than 200 countries from 1996 to 2017 (Gaulier and Zignago, 2010; CEPII, 2019a). The database comprises approximately 5111 product items at the six-digit level of the HS product classification. Using Equations (1)–(3), we compute the bilateral EM and IM as well as the bilateral overall share of Turkey's exports to 174 countries over the period 2007–2017, accounting for over 90% of Turkey's exports. The coverage of partner countries and time period was determined by the availability of the data for bilateral export flows and explanatory variables, especially LPI data.

Tables 1 and 2 present the results of the decomposition of Turkey's exports into EMs and IMs, respectively. The results for Turkey's top 20 partner countries are listed in descending order EM and IM values. The results show that the bilateral EM is considerably larger for export partners that are closer and larger, as expected. For example, Turkey has higher EMs with neighboring countries such as Iraq, Georgia and Azerbaijan, and with larger markets, like Germany and the United Kingdom. This suggests that proximity plays an important role in export diversification of Turkey, meaning that exporters face a lower fixed cost when entering neighboring countries than more distant countries. These data also suggest that Turkey tends to export a greater variety of products to rich and larger countries, which previous studies show is true for other developing countries (e.g., Amurgo-Pacheco and Pierola, 2008). The data in Table 1 also show that Turkey has experienced a significant increase in the EM of exports from 2007 to 2017. This increase is mainly explained by the need to search for new export destinations during the global financial crisis of 2008. At that time, Turkish firms were forced to re-orient their exports away from Europe and the US towards emerging markets in Africa, Asia and the Middle East, leading to an increase in its EMs. The increase in the EM to non-traditional markets may also be partially explained by the growing integration of Turkish firms into global production networks in recent years.

In the case of IMs, Table 2 shows that bilateral IMs are generally

**Table 1**

Top 20 importers of products from Turkey with highest extensive margins and corresponding LPI levels.

Rank	2007			2017			Sample period		
	Importer	EM	LPI	Importer	EM	LPI	Importer	EM	LPI
1	Iraq	0.881	2.03	Iraq	0.905	2.18	Iraq	0.930	2.15
2	Liberia	0.873	2.31	Netherlands	0.896	4.02	Georgia	0.860	2.53
3	Azerbaijan	0.854	2.29	Turkmenistan	0.863	2.41	Azerbaijan	0.850	2.46
4	Bulgaria	0.853	2.87	Syria	0.860	2.30	Turkmenistan	0.837	2.42
5	Georgia	0.828	2.37	Bulgaria	0.852	3.03	Germany	0.820	4.12
6	Albania	0.808	2.08	Germany	0.845	4.20	UAE	0.811	3.73
7	Romania	0.801	2.91	Georgia	0.838	2.44	Romania	0.791	3.00
8	Germany	0.799	4.10	Cyprus	0.834	3.15	UK	0.791	3.98
9	Kazakhstan	0.790	2.12	Romania	0.832	3.12	Libya	0.784	2.34
10	UAE	0.787	3.73	UK	0.832	3.99	Albania	0.784	2.48
11	Russia	0.784	2.37	Switzerland	0.825	3.90	Bulgaria	0.780	2.98
12	Spain	0.759	3.52	UAE	0.825	3.96	Russia	0.772	2.58
13	UK	0.759	3.99	Kuwait	0.812	2.86	Hong Kong	0.766	3.97
14	Saudi Arabia	0.738	3.02	Iran	0.807	2.85	Switzerland	0.764	3.92
15	Syria	0.721	2.09	Azerbaijan	0.798	2.41	Iran	0.759	2.57
16	France	0.716	3.76	France	0.798	3.84	Syria	0.757	2.28
17	Greece	0.714	3.36	Russia	0.796	2.76	Saudi Arabia	0.746	3.14
18	Hungary	0.708	3.15	United States	0.793	3.89	Italy	0.746	3.67
19	Libya	0.706	2.40	Italy	0.792	3.74	France	0.738	3.84
20	Algeria	0.705	2.06	Hong Kong	0.786	3.92	Lebanon	0.733	2.77

Notes: Sample period represents the 11-year average values of EM and LPI for the period 2007–2017.

Source: Authors' calculation based on the sample included in the estimations.

**Table 2**

Top 20 importers of products from Turkey with highest intensive margins and corresponding LPI levels.

Rank	2007			2017			Sample period		
	Importer	IM	LPI	Importer	IM	LPI	Importer	IM	LPI
1	Eritrea	0.823	2.19	Turkmenistan	0.337	2.41	Turkmenistan	0.269	2.42
2	Solomon Isl.	0.282	2.08	Iraq	0.321	2.18	Eritrea	0.266	2.03
3	Iraq	0.233	2.03	Syria	0.299	2.30	Iraq	0.258	2.15
4	Turkmenistan	0.183	2.63	Georgia	0.206	2.44	Bhutan	0.202	2.32
5	Georgia	0.158	2.37	Eritrea	0.194	2.09	Georgia	0.192	2.53
6	Azerbaijan	0.146	2.29	Yemen	0.192	2.27	Syria	0.175	2.28
7	Burundi	0.139	2.29	Azerbaijan	0.183	2.41	Azerbaijan	0.175	2.46
8	Tajikistan	0.114	1.93	Comoros	0.144	2.56	Solomon Isl.	0.122	2.38
9	Malta	0.103	2.31	Libya	0.138	2.11	Libya	0.119	2.34
10	Lao PDR	0.102	2.25	Gambia	0.134	2.40	Armenia	0.116	2.45
11	Chad	0.101	1.98	Sierra Leone	0.134	2.08	Sierra Leone	0.114	2.02
12	Albania	0.098	2.08	Albania	0.133	2.66	Gambia	0.111	2.42
13	Bosnia & H.	0.096	2.46	Niger	0.115	2.07	Tajikistan	0.095	2.25
14	Armenia	0.095	2.14	Armenia	0.114	2.61	Comoros	0.093	2.42
15	Sierra Leone	0.088	1.95	Eq. Guinea	0.111	2.32	Yemen	0.092	2.44
16	Gambia	0.087	2.52	Benin	0.104	2.75	Albania	0.092	2.48
17	Bulgaria	0.084	2.87	Chad	0.096	2.42	Sao T. & Pr.	0.091	2.62
18	Cyprus	0.083	2.92	Cyprus	0.094	3.15	Cayman Isl.	0.085	2.59
19	N.Macedonia	0.078	2.43	Trinidad & Tobago	0.092	2.42	Moldova	0.085	2.49
20	Cuba	0.076	1.87	Jamaica	0.091	2.52	N. Macedonia	0.083	2.58

Notes: Sample period represents the 11-year average values of IM and LPI for the period 2007–2017.

Source: Authors' calculation based on the sample included in the estimations.

larger for smaller and less-developed countries such as Turkmenistan, Eritrea and Iraq. It appears that Turkey exports relatively large quantities of a relatively small number of products to developing countries with low purchasing power. A large body of work has also found that small countries trade smaller product varieties than big countries (e.g., [Lee and Kim, 2012](#)). The data in [Table 2](#) also indicate that Turkey's bilateral IMs have grown over the period 2007–2017, but that this growth was much smaller in magnitude than the EM. This implies that Turkey's export growth during the study period was driven largely by the expansion of exports of new products rather than growth in the quantity or rise in the prices of existing exports.

The descriptive analysis so far implies that the EM is more important than the IM for Turkey, and that the magnitude of the EM largely depends on the geographical proximity and economic size

of its trading partners. Moreover, the IM seems to matter more for the trading partners with a relatively small market size and weak economic conditions.

### 3.2. Measuring logistics performance

In order to assess the impact of logistics performance on export margins, this paper uses four alternative proxies. The first is the overall LPI score developed by the World Bank ([Arvis et al., 2012](#); [World Bank, 2019a](#)). The World Bank's LPI database contains information on more than 170 countries for the period 2007–2018. The LPI score measures the logistics performance of a country and is constructed from six core indicators using principal component analysis: customs, infrastructure, international shipments, logistics quality and competence, tracking and tracing, and timeliness. None

of these indicators independently guarantees good logistics performance, and their inclusion is based on empirical studies and extensive interviews carried out with specialists in international freight transport. The overall LPI has been aggregated as a weighted average of these six core indicators. The value of an LPI score ranges from 1 to 5, with a score of 5 representing the best logistics performance.

The second proxy is the quality of transport infrastructure (QTI), which is retrieved from the World Economic Forum's global competitiveness index (GCI) database (World Economic Forum, 2019). The GCI database is composed of 12 pillars that describe the competitiveness of countries, one of which is transport infrastructure. The QTI pillar itself consists of four sub-indicators: quality of road network/infrastructure, quality of railroad infrastructure (efficiency of train services), quality of port infrastructure (efficiency of seaport services), and quality of air transport infrastructure (airport connectivity). These four sub-indicators are included in the calculation of the overall QTI index, which ranges from a low of 1 to a high of 7, with 7 indicating the best performance. The index is available for the period 2007–2018 and covers more than 150 countries.

The third is the liner shipping connectivity index (LSCI) provided by the United Nations Conference on Trade and Development (UNCTAD, 2019). This index captures a country's integration into existing global shipping networks by measuring liner shipping connectivity. It is calculated based on five components of the maritime transport sector: containership deployment; container carrying capacity; number of shipping companies; liner services and vessels per company; and average and maximum vessel size. The index generates a value of 100 for the country with the highest average in 2006, which was China (maximum value in 2006 = 100). The most updated data range is from 0 to 170 in our sampling period. A higher value indicates better shipping connectivity. The index provides data on more than 170 countries for the period 2004–2019.

The last proxy for the measures of logistics performance is the ease of trading across borders score (EoT) taken from the World Bank's Doing Business Database (World Bank, 2019b). For exporting and importing the goods, this measure considers the time and cost necessary to complete following stages: document preparation; customs clearance and inspections; inland transport and handling; and port and terminal handling. This score is calculated as the simple average of scores for the time and cost for documentary compliance and border compliance to export and import; it is recorded as a percentage, and so ranges from 0 to 100. A higher score indicates a better performance. This score covers more than 190 countries and is available for 2004–2019.

To establish the performance of Turkey with regard to these logistics performance indicators, the average scores, as well as world rankings of these indicators are presented in Table 3. This table also displays the mean, minimum, and maximum values for

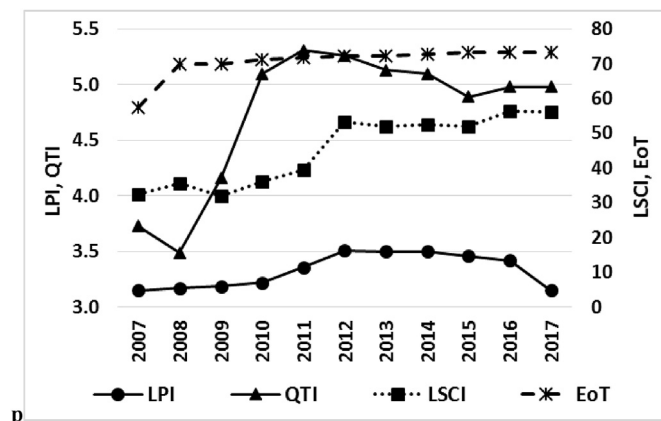


Fig. 1. Turkey's Logistics Performance Indicators from 2007 to 2017.

Notes: The left vertical axis shows values for LPI and QTI, and the right vertical axis for LSCI and EoT.

the full sample, along with countries with the worst and best performance for each indicator. Turkey exceeds the global average for all indicators, yet it lags far behind most high-income countries, a fact that may hinder the growth and diversification of Turkish exports. In particular, Turkey's rank for the EoT is much lower than by other indicators, though the LSCI places Turkey in relatively good position, ranked 21st of 144 countries.

The evolution and the current situation of logistics performance in Turkey from 2007 to 2017 is displayed using different indicators in Fig. 1. We observe in that figure the indicators considered in this work (in terms of score) have improved significantly in the early years of the sample period (2008–2012), but then remained stagnant, and most recently, have contracted (2014–2017). The improvement was spectacular for the QTI: Turkey's score increased from 3.5 in 2008 to 5.3 in 2011. However, the data shows that Turkey registered a notable decline in the world rankings of most indicators except the QTI between 2007 and 2017 (note that yearly rankings of the indicators for Turkey are not reported to save space). This change could indicate that other countries improved their logistics performance by greater amounts during the study period. These stylized facts show that in comparison to high-income countries, Turkey's rank in the majority of these indicators is relatively low, indicating substantial room for improvement.

Tables 1 and 2 also document the relationship between a country's export margins and its LPI scores. As these tables show, a higher LPI score is generally positively related to EMs. In particular, larger and more developed countries with a higher score (such as those in Europe) have higher EMs, and import a greater variety of products from Turkey. This implies that trade facilitation is essential for developing countries to export a wider variety of products,

Table 3  
Summary statistics for logistics performance indicators.

Statistics	LPI	QTI	LSCI	EoT
Mean	2.85	4.06	23.78	65.00
Median	2.67	3.96	14.29	71.23
Min.	1.99 (Afghanistan)	1.36 (Congo, D.R.)	2.31 (Greenland)	0.93 (Uzbekistan)
Max.	4.10 (Germany)	6.65 (Switzerland)	152.54 (China)	96.65 (Singapore)
Turkey (score)	3.33	4.74	45.27	70.66
Turkey (rank)	32	40	21	90
# of countries	157	141	144	175

Notes: Logistics performance index (LPI) ranges from 1 to 5; quality transportation index (QTI) ranges from 1 to 7; liner shipping connectivity index (LSCI) ranges from 0 to 170; and ease of trading borders (EoT) score ranges from 0 to 100. The statistics are based on the average values for the period 2007–2017.

as it causes the fixed costs of entering new markets to fall (Dennis and Shepherd, 2011). In terms of the IM, we observe that Turkey exhibits (on average) higher IMs with small, underdeveloped and low-income trade partners (such as Eritrea, Iraq and Bhutan) that have lower LPI scores (Table 2). In contrast to its effect on the EM, trade facilitation seems to be less important for the expansion of existing exports, an observation in line with the findings of Lee and Kim (2012).

### 3.3. Other explanatory variables

Besides the logistics performance indicators, we also include several control variables shown to be significant in explaining export margins patterns by previous studies (Persson, 2013; Feenstra and Ma, 2014; Beverelli et al., 2015). The first variable that is likely to affect EMs is the exporter's gross domestic product (GDP), which serves as a proxy for export capacity (Persson, 2013). The GDPs of importers are also included as a proxy for import demand. We expect that larger countries systematically trade in a wider range of products (EM) as well as in larger volumes (IM), as suggested by Hummels and Klenow (2005). Both variables are collected from the World Development Indicators published by the World Bank (World Bank, 2019c).

The third control variable is the bilateral distance variable between Turkey and its trading partners. According to the gravity literature, countries tend to trade more with geographically closer partners as trade costs fall. Accordingly, the bilateral distance is expected to have a negative effect on both EM and IM. Data on the bilateral distance variable was taken from the CEPII database (CEPII, 2019b).

Finally, we add a crisis dummy to control the impacts of the global economic and financial crisis on both margins. This variable also allows observation of the margins' individual reactions to economic conditions in a partner country. The crisis dummy takes the value one the year 2009 and zero otherwise. In line with the previous literature, we expect the crisis to have a negative impact on export values and on export margins. The definition and data sources for all variables are given in Table 4.

## 4. Empirical methodology

In this study, we consider an augmented gravity model to

explore the impact of logistics performance on the export variety of Turkey, where all variables (except the crisis dummy) are natural logarithms:

$$Y_{ijt} = \alpha_0 + \alpha_1 \ln GDP_{it} + \alpha_2 \ln GDP_{jt} + \alpha_3 \ln DIST_{ij} + \alpha_4 Crisis_{ijt} + \alpha_5 \ln LP_{it} + \alpha_6 \ln LP_{jt} + \alpha_7 \ln LP_{it} \times \ln LP_{jt} + \mu_j + v_{ijt} \quad (4)$$

where subscripts  $i, j, t$  denote Turkey, partner country, and year, respectively. Alternative dependent variables ( $Y_{ijt}$ ) are employed in Equation (4). As a benchmark, we estimate the value of Equation (4) using exports in US dollars ( $EV_{ijt}$ ) from Turkey to partner country  $j$ . In a next step, the overall margin ( $OV_{mt}$ ) is used as the dependent variable, as defined in Section 3.1. Finally, as a key point of this work, we consider the bilateral extensive ( $EM_{mt}$ ) and intensive margins ( $IM_{mt}$ ) of exports between to partner country  $j$  as the dependent variable, as specified by Hummels and Klenow (2005).

Regarding the explanatory variables, we include a set of control variables commonly used in gravity equations, namely the exporter's and partner country's GDP ( $GDP_{it}$  and  $GDP_{jt}$ , respectively), and bilateral distance ( $DIST_{ij}$ ). Moreover, since financial crises have a detrimental effects on export patterns, we also control for the impact of the 2008–2009 global financial crisis on export margins using a crisis dummy ( $Crisis_{ijt}$ ).

For the purposes of this study, the key variables of interest are  $LP_{it}$  and  $LP_{jt}$ , which represent the logistics performance (LP) of the exporter (Turkey) and partner countries, respectively. To measure LP, we used four indicators: logistics performance index (LPI), the quality of transport infrastructure (QTI), the liner shipping connectivity index (LSCI), and the ease of trading borders score (EoT). However, these indicators have several drawbacks. First, they are provided at the country level, not at the bilateral level. This can make quantifying the effects of the logistics performance on export margins challenging. Second, their values do not change substantially year-to-year (especially the LPI), making it almost impossible to detect relationships between logistics performance indicators and export margins. To address this limitation, an interaction term between exporter's LP and importer's LP ( $\ln LP_{it} \times \ln LP_{jt}$ ) is created to assess the shared impact of logistics performance changes—both in Turkey and in its trading partners—on export margins. In other words, the inclusion of this interaction term allows us to determine whether or not logistics improvements in the destination country enhances the benefits of better logistics performance at home.

**Table 4**  
Variable definitions and data sources.

Variable	Definition	Data Source
$EV_{ijt}$	Bilateral value of exports from Turkey to its trading partner, measured in nominal USD	CEPII's BACI database
$OV_{mt}$	Bilateral overall margin of Turkey's exports to its trading partner	CEPII's BACI database
$EM_{mt}$	Bilateral extensive margin of Turkey's exports to its trading partner	CEPII's BACI database
$IM_{mt}$	Bilateral intensive margin of Turkey's exports to its trading partner	CEPII's BACI database
$GDP_{it}$	Turkey's GDP, measured in nominal USD	World Bank's World Development Indicators (WDI)
$GDP_{jt}$	Importer's GDP, measured in nominal USD	World Bank's World Development Indicators (WDI)
$DIST_{ij}$	Bilateral distance in kilometers between Turkey's capital and its trading partner's capital	CEPII's GeoDist database
$Crisis_{ijt}$	Crisis dummy that takes value one if the year is 2009, and zero otherwise	Authors' own construction
$LPI_{it}$	Logistics performance index of Turkey	World Bank's LPI database
$LPI_{jt}$	Logistics performance index of Turkey's trading partner	World Bank's LPI database
$QTI_{it}$	Quality of transport infrastructure index of Turkey	World Economic Forum's Global Competitiveness Index (GCI) database
$QTI_{jt}$	Quality of transport infrastructure index of Turkey's trading partner	World Economic Forum's Global Competitiveness Index (GCI) database
$LSCI_{it}$	Liner shipping connectivity index of Turkey	United Nations Conference Trade and Development's (UNCTAD) maritime transport database
$LSCI_{jt}$	Liner shipping connectivity index of Turkey's trading partner	United Nations Conference Trade and Development's (UNCTAD) maritime transport database
$EoT_{it}$	Ease of trading borders score of Turkey	World Bank's Doing Business database
$EoT_{jt}$	Ease of trading borders score of Turkey's trading partner	World Bank's Doing Business database



**Table 5**  
Estimation results: Logistics performance index (LPI).

Variables	EV	OV	EM	IM
$GDP_{it}$	−0.062 (0.130)	0.731*** (0.119)	0.332*** (0.093)	0.399*** (0.111)
$GDP_{jt}$	1.411*** (0.185)	0.433*** (0.163)	0.705*** (0.147)	−0.272* (0.147)
$DIST_{ij}$	−4.929*** (0.349)	−4.167*** (0.315)	−2.419*** (0.258)	−1.748*** (0.259)
$Crisis_{ijt}$	−0.101** (0.044)	0.095** (0.041)	0.067* (0.039)	0.028 (0.053)
$LPI_{it}$	8.233*** (1.545)	3.838*** (1.340)	5.644*** (1.300)	−1.806 (1.439)
$LPI_{jt}$	6.942*** (1.656)	4.122*** (1.439)	5.426*** (1.324)	−1.304 (1.509)
$LPI_{it} \times LPI_{jt}$	−6.188*** (1.364)	−3.861*** (1.189)	−4.783*** (1.090)	0.921 (1.249)
Constant	10.984*** (4.025)	−4.541 (3.647)	−13.165*** (3.405)	8.625** (3.573)
Observations	1696	1695	1695	1695
Partners	156	156	156	156
F-stat. (model)	238.8***	104.9***	53.9***	51.7***
F-stat. (fixed effects)	43.1***	42.8***	28.3***	18.1***
$R^2$	0.962	0.917	0.850	0.844

Notes: All variables provided as natural logarithms except dummies. All models include country fixed effects. Robust standard errors in parentheses. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

The variable  $\mu_j$  is also included in Equation (4) in order to capture the fact that non-trade barriers in the importing country may affect Turkey's bilateral exports. Finally,  $v_{ijt}$  is a stochastic, idiosyncratic error term. A detailed description of the variables and data sources is given in Table 4.

Our sample comprises an unbalanced panel of around 174 importer countries  $j$  for the time period ( $t$ ) 2007–2017. The choice of the partner countries and time period for this study is primarily dictated by the availability of data, particularly logistics performance indicators. We apply two common techniques to Equation (4) in order to obtain reliable estimates. First, Equation (4) is estimated with pooled ordinary least squares (OLS) with importer fixed effects. However, pooled OLS with fixed effects may lead to biased results due to the presence of zero trade flows and heteroscedasticity (Santos-Silva and Tenreyro (2006, 2011)). In order to address the issue of zero trade flows and heteroscedasticity, we also estimate Equation (4) using the Poisson pseudo-maximum likelihood (PPML) estimator, as suggested by Santos-Silva and Tenreyro (2006). The advantage of this procedure is that it includes observations with zero observations, which are dropped from the estimations because of the log transformation. Additionally, the data do not have to follow a Poisson distribution (Yadav, 2014). In the PPML method, the dependent variables are included in estimations as levels rather than in log form, whereas explanatory variables are included in log form.

## 5. Estimation results

Table 5 presents the OLS estimates of Equation (4) for four alternative dependent variables (bilateral export value, overall margin, EM and IM). Each of these four dependent variables is regressed on a set of logistics performance indicators, namely exporter's and importer's LPI, and gravity-type control variables like GDP, distance, and crisis dummy. The results were obtained from an OLS estimation with importer fixed effects, but these coefficients are not reported for ease of presentation. Note that all variables considered in the models (except the crisis dummy) are expressed as natural logarithms, allowing us to interpret the estimated coefficients as elasticities.

As can be observed from Table 5, the estimated effects of the variables of interest, exporter's and importer's LPI, on both bilateral export values and the overall margins is positive and statistically significant. The results in this table's first two columns provide strong empirical support for the notion that improvements in logistics performance in both the exporting and importing country are key to facilitate exports. This finding is consistent with those of previous studies that use the LPI as a proxy for trade facilitation indicator, such as Saslavsky and Shepherd (2014), Marti et al. (2014) and Çelebi (2019).

In terms of the magnitude of LPI variables, the results suggest that a one-percent improvement in the logistic performance of the exporting country (importing country) will increase the bilateral export value by around 8.2 percent (6.9 percent), and that of overall margin by 3.8 percent (4.2 percent). In addition, the coefficient for the effects of the exporter LPI on the bilateral exports is higher than that of the importer LPI, indicating that Turkish exporters are more sensitive to home market conditions than those of their import partner. This finding thus supports the intuitive argument made by Marti et al. (2014) that an improvement in the infrastructure or customs clearance procedures in a developing country, due to its previous deficits, exerts a larger effect on trade than improvements in developed countries.

As expected, both the LPI of both exporters and importers has a positive, statistically significant influence on the EM of the exports. Specifically, a one-percent increase in the exporting country's LPI score (importing country's LPI score) leads to an approximately 5.6 percent (5.4 percent) increase in the EM. In sharp contrast, both LPI variables display a negative impact on the IM of exports, though these changes are not statistically significant.<sup>1</sup> Taken together, these results suggest that exports respond positively to an improvement in the logistics of both the exporting and importing country, and that much of this increase in exports materializes through the EM. The finding of a positive and large effect on the EM and negative but insignificant effect on the IM is broadly consistent with the results reported in previous studies (Lawless, 2010; Feenstra and Ma, 2014) and that of Lee and Kim (2012), who find that trade facilitation benefits are substantially greater for developing countries in terms of the EM than the IM. Consistent with the theoretical predictions of Melitz (2003) and Chaney (2008) models, the estimates in this study clearly indicate that an improvement in the logistics or trade facilitation affect exports only via its effect on fixed trade costs, a result in line with those of other studies (Lawless, 2010; Dutt et al., 2011; Persson, 2013).

An interaction term between exporter's LPI score and importer's LPI score was also included in the regressions to identify the shared effect of these two variables on Turkey's exports and export margins. As shown in Table 5, the coefficient on the interaction term is negative and statistically significant in all specifications (except the IM of exports). These results indicate that the positive impact of the exporter's LPI score on export variables is partially cancelled out by trading with advanced countries with better logistics infrastructure. In contrast, an improvement in logistics at home leads to a larger impact on export values and margins when Turkey trades with less-developed countries. Hence, the results suggest that while it will have little effect on exports to advanced nations such as EU members, improvements in logistics infrastructure at home can be important avenue for Turkey to expand and diversify its exports to less-developed countries.

<sup>1</sup> Following Lee and Kim (2012), we also include Turkey's LPI in quadratic form in the gravity equation in order to control for a potential nonlinear relationship between LPI and EM. The results show that Turkey's LPI has a decreasing marginal effect on EM, in line with the findings of Lee and Kim (2012).

**Table 6**  
Estimation results: Quality of transport infrastructure (QTI).

Variables	EV	OV	EM	IM
$GDP_{it}$	0.089 (0.155)	0.700*** (0.132)	0.495*** (0.139)	0.204 (0.133)
$GDP_{jt}$	1.096*** (0.216)	0.219 (0.184)	0.241 (0.214)	−0.022 (0.195)
$DIST_{ij}$	−2.300*** (0.136)	−2.231*** (0.115)	−1.015*** (0.113)	−1.216*** (0.103)
$Crisis_{ijt}$	−0.131*** (0.044)	0.099** (0.040)	0.045 (0.035)	0.054 (0.047)
$QTI_{it}$	2.850*** (0.438)	2.319*** (0.376)	2.009*** (0.319)	0.310 (0.366)
$QTI_{jt}$	3.017*** (0.528)	2.398*** (0.453)	2.348*** (0.389)	0.050 (0.445)
$QTI_{it} \times QTI_{jt}$	−1.862*** (0.319)	−1.650*** (0.276)	−1.377*** (0.223)	−0.273 (0.266)
Constant	−3.658 (2.717)	−14.694*** (2.353)	−15.697*** (1.919)	1.004 (2.291)
Observations	1526	1525	1525	1525
Partners	140	140	140	140
F-stat. (model)	245.1***	114.1***	66.2***	60.2***
F-stat. (fixed effects)	52.4***	51.9***	37.8***	22.6***
R <sup>2</sup>	0.963	0.923	0.874	0.864

Notes: All variables provided as natural logarithms except dummies. All models include country fixed effects. Robust standard errors in parentheses. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

Turning now to the control variables in Equation (4), we find that estimated coefficients generally have signs consistent with expectations. Exporter's GDP is positively correlated with export margins, implying that larger countries export not only more of the same products (IM), but a greater product variety (EM). The only exception is the negative response of Turkey's bilateral exports, though this variable's contribution is insignificant. This finding supports those of Lawless (2010) and Feenstra and Ma (2014), who also report that exporter's GDP has a positive effect on the EM and IM. At the same, the effects of importer's GDP on the bilateral export values and margins are statistically positive.

However, the importer's GDP carries an unexpected and statistically significant negative sign in the case of the IM. In line with these results, Lee and Kim (2012) also describe a positive effect of importer's GDP on the EM but negative effects for the IM. Apart from the effect of importer's GDP on IM, the evidence suggests that sustained economic growth, particularly at home, is the main driver for Turkey's export growth and ability to offer a wide range of products in export markets.

We also examine the impact of the bilateral distance variable on exports. As seen in Table 5, the bilateral distance variable is significantly and negatively associated with the all dependent variables, as to be expected. This suggests that countries tend to reduce their trade relationships when they are far from each other, due to the transportation costs. This is in line with prior empirical studies (Lee and Kim, 2012; Persson, 2013; Feenstra and Ma, 2014). Meanwhile, the magnitude of the coefficient is noticeably larger for the EM, which is similar to finding of Lawless (2010). This finding is quite surprising given the fact that distance represents transportation costs (variable costs). One plausible reason could be that distance variable may capture trade inhibiting fixed costs other than transportation costs, as suggested by Lawless (2010).

Finally, the results show that crisis dummy has an adverse effect on the bilateral export value, while it has a positive effect on both the overall margin and EM. This suggests that the global financial crisis of 2008–2009 led to decline in Turkish exports during the study period. In addition, the positive sign of the EM indicates that Turkish exporters mitigate some of the negative impact of crisis on

**Table 7**  
Estimation results: Liner shipping connectivity index (LSCI).

Variables	EV	OV	EM	IM
$GDP_{it}$	−0.371 (0.283)	1.024*** (0.268)	0.549* (0.281)	0.475* (0.287)
$GDP_{jt}$	1.249*** (0.222)	0.057 (0.198)	0.490*** (0.188)	−0.433** (0.184)
$DIST_{ij}$	−0.155 (0.240)	−0.194 (0.202)	−0.608*** (0.202)	0.414** (0.207)
$Crisis_{ijt}$	−0.040 (0.058)	0.135** (0.056)	0.086 (0.061)	0.049 (0.070)
$LSCI_{it}$	1.761*** (0.317)	1.127*** (0.295)	1.350*** (0.308)	−0.224 (0.322)
$LSCI_{jt}$	1.150*** (0.286)	1.233*** (0.259)	1.484*** (0.289)	−0.251 (0.310)
$LSCI_{it} \times LSCI_{jt}$	−0.359*** (0.077)	−0.370*** (0.069)	−0.417*** (0.080)	0.047 (0.082)
Constant	−11.517* (6.879)	−34.898*** (6.575)	−27.490*** (6.614)	−7.408 (7.428)
Observations	1527	1523	1523	1523
Partners	143	143	143	143
F-stat. (model)	225.8***	68.3***	30.6***	26.6***
F-stat. (fixed effects)	35.9***	30.1***	12.4***	11.8***
R <sup>2</sup>	0.960	0.880	0.767	0.741

Notes: All variables provided as natural logarithms except dummies. All models include country fixed effects. Robust standard errors in parentheses. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

exports by exporting new products or expanding into new markets. Previous studies report similar evidence that the global financial crisis has affected the trade flows through IM rather than EM (Bricongne et al., 2012; Muraközy, 2012).

## 6. Robustness checks

The results to this point indicate that logistics performance stimulates the growth of exports in Turkey, and that the EM explains most of this growth. To verify the robustness of this analysis, we conduct two additional analyses. The first robustness test is carried out using alternative measures of logistics performance, while the second is based on the PPML.

We first extend our benchmark regression by employing three additional measures of logistics performance indicators (QTI, LSCI, and EoT). The effects of the different types of measures of logistics performance are investigated separately because they are highly correlated. As can be seen from the results in Tables 6–8, the estimated coefficients for these indicators are nearly identical to those from LPI (though smaller in magnitude), suggesting that the results are robust across different indicators of logistics performance. As expected, each of these indicators—except a few cases for EoT—is significant and has a positive impact on the value of exports and margins (bilateral overall margin and EM). We also observe a similar pattern for the impact of the logistics indicators on the IM, i.e., they continue to have a negative but insignificant effect on the IMs of exports. As in Table 5, we also show that the impact of the logistics performance on exports operates through the EM as fixed costs decline.

In line with the estimates of Equation (4) (Table 5), the positive association between the logistics performance indicators (other than QTI) and bilateral export values is stronger when the exporter's indicators are considered, as suggested by Martí et al. (2014). Consistent with our earlier results, the coefficient on the interaction remains negative and significant, although the effect is not significant for the IM. Overall, the evidence indicates that Turkey's exports are positively related to both its local and its import partner's logistics conditions, and the effect of its local

**Table 8**  
Estimation results: Ease of trading borders index (EoT).

Variables	EV	OV	EM	IM
$GDP_{it}$	−0.035 (0.165)	0.764*** (0.154)	0.481*** (0.176)	0.283* (0.158)
$GDP_{jt}$	1.284*** (0.209)	0.294 (0.190)	0.650*** (0.202)	−0.356* (0.185)
$DIST_{ij}$	−4.960*** (0.341)	−4.215*** (0.314)	−2.429*** (0.261)	−1.787*** (0.259)
$Crisis_{ijt}$	−0.187*** (0.050)	0.069 (0.049)	0.026 (0.056)	0.043 (0.061)
$EoT_{it}$	2.483*** (0.939)	1.471* (0.776)	1.424 (0.932)	0.047 (0.484)
$EoT_{jt}$	0.922 (0.976)	0.869 (0.805)	0.922 (0.922)	−0.054 (0.501)
$EoT_{it} \times EoT_{jt}$	−0.222 (0.230)	−0.211 (0.190)	−0.227 (0.217)	0.017 (0.118)
Constant	12.510** (5.480)	−3.738 (4.841)	−15.300*** (5.209)	11.563*** (3.840)
Observations	1880	1878	1878	1878
Partners	174	174	174	174
F-stat. (model)	229.8***	73.1***	36.9***	29.4***
F-stat. (fixed effects)	45.1***	34.9***	19.1***	12.0***
$R^2$	0.960	0.885	0.795	0.756

Notes: All variables provided as natural logarithms except dummies. All models include country fixed effects. Robust standard errors in parentheses. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

logistics dominates. This evidence once again suggests that improved logistics services at home are essential to Turkey's export success, both in terms of export value and export diversity. The rest of the estimated coefficients are very similar to those reported in Table 5, except that in a few cases the distance variable loses its significance for the dependent variable LSCI.

PPML estimates of Equation (4) for each of the logistics performance indicators are reported in Appendix Tables A1–A4. PPML estimation yields results that are very similar to the OLS results from Tables 5–8. The results of the PPML model show a positive impact of logistics performance indicators on exports for all indicators except the EoT. Similarly, we again find that logistics improvement in the exporting and importing countries increase the EM, whereas they are not significant for the IM. These results also confirm our earlier findings that the effect of local conditions on export expansion is stronger than that of the importing partner. As for the control variables, most of the effects are relatively robust to different measures of logistics indicators and dependent variables.

Apart from the sensitivity analyses above, we also check whether our regressions suffer from problems of multicollinearity and endogeneity. Potential multicollinearity is detected with the variance inflation factor (VIF) for each set of estimations in this paper. As a rule of thumb, a VIF larger than ten may be indicative of multicollinearity. Mean (maximum) VIF values are calculated as 1.49 (1.84), 1.35 (1.80), 2.12 (4.41), and 1.34 (1.96) for the estimation results reported in Tables 5–8, respectively. These very low VIF values indicate there is no empirical evidence of severe multicollinearity for any set of estimations in this study.

Endogeneity of income level (GDP) in gravity equations has been addressed by some studies (e.g., Frankel and Romer, 1999; Cyrus, 2002). The main motivation is that GDP can be considered as potentially endogenous to trade flows since it is a function of exports. However, gravity equation approaches that take the endogeneity of GDP into account have not prevailed in the empirical trade literature. Studies have shown that there is no evidence that controlling for endogeneity of GDP in gravity models changes the results substantially (e.g., Frankel and Romer, 1999; Cyrus, 2002). In

addition, Baier and Bergstrand (2007) and Rudolph (2011) point out some plausible reasons for ignoring the potential endogeneity of GDP in this context. First of all, GDP is a function of the difference between exports and imports, and net export is a very small proportion of GDP. Therefore, GDP's connection to pure exports is much less direct. Moreover, there should not be much simultaneity between GDP and bilateral exports, since GDP depends on multi-lateral exports. Thus, bilateral exports may have much less of an effect on GDP.

Even though the endogeneity of GDP in our models may not be a major problem for the reasons discussed, we use following alternative specifications to control for the potential endogeneity of GDP: First, we drop Turkey's real GDP from the regression and replace the dependent variable (EV) with the export share defined as log of the ratio of real exports to real GDP of Turkey. In another alternative specification, we use lagged values (t-1) for Turkey's real GDP in estimations. Lastly, we apply instrumental variable regression (two-stage least squares) using lags of the endogenous variable (Turkey's real GDP) as its instruments. The results of all alternative specifications, which are available upon request, are quite similar to the main findings reported above.

## 7. Conclusions

Logistics infrastructure is a key component for expanding and diversifying exports. However, most developing countries face logistics deficiencies that affect their ability to deliver products to the world markets and integrate within global production networks. This paper utilizes highly disaggregated exports data from Turkey for the period 2007–2017 to illustrate the crucial role that logistics conditions play in achieving higher export growth and diversification in developing countries.

In this work, the effects of various logistics infrastructure measures on exports are decomposed into their effects on the EM and IM, which are calculated using methodology developed by Hummels and Klenow (2005). This approach allows us to capture the effects of logistics on the export variety (EM of exports) and the volume of exports (IM of exports). Preliminary results show that the EM has played a much more important role in the growth of Turkey's exports than the IM, indicating that export diversification is a key component of export growth in a developing country.

Gravity estimates suggest that logistics infrastructure positively influences export values and that it has a greater impact on the EM than the IM. Our results further indicate that Turkish exporters are more sensitive to improvements in local market logistics performance than in import partners' logistics performance. These findings are robust to a variety of alternative measures of logistics performance and estimation methods. Thus, we conclude that there are significant payoffs for developing countries to improve their local logistics infrastructure, as efficient, reliable and affordable infrastructure services is important to promote exports and increase the variety of products exported. In addition, the findings of this study imply that policies that generate favorable logistics conditions enable local firms in developing countries to ship goods on time and in good condition—important factors if they are to actively participate in global production networks. A policy setup designed in this context can help developing countries to expand their product lines, stabilize their export earnings and stimulate export growth, thereby leading to sustainable economic development.

On the basis of these findings, we recommend two avenues for future research. First, it would be worthwhile to examine the effects of logistics infrastructure on trade using firm-level data for single (or small group of) countries, because the incorporation of information on firm heterogeneity within regression models

provides more reliable estimates (Berns and Kikkawa, 2019). Second, it would be interesting to decompose total export flows into final and intermediate goods, because the effect of logistics infrastructure is expected to be different across these product types. The decomposition of gross export flows into two components also allows rough assessment of the effects of logistics infrastructure on a country's involvement in global production networks.

## Appendix

**Table A1**  
PPML Estimations: Logistics Performance Index (LPI)

Variables	EV	OV	EM	IM
$GDP_{it}$	−0.005 (0.010)	0.582*** (0.089)	0.218*** (0.033)	0.389*** (0.124)
$GDP_{jt}$	0.123*** (0.016)	0.114 (0.103)	0.380*** (0.049)	−0.242* (0.146)
$DIST_{ij}$	−0.001 (0.026)	−0.445*** (0.138)	0.039 (0.076)	−0.349** (0.142)
$Crisis_{ijt}$	−0.009** (0.004)	0.046 (0.033)	0.029* (0.016)	−0.004 (0.082)
$LPI_{it}$	0.854*** (0.132)	3.355*** (1.284)	2.657*** (0.532)	−1.186 (2.456)
$LPI_{jt}$	0.746*** (0.138)	3.788** (1.509)	2.422*** (0.531)	−0.862 (2.721)
$LPI_{it} \times LPI_{jt}$	−0.659*** (0.113)	−3.599*** (1.258)	−2.150*** (0.445)	0.520 (2.226)
Constant	−1.273*** (0.355)	−22.422*** (2.421)	−18.795*** (1.185)	−3.787 (4.470)
Observations	1696	1697	1697	1697
Partners	156	156	156	156
Pseudo log-likelihood	−3666.6	−118.7	−1128.1	−216.3
$R^2$	0.960	0.953	0.911	0.678

Notes: All variables provided as natural logarithms except dummies. All models include country fixed effects. Robust standard errors in parentheses. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

**Table A2**  
PPML Estimations: Quality of Transport Infrastructure (QTI)

Variables	EV	OV	EM	IM
$GDP_{it}$	0.004 (0.012)	0.544*** (0.086)	0.236*** (0.036)	0.279** (0.125)
$GDP_{jt}$	0.099*** (0.018)	−0.010 (0.105)	0.315*** (0.054)	−0.178 (0.203)
$DIST_{ij}$	−0.068*** (0.023)	−1.426*** (0.129)	−0.954*** (0.062)	−0.316* (0.190)
$Crisis_{ijt}$	−0.011*** (0.004)	0.042 (0.031)	0.021 (0.015)	0.028 (0.046)
$QTI_{it}$	0.288*** (0.040)	1.288*** (0.342)	1.004*** (0.136)	−0.026 (0.435)
$QTI_{jt}$	0.301*** (0.049)	1.516*** (0.405)	1.089*** (0.149)	−0.418 (0.651)
$QTI_{it} \times QTI_{jt}$	−0.188*** (0.029)	−1.013*** (0.256)	−0.671*** (0.089)	0.069 (0.389)
Constant	0.006 (0.350)	−10.732*** (2.392)	−10.158*** (1.175)	−3.641 (4.514)
Observations	1526	1527	1527	1527
Partners	140	140	140	140
Pseudo log-likelihood	−3309.1	−99.2	−1029.8	−176.1
$R^2$	0.961	0.944	0.919	0.656

Notes: All variables provided as natural logarithms except dummies. All models include country fixed effects. Robust standard errors in parentheses. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

**Table A3**  
PPML Estimations: Liner Shipping Connectivity Index (LSCI)

Variables	EV	OV	EM	IM
$GDP_{it}$	−0.026 (0.024)	0.351* (0.204)	0.114 (0.079)	−0.032 (0.386)
$GDP_{jt}$	0.105*** (0.019)	−0.102 (0.114)	0.389*** (0.059)	−0.293 (0.477)
$DIST_{ij}$	−0.366*** (0.036)	−1.370*** (0.220)	0.014 (0.124)	−0.596 (0.758)
$Crisis_{ijt}$	−0.003 (0.005)	0.050 (0.041)	0.037* (0.019)	−0.054 (0.127)
$LSCI_{it}$	0.194*** (0.030)	0.514** (0.224)	0.506*** (0.102)	0.001 (0.625)
$LSCI_{jt}$	0.145*** (0.028)	0.398* (0.210)	0.379*** (0.092)	−0.150 (0.571)
$LSCI_{it} \times LSCI_{jt}$	−0.044*** (0.008)	−0.103* (0.057)	−0.112*** (0.024)	0.046 (0.152)
Constant	2.369*** (0.657)	−3.609 (5.926)	−14.789*** (2.326)	8.824 (15.814)
Observations	1527	1548	1548	1548
Partners	143	143	143	143
Pseudo log-likelihood	−3274.3	−89.9	−955.2	−192.6
$R^2$	0.959	0.939	0.911	0.485

Notes: All variables provided as natural logarithms except dummies. All models include country fixed effects. Robust standard errors in parentheses. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

**Table A4**  
PPML Estimations: Ease of Trading Borders Index (EoT)

Variables	EV	OV	EM	IM
$GDP_{it}$	−0.004 (0.014)	0.506*** (0.089)	0.248*** (0.040)	0.221 (0.183)
$GDP_{jt}$	0.116*** (0.018)	0.036 (0.101)	0.325*** (0.058)	−0.397** (0.189)
$DIST_{ij}$	−0.445*** (0.026)	−4.366*** (0.409)	−1.574*** (0.184)	−2.813*** (0.305)
$Crisis_{ijt}$	−0.017*** (0.004)	0.031 (0.034)	0.005 (0.017)	−0.031 (0.086)
$EoT_{it}$	0.240** (0.096)	0.245 (0.292)	0.588* (0.333)	−0.607 (0.900)
$EoT_{jt}$	0.098 (0.098)	0.118 (0.288)	0.332 (0.327)	−0.795 (0.809)
$EoT_{it} \times EoT_{jt}$	−0.024 (0.023)	−0.025 (0.068)	−0.084 (0.077)	0.194 (0.190)
Constant	2.448*** (0.515)	15.918*** (4.003)	−4.860** (2.213)	25.746*** (5.511)
Observations	1880	1895	1895	1895
Partners	174	174	174	174
Pseudo log-likelihood	−4029.9	−119.1	−1186.3	−249.1
$R^2$	0.958	0.942	0.913	0.557

Notes: All variables provided as natural logarithms except dummies. All models include country fixed effects. Robust standard errors in parentheses. \*\*\*p < 0.01, \*\*p < 0.05, \*p < 0.1.

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