IDENTIFYING THE EFFECTS OF CORRUPTION PERCEPTION ON THE RELATIONSHIP BETWEEN INTERNATIONAL TRADE AND LOGISTICS PERFORMANCE IN DEVELOPING COUNTRIES

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Abstract. *Purpose* – logistics creates a strategic effect by playing a facilitating role in international trade, which has a significant impact on the economic performance of countries. Logistics performance and corruption play an influential role in determining the trade efficiency levels of developing countries. There are two purposes in this research. First purpose is to determine the international trade efficiency level of developing countries based on logistics performance. The second purpose is to determine the efficiency level of trade based on both logistics performance and corruption levels.

Research methodology – output-oriented data envelopment analysis (DEA) has been applied in the research. The research covers the years 2012–2020. The sample area is developing countries.

Findings – countries with full efficiency levels in 2012–2020 have been determined according to both logistics performance and corruption scores.

Research limitations – the research covers the years 2012–2020. The sample area is developing countries.

Practical implications – the reduction of corruption levels in some developing countries is an important factor in increasing the level of international trade efficiency.

Originality/Value – this research highlights the role of corruption in the relationship between trade and logistics performance.

Introduction

The literature agues that international trade has significant effects on the growth and competitiveness of national economies (Acar & Yurdakul, 2015), and these relationships have been supported by the studies performed in different economies (e.g. Elbeydi et al., 2010; Akhter et al., 2022; Dragusha et al., 2023). Thus, most of the developing countries aim to increase their national income by pursuing outward-oriented development policies. In this context countries undersigned many bilateral and multilateral trade agreements and participating global and/or regional trade unions. This highlights the importance of promoting foreign trade, particularly exporting, to economic prosperity.

Along with this widely supported concept regarding globalization and increasing competition, research studies show that improvements in logistics performance facilitate international

trade in different ways (Gani, 2017), such as reducing the impact of distance and transport costs, providing better infrastructure and so on (Çelebi, 2019). This will result in reducing the overall international trade costs, while increasing the level of competition and economic growth. In this respect, logistics has been considered as one of the main determinants of the international trade performance of countries.

Basically, it is easy to say improvements in logistics have reduced transportation costs. However, the development of logistics activities not only reduces transportation costs, but also it has a positive effect in reducing the production costs via supporting the supply chains (Lapinskaitė & Kuckailytė, 2014). Moreover, logistics services ensure the mobility of products in a safe, reliable, quick, and efficient manner which means reducing costs in international trade. Thus, it is considered that logistics is one of the key elements in international trade together with globalization and increasing competitiveness (Martí et al., 2014).

In this framework literature is full of conceptual and empiric studies articulating the mutual relationship between foreign trade and international logistic performance of the countries. Especially the logistics performance of developing countries has been considered as vital for them to increase their share in global trade and to benefit from the revenues of globalization (Ofluoğlu et al., 2018).

Logistics industry, particularly transportation, as a facilitator in international trade grew significantly while logistics became a significant part of the business economic system and major global economic activity in recent years (Yurdakul & Acar, 2015). Moreover, a recent study shows that countries with greater capability in logistics are taking the lead over their competitors regarding the World Economic Forum's Global Competitiveness Index (GCI). This and other related studies indicate that there is a strong relationship between logistics performance and the general competitiveness of a country (Erkan, 2014; Kabak et al., 2020).

However, global logistics business is full of challenges. Thus, logistics managers must deal with many non-tariff barriers as well as problems such as costs, exchange rate differences, and different customs regimes to ensure the effective and efficient flow of goods. One of the important problems which can be considered a non-tariff barrier in developing countries is corruption. Since this problem negatively affects international logistics networks, there is a vast literature about the negative effects of corruption on economic development, foreign direct investment, international trade, and international logistics performance.

The fact that corruption trends are higher in developing countries causes these countries to be more affected by the negative effects of corruption in their international trade activities and performances. In addition, considering the close relationship between logistics performance and international trade, it is expected that corruption will weaken the effect of both logistics performance and logistics performance on trade. At this point, there are two main motivations for this research. These motivations also address research questions. The research questions are as follows:

- *Research Question 1:* Can trade efficiency levels be determined according to the logistics performance of developing countries?
- *Research Question 2:* Can trade efficiency levels be determined according to both logistics performance and corruption of developing countries? What are the differences according to the first research question?

In accordance with these two research questions, this empirical study has two aims. One of the two aims is to determine the international trade efficiency level of developing countries based on logistics performance. The other aim is to determine the efficiency level of trade based on both logistics performance and corruption levels.

In the literature, it is seen that data envelopment analysis is commonly preferred to determine the efficiency levels (Rashidi & Cullinane, 2019; Polat et al., 2022; Kara, 2022; Kara & Çetinkaya, 2022). Thus, DEA analysis was preferred to achieve the research objectives. With this analysis, efficiency levels based on input and output variables can be determined. In addition, it is aimed to provide suggestions to countries by detecting changes in activity levels by considering corruption based on the comparison of these two results. In this context, data envelopment analysis has been applied to determine the international Trade (% of GDP) efficiency levels of developing countries. The fact that trade efficiency has been determined by considering the effect of corruption on trade as well as logistics performance with this empirical research makes the study different from the other research. However, the limitations of the current research can be considered as the fact that a model was created in which only logistics performance and corruption variables were used to determine the international trade efficiency levels of countries, the research period was limited to the 2012–2020 period, and the data set was obtained from secondary reports.

The second part of the article is dedicated to establishing a conceptual framework based on a literature review. In the third part, the methodology of the research is explained. In the fourth part, the findings of the empirical research are given. In the last part, conclusions based on the findings and implications and suggestions for countries have been developed.

1. Conceptual framework and literature review

The interrelationships between international trade and international logistics regarding the effect of corruption will be conceptually examined in the following sub-sections. This review provides a framework based on the building blocks of the main concepts of the research and examining their relationships.

1.1. Importance of foreign trade in economic prosperity

It can be considered that Adam Smith was the first to highlight the positive effect of International Trade on Economic Growth (Smith, 2010). The thesis that foreign trade is the engine of growth was discussed in the context of Adam Smith's theory of specialization. According to Adam Smith's theory, a country should produce and specialize in whatever goods it can produce more cheaply than others, and so which provide an "Absolute Advantage". Therefore, it should export these goods that it can produce at low cost and import the goods that it can produce at a high cost from foreign countries.

Ricardo expanded the theory within the framework of the theory of comparative advantage and carried it to new horizons. Later, the relationship between foreign trade and economic growth has been confirmed by Michaely (1977) and Feder (1983). Since then, the relationship between import, export and economic growth has been one of the important

issues discussed in the economics literature. The increase in the number of imports and exports, that is, in the volume of foreign trade, can increase economic growth by increasing employment and labor productivity by creating technological innovations and the transition to economies of scale. In foreign trade, on the one hand, economic growth is achieved due to economies of scale and increased productivity by selling products to wider markets, on the other hand, imports of intermediate and capital goods and basic raw materials from abroad help countries to easily access the inputs they need and thus increase their economic growth.

In studies on the relationship between foreign trade and growth, most of the researchers on economics argue that exports affect growth more, particularly in developing or less-developed countries (Vohra, 2001) such as Libya (Elbeydi et al., 2010), Jordan (Shihab et al., 2014), Pakistan (Saleem & Sial, 2015), India (Mishra, 2011; Kumari & Malhotra, 2014), Turkey (Bahramian & Saliminezhad, 2020) and China (Mah, 2005; Kumari & Malhotra, 2014). On the other hand, those who argue that imports are also effective on economic growth are not to be underestimated. According to this approach, imports provide the intermediate goods and capital goods needed by the country in production in the most appropriate variety and positively affect the country's economy with the effect of the decreasing cost of capital (Şahin & Durmuş, 2018).

However, the increase in international trade numbers also contains many question marks. That is, the ratio of imports to exports or the added value created by the exported goods are the data that should always be questioned. In this context, in general, the necessity of evaluating the international trade of a country emerges not only in terms of numbers but also in terms of efficiency.

1.2. Relationship between International Trade and International Logistics

The demand of the manufacturers to transport their products to the consumers with minimum time loss and low cost but reliably creates the necessity of working in connection with various industries in domestic economies. These links have been strengthened through effective transport and logistics systems. In this context, logistics services not only provide industrial connections within the domestic economy, but also connect the domestic economy to the international economy (Gani, 2017). Moreover, logistics, particularly transportation-related activities, determines the amount of trade and goods exchange (Hesse & Rodrigue, 2004) by facilitating international trade as it enables companies to effectively complete the import, export and related transactions of goods and services. Therefore, logistics services, which ensure the mobility of the products in a safe, reliable, quick, and efficient manner while reducing costs, have become one of the key elements in international trade during globalization and increasing competitiveness (Martí et al., 2014).

International trade broadly refers to transferring the finished goods of a company to the other company in the importing country by exporting it with the aim of making a profit. International trade increases national income and reduces poverty under favorable conditions. Thus, as it is argued in one of the OECD/WTO reports that international trade contributes to both economic and social development (OECD/WTO, 2013). Therefore, factors which disturb the smooth and cost-effective flow of trading commodities such as bureaucratic procedures to be done in the process of exchanging produced goods between countries, documents

to be arranged, legal regulations to be complied with, transportation and insurance costs incurred, and expenses arising from delays cause significant trade costs. For this reason, simplifying the procedures to be followed in international trade, reducing the number of documents, using common documents and legislation, establishing an effective logistics system, and increasing the quality of logistics services have become the priority objectives for increasing the world trade volume. In this context, especially high logistics costs and inadequacy of logistics services are considered as barriers to international trade. Therefore, countries are expected to increase their logistics performance to minimize these obstacles (Ofluoğlu et al., 2018).

There are many studies in literature that evaluate the relationship between international trade and logistics, both conceptually and empirically. Puertas et al. (2014) argued that an efficient supply chain system in international trade requires logistics as the enabler of organization and synchronization of trade flows. Meanwhile, based on their findings in developing countries, the same authors claimed that the underdevelopment of logistics can cause an increase in trade costs and impede the efficient movement of goods (Martí et al., 2014). Shepherd (2016) pointed out that improved logistics performance can positively affect export and facilitate trade by increasing the efficiency of trade in goods, reducing the cost, providing the simplicity of the procedures, and more efficiently processing the necessary documentation accompanying trade.

Bensassi and colleagues examined the bilateral exports from 19 Spanish regions to 64 destinations by using an augmented gravity model of trade. Their findings proved the positive correlation between logistics performance based on the number, size and quality of logistics facilities and the trade (export) flows in goods (Bensassi et al., 2015). A more recent study conveys the findings of Bensassi and colleagues' study to new frontiers and proved that logistics performance is more critical for exporting countries than for importers (Host et al., 2019). As a global study, the World Bank's LPI report findings showed that among countries with similar income levels, those with better logistics performance stood out with an additional 1% GDP growth and 2% trade growth (Arvis et al., 2016).

More recently, Bugarčić et al. performed an empirical study considering the logistics performance and the trade volume of the Central and Eastern European (CEECs) and Western Balkans countries. Their analysis based on the gravity model statistically proved the common assumption about the improved logistics performance and logistics services lead to a positive impact on the international trade volume. Thus, they claimed that better logistics performance of the countries will lead to increased bilateral trade while reducing trade costs (Bugarčić et al., 2020).

Korkut et al. (2021) have used it to analyze the relationship between international trade and logistics by considering different modes of transport function of logistics and related infrastructural investments. They used panel co-integration and panel causality analyzes to compare the current account balance data of the G20 countries in international trade with the infrastructure expenditures of the countries on the highways, railways, airlines, and seaways. As they expected, data analyses revealed that there is a co-integration between international trade and logistics infrastructure investments.

As can be clearly seen from these studies in the literature, there is a strong relationship between logistics and trade. So, as is repeatedly argued in the literature, researchers of the current study assumed that logistics is one of the determinants of the efficiency of trade, and it is a cost item for the companies as well as the value it creates.

1.3. Logistics performance of the countries

Logistics should not be considered as a mere transportation activity. Logistics, which is one of the basic elements of international trade and international supply chains, covers a set of core activities associated with various public and private sector institutions ranging from transportation, warehousing, cargo consolidation, customs clearances to domestic distribution and payment systems to the transformation and circulation of goods (Arvis et al., 2012; Hesse & Rodrigue, 2004). Thus, to improve the effectiveness and the efficiency of a logistics system all these basic activities should be considered and evaluated in a competitive manner.

In a competitive business environment, logistics performance has a significant impact on many strategic decisions such as which countries the companies will be in, which suppliers they will buy from, and which markets they will enter. High logistics costs and low level of logistics service constitute an obstacle to trade, foreign direct investments, and thus economic growth. For these reasons, improving a country's logistics performance has become an important development policy goal.

To improve a system or a process, first, it should be measured by a valid criterion. However, there is not any logistics performance criteria list which has been agreed upon. However, studies dealing with the relationship between international trade and international logistics performance empirically took into account the LPI values developed by the World Bank in order to measure the logistics performances of countries (e.g. Nguyen & Tongzon, 2010; Martí et al., 2014; Puertas et al., 2014; Bensassi et al., 2015; Gani, 2017; Jiang & Wu, 2017; Wang et al., 2018; Ofluoğlu et al., 2018; Bugarčić et al., 2020).

At the macro level, logistics performance is among the main indicators pointing to the logistics competencies of countries (international transportation, customs services, international transportation legislation, import and export transactions, etc.) (Halaszovich & Kinra, 2020). Logistics Performance Index (LPI) was developed by the World Bank (WB). It provides feedback, based on a global survey, to help countries develop logistics reform programs to increase their trade capability and competitiveness. With this index study, the WB aims to create a competitive environment between countries and tries to determine the situation for countries to improve their logistics performance. The LPI provides detailed information about the logistics environments of countries, their basic logistics processes and organizations, and their time and cost performances. So, countries can find the opportunity to compare themselves with other countries in terms of international logistics activities, and they can see the opportunities and obstacles in front of them.

The WB's LPI has been calculated every two years since 2007 and measures the international logistics performance of approximately 160 countries. However, there are also many criticisms about the research methodology and calculation algorithm of this index. Despite all the criticisms written about its subjective aspects, it is possible to say that LPI is an appropriate

measurement to compare countries regarding logistics performance (Acar et al., 2015; Polat et al., 2022). Besides the WB, also a worldwide logistics company (Agility) has measured the international logistics performance of the emerging economies and release the annual AEMLI (Agility Emerging Markets Logistics Index) report since 2011.

AEMLI reports in 2011–2018 are based on three key components. These components are Market size and attractiveness (50%), Market compatibility (25%), and Connectedness (25%). In determining the market size and attractiveness score, the economic outputs, growth rates, financial stability and population sizes of the countries are considered. Market compatibility score determines the market accessibility of countries, the size of foreign investments and the level of economic development based on logistics services. Connectedness, on the other hand, is determined based on the national and international transport connections of the countries. As of 2019, AEMLI reports are calculated based on Domestic opportunities (33%), International opportunities (33%) and Business fundamentals (33%). The Domestic Opportunities score is determined according to the economic and population sizes of the countries, income equality, urbanization levels and the development status of business clusters. International opportunities are determined based on countries' international logistics market sizes, logistics-based trade sizes, infrastructure, and success in customs processes. Business fundamentals, on the other hand, are calculated depending on the legal regulations in the countries, the amount of credit and debt, the success of the fight against corruption, inflation, financial expenditures caused by crime and violence, and local stability.

The impact of the logistics performances of developing countries on the commercial activities of the countries is inevitable. As stated in AEMLI reports, logistics activities directly affect market efficiency. As a result, international trade efficiency is directly affected. At this point, the first hypothesis of testing international trade efficiency based on the logistics performance of developing countries is as follows:

H1: International trade efficiency of developing countries based on logistics performance can be ascertained, and the efficiency levels of countries can be determined.

1.4. Effects of corruption

Corruption is a concept that has existed since ancient times and was defined by Kaufmann (1997) as the misuse of public goods by public servants for their own benefit. Meanwhile, Tanzi (1998), referring to the fact that it is not that easy to define corruption, supported a definition as the malicious use of public power for personal gain. When current studies are examined, it is understood that the view of "abuse of public power for personal benefit" is generally accepted (e.g. Dong, 2011; Larson, 2020). In addition, Bahoo et al. (2020) drew attention to seven main streams in their research to determine the corruption agenda in the concept of international business. Among them, the fight against corruption, the determinants of corruption, the effect of corruption on companies, the relationship between the political environment and corruption, the anti-corruption management, the effect of corruption on foreign investors and trade. Thus, it is clearly understood that the relationship between corruption and trade is on the agenda of international literature.

According to the existing literature, studies examined the effects and the relationship of the corruption regarding different aspects and the factors such as trade, economic growth, foreign direct investment, political regime, CO2 emissions and so on. Although there are few studies claiming to the contrary (e.g. Egger & Winner, 2005; Méndez & Sepúlveda, 2006; Aidt et al., 2008; Dong, 2011) it is stated that there is no evidence that corruption has positive effects in the majority of the studies in the literature. Also, corruption researchers paid too much attention to less developed and developing countries.

There is extensive literature on the relationship between corruption and international trade (e.g. Trefler, 1995; Eaton & Kortum, 2002; De Jong & Bogmans, 2011; Leitão, 2021). One of the most outstanding works, among others, is the work of Trefler (1995), who calls corruption the "mystery of missing trade". De Jong and Bogmans (2011) claimed that corruption would reduce the volume of international trade. Accordingly, Eaton and Kortum (2002) gave a ratio, assertively argued that international trade would be five times larger than its current state if there were no frictions such as corruption. However, de Jong and Borgmans (2011) have argued that corruption can facilitate international trade if the related systems and/or institutions are not well developed or of low quality.

Meanwhile, the literature regarding the relationship between corruption and logistics is relatively smaller than the corruption and international trade relationship. Although it has not been proven statistically, it is an expected finding that most of the related publications originate from developing countries (e.g. Stefanovskiy et al., 2012; Omran, 2012; Seabra et al., 2016; Uca et al., 2016). Also, some researchers have used panel data of the countries (world, EU28 etc.) to examine econometric models (e.g. Larson, 2020; Goel et al. 2021). Following these opposing views, identifying the effects of corruption on trade efficiency based on logistics performance is one of the main objectives of this research. There are also studies on research aimed at reducing corruption in international transportation activities (Sarker et al., 2021). Considering the level of corruption, which plays an important role in the impact of logistics performance on international trade, the second hypothesis for determining the level of international trade efficiency is as follows.

H2: Based on both logistics performance and corruption, the international trade efficiency of developing countries can be ascertained, and the efficiency levels of the countries can be determined.

2. Methodology

There are many studies in the literature dealing with the relationships between the logistics performance levels of countries and their trade-based economic indicators (Martí et al., 2014; Faria et al., 2015; Danaci & Nacar, 2017; Gani, 2017; Çelebi, 2019; Bugarčić et al., 2020; Song & Lee, 2022). However, there are a limited number of studies dealing with the relationship between logistics performance and corruption (Seabra et al., 2016; Larson 2020). In addition, there are rare articles dealing with the relationship between logistics performance, corruption, and trade-based economic indicators (Uca et al., 2016). There are regression models (Larson, 2020; Shikur, 2022), panel data models (Tang & Abosedra, 2019), structural equation models (Sénquiz-Díaz, 2021) that try to explain the relationship between logistics performance, trade,

and corruption variables. In this research, the relationships between logistics performance, corruption, and international trade are examined by data envelopment analysis considering the developing countries, and the trade efficiency levels of the countries based on both logistics performance and corruption scores have been revealed.

In this context, the research was carried out in three stages. In the first stage, Trade (% of GDP) efficiency levels were determined based on the logistics performance of developing countries by DEA. In the second stage, the efficiency levels of Trade (% of GDP) based on logistics performance were determined by considering the effect of corruption by DEA. In the third stage, the efficiency level findings obtained in Model 1 and the efficiency level findings obtained in Model 2 were compared. The empirical analysis flowchart is shown in Figure 1.

2.1. Variables and sampling

The role of corruption is examined in this empirical research, which is expected to affect the relationship between the logistics performance of developing countries and the share of trade in gross domestic product (Trade (% of GDP)). Data envelopment analysis has been applied in the research. At this point, two data envelopment models were created. In the first data envelopment model (Model 1), "sub-dimensions of logistics performance" of developing countries were determined as input variables, and "share of trade in gross domestic product" as output variables. In the second data envelopment model (Model 2), "Sub-dimensions of logistics performances" and "Corruption perceptions" of developing countries were determined as input variables, and "The share of trade in gross domestic product" as output variables. The purpose of Model 1 is to determine the efficiency level of the share of trade in gross domestic product of developing countries based solely on logistics performance. The purpose of Model 2 is to determine the efficiency level of the share of trade in gross domestic product of developing countries based on both logistics performance and corruption.
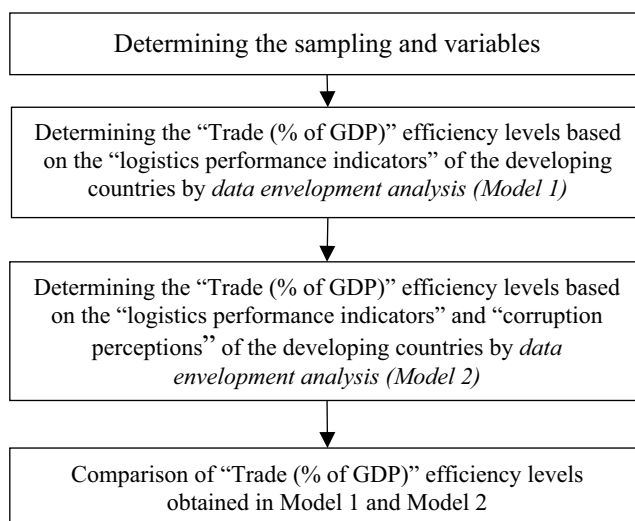
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│     Determining the sampling and variables       │
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│  Determining the "Trade (% of GDP)" efficiency   │
│  levels based on the "logistics performance       │
│  indicators" of the developing countries by      │
│  data envelopment analysis (Model 1)              │
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│  Determining the "Trade (% of GDP)" efficiency   │
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│  the developing countries by data                 │
│  envelopment analysis (Model 2)                   │
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│  Comparison of "Trade (% of GDP)" efficiency     │
│  levels obtained in Model 1 and Model 2           │
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Figure 1. Empirical analysis flow chart

The current empirical research considers developing countries as sampling which takes place in the "Agility Emerging Markets Logistics Index (AEMLI)" report. It should be noted that this report has been chosen because it is appropriate to the main assumption of this study and considers emergent economies which have the potential to suffer from corruption. In this context, it is aimed to determine the efficiency values of the developing countries in each year between the years 2012–2018. The logistics performance scores of developing countries were obtained from the AEMLI reports. Corruption perceptions scores were obtained from reports published by the "Transparency International" organization (Corruption scores have been taken as "1/corruption" score in the analyses, since the negative impact of corruption scores was considered). The share of trade in gross domestic product is obtained from the "World Bank" reports. When the reports are examined, it has been determined that there are deficiencies in the data announced by the countries. For this reason, countries were determined for each year. The variables, periods and number of countries used in this study are shown in Table 1.

Table 1. Variables and sampling

Models	Period	Input Variable	Output Variable	Sampling
Model 1	2012	Market size & attractiveness, Market compatibility, Connectedness	Trade (% of GDP)	41 countries
	2013, 2014, 2015, 2016			45 countries
	2017, 2018			49 countries
	2019	Domestic opportunities, International opportunities, Business Fundamentals	Trade (% of GDP)	48 countries
	2020			49 countries
Model 2	2012	Market size & attractiveness, Market compatibility, Connectedness, Corruption	Trade (% of GDP)	41 countries
	2013, 2014, 2015, 2016			45 countries
	2017, 2018			49 countries
	2019	Domestic opportunities, International opportunities, Business Fundamentals, Corruption	Trade (% of GDP)	48 countries
	2020			49 countries

2.2. Data envelopment analysis

Charnes et al. (1978) introduced the data envelopment analysis method, which enables the determination of efficiency levels based on inputs and outputs, to the literature. DEA is useful in determining the efficiency levels of the variables, considering the relationships between the data in different measurement units. It is also a commonly used non-parametric mathematical modeling method in operation research and economics. DEA makes measurements based on total factor productivity. It's also useful for benchmarking. Mathematical expression of total factor load is seen in Eq. (1) (Zionts, 1968):

$$Total\ Factor\ Efficiency = \frac{\sum_{r=1}^{s} u_{rk} Y_{rk}}{\sum_{r=1}^{m} v_{rk} X_{rk}} . \tag{1}$$

$Y_{rk} \left(r = 1, ..., s \right)$ It is the amount of output produced by the decision unit.

$X_{ik} \left(i = 1, ..., m \right)$ It is the amount of input used by the decision unit.

$u_{rk} \left(r = 1, ..., s \right)$ It is the weight coefficient that the decision unit gives to the outputs.

$v_{ik} \left(i = 1, ..., m \right)$ It is the weight coefficient that the decision unit gives to the inputs.

In this study, the output-oriented CCR-O (Charnes et al., 1978) model, one of the DEA methods, was applied. The reason for choosing this model is to achieve the maximum output level. Charnes et al. (1989) points out that the main goal of the CCR model is to bring the sum of the weighted inputs to the minimum level while maximizing the output level. In this study, two CCR models were developed and applied to all years. Therefore, the CCR model constructs are common. However, there are differences in the Indices and Parameters used in the models. The objective function (Eq. (2)) of the CCR model, Constraints (Eq. (3)) objective function (Eq. (4)) of the dual model, Constraints (Eq. (5)) are as follows:

Objective Function:

$$\min e_k = \sum_{i=1}^{m} v_i x_{ik}. \tag{2}$$

Constraints:

$$\sum_{i=1}^{m} v_i x_{ij} - \sum_{r=1}^{s} u_r y_{rj} \geq 0 \quad j = 1, ..., n;$$

$$\sum_{r=1}^{s} u_r y_{rk} = 0;$$

$$u_r, v_i \geq 0; \; r = 1, ..., s; \; i = 1, ..., m. \tag{3}$$

Objective Function (Dual model):

$$Max \, Z_k. \tag{4}$$

Constraints (Dual model):

$$\sum_{j=1}^{n} \varphi_{jk} x_{ij} - x_{ik} \leq 0;$$

$$z_k y_{rk} - \sum_{r=1}^{s} \varphi_{jk} y_{rj} - x_{ik} \leq 0;$$

$$\varphi_{jk} \geq 0; \; r = 1, ..., s; \; i = 1, ..., m; \; j = 1, ..., n. \tag{5}$$

The indices of Model 1 are as follows:

Indices (for Model 1):

i AEMLI indicators i = 1,2..., m (m = 3)

r Trade (% of GDP) r = 1,2..., s (s = 1)

j Countries j = 1,2..., n (n = 41 *for* 2012; n = 45 for 2013, 2014, 2015 ,2016; n = 49 *for* 2017, 2018, 2020; n = 48 *for* 2019).

The indices of Model 2 are as follows:

Indices (for Model 2):

i   AELPI indicators and CPI *i* = 1,2..., *m* (*m* = 4)

r   Trade (% of GDP) *r* = 1,2..., *s* (*s* = 1)

j   Countries   *j* = 1,2..., *n* (*n* = 41 *for* 2012; *n* = 45 *for* 2013, 2014, 2015, 2016;
n = 49 *for* 2017, 2018, 2020; *n* = 48 *for* 2019).

The parameters of Model 1 and Model 2 are as follows:

Parameters:

v_i : "i" weight given to logistic performance input (with CPI for model 2).

u_r : "r" weight given to trade (% of GDP) output.

x_{ik} : "k" score of the "i" logistics performance input (with CPI for model 2) of the decision
unit.

y_{rk} : "k" score of the "r" trade (% of GDP) output of the decision unit.

$v_i x_{ij}$: "j" country's weighted input score.

$u_r y_{rj}$: "j" country's weighted output score.

2.3. Findings

In this empirical research, first of all, the trade (% of GDP) efficiency levels of developing countries between 2012 and 2020 were determined by DEA analysis. At this stage, the findings of the Trade (% of GDP) efficiency levels based on the logistics performances of the countries have been obtained. As seen in the Table 2, two countries (Bahrain, Vietnam) for 2012, three countries (Bahrain, Cambodia, Vietnam) for 2013 and 2014, three countries (Libya, Cambodia, Venezuela) for 2015, two countries (Vietnam, Cambodia) for 2016, three countries

Table 2. Countries with 100% Trade (% of GDP) efficiency with and without corruption

2012			2013			2014		
Country	(Without CPI)	(With CPI)	Country	(Without CPI)	(With CPI)	Country	(Without CPI)	(With CPI)
Bahrain	1	1	Bahrain	1	1	Bahrain	1	1
Vietnam	1	1	Cambodia	1	1	Cambodia	1	1
			Vietnam	1	1	Vietnam	1	1
2015			2016			2017		
Libya	1	1	Vietnam	1	1	Libya	1	1
Cambodia	1	1	Cambodia	1	1	Vietnam	1	1
Venezuela	1	1	Bahrain	0.85	1	Cambodia	1	1
			Ukraine	0.79	1	Bahrain	0.93	1
						Ukraine	0.75	1
2018			2019			2020		
Vietnam	1	1	Angola	1	1	Libya	1	1
Libya	1	1	Vietnam	1	1	Vietnam	1	1
Mozambique	1	1	Mozambique	1	1			
Bahrain	0.96	1						
Ukraine	0.63	1						

(Libya, Vietnam, Cambodia) for 2017, three countries (Libya, Vietnam, Mozambique) for 2018, three countries (Angola, Vietnam, Mozambique) for 2019, and two countries (Libya, Vietnam) for 2020 stand out as countries with full efficiency level. This finding supported the assumption of Hypothesis1 in the context of the countries mentioned above.

According to the Trade (% of GDP) activities of countries based on both logistics performance and corruption levels (Table 2), it is seen that Bahrain and Ukraine have been added among the countries with full efficiency levels for 2016, 2017 and 2018 regarding the logistics performance. This finding indicates that Bahrain and Ukraine are the countries which increase their trade (% of GDP) activities to full efficiency level because of their successful implementation of anti-corruption policies. This finding supported the assumption of Hypothesis 2.

The other main finding of the empirical research is that when the corruption levels of the countries are considered, the Trade (% of GDP) efficiency levels of some countries increase. Countries with increased efficiency levels are presented in the Appendix. These countries with the highest increase in efficiency levels over the years are:

- Qatar (22%), Malaysia (9%) and Ukraine (8%) in 2012,
- Qatar (23%), Ukraine (14%) and Uruguay (11%) in 2013,
- Qatar (28%), Chile (24%) and Ukraine (17%) in 2014,
- Qatar (38%), Malaysia (25%) and Chile (24%) in 2015,
- Qatar (35%), Malaysia (33%) and Chile (27%) in 2016,
- Qatar (31%), Malaysia (28%) and Chile (27%) in 2017,
- Qatar (38%), Ukraine (37%) and Malaysia (35%) in 2018,
- Ukraine (29%), Malaysia (20%) and Chile (17%) in 2019,
- Ukraine (26%), Qatar (21%) and Malaysia (20%) in 2020.

This finding reveals that Qatar, Ukraine, Malaysia, and Chile are the top countries which increase the efficiency in trade within time frame of the current research. Thus, both of our hypotheses were accepted. Figure 2 shows the efficiency levels.

However, the supplementary aim of this study is to provide suggestions to countries by detecting changes in activity levels by considering corruption based on the comparison of the findings of hypothesis 1 and 2. In this sense, considering the corruption perception index data between 2012 and 2020, it is seen that the countries that have reached the level of full efficiency in international trade are Bahrain (2017, 2018) and Ukraine (2016, 2017, 2018). Besides, it has been observed that there are countries whose efficiency levels have increased even though they have not reached the full efficiency level in international trade between 2012 and 2020 such as Qatar, Malaysia, and Chile (see Appendix). In addition to the years of full efficiency, Ukraine has increased its efficiency level in 2012, 2013, 2014, 2019 and 2020.

3. Results and discussion

The mutual relationship between international trade and logistics, and the effects of the corruption -mostly negative- on these concepts are generally known and accepted by experts and practitioners. Also, in literature, there are a vast number of scientific studies exposing the relationships between and among these concepts mentioned above. Even though different
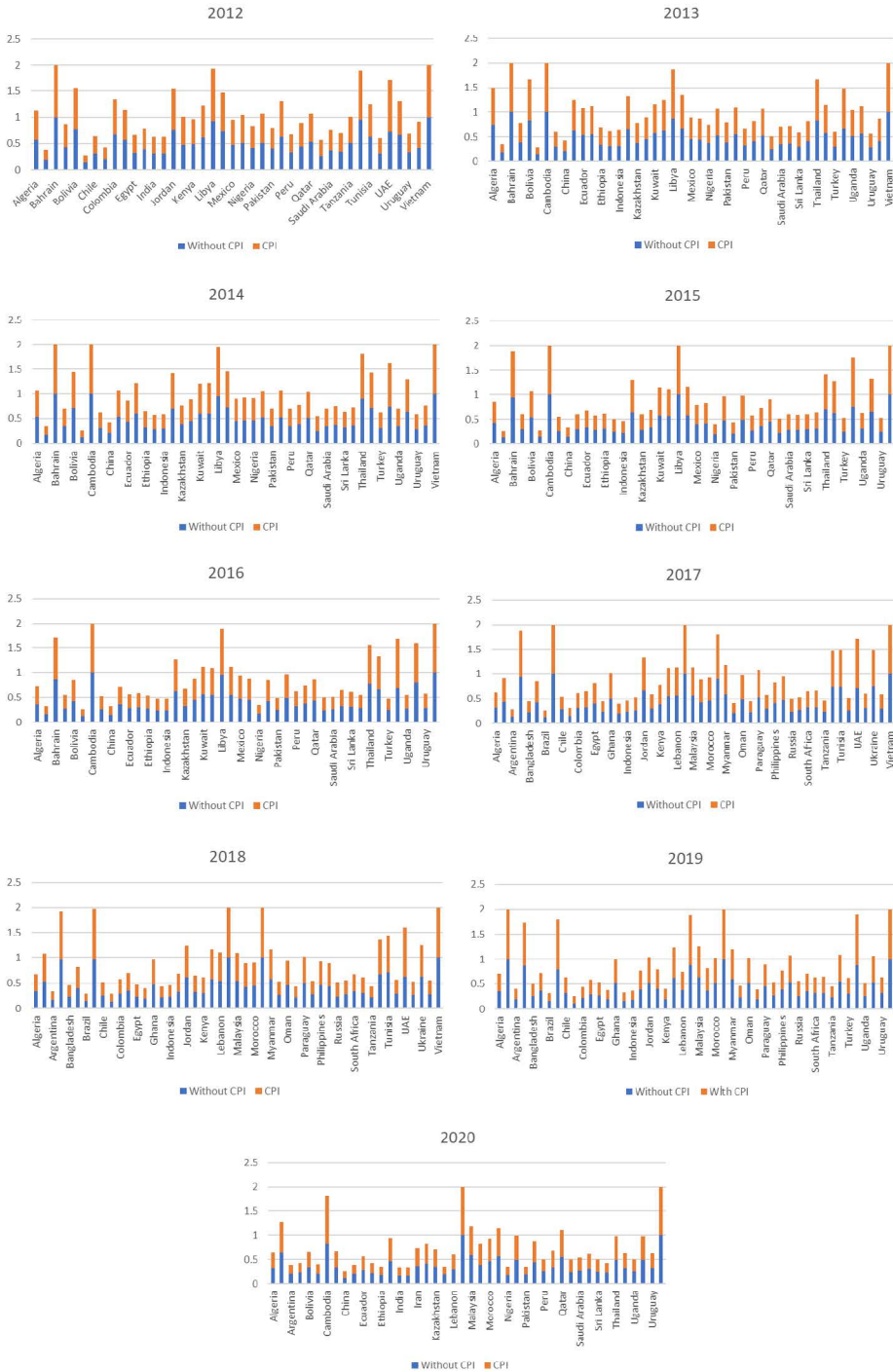
Figure 2. Trade efficiency levels of developing countries

methodologies are used, many scientific studies have verified the mutual relationship between logistics and international trade (e.g. Nguyen & Tongzon, 2010; Bensassi et al., 2015; Gani, 2017; Wang et al., 2018; Korkut et al., 2021).

Besides, because both international trade and logistics activities need coordination and collaboration of many shareholders, there is always a probability of encountering a weak point along the supply chain that is corrupt. However, the studies considering the variables of international trade, logistics performance and corruption together are very rare particularly with a macro approach (e.g. Uca et al., 2016). Gani (2017) claimed that complex business administrative procedures can create more inefficiency as well as create an environment for corruption to emerge, but he has not proven this empirically.

Thus, the current study examines the interrelationships between the international trade and international logistics performance of the emerging economies under the consideration of the effect of corruption. An econometric model has been established to reveal the relationships by considering the international trade efficiency, international logistics performance, and the corruption assumption of sampling countries.

Based on the findings, it has been determined that corruption level plays an active role in international trade efficiency based on logistics performance. With the findings of this research, it has been revealed that international trade efficiency and the international trade efficiency based on logistics performance can be ascertained in developing countries by DEA. According to the findings of the related hypothesis 1, between the years 2012–2020 which are the time limits of our research, Bahrain (2012, 2013, 2014), Vietnam (all years except 2015), Cambodia (2013, 2014, 2015, 2016, 2017), Libya (2015, 2017, 2018, 2020), Venezuela (2015), Mozambique (2018, 2019) and Angola (2019) were identified as countries with full efficiency. These findings carry the retrospective perspective, which compares the obtained logistics performance level as a result of investments in developed countries with the international trade data, to different horizons in respect of emergent economies. It can be interpreted that logistics is not the sole factor determining international trade efficiency. The fact that this relationship has been verified only in some of the developing countries can be interpreted as logistics is not the only factor that determines the efficiency of international trade. This inference, of course, reveals the question of what could be the missing point.

To find an answer to this question, the corruption factor was added to the analysis in the continuation of the study. According to the Hypothesis 2 test finding obtained by considering the years 2012–2020, Bahrain (2012, 2013, 2014, 2017, 2018), Vietnam (all years except 2015), Cambodia (2013, 2014, 2015, 2016, 2017), Libya (2015, 2017, 2018, 2020), Venezuela (2015), Mozambique (2018, 2019), Angola (2019) and Ukraine (2016, 2017, 2018) are countries with full activity. As can be seen from the findings, the analysis revealed the fact that the relations that are predicted to be carried forward in this way will be proven to be valid in more countries and for more years. Thus, it has been concluded that international trade efficiency levels can be determined based on the logistics performance of countries, together with corruption, which is among the main problems of developing countries. Also, these findings represent the novelty and the contribution of our study to literature.

Conclusions, implications, and limitations

The findings of this study can be interpreted into two results in general. First, in line with the general opinion, the results of this empirical research also revealed that corruption affects the efficiency of international trade in most of the developing countries. In determining the international trade efficiency of countries in the context of logistics performance, only looking at the LPI data may be biased as it does not reveal the individual or holistic behavior models of people, which are the basic building blocks of the business philosophy. Therefore, current research findings show that considering logistics performance under the influence of corruption perception in determining international trade efficiency provides more significant results. In this context, it may even be considered to update the LPI calculation by incorporating corruption perception data as a sub-dimension.

This study also has a practical implication. The results of this research can be used to inform policymakers and supply chain managers to be aware of the effects of corruption on international logistics performance at the country level. In addition, it is seen and recommended as remarkable studies in examining the relations between other macroeconomic indicators (such as income level, political stability, and institutional quality), logistics performance and corruption.

It should be considered by researchers as the limitations of the current research that models were established using only logistics performance and corruption variables in determining the international efficiency levels of countries, the research period was 2012–2020, the data set was obtained from secondary reports, the DEA analysis was determined as output-oriented, and the sample area was only the developing countries. At this point, it is recommended that researchers examine logistics performance and trade efficiency levels based on corruption with various DEA models. In addition, it is believed that the impact of corruption in the sample of developed and underdeveloped countries is considered and compared with these research findings, which is a valuable research topic.

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APPENDIX

Countries with increased Trade (% of GDP) activity when corruption is included.

Country	(Without CPI) (%)	(With CPI) (%)	Country	(Without CPI) (%)	(With CPI) (%)	Country	(Without CPI) (%)	(With CPI) (%)
2012			2013			2014		
Chile	0.31	0.51	Turkey	0.30	0.33	Chile	0.31	0.55
China	0.19	0.23	Uruguay	0.28	0.39	Saudi Arabia	0.35	0.46
Saudi Arabia	0.36	0.40	Malaysia	0.67	0.77	Uruguay	0.29	0.42
South Africa	0.34	0.38	Kuwait	0.58	0.61	Malaysia	0.73	0.84
Turkey	0.30	0.35	Oman	0.53	0.57	Kuwait	0.61	0.67
Uruguay	0.34	0.41	Qatar	0.53	0.76	Qatar	0.51	0.79
Qatar	0.53	0.75	Saudi Arabia	0.36	0.41	Ukraine	0.65	0.82
Ukraine	0.65	0.73	Ukraine	0.56	0.70			
Malaysia	0.73	0.82						
Thailand	0.94	0.98						
2015			2016			2017		
Chile	0.28	0.52	Chile	0.26	0.53	Chile	0.27	0.54
Colombia	0.30	0.38	China	0.15	0.22	China	0.14	0.21
Egypt	0.29	0.36	Paraguay	0.48	0.55	Jordan	0.66	0.76
South Africa	0.30	0.37	Saudi Arabia	0.26	0.42	Morocco	0.46	0.53
Turkey	0.26	0.32	South Africa	0.32	0.39	Oman	0.48	0.60
Uruguay	0.26	0.42	Sri Lanka	0.30	0.36	Qatar	0.47	0.78
Kuwait	0.58	0.71	Turkey	0.24	0.31	Saudi Arabia	0.27	0.43
Oman	0.48	0.56	Uruguay	0.29	0.50	Turkey	0.26	0.31
Qatar	0.46	0.84	UAE	0.68	0.81	Ukraine	0.75	1.00
Saudi Arabia	0.30	0.47	Bahrain	0.85	1.00	Uruguay	0.30	0.45
Ukraine	0.66	0.96	Jordan	0.63	0.74	UAE	0.71	0.79
Bahrain	0.94	1.00	Kuwait	0.56	0.63	Bahrain	0.93	1.00
Malaysia	0.58	0.83	Malaysia	0.56	0.89	Malaysia	0.57	0.85
Thailand	0.71	0.82	Morocco	0.44	0.51			
			Oman	0.42	0.59			
			Qatar	0.43	0.78			
			Tunisia	0.66	0.72			
			Ukraine	0.79	1.00			
2018			2019			2020		
Chile	0.26	0.55	Chile	0.32	0.49	Chile	0.33	0.52
China	0.14	0.21	China	0.11	0.19	Myanmar	0.57	0.66
Saudi Arabia	0.28	0.47	Saudi Arabia	0.35	0.43	Oman	0.49	0.58
Sri Lanka	0.31	0.37	Uruguay	0.32	0.45	Qatar	0.55	0.76
Turkey	0.29	0.37	Malaysia	0.63	0.83	Saudi Arabia	0.27	0.36

End of Appendix

Country	(*Without CPI*) (%)	(*With CPI*) (%)	Country	(*Without CPI*) (%)	(*With CPI*) (%)	Country	(*Without CPI*) (%)	(*With CPI*) (%)
2018			2019			2020		
Uruguay	0.28	0.48	Qatar	0.54	0.71	Ukraine	0.49	0.75
Jordan	0.62	0.72	Ukraine	0.53	0.82	Uruguay	0.31	0.44
Malaysia	0.54	0.89				Malaysia	0.59	0.79
Morocco	0.45	0.57						
Oman	0.47	0.67						
Qatar	0.44	0.82						
Tunisia	0.72	0.82						
UAE	0.63	0.71						
Ukraine	0.63	1.00						