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Revisiting the link between port infrastructure quality, logistics performance, seaborn trade, and economic growth

-Does port infrastructure quality and logistics performance affect trade and economic growth?

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Abstract

Highlighting the greater perspective of quality of port infrastructure and logistics performance effect on seaborne trade and national economy. This research considered 93 countries with seaports in order to analyse the contributing effects of improved quality of port infrastructure and logistics performance for a country. Thus, generating a better overview of how these two factors contribute and affect seaborne trade and national economy of a country. With the use of an unpractised structural equation model (SEM) within port economic research, the effects of the three individual time periods 2014 t_1, 2016 t_2, and 2018 t_3 could be analysed. The results revealed from its significance that quality of port infrastructure had a direct positive impact on a nation's logistics performance for the periods t_1 and t_2. Further quality of port infrastructure had a significant impact on the national economy for the period t_1. Considering logistics performance, it was found to have a significant effect on a nation's seaborne trade for t_1. Lastly, seaborne trade was found to have a significant impact on a nation's national economy for the period t_3. The significant result of the analyse in line with the findings from existing port economic research, but the SEM model used provides new insight into how time periods can be analysed.

Keywords: port infrastructure, port investment, infrastructure quality, logistics performance, logistics quality, seaborne trade, international trade, national economy, economic growth, economic development

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1. Introduction

1.1 Research Background

Ports create a direct gateway for a country into the global trade by serving as a direct link to the maritime transport which carries more than 80% of world trade in terms of volume and is considered the lifeblood of the world trade (Stopford , 2009). Ports, therefore, have a significant economic function for a country as it facilitates international trade and the exchange of goods with other nations. This is important as trade positively impacts economic growth for developed and developing countries (Were, 2015). Ports are also seen to have other positive economic effects, such as attracting new industries, companies, investors and generating employment near them (Mudronja et al., 2020). Which from a historical perspective has developed seaports into more economically advanced cities within a nation (Shan et al., 2014).

Globalization has given ports a more complex and essential role as they have become more integrated into the global supply chain, which has extended their function as just a hub for cargo handling (Munim & Schramm, 2018). This has made the ports become a crucial link that connects the global supply chain with regional production and the consumption market, which has extended their function as logistics providers (Notteboom et al., 2022). The extended role of the port has put more pressure on the port performance as factors such as "lean" and "just in time" production within the supply chain is dependent on reliable and predictable deliveries (Munim & Schramm, 2018). Therefore, the ports capability of performing in an effective and efficient way determines to what extent they can compete in the global supply chain and be a part of the international trade market (Lee & Cullinane, 2016).

For a country to be competitive in the global supply chain and gain increased trade and economic growth from the ports, the need to develop and invest in port infrastructure quality and logistics performance is essential. As the quality of port infrastructure directly relates to ports being more efficient when it comes to handling and moving cargo, which means that ports can handle and keep the transport costs for the freight down. Therefore, it becomes more lucrative to trade with countries that offer good infrastructure (S. Wilson & Abe, 2011). It will also be easier for countries that have a high standard of logistics performance to trade. As higher quality in logistics performance enhanced the efficiency of the supply chain, which facilitated exports and, therefore, increases the country's economic growth (Tang & Abosedra, 2019).

1.2 Problem description

That ports fulfil a vital function for a country by contributing to increased trade and economic growth has been acknowledged in previous academic research. However, the contributing effect that port infrastructure and logistics performance have on a country's trade and economic growth has not gained the same attention. Although research has been made in the field and has been able to see a positive relationship between port infrastructure quality, logistics performance on trade and economic growth, these studies have largely focused on a single country or a region. Less focus has been given to the overall effect that port infrastructure quality and logistics performance have on a country's trade and economic growth, by considering multiple countries in the research. Which makes it hard to get a predictive and general overview of the effects that quality of infrastructure and logistics performance has on a country even if such signs exist.

The lack of a predictable overview of the effect of quality port infrastructure and logistics performance can be problematic as the majority of investments in ports are made with the help of tax money. Investments in improved port infrastructure and logistics are generally expensive investments. Today however it is difficult to predict what contributing economic impact such investments have for a country. The combination of a missing predictive overview of the economic effect of investment in port infrastructure and the vast amount of tax money that is needed for such investment may cause such investments to be questioned by the public, politicians, and investors.

1.3 Research purpose

This research will look at what effect quality of port infrastructure and logistics performance has on seaborne trade and national economy by considering multiple countries in the analysis. The purpose is thereby to generate an overview over the relationship of port infrastructure quality and logistics performance on a nation's seaborn trade and national economy.

This research revisits and contributes to the existing research by (Munim & Schramm, 2018), which looked at the broader relationship between port infrastructure quality and logistics performance effect on seaborne trade and economic growth. By using development indicators representing 91 countries collected from (https://data.worldbank.org/) they were able to form ten observed variables from three different years. These ten observed could represent the four independent variables quality of port infrastructure, logistics performance, seaborne trade, and national economy. Further the variables could be analysed and evaluated using the partial least squares structural equation model. In this way, a broader relationship between the quality of port infrastructure and the logistics performance effect on seaborne trade and economic growth could be seen.

1.4 Thesis structure

Including the introduction, the thesis is structured into eight chapters. After the introduction, chapter two discusses the procedure of port infrastructure investments. Chapter three presents the literature that has been reviewed and sums up the developed hypotheses. Chapter four sums up the conceptual model used in the thesis. Chapter five presents the sample, data, and measures, including the choice of method. Further, chapter six outlines the analysis and results, then discusses these in chapter seven. Last, chapter eight gives the concluding remark and limitations of the thesis, followed by suggestions for further research.

2. Port infrastructure investment

Major investments are required to develop and improve port infrastructure and can be considered a complex task due to the external drives. The complexity is also related to the port’s strategy of ownership and management which often is a balance between private owners and the state. To simplify the area of responsibility for investing in port infrastructure, it is possible to divide the infrastructure into three parts, basic, operational, and superstructure.

In terms of investments in basic port infrastructure, this applies to developments in such as port entrances, maritime access channels, sea locks, and hinterland connections (*Port Reform Toolkit*, 2007). These are investments that are usually carried out by the government as it is often seen as a public task (*Port Reform Toolkit*, 2007). Why Investments in basic port infrastructure are in the interest of the government is because such investments can generate economic income for the country. As it will be easier to displace goods if the port has good hinterland connections or well-functioning port entrances or sea locks. This makes it easier for both the domestic and foreign markets to trade with each other. However, such investments are usually demanding because they are usually long-term investments that require major finance. This makes it difficult to attract private investors to certain basic port infrastructure investments such as breakwater structures, locks, port entrances, and channels (*Port Reform Toolkit*, 2007). Since such projects do not pay dividends after 20-30 years and therefore entail great financial risks. Therefore, the basic port infrastructure is most often financed through governance investment budgets or funds. In cases of major basic port infrastructure investments, such as the expansion of the Port of Rotterdam's port facility Maasvlakte 2, Governance can facilitate such investments through loans from international financial institutions (European Investment Bank, 2012).

However, it is not obvious that the government always invests in basic port infrastructure. Regarding the private service port model, the private sector is responsible for investing in such infrastructure. The model is characterized by being fully privatized in the form of development, investment, and operation without influence from the public sector (Sorgenfrei, 2013). This type of management model of a port is quite unusual as it can only be found in the United Kingdom and New Zealand (Sorgenfrei, 2013). However, that the government invest in basic port infrastructure can be seen as a way of success as 63% of the world's top container ports, basic infrastructure has been developed and maintained by the national government or the public port authority (*Port Reform Toolkit*, 2007).

There are more options when it comes to financing operational and superstructure infrastructure. Since such investments are generally not as financially demanding and involve less risk because they generate dividends earlier than basic port infrastructure investments (*Port Reform Toolkit*, 2007). Which enables the private sector to contribute to the financing.

How investments between governance and the private sector are made in operational and superstructure depends on the type of management model that the port operates with. In port management models such as the Public service port and Tool port, the state owns and operates the operational infrastructure and superstructure (Sorgenfrei, 2013). This contributes to the governance finance, invest, and develop the operational and superstructure infrastructure themself in these models. The private sector has limited influence in investments in such port models as they can be seen to be major controlled by the governance. However, the public service port and tool port models are not that widely used compared to the landlord management model (Sorgenfrei, 2013). This possibly since the private sector is limited in investing in the superstructure and operational infrastructure in these models and instead chooses to focus on ports with a landlord model. As in the landlord model, the private sector can operate and become a concessionaire in a port terminal over a more extended period, usually from 20-30 years (*Port Reform Toolkit*, 2007). This means that the private sector can invest in and finance the operational and superstructure infrastructure in the terminal itself. This allows them to focus on investments in the terminal that benefit and make their port operation efficient. In this model, the governance instead focuses on the basic port infrastructure. This type of port management model is considered a successful and effective way of financing the operational and superstructure infrastructure. Since it creates a mixed interest role for the success of the port from both the government and private actors in the development and investment in the port. The Landlord port model is today a widespread management model, especially in the western world. Many of the largest ports in the world such as the port of New York and New Jersey, Singapore, and Rotterdam operate with this model (*Port Reform Toolkit*, 2007).

Table 1. Investment in port infrastructure (Port Reform Toolkit, 2007)**.**

TYPE	**Basic Infrastructure**	**Operational Infrastructure**	**Port Superstructure**
	• Maritime access channels. • Port entrance. • Protective works, including breakwaters and shore protection. • Sea locks. • Access to the port for inland transport (roads and tunnels). • Rail connection between the hinterland and the port. • Inland waterways within the port area and connecting port areas with their hinterland	• Inner port channels and turning and port basins. • Revetments and slopes. • Roads, tunnels, bridges, in the port. • Quay walls, jetties, and finger piers. • Docks. • Access roads to general road infrastructure. • Rail connection to general rail infrastructure • Dry docks for ship repair.	• Paving and surfacing. • Terminal lighting. • Parking areas. • Sheds, warehouses, and stacking areas. • Tank farms and silos. • Offices. • Repair shops. • Other buildings required for terminal operations.
Public Service Port	Public	Public	Public
Tool Port	Public	Public	Public
Landlord Port	Public	Private	Private
Private Service Port	Private	Private	Private

3. Literature review

3.1 Purpose of the literature review

The purpose of the literature review is to gain a deeper understanding of the four variables quality of port infrastructure, logistics performance, seaborne trade, and national economy. Through the literature review, knowledge can be obtained from previous research that has highlighted the relationship between the four variables. The literature review also allows us to see what type of prior research has been done in the field and the ideas and methods that have been used in these studies. This gives us an overview of the existing knowledge and allows critical evaluation in order to see where there are research gaps within the field. Further, the in-depth insight into previous and existing research in the field enables the hypothesis development for this research.

3.2 Method used for the literature review

Step 1: Identify relevant sources

The conducted literature review used search engines such as Oria, Scopus, Web of Science, and ScienceDirect to find relevant articles, dissertations, reports, and books related to the topic of this research. The main goal was to find literature highlighting the relationship and the effects of the four variables in this research, quality of port infrastructure, logistics performance, seaborne trade, and national economy. Therefore, keywords such as "quality of port infrastructure" and "logistics performance," "logistics performance," and "seaborne trade" were used in the search engines. This allowed to narrow down and find the most relevant articles, dissertations, reports, and books related to the topic of this research.

Step 2: Evaluate sources

It was of importance that the literature was from reliable and quality sources and therefore only "peer-reviewed" articles or well-known and high-quality journals were used. This evaluation step allowed us to further narrow down the literature used in this research.

Step 3: Compose the literature review

After identifying and evaluating the literature it was read through properly and finally written down, creating six chapters.

3.3 Structure of the literature review

The structure of the literature review is as follows. First, the effects of Quality of port infrastructure (QPI) on Logistics performance (LPI) and QPI on Seaborne trade (ST) are evaluated. Last, the QPI effect on National economy (NE) is assessed. Then the effects of LPI on ST and LPI on NE are evaluated. Last, the literature review looks at the effects of ST on NE.

3.4 Quality of port infrastructure and logistics performance

Ports serve as the gate that connects the maritime transport to the shore. To distribute the cargo from the shore to the inland, logistics functions such as land-based transport and the ability to shift to other transport modes are required (Simcock, 2016). Port economic studies have thus been able to see a positive relationship between improvements in port infrastructure and the effect on logistics performance.

(Munim & Schramm, 2018) considered 91 countries with a yearly container port traffic of 200 000 (TEU), where the relationship between quality of port infrastructure and the effect on a country's logistics performance was found significant. (Yeo et al., 2020) considered 62 countries in their port economy study and saw the same type of relationship between quality of port infrastructure and the effect on a country's logistics performance. Better logistics performance was also seen to contribute to increased seaborne trade and economic growth. Something that was found even for 32 countries along the maritime silk road (Rui Liang & Ziyang Liu, 2021). This could indicate that investing in port infrastructure has contributing effects on a country. However, these studies used the structural equation model, measured similar variables, and used data from the world bank which may reflect the similar answers in the study.

A study that has not measured several countries' quality of port infrastructure related to logistics, and instead focused on one country and which saw other relationships as those previous mentions are the one from (Deng et al., 2013). Which considered five major port clusters in China, where the port's economical role in the region was investigated. One of the variables tested was the relationship between port supply and value-added activity in ports, where no relationship was found. This means that investment into port infrastructure did not affect the port logistics such as storage in the port or the transport from port to the city.

Improvement in the quality of port infrastructure could be seen as especially necessary to stimulate trade and economic growth for developing countries (Munim & Schramm, 2018; Yeo et al., 2020). For African coastal countries, poor and unreliable port performance did not only have the effect such as causing higher freight rates but also harmed Africa's logistics chain (Mlambo, 2021). The average turnaround time for vessels in ports in the world is considered 0.88 days, while the average turnaround time for vessels in African countries is considered 2 days (Mlambo, 2021). This makes African ports among the lowest ranked in the world regarding efficient port turnaround time. The poor port infrastructure can explain the long turnaround time that African ports possess, which creates inefficient port performance and hinders cargo flow from ship to shore and wise verse. This inefficiency makes it difficult for African countries to be competitive in global trade. Therefore, it is crucial for African countries to invest in port infrastructure to raise port performance and streamline and facilitate trade for African countries (Mlambo, 2021).

Based on the above-discussed literature, the following hypothesis is put forward.

H1 (a) Quality of port infrastructure has a positive effect on logistics performance.

3.5 Quality of port infrastructure and Seaborne trade

Quality of port infrastructure enables a port to be more efficient considering the handling and movement of cargo, which means that ports that can offer such quality can handle and keep the transport costs for the cargo down. This makes it more lucrative to trade with countries that can provide good port infrastructure since 30% of the entire trade cost can be related to the transportation cost (S. Wilson & Abe, 2011). This makes it difficult for countries with low-quality infrastructure to keep transport costs down since 40% of transport costs are related to low-quality infrastructure (Limão & Venables, 2001). Further, this may cause consequences for such countries as a 10% increase in transport costs can reduce trade volume by up to 20% (Limão & Venables, 2001).

Why the quality of port infrastructure is so important for trade can partly be explained by the global supply chain. Where reliable displacement of goods is an essential factor in order for the chain to run smoothly. Countries with poor port infrastructure can therefore be considered more unreliable for companies to use. Since the use of ports with poor infrastructure increases the risk of delays of the cargo which can negatively affect companies supply chain.

However, modern ports with improved information technology allow real-time tracking of cargo (Heilig et al., 2017), which increases the cargo's traceability, making such ports a more reliable choice for companies to use. Since such ports allow companies to have greater control and coordination of the cargo flow and ultimately their supply chain. Therefore, it is safer for companies to choose countries with high-quality port infrastructure for handling their goods as it is a more reliable choice and lowers the chances for delays in the lead-time (Y. Park & Dossani, 2020). This however does not mean that countries with developed infrastructure should stop investing in ports, especially considering the technical development that is taking place and where today's supply chain is so interconnected. As it can be seen that ports that are ineffective can affect the efficiency negative for surrounding ports (Liu, 2020)

(Munim & Schramm, 2018) did not find support for the direct effect of quality of port infrastructure on seaborne trade for a country. However, the quality of port infrastructure would affect the logistics performance, which positively affected seaborne trade for a country. Therefore, investments in port infrastructure were considered necessary for countries, especially considering developing countries. By measuring similar variables with the same type of structural equation model, the same kind of pattern could be seen for countries along the maritime silk road (Rui Liang & Ziyang Liu, 2021). Port infrastructure did not affect the seaborne trade but the logistics performance, which positively affected seaborne trade.

Based on former studies the following hypothesis is suggested.

H1 (b) Quality of port infrastructure has a positive effect on seaborne trade.

3.6 Quality of port infrastructure and National economy

In China, a clear relationship was found between investment in port infrastructure and its contribution to economic growth within the region where the investment was made (Song & van Geenhuizen, 2014). Investment in port infrastructure increased industrialization and manufacturing productivity in the invested regions which caused higher economic activity.

These investments were also seen to contribute to expanding the hinterland network, which increased the connectivity to these regions. This contributed to even higher economic activity, which ultimately positively impacted the GDP of these regions (Song & van Geenhuizen, 2014). It was also found that port infrastructure investment in one region had positive economic spillover effects on surrounding regions. As the ports created a gateway for trade for the surrounding regions, which enabled companies in the surrounding region to expand their market and increase their economic activity. Developments in ports can also be considered to increase the integration with other surrounding regions as port development promotes the development of the transport hinterland connectivity (D. Wang & Li, 2019). This means that the port gains a more significant role in the surrounding regions. The spillover effect to other regions would also consider increasing as greater the port infrastructure investment was (Song & van Geenhuizen, 2014). The same positive impact that investments in port infrastructure could have for a region was also found in South Korea. An increase of 1% of container throughput in container ports increased economic growth in the region by 7%, and 1 tonne more cargo throughput in a non-container port increased the economic growth of the region by 2.78% (J. S. Park & Seo, 2016).

Related to Europe it could be seen from 120 port regions in 13 European countries that a 10% increase in cargo throughput could generate a 6-20% increase in GDP for the region (Bottasso et al., 2014). This could generate a spillover effect to other European regions and increase their GDP between 5-18% (Bottasso et al., 2014). (Mudronja et al., 2020) could see similar results in a study of 107 European port regions, as an increase of 10% cargo throughput in one region could increase the GDP between 8-10% for the same region. The port activity has also been found to have a socio-economic impact on a region in terms of generating more jobs. As it could be seen from port regions in 10 western European countries, that an increase of one million tons of cargo or 90.000-100.00 TEU in a port could generate around 400-600 jobs (Bottasso et al., 2013). Even though many studies that have been made regarding the port infrastructure's effect on economic growth, the focus has been on a single country or a region. However, the positive relationship of quality of port infrastructure can be considered on a broader level. As the quality of port infrastructure was found to have positive effects on the economic growth of 91 developed and developing countries (Munim & Schramm, 2018).

Therefore, the following hypothesis is proposed

H1 (c) Quality of port infrastructure has a positive effect on national economy.

H1 (d): Quality of port infrastructure has a positive effect on national economy mediated through logistics performance.

H1 (e) Quality of port infrastructure has a positive effect on national economy mediated through seaborne trade.

H1 (f) Quality of port infrastructure has a positive effect on national economy mediated through logistics performance and seaborne trade.

3.7 Logistics performance and Seaborne trade

High standards of logistics performance have become of greater importance, as logistics performance has been seen to have a significant effect on seaborne trade (Munim & Schramm, 2018). The higher degree of logistics performance, the more efficient and reliable service the country can offer in terms of handling and moving goods. This performance is crucial in today's supply chain, where terms such as "lean" and "just in time" are based on efficient and reliable movement of goods. Countries with solid logistics performance can therefore be considered more reliable for companies and countries to trade with.

For a typical import country, a 1% improvement in logistics quality can increase the trade by 18% and for an export country, a 1% improvement in logistics quality can increase the trade by 16% (Çelebi, 2019). For the ASEAN countries, it was found that container throughput and cargo throughput had a strong relationship with a country's trade. Meaning that port logistics development strongly affects a country's trade performance (Wu, 2020). However, developing countries can benefit even more from efficient logistics performance than developed countries. As logistics performance effect developing countries' seaborne trade to a greater extent (Munim & Schramm, 2018). The export for a low-income country can increase as much as 94% with a 10% improvement in logistics quality, compared to upper-middle-income countries that can have a 41% increase in export with a 10% improvement in logistics quality (Çelebi, 2019).

The concept of logistics performance is strongly associated with time and cost in terms of export and import goods, where high-income countries are considerably more efficient than low-income countries. For example, exporting meat from Australia takes 36 hours to complete the border compliance and costs about 749 dollars, while exporting nutmeg from Grenada takes 101 hours and costs 1,034 dollars on average (World Bank, 2015). In Canada, border control to export/import from the US can be completed in two hours while in Cameroon it takes the importer 160 hours and 108 hours for the exporter to complete border compliance (World Bank, 2015).

However, it can be seen that improvements in logistics performance considering time and cost have positive effects for both developed and developing countries in terms of increased trade. Reducing the export process by 1% considering time can increase the trade by 1,37% and an improvement of 1% in the trade process in terms of cost can increase the bilateral trade by 0,49% (Hausman et al., 2013). At the same time, it is not only countries that possess solid logistics that can receive increased trade. Neighbouring countries, especially landlocked countries benefit from such logistics quality as it impacts their ability to trade. In fact, for a landlocked country, the logistics quality of a neighbouring country has more influence than their own in the capability of trade, especially if such a neighbouring country has access to coast (Behar & Manners, 2008).

Based on the previous literature the following hypothesis is put forward.

H2 (a) Logistics performance has a positive effect on Seaborne trade.

3.8 Logistics performance and National economy

With improved logistics performance, a country can offer efficient and reliable movement of goods, which makes them competitive trade alternatives in the international trade market. Improved logistics performance facilitates the export and import for the domestic market and the foreign market. Which, in this way, increases economic activity within the country.

Considering 23 countries in Asia it was found that a country's ability to export had a strong influence on the economic growth (Tang & Abosedra, 2019). At the same time, it was possible to see that a country's ability to export and trade was strongly linked to the logistics performance of the country (Tang & Abosedra, 2019). Higher quality in logistics performance enhanced the efficiency of the supply chain, which facilitated exports and, therefore, increased the economic growth of a country. In fact, it was found that a 1% growth in logistics performance could increase the country's economic growth by 0,69% (Tang & Abosedra, 2019). However, for such an upgrade in logistics performance, the country's government needed to be politically stable. Corruption and instability were considered to hinder the development of logistics performance in a country (Tang & Abosedra, 2019). In China, it was found that the logistics infrastructure related to maritime transport had a significant effect on China's economic development. The maritime logistics infrastructure had the greatest impact on National GDP, Exports, and GDP per capita out of the road, air, and seaborne transport (C. Wang et al., 2021). However, the logistics infrastructure of road and air also impacted international trade and economic growth (C. Wang et al., 2021).

(D'Aleo & Sergi, 2017) did not see the same positive relationship between logistics performance on the national economy in their study. They found a negative correlation between the logistics performance indicators in relation to the global competitiveness index, gross domestic product, and trade of 41 European countries. Which indicated that logistics performance such as infrastructure, international shipment, logistics competence, and tracking and tracing had no significant impact on the economic growth of European countries in their study.

(Munim & Schramm, 2018) found a direct relationship between the logistics performance of a country and its effect on economic growth by considering 91 countries with seaports. At the same time, the same direct relationship between logistics performance effect on economic growth could not be found with similar variables, data, and models for 31 countries along the maritime silk road (Rui Liang & Ziyang Liu, 2021). However, the mediate effect of port infrastructure on logistics performance had a significant affected on economic growth for countries along the maritime silk road.

Based on the above-discussed literature the following hypothesis will be put forward.

H2 (b) Logistics performance has a positive effect on national economy.

H2 (c) Logistics performance has a positive effect on national economy mediated through seaborne trade.

3.9 Seaborne trade and National economy

With the help of seaborne trade, a nation gets access to global trade, enabling the country to expand the import and export market and thus generate increased trade. The expanded market enabled by the seaborne trade can increase the in and output of goods, contributing to increased economic activity for the nation.

(Huchet-Bourdon et al., 2018) found a positive linear relationship between high-quality goods and trade. The higher the quality of a country's export, the more significant impact it had on trade and economic growth. Therefore, it becomes more difficult for developing countries to gain positive effects of trade on economic growth since their export consist of lower quality goods. (Were, 2015) could see the same relationship between developed, developing, and least-developed countries. The effect of trade on economic growth was positive for developed and developing countries while the impact of trade on economic growth for least developed countries was found insignificant. This could partially be explained by the fact that least developed countries export low-value commodities which are price volatile (Were, 2015). This makes least developed countries not as competitive in world trade compared to developed countries. As developed countries can add value to goods which make them benefit from both import and export and therefore gains a higher impact of trade on the economic growth.

(Rui Liang & Ziyang Liu, 2021) found a negative relationship between seaborne trade and its effect on the national economy for 32 countries along the maritime silk road in their multi-variable observation. The same type of negative result could be seen by (Munim & Schramm, 2018) in a similar observation of 91 developed and developing countries around the world. However, the negative association between seaborne trade and the national economy was most noticeable in developed countries. This could be explained by the fact that developed countries do not manufacture at the same level as developing countries as they focus more on producing services. This means that developed countries have a greater focus on imports than developing countries which both export and import to a greater extent. However, exports had a greater impact on economic growth for developing countries than for developed countries. It was also seen that trade enabled developed and least-developed countries to attract foreign investors to a greater extent. For a developing country like Pakistan, seaborne trade is very important in order to stabilize the domestic economy. As 97% of Pakistan's trade is considered to come from shipping (Kalim, 2018). At the same time, the political instability in the country can hinder the development of maritime trade with other countries. This makes it difficult for a developing country like Pakistan to achieve economic stability and growth (Kalim, 2018).

Based on the above studies the following hypothesis is suggested

H3 Seaborne trade has a positive effect on national economy.

3.10 Summarization of hypothesis

From the literature review, ten hypotheses have been constructed, which are summarized in table 2. The developed hypotheses have further enabled us to elaborate the conceptual model of this research.

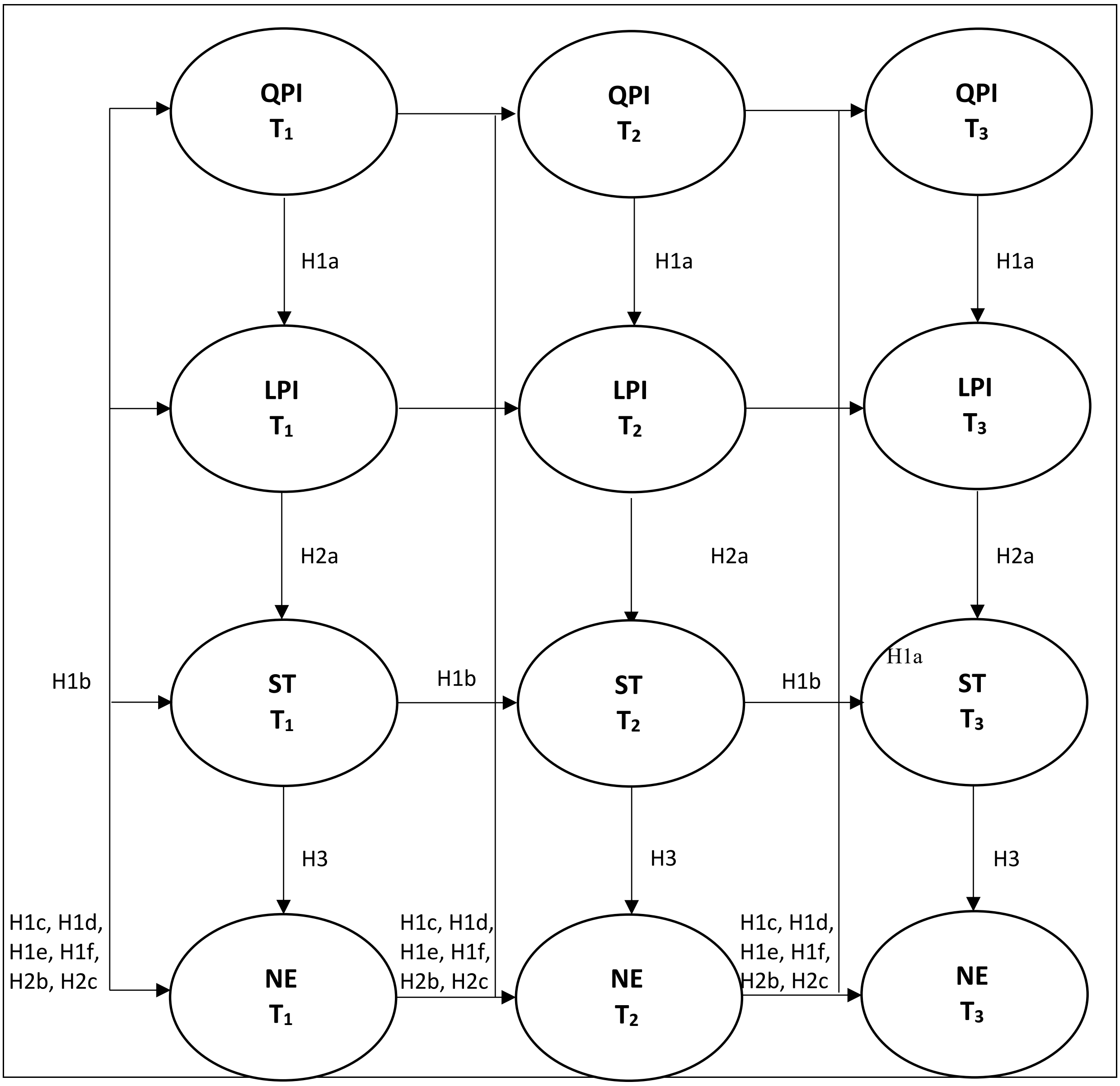
Table 2. Summarization of hypothesis

Hypothesis 1(a)	*Quality of port infrastructure has a positive effect on logistics performance.*
Hypothesis 1(b)	*Quality of port infrastructure has a positive effect on seaborne trade.*
Hypothesis 1(c)	*Quality of port infrastructure has a positive effect on national economy.*
Hypothesis 1(d)	*Quality of port infrastructure has a positive effect on national economy mediated through logistics performance.*
Hypothesis 1(e)	*Quality of port infrastructure has a positive effect on national economy mediated through seaborne trade.*
Hypothesis 1(f)	*Quality of port infrastructure has a positive effect on national economy mediated through logistics performance and seaborne trade.*
Hypothesis 2(a)	*Logistics performance has a positive effect on Seaborne trade.*
Hypothesis 2(b)	*Logistics performance has a positive effect on national economy.*
Hypothesis 2(c)	*Logistics performance has a positive effect on national economy mediated through seaborne trade.*
Hypothesis 3	*Seaborne trade has a positive effect on national economy*

4. Conceptual Model

The conceptual model in figure 1 shows the variables Quality of port infrastructure (QPI), Logistics performance (LPI), Seaborne trade (ST), and National economy (NE) linkage to the ten developed hypotheses. The conceptual model can be considered to support the neoclassical economic growth theory proposed by (Lakshmanan, 2011). Which means that investment in transport infrastructure, in this case port infrastructure contributes to increased economic growth for a country. As such investments create better conditions for a country's flow of production, trade, and economy.

Figure 1. *Conceptual model*



5. Methodology

5.1 Sample

The conceptual model in this study has been tested with a sample of 93 countries which can be seen in the appendices table 9. The representative sample consisted of both developed and developing countries and common for them all is that they possess and have access to seaports within their nation. In order to eliminate bias in the research from smaller island nations with limited trade and economic activity, a criterion was set on the sample. Where only countries with annual container traffic of 200, 000 twenty equivalent units (TEU) or more were selected to be part of the sample.

5.2 Data

The panel data for this research was collected through a secondary dataset using the World Bank Open Data (https://data.worldbank.org/) as the single source for data collection. Since the 1960s, the World Bank has compiled official statistics from economies around the world on topics such as social progress, quality of life, economic development, physical infrastructure, environment, and government performance. The development statistics that the world bank has collected annually have made them able to establish a complete set of 1,400 time series development indicators in various subjects (*World Bank Data*, n.d.). Today a total set of 217 economies around the world are included in these development indicators which enables to statically cross-country compare the development performance of these economies (*World Bank Data*, n.d.). This study investigates topics such as seaborne trade and logistics performance which includes many aspects and are hard to directly measure. The variety of development indicators that the database offers have enabled us to measure these topics. By collecting data from several development indicators to describe each of the four key concepts in this research, port infrastructure quality, logistics performance, seaborne trade, and national economy.

Development indicators subjected to economic development and physical infrastructure were in particular focus in this research. In total, 10 development indicators were collected in this research to describe port infrastructure quality, logistics performance, seaborne trade, and national economy, as shown in table 3. To test the conceptual model in this research and get sufficient results, at least three observations of the data needed to be tested. (Serva et al., 2011) argues for this as a minimal critical criterion in the use of fitting models for linear change. However, the logistics performance indicators used in this research are only obtained every other year from the World Bank. The year 2018 contained all the latest updated logistics performance indicators and therefore the panel data of this research was collected from the period years 2014-2018. This enabled us to measure three observations for the years 2014 (t_1), 2016 (t_2), and 2018 (t_3).

5.3 Measures

Port infrastructure quality, logistics performance, seaborne trade, and national economy are hard to directly measure as they as previously mentioned involve several aspects. Therefore, they were formed as four independent latent variables in this research. A latent variable in a measurement model can be described as an unobserved variable that needs support and influence from observed variables to be measured appropriately (Millsap, 2011). For that reason, a complete set of ten observed variables seen in table 3 was selected to support and measure the four independent variables in this research. The complexity of using several observed variables to measure the latent variables served as the motivation to use the structural equation model (SEM) in this research. Since the (SEM) model enables measuring relationships between observed and latent variables and evaluates the relationship between latent variables (F. Hair Jr et al., 2014). The use of (SEM) is also prominent since the model enables to explain and simplify statistical relationships in complex models (Dash & Paul, 2021).

5.3.1 Quality of port infrastructure (QPI)

The World Bank database possesses a single development indicator called QPI that directly measures the quality of port infrastructure for countries. Therefore, no additional indicators were needed in order to reflective measure the latent variable Quality of port infrastructure. A total of 150 economies are included in this indicator and have been measured through surveys of how business executives perceive their country's port facilities. These surveys have used a scale of 1-7. Where a score of 1 in port infrastructure is seen as extremely undeveloped and a score of 7 is considered effective by international standards (*World Bank Open Data | Data*, n.d.).

5.3.2 Logistics performance (LP)

Logistics performance was reflectively measured with six observed variables, as shown in table 3. The choice of using these to measure logistics performance was since the World Bank considers all these six indicators as logistics indicators. Common to all these logistics indicators is that they are developed through questionary surveys conducted by the World Bank Organization, and which have been performed by institutes around the world. Individuals and companies connected to the logistics industry worldwide have been the focus of responding to these surveys. The questionnaire survey was based on what companies and individuals thought about the logistical performance in the country that they operated in. Yet also for other markets considered the main export and import markets for the countries they operated in (Arvis et al., 2018). In total 160 countries are included in these logistics performance indexes. The questionary surveys were derived from a scale of 1-5 where a score of 1 was considered very low logistical performance and a score of 5 was considered very high.

5.3.3 Seaborne trade (ST)

Seaborne trade was reflectively measured with two observed variables. These two observed variables were Container port traffic (CT) and Liner shipping connectivity (LSC), as these indicators taken together give a better representation of the Seaborne trade of a country (Munim & Schramm, 2018).

Container port traffic measures the number of movement of twenty-foot equivalent unit (TEU) containers from land-based transport to seaborne transport and the opposite way around for a country (*World Bank Open Data | Data*, n.d.). Therefore the (CT) indicator predicts the container trade flow of a country.

Liner shipping connectivity is a measurement of how integrated a country is in the global liner shipping network (Notteboom et al., 2022). This by considering several parameters such as weekly scheduled ship calls, the number of shipping companies within a country, the average vessel size, and the number of the directly connected port within a country (Notteboom et al., 2022).

5.3.4 National Economy (NE)

National economy was reflectively measured with the single observed variable GDP per capita (GDPc). The use of GDP per capita as an observed variable to describe the latent variable national economy has been used in similar studies by (Munim & Schramm, 2018; Rui Liang & Ziyang Liu, 2021). GDP describes the size of a country's economy by measuring the value of all goods and services produced. Therefore, it is positively affected as the population grows because it usually means that both consumption and production increase (OECD, 2013). To see how the economy develops in relation to the population, GDP per capita is calculated (OECD, 2013). GDP per capita can be considered a measure of the country's prosperity and therefore serves as a great observed variable to describe the latent variable National Economy.

Table 3. Measurement table

Latent Variable	Observed Indicator	Abbreviation
Quality of port infrastructure (QPI)	Quality of port infrastructure	QPI
Logistics performance (LP)	Ability to track and trace consignments	LPIAT
	Competence and quality of logistics services	LPICQ
	Ease of arranging competitively priced shipments	LPIEA
	Efficiency of customs clearance process	LPIEC
	Frequency with which shipments reach consignee within scheduled or expected time	LPIFS
	Quality of trade and transport-related infrastructure	LPIQT
Seaborne trade (ST)	Container port traffic (‘000 TEUs)	CT
	Liner shipping connectivity index	LSC
National economy (NE)	GDP per capita, PPP (Int. $)	GDPc

5.4 Data Analysis

There are mainly two types of techniques applied to the use of the structural equation model. These are the Covariance based Structural Equation Model (CB-SEM) and Partial Least Squares based Structural Equation Model (PLS-SEM). CB-SEM is appropriate in research that aims to confirm or reject theory while the PLS-SEM is more suitable for exploring hypotheses in research (F. Hair Jr et al., 2014).

For the given approach of this research, the PLS-SEM method has been conducted. Firstly the PLS-SEM is considered better suited to identify relationships between latent variables compared to CB-SEM since the PLS-SEM possesses a higher degree of static strength (Hair et al., 2019). This makes PLS-SEM more suitable for secondary data than CB-

SEM as the use of secondary data often creates complex models that are difficult to analyse with the CB-SEM technique (Hair et al., 2019). This makes the PLS-SEM a better choice as it is a more robust technique to analyse complex models (Hair et al., 2019).(F. Hair Jr et al., 2014) recommends PLS-SEM over CB-SEM if the purpose of the study is more to explore hypotheses than to support the theory. The PLS-SEM has also other advantages as no previous distributional requirements and goodness of fit are needed compared with the CB-SEM method (F. Hair Jr et al., 2014). The PLS-SEM analysis in this research was conducted with the use of the SmartPLS 3.0 version. Which is a prominent statistical software program constructed for latent modeling in Partial Least Squares based Structural Equation Modelling.

Table 4. Descriptive Statistics

Variables	N	Mean	Median	Min	Max	S.D	Skewness	Kurtosis
LPI (t1)	93	0	0	-3,028	1,759	1	-0,656	0,549
LPI (t2)	93	0	0,024	-2,576	1,961	1	-0,116	-0,509
LPI (t3)	93	0	-0,028	-2,986	2,019	1	-0,16	0,47
NE (t1)	93	0	-0,249	-1,432	2,856	1	0,69	-0,349
NE (t2)	93	0	-0,272	-1,385	2,733	1	0,966	0,397
NE (t3)	93	0	-0,201	-1,486	2,431	1	0,71	-0,366
QPI (t1)	93	0	0,192	-2,041	1,545	1	-0,899	-0,205
QPI (t2)	93	0	0,053	-2,525	1,696	1	-1,079	0,856
QPI (t3)	93	0	0,156	-2,577	1,723	1	-1,143	1,271
ST (t1)	93	0	-0,179	-1,213	4,548	1	1,576	3,653
ST (t2)	93	0	-0,213	-1,071	7,093	1	4,012	26,166
ST (t3)	93	0	-0,199	-1,236	5,361	1	2,039	7,724

6. Analysis and Results

Through PLS-SEM, the conceptual framework can be developed into a path model which can further be analysed and tested. The path model consists of the measurement and the structural model. The measurement model or the so-called outer model represents how different indicators (observed variables) affect the respective construct. While the structural model or inner models represent how different constructs relate to each other (Hair et al., 2017). When using the PLS-SEM model there are two different ways of measuring the relationship between the latent and observed variables, these are the formative and reflective measurements. When using the formative measurement, the observer variables form the latent variable and thus define and encompass the meaning of the latent variable. Therefore, the arrows go from the latent variables to the factor. However, formative variables are necessarily not positively related to each other as they are all contributing parts to form the concept of the latent variable (Sarstedt et al., 2017). Therefore, it is essential with formative measures that enough observed indicators are used to fully specify the content of the latent variable. When using the reflective measurement, the observed variables have a positive relationship with one another and can explain the latent variable. Therefore, there is a direct relationship between the latent variable to the observed variable and the arrows go from the factor to the latent variables (Sarstedt et al., 2017). Since each observed variable in this research is based on the definition of the latent variable to which it belongs, this research used reflective measures for all latent variables in this research.

6.1 Evaluation of the measurement model

As this research used the PLS-SEM method the confirmative composite analyses (CCA) were used to measure the reliability and validity of the model. The reliability analysis of the measurement model was made according to (Hair et al., 2019) guidelines of reflective models. The model was tested for its indicator reliability, composite reliability, convergent validity, and discriminant validity by analyzing the factor model with the standard maximum iterations of 300 in the Smart PLS-SEM software.

6.2 Reliability

The first step involved analysing the indicator reliability by estimating the factor loadings. Factor loadings above 0,708 are recommended to provide sufficient reliability of the item as s construct with this value can define 50% of the indicators variance (Hair et al., 2019). Of the 30 items estimated, 17 had a factor loading above the recommended level while 13 items were below this limit, as shown in table 5. However, none of the items scored below the value of 0.4 which can be considered an approved level as long as they do not affect the average variance extracted (AVE) of their constructs negatively (Sarstedt et al., 2017). None of these indicators adversely affected the AVE of their constructs and therefore all indicators were maintained.

The next step in the reliability analysis of the measurement model was to estimate the consistency reliability of the construct with the use of composite reliability (CR) and Cronbach's alpha (CA). In terms of CR value, it should be between 0,6-0,7 to be considered acceptable while a value between 0,7-0,9 is seen as satisfactory to good (Hair et al., 2019). As seen in table 5 all factors ranged between the 0,6 -0,9 and were therefore considered satisfying values. However, the quality of port infrastructure and national economy constructs indicated a value of 1,00 which could be seen as a little problematic. As values over 0,95 can either indicate that the item is redundant or that there are missing values in the data collection which creates straight lines in the data (Hair et al., 2019). Which triggers an error for the indicators as it creates inflated correlations between the indicators (Hair et al., 2019). This was considered a reasonable explanation as some developing countries examined in the sample did not possess all the data and therefore showed missing values.

Estimating the consistency reliability was made with the use of Cronbach's alpha. In terms of Cronbach's alpha, the recommended values should be above 0,70 (Hair et al., 2019). However, Cronbach's measurement can be seen as a little more unprecise compared to the composite reliability. Since with the compositive reliability, the items are weighted according to the individual loadings of the construct indicators, and therefore the reliability can be seen as higher compared to Cronbach's alpha (Hair et al., 2019). While the Cronbach's alpha measure assumes that all the items are likewise reliable and therefore show lower loading values compared to the composite reliability (Hair et al., 2019). This could explain why the seaborne trade constructs showed significantly lower values with Cronbach's alpha compared to composite reliability. However, all the other constructs can be seen as acceptable as they indicated a value above the recommended 0,7 value.

Table 5. *Reliability and validity*

FACTORS	Loading	Cronbach's alpha	Composite reliability	AVE
Quality of port infrastructure				
QPI t_1	1	1	1	1
QPI t_2	1	1	1	1
QPI t_3	1	1	1	1
Logistics performance t_1		0,85	0,797	0,491
LPIAT t_1	0,778			
LPICQ t_1	0,786			
LPIEA t_1	0,586			
LPIEC t_1	0,705			
LPIFS t_1	0,506			
LPIQT t_1	0,791			
Logistics performance t_2		0,806	0,716	0,414
LPIAT t_2	0,615			
LPICQ t_2	0,484			
LPIEA t_2	0,692			
LPIEC t_2	0,595			
LPIFS t_2	0,639			
LPIQT t_2	0,795			
Logistics performance t_3		0,831	0,757	0,456
LPIAT t_3	0,748			
LPICQ t_3	0,561			
LPIEA t_3	0,739			
LPIEC t_3	0,645			
LPIFS t_3	0,528			
LPIQT t_3	0,786			
Seaborne trade t_1		0,723	0,24	0,567
CT t_1	0,693			
LSC t_1	0,809			
Seaborne trade t_2		0,731	0,265	0,576
CT t_2	0,79			
LSC t_2	0,727			
Seaborne trade t_3		0,67	0,015	0,504
CT t_3	0,719			
LSC t_3	0,7			
National economy				
GDPc t_1	1	1	1	1
GDPc t_2	1	1	1	1
GDPc t_3	1	1	1	1

6.3 Validity

To assess the validity of the model, convergent validity and discriminant validity were estimated. The convergent validity of the constructs was estimated by the average variance extracted (AVE) of the constructs. To indicate that the construct explains at least 50% of the variation of its elements, an acceptable score should be 0.50 or above for the AVE (Hair et al., 2019). As seen in table 5, all the constructs surpassed this level except the logistics performance indicators which was slightly under the 0,50 value. However, since these values were close to the accepted level, they were considered credible.

To estimate the discriminant validity of the constructs, the Fornell-Larcker criteria were estimated. Which refers to how empirically diverse a construct is from other constructs in the structural model (Hair et al., 2019). To estimate the Fornell-Larcker criteria, the square root of each construct's AVE is estimated in the structural model. The square root value of a construct needs to be higher than the construct's correlation with other constructs in the structural model (Hair et al., 2019). As seen in table 6, all the constructs met the Fornell-Larcker criteria which were also supported by the cross-loading seen in appendices table 8.

Table 6. Fornell-Larcker criterion

	LPI t_1	LPI t_2	LPI t_3	NE t_1	NE t_2	NE t_3	QPI t_1	QPI t_2	QPI t_3	ST t_1	ST t_2	ST t_3
LPI t_1	**0,701**											
LPI t_2	0,347	**0,644**										
LPI t_3	0,379	0,516	**0,675**									
NE t_1	0,067	0,227	0,348	**1,000**								
NE t_2	-0,052	0,173	0,147	0,343	**1,000**							
NE t_3	0,043	0,125	0,188	0,578	0,319	**1,000**						
QPI t_1	0,360	0,200	0,287	0,216	0,099	0,171	**1,000**					
QPI t_2	0,147	0,357	0,158	0,064	0,172	-0,031	0,176	**1,000**				
QPI t_3	0,330	0,332	0,261	-0,005	-0,082	0,037	0,268	0,328	**1,000**			
ST t_1	0,473	0,413	0,375	0,186	0,053	0,189	0,208	0,039	0,327	**0,753**		
ST t_2	0,351	0,316	0,305	0,212	-0,055	0,106	0,178	-0,063	0,272	0,641	**0,759**	
ST t_3	0,324	0,250	0,299	0,203	0,050	0,215	0,157	0,079	0,153	0,728	0,651	**0,710**

6.4 Evaluation of the Structural model

The structural model represents how the constructs relate to each other and therefore allows testing the relationship of the hypothesis. The hypothesis was evaluated based on their path coefficients, p-value, t-value, and effect size F^2 value. The effect size F^2 value measures how strong the effect is between the observed and dependent variables. Since this model looks at mediating relationships, the formula $f^2=r^2/1-r^2$ proposed by (Cohen, 2007) was used to determine F^2 effects for all relationships. F^2 value of 0.02 is seen as weak, 0.15 medium, and 0.35 as a large effect size between the observed and dependent variable (Cohen, 2007). However, the F^2 values only represent the effect between variables and do not represent the significance of the results for the sample. Therefore, the PLS-SEM bootstrapping calculation was made in the Smart-PLS software with a subsample of 2000 in a one-tailed test with a significant level of 5%. Based on this, it was possible to estimate the t-value and p-value, which are indicators of the model's significance. Traditionally, a one-tailed test with a significant level of 5%, the hypothesis should have a p-value ($p < 0.05$) and t-value ($t > 1.645$) to have a significant level of 5% (Winship & Zhuo, 2020). Considering the path coefficients, they indicate the hypothesis relationship and range from -1 to + 1. Path coefficients with values close to + 1 indicate a strong positive relationship and values close to -1 indicate a strong negative relationship of the hypothesis (F. Hair Jr et al., 2014). First, the direct relationships between the independent and dependent variables were estimated for the hypotheses, H1(a), H1(b), H1(c), H2(a), H2(b), and H3. Then the indirect mediating relationship for the variables was estimated for hypotheses H1(d), H1(e), H1(f), and H2(c).

As presented in table 7, H1(a) t_1- t_1, H1(a) t_2- t_2, H1(c) $t_1 - t_1$, H2 (a) t_1- t_1 and H3 t_3- t_3 all has t-values ($t > 1.645$) and p-values (p-value <0.05). These hypotheses are therefore significant and supported.

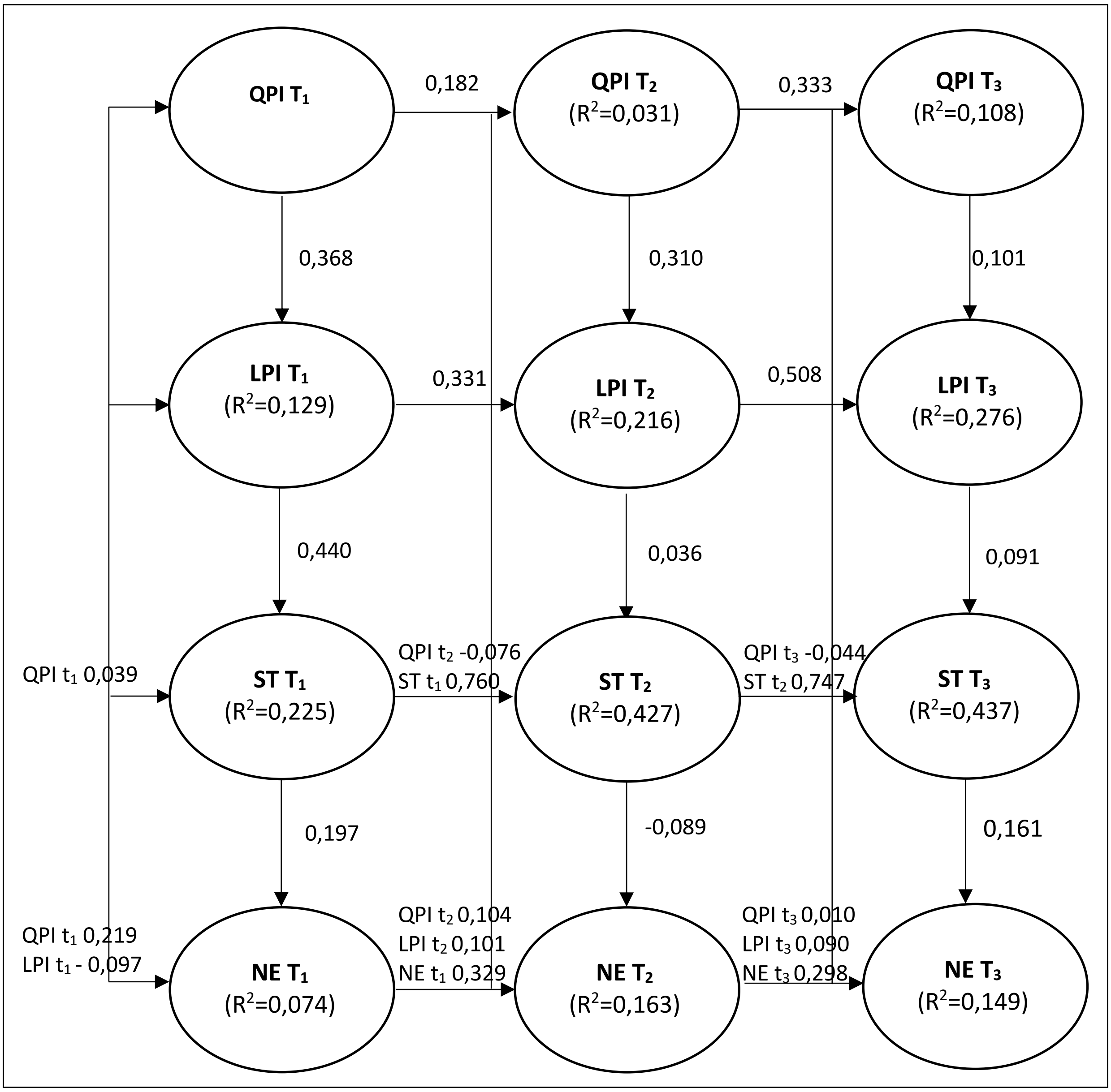
The supported hypotheses have the following effect size (F^2). H1(a), Quality of port infrastructure t_1, has a medium effect (F^2 = 0,157) on Logistics performance t_1. H1(a), Quality of port infrastructure t_2, has a weak effect (F^2 = 0,106) on Logistics performance t_2. H1(c), Quality of port infrastructure t_1, has a weak effect (F^2 = 0,051) on National Economy t_1. H2 (a), Logistics performance t_1 has a medium-large effect (F^2=0,240) on Seaborne trade t_1. H3, Seaborne trade t_3 has a weak effect (F^2=0,027) on National economy t_3.

Table 7. Results of the PLS-SEM Estimation – one tailed test

Hypothesis	Relation	Beta	T value	P Value	F^2 Value	Effect size
H1 (a)	QPI t_1 – LPI t_1	0,368	3,385	0,000	0,157	Medium
H1 (a)	QPI t_2 – LPI t_2	0,310	2,874	0,002	0,106	Weak
H1 (a)	QPI t_3 – LPI t_3	0,101	1,103	0,135	0,010	Very Weak
H1 (b)	QPI t_1 – ST t_1	0,039	0,592	0,277	0,002	Very Weak
H1 (b)	QPI t_2 – ST t_2	-0,076	1,047	0,148	0,006	Very Weak
H1 (b)	QPI t_3 – ST t_3	-0,044	1,063	0,144	0,002	Very Weak
H1 (c)	QPI t_1 – NE t_1	0,219	2,395	0,008	0,051	Weak
H1 (c)	QPI t_2 – NE t_2	0,104	1,272	0,102	0,011	Very Weak
H1 (c)	QPI t_3 – NE t_3	0,010	0,109	0,457	0,000	Zero
H1 (d)	QPI t_1 – LPI t_1 – NE t_1	-0,040	0,576	0,282	0,002	Very Weak
H1 (d)	QPI t_2 – LPI t_2 – NE t_2	0,031	1,012	0,156	0,001	Very Weak
H1 (d)	QPI t_3 – LPI t_3 – NE t_3	0,009	0,523	0,301	0,000	Zero
H1 (e)	QPI t_1 – ST t_1 – NE t_1	0,007	0,508	0,306	0,000	Zero
H1 (e)	QPI t_2-ST t_2- NE t_2	0,017	0,843	0,200	0,000	Zero
H1 (e)	QPI t_3 – ST t_3- NE t_3	-0,006	0,933	0,176	0,000	Zero
H1 (f)	QPI t_1 – LPI t_1 – ST t_1 – NE t_1	0,031	1,262	0,104	0,001	Very Weak
H1 (f)	QPI t_2- LPI t_2 – ST t_2 – NE t_2	-0,004	0,735	0,231	0,000	Zero
H1 (f)	QPI t_3 – LPI t_3 – ST t_3 – NE t_3	0,002	0,518	0,302	0,000	Zero
H2 (a)	LPI t_1 – ST t_1	0,440	4,954	0,000	0,240	Medium-Large
H2 (a)	LPI t_2 – ST t_2	0,036	0,841	0,200	0,001	Very Weak
H2 (a)	LPI t_3 – ST t_3	0,091	1,329	0,092	0,008	Very Weak
H2 (b)	LPI t_1 – NE t_1	-0,097	0,650	0,258	0,010	Very Weak
H2 (b)	LPI t_2 – NE t_2	0,101	1,146	0,126	0,010	Very Weak
H2 (b)	LPI t_3 – NE t_3	0,090	0,807	0,210	0,008	Very Weak
H2 (c)	LPI t_1 – ST t_1 – NE t_1	0,085	1,466	0,071	0,007	Very Weak
H2 (c)	LPI t_2 – ST t_2 – NE t_2	-0,013	0,768	0,221	0,000	Zero
H2 (c)	LPI t_3 – ST t_3 – NE t_3	0,015	0,981	0,163	0,000	Zero
H3	ST t_1 – NE t_1	0,197	1,505	0,066	0,040	Weak
H3	ST t_2 – NE t_2	-0,089	0,999	0,159	0,008	Very Weak
H3	ST t_3 – NE t_3	0,161	1,694	0,045	0,027	Weak
Non-Hypothesis	QPI t_1 – QPI t_2	0,182	1,437	0,075	0,034	Weak
	QPI t_2– QPI t_3	0,333	2,622	0,004	0,125	Weak-Medium
	LPI t_1 – LPI t_2	0,331	2,580	0,005	0,123	Weak-Medium
	LPI t_2– LPI t_3	0,508	5,521	0,000	0,349	Large
	ST t_1 – ST t_2	0,760	3,460	0,000	1,370	Large
	ST t_2 - ST t_3	0,747	4,811	0,000	1,260	Large
	NE t_1 – NE t_2	0,329	2,707	0,003	0,122	Weak-Medium
	NE t_2– NE t_3	0,298	2,217	0,013	0,097	Weak-Medium

In figure 2, the direct effects of the variables (path coefficients) and the explanatory power of the conceptual model (coefficients of determination R^2) is presented. The coefficients of determination indicate the explanatory variance in each dependent variable and R^2 values of 0.75, 0.50, or 0.25 are described as significant, moderate and weak (Hair et al., 2011). The path coefficients in the model range from -0,097 to 0,760 and the R^2 ranged between 0,031 to 0,437 while the effect size F^2 ranged from 0,000 to 0,240.

Figure 2. Conceptual model with path coefficients and coefficients of determination



7. Discussion

This research looked into the relationship and effect of Quality of port infrastructure, Logistics performance on Seaborne trade and National economy for 93 countries. This was made by analysing development indicators for three periods 2014 t_1, 2016 t_2, and 2018 t_3 for 93 countries. Of the total ten hypotheses developed and evaluated, this research was able to find support and positive significance for four hypotheses through their t-values ($t > 1.645$) and p-values (p-value < 0.05). In addition, these hypotheses were estimated based on their effect size (f^2) value.

Quality of port infrastructure on Logistics performance

Hypothesis H1(a), Quality of port infrastructure on Logistics performance can be considered the most significant hypothesis. As it showed a positive significance over two periods t_1-t_2. This indicates that improvements in the quality of port infrastructure had a positive impact on a country's logistics performance over these two periods. The effect size f^2 value indicated that the quality of port infrastructure had a medium effect on logistics performance for t_1 and a weak effect size for t_2. The higher effect size on t_1 is also confirmed by a higher significance level value. This significance is similar to previous empirical findings by

(Munim & Schramm, 2018, Yeo et al., 2020, Rui Liang & Ziyang Liu, 2021) all saw the same type of significant relationship between improved port infrastructure and improved logistics performance for a country by evaluating multiple nations in their analysis. Similar to this research the three studies used SEM to approach the analysis. However, these studies used a different type of path model, which enabled an overview of the indicator's effect over these time periods. This study instead used three constructs t_1, t_2, and t_3 that represented each time period. In this way, it was possible to see that improvement in the quality of port infrastructure had a positive significance for a country for the individual period t_1 and t_2 but did not indicate a positive significance for the period t_3.

(Yeo et al., 2020, Rui Liang & Ziyang Liu, 2021) covered the same time period as this study t_1, t_2, and t_3 but also included 2 representatively 3 more time periods in their research analyses. The two research also used slightly differently observed variables to measure port infrastructure and fewer countries were included in the sample compared to this research. However, as previously mentioned, common to these research analyses is that those similar to this study saw a positive significance of quality of port infrastructure on logistics performance for a country. (Munim & Schramm, 2018) used the same type of observed variables to measure the quality of port infrastructure and logistics performance as in this research. The study included 91 countries in the sample, which is in the line with the number of countries that this study included in the analysis. (Munim & Schramm, 2018) analysed the relationship between the quality of port infrastructure and logistics performance over a different time period compared to this research. However, similar to this research they saw a clear significance of quality of port infrastructure and the effect on logistics performance.

Quality of port infrastructure on National economy

Quality of port infrastructure on National economy H1(c) $t_1$was the second hypothesis seen as significant. This indicates that improved quality of port infrastructure had a significant positive impact on a country's GDP per capita for t_1. Considering the f^2 value, it can be seen that the effect size of the quality of port infrastructure had a weak impact on a nation's GDP per capita.

The significance of improved quality of port infrastructure on national economy for t_1 for a country is in line with the findings of (Munim & Schramm, 2018), which saw the same type of significance but for three time periods. Something that this research did not find, as t_2 and t_3 were not found significant. However, as previously mentioned, (Munim & Schramm, 2018) measured a different time period and used a different PLS-SEM model.

The hypothesis quality of port infrastructure effect on national economy was developed by including the empirical research by (Song & van Geenhuizen, 2014; D. Wang & Li, 2019). These two studies did not focus on the direct effect of improved quality of port infrastructure on a country's national economy but instead on the indirect economic factors.

For instance, improved port infrastructure in a region was considered to increase industrialization and production and contribute to expanded hinterland infrastructure within the region. This contributed to enhanced economic exchange with other regions, increased employment, and GDP per capita growth for these regions (Song & van Geenhuizen, 2014; D. Wang & Li, 2019). Indicating such indirect effects has not been the object of this research, as it needs to be analysed deeper on a regional level. However, from (Song & van Geenhuizen, 2014; D. Wang & Li, 2019) perspective, it may be possible that such economic indirect effects of improved port infrastructure occurred during the measured time period in this research. Which this research has not been able to identify due to the analysis method.

Logistics performance on Seaborne trade

Logistics performance on Seaborne trade t_1-t_1 showed a positive significance by its t-values ($t > 1.645$) and p-values ($p\text{-value} < 0.05$) and therefore is considered supported. Seaborne trade was measured by the observed variables liner shipping connectivity and container port traffic. This means that improved logistics performance positively impacted a country's liner shipping connectivity and container port traffic during the period t_1. Regarding the f^2 value, hypothesis H2 (a) t_1 achieved the highest f^2 value (F^2= 0,240) of the significant hypotheses. This indicates that improved logistics performance had a medium-large impact on these countries' seaborne trade in the form of liner shipping connectivity and container port traffic.

The significance of Logistics performance on Seaborne trade has been noticed in previous empirical studies. (Behar & Manners, 2008; Çelebi, 2019; Hausman et al., 2013; Munim & Schramm, 2018; Wu, 2020) could see that improvements in logistics performance had the greatest impact on seaborne trade for developing countries. This study has not performed a multigroup analysis that has looked at differences between developed and developing countries. However, the countries included in the sample consist of both developed and developing countries. The result from hypothesis H2 (a) t_1 thereby indicates that improved logistics performance significantly impacted logistics performance for both developed and developing countries.

Seaborne trade was measured with container port traffic (TEU). The significance from H2(a) t_1 indicates that improved logistics performance positively impacts the container port traffic for a country. (Wu, 2020) saw the same connection for ASEAN countries between the period 2007-2014 as improved port logistics positively impacted trade volume in terms of container throughput for these countries.

Seaborne trade on National economy

Seaborne trade on National economy t_3-t_3 was the last hypothesis considered significant. However, the significant level for this indicator was just slightly below (p-value <0.05) and above ($t > 1.645$). The significance of Seaborne trade on national economy still indicates that liner shipping connectivity and container throughput had a significant impact on GDP per capita for t_3 for a country. Considering the f^2 value, it indicates that seaborne trade had a weak-medium effect size on the national economy in the form of GDP per capita.

(Munim & Schramm, 2018; Rui Liang & Ziyang Liu, 2021) could not see any significance between seaborne trade and national economy for 91 respectively 32 countries in their analysis. However, in addition, (Munim & Schramm, 2018) performed a multi-group analysis in the same research. The multi-group analysis indicated that seaborne trade had a positive impact on the national economy of developing countries but not on developed countries. However, these studies used a different type of PLS-SEM model compared to this study and analysed other time periods. Therefore, it is uncertain to say whether this research would have obtained similar results with a multi-group analysis.

(Huchet-Bourdon et al., 2018; Were, 2015) could see a positive relationship between increased trade and economic growth for both developed and developing countries. This is similar to the results for t_3 in this research, as both developed and developing countries are included in the sample. (Huchet-Bourdon et al., 2018; Were, 2015) analysed the relationship between increased trade and economic growth for a time period of 10-17 years and thus saw an average value of the relationship between increased trade and economic growth for the time period. While this research has analysed individual years, we have not been able to see a significance between seaborne trade and national economy for t_1 and t_2 for the countries in the sample.

Not supported hypothesis

Through the analysis, non-significant hypotheses were also found which can be considered to not be in line with the results from similar studies. (Munim & Schramm, 2018; Yeo et al., 2020) found a direct significance between a country's logistics performance and its impact on the national economy in the form of GDP. This direct relationship is something that this research has not find any support for in terms of significance which is similar to (Rui Liang & Ziyang Liu, 2021)

It was not possible to see any significant relationship between the mediated hypotheses H1(d), H1(e), H1(f), and H2(c) in this research. Nonetheless, mediate relationships of port infrastructure, logistics performance, seaborne trade, and national economy relationships have been harder to identify compared to the direct relationships in port economy research. Yet (Munim & Schramm, 2018; Rui Liang & Ziyang Liu, 2021) saw a significant relationship between port infrastructure's effect on the national economy through logistics performance. Although, (Munim & Schramm, 2018) measured this mediate relationship between a different time period compared to this study and(Rui Liang & Ziyang Liu, 2021) included additional observed variables to measure port infrastructure.

However, it can be considered that there is a mediated connection between the direct relations for t_1. Since the quality of port infrastructure affects logistics performance, which in turn affects seaborne trade, and quality of port infrastructure has a positive impact on the National Economy.

A similar coherent relationship could be seen by (Munim & Schramm, 2018; Rui Liang & Ziyang Liu, 2021). As both found that quality of port infrastructure did not directly affect seaborne trade but quality of port infrastructure had a positive impact on logistics performance which in turn affected seaborne trade. This relationship is consistent with the result for t_1 in this study.

8. Conclusion

8.1 Concluding remarks

This research aimed to identify if port infrastructure quality and logistics performance affect seaborne trade and economic growth. The results indicate from its significance that quality of port infrastructure had a direct positive impact on a nation's logistics performance for the period t_1 and t_2. Further, quality of port infrastructure significantly impacted the national economy considering the period t_1. In terms of logistics performance, it was found to have a positive direct significant on a nation's seaborne trade for t_1. Lastly, seaborne trade was found to significantly impact a nation's national economy for the period t_3.

Overall, the significant hypotheses in this research are in line and support findings in existing port economics research.

8.2 Limitations and suggestions for further research

Due to the time limit of the master thesis, this research has not been able to perform a multigroup analysis where differences between developed and developing countries have been analysed. This would have been interesting as it could have generated insight into the differences in the variables' impact on developed and developing countries. Further, this had possibly enabled us to confirm more hypotheses in this research.

Previous SEM models used in port economic research have generated a significance value that represents the significance of the indicator for the whole time period analysed. The model used in this research has instead enabled us to analyse the significance of the indicators for each individual time period. However, as the significance varied for the individual time periods, no hypothesis could be confirmed as significant for all three time periods. This is something that existing port economic studies have been able to confirm due to the design of the path model. However, the path model used in this research has contributed with a different insight into how time periods can be analysed to see the variables effect from year to year.

This may open up the use of this model in future research to a greater extent. A greater degree of use of this model in future research could also enable to find ways of generating higher levels of reliability and validity of the model.

To better understand the implication of the results of this research, it would be of interest to use the same model and time period as in this research but also include (Munim & Schramm, 2018) time periods 2010 and 2012. In addition, a multigroup analysis should be added in order to analyse the variable's influence on developed and developing countries. Such an analysis would provide a better insight into how improvements in port infrastructure and logistics performance affect and develop seaborne trade and national economy for a country from year to year over a longer period of time. The multi-group analysis could further enable to generate interesting information about the different effects of the variable considering developed and developing countries from year to year.

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Appendices

Table 8. Factor and cross-loadings

	LPI t_1	LPI t_2	LPI t_3	NE t_1	NE t_2	NE t_3	QPI t_1	QPI t_2	QPI t_3	ST t_1	ST t_2	ST t_3
LPIAT t_1	**0,778**	0,323	0,250	-0,022	0,002	-0,013	0,370	0,193	0,222	0,368	0,305	0,306
LPICQ t_1	**0,786**	0,312	0,358	0,058	-0,004	0,023	0,313	0,134	0,191	0,392	0,281	0,242
LPIEA t_1	**0,586**	0,034	0,125	0,012	-0,004	-0,084	-0,020	0,098	0,162	0,222	0,001	0,072
LPIEC t_1	**0,705**	0,160	0,259	0,054	-0,182	0,034	0,380	-0,043	0,212	0,280	0,227	0,178
LPIFS t_1	**0,506**	0,229	0,259	0,210	0,117	0,175	0,008	0,047	0,158	0,146	0,152	0,083
LPIQT t_1	**0,791**	0,275	0,291	0,054	-0,074	0,056	0,187	0,146	0,403	0,453	0,326	0,322
LPIAT t_2	0,172	**0,615**	0,254	0,229	0,173	0,039	0,171	0,143	0,181	0,241	0,167	0,075
LPICQ t_2	0,010	**0,484**	0,263	0,239	0,161	0,123	-0,088	0,202	-0,108	0,021	0,013	-0,014
LPIEA t_2	0,296	**0,692**	0,305	0,128	0,081	0,104	0,135	0,177	0,227	0,302	0,239	0,234
LPIEC t_2	0,343	**0,595**	0,375	0,123	0,080	0,138	0,222	0,293	0,429	0,434	0,251	0,174
LPIFS t_2	0,150	**0,639**	0,425	0,224	0,128	0,095	0,181	0,197	0,205	0,174	0,215	0,172
LPIQT t_2	0,259	**0,795**	0,332	0,014	0,093	-0,005	0,064	0,325	0,181	0,298	0,246	0,230
LPIAT t_3	0,261	0,308	**0,748**	0,301	0,083	0,082	0,245	0,112	0,148	0,276	0,228	0,204
LPICQ t_3	0,227	0,321	**0,561**	0,183	0,143	0,171	0,337	0,176	0,235	0,215	0,154	0,090
LPIEA t_3	0,254	0,367	**0,739**	0,231	0,110	0,067	0,313	0,169	0,189	0,212	0,225	0,164
LPIEC t_3	0,270	0,272	**0,645**	0,173	0,086	0,089	0,111	0,085	0,305	0,103	0,175	0,150
LPIFS t_3	0,170	0,242	**0,528**	0,200	0,088	0,191	0,054	0,028	0,002	0,211	0,088	0,179
LPIQT t_3	0,322	0,496	**0,786**	0,294	0,093	0,163	0,127	0,078	0,176	0,409	0,302	0,344
GDPc t_1	0,067	0,227	0,348	**1,000**	0,343	0,578	0,216	0,064	-0,005	0,186	0,212	0,203
GDPc t_2	-0,052	0,173	0,147	0,343	**1,000**	0,319	0,099	0,172	-0,082	0,053	-0,055	0,050
GDPc t_3	0,043	0,125	0,188	0,578	0,319	**1,000**	0,171	-0,031	0,037	0,189	0,106	0,215
QPI t_1	0,360	0,200	0,287	0,216	0,099	0,171	**1,000**	0,176	0,268	0,208	0,178	0,157
QPI t_2	0,147	0,357	0,158	0,064	0,172	-0,031	0,176	**1,000**	0,328	0,039	-0,063	0,079
QPI t_3	0,330	0,332	0,261	-0,005	-0,082	0,037	0,268	0,328	**1,000**	0,327	0,272	0,153
LSC t_1	0,439	0,339	0,275	0,066	-0,076	0,033	0,195	0,034	0,334	**0,809**	0,517	0,420
CT t_1	0,257	0,281	0,294	0,232	0,183	0,279	0,111	0,024	0,142	**0,693**	0,445	0,711
LSC t_2	0,328	0,237	0,230	0,141	-0,058	-0,050	0,150	0,106	0,284	0,482	**0,727**	0,470
CT t_2	0,213	0,243	0,233	0,180	-0,027	0,197	0,122	-0,185	0,138	0,491	**0,790**	0,517
LSC t_3	0,223	0,157	0,191	0,065	-0,085	0,064	0,129	0,107	0,116	0,450	0,489	**0,700**
CT t_3	0,236	0,196	0,232	0,222	0,152	0,239	0,095	0,007	0,101	0,582	0,435	**0,719**

Table 9. List of countries

Angola	Ghana	Nigeria
United Arab Emirates	Greece	Netherlands
Argentina	Guatemala	Norway
Australia	Hong Kong SAR, China	New Zealand
Belgium	Honduras	Oman
Benin	Indonesia	Pakistan
Bangladesh	India	Panama
Bulgaria	Ireland	Peru
Bahrain	Iran, Islamic Rep.	Philippines
Brazil	Iceland	Poland
Canada	Israel	Portugal
Chile	Italy	Qatar
China	Jamaica	Romania
Cote d'Ivoire	Jordan	Russian Federation
Cameroon	Japan	Saudi Arabia
Congo, Rep.	Kenya	Senegal
Colombia	Cambodia	Singapore
Costa Rica	Korea, Rep.	El Salvador
Cyprus	Kuwait	Slovenia
Germany	Lebanon	Sweden
Denmark	Sri Lanka	Thailand
Dominican Republic	Lithuania	Trinidad and Tobago
Algeria	Latvia	Tunisia
Ecuador	Morocco	Turkey
Egypt, Arab Rep.	Mexico	Tanzania
Spain	Malta	Ukraine
Estonia	Myanmar	Uruguay
Finland	Mozambique	United States
France	Mauritius	Vietnam
United Kingdom	Malaysia	Yemen, Rep.
Georgia	Namibia	South Africa