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Optimal transit corridors for Ethiopia

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Background: Ethiopia has been landlocked since Eritrea, a former province, gained independence. Its imports and exports by sea are now sent via neighbouring coastal states, mainly Djibouti, and it needs to ensure sustainable access to multiple transit corridors.

Objective: This article aims to evaluate alternative transit corridors to Ethiopia in terms of basic port infrastructure, and logistics costs. The findings provide insights to inform policy on securing reliable maritime access to the country.

Method: This study adopts a case study approach by using secondary data to evaluate alternative transit corridors. Following a critical review of theoretical and empirical literature, descriptive statistics are presented using tables, graphs and charts.

Results: Low-cost, high-capacity and high-frequency global maritime freight trade is easier through Djibouti than through Mombasa in Kenya or Port Sudan, owing to its better liner shipping connectivity. Thus, Ethiopia should continue to import containerised cargo through the Port of Djibouti. However, direct access to the sea is also important for national defence and security.

Conclusion: Ethiopia should therefore secure access through multiple ports to safeguard national security, regardless of economic feasibility. This can be realised by directing break-bulk, dry bulk and petroleum products through ports in Sudan and Kenya. In addition, particular emphasis should be given to seaports closest to the country's economic centre, such as Berbera in Somaliland and Asseb and Massawa in Eritrea.

Keywords: landlocked; transit corridor; infrastructure development; container shipping; dry bulk shipping; logistics cost.

Introduction

No country is self-sufficient. All nations are involved in international trade to obtain inputs to improve production and productivity (Rodrigue, Comtois & Slack 2006). International trade is growing in terms of value and tonnage, and on average the value of world merchandise trade increased by 7% between 1980 and 2011 (WTO 2013). Shipping carries 80% – 90% of global trade by volume and 60% – 70% of global trade by value (Brooks & Faust 2018). Shipping operations require access to the sea and adequate port facilities (Rodrigue et al. 2006). However, about 20% of countries around the world are landlocked (Lahiri & Masjidi 2012), and 40% of the population of Africa lives in landlocked countries (Jouanjean, Gachassin & Te Velde 2015).

Although *the United Nations Convention on the Law of the Sea, Part X Article 125* gives landlocked states the right to pass through the territories of transit states to access the sea, exercising this right requires bilateral, subregional or regional agreements between landlocked and transit states. Goods passing through transit corridors should not be subject to customs duty, but landlocked countries must pay for facilities such as railways, roads and port facilities, in line with negotiated agreements (United Nations 1982). Negotiations and agreements play a pivotal role in optimising the benefits of landlocked states' rights (Bayeh 2015). Reaching wise and fair agreements requires identification and effective application of objective criteria (Fisher, Ury & Patton 2011), which should be applied in selecting optimal transit corridors and negotiating with transit neighbours.

Ethiopia became a landlocked country when its former province of Eritrea gained independence in 1992 (The Economist 2012). Nevertheless, Eritrea's port of Assab continued to handle more than 75% of Ethiopia's imports until the outbreak of war in 1998 (Snow et al. 2003), after which a significant percentage of Ethiopian imports and exports shifted to Djibouti. The Ethio-Djibouti transit corridor is now Ethiopia's main maritime gateway, handling over 90% of its trade cargo (Ursu & Van Den Berg 2018).

Lack of direct access to the sea may affect landlocked countries' defence and security (Mishra & Singh 2008), so, setting aside the economic benefits, Ethiopia's dependence on a single corridor may endanger its national security. Diversifying import and export cargo through different transit corridors and seaports is essential to preserve the country's national interest and increase its bargaining power in bilateral and multilateral negotiations. The government of Ethiopia recognises this in its national logistics strategy to be implemented from 2018 to 2028 (Ministry of Transport and EMAA 2019).

This study evaluates three alternative transit corridors to Ethiopia, through Djibouti, Sudan and Kenya. The findings reveal that the Port of Djibouti is optimal for container shipping as a result of its greater maritime connectivity, geographical proximity and infrastructural development. Thus, Ethiopia should continue to utilise Djibouti particularly for containerised cargo imports. To increase its access to multiple corridors and seaports, break-bulk cargo, petroleum products and dry bulk cargo might be imported through other neighbouring transit corridors.

Overview of Ethiopia's maritime access

Eritrea, a former province of Ethiopia, became an independent state through a referendum in 1992. This made Ethiopia a landlocked country because it lost its Red Sea ports of Assab and Massawa to the new state (The Economist 2012). Assab port continued to handle over 75% of Ethopia's imports under a bilateral agreement for transit movements signed in 1992 (Snow et al. 2003). However, the outbreak of a border war between the two countries ended Ethiopia's access to these ports, marking the beginning of its dependence on the Port of Djibouti (Maritime & Transport Business Solutions [MTBS] 2014).

Since the outbreak of the Ethiopia–Eritrea war in 1998, a significant percentage of Ethiopia's imports and exports has shifted to Djibouti. In 1993, Ethiopia signed a port utilisation agreement with Djibouti, giving it the right of access to the Port of Djibouti to import and export transit goods. The agreement also gave Ethiopia a right to a duty-free plot of land at the Port of Djibouti, harmonised transport and communication operations to facilitate smooth flows of cargo and information and harmonised formalities for the movement of peoples, vehicles and aircraft (Giorgis 1995). Following the increase in Ethiopian cargo passing through the Port of Djibouti, the port authority invested US$15 million in expanding the terminal (Snow et al. 2003). Further agreements approved by the Ethiopian parliament have been made between Ethiopia and Djibouti, relating to port utilisation and cargo transit services (Federal Democratic Republic of Ethiopia [FDRE] 2002) and multimodal transport services (FDRE 2007). These will improve Ethiopia's cross-border logistics through the Port of Djibouti (MTBS 2014).

In August 2003, Somaliland and Ethiopia signed a bilateral agreement, which took effect on 01 July 2005, to improve truck road links and establish customs and ports (UNPO 2005). This allowed Ethiopia to use the port of Berbera, northwestern Somalia. An agreement was also signed between Ethiopia and Sudan for cooperation on transport and communication and to research the potential to build roads to connect their border cities (Giorgis 1995). Ethiopia has been using Port Sudan for exports and has made efforts to use Sudanese ports for imports. For instance, 50 000 metric tons of fertiliser was imported through Port Sudan in January 2015 (Abdu 2015).

Ethiopia is part of the Lamu Port–South Sudan–Ethiopia Transport (LAPSSET) Corridor Project, an infrastructure project dedicated to providing sea access to several east African nations through Lamu. This port will consist of 32 deep-sea berths. The corridor comprises two elements: an infrastructure corridor involving the development of road, railway, pipelines and power transmission and a 50-km economic corridor on either side of the infrastructure corridor where industrial investments will be situated (Chome 2020; LAPSSET Corridor Development Authority 2016). Construction of three berths at Lamu Port was completed in July 2020 (Ochieng 2020).

In addition to being landlocked, a unique characteristic of Ethiopia's import logistics is the semi-monopolistic Ethiopian Shipping and Logistics Service Enterprise (ESLSE). In May 2000, the office of the prime minister of the Federal Democratic Republic of Ethiopia issued a letter aimed at improving foreign currency utilisation from sea imports into the country. The letter, addressed to the National Bank of Ethiopia, regional governments and ministerial offices, required government and private importers to buy all import cargos under free on board (FOB) arrangements and transport them by using the Ethiopian Shipping Line (ESL) if purchased by using the country's foreign currency reserves or loans. Importers would be allowed to use foreign vessels if ESL did not or could not provide services in specific countries for various reasons (FDRE, Office of the Prime Minister 2000). Ethiopian Shipping Line would then issue a letter of verification to the bank allowing foreign vessel utilisation. Ethiopian Shipping Line's rights and obligations were transferred to the ESLSE under Council of Ministers Regulation no. 255/2011. The Ethiopian government's FOB directive gave ESLSE an exclusive right to transport all of Ethiopian's sea imports (Ministry of Transport and EMAA 2019). This system aimed to save foreign currency but blocked the market to foreign competition (MTBS 2014).

Ethiopian Shipping and Logistics Service Enterprise was established in 2011 with a capital of 3760 million Ethiopia Birr to provide multimodal transport, freight forwarding, dry port, containerisation, warehousing and other related services. It resulted from a decision by the Ethiopian parliament to merge three government-owned companies in the logistics sector: Ethiopian Shipping Lines Share Company (SC), the Ethiopian Maritime and Transit Services Enterprise and the Dry Ports Service Enterprise (FDRE 2011).

A government-owned land transport company, Comet Transport SC, was also incorporated into ESLSE in 2014 (Abdu 2014). Ethiopian Shipping and Logistics Service Enterprise is responsible for supporting the country's economy by providing value-added services to its customers (FDRE 2011; MTBS 2014).

Ethiopia's logistics sector has recently been opened up to international logistics service providers by allowing joint ventures for freight forwarding and shipping agency services between Ethiopian and foreign investors, where the foreign investor owns a maximum of 49% (FDRE 2020; Investment Commission 2018). Furthermore, as stipulated in the country's national logistics strategy and policy, the government of Ethiopia has promised step-by-step liberalisation of the maritime sector and multimodal transport to admit international logistics operators (Ministry of Transport and EMAA 2019, 2020).

Methodology

This study applies a case study approach by using secondary data obtained from various sources, including the Sea Ports Corporation of Sudan, Kenya Ports Authority, the Port of Djibouti, Berbera Port Authority, the World Bank database, ESLSE, Google Maps and articles from scientific journals. Following a critical review of theoretical and empirical literature, descriptive statistics are presented. The cost and tariff analysis results are then discussed by using tables, graphs and charts to guide decision-making in selecting transit corridors and seaports.

Theoretical framework

Cost of being landlocked

Landlocked countries need to cross through transit states to increase their participation in global trade. Several challenges arise from their lack of direct access to the sea. Although being landlocked does not necessarily cause countries to become poor or have low economic growth, 38% of the world's most impoverished societies live in landlocked countries (Collier 2007). Landlocked countries' economic and social development is lower than that of coastal countries (Uprety 2006). They have higher trading costs as a consequence of higher land transport costs for imports and exports (Christ & Ferrantino 2011), owing both to the distance to sea ports and the passage across transit countries' borders (Uprety 2006).

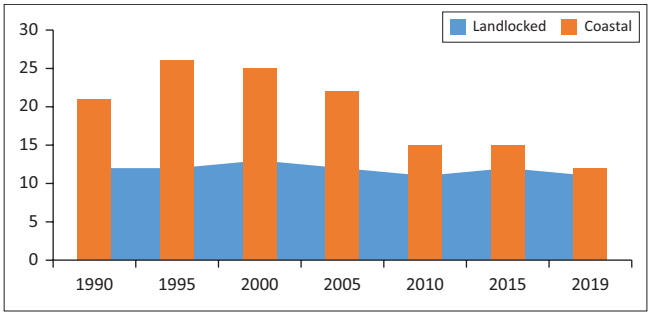
However, effective assessment of actual and potential transit corridors may promote the efficiency of transit businesses and improve regional and interregional connectivity (Vinokurov & Tsukarev 2018). In addition, efficient ports promote trade growth by empowering greater quantities of imports and exports (Kalgora 2019). Kalgora, Abdoulkarim and Kossivi (2019) recommended that efficient combinations of intermodal transport systems should also be considered in assessing optimal transit corridors for landlocked states. The quality of the transport infrastructure and organisational restructuring may determine the performance of cross-border corridors (Hanaoka et al. 2019; Kawasaki, Kobayashi & Shibasaki 2021). The challenges faced by landlocked countries include socio-economic, political and infrastructural aspects.

Socio-economic and political aspects

Landlocked countries' neighbours may differ politically, socially, economically and geographically (Lahiri & Masjidi 2012). Socio-political relationships between landlocked and transit states will have a major impact on the use of transportation infrastructure, and landlocked countries' problems will be exacerbated if they are surrounded by neighbours with socio-economic problems (Wilson 2008). For example, Switzerland (Europe) has access to well-developed transport infrastructure in Germany, Italy, Belgium, France and the Netherlands, whereas Uganda's neighbours – Kenya, Somalia, Sudan, Tanzania and the Democratic Republic of Congo (DRC) – suffer from social, economic and political problems (Collier 2007). Uganda uses Mombasa Port in Kenya for 90% of its exports and 78% of its imports. However, the partnership between the two countries was interrupted after Kenya's 2007 elections, and the railway connecting Uganda with Mombasa Port was torn up in protest against Uganda's president (Wilson 2008). In general, development will be difficult in landlocked countries with scarce natural resources and transit corridors through countries with socio-economic problems (Collier 2007).

The United Nations (UN) categorises a significant percentage of landlocked countries as low-income. As shown in Figure 1, over 30 years the number of low-income coastal countries reduced from 21 to 12, whereas the number of low-income landlocked countries hardly changed (12–11). This implies that landlocked countries are unable to develop beyond the low-income category, whereas coastal countries enjoy greater income improvements.

Regarding export structure, landlocked developing countries' exports are highly concentrated in less diversified primary commodities (United Nations [UN] 2014), and African landlocked developing countries' share of merchandise exports declined between 2013 and 2017. These countries are still struggling with challenges such as insufficient quantities of and high prices for physical infrastructure, delays in cargo flows as a result of poor customs facilitation and border



Source: Based on the data from World Bank, 2020, *GNI per capita in US$ (Atlas methodology)*, The World Bank, n.d., viewed 13 February 2021, from https://data.worldbank.org/indicator/NY.GNP.ATLS.CD?locations=XT.

FIGURE 1: Low-income African countries.

procedures and declining proportions of GDP and employment in manufacturing (United Nations Economic Commission for Africa [UN ECA] 2019).

Some landlocked developing countries in Africa are characterised by political instability. For instance, according to the World Bank, between 2018 and 2020 six landlocked countries were either politically unstable or faced social and institutional fragility, and some transit neighbours were also struggling with similar problems. In addition to internal instability, some landlocked countries are involved in inter-state border disputes with their coastal neighbours, as in the case of Eritrea and Ethiopia, South Sudan and Sudan, Mali and Mauritania, Malawi and Tanzania, Kenya and Uganda, Lesotho and South Africa, Chad and Libya and Uganda and the DRC (Sone 2017). Such disputes hinder long-term commitments to cross-border infrastructure development and border trade.

Poor infrastructural development

Landlocked countries rely on their transit neighbours' trade and transport infrastructure for their seaborne trade. Inadequate infrastructure, inefficient transport and cumbersome government regulations in both transit and landlocked countries hamper freedom of transit. Furthermore, transit countries' ability to improve their infrastructure from their own resources may be very limited because many are themselves developing countries (Uprety 2006). Although progress has been made in expanding and upgrading the infrastructure of African landlocked developing countries, insufficient physical infrastructure and high prices continue to hinder development (UN ECA 2019). Thus, development assistance to address hard and soft infrastructural gaps in landlocked countries is essential.

Transaction cost theory

Transaction cost theory is based on the assumptions that humans have limited capacity to understand and solve complex problems, and that they engage in opportunistic behaviour in their own self-interests (Williamson 1981). Three critical dimensions for describing transactions are uncertainty, frequency and transaction-specific investments. Opportunism is particularly likely where investments in human and physical capital are involved (Williamson 1979), which implies that Ethiopia's dependence on a single transit corridor and investments in specific assets may result in opportunistic behaviour by Djibouti.

Ethiopia and Djibouti have built a 751.7-km standard gauge, electrified railway, amounting to a total investment of about US$4 billion. The line starts in Addis Ababa, runs through inland ports such as Modjo and ends in Djibouti (CREC 2018), and it was constructed through mutual investment. The Ethiopian section of the line cost $3.4 billion, financed 70% by the Exim Bank of China and 30% by the Ethiopian government and the Djibouti government contributed only $878 million (Railway Technology 2017). Thus, transit countries may engage in opportunistic behaviour to reduce their economic burden.

Opportunism can be controlled through explicit contracts that govern the relationship. Establishing strong and enduring relational norms and trust will also reduce opportunistic behaviour (Yaqub 2009). For example, in an infinitely repeated game setting, a bilateral cooperation model between a landlocked and coastal neighbour revealed that, rather than issuing unilateral policies for individual country gain, sustainable cooperation equilibrium will result from designing domestic policies to maximise both countries' economic benefits (Lahiri & Masjidi 2012).

The challenges facing landlocked countries can be reduced through integrated development strategies implemented by both landlocked and transit countries. This includes encouraging neighbours to develop better policies and achieve economic growth, expanding air transportation through low-cost airlines and increasing trade with sub-regional countries (Collier 2007). Integrating different modes of transportation, such as roads and railways, with port operations, and establishing a modern information communication system for customs clearing and cross-border information sharing are also crucial to minimise the drawbacks of being landlocked (Arvis, Raballand & Marteau 2010).

Ports' competitiveness

All alternative ports should be evaluated to establish sound justifications and achieve good deals. Rebelo's (1992) criteria for evaluating transit corridors include infrastructure, operations, traffic, trade facilitation, trade logistics and trade, transit and transport institutions. According to Merk and Li (2013), ports' competitiveness can be evaluated in terms of three main determinants: their connections with other ports, strong hinterland connections with various modes of transport and effective operations measured by the rough utilisation rates and productivity of cranes, yards and berths. These are summarised in Table 1.

Of the various criteria shown in Table 1, the most important port selection attributes for the purposes of this study were selected in consultation with high-level shipping and logistics experts. These are presented in Table 2.

Results and discussion

Ethiopia is located in the East African region known as the Horn of Africa, bordering Eritrea in the north, Kenya in the south, Sudan in the northwest, South Sudan in the west and southwest, Djibouti in the northeast and Somalia in the east. It is the most populous landlocked country in the world and the second most populous nation in Africa, with about 115 million inhabitants in 2020 (World Population Review 2021). Ethiopia may potentially secure maritime access through corridors to the Port of Djibouti (Djibouti), Berbera Port (Somaliland), Port Sudan (Sudan), Massawa and Asseb ports (Eritrea), Mombasa Port (Kenya) and the ports of Bosaso, Mogadishu and Kismayu (Somalia).

Although an agreement for peace, friendship and comprehensive cooperation was concluded between

Ethiopia and Eritrea in September 2018, a specific agreement for port utilisation has not yet been signed to secure Ethiopia's access to ports in Eritrea. Widespread activities by a terrorist group, Al-Shabaab, remain a potent threat to peace and security in Somalia, with many attacks on civilians and government institutions (United Nations Security Council 2019). The prolonged conflict in Somalia has become a major hinderance to considering the country for transit services.

TABLE 1: Sea port selection criteria.

Author	Region	Key drivers
Balla et al. (**2016**)	West and Central Africa	• Soft infrastructure • Hard physical infrastructure
Song and Yeo (**2004**)	China	• Cargo volumes • Port location • Port facilities • Service levels
Parola et al. (**2017**)	Global	• Port costs • Hinterland connectivity • Port infrastructure • Port service quality • Nautical accessibility • Hinterland proximity • Port's geographical location • Operational efficiency • Maritime connectivity • Port site
Chang, Lee and Tongzon (**2008**)	Global	• Local cargo volumes • Berth availability • Transshipments • Terminal handling charges • Port location • Feeder network
Fanou and Wang (**2018**)	Africa: Landlocked	• Number of navigation lines • Port fees • Nature of the terrain • Transport infrastructure availability • Number of countries through which shipments will pass • Port's service levels • Distance between the seaport and the landlocked country's capital • Safety levels and relations with neighbouring countries

Source: Compiled from: Balla et al.(2016), Song and Yeo (2004), Parola et al. (2017), Chang, Lee and Tongzon (2008), Fanou and Wang (2018).

Note: Please see the full reference list of the article, Takele, T.B. & Tolcha, T.D., 2021, 'Optimal transit corridors for Ethiopia', *Journal of Transport and Supply Chain Management* 15(0), a567. https://doi.org/10.4102/jtscm.v15i0.567, for more information.

TABLE 2: Criteria for evaluating transit corridors.

Variable	Category	Performance indicators
Port hard infrastructure	Berth availability	• Maximum berth draft • Total berth length
	Superstructure	• Port-side gantry cranes • Cargo handling productivity
	Port location and connectivity	• Maritime connectivity • Distance between port and landlocked country's hinterland centre (Modjo) • Intermodal connections
Cargo	Volumes	• Annual container throughput
	Handling	• Stevedoring • Terminal handling • Port dues • Wharfage

Source: Compiled from: Song and Yeo (2004), Parola et al. (2017), Chang et al. (2008) and Fanou and Wang (2018).

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In March 2018, an investment agreement was signed between Dubai Ports World, Ethiopia and Somaliland for infrastructural development of Berbera Port and upgrading of the Ethiopia–Somaliland transport corridor. However, Somalia's President Mohammed Abdullahi Farmajo rejected the legitimacy of this contract (Kantack 2018), and it has become a new source of intra- and inter-state tension in the Horn (Musa & Horst 2019). This situation, along with poor infrastructural development, will hinder effective utilisation of Berbera Port for transit cargos.

In view of these facts, the Port of Djibouti, Port Sudan and Mombasa Port can currently be considered as potential transit corridors for Ethiopia's cargo. Thus, critical analysis was conducted on these ports to identify an optimal transit corridor for the country.

Distances to potential ports

Distances from hinterlands to seaports are a major factor in selecting transit corridors for landlocked countries. Multimodal cargo is transported via the Port of Djibouti to inland destinations in Ethiopia, mainly to Modjo dry port (UNCTAD 2018). With direct rail and road connections to the Port of Djibouti, Modjo dry port is the largest port in the country, located 73 km from the country's capital, Addis Ababa. It handles more than 78% of the country's multimodally transported imports (Ethiopian Shipping and Logistics Service Enterprise [ESLSE] 2020d). Therefore, in this study Modjo was considered as the hinterland destination for Ethiopia's imports. Road distances from Modjo to transit seaports are presented in Figure 2.

The Port of Djibouti is much closer to Ethiopia than Port Sudan and Mombasa Port, which are more than double the distance from Modjo. However, in addition to distance, road quality, truck-handling capacity, levels of congestion, availability of other modes of transport (mainly rail) and lengths of roads must be taken into consideration when comparing viable ports.

Port infrastructure and connectivity

Port infrastructure refers to physical facilities used in handling day-to-day activities such as berths, suitable cranes, quays, straddle carriers, forklifts and storage areas (Stopford 2009). Alternative ports' infrastructural development was evaluated in terms of berthing capacity, number of cranes and

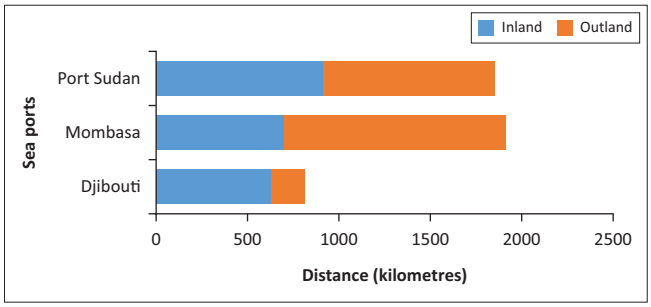

FIGURE 2: Distance from Modjo to discharging seaports.

productivity. As shown in Table 3, based on these criteria, the Port of Djibouti is positioned more competitively than Mombasa Port and Port Sudan, with the deepest draft, most ship-to-shore gantry cranes and best quay productivity.

Capacity of ports' container terminals

Container terminals generally have several berths with one or more heavy-lift cranes and a collection area for containers. Containers are stacked up to five blocks high by using gantry cranes (Stopford 2009).

The competitiveness of transit corridors' container terminals was evaluated in terms of cargo-handling capacity and actual throughput in 2019 (Figure 3). Although Mombasa Port has a greater container-handling capacity, its utilisation rate is 86%, so importing many more containers through Mombasa Port may result in congestion. On the other hand, the Port of Djibouti has the capacity to handle 1.4 million 20-foot equivalent units (TEU) per year, with a 66% utilisation rate, as well as higher productivity at 681 TEU per metre of quay per annum. Its existing utilisation rate and crane productivity will enable it to handle additional containers for transit and/or trans-shipment.

Comparison of port tariff structures

The potential transit ports were compared for containers and dry bulk cargo, that is fertiliser handling. As shown in Figure 4, TEU container transit imports cost $602 at Port Sudan, $254 at Mombasa Port and $450 at the Ports of Djibouti for stevedoring, terminal handling charges (THCs) and wharfage and/or port dues. Regarding dry bulk imports, total port costs for stevedoring, shore handling and other services up to the loading of bagged fertiliser or grain onto truck or rail cost $13.01 at Port Sudan, $16.40 at Lamu Port[1] and $18.93 at the Port of Djibouti. Lower rates are charged by Mombasa Port for containers and Port Sudan for dry bulk. However, these two ports are located further from Ethiopia, resulting in higher land transportation costs.

TABLE 3: Ports' infrastructure and connectivity.

Indicators	Djibouti	Mombasa	Sudan
Berth (metres)			
Deepest berth	18	13.5	16
Total berth length	3774	4727.2	5698
Ship-to-shore gantry cranes (STS)	12	10	8
Quay productivity: TEU per metre of quay	681	469	n/a

Source: Compiled from Kenya Ports Authority (2020), Sudan Sea Ports Corporation (2017), Djibouti Ports & Free Zone Authority (2018) and Humphreys (2019).

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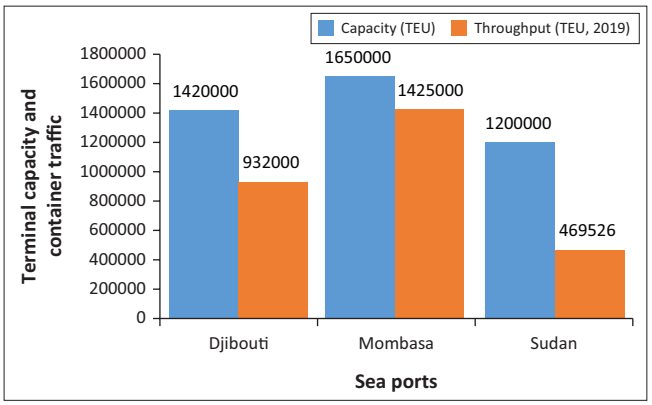
n/a, not applicable; TEU, 20-foot equivalent units.



Source: Authors, based on data extracted from Kenya Ports Authority (2020), Sudan Sea Ports Corporation (2017), Djibouti Ports & Free Zone Authority (2018) and UNCTAD (2020).

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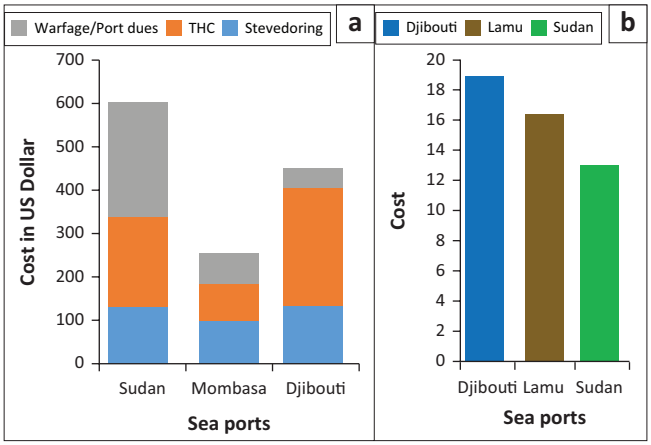
FIGURE 3: Container terminal capacity and container traffic (20-foot equivalent units).

Corridors logistics cost analysis

Container shipping

The total cost of importing a standard TEU from Shanghai in China to Modjo dry port was computed by using different transit ports. Freight quotes were collected in January 2021 from major liner shipping companies operating in East Africa and from freight forwarders. The total cost consists of sea freight, basic port charges and land transportation costs. Terminal-handling charges and wharfage/port dues were used to calculate port charges, but documentation fees and other charges were excluded. Land transport costs were $0.92 per TEU per kilometre from the Port of Djibouti to Modjo dry port. These were computed based on the tariff used by ESLSE, the major carrier in Ethiopia, since October 2020. The roads from Ethiopia to all transit corridors are paved and have quite similar topography, so the same road transport costs were applied to the other corridors to Mombasa and Sudan.

The cost of sea freight (basic ocean freight and stevedoring) from Shanghai to discharging seaports is about $2596 for the Port of Djibouti, $3117 for Mombasa Port and $6060 for Port Sudan. Sea freight costs are lower for imports into the Port of Djibouti, whereas importing a TEU through Port Sudan costs



Source: Authors, based on data extracted from Kenya Ports Authority (2012), Sudan Sea Ports Corporation (2017) and Djibouti Ports & Free Zone Authority (2018), freight forwarders

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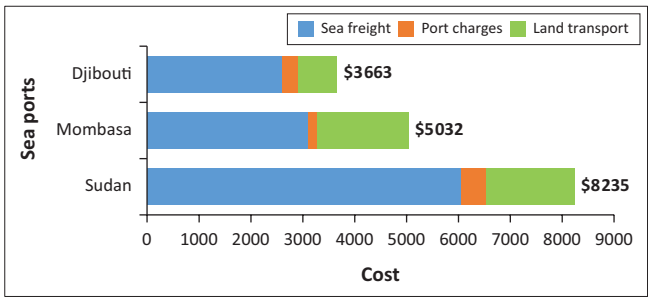
FIGURE 4: (a) Port charges for containers/20-foot equivalent units and (b) stevedoring and shore-handling charges for dry bulk per ton.

1.Mombasa Port Authority's 2012 tariff is applied to Lamu Port for the purposes of this research.

more than twice as much as through Djibouti. The reasons for this big difference in maritime transport costs require further analysis (see Figure 5).

Maritime transport costs, and particularly container shipping, are determined by several factors. Liner shipping connectivity (the number of carriers providing a direct service, deployed containers, the number of services, vessel sizes), ports' levels of infrastructural development (berth length, maximum draft, storage capacity) and transit times impact on liner freight rates (Wilmsmeier & Hoffmann 2008). Sanchez et al. (2003) find that more efficient ports (measured by hourly container-loading rates, average containers loaded per vessel and waiting times) are associated with lower freight rates. In this respect, the identified ports differ considerably in terms of connectivity and efficiency. Figure 6 shows transit ports' liner shipping connectivity and vessels' carrying capacity.

UNCTAD's liner shipping connectivity index (LSCI) was used to capture countries' container port connectivity. The LSCI uses statistics on scheduled ship calls, deployed containers, the number of shipping companies and liner services, average vessel size and directly connected ports. The higher the index, the easier it is to access high-frequency and high-capacity global shipping (Rodrigue & Notteboom 2020). Based on the performance statistics presented in Figure 5, the Port of Djibouti has a higher LSCI index. This implies that Ethiopia will have better access to maritime containerised transport through the Port of Djibouti than through Mombasa Port or Port Sudan. Increased ship size is important to achieve economies of scale, but bulk ships necessitate greater investments in constructing terminals with deeper drafts and higher cargo-handling equipment (Stopford 2009). The Port of Djibouti also handles container vessels with larger average and maximum carrying capacities. Lei and Bachmann (2019) suggest that more vessel calls, higher container throughput and larger numbers of containers loaded/unloaded per vessel lead to lower freight rates. The differences in sea freight costs between Djibouti, Mombasa and Sudan are compatible with each port's maritime connectivity and vessel capacity.



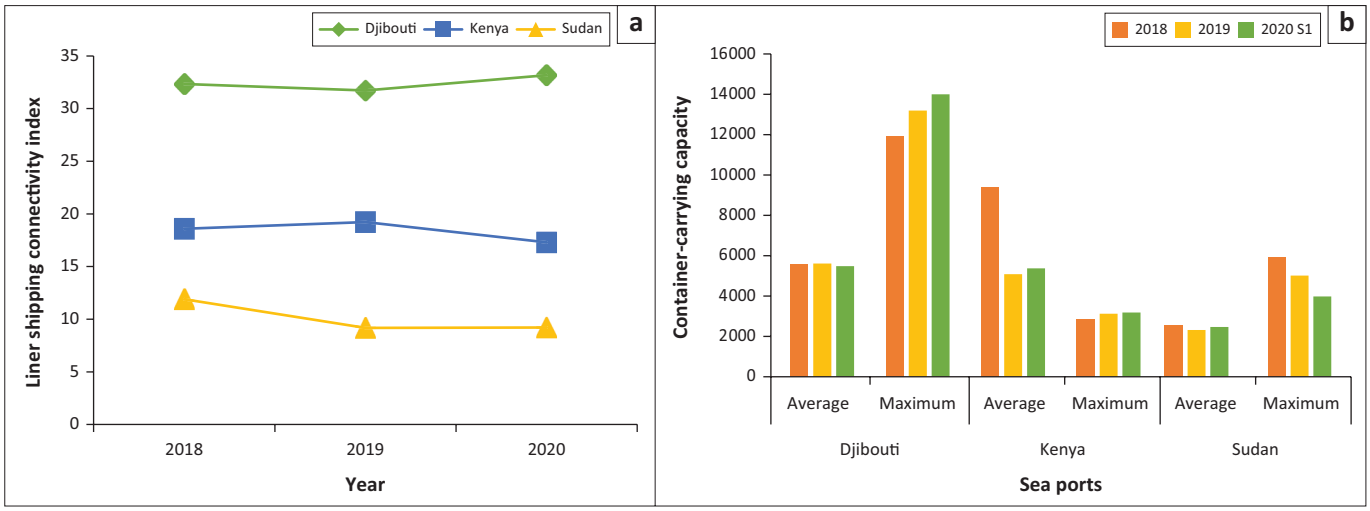
Source: Authors, based on data extracted from Kenya Ports Authority (2012), Sudan Sea Ports Corporation (2017), Djibouti Ports & Free Zone Authority (2018), ESLSE (2020c), and Liner Shipping Companies (2021).

Note: Please see the full reference list of the article, Takele, T.B. & Tolcha, T.D., 2021, 'Optimal transit corridors for Ethiopia', *Journal of Transport and Supply Chain Management* 15(0), a567. https://doi.org/10.4102/jtscm.v15i0.567, for more information.

FIGURE 5: Cost of importing a 20-foot equivalent units container from Shanghai to Modjo.

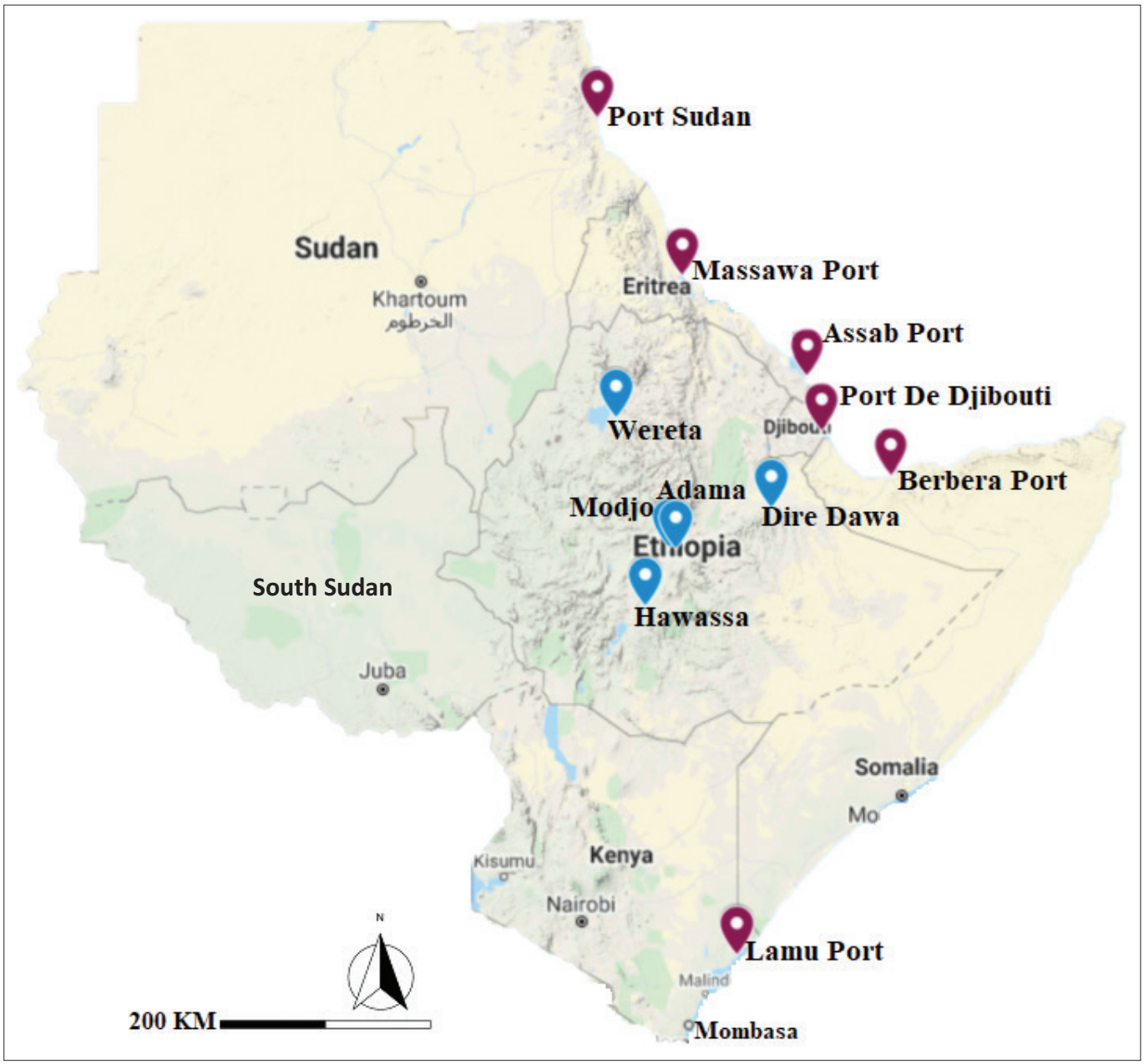
Transporting a TEU from the Port of Djibouti to Modjo costs about $750. However, the long out-land distances to Port Sudan and Mombasa Port result in much higher logistics costs of $1705 and $1760, respectively. The total logistics costs of importing a TEU container from Shanghai seaport to Modjo dry port through the discharging seaports are summarised in Figure 7. In this regard, importing containers through Djibouti costs $3663, which is less than half the cost of Port Sudan. The Port of Djibouti's relatively high liner shipping connectivity and productivity, as well as geographical proximity, contribute to lower logistics costs.

The above analysis proves that the Port of Djibouti's well-developed infrastructure, rail connections to Ethiopia (Modjo and Addis Ababa), lower total container transport costs and geographical proximity make it optimal for Ethiopia's container shipping. This implies that the Port of Djibouti should continue to be the main transit corridor for Ethiopia,



Source: Compiled from United Nations Conference on Trade and Development (UNCTAD), 2021, *Maritime transport indicators*, UNCTADStat, n.d., viewed 17 February 2021, from https://unctadstat.unctad.org/wds/ReportFolders/reportFolders.aspx.

FIGURE 6: (a) Liner shipping connectivity index and (b) container-carrying capacity (20-foot equivalent units) per container ship.



Note: This is the authors' elaboration based on Google Maps.

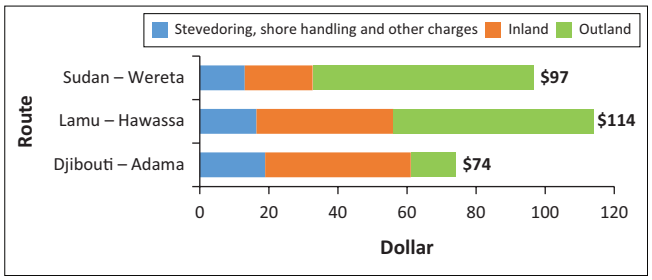
FIGURE 7: Location of seaports and inland destinations.

particularly for containerised cargo imports and exports. However, considering the country's vast geographical size and population of more than 115 million, it is essential to secure reliable access to multiple transit corridors, irrespective of their economic feasibility. In this regard, dry bulk cargo such as soil fertiliser might be imported through different transit ports.

Dry bulk shipping

Fertiliser is the major dry bulk cargo imported and distributed to all corners of Ethiopia. In 2019–2020, ESLSE transported imports of 1 million metric tons of wheat and 0.87 million metric tons of coal from loading ports to the Port of Djibouti and 1.45 million metric tons of soil fertilisers from loading ports to inland farmers' receiving and dispatching posts (ESLSE 2020a, 2020b).

Dry bulk freight rates are determined based on interactions between demand and supply (Beenstock & Vergottis 1989), as freight is a function of the balance between the quantity demanded in ton miles and the supply of ship services by fleet tonnage (Glen 2006). In addition, length of laycan periods, vessel size (deadweight tonnage) and shipping routes impact on dry bulk freight shipping rates (Alizadeh & Talley 2011). As a result, there will be no significant differences in dry bulk shipping rates for sea freight from geographically proximal discharging ports such as Djibouti and Berbera. This leads to an emphasis on infrastructural quality and the costs of ports and land transport in selecting transit corridors for dry bulk imports. Dry bulk cargos can be imported into Ethiopia through various neighbouring transit corridors.



Source: Authors, based on data extracted from Kenya Ports Authority (2012), Sudan Sea Ports Corporation (2017), Djibouti Ports & Free Zone Authority (2018), freight forwarders and ESLSE.

Note: Please see the full reference list of the article, Takele, T.B. & Tolcha, T.D., 2021, 'Optimal transit corridors for Ethiopia', *Journal of Transport and Supply Chain Management* 15(0), a567. https://doi.org/10.4102/jtscm.v15i0.567, for more information.

FIGURE 8: Logistics costs for dry bulk imports (per ton).

For Ethiopia's 2020–2021 fertiliser imports, ESLSE has agreed with the Ministry of Agriculture to transport 1.8 million metric tons of fertiliser from loading ports to inland destinations. The carrier's responsibility includes sea transportation, port handling and inland transportation (ESLSE 2020a). Per ton-kilometre (tkm) cost calculations for fertiliser were based on ESLSE inland transport costs for 2020–2021. Fertiliser transportation costs about $0.068 per tkm from the Port of Djibouti to inland destinations in Ethiopia. Costs for the Ethio-Djibouti transit corridor were applied to the other corridors for the purposes of this study, although they may vary.

The logistics cost per ton was computed for each transit corridor with different inland destinations: Wereta for the northern part of the country (Port Sudan), Hawassa for the southern part (Lamu Port) and Adama for the east and central parts (Port of Djibouti). Figure 8 summarises the logistics costs for each transit corridor.

Conclusion

Ethiopia became the most populous landlocked country when its former province of Eritrea gained independence. For over two decades, its imports and exports have been dependent on the Port of Djibouti, which handles more than 90% of the country's import and export trade by sea. With the strategic significance of maritime access and the country's large geographical size and population, securing access to the sea through multiple transit corridors is essential for Ethiopia. As a result, this study evaluates alternative transit corridors that might serve Ethiopia's international trade.

Three ports are compared (Port of Djibouti, Mombasa Port and Port Sudan) with Ethiopia's containerised and dry bulk cargo imports from the perspective of logistics costs. The total logistics costs, including sea freight, port charges and land transport, of importing a TEU from Shanghai to Modjo dry port are around $3663 through Djibouti, $5032 through Mombasa Port and $8235 through Port Sudan. With regard to container shipping, until now all container imports (with the exception of waived imports) into Ethiopia have been carried by ESLSE. Importing containers through different transit discharging seaports would distribute the consolidated freight, but might reduce the benefits of consolidated shipments, such as reduced freight rates. Compared with Port Sudan and Mombasa Port, the Port of Djibouti scores higher for liner shipping connectivity, which is associated with lower freight rates (Sanchez et al. 2003; Wilmsmeier & Hoffmann 2008). Accordingly, importing through the Port of Djibouti results in lower sea freight rates. In addition, geographical proximity and railway connections to Modjo make the Port of Djibouti optimal for container shipping to Ethiopia. The findings of this research clearly show that Ethiopia should continue to utilise Djibouti port for its containerised cargo imports and exports.

Direct access to the sea is important for national security (Mishra & Singh 2008). Thus, selecting transit ports for Ethiopia should go beyond economic feasibility, as the country must secure access through multiple ports to safeguard national security. Considering its large geographical size, different transit corridors and seaports can be utilised for different regions of the country, particularly for handling dry bulk and liquid bulk cargos. For example, soil fertiliser might be imported through Port Sudan to Wereta for northern Ethiopia, through Lamu Port (Kenya) to Hawassa for southern Ethiopia and through the Port of Djibouti to Adama for east and central parts of the country. In addition, further efforts should be made to ensure sustainable access to the seaports of several neighbouring countries, with particular emphasis on seaports within a short geographical distance from the country's economic centre. These ports are Djibouti, Berbera in Somaliland and Asseb and Massawa in Eritrea.

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Competing interests

T.B.T. and T.D.T. have declared that no competing interest exists.

Authors' contributions

T.B.T. was responsible for the analysis and interpreted the data. T.D.T. wrote the manuscript and edited the text.

Ethical considerations

This article followed all ethical standards for research without direct contact with human or animal subjects.

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Data availability

The data that support the findings of this study are available from the corresponding author, T.B.T., upon reasonable request.

Disclaimer

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