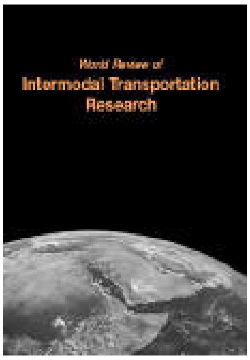

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State of digital technology adoption in intermodal freight transport: empirical evidence from Ethiopia

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State of digital technology adoption in intermodal freight transport: empirical evidence from Ethiopia

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Abstract: The present study assesses the level of digital technology adoption in the inter-modal freight transport system, with the case study of Ethiopia. To achieve the objectives, we utilized questionnaires and conducted site visits to the companies involved. The results show that all the companies have an equally high level of fundamental technology adoption. However, the use of advanced information and communication technologies, such as artificial intelligence and the internet of things, is limited. Ethiopian's railway transport company uses up-to-date technologies (such as real-time tracking and communication with drivers), whereas road transport companies widely use conventional technologies (such as phone calls) in providing transport services. To increase the level of digital technology adoption, and thus the overall efficiency of the intermodal transport systems, the study revealed a need for investment in human resources, encompassing awareness creation and IT skills training, in parallel to investments in the actual technologies.

Keywords: technology adoption; digital technologies; ICT; Ethiopia; low-income countries; intermodal freight transport; IFT.

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1 Introduction

1.1 Background

The application and enhancement of information and communication technologies (ICT) are increasing in today's world more than ever (World Bank Group, 2016; Pew Research Center, 2019; Acheampong et al., 2022). In systems such as intermodal freight transport (IFT), which engages numerous stakeholders and activities, the advantages of using ICT are manifold. Adopting ICT in IFT promotes integration and transparency, minimises costs, enhances time utilisation, and increases quality of service (Hricová and Balog, 2015; Altuntaş Vural et al., 2020). Real-time planning and management, customer satisfaction, and security are facilitated by adopting digital technologies at ports (Ángel González et al., 2008; Scholliers et al., 2016; Heilig et al., 2017). Digital technologies also have applications in route optimisation and tracking and tracing in railway and road transport and may reduce potential accidents during transportation (Wang et al., 2017; Muñuzuri et al., 2020). Despite its benefits, the adoption of digital technologies is still slow in IFT especially in low-income countries (Harris et al., 2015; Paulauskas et al., 2021). The cost of investments, satisfaction with current operations, and uncertainty are among the barriers to adopting these technologies (Shibasaki, 2018; Janbaz et al., 2018).

Studying the level of technology adoption in the transport system helps uncover potential benefits from digitalisation and identifies areas where technological improvements are required (Davies et al., 2007; Philipp, 2020). Measuring the level of digitalisation comprises both qualitative and quantitative aspect. Researches have adopted different approaches to come up with quantitative indices for these measurements. This includes Digital Adoption Index (DAI), ICT Development Index (IDI) and Network Readiness Index (NRI). adoption of general purpose technologies (GPT) including use of computers, phones, internet and web services at individual, business and government level are underscored by these indices (The World Bank, 2019; ITU, 2016; World Economic Forum, 2020). GPTs are defined as highly versatile technologies with a potential to bring major economic transformations within firms and across nations. However, the level of utilisation of these technologies in various aspects of sector specific operation and business processes is missing in the aforementioned indices. Generally, literature that quantify the extent of digitalisation in intermodal transport is scarce. The existing literature mainly focuses on the use of ICT in road haulage and ports (Davies et al., 2007; Marchet et al., 2009; Evangelista and Sweeney, 2014; Philipp, 2020). Cirera et al. (2021a) developed a firm-level technology adoption survey, but in general, there is a lack of structured quantitative measurement of technology adoption in this sector in the literature.

Ethiopia is a low-income but one of the fastest growing economies in Africa. As is the case for many land-locked countries, dry ports play a crucial role in facilitating IFT in import-export chains. The intermodal transport system is at an early development stage and features like high delays, cumbersome bureaucracies, massive paper works and limited technology implementation underline the system in the region. The present study investigates the level of digitalisation in the IFT of Ethiopia. The main objective of the research was to formulate a method to measure the prevalence of GPT and the level of digitalisation in IFT of the country. The second objective was to identify perceived benefits and barriers of adopting digital technologies in companies involved in the sector. The outcomes of the study could be used for decision makers to show key areas where digitalisation is required in the sector. It also provides insights into the preparations required before introducing digital technologies. This research also adds to the case studies about freight transport on the African continent and contributes to the inventory of the development of ICT systems and their use in intermodal transport.

After this introduction, where the context and purpose of the study is presented, a brief review summarises available literature on the topic and positions the research in this field. Next, the methodological approach is described in Section 2, followed by a presentation of the survey results in Section 3. Finally, the results are further discussed and the study is concluded with key findings and recommendations in Sections 4 and 5.

1.2 Literature review

This sub-section aims to provide a literature background on digital technologies adoption in IFT and their measurements. Studies that concentrate on this area are presented. In addition, the adoption of technologies in various economies is highlighted and the identified gap in measuring the extent of adoption is acknowledged.

There is an extensive application of digital technologies in IFT. The technology is used for monitoring goods and trucks, as a decision-supporting system, for communication, and to exchange documents (Devlin and McDonnell, 2009). The manifold applications result in faster delivery/pick up, reduced cost of logistics, high visibility, and higher customer satisfaction in the IFT system (Torlak et al., 2020;

Paulauskas et al., 2021). Nevertheless, the adoption of digital technologies in IFT is still low in low-income countries (Sanchez-Gonzalez et al., 2019).

Digital technologies were first introduced to the world in the 1960s, marking the third industrial revolution. Automation, digitalisation and computerisation of processes marked this area. Today, we are in the fourth industrial revolution (industry 4.0), that includes use of internet of things (IoT), big data, artificial intelligence, and cloud computing. These technologies are also referred as GPT (Rousseau and Jovanovic, 2005; Cirera et al., 2021a, 2021b). This term refers to generic technologies having a high impact in changing the economic and social structure of a society. The application of the Industry 4.0 technologies is yet limited in IFT especially in developing economies (World Bank Group, 2016; Farquharson et al., 2021).

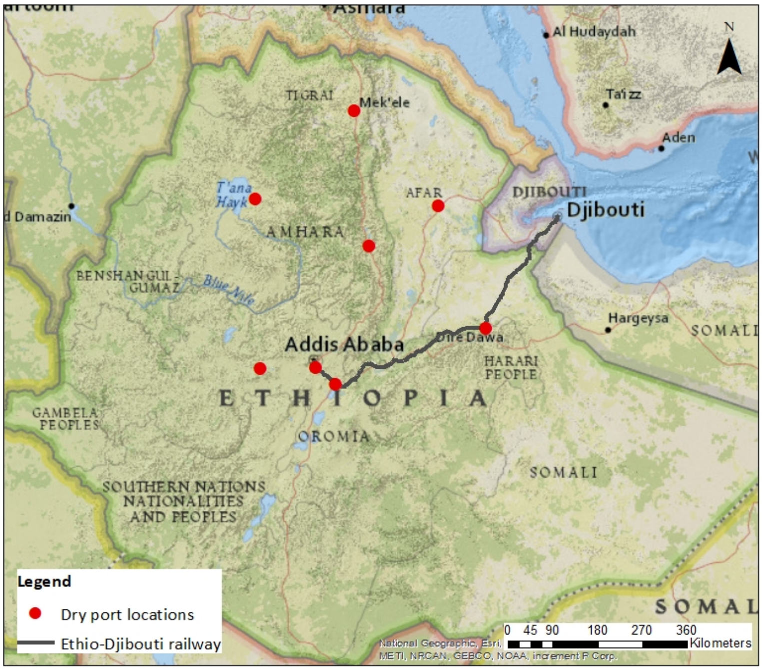
It is important to study adoption of digital technologies in firms because it enables decision makers to plan for the type and area of technology adoption. Such studies identify potential developments and necessary policies that companies need to adopt to benefit from digital technologies (Fruth and Teuteberg, 2017; Sanchez-Gonzalez et al., 2019). To study levels of digital technology adoption, Paulauskas et al. (2021) formulated digital readiness indices for ports. According to their study, ports were divided into analogue, monitor, adopter, developer, and smart, considering the digital index developed for the port. Global indices such as DAI, IDI and NRI are also employed to quantify level of digitalisation at national level. These indices rank countries based on criteria like adoption of digital technologies (such as, internet, websites, mobile-cellular access and computers) and IT skills and readiness of countries for digitalisation (World Bank Group, 2016; ITU, 2016; World Economic Forum, 2020). Other indices are also covered in the literature, considering human and organisational factors. These studies do not purely focus on the state of digitalisation in their calculations, but instead focus on all factors that will affect the adoption of digital technologies (Desai et al., 2002; Esche and Hennig-Thurau, 2014; Incekara et al., 2017).

Evangelista and Sweeney (2006) conducted one of the studies that solely focuses on the level of digitalisation in logistics practices. The study shed a light on the level of ICT adoption in third party logistics (3PLs). In addition, they indicated the difference in the number of firms adopting contemporary ICT among full haulage and advanced logistics. Evangelista and Sweeney (2014) studied ICT adoption in road freight haulage. They identified the major activities road transport companies undertake and explored the use of ICT in performing these tasks. A firm-level technology adoption framework was proposed by Cirera et al. (2021a). This study examines technology adoption in firms and their utilisation in various sectors in contrast to the aforementioned studies. From the literature review, it was found that there is still a lack of a structured framework for measuring the level of digitalisation, particularly in IFT systems. This study addressed this gap by studying level of digital technology adoption in IFT for the case of Ethiopia.

2 Methodology

This section is devoted to provide reader with the procedures employed throughout the study, encompassing from data collection leading up to formulation of conclusions. The study area is introduced first to give geographical context and insight on how the transport system is carried out in Ethiopia followed by introduction of the study framework. In the next sub-section, information regarding organisations approached in the study are described. Features like the total number of companies and their size are provided to give background information on the respondents involved in the study. The data collection method used for the study is explained in the section that follows. Finally, type of data and tools gathered and analysis method are discussed, to ensure the transparency and replicability of the study.

Figure 1 Study area illustrating key import-export corridor and dry port locations in Ethiopia (see online version for colours)



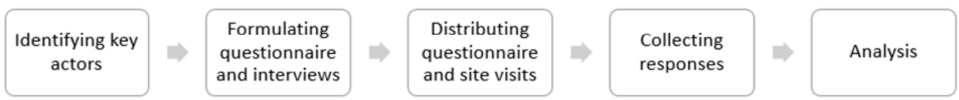
2.1 Study area

In Ethiopia, intermodal transport is mainly implemented using the Ethio-Djibouti corridor. More than 90% of the country's import and export takes place through this corridor. Two types of arrangements applies for goods transportation in this import and export corridor. The first is referred as uni-modal transport, whereby carriers are responsible for transporting goods only to/from a seaport. The second arrangement is multimodal transport. This is where the concept of intermodal transport is implemented, by which goods can be transported up to dry ports using a single carrier. The owners are responsible for carrying the goods from dry port to the final destination. As part of the intermodal transport system, there are currently eight functional dry ports in the country. For goods passing through the intermodal system, goods collected from or delivered to Djibouti port are transported to/from the dry ports either by truck or rail. Figure 1 shows the study area including the transport corridor and dry ports considered under the study.

2.2 Study framework

This study follows a qualitative analysis to depict the level of digitalisation in IFT sector of Ethiopia. The data collection started by identifying and describing the key actors that play an important role in carrying out IFT in the region. Subsequently, questionnaires were prepared to gather the required data from the companies. Separate questionnaires were prepared for different stakeholders as depicted in Appendix A. Administration of the questionnaires to the targeted groups was then undertaken. The collected responses are visually presented through graphs and tables showing the practice of digital technology utilisation in the sector. The steps followed in the study are indicated in Figure 2.

Figure 2 Steps followed in the study



2.3 Key actors

The key stakeholders considered in the study were companies involved in shipping the intermodal transport units from seaport to dry ports. These include public entities such as dry port authority, Railway Company, Ethiopian Shipping and Logistics Service Enterprise (ESLSE), and private entities like road transport companies and freight forwarders. The proper operation of intermodal transports is highly dependent on efficiency of these bodies. In addition, government bodies such as Ministry of Transport (MOT) and Ethiopian Maritime Authority (EMA) have a significant role in the IFT system. These bodies are responsible for formulating policies, long term planning, decision-making and execution of policies. ESLSE is the sole intermodal operator in the country currently and has its own trucks, but usually outsources its transport service to transport companies. Some customs clearing and forwarding tasks are also outsourced to freight-forwarding companies. In addition, the eight dry ports in the region are operated under ESLSE.

Road transport companies that own tippers and general haulage trucks were considered in this study. The Federal Transport Authority (FTA) of Ethiopia has categorised road freight transport service providers based on the age of the trucks. Table 1 shows the categories of transport companies based on the age of their vehicles. Level IV transport companies were not included in this study because they are very small-scale companies owning a small number of vehicles. In addition, these companies are restricted to travel only within the country, which limits their involvement in IFT. Level I road transport companies are more modern and financially strong than Level II and Level III, while Level III is the least financially robust among them.

The Ethio-Djibouti railway is the sole railway operator in Ethiopia currently. It connects Addis Ababa to the Djibouti port providing public and freight transport services. Ethio-Djibouti Standard Gauge Rail Transport S.C. controls operations in the corridor. The corridor contains twenty railway stations and seventeen of them are found in Ethiopia while the remaining three are in Djibouti.

Table 1 Number and fleet size of road freight transport companies

Transport company category	*Age of trucks*	*No. of companies*	*No. of vehicles owned*
Level I	< 10 years	34	5,059
Level II	10–20 years	22	3,009
Level III	20–30 years	20	1,799
Level IV	> 30 years	22	852
Total		98	10,719

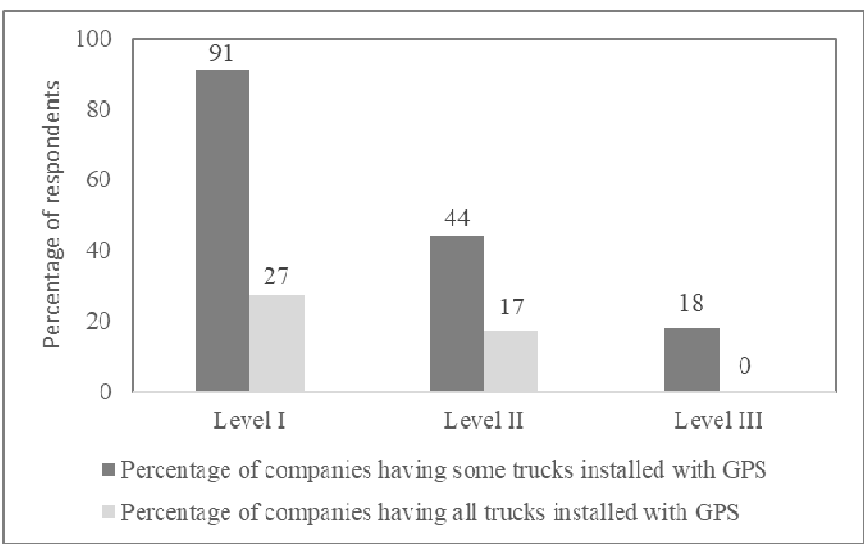
Source: FTA of Ethiopia

These companies were categorised into small, medium, and large based on the number of employees they have as indicated in Table 2. It was observed that most road transport and freight-forwarding companies are classified as small companies, having 1 to 49 employees. Only four companies from Level I were large companies (with more than 250 employees). Similarly, the highest proportion of freight-forwarding companies are small sized (81%).

Table 2 The number of employees in different levels of transport and freight-forwarding companies

Road transport companies	*No. of employees*		
	1–49 (small sized)	*50–249 (medium sized)*	*250+ (large sized)*
Level I	16	2	4
Level II	15	3	0
Level III	16	1	0
Total	47 (82%)	6 (10%)	4 (7%)
Freight forwarders	30 (81%)	5 (13%)	2 (5%)

Figure 3 Proportions of road transport companies owning GPS-installed trucks



Out of the 22 level I companies, 91% responded that they own Global Positioning System (GPS)-installed trucks, as shown in Figure 3. Of these percentages, only 27% have a full GPS installed on their trucks. More than half of the companies from levels 2 and 3 reported that they do not own GPS-installed trucks. Overall, 54% of transport companies contacted responded that they use GPS.

Both the railway company (Ethio-Djibouti Standard Gauge Rail Transport S.C.) and dry port authority (owned by ESLSE) are large-sized companies with more than 250 employees. The railway covers 750 km and electrified trains are used. There are ten types of wagon in operation based on the type of goods. Terminal tractors and chassis are used in the dry port and the lifting of containers is carried out using stackers and forklifts.

2.4 Data collection and responses

The questionnaires were distributed to road transport and freight forwarding companies. The lists of transport companies working in the corridor were acquired from FTA and all these companies were approached except seven companies whose address was not possible to find. There were 70 questionnaires distributed to the road transport companies, of which six were eliminated for incomplete responses and eight did not respond (a response rate of 88.6%). Finally, 57 responses were found suitable for the analysis (Table 2). However, we were unable to find a similar list for freight forwarders and therefore only the companies the authors could locate were contacted in the study. Nonetheless, it was found that there are 294 registered freight forwarders operating in Ethiopia. They plan, control, and operate the transportation of goods on behalf of importers and exporters. For the present study, 50 companies were contacted to assess their level of technology use, of which eight did not respond and five responses were incomplete, and were excluded. Therefore, 37 responses were found to be suitable for further analysis, as shown in Table 3. In addition, a visit and an interview were carried out at dry ports and a railway company. The data collection was undertaken from June 2021 to October 2021.

Table 3 The number of road transport and freight-forwarding companies contacted for the study

Transport company category	*No. of valid responses*
Level I	22
Level II	18
Level III	17
Freight-forwarding companies	37
Total	94

To collect data about railway service, the Ethio-Djibouti Standard Gauge Rail Transport S.C. head office, the overall control centre (OCC), and one station with a dry port facility (Indodee) were visited during the survey to understand the level of technology used in carrying out their tasks. In addition, two dry ports (Mojo and Kality dry port) were visited. Structured interviews were conducted with managers of the dry port during these visits, where the questions in part 3 of Appendix A were presented to the interviewees. The respondents were in managerial positions in operation and IT departments, and were able to give full explanations to the questions.

2.5 Data description and analysis

The study used a survey and site visits to investigate the level of digital technology utilisation and the barriers and benefits of adoption in IFT in Ethiopia. The questionnaire, as shown in Appendix A, contains four sections. The first part is intended to obtain general information about companies, including the number of employees, year of establishment, number and type of vehicles including information about their GPS installation. The next two parts were prepared by considering technology adoption from two perspectives: the ubiquity of GPT and the level of digitalisation, as suggested in the framework by Cirera et al. (2021a). The framework considered technology adoption from three angles. The first one is the measurement of GPT adoption. The second and third perspectives focus on the use of technologies in general and sector specific business functions. The second part of the questionnaire identifies whether or not the technologies are present in the companies.

The third part addresses the application of digital technologies in carrying out tasks specific to the companies. The study identified the level of digitalisation in the companies from the responses to the questions in this part. The application of digital technologies is considered general business activities and sector-specific activities. When the technologies are applied to carry out business activities, such as business administration, payments, and sales, they are referred to as general business technologies. Sector-specific technologies, on the other hand, are those used in handling tasks specific to companies. The actual tasks that transport companies undertake include track and trace, communication with drivers, proof of delivery (POD), managing delivery errors, and routing and scheduling. The main tasks freight forwarders carry out are providing documents to port and customs authorities, tracing goods, and facilitating or providing transport service until the goods reach their destination point according to the contract. The last part of the questionnaire asks for information on the perceived benefits companies gain and the challenges they face in adopting technologies.

To understand the level of GPT adoption in companies taking part in IFT, a numerical value was given to each GPT component. This study considered ten components of GPT and each was given a value of one as indicated in Appendix B. Therefore, a GPT score having a maximum value of ten was developed for individual companies based on the adoption of the ten GPT components. For the level of digitisation score, the responses were coded according to Appendix B (separate tables for transport and freight forwarders), based on the technological advancement of their practices. Companies using the least advanced methods scored less and vice versa. Accordingly, the maximum level of digitalisation score for transport companies is 33 while the minimum is 6. This range is between 8 and 27 for freight-forwarding companies. Stata 14 was used for the statistical analysis of the data.

3 Results

In this section, the main findings of the study are presented. The first sub-section shows the presence of GPT in the companies engaged in IFT. This sub-section aims to determine whether the companies obtain the fundamental technologies that significantly affect the level of digitalisation, a topic explored the next section. Section 4.2 is about the level of digital technologies implemented in the organisations encompassing their utilisation in both business activities and sector-specific tasks. The results on the benefits and obstacles of adopting digital technologies is finally presented giving insight on respondents' perspective that can inform future technological planning.

3.1 GPT prevalence

Electricity and information technologies (IT) are the two most important GPTs known (Jovanovic and Rousseau, 2005; Crafts, 2021). This study assesses GPT' level of adoption in intermodal transport in view of the three industrial revolutions: Industry 2.0, Industry 3.0, and Industry 4.0. The versatility of GPTS implies a high degree of adoption of these technologies and the use of digital technologies in the companies. The absence of GPTS will significantly affect digitalisation because they function as a building blocks for technological advancement of any nation (Rousseau and Jovanovic, 2005).

3.1.1 Industry 2.0

The era of technological advancement of using electricity is referred to as Industry 2.0. The revolution started from the end of the 19th century. The responses indicate that all the companies have access to power and they all face power outages. However, of the 77% of road transport companies owning a generator, only 44% of level III companies use a generator while 100% of level II transport companies use one. The results showed that there is a significant difference ($p < 0.05$) between the level III and other companies in owning a generator. There are 95% of freight-forwarding companies owning generator (Table 4). The result shows that freight forwarders have a significantly higher number of companies who own a generator ($p < 0.05$) than road transport firms.

Table 4 Industry 2.0 in road transport companies and freight-forwarding companies

Adoption of Industry 2.0	*Transport companies*				*Freight-forwarding companies*
	Mean	*Level I*	*Level II*	*Level III*	
Power, %	100	100	100	100	100
Power outage, %	100	100	100	100	100
Own a generator, %	77	82	100	44	95

The interview with the railway and dry port companies shows that both companies have access to power as well as a generator in all their branches.

3.1.2 Industry 3.0

Industry 3.0 refers to the age of technological advancement regarding ICT. In this study, the level of ICT adoption was assessed in terms of owning a telephone, smartphones, computers, internet access, and the use of enterprise software. All the companies own telephone and computer while 64% of the transport companies own smartphones. The variation among levels I, II, and III is large, 77% of level I companies own a smartphone, while only 44% do so at level III. This difference is significant with $p < 0.05$ unlike the difference between levels II and III. There is no significant difference in use of smart phones between freight forwarding and transport companies. Software (enterprise and industry-specific software applied in transport related tasks) use in levels I and II road transport companies is significantly higher than level III transport companies and 87% of all the companies have internet access. The difference in access to the internet is significant between levels I and III as well as between levels II and III ($p < 0.05$ and $p < 0.1$ respectively). However, there is no significant difference in percentage of transport companies that provide web-based services.

There is a comparable proportion of companies owning telephones, computers, smartphones and cell phones between transport and freight forwarding companies. A significantly higher proportion of freight-forwarding companies uses software compared to transport companies ($p < 0.01$). Among the freight forwarding companies, 100% have internet access but only 87% for transport companies ($p < 0.05$) and the use web-based services are also higher in freight-forwarding companies with $p < 0.1$ (Table 5).

Table 5 Industry 3.0 in road transport and freight-forwarding companies

Industry 3.0 technology	*Road transport companies*				*Freight-forwarding companies*
	Mean	*Level I*	*Level II*	*Level III*	
Having a telephone, %	100	100	100	100	86
Having a cell phone, %	91	95	94	82	84
Having a smartphone, %	64	77	67	44	80
Having a computer, %	100	100	100	100	100
Use of software, %	52	68	61	19	81
Having internet access, %	87	95	94	69	100
Providing web-based services, %	32	36	39	18	54

Industry 3.0 technologies, including telephones, cell phones, smartphones, computers, and web-based services, are available in both railway and dry port companies. The railway uses fibre internet throughout the corridor, while dry ports use broadband internet. Freight management, maintenance, and planning software are used by the railway company. Enterprise resource planning (ERP) is implemented in dry ports.

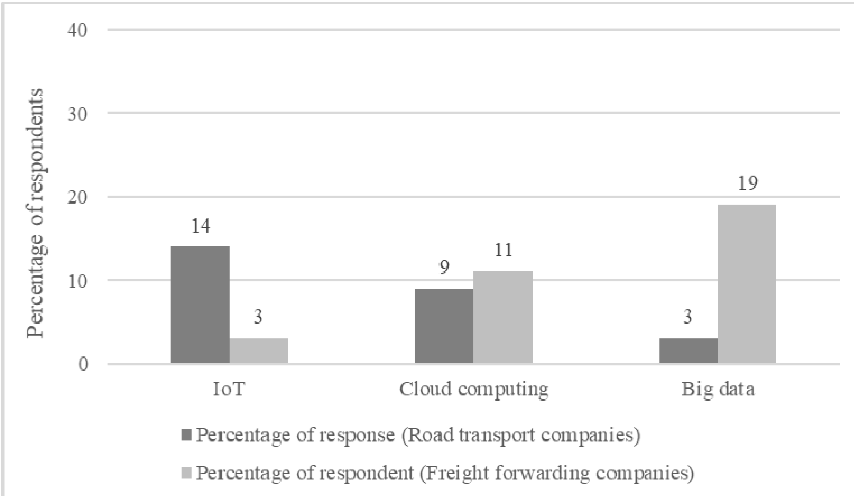
3.1.3 Industry 4.0

Industry 4.0 technologies (such as robotics, cloud computing, the IoT, and big data) are the extension of Industry 3.0 underlined by time when networking between machines and companies have grown larger. The study showed that these technologies are not widely used by the transport companies or freight-forwarding companies (Figure 4). 74% of road transport companies responded that they do not use any of the Industry 4.0 technologies, while 67% of FF companies do not use 4.0. The IoT and big data are relatively highly implemented technologies in this regard for road transport and forwarding companies respectively.

The Industry 4.0 technologies of cloud computing and IoT are implemented by the railway company and in dry ports.

The results showed that the average score for road transport and freight-forwarding companies was seven and eight respectively. The railway company and dry port authority, on the other hand, get a score of nine and ten respectively.

Figure 4 Percentages of companies adopting Industry 4.0



3.2 Level of digitalisation in the intermodal transport sector

3.2.1 Digital technologies in business activities

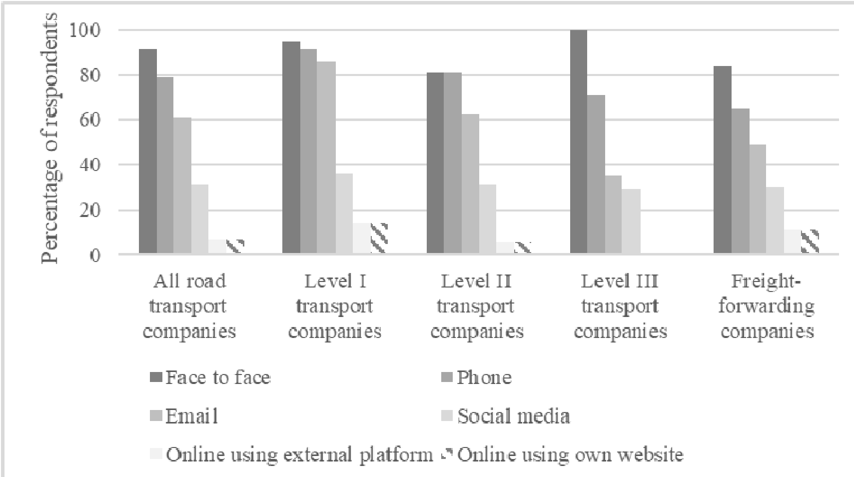
The practice of technologies in business activities, including communication with customers and payment methods, is taken into consideration in this study. Communication with customers is mainly made using face-to-face communication. Figure 3(a) shows 91% of respondents replied that they meet their customers face to face for communication. The second most used method is use of the phone (79%). Online communication means using external platforms or their own websites. These methods are the least implemented in the sector and only 7% of respondents claim to use them [Figure 3(a)].

Technology usage in communication with customers shows a great deal of variation between the levels of transport companies. Figure 3a shows online communication using an external platform and a company's own website are not implemented in level III. A relatively high number of companies from levels I and II use e-mail and social media, or an app. Similar to road transport companies, the highest proportion of freight-forwarding companies (84%) make communications with their customers face to face. The phone is the second most used method at 65%. The least used methods are online using an external platform and online using their own platform.

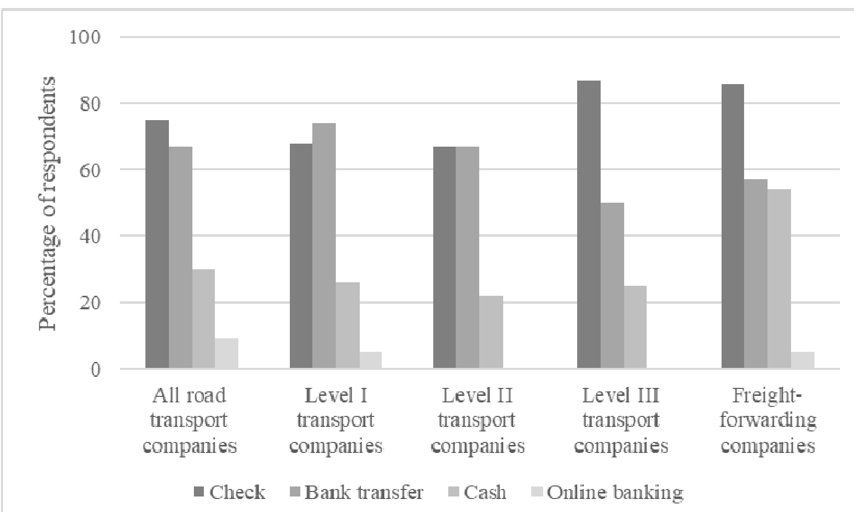
The main payment method used by the transport companies is checks. They account for 75%, as shown in Figure 3(b). The most primitive cash system is being replaced by checks. Even if paperwork is still involved in using checks for payment, this is considered a good advancement. From the total road transport companies, 67% of respondents answered that they use bank transfers as their payment method. Online banking is the least used method.

Payment methods used within the level of transport companies show similar patterns as indicated in Figure 3(b). Most freight-forwarding companies use checks as their payment method. Cash and bank transfers are also quite widely used at 54% and 57% respectively. Only 5% of companies use online banking [Figure 3(b)].

Figure 5 Application of digital technologies to undertake business activities in road transport and freight-forwarding companies, (a) while communicating with customers and (b) while making payments.



(a)



(b)

Both railway and dry port companies mainly communicate with their customers face to face. E-mail is the other method used by the railway company. Both companies use similar payment methods, which are checks.

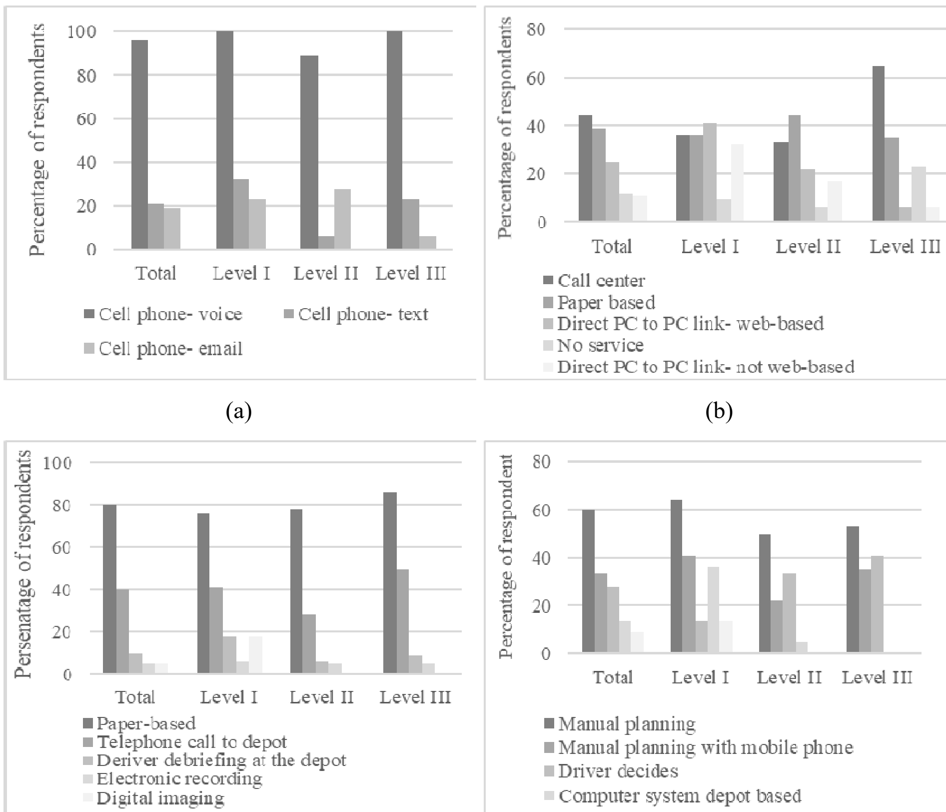
3.2.2 Digital technologies in sector-specific activities

Road transport companies

In providing tracking and tracing, most companies are observed to use call centres, as shown in Figure 6(b). The lowest percentage of the companies (11%) use a direct

PC-to-PC (personal computer to personal computer) link (not web-based). 12% of the companies do not provide the tracking and tracing service. The number of companies not providing this service is higher in the level III road-transport companies. It can also be observed that level III mainly uses a call centre while a PC-to-PC link is rarely used.

Figure 6 Digital technologies practiced in road transport companies considered under the different levels of road transport companies, (a) means of communication with driver (b) tracking and tracing practices, (c) means of managing delivery errors, and (d) routing and scheduling method



(a) (b)

(c) (d)

Communication with drivers mainly relies on cell phone calls [Figure 5(a)]. Radio and satellite networks are not used by any company. Respondents also pointed out social media (such as Telegram), as a means of communication with drivers. The variation at operator level is not huge as shown in Figure 6(a).

A paper signature from a recipient is used to confirm the delivery of goods. All the companies use the paper-based method and 7% use an electronic signature in addition to a paper signature. Delivery errors are managed using a paper-based method by 80% of the companies. A telephone call to a depot is the next highly implemented method [Figure 6(c)]. Both digital imaging and electronic recording are used by 5% of the road transport companies. The majority of the companies use a manual routing and scheduling method (60%), as shown in Figure 6(d). Only 9% use real time methods.

Freight-forwarding companies

The study found out that the status of goods is easily tracked to the seaports using a web-based platform provided by the shipping companies. However, once the freight has left the seaport, it becomes difficult to trace the goods. Out of 65% of forwarding companies that facilitate inland transport services, 32% replied they do not know where the goods are until they reach dry port or the destination point, while the remaining 68% replied that they use phone calls. Even when goods reach dry ports, there is no real-time tracing system. Only 59% replied that they use a web-based platform to trace goods at dry ports. The respondents complained that the web-based system provided by ESLES is slow and mostly out of service. So, they rarely use it. 40% responded that they use phone calls to check on the status of goods in dry port. 24% and 22% claimed that they go in person to ESLES and they use e-mail respectively. The responses also showed that scheduling and arrangements with transport companies is done over the phone or by contacting them in person. All respondents use a web-based platform when providing documents to the customs authority. However, documents, such as receipts and invoices, need to be provided in person for the port authority.

The railway and dry port company

The railway system uses up-to-date digital technologies when carrying out transport tasks. Trains are fully computerised and a direct web-based pc-to-pc link is used to track and trace these tasks. Radio networks are used to communicate with drivers at any time. A real-time method using computers in trains is used for routing and scheduling. POD takes place using a paper-based signature. E-mail and telephone calls to the depot are used to solve delivery errors.

From the visit and interview in dry ports, it was found out that internal communication in ports with crane operators, drivers, and gate controllers is carried out using a radio system in dry ports, while e-mail is used to communicate with transport companies, freight forwarders, and customs. Incoming and outgoing trucks are controlled using a computer-based method. The stacking of containers takes place manually, while their location is managed using radio frequency identification (RFID). Electronic data interchange (EDI) system is used to manage port documents.

3.3 The correlation between GPT and the practice of digital technologies

The correlation output is shown in Table 6 with a GPT score and digitalisation score being the independent and dependent variables respectively. A GPT score indicates the prevalence of GPT, while a digitalisation score indicates the level of digitalisation of activities in firms. The table indicates that there is a strong correlation between GPT prevalence and the use of digital technologies by road transport companies ($p < 0.001$), while this is weak in freight-forwarding companies ($p > 0.1$).

Table 6 Correlation between the GPT score and digitalisation score in road transport and freight-forwarding companies

Road transport companies	
Variable	*Coefficient (β)*
Digitalisation score	1.36*** (4.496)
Intercept	4.845* (2.155)
Freight-forwarding companies	
Variable	*Coefficient (β)*
Digitalisation score	0.226 (0.752)
Intercept	17.157*** (6.876)

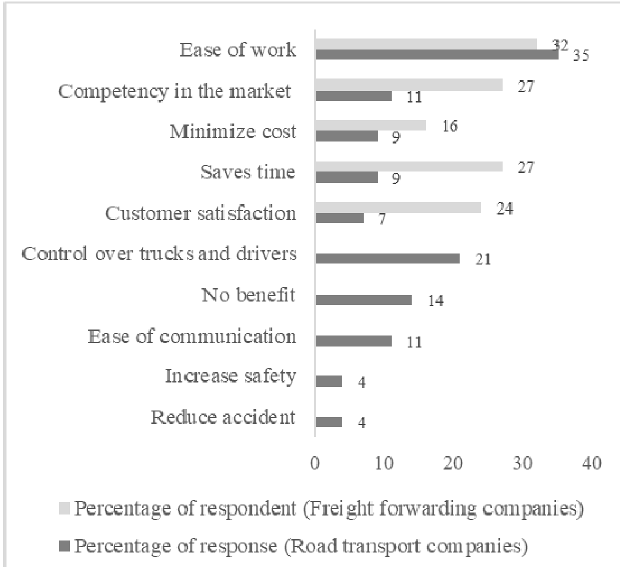
Note: t statistics in parenthesis; ***p ~0, **p < 0.001, *p < 0.01.

3.4 Benefits and barriers of adopting technologies in intermodal transport

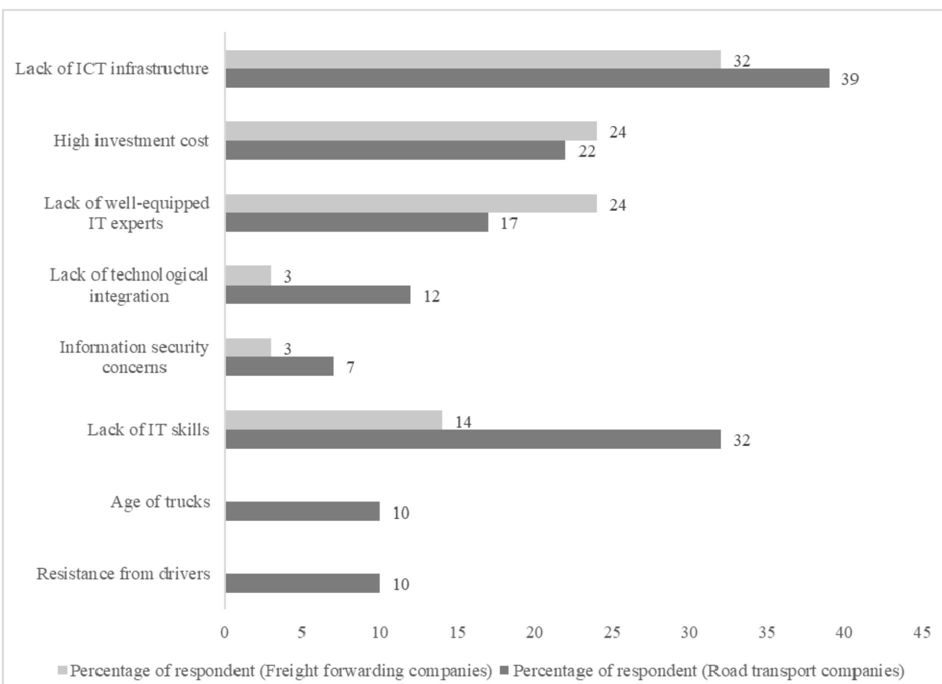
With respect to the main benefits, the highest percentage of respondents from both road transport and freight-forwarding companies, 35% and 32% respectively, stated that adopting digital technologies would ease their work. The next highest percentage of responses (27%) from freight forwarders was that technologies help them to stay competent in the market and they save time. In road transport companies, staying competent in the market received a low proportion of responses. The advantage of gaining control over trucks and drivers received the second highest response for road transport companies. Increasing safety and reducing accidents were advantages mentioned only by road transport companies, although by the lowest proportion of respondents [Figure 7(a)].

Despite the respondents' agreement on the various benefits ICT brings to their organisations, they gave the points indicated in Figures 7(b) as a constraint for the adoption of technologies. The overall picture is that of poor framework conditions in different dimensions, as expected for a developing country. The lack of ICT infrastructure in the country is considered to be the biggest barrier to adopting technology both in road transport and freight-forwarding companies. The high investment cost, lack of well-equipped IT experts, and lack of IT skills in companies are the major barriers pointed out by both road transport and freight-forwarding companies. On the other hand, information security concerns is the least mentioned barrier.

Figure 7 (a) Benefits and (b) barriers to adopting digital technologies in the respective road transport and freight-forwarding companies



(a)



(b)

Note: Some responses were relevant for road transport companies only and therefore there are no results from freight forwarding companies shown in the graph.

4 Discussion

4.1 The ubiquity of GPT and its implications

Access to electricity is one of the fundamental requirements for digitalisation since the use of other digital technologies is built upon it. In this regard, digitalisation in low-income countries could face a huge challenge because more than half of the population in low-income countries do not have access to electricity (The World Bank, 2019). Similarly, this study conducted in Ethiopia found that all the companies approached in this study face power outages, hence a high need for the use of generators. A substantial proportion of both road transport and freight-forwarding companies own generators (77% and 95% respectively), compared to 18% and 7% of firms in Vietnam and Brazil respectively (Cirera et al., 2021a, 2021b). This shows that the companies in IFT have the potential to push forward with digitalisation despite the setbacks of unstable electricity. However, the level III transport companies (owning old fleets) have the lowest percentage (44%) of backup electricity. This could be an indication that the companies are satisfied with the current way of operation and number of customers they have and are not inclined to incorporate modern technologies. In addition, current limitation of electric accessibility may restrict the use of digital technologies for clients and end users (including importers, exporters, and consumers).

Another important GPT taking a major role in digitalisation is the internet. All freight forwarding companies use internet for it is an integral part of their business, failure to use it could result in loss of competition in the market. However for transport companies basic services could be undertaken without using internet and therefore there is a lower percentage of the all companies (87%) having access to the internet. Nevertheless, internet plays a great role in enhancing transport service quality like for quick delivery, real time tracking of goods, providing updates on transport status to clients and the like. Therefore, internet is largely used in the transportation sector of developed economies [for example, 99% of transport companies in Sweden use internet (Statista, 2018)] and similarly over 90% of most developed economies have internet coverage (SCB Statistical Database, 2021; The World Bank, 2019). On the contrary, in sub-Saharan African countries, only 21% of the population has access to the internet. In the transport sector of Ethiopia, the significantly low percentage of level III (69%) companies using internet shows that the companies in this category prioritise the delivery of basic transport services. As a consequence, they have not seen internet connection as important enough for their competitive advantage to justify the added cost for it. More coverage of internet in transport companies would increase the quality of transport service and integration with freight forwarding companies for a seamless transverse intermodal transport systems.

Despite the widespread use of cell phones, the results show that smartphones are not widely used in either road transport or freight forwarding companies. The contrast in smartphone ownership is also underscored between advanced and emerging economies, with 76% and 45% of population owning smartphones in advanced and emerging economies respectively (Pew Research Center, 2019). However, the use of smartphones is an integral part of digitalisation particularly in intermodal transport they have various applications that foster seamless communication among stakeholders. Information could be provided at the fingertips of actors in the transport chains whilst swift document sharing can be achieved via different applications. Likewise, websites are powerful GPT used in digitalising customer services, conducting business activities and disseminating information within companies. Most businesses in developed economies provide web services or home pages (OECD, 2022). However, websites are the least implemented tools in both road transport and freight forwarding companies in this study. A possible reason for this could be the limited usage of the internet among their customers. Another reason is the lack of IT expertise required to develop and maintain effective web services. Similarly, this could also be attributed to the low use of enterprise and industry-specific software in the companies surveyed. ERP and customer relationship management (CRM) are increasingly applied business software (OECD, 2020) that increase efficient organisation management and customer relationships. This software are used in companies that involved in IFT including dry port authority, rail way company and a few freight forwarding companies in Ethiopia. Nevertheless, even more software utilisation is required to modernise the system.

The survey results show that industry 4.0 technologies have been implemented in a limited proportion of IFT companies in Ethiopia. These technologies are not widely prevalent on a global scale as well. Technologically advanced countries as Sweden have implementation of 75% cloud computing, 19% big data analysis, 40% IoT and 10% AI in their businesses (OECD, 2022). The reason for the low implementation of the technologies in Ethiopia could be the low realisation of Industry 3.0 within the sector. Limitations in awareness of the technologies, capital constraints and lack of IT expertise may also contribute to this.

Comparing the prevalence of GPT in low-income countries with the results in this study reveals that there is less resistance from the service provider's side in moving towards digitalisation. However, there is huge work that needs to be done in reaching out to the final consumers. Providing the required GPT in low-income countries is crucial in this regard for a seamless end-to-end flow of information and goods to be ensured.

4.2 Level of digitalisation in the intermodal transport system

The current business approach employed to reach customers and the payment method heavily relies on traditional practices. Considerable time is consumed by adhering to conventional face-to-face meetings with customers. Furthermore, this limits the opportunity to reach new customers and so restricts the expansion of the companies' customer base. The restricted access to internet and provision of web-based services discussed in the previous results are linked to the continued usage of outdated systems in the sector. Another pressing concern demanding significant attention is governing cash and check payment systems practiced by the companies. Cashless transaction needs be implemented nationwide to enable more efficient, convenient and speedy transactions (Rahman et al., 2022).

One aspect of digitalisation in freight transport is its implementation in tracking and tracing. The results indicate that getting freight information while using road transport is challenging. Most road transport companies use phone calls and paper-based methods as a source of information during transport. Freight forwarders responded that they could easily track their goods at the seaport online. In dry ports as well, an online platform provides information about arrival and departure of containers. However, between these points, users are unable to track their goods. In addition, freight forwarders and transport companies use phone calls, e-mail, and in-person checking to get information from dry ports because the online system is frequently down even if it exists. This information discontinuity has significantly reduced the traceability of goods in the transport system. From a global perspective, tracking and tracing is an ongoing development in IFT. Providing real-time freight information to all stakeholders is a challenge requiring innovative solutions worldwide (Dürr and Giannopoulos, 2003; Di Fazio et al., 2016). Providing a platform that integrates the information from all the stakeholders will result in a more visible IFT system.

There is a promising trend of installing GPS in trucks, especially in level I road transport companies, which could enable further digitalisation. However, tasks such as routing and scheduling, POD, and management of delivery errors, are still largely carried out manually in these companies. Current global trends indicate that transport activities are becoming more digitalised. Real-time routing and scheduling is practiced in developed countries, such as the UK and Spain (Davies et al., 2007; Fernández Vázquez-Noguerol et al., 2018; Fancello et al., 2020). Various software are widely used for real-time routing and scheduling, and other fleet management tasks (Campbell and Savelsbergh, 2004). Integrating these practices in the road transport companies would enable a faster and more efficient transport system. It was also indicated in the previous section that the companies in this study use software to limited extent and that availability of skilled ICT expert could be a potential challenge for full-scale installation of software for integrated tracking solutions. The level III (old fleet) transport companies may find it difficult to modernise their system in the same pace as the levels I and II companies because they are small-scale companies. A possible mitigation for this could involve segmenting the market so that the levels II and III transport companies compete but work in collaboration with the level III. Allocating district service zones for different categories is one approach of achieving this. In contrast, the railway transport companies adopt up-to-date technologies to run their operations.

A strong correlation is observed between the prevalence of GPT (GPT score) and the level of digitalisation (digitalisation score) in road transport companies. This indicates that there is potential for road transport companies to advance their service just by incorporating more GPT, such as internet, web-based services and software, which are currently available to a limited extent. However, the loose correlation for the scores in freight-forwarding companies shows that these companies are not advancing their service even if the GPT are available. One reason for this is that, as mentioned in some of the interviews, they completely rely on government bodies [such as ESLSE, the Ethiopian Minister of Transport (EMT) and the Ethiopian Maritime Authority (EMA)] for their decisions regarding modernising their service. The intermodal shipping is facilitated by ESLSE, who also owns and runs the dry ports. Policies and guidance are formulated by the EMT and EMA, having a significant influence on freight forwarders' operations. Therefore, no matter how much they adopt the GPT mentioned in this study, in the end they will be limited to using the methods and tools available by these bodies, for example regarding operations in port operations, for following the status of containers, concerning the functionality of currently available web services. Establishment of a collaborative partnership between private and public entities could enable the development of a more contemporary transportation system, where more of the potential of digitalised technologies is realised.

4.3 Benefits and barriers of adopting digital technologies in intermodal transport

The most expected benefit of digital technologies for both road transport and freight forwarding companies is the enhanced ease of work. However, competency in the market is mainly seen as beneficial for freight forwarding companies. This indicates that road transport companies already have a secured market irrespective of modernising their service while it is not the situation for freight forwarding companies. This explains why the freight forwarders adopt more GPT technologies than the road transport companies as depicted in the result. In addition, 14% of respondents from road transport companies responded there is no benefit in adopting technologies whilst none from freight forwarders provide this response. This is also an indication that more resistance to future technology adoption could be expected from road transport companies. The driving force for technology adoption for these companies is more inclined to be the improvement of service quality. Increased control of the drivers is the second most voted benefit for the road transport companies would expect. At the same time, resistance from drivers is a challenge they expect, and this paradox shows a conflict of interests between the parties. A successful implementation, would have to take this conflict and the possibility to reach common ground into account in the planning process.

5 Conclusions

This study assessed the extent of digital technology adoption in IFT in Ethiopia. The stakeholders involved in IFT, including road transport companies, freight-forwarding companies, railway, and dry port companies, were surveyed. Sufficient prevalence of GPT, except for industry 4.0 related technologies, was found in all companies that participated in the survey. The low level of implementation of digital technology adoption found in the study indicates that there is significant potential for improving the efficiency of information management and, as a consequence, the overall efficiency of the studied intermodal transport systems. Significant differences in the level of internet access, use of software and web-based services were found among transport companies and between transport and freight-forwarding companies. In this regard, the road transport companies have not yet seen a competitive advantage to drive their technology adoption forward. A correlation analysis suggests that there is more room to increase digitalisation in road transport companies by introducing more GPT. The technologies and methods used in general business and tasks specific to each company were also identified. Face-to-face communication with customers was common for all the companies. The level of technological understanding by customers is one reason for the widespread use of face-to-face interaction. On the other hand, the companies do not provide web-based, user-friendly means of communication. The online banking system in the country is still underdeveloped and limits the companies to using mostly paper-based services (checks) for economic transactions.

Despite the fact that Ethiopia is not a technologically advanced country, the state of transport companies indicates promising progress in technology adoption. The Djibouti railway, in particular, utilises the latest digital technologies to perform tasks, including fleet management, communication within the organisation, tracking and tracing, routing and scheduling. However, the road transport sector is observed to lag in this regard. It was found that there is a strong variation in technologies among the levels of transport companies regarding tracking and tracing, communication with drivers, and routing and scheduling. To create a seamless transport chain, a systematic implementation of technologies in road transport needs to be considered. This includes tracking and tracing services and real-time communication with drivers and customers. The Level III (old fleet) transport companies may find it difficult to modernise their system at the same pace as the Level I and II companies because they are small-scale companies. Paperwork for quality control activities, such as POD, is still prevalent in both road and railway transport companies, while dry ports have started to reduce this using computerised gate control systems.

Even though the respondents agree on the benefits that ICT brings to their organisations, they mentioned constraints in framework conditions for its adoption. A lack of IT infrastructure and expertise, economic constraints but also the reluctance to change of drivers and truck owners were the main challenges discussed. This reveals a need for investment in human resources, encompassing awareness creation and IT skills training, in parallel to the investments in the actual technologies. Specific measures to improve these framework conditions are thus needed to increase the adoption rates of ICT in intermodal transport. Future work required to further underpin these strategies includes extending the scope of the survey to take into account more underlying factors (external and internal company) for technology adoption and monitoring the adoption over time in response to both autonomous technology developments and specific policy measures to increase the adoption of technologies.

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Appendix A

Questionnaires presented to stakeholders

Questionnaire distributed to transport companies

Part 1 General information

1 What is the name of the organisation?

2 What is your position in the organisation?

☐Senior management ☐Management ☐Operation

☐ Other (please specify)

3 How many employees does the company have?

☐ 1-–49 ☐ 50–249 ☐ 250+

4 How many years ago was the company established?

☐ 1–5 ☐ 6–10 ☐ 10–20 ☐ 20+

5 What type of vehicles do you own?

☐ General haulage ☐ Temperature controlled

☐ Bulk tippers ☐ Tankers

☐ Other (please specify)

6 How many vehicles do you own for each type of vehicle in question no. 5?

7 Do you have GPS-installed vehicles?

☐ Yes ☐ No

8 If yes, how many vehicles are installed with GPS?

Part 2 Adoption of general-purpose technologies

Industry 2.0

1 Does the organisation have electricity?

☐Yes ☐No

2 Do you encounter any power outages in the organisation?

☐ Yes ☐No

3 Does the organisation use a generator?

☐ Yes ☐No

4 If yes, what energy source do you use?

☐ Solar power ☐ Fuel ☐ Wind power

5 Do you use an uninterruptable power supply (UPS)?

☐ Yes ☐No

Industry 3.0

6 Does the company own a telephone?

☐ Yes ☐No

7 If yes, how many?

☐ 0–5 ☐ 5–10 ☐ 10–20 ☐ 20+

8 Does the company own a cell phone?

☐ Yes ☐ No

9 If yes, how many?

☐ 0–5 ☐ 5–10 ☐ 10–20 ☐ 20+

10 Does the company own a smartphone?

☐ Yes ☐ No

11 If yes, how many?

☐ 0–5 ☐ 5–10 ☐ 10–20 ☐ 20+

12 Does the company own a computer?

☐ Yes ☐ No

13 If yes, how many?

☐ 0–5 ☐ 5–10 ☐ 10–20 ☐ 20+

14 Does your company have internet access?

☐ Yes ☐ No

15 If yes, what type of internet?

☐ Dialup ☐ Wireless ☐ Broadband ☐ Fibre

☐ Other (please specify)

16 Does the company use enterprise software?

☐ Yes ☐ No

17 If yes, what type of software do you use?

☐ Government mandated software

☐ Purchased Software

☐ Software developed specifically for the company

18 Briefly explain the name and purpose of the software you use.

Industry 4.0

19 Which one of the following digital technologies does the company use?

☐ Cloud computing ☐ Big data ☐ Artificial intelligence (AI)

☐ Robot ☐ Internet of things (IoT) ☐ Other (please specify)

Part 3 Level of digitalisation

A General business activities

1 How do you communicate with customers who want to do business with you?

☐ Face-to-face meeting ☐ Using social media or an app

☐ Direct communication by phone ☐ Online using external digital platform

☐ Direct communication by email ☐ Online using your own website

☐ Other (please specify)

2 What payment methods do you use?

☐ Cash ☐ Check ☐ Online bank

☐ Debit/credit card ☐ Bank transfer ☐ Online platform

☐ Other (please specify)

B Sector-specific activities

1 What do you use for your track and trace system?

☐ Paper-based ☐ Direct PC-to-PC link – web-based

☐ Call center

☐ Direct PC-to-PC link – not web-based ☐ Other (please specify)

2 How do you communicate with drivers?

☐ Cell phones – voice ☐ Satellite systems

☐ Cell phones – short text (SMS) ☐ Radio network

☐ Cell phones – e-mail (GPRS; 2G or 3G) ☐ Other (please specify)

3 What are the company proof of delivery (POD) systems?

☐ Paper-based signature ☐ Electronic signature (real time)

☐Electronic signature (batch process) ☐ Other (please specify)

4 What are the company's systems for managing delivery errors?

☐ Paper-based methods ☐ Digital imaging

☐ Driver debriefing back at depot ☐ Electronic recording

☐ Telephone calls to depot

☐ Other (please specify)

5 What are the company's routing and scheduling systems?

☐ Manual planning ☐ Computerised system (depot based)

☐ Manual planning with cell phone ☐ Real-time methods: manual communication – GSM

☐ The drivers decide ☐ Real-time methods: electronic information- in-cab computer

☐ Other (please specify)

6 How long on average will it take you to avail trucks after receiving an order (in hours)?

7 Do you provide web-based services?

☐ Yes ☐ No

8 Are you likely to adopt advanced digital technologies in the coming years?

☐ Yes ☐ No

9 If yes, in approximately how many years?

☐ 1-2 ☐ 3-5 ☐ 6-8 ☐ 8-10 ☐ 10+

10 What are the benefits you gain from adopting digital technologies?

11 What are the main obstacles that prevent you from adopting technologies in your organisation?

2 Questionnaire distributed to freight forwarders

Part 1 General information

1 What is the name of the organisation?

2 What is your position in the organisation?

☐Senior management ☐Management ☐Operation

☐ Other (please specify)

3 How many employees does the company have?

☐ 1-49 ☐ 50-249 ☐ 250+

4 For how many years has your company been in operation?

☐ 1-5 ☐ 6-10 ☐ 10-20 ☐ 20+

5 What types of vehicle do you own?

☐ General haulage ☐Temperature controlled

☐ Bulk tippers ☐ Tankers

☐ Other (please specify)

6 How many vehicles do you own for each type of vehicle in question no. 5?

7 Do you have GPS-installed vehicles?

☐ Yes ☐ No

8 If yes, how many vehicles are installed with GPS?

Part 2 Adoption of general-purpose technologies – similar to part II of questionnaire for transport companies

Part 3 Level of digitalisation

A General business activities – similar to part III, A of questionnaire to transport companies

B Sector-specific activities

1 How do you get information about the status of cargo before and at seaports?

☐ Phone call ☐ E-mail ☐ Web-based platform

☐ Other (please specify)

2 How do you get information about the status of cargo while in dry ports?

☐ Phone call ☐ E-mail ☐ Web-based platform

☐ Other (please specify)

3 How do you get information about the status of cargo during inland transportation?

☐ Phone call ☐ E-mail ☐ Web-based platform

☐ Other (please specify)

4 How do you provide documents to the seaport authority?

☐ In person ☐ EDI or other electronic means ☐ Web-based platform

☐ Other (please specify)

4 How do you provide documents to the dry port authority?

☐ In person ☐ EDI or other electronic means ☐ Web-based platform

☐ Other (please specify)

5 How do you provide documents to the customs commission?

☐ In person ☐ EDI or other electronic means ☐ Web-based platform

☐ Other (please specify)

6 How long, on average, does it take you to analyse requests from port/customs and provide appropriate response/data to ports (in hours)?

7 How do you communicate and schedule with transport companies?

☐ Phone call ☐ E-mail ☐ Web-based platform

☐ Other (please specify)

8 How long, on average, does it take you to find an appropriate transport company and finalise a deal with them (in hours)?

9 Do you provide a web-based service?

☐ Yes ☐ No

10 Are you likely to adopt advanced digital technologies in the coming years?

☐ Yes ☐ No

11 If yes, in approximately how many years?

☐ 1-2 ☐ 3-5 ☐ 6-8 ☐ 8-10 ☐ 10+

12 What are the benefits you gain from adopting digital technologies?

13 What are the main challenges that prevent you from adopting technologies in your organisation?

Questionnaire distributed to dry port authority

Part 1 General information – similar to part I of questionnaire to transport companies

Part 2 Adoption of general-purpose technologies – similar to part II of questionnaire to transport companies

Part 3 Level of digitalisation

A General business activities - similar to part III, A of questionnaire to transport companies

B Sector-specific activities

1 How do you communicate with seaports?

☐ Radio ☐ Phone calls ☐ Computer based

☐ Other (please specify)

2 How do you communicate with shippers/freight forwarders/transitors about the status of containers?

☐ Phone calls ☐ E-mail ☐ Web-based platform

☐ Other (please specify)

3 How do you communicate with truck and rail companies accessing the port to load or unload goods?

☐ Phone calls ☐ E-mail ☐ Web-based platform

☐ Other (please specify)

4 How do you communicate with governmental authorities (including customs)?

☐ Phone calls ☐ Single window

☐ Other (please specify)

5 How do you control port incoming/outgoing gate?

☐ Paper-based control ☐ Electronic tags/automatic control

☐ Computer-based control ☐ CCTV cameras

☐ Other (please specify)

4 How do you communicate internally with crane operators and vehicle drivers within the port?

☐Radio ☐DGPS ☐Dead reckoning/laser radar ☐RFID

☐ Other (please specify)

5 How is the stacking of containers carried out?

☐Manually ☐Software

☐ Other (please specify)

6 How do you locate cargo in ports?

☐ Manually using paper ☐ RFID ☐ GPS

☐ Other (please specify)

7 How do you manage documents?

☐ Paper based ☐ Electronically [electronic data interchange (EDI)] ☐ Software

8 How is customs inspection carried out?

☐ Manually ☐ Use of x-rays ☐ Use of cameras ☐ RFID

☐ Other (please specify)

9 What types of truck are used within the dry port?

10 What type of cranes and equipment are used within the dry port?

11 Do you provide a web-based service?

☐ Yes ☐ No

12 Are you likely to adopt advanced digital technologies in the coming years?

☐ Yes ☐ No

13 If yes, in approximately how many years?

☐ 1-2 ☐ 3-5 ☐ 6-8 ☐ 8-10 ☐ 10+

14 What are the benefits you gain from adopting digital technologies?

15 What are the main challenges that prevent you from adopting technologies in your organisation?

Appendix B

Numerical codes used for scoring

1 GPT score

Table A1 Coding of responses used to calculate GPT score

GPT	*Value*	
	Yes	*No*
Access to electricity	1	0
Own a generator	1	0
Own a telephone	1	0
Own a cell phone	1	0
Own a smartphone	1	0
Own a computer	1	0
Have an internet connection	1	0
Use software	1	0
Provide a web-based service	1	0
Industry 4.0 technologies	1	0
GPT score	Sum	
Maximum total	10	

2 Level of digitalisation score – transport companies

Table A2 Coding of responses used to calculate level of digitalisation score for transport companies

Variables	*Value*					
Communication with customers	Face to face	Phone	Email	Social media	Online external platform	Online internal platform
	1	2	3	4	5	6
Payment method	Cash	Check	Bank transfer	Online banking		
	1	2	3	4		
Track and trace	No service	Paper based	Call center	Direct PC-to-PC,_not web-based	Direct PC-to-PC,_web-based	
	0	1	2	3	4	
Communication with drivers	Cell phone -voice	Cell phone -text	Email	Social media	Radio network	Satellite system
	1	2	3	4	5	6
Proof of delivery	Paper-based signature	Electronic signature by batch	Electronic signature real time			
	1	2	3			
Managing delivery error	Paper-based method	Driver debriefing back to depot	Telephone calls to depot	Digital imaging	Electronic recording	
	1	2	3	4	5	
Routing and scheduling	Manual planning with paper	The drivers decide	Manual planning with cell phone	Depot-based computerised system	Real-time method: manual communication	Real-time method: information in cab computer
	1	2	3	4	5	6

3 Level of digitalisation score – freight-forwarding companies

Table A3 Coding of responses used to calculate level of digitalisation score for freight-forwarding companies

Variables	*Value*					
Communication with customers	Face to face	Phone	Email	Social media	Online – external platform	Online – internal platform
	1	2	3	4	5	6
Payment method	Cash	Check	Bank transfer	Online banking		
	1	2	3	4		
Information in seaport	Phone call	Email	Web-based platform			
	1	2	3			
Information in dry port	In person	Phone call	Email	Web-based platform		
	1	2	3	4		
Information while in inland transport	No service	Phone call				
	0	1				
Document to seaport authority	In person	DHL	Web-based	Electronic		
	1	2	3	4		
Document to dry port authority	In person	DHL	Web-based	Electronic		
	1	2	3	4		
Document to customs	In person	DHL	Web-based	Electronic		
	1	2	3	4		
Communication with transport companies	In person	Phone calls				
	1	2				