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ORIGINAL ARTICLE

Examining port selection factors in Sub-Saharan Africa using the modified importance-performance analysis

Hokey Min[1] · Byung-In Park[2]

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Abstract

As a growing volume of international shipments are carried by ocean carriers and handled by ports worldwide, ports have been at the heart of international trade and serve as a key **node** in global supply chain activities. Since many competing ports worldwide vie to be the first choice for shippers' global supply chains, they offer various maritime logistics services and pricing options. As such, selecting the right seaport has become an arduous task. In this regard, Sub-Saharan seaport selection is no exception. Considering a lack of attention paid to the rapidly developing African ports that can be an accelerator for business opportunities in the emerging Sub-Saharan African market, this paper investigates how African shippers select ports and examines to see if there is any significant difference in African shippers' port selection behavior due to their varying priorities among different countries. We use the Partial Least Squares Structural Equation modeling (PLS-SEM) and Importance-Performance Analysis (IPMA), for an empirical analysis of shippers in Uganda and Nigeria. We find many cross-national differences between the two countries in their port selection strategies. In particular, we discover that African shippers' geographical proximity to the coastal area influences their port selection decision. Also, our importance-performance map analysis (IPMA) revealed that African shippers consider cargo safety, port security, and port service quality the most crucial factors in their port selection. On the other hand, we found that Chinese shippers using the African ports valued port connectivity via multi-modal transfer links more than their African counterparts. In other words, domestic African shippers tended to have different priorities in selecting African ports from foreign Chinese shippers.

Keywords Port selection factors · Global maritime logistics · Sub-Saharan Africa · Structural equation model · Importance-performance map analysis

✉ Hokey Min
hmin@bgsu.edu

[1] Department of Management, Allen and Carol Schmidthorst College of Business, Bowling Green State University, Bowling Green, OH 43403, USA

[2] Department of Logistics and Transportation, Chonnam National University, Yeosu, Korea

1 Introduction

The growing tension between the Western world (especially U.S., Canada, and the European Union) and China, coupled with the ongoing war between Russia and Ukraine, have obliged many countries to reconfigure their trade routes and the subsequent maritime logistics operations. The reconfiguration often starts with changes in port-to-port connections. Since these reshape shipping routes (or lanes) and the subsequent liner service network, they profoundly impact maritime logistics. To improve the efficiency of port-to-port links, importers and exporters need to carefully choose their origin and destination ports. Although port selection is one of the most widely studied subjects of maritime logistics, the existing literature has mostly focused on the selection of seaports in traditional shipping routes linking the west-to-east hemisphere or north-to-south hemisphere, excluding the Sub-Saharan African continent (Murphy et al. 1992; Lirn et al. 2004; Tongzon 2009; Sanchez et al. 2011; Lirn et al. 2015; Gohomene et al. 2016; Lagoudis et al. 2017; Somensi et al. 2017; Luo et al. 2022). Though often overlooked, Sub-Saharan Africa is one of the fastest-growing regions in terms of population and economic growth. According to United Nations world population projections, more than half of the people added to world population over the rest of this century will be in Sub-Saharan Africa due to that region's high fertility rate (Population Matters 2023). Sub-Saharan Africa's population has been growing at approximately 2.7% a year for the last decade, which is more than double of South Asia (1.2%) and Latin America (0.9%) (Economist 2020). Parallel with its booming population growth, Sub-Saharan Africa has enjoyed constant growth in gross domestic product (GDP) since 1994, except for the year 2020 in the midst of the pandemic, and its latest GDP growth rate in 2021 registered 4.15%, with a 6.14% increase from 2020 (Macrotrends 2023). These trends will propel more economic development, foreign direct investment, and the subsequent increase in international trade with the Sub-Saharan Africa region. As global trade expands, more goods will flow into and out of the region's ports. In other words, ports in this region can play a key role in boosting its economic prosperity for years to come.

Although ports have become a key engine for Sub-Saharan Africa's economic development, this region still suffers from the antiquated logistics infrastructure, including port facilities built during the colonial era. Thus, logistics service providers are often riddled with various unique challenges. These include chronic port congestion, bureaucratic customs, inadequate land infrastructure, port security, debt vulnerability with a lack of liquidity, complicated feeder networks in a regional hub-and-spoke system, and potential labor issues emanating from the slow recovery from the COVID-19 pandemic. Due to these unique challenges, traditional port selection factors such as port location, port charges, berth availability, and port services may not necessarily influence shippers' or carriers' port selection decisions as much as in other continents. Therefore, there is a growing need for conducting research investigating port selection factors unique to Sub-Saharan Africa, at the same time assessing the extent of their impacts on port competitiveness.

With this in mind, this paper aims to identify critical influencing factors for port selection in the Sub-Saharan African region based on an empirical analysis of actual data collected from shippers in Nigeria and Uganda, representing the economic powerhouses of Sub-Saharan Africa. To elaborate, the main objectives of this paper are to investigate the role of these factors in improving port competitiveness, using the Partial Least Square (PLS)-Structural Equation Model (SEM), and identify those factors that significantly impact port performance, using the Importance-Performance Map Analysis (IPMA). Predicated on these empirical analyses, the paper proposes a port development strategy that will be a helpful guide for port administrators in Sub-Saharan Africa. This paper is one of the first to examine domestic and foreign (e.g., Chinese) shippers' port selection behaviors in Nigeria and Uganda.

2 Prior literature

For the last several decades, port selection/evaluation and its related subjects, such as port competitiveness, have been the most researched area in the maritime logistics literature (Slack 1985; Murphy et al. 1992; Nir et al. 2003; Tiwari et al. 2003; Lirn et al. 2004; Tongzon 2009; Caillaux et al. 2011; Sanchez et al. 2011; Lirn et al. 2015; Gohomene et al. 2016; Lagoudis et al. 2017; Somensi et al. 2017; Min and Park 2020; Feo and Martinez 2022; Luo et al. 2022). Despite the abundant literature on port selection, past studies rarely examined the port selection issues more relevant and unique to the Sub-Saharan African setting. They focused on the emerging market potentials of major Sub-Saharan African ports (e.g., ports of Lagos in Nigeria, Mombasa in Kenya, and Dar es Salaam in Tanzania), including part of China's ambitious One Belt One Road project.

Despite a plethora of prior studies dealing with port selection issues, prior literature has only shed light on the relative importance of various factors influencing port selection decisions from a specific stakeholder's standpoint. Herein, a specific stakeholder refers to a carrier, a shipper, or a forwarder who may have different vested interests in selecting a particular port. For instance, carriers may be more interested in shipping lanes, berth availability, and a port's prompt response to port service calls than the others. In contrast, shippers (or forwarders) may be more interested in intermodal links, port safety/security, and port pricing affecting their profitability than others (Park and Jung 2018). Since these varying levels of interest among different stakeholders may complicate the port selection decision and consequently change the dynamics of port selection factors, this issue is worthy of another scientific inquiry from a diverse stakeholder's viewpoint.

In fact, some pioneering research focusing on port selection issues from shippers' or forwarders' perspective were conducted in the past. One of the first of those studies include Slack (1985), who investigated the relative importance of port selection criteria in North America and Western Europe from forwarders' and exports' perspectives. His study discovered that port pricing and service considerations of surface transportation and ocean carriers were more important in port selection than port infrastructure from shippers' viewpoint. Murphy et al. (1992) analyzed the international seaport selection factors from multiple dimensions (e.g., carriers vs.

shippers, just-in-time (JIT) users vs. non-JIT users). Their empirical analyses indicated that port equipment availability, freight information, the frequency of freight damage and loss, and cargohandling costs were perceived to be most important in port selection by shippers. Their studies were of the first attempts to examine the differences in port selection criteria from a different role of port stakeholders. Ugboma et al. (2006) employed the analytical hierarchy process (AHP) to analyze the relative importance of port selection factors in Nigeria from a forwarder's perspective. Based on a shippers' survey, they found that shippers tended to emphasize port efficiency, the frequency of ship visits, adequate port infrastructure, and port location, while a quick response to port users' needs was insignificant to them. De Langen (2007) conducted an e-mailing survey of Austrian shippers and forwarders to check for differences in port selection decisions between them. He found that shippers and forwarders had similar views on port selection in contestable hinterlands, but shippers had lower price elasticity of demand for port services than forwarders. His study result, however, was first based on a small sample (less than 20) of shippers and forwarders. Going further, Yuen et al. (2012) analyzed the relative importance of factors determining container port competitiveness from three groups of port users (shipping lines, forwarders, and shippers), primarily in China. They evaluated the relative importance of port competitiveness factors based on interviews and surveys of industry experts and the analytic hierarchy process (AHP). They discovered that port costs are considered the most important factor in port competitiveness for shipping lines, while both forwarders and shippers considered port location as the most important factor.

Min and Park (2020) recently proposed a Kano model, first introduced in Kano (1984), to identify multidimensional, non-linear port selection attributes, including intermodal network accessibility and service route diversity. To test the model, they collected data from a survey of port users and port service providers (port authorities) from three major hub ports in Korea, serving the Asia–Pacific region. They found marked differences in the perceived importance of port selection factors between port users and port service providers. Their findings confirmed the gaps between the service expectations of port users and the actual performance of port service providers. Similarly, Feo and Martinez (2022) compared shippers' and freight forwarders' port choice criteria to identify significant differences between these port users in Spain. Their analysis of a mixed logit model revealed that shippers and freight forwarders differ only in the valuation of the cost attribute, with the latter being more cost-sensitive.

Without recognizing differences in port selection priorities among port users or port service providers, many studies focused mainly on the shippers' perspective. These include Nir et al. (2003), Tiwari et al. (2003), Veldman and Bukmann (2003), Yeo et al. (2008), Onut et al.(2010), Yeo et al. (2011), Caillaux et al. (2011), Steven and Corsi (2012), Castillo-Manzano et al. (2013), Ng et al. (2013), and Onwuegbuchunam (2013). Key influencing factors impacting port selection decisions identified by these studies are summarized in Table 1.

As this literature review reveals, most prior studies on port selection seldom looked into foreign shippers' perspectives in choosing their exporting and importing ports in less-developed countries such as Sub-Saharan nations. Furthermore, most

Table 1 Key port selection factors identified by the selected prior literature

Key influencing Factors		①	②	③	④	⑤	⑥	⑦	⑧	⑨	⑩	⑪	⑫	⑬	⑭	⑮	⑯	⑰
Port setting	Port distance (PL1)				●				●	●				●	●	●		
	Transit time (PL2)			●		●		●		●	●	●	●					
	Inland shipping cost (PL3)	●		●		●			●	●	●		●		●			
	Geographical location (PL4)	●					●	●		●			●	●				
Port effectiveness	Demurrage charge (PE1)	●			●				●			●						
	Cargo damage (PE2)		●				●	●		●			●					
	Quick customer response (PE3)		●				●		●									
	Service quality (PE4)					●		●	●				●					
	Customs process (PE5)	●											●					
	Port safety and security (PE6)	●								●			●					
Port connectivity	A frequency of ship visits (PC1)	●		●	●	●	●	●		●		●	●			●		●
	Multimodal transfer (PC2)	●				●	●		●	●				●				
	Service frequency (PC3)			●	●								●					
Port cost	Port charge (PCS1)	●								●	●		●		●		●	
	Freight rate (PCS2)		●								●	●	●				●	●
Port facility	Port infrastructure (PF1)	●	●		●		●	●	●	●		●	●			●	●	
	Port size (PF2)	●			●							●	●	●			●	

① Slack (1985), ② Murphy et al. (1992), ③ Nir et al. (2003), ④ Tiwari et al. (2003), ⑤ Veldman and Bukmann (2003), ⑥ Ugboma et al. (2006), ⑦ De Langen (2007), ⑧Yeo et al. (2008, 2011), ⑨ Onut et al. (2010), ⑩ Caillaux et al. (2011), ⑪ Steven and Corsi (2012), ⑫ Yuen et al. (2012), ⑬ Castillo-Manzano et al. (2013), ⑭ Ng et al. (2013), ⑮ Onwuegbuchunam (2013), ⑯ Min and Park (2020), ⑰ Feo and Martinez (2022)

past literature rarely presented a data visualization tool that can graphically capture the relative importance of port selection factors/attributes and thus help port policymakers formulate effective port development or port marketing strategies. To fill these research gaps, this paper examines how foreign port users make their importing and exporting port selection decisions in Sub-Saharan Africa. Then, we analyze the relative importance of port selection factors using the Importance-Performance Map Analysis (IPMA) as a visual aid. The paper also explains how port policymakers can prioritize and leverage some key port attributes for luring port users as competitive differentiators.

3 Research methodology

We use a quantitative research design, analyzing cross-sectional data collected from surveys of shippers (both domestic and foreign), using the two major hub ports in Sub-Saharan Africa: Lagos, Nigeria, and Kampala, Uganda. Through the survey, we compiled a stratified random sample of 334 observations. We used multiple means (e-mail, telephone, in-person interviews) to increase responses and sample sizes to conduct surveys in different countries (Uganda, Nigeria). We started collecting data from those countries on January 10, 2022 and ended data collection on March 14, 2022. noted that a sample exceeding 200 valid responses is large enough for analysis in structural equation modeling. As summarized in Table 2, more than one-third (36%) of the responding firms belonged to the primary sector (agriculture, forest, fishery). In comparison, one-third (33.1%) of them belonged to the tertiary sector (e.g., logistics, wholesale trade, retail trade, tourism), and a little less than one-third (30.9%) belonged to the secondary sector (e.g., manufacturing, construction). Thus, various industry sectors are equally represented in this sample. More than half (54.8%) of the respondents have at least 5 years of experience in their current positions.

Due to the challenges of conducting surveys in three countries, we hired the marketing research firms: (1) Collyer Logistics North China Limited (Xiamen Branch, China), (2) Tbabca Global Maritime and Logistics Consulting (Apapa and Lagos, Nigeria), and (3) Day Break Innovations (Kampala, Uganda). For the representation of foreign shippers using the Ports of Lagos and Kampala, we primarily targeted Chinese shippers since China is one of the largest players doing business with many Sub-Saharan African firms and the included Sub-Saharan African ports are important parts of their worldwide One Belt and One Road program. We also targeted domestic shippers using the ports of Lagos and Kampala since Lagos happens to be one of the biggest hub ports in Sub-Saharan Africa, and Kampala is a crucial connecting port linking other major ports such as Mombasa, Kenya, and Dar es Salaam, Tanzania, through road corridors in Sub-Saharan Africa.

3.1 Questionnaire and conceptual model development

Questionnaire items were developed based on the port selection criteria proposed by Martinez and Feo (2016), as well as other factors potentially affecting the port selection decisions listed in Table 1. Since some shippers may consider certain port selection factors while others may not, we employed a *stated preference* method for conducting surveys. The method is a family of survey techniques used to examine respondents' statements about their preferences in choice processes, including port choices (Kroes & Sheldon 1988). All measures of the constructs we used for model experiments were primarily adopted from previous studies, summarized in Table 1. These constructs include port setting, port effectiveness, port connectivity, port cost, and port facility. These constructs were included in a number of prior studies (Slack 1985; Murphy et al. 1992; Tiwari et al. 2003; Veldman and Bukmann 2003; Ugboma et al. 2006; De Langen 2007; Onut et al. 2010; Yuen et al. 2012; Castillo-Manzano et al. 2013; Onwuegbuchunam 2013; Ng et al. 2013; Park and Jung 2018), considered as import port selection criteria. The constructs were measured using a 7-point Linkert scale (1-'strongly disagree' to 7-'strongly agree'). In particular, we adopted partial least squares-structural equation modeling (PLS-SEM) using SmartPLS 4.0 software to analyze the data obtained from the survey. PLS-SEM was built upon the conceptual research model depicted in Fig. 1.

3.2 Analysis of PLS-SEM results

To identify factors influencing port selection significantly, we employed a formative SEM model to avoid the preconceived pattern of intercorrelations among indicators (Simonetto 2012; Hanafiah 2020). Since some port selection factors may be

Table 2 A summary of survey respondents' profiles

Nation	Sample size	Respondents' profiles								Responding firms' profiles									
		Gender		Age		Position		Years of experience		Years of business		Number of employees		Total asset (in $ million)		Industry sector category		Percentage of ownership	
China	73	M	40 (54.8%)	18–29	20 (24.7%)	L	44 (60.3%)	0–5	25 (34.2%)	– 20	52 (75.3%)	50	47 (64.4%)	$3 M	29 (39.7%)	P	39 (53.4%)	FO	14 (19.2%)
		F	33 (45.2%)	30–39	40 (54.8%)	M	24 (32.9%)	5–9	22 (30.1%)	20–39	15 (20.5%)	50–99	15 (20.5%)	$3 M–$6 M	26 (35.6%)	S	7 (9.6%)	DO	59 (80.8%)
				40–49	10 (13.7%)	E	5 (6.8%)	10–14	17 (23.3%)	40–59	2 (2.7%)	100–149	2 (8.2%)	$6 M–$9 M	10 (13.7%)	T	27 (37.0%)		
				60+	3 (4.1%)			15+	9 (12.3%)	60+	1 (1.4%)	150+	1 (6.8%)	$9 M+	8 (11.0%)				
Nigeria	120	M	81 (67.5%)	18–29	18 (16.8%)	L	57 (47.5%)	0–5	33 (27.5%)	– 20	49 (40.8%)	50	26 (21.7%)	$3 M	34 (28.3%)	P	30 (25.0%)	FO	40 (33.3%)
		F	39 (32.5%)	30–39	51 (47.7%)	M	41 (34.2%)	5–9	48 (40.0%)	20–39	51 (42.5%)	50–99	40 (33.3%)	$3 M–$6 M	36 (30.0%)	S	40 (33.3%)	DO	80 (66.7%)
				40–49	22 (20.6%)	E	22 (18.3%)	10–14	23 (19.2%)	40–59	20 (16.7%)	100–149	22 (18.3%)	$6 M–$9 M	30 (25.0%)	T	50 (41.7%)		
				60+	16 (15.0%)			15+	16 (13.3%0	60+	–	150+	32 (26.7%)	$9 M+	20 (16.7%)				
Uganda	121	M	76 (62.8%)	18–29	15 (12.5%)	L	41 (33.9%)	0–5	42 (34.7%)	– 20	69 (57.0%)	50	31 (25.6%)	$3 M	39 (32.2%)	P	44 (36.4%)	FO	37 (30.6%)
		F	45 (37.2%)	30–39	50 (41.7%)	M	50 (41.3%)	5–9	62 (51.2%)	20–39	40 (33.1%)	50–99	53 (43.8%)	$3 M–$6 M	44 (36.4%)	S	50 (41.3%)	DO	84 (69.4%)
				40–49	45 (37.5%)	E	30 (24.8%)	10–14	15 (12.4%)	40–59	8 (6.6%)	100–149	26 (21.5%)	$6 M–$9 M	23 (19.0%)	T	27 (22.3%)		
				60+	10 (8.3%)			15+	2 (1.7%)	60+	4 (3.3%)	150+	11 (9.1%)	$9 M+	15 (12.4%)				

Table 2 (continued)

Nation	Sample size	Respondents' profiles								Responding firms' profiles									
		Gender		Age		Position		Years of experience		Years of business		Number of employees		Total asset (in $ million)		Industry sector category		Percentage of ownership	
Total	334	M	197 (62.7%)	18–29	53 (17.7%)	L	142 (45.2%)	0–5	100 (31.8%)	– 20	173 (55.1%)	50	104 (33.1%)	$3 M	102 (32.5%)	P	113 (36.0%)	FO	91 (29.0%)
		F	117 (37.3%)	30–39	141 (47.0%)	M	115 (36.6%)	5–9	132 (42.0%)	20–39	106 (33.8%)	50–99	108 (34.4%)	$3 M–$6 M	106 (33.8%)	S	97 (30.9%)	DO	223 (71.0%)
				40–49	77 (25.7%)	E	57 (18.2%)	10–14	55 (17.5%)	40–59	30 (9.6%)	100–149	54 (17.2%)	$6 M–$9 M	63 (20.1%)	T	104 (33.1%)		
				60+	29 (9.7%)			15+	27 (8.6%)	60+	5 (1.6%)	150+	48 (15.3%)	$9 M+	43 (13.7%)				

*M male, F female, E executive, M middle manager, L low-level manager, P primary industry, S secondary industry, T tertiary industry, FO foreign, DO domestic

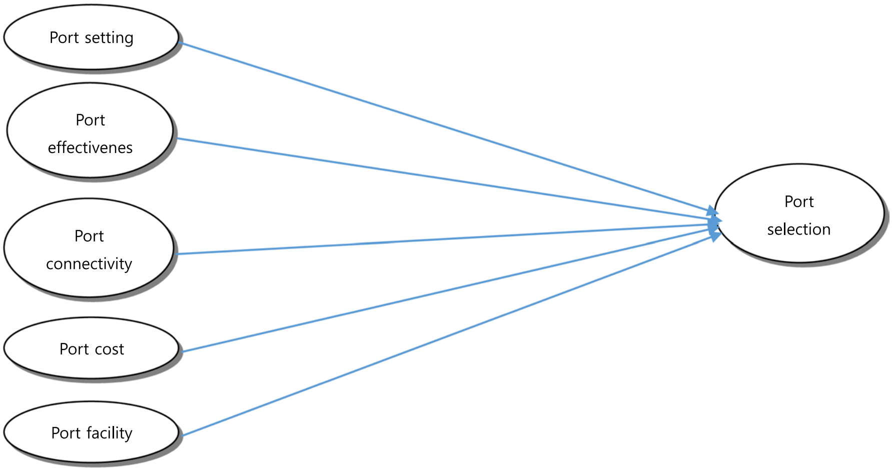

Fig. 1 A conceptual research model

correlated, we need to test for multicollinearity. Thus, we checked a variance influence factor (VIF) that determines the strength of the correlation among factors. As shown in Table 3, the VIFs of all 17 factors were below the threshold, indicating the absence of serious collinearity (Hair et al. 2020, 2022). Table 3 also reveals that some factors seem to be highly collinear and thus were combined to eliminate collinearity. Specifically, PS1 (port distance), PS2 (transit time), and PS3 (inland shipping cost) were combined into the PS123f variable. Likewise, PE1 (demurrage charge) and PE2 (cargo damage) were combined to the PE12f variable, while PE3 (quick customer response) and PE5 (customs process) were combined to become PE35f. PE4 (service quality) and PE6 (port safety and security) were combined into PE46f. For a similar reason, PF1 (the frequency of ship visits) and PF3 (service frequency) were combined into the PF13f variable.

In addition, to ensure content validity of the formative measurement model, we checked to see if the relative contribution level of outer weights and the absolute contribution level of outer loadings are statistically significant and found that their levels of significance were within the acceptable level (less than 5%) according to *t* values estimated by bootstrapping according to the analysis results summarized in Tables 3 and 4.

The results of PLS-SEM, displayed in Fig. 2, reveal that all but one criteria significantly affected a port selection decision at $\alpha = 0.05$, $|t| > 1.65$ (Hair et al. 2022). When we examined the relevance of the significant relationships suggested by Hair et al. (2022), we learned that port effectiveness turned out to be the most influential, whereas port cost was the least influential in port selection. Port effectiveness was followed by port facility and connectivity in terms of the extent of their impact on port selection. Furthermore, to assess the explanatory power of our PLS-SEM and measure the strength of an association between five port criteria and a port selection decision, we estimated the R^2 value (Shmueli 2010). The R^2 value of our model was 0.5097, exceeding 0.50 and is thus considered to

Table 3 Analysis of path coefficient values in the formative measurement model

Criteria	E−stimated item	Item content (factor)	VIF/VIF China	Outer weights		Outer loadings		Coefficient	
				Relative contribution	*t* value	Absolute contribution	*t* value	β value	*t* value
Port setting	PS1	Port distance	1.8828/**4.6196**	0.3261	2.0504	0.7425	8.7948	0.1089	1.8249
	PS2	Inland transit time	2.2058/4.8952	− 0.0286	0.1490	0.6543	6.2715		
	PS3	Inland shipping cost	1.7089/3.4391	0.3922	2.5255	0.7698	7.4971		
	PS4	Geographical location	1.3741/2.8130	0.5522	3.9381	0.8596	11.4917		
Port effectiveness	PE1	Demurrage charge	1.4775/5.3567	0.2637	2.8024	0.6766	10.7546	0.2904	3.8521
	PE2	Cargo damage	1.4318/5.4156	0.0711	0.7162	0.5739	7.9197		
	PE3	Quick customer response	1.3345/6.0816	0.3281	3.6142	0.6974	10.0517		
	PE4	Service quality	1.4740/5.2388	0.2148	2.2586	0.6519	9.8398		
	PE5	Customs process	1.5830/6.6040	0.3285	3.8397	0.7734	13.4011		
	PE6	Port safety and security	1.4269/3.9566	0.2372	2.5223	0.6657	8.8142		
Port connectivity	PC1	Handling of ship visits	1.1821/2.1549	0.2757	3.2369	0.6037	7.7288	0.2195	3.2362
	PC2	Multi-modal transfer	1.1750/2.2288	0.6098	7.5474	0.8379	18.4671		
	PC3	Service frequency	1.2254/2.6012	0.4361	5.1057	0.7397	10.8415		
Port cost	PCS1	Port charge	1.2358/3.3401	0.7337	6.7359	0.9219	18.0942	0.0698	1.3364
	PCS2	Freight rate	1.2358/3.3401	0.4308	3.3537	0.7513	8.1503		
Port facility	PF1	Port infrastructure	1.1236/1.4231	0.5795	6.2018	0.7935	10.9899	0.2158	4.0642
	PF2	Port size	1.1236/1.4231	0.6451	6.9357	0.8373	14.3736		
Overall importance	OA1	Importance of all factors	1.1160/1.8793	0.5323	10.8099	0.7548	22.4561		
	OA2	Overall port efficiency	1.1827/2.4463	0.4661	13.0911	0.7444	14.8688		
	OA3	Overall cargo handling	1.3741/2.6594	0.3823	10.9247	0.6571	11.6851		

The threshold of one-tailed *t* tests (level of significance): *$t=2.33$ ($p=0.01$), **$t=1.65$ ($p=0.05$), ***$t=1.28$ ($p=0.10$)

Table 4 Evaluating the collinearity and coefficients of a modified structural model

Criteria (indicator)	VIF	Coefficient	Standard deviation	*t* value	f^2 effect size
Port setting → overall	1.5546	0.1119	0.0585	1.9138**	0.0164
Port effectiveness → overall	1.8266	0.2839	0.0731	3.8847*	0.0900
Port connectivity → overall	1.6395	0.2198	0.0694	3.1654*	0.0601
Port cost → overall	1.5201	0.0699	0.0536	1.3034***	0.0065
Port facility → overall	1.6595	0.2210	0.0531	4.1627*	0.0600

The threshold of one-tailed *t* tests (level of significance): *$t=2.33$ ($p=0.01$), **$t=1.65$ ($p=0.05$), ***$t=1.28$ ($p=0.10$)

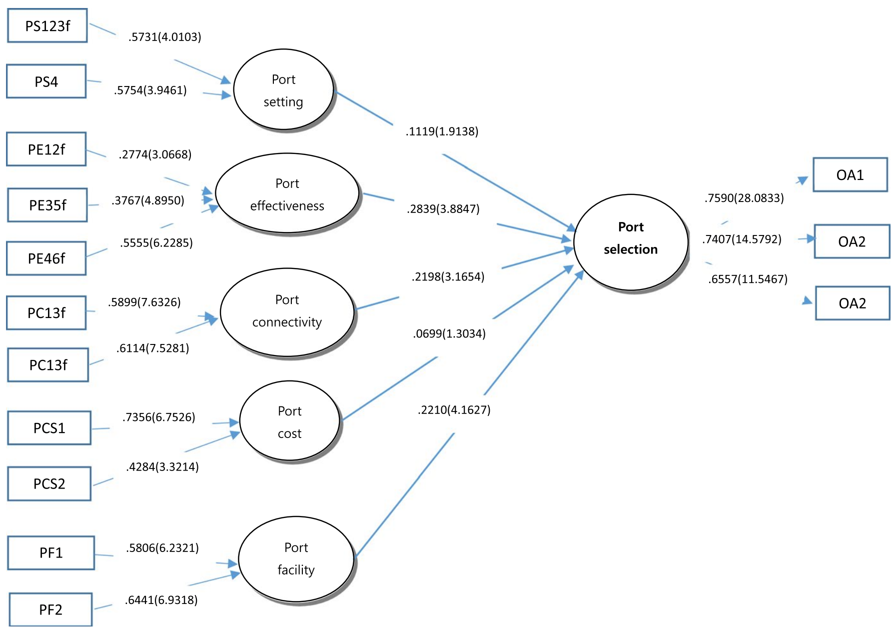

Fig. 2 The PLS_SEM results with *β* and *t* values (in parentheses)

be sufficient for explaining the association between the five criteria and the port selection decision according to the benchmark R^2 value suggested by Henseler et al. (2009) and Hair et al. (2011).

As discussed above, we found sufficient predictive power of our PLS-SEM. To assess predictive power, we followed the PLSpredict process recommended by Shmueli et al. (2016) and Shmueli et al. (2019). Specifically, we estimated prediction errors on a holdout sample, and summaries of these errors by using common prediction metrics such as root mean squared error (RMSEA), mean absolute error (MAE), and mean absolute percentage error (MAPE). Since the evaluation of the predictive power of PLS-SEM typically involves a comparison of the RMSEA and MAE of PLS-SEM with those of a naïve benchmark (e.g., linear regression model benchmark), we calculated the RMSEA and MAE for both our PLS-SEM and a linear regression model (LM) as shown in Table 5.

Table 5 shows that the RMSEA and MAE of PLS-SEM are smaller than those of an LM benchmark in two out of three Q^2predicts measuring predictive redundancy. Herein, the positive value of Q^2 prediction indicates sufficient predictive relevance (Chin 1998; Shmueli et al. 2016; Chin et al. 2020). That is to say, our PLS-SEM shows a reasonable predictive power (Cohen 1988; Shmueli et al. 2019; Hair et al. 2022).

So far, we have evaluated the validity of the proposed PLS-SEM. As a next step, we need to examine whether there exist any significant differences in priorities of port selection factors among shippers of different nationalities. When using the PLS-SEM, group comparisons among three nations (China, Nigeria, and Uganda) can be misleading unless we establish the invariance of their measures (Henseler et al. 2016; Hair et al. 2018). Therefore, we analyzed the measurement invariance of composite models (MICOM) before undertaking multigroup analyses in PLS-SEM. Table 6 summarizes the analysis results of MICOM. As shown in Table 6, the compositional invariance of certain port selection criteria cannot be verified. In addition, permutation means and permutation p value allow us to determine if there exists any significant correlation between shippers of different nationalities. In other words, we attempted to avoid any resulting bias due to national heterogeneity by following MICOM procedures. For instance, we cannot verify the compositional invariance between Chinese and Nigerian shippers for connectivity and overall port selection criteria. A separate multigroup analysis for each country is needed to avoid misinterpreting PLS-SEM analysis results.

4 importance-performance map analysis of port selection factors

Recognizing potential differences in the priority of port selection factors among shippers of different nationalities, we conducted the Importance-Performance Map (or Matrix) Analysis (IPMA) suggested by Martilla and James (1977). IPMA is designed to gauge the predictor variables' importance (priority) and performance to improve a target construct (Ringle and Sarstedt 2016). Although Min nd Park (2020) used the analytic hierarchy process (AHP) to determine the priority of port selection criteria, we use the SmartPLS 4.0 to determine the priority (or relative importance)

Table 5 The predictive power assessment using PLS predict

	Manifest variables (MV) of a target component	Q^2predict	PLS-SEM_RMSE	PLS-SEM_MAE	LM_RMSE	LM_MAE
MV or indicators	OA1	0.3258	0.7273	0.5539	0.7366	0.5510
	OA2	0.2356	0.7515	0.5919	0.7621	0.5946
	OA3	0.1593	0.9248	0.7636	0.9158	0.7505

Table 6 The cross-national assessment of compositional invariance in the MICOM procedure

Comparative Group	Criteria	Original correlation	Correlation permutation mean	5.00%	Permutation p-value	Compositional invariance established?
China vs. Nigeria	Setting	0.9974	0.8065	0.3271	0.9196	Yes
	Effectiveness	0.9157	0.9619	0.8864	0.1112	Yes
	Connectivity	0.8872	0.9763	0.9100	0.0253*	No
	Cost	0.9765	0.9520	0.8168	0.4940	Yes
	Facility	0.9386	0.9636	0.8655	0.2031	Yes
	Overall	0.9557	0.9917	0.9765	0.0046**	No
China vs. Uganda	Setting	0.8801	0.9243	0.7369	0.2321	Yes
	Effectiveness	0.9930	0.9608	0.8869	0.8441	Yes
	Connectivity	0.9628	0.9844	0.9410	0.1213	Yes
	Cost	0.7076	0.9579	0.8394	0.0076**	No
	Facility	1.0000	0.9679	0.8829	0.9865	Yes
	Overall	0.9870	0.9952	0.9858	0.0658	Yes
Nigeria vs. Uganda	Setting	0.8784	0.9596	0.8499	0.0813	Yes
	Effectiveness	0.9086	0.9115	0.7524	0.3762	Yes
	Connectivity	0.6228	0.9393	0.7687	0.0090**	No
	Cost	0.3467	0.9072	0.6588	0.0039**	No
	Facility	0.9225	0.9326	0.7577	0.3020	Yes
	Overall	0.8580	0.9730	0.9215	0.0053**	No

*Significant at $\alpha = 0.01$, **Significant at $\alpha = 0.05$

of each port selection criterion, so as to obviate any subjective bias (Höck et al. 2010; Rigdon et al. 2011; Ringle and Sarstedt 2016; Schloderer et al. 2014; Hair et al. 2022). The results of SmartPLS 4.0 are summarized in Table 7.

Table 7 indicates that priority scores of port selection criteria vary depending on the nationality of shippers. For instance, Chinese shippers regarded port connectivity as the most important criterion for choosing a port in Sub-Saharan Africa, whereas Nigerian and Ugandan shippers prioritize port effectiveness as the most important criterion. To elaborate, as summarized in Table 8, Chinese shippers tend to take port call frequency as most serious in choosing a port, while Ugandan shippers took port distance, inland transit time, and inland shipping cost most seriously, probably because Uganda is a landlocked country. Overall, shippers regarded PE46f

Table 7 A comparison of cross-national priorities of port selection criteria

Criteria	Aggregate			China			Nigeria			Uganda		
	Priority score	Performance	t-value	Priority score	Performance	t-value	Priority score	Performance	t-value	Priority score	Performance	t-value
Setting	0.0881	86.4367	1.9138**	0.0363	86.0482	0.4874	0.3131	92.4899	2.9214*	0.2010	86.6310	1.8533**
Effectiveness	0.3156	83.3341	3.8847*	0.2946	88.1567	1.6298**	0.5460	88.3252	5.4033*	0.2644	83.0835	1.1736**
Connectivity	0.1934	74.6140	3.1654*	0.3257	81.4398	2.1918**	0.1218	74.0360	1.7812**	0.1279	72.2772	1.6692**
Cost	0.0587	79.4651	1.3034***	0.0062	87.5162	0.0424	0.1251	80.9556	1.7213**	0.0597	77.6059	0.9870
Facility	0.1928	81.0558	4.1627*	0.2142	82.7958	1.7260**	0.1772	86.7024	2.1571**	0.1638	81.3901	2.7930*
Overall		79.1722			86.2820			78.7682			71.6822	

*Significant at $\alpha = 0.01$, **Significant at $\alpha = 0.05$

(Port service quality, security, and safety) as the most important factor for selecting the Sub-Saharan African port.

Before performing the IPMA, we need to test the normality of data sets collected from different multi-groups (i.e., China, Nigeria, and Uganda). Both Kolmogorov–Smirnov and Shapiro–Wilk tests confirmed *normality*. This justifies a paired *t* test that determines significant statistical differences in port selection priorities and perceived port performances among the multi-groups (Hanusz et al. 2016). As summarized in Table 9, we found significant differences in perceived port performances between Nigerian and Ugandan shippers and between Chinese and Ugandan shippers. This result is not unexpected in that Ugandan shippers have to use foreign seaports for transshipment or modal transfers since the country is landlocked. In contrast, both Chinese and Nigerian shippers can use their own seaports.

In an effort to capture factors most critical for the port selection decision and determine how well shippers feel major ports in Sub-Sahara Africa perform in terms of those factors, we develop a series of IPMA maps that allow us to formulate wise business strategies for port authorities in Sub-Saharan Africa. The IPMA map shown in Fig. 3 graphically displays the combined measures of factor importance and performance scores in a two-dimensional grid. This grid is divided into four quadrants: (1) 'concentrate here'; (2) 'keep up with the good work'; (3) 'low priority'; (4) 'possible overkill' (Martilla and James 1977). However, these four quadrant classification schemes do not indicate a sense of urgency in improving performance (Lai and Hitchcock 2015; Garver 2003; Slack 1994).

Recognizing this shortcoming, we modify the conventional IPMA map by measuring the Euclidean distances between the location of a factor and end-point A, B,

Table 8 The priority of port selection factors by nation

Aggregate			China			Nigeria			Uganda		
Factor ID	Priority	Performance	Factor ID	Priority	Performance	Factor ID	Priority	Performance	Factor ID	Priority	Performance
PS123fT	0.0456*	85.9652	PS123fC	0.0301	86.3014	PS123fN	0.1130	93.4555	PS123fU	0.1138*	79.2337
PS4T	0.0425*	86.9427	PS4C	0.1088*	83.9449	PS4N	0.2001*	91.9444	PS4U	0.0585*	82.3691
PE12fT	0.0727*	78.3648	PE12fC	0.0530**	89.6521	PE12fN	-0.0132	87.5715	PE12fU	0.0459***	65.8675
PE35fT	0.0947*	84.1074	PE35fC	0.1328	91.0089	PE35fN	0.2430*	87.0282	PE35fU	0.0448***	77.8657
PE46fT	0.1482*	85.2770	PE46fC	0.1819**	77.8654	PE46fN	0.3162*	89.2904	PE46fU	0.0656*	77.8387
PC13fT	0.1041*	74.0779	PC13fC	0.1439*	85.9589	PC13fN	0.1225*	74.0600	PC13fU	0.0656**	71.8106
PC2T	0.0893*	75.2389	PC2C	0.0019*	85.6164	PC2N	-0.0007	78.1250	PC2U	0.0964*	65.9091
PCS1T	0.0365*	79.8567	PCS1C	0.0043	88.3562	PCS1N	0.0185	86.4583	PCS1U	0.0782*	69.8347
PCS2T	0.0222*	78.8217	PCS2C	0.0935*	80.4795	PCS2N	0.1066*	80.0000	PCS2U	-0.0080	71.9008
PF1T	0.0926*	83.0414	PF1C	0.1207*	84.5890	PF1N	0.0497	93.7500	PF1U	0.1068*	73.9669
PF2T	0.1002*	79.2197	PF2C	0.0192*	75.6164	PF2N	0.1275*	83.9583	PF2U	0.1092*	71.2810
Overall		79.1722	Overall		86.2863	Overall		78.7682	Overall		71.6822

1. T was added to the factor ID for the aggregate data; C was added to the factor ID for China; N was added to the factor ID for Nigeria; U was added to the factor ID for Uganda

2. Significance of priority scores: *$\alpha = 0.10$, **$\alpha = 0.05$, ***$\alpha = 0.01$ (bootstrapping *t* value)

Table 9 Paired *t* test results

		Paired differences					t-value	Degree of freedom	Two-tail test significance (p-value)
		Mean	Standard deviation	Average standard error	95% confidence interval				
					Lower limit	Upper limit			
Pair 1	Priorities of China vs. Nigeria	-0.0369	0.1213	0.0366	-0.1184	0.0446	-1.0096	10	0.3365
Pair 2	Priorities of Nigeria vs. Uganda	0.0460	0.1163	0.0351	-0.0321	0.1242	1.3128	10	0.2186
Pair 3	Priorities of Uganda vs. China	-0.0091	0.0649	0.0196	-0.0527	0.0345	-0.4662	10	0.6510
Pair 4	Performances of China vs. Nigeria	-0.6417	6.6928	2.0180	-5.1380	3.8546	-0.3180	10	0.7570
Pair 5	Performances of Nigeria vs. Uganda	12.5240	5.5051	1.6599	8.8256	16.2224	7.5452	10	0.0000
Pair 6	Performances of Uganda vs. China	-11.8823	5.5738	1.6806	-15.6268	-8.1377	-7.0704	10	0.0000

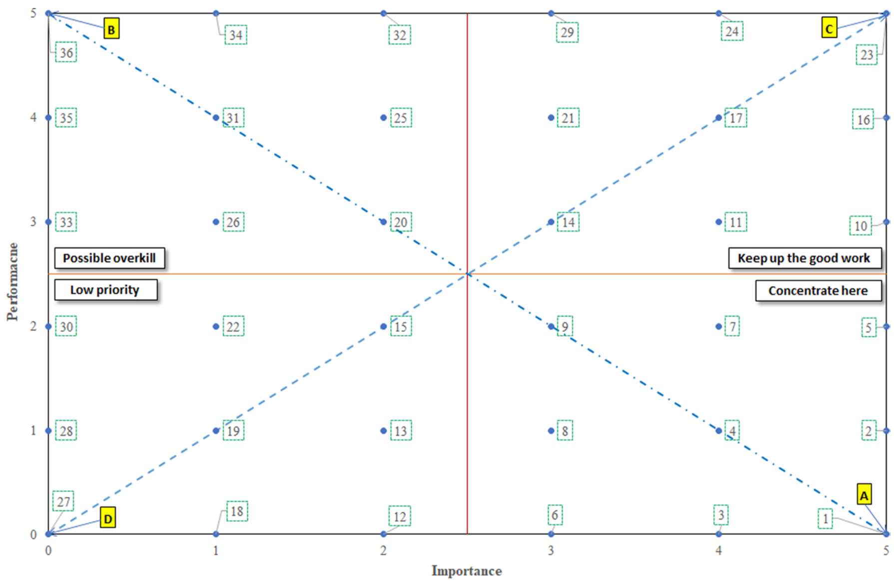

Fig. 3 Four quadrants of the IPMA Grid

C, or D and then gauging the degree of urgency. For example, if a distance between the factor and the end-point A is short, while the distance from end-point B is long, the sense of urgency is greater.

This distance can be calculated from Eq. (1).

$$u_i = \left[\alpha \left(\frac{\sqrt{\{100(x_m - x_i)\}^2 + (y_i - y_0)^2}}{\sqrt{\{100(x_m - x_0)\}^2 + (y_n - y_0)^2}} \right) + \beta \left(\frac{\sqrt{\{100(x_m - x_i)\}^2 + (y_n - y_i)^2}}{\sqrt{\{100(x_m - x_0)\}^2 + (y_n - y_0)^2}} \right) \right] / 2, \tag{1}$$

where (x_m, y_0) = A coordinate; (x_0, y_n) = B coordinate; $(x_{m},_{in}$ = C Coordinate; (x_i, y_i) = factor i's coordinate; α = estimated weight of performance = 1; β = estimated weight of priority = 0.05.

The smaller the u_i, the more urgent the strategic action is.

4.1 Results of IPMA for all shippers

As shown in Fig. 4, PC13fT (ship handling at the port and port services), PC2T (multi-modal transfer links), and PF2T (port size) are in the 'concentrate here' quadrant of the IPMA map. On the other hand, the factors PS4T (geographical location) and PS123T (port distance, inland transit time, and inland shipping cost) are in the 'possible overkill' quadrant, indicating that too much emphasis was placed on factors with limited impact on port performance. As such, port authorities should redirect their efforts and resources to PC13fT (ship handling and port services), PC2T (multimodal transfer links), and PF2T (port size), instead of PS4T (geographical location) and PS123T (port distance, inland transit time, and inland shipping cost). Table 10 also indicates that PC13fT (ship handling at the port and port services) have the greatest sense of urgency in developing strategic actions for improving port performance. PC2T (multimodal links) happens to be another factor that deserves close attention for improvement, due to its second-highest urgency ranking. In particular, it should be noted that although PC13fT (port connectivity in terms of ship handling at the port and port services) have a relatively high importance score (0.1041), its impact on port performance (74.0779) is relatively low, as recapitulated in Table 10. Table 10 indicates that a 1-unit increase in its performance from 74.0779 to 75.0779 would lead to a 0.1041 improvement (from 79.1722 to 79.2763) in the overall port performance.

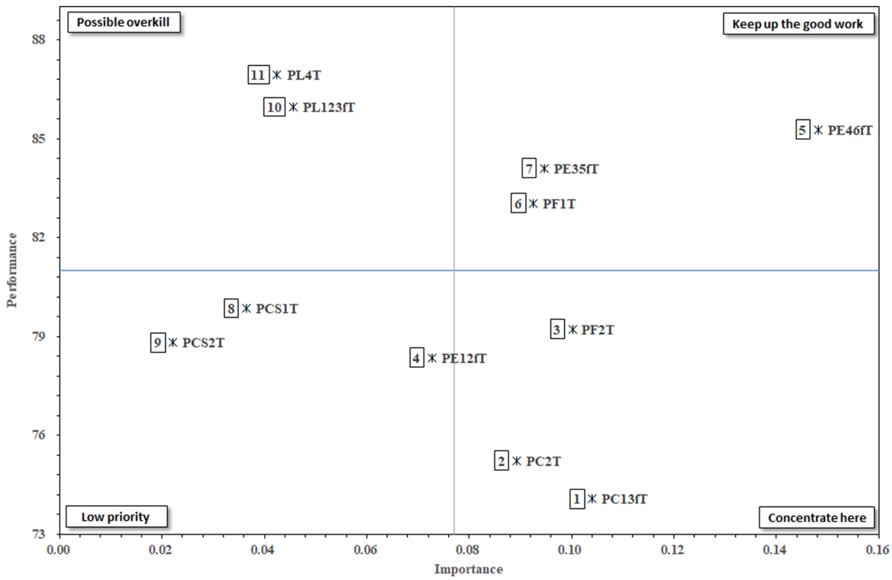

Fig. 4 IMPA map for the entire shippers

Table 10 A summary of the degree of urgency for strategic actions

Entire sample			China			Nigeria			Uganda		
Factor ID	U_i index	Urgency ranking	Factor ID	U_i index	Urgency ranking	Factor ID	U_i index	Urgency ranking	Factor ID	U_i index	Urgency ranking
PL123fT	0.3952	10	PL123fC	0.3542	8	PL123fN	0.3197	7	PL123fU	0.3097	7
PL4T	0.4161	11	PL4C	0.2268	5	PL4N	0.2448	4	PL4U	0.4050	11
PE12fT	0.2416	4	PE12fC	0.3619	9	PE12fN	0.4040	11	PE12fU	0.2439	5
PE35fT	0.2937	7	PE35fC	0.3072	6	PE35fN	0.1767	1	PE35fU	0.3555	9
PE46fT	0.2769	5	PE46fC	0.0800	1	PE46fN	0.1773	2	PE46fU	0.3310	8
PC13fT	0.1434	1	PC13fC	0.2233	4	PC13fN	0.2261	3	PC13fU	0.2550	6
PC2T	0.1810	2	PC2C	0.3891	10	PC2N	0.3643	8	PC2U	0.1563	1
PCS1T	0.3291	8	PCS1C	0.4110	11	PCS1N	0.3671	9	PCS1U	0.2165	3
PCS2T	0.3495	9	PCS2C	0.2094	2	PCS2N	0.2529	6	PCS2U	0.3704	10
PF1T	0.2772	6	PF1C	0.2226	3	PF1N	0.3757	10	PF1U	0.2335	4
PF2T	0.2033	3	PF2C	0.3096	7	PF2N	0.2474	5	PF2U	0.1933	2
Overall	79.1722		Overall	86.2863		Overall	78.7682		Overall	71.6822	

1. T was added to the factor ID for the aggregate data; C was added to the factor ID for China; N was added to the factor ID for Nigeria; U was added to the factor ID for Uganda

4.2 Results of IPMA for the cross-national (Chinese, Nigerian, and Ugandan) shippers

As summarized in Table 8, among Chinese shippers, PC13fC (ship handling at the port and port services), PC2C (multi-modal transfer links), PE46fC (service quality and safety/security), PF2C (port size), PE12fC (demurrage charge and freight damage), and PF1C (port infrastructure) factors are considered relatively important in their port selection; their importance scores are at least 0.0909 or higher. Generally, Chinese shippers feel satisfied with port performances, given that their overall perceived port performance was the highest (86.2863), as shown in Table 8. Unlike Nigerian and Ugandan shippers, they thought that PE46fC (port service quality, safety, and security), PCS2C (freight rate), and PS4C (geographical location) factors needed closer attention for improvement given their highest urgency rankings, as shown in Tables 8 and 10. They also belong to the 'concentrate here' quadrant of the IPMA map displayed in Fig. 5.

Similar to Chinese shippers, Nigerian shippers tend to regard PE46fN (port service quality, safety, and security), PE35fN (quick customer response and customs process), PL4N (geographical location), PF2N (port size), PC13fN (ship handing at the port and multimodal transfer links), PS123fN (port distance, inland transit time, and inland shipping cost), and PCS2N (freight rate) as important factors for their port selection as shown in Fig. 6. These findings are mostly congruent with those of Ugboma et al. (2006) and Ogwuegbuchunam (2013). However, their sense of urgency seems to differ somewhat from their Chinese counterparts in that they feel that the PE35fN (quick customer response and customs process) factor needs more attention than any other factor, in terms of improving port performance.

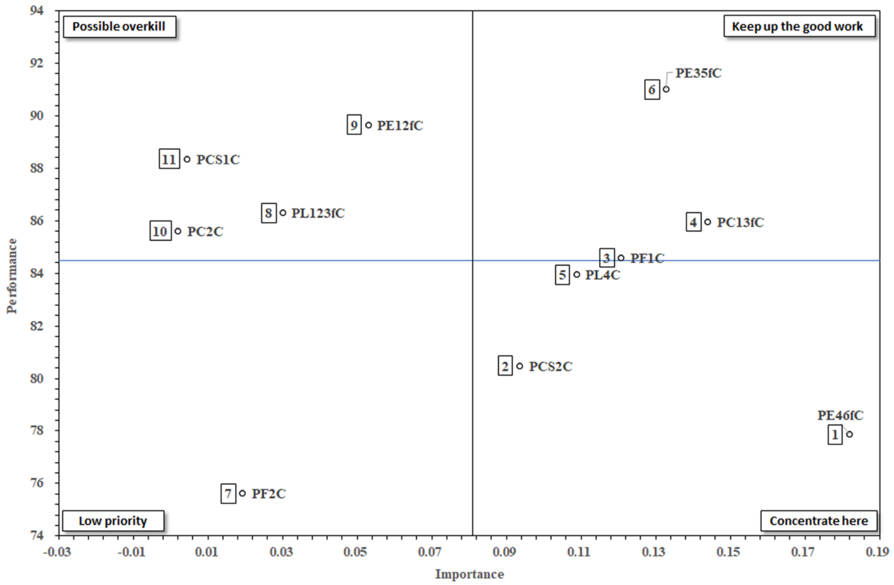

Fig. 5 IMPA map for China shipper

In contrast with Chinese and Nigerian shippers, Ugandan shippers valued PS123fU (port distance, inland transit time, and inland shipping cost) the most, as shown in Fig. 7. Their perceived overall port performance value was the lowest (71.6822) compared to Chinese and Nigerian shippers. The rationale is that Ugandan shippers are known to rely for their foreign trade either on the port of Mombasa, Kenya, which is 1200 km away from Kampala, or on the port of Dar-es-salaam, Tanzania, which is 1600 km away from Kampala, due to the country's landlocked situation. To make things worse, Ugandan shippers often have to use underdeveloped, archaic, inland ports (e.g., the ports of Jinja near the Victoria Lake, Kisumu, Kenya, and Musoma, Tanzania) as transshipment facilities (UNECA 2010; Bhattacharjee 2022). This is why Ugandan shippers have had the highest sense of urgency for the PC2U (multi-modal transfer links), PF2U (port size), and PCS1U (port charge) factors for improving port performance. It is noted that, according to the Shippers' Council of East Africa, the cost of shipping from Kampala to Mombasa is the highest ($2.50 per ton) in East Africa, being well above the average shipping cost ($1.80 per ton) in that region (Anami 2022). In particular, the Ugandan port authority should pay much closer attention to port connectivity issues related to multimodal transfer capabilities, since the PC2U factor has the highest importance in port selection, but its performance is relatively poor, with a score of 65.9091, substantially below the overall performance score of 71.6822.

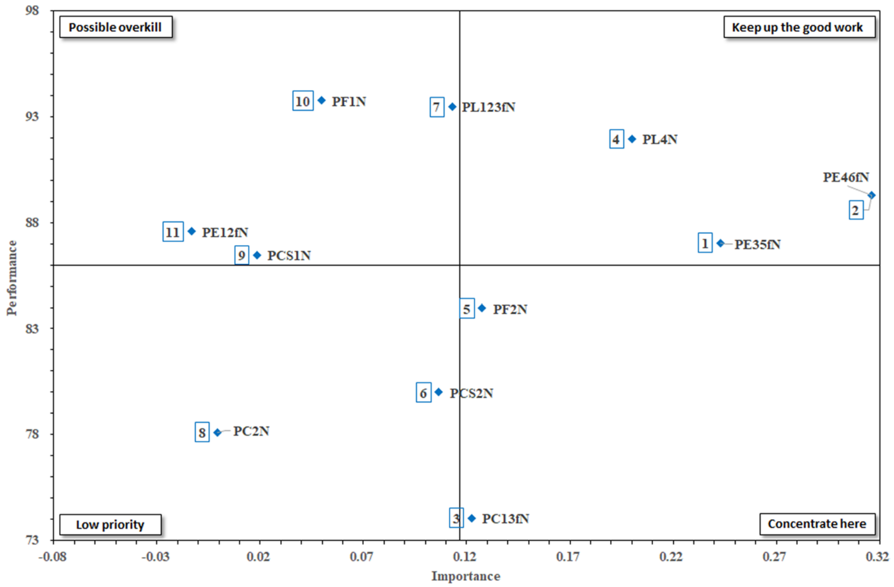

Fig. 6 IMPA map for Nigeria shipper

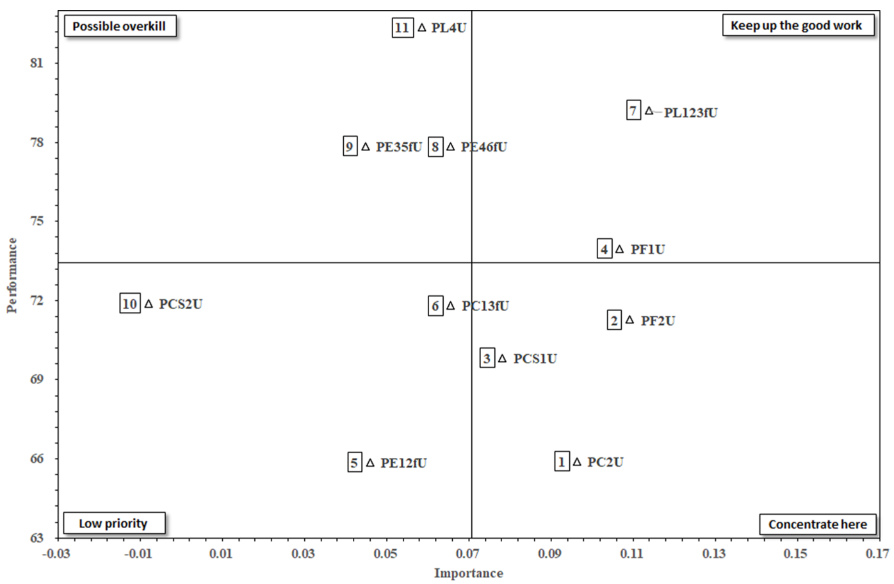

Fig. 7 IMPA map for Uganda shipper

5 Conclusions and future research directions

The paper identifies specific port selection factors and examines their role in port selection decisions in Sub-Saharan Africa, from a cross-national shippers' perspective. Thus, the paper brings in those underdeveloped countries' perspectives, missing in the existing port selection literature. This paper also makes a theoretical contribution to the current body of literature by conducting the importance-performance map analysis (IPMA) to determine the prioritized port selection factors most crucial for improving port performances in Sub-Saharan Africa. In so doing, the paper proposes the modified IPMA by developing a mathematical equation that allows us to gauge the sense of urgency for taking the strategic action plan needed for port performance improvement. The proposed modified IPMA helps policymakers (e.g., port authorities) identify the prioritized strategic action plans while assisting them to better utilize their limited resources by reassigning them from overinvested areas to underinvested ones.

In closing, this study found that the priorities of port selection factors varied depending on shipper nationality and geography (especially landlocked vs. coastal situations). This finding indicates that strategic action plans customized for each shipper's nationality should be developed rather than adopting the "one-size-fits-all" port development strategies (Slack 2001; Moglia and Sanguineri 2003; van der Lugt 2017). For instance, our IPMS analyses revealed that Chinese shippers viewed port connectivity as the most critical factor for their selection of Sub-Saharan African ports, while Nigerian and Ugandan shippers regarded port effectiveness as the most important port selection criterion. Specifically, the Chinese shippers prioritized port services, safety/security, and multi-modal transfers over the other factors in their port selection decision. Therefore, the port authorities in Sub-Sharan Africa need to pay closer attention to the improvement of port services, safety/securities, and multi-modal connectivity than before to attract more Chinese shippers. In addition, it is noted that differences in the perceived importance of port selection factors between Ugandan and Chinese shippers might be attributed to the fact that Sub-Saharan African inland ports differ radically from Chinese inland ports in that the landlocked geography heavily constrains the former, whereas the latter was not (Haralambides et al. 2011; Yang and Chang 2019; Ahnsah et al. 2020).

As noted above, this paper focused on the East African port selection behavior exhibited by Ugandan, Nigerian, and Chinese shippers. As such, our findings cannot be generalized to other African (e.g., South or North African) situations. Given the future economic potential of Sub-Saharan Africa, this study can be extended to include other underdeveloped African countries such as Sudan, Namibia, Congo, and Malawi. Another line of research that is needed in the future includes the comparisons of opinions regarding port selection among shippers, carriers, and third-party logistics providers (3PLs).

Data availability Some of the non-confidential data will be available from the authors upon request.

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