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Digital Transformation and Mobilization of Port Revenues at the Autonomous Port of Douala

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ABSTRACT

The objective of this study is to analyze the contribution of digitalization on the mobilization of port revenues at the autonomous port of Douala (PAD) in Cameroon. To achieve this, the method we used is inspired by a model for estimating [1]. who explicitly took into account the role of digitalization supports in tax mobilization. The secondary data used cover the period 2010-2023 and come from several databases, including: INS, DGD, MINFI, WEO, WDI, PAD, etc. These were processed with SPSS 2017 software. Our results, through components such as CAMCIS and e-GUCE, show that digitalization positively influences the mobilization of port revenues. However, the use of the Internet of Things has negative and insignificant effects on the performance of port revenues.

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Introduction

Digital transformation is a requirement of port supply chain systems to withstand the competitiveness of global port platforms and create new revenues and commercial value chains, thanks to a centralized digital tool that maximizes the use of information [1, 2]. Digitalization has enabled the development of the maritime supply chain in recent years [3, 4]. The primary function of a port organization is to provide dematerialized port passage services to ensure collective intelligence between the different parts of the port space [5, 6].

The work of concludes that a digital port supply chain is an efficient process that generates new business revenues for firms through the exploitation of new digital and analytical approaches and methods [7-9]. Frederico by defining the port supply chain uses disruptive technologies of Industry 4.0 to streamline port supply chain activities and relationships to create strategic advantages for all stakeholders. The studies of emphasize that the alignment of ICT with the port business firstly ensures value creation and experience improvement. In this perspective, two conceptions are visible: the implementation of new digital technologies in the port Supply Chain allowing the creation of commercial relations and the second is linked to the roles of these technologies in the transformation and operational performance of ports [10, 11].

Globally, the port sector was among the first to digitize its logistics operations and processes WCO, 2023. Since then, information-sharing platforms, such as the port community based on Electronic Data Interchange (EDI), have been established. Today, some global ports are being operated and optimized to facilitate trade, as well as single window programs, customs revenue security, and digitalized e-commerce [12].

For Onguene , 2022, we have moved from manual management of information flows to more optimal management based on the port information system [13]. Indeed, for port ecosystems, intangible digital infrastructures have become at the same level as physical infrastructures as an economic priority. The competitiveness of a port is measured by its speed and the effectiveness/efficiency of its terminals, as well as the quality of the service offered [2]. The port being a space of transit and passage of goods should be an easy and quick exercise for the collection of port revenues which contribute to the budget of a State and consequently to inclusive growth [14-17].

According to Dossa and Bakena , 2024 several empirical studies have looked at the relationship between digitalization and tax performance [1]. But just like the theories in this area, the empirical conclusions are not unequivocal. For some, there is a positive relationship between digital transformation and tax performance. While some authors conclude that there is no linear relationship between the two concepts. The effect of digitalization on tax revenue mobilization is conditioned by other institutional factors. Another group of authors finds negative effects of digitalization on tax performance. The digitalization of a port or port platform involves the use of advanced digital technologies to optimize port revenue under certain conditions. For the latter, dematerialization can contribute to the narrowing of the tax base because of the difficulties in broadening the tax base to include most of the services and intangible products sold over the internet to households [18, 19].

In this article, we understand the performance of port revenues through the mobilization or improvement of port resources. From the above developments arises the following question: What is the contribution of the digitalization of the Autonomous Port of Douala (PAD) on the mobilization of port revenues? The objective of this work is to evaluate the effect of digitalization on the mobilization of port revenues at the PAD. The structure of our study will be structured around a (i) review of theoretical and empirical literature, (ii) a methodology, (iii) analysis of results and discussions, (iv) finally the conclusion and the implications for economic policy.

Literature Review

Theoretical Literature

The economic literature used to assess the mobilization of public revenue is multifaceted and is based on traditional and modern theories [17]. The neoclassical theory of optimal taxation is based on minimizing the impact of state intervention in the economy. This rule ensures that goods for which the compensated demand varies little as a function of all prices must then be relatively more heavily taxed [20]. The capture, measurement, control, storage, processing and distribution of information and collecting, transforming and transmitting information" [21, 22]. Thus, taxation constitutes a central element of public policies and their economic consequences are considerable [23]. In line with these traditional theories, we can also cite the Pigouvian tax (Pigou, 1920), the theory of fiscal exchange Niskanen, the theory of public choices [24-26, 17].

Modern theories that incorporate optimal taxation Mirrlees, 1971, institutional theory and the theory of New Public Economy Alesina, 1987; Alesina and Roubini, 1992 argue that the improvement of tax performance is accompanied by technological advances. Dematerialization must address the problem of information asymmetry in the context of divergence of interest (agency theory and its costs) due to opportunistic users (Fama, 1980). The diversity of actors and their preferences influence the progress of any technological project (Alsène, 1990). There is then an interaction between digitalization with its rules and resources and the organization, this interaction makes dematerialization as a social product of human action. Emphasizes that there is an interaction between information systems, actors and social systems while considers technology as structuring the uses that are made of it. The need for user involvement within the technical system [27-31].

Empirical Literature

Empirical studies related to port revenue mobilization in both developing and developed countries are quite extensive. Several studies have focused on the relationship between digitalization and the mobilization of port resources. They specify that port digitalization allows the customs administration to have a large volume of data on the basis of optimal management and to reconstruct the tax base and thus detect missing declarations or attempts at customs fraud. Port digitalization constitutes one of the openings for ports in developing countries to meet the challenges of collecting their own resources. Dematerialization occupies an important place in the management of the port supply chain as well as the contribution of exchange and circulation of data on performance and that these systems are very numerous and diversified Bayraktar et al., 2009 and can be classified into three main categories namely the Extended Enterprise IS (IS Enterprise-Wide) which contains ERP capable of integrating and optimizing transactions in the organization.

The empirical analysis of the work assessing the effect of digitalization on the performance of port revenues seems to date back to the study of based on descriptive methods, this result is identical to that of Yamen et al, 2023 who used a similar model, the same global digitalization index and the same estimation technique. The notion of Big Data (BD) is a term that describes the large volume of structured and unstructured data that organizations regularly manage. In view of the large mass of this data, their analysis makes it possible to select the most important ones that serve for better decision-making for port stakeholders. According to Wamba et al., 2015 from a management point of view, (BD) is a global approach to obtaining actionable information in order to create a competitive advantage.

Thus, according to the analysis of Big Data is developed from a 5V perspective relating to: volume, speed, variety, veracity and value. In this sphere of digitalization, firms are increasingly aware of the imperative of analyzing big data. From the perspective of DSC, claimed that big data analytics (BDA) helps reduce order-to-delivery times, improve customer relationships, and increase the efficiency and competitiveness of the port supply chain. Other authors demonstrated the positive impact of (BDA) on port revenue performance. Other studies have used more sophisticated models and estimation methods. For example, uses a panel model on a sample of 27 European Union Member States during the period 2015-2019. He finds via the generalized method of moments (GMM) that the digitalization of public services strengthens the mobilization of tax revenues.

The work of on (IoT) has demonstrated impacts on the port supply chain, by enabling the connection of products circulating in this chain and also to provide and track real-time information on its products, which improves revenue visibility. However, apart from its positive impacts, (IoT) can create potential threats to business security and stakeholder privacy. In their study covering 102 developing countries during the period 1995-2015, using a panel model and resorting to the generalized method of moments [15]. Shows that the increase in internet use is associated with a greater extent of reform and tax revenues in developing countries. Using a panel of 41 sub-Saharan African countries and 33 OECD countries and using the generalized method of moments find that digitalization promotes economic growth and thereby increases port revenues [16].

For Cloud Computing allows for improved integration with other digital technologies, due to the considerable exchange of data throughout supply chains. Using a fixed effects panel model and a Within estimator on 96 developing countries over the period 2005-2016, find that the diffusion of ICTs positively affects public revenues. For in Nigeria digitalization negatively influences the compliance of public revenues. Use a sample of 54 African countries and estimate a panel data model by Generalized Least Squares (GLS) over the period 1996-2019 and conclude that digital transformation significantly stimulates public revenue mobilization in Africa [17].

In summary, the literature on the relationship between digital transformation and port revenue mobilization is not unambiguous theoretically, let alone empirically. Beyond a positive correlation it can generate, the digitalization of the economy raises questions. Thus, additional and in-depth research is needed to better guide public authorities.

Methodology

The methodology adopted in this study is divided into three parts: data presentation, model specification and estimation technique.

Presentation of Data

As part of our study, the secondary data used cover the period 2010-2023 and come from several databases. We have in particular statistics from the INS, the DGD, the MINFI, the WEO, the WDI, the PAD, WGI and the World Bank. The choice of the study period is linked to the availability of data but also to the digitalization dynamics undertaken at the PAD since 2010. The operationalization of the variables is presented in the form of a summary (table 1) which condenses the explanatory variables and variables to be explained, the indicators, the modalities, as well as their respective sources and expected signs.

Table 1: Operationalization of Study Variables

Variables	Definitions	Signs	Data sources
Variable to be explained M _ *ris i*	Variables to be explained: level of mobilization of port revenues		(PAD, 2024)
Explanatory variables			
NuCamcis	Use of the Cameroon Customs Information System (CAMCIS)	+	(WGI, 2024)
e- guce_hd	electronic and broadband foreign trade	+	(WGI, 2024)
Nuia	Users of artificial intelligence in terminals	+	(WGI, 2024)
Nuido	Using the Internet of Things	-	(WGI, 2024)
Clo_com	Cloud Computing	+/-	(WGI, 2024)
Nufe	Electronic invoicing		(WGI, 2024)
Tale	Bill of leading (maritime transport document) electronic	+	(WGI, 2024)
Iume	Indicator of use of electronic or robotic handling	-	(WGI, 2024)
Big Data	Use of Big Data by Shipping Agents	-	(WGI, 2024)
SCS	Exploitation of cyber security programs	+	(WGI, 2024)
Block Chain	improving the performance of sustainable maritime transport	+/-	(WGI, 2024)
Cargo_Web	Business Software Package Index for PAD	+	(WGI, 2024)
SIP	Smart Ports Indicator	+	(WGI, 2024)

Source: Author from data

Model Specification

The specification of this study is inspired by the model used by [1] who explicitly took into account the role of digitalization supports in tax mobilization, unlike the traditional models often used. Their work analyzes tax mobilization through the prism of the volume of tax revenues, but is limited to tax pressure through digitalization factors.

The model is specified as follows:

$\mathbf{M\_r}\,\boldsymbol{is} = \boldsymbol{f}\,(\mathbf{Y}) = \beta_0 + \beta_1\, Nu$ Camcis $i\,, t + \beta_2$ e- guce_hd $i\,, t + \beta_3$Nuia $i\,, t + \beta_4$ Nuido $i\,, t + \beta_5\, Urb\, i\,, t + \beta_6$ Clo $\_\ com\ i$, □ $+ \beta_7$ Nufe $i\ i\,, t + \beta_8 + \beta_9$ Iume $+ \beta_{10}$ Big _ data $i\,, t + \beta_{11}$ SCS $i\,, t + \beta_{12}$ Block _ Chain $i\,, t + \beta_{13}$ Cargo _ Web $i\,, t + \beta$ 14 SIP $i\,, t + \mu\, i + \delta\, t + i\,, t$

Where $\mathbf{M\_}\boldsymbol{ris}$ represents the mobilization of port revenues, $\mathbf{Y}$ = (Camcis, e- guce_hd, Nuia, Nuido i, Urb, Clo $\_\ com$…….) represents the vector of explanatory variables making it possible to capture the level of port digitalization at the PAD by following the empirical work of Rioppel et al. (2021) who also tried to highlight the contribution of port digitalization to the mobilization of port revenues. $\boldsymbol{\mu}$ represents the unobserved specific effect, $\boldsymbol{\delta\, t}$ the temporal effect common to all digital tools and $\boldsymbol{\varepsilon\, i}$, the error term. $\boldsymbol{\beta\ i\ i} = \{\mathbf{0}, \ldots, \mathbf{14}\}$ $\boldsymbol{et\ \alpha\ j, j} = \{\mathbf{0}, \ldots, 9\}$ are parameters to be estimated.

Estimation Technical

In this study, data analysis is done using a multiple linear regression model. Before proceeding with the multiple regression, we performed a dimension reduction to construct indicators of port digitalization and port revenue mobilization from the indicators and scales present in the operationalization table of the variables present in Table 1. This construction was done using Multiple Component Analysis (MCA), a method adapted to the reduction of the dimensions of qualitative variables.

Results and Discussions

The results of multiple linear regression will be presented. We present respectively the contribution of the use of a CAMCIS, e- guce, IA, Iod, of a SIP, Cargo web on the mobilization of port revenues. The results of the regression are contained in the table below. The modeling is chosen based on the overall significance and the set of significant parameters.

Table 2: Estimation of the Contribution of Digitalization to the Mobilization of Port Revenues

Coefficients [a]						
Model		**Unstandardized coefficients**		**Standardized coefficients**	**t**	**Sig .**
		B	**Standard error**	**Beta**		
1	(Constant)	0.864	0.726		1,541	0.127
	Use of the Cameroon Customs Information System (CAMCIS)	0.012	0.231	0.448	-0.082	0.000
	electronic and broadband foreign trade	0.064	0.267	0.147	0.444	0.075
	Users of artificial intelligence in terminals	-0.415	0.220	-0.258	-2,624	0.320
	Using the Internet of Things	-0.474	0.098	-0.820	-3,829	0.430
	Cloud Computing	0.346	0.075	0.606	3,896	0.006
	Electronic invoicing	0.120	0.205	0.122	-1,129	0.357
	Bill of leading (maritime transport document) electronic	0.012	0.1	0.001	-0.034	0, 334
	Indicator of use of electronic or robotic handling	-0.064	0.567	-0.007	0.044	0.058
	Use of Big Data by Shipping Agents	-0.415	0.220	-0.258	-2,624	0.220
	Exploitation of cyber security programs	0.474	0.008	-0.520	-2,829	0.011
	improving the performance of sustainable maritime transport	-0.004	0.003	-0.020	-1,009	0.671
	Business Software Package Index for PAD					
		0.114	0.004	-0.220	-3,339	0.071
	Smart Ports Indicator	-0.112	0.067	-0, 330	-1,345	0.056
a. Variable to be explained: mobilization of port revenues						

Source: Author from SPSS

Effect of the use of the Cameroon Customs Information System (CAMCIS) on the Mobilization of Port Revenues
the results of our regression show that digitalization through CAMCIS has positive and significant effects on the mobilization of port revenues. The associated coefficient is at the threshold of 1% (0.000). This means that digitalization positively influences the mobilization of port revenues. The more the different port actors of the PAD are interconnected in CAMCIS, the more the public authorities mobilize more and better customs and port revenues. These results are in line with the work of (Dossa and Bakena , 2024)[1]. This is justified by considering digitalization as a contribution to the establishment of a credible environment for the transparency of public revenue collection.

Effect of the High-Speed Electronic Single Window for Foreign Trade
The results from our regression mean that the coefficient associated with an e- Guce is positive and significant at the 10% threshold (0.075). This leads us to conclude that the digitalization of the single window for foreign trade (GUCE) by an e-GUCE positively influences the mobilization of port revenues in the PAD of Cameroon. As shown by the work of (Gnangnon and Brun, 2018), the growing role of ICT supporting digitalization facilitates the collection of revenues and the centralization of these revenues, allowing for better tax governance [15].

Effect of the use of Artificial Intelligence in Port Terminals on Revenue Mobilization
It emerges from our regression that the coefficient associated with the implementation of artificial intelligence (AI) is insignificant, because its threshold is 0.320. This leads us to invalidate the hypothesis that the use of AI in PAD port terminals significantly influences the mobilization of port revenues. Therefore, AI does not explain the performance of port revenue mobilization.

Effect of the use of the Internet of Things at the PAD on the Mobilization of Port Revenues
The use of the Internet of Things has negative and statistically insignificant effects at the 0.430 threshold on port revenue mobilization. This negative effect on revenue mobilization can be explained by the inability of port authorities to deploy their collection and control strategies by integrating this tool.

Effect of using Cloud Computing on Revenue Mobilization
The results of the regression analyses establish that the cloud computing has a positive influence at the threshold of 0.006 on the performance of port revenue mobilization. These results are similar to those obtained by a number of authors, including those of: Thierry, who have conducted similar studies.

Effect of Electronic Invoicing on the Mobilization of Port Revenues
The practices of using electronic invoices in all port activities improve the mobilization of port revenues at the threshold of 0.357. However, the hypothesis that electronic invoicing could have a positive influence on the mobilization of port revenues is rejected, which seems similar to the results obtained. Electronic invoicing allows for the improvement of financial governance, better mobilization of PAD financial resources, and the reduction of transaction costs by making port revenue collection more efficient.

Effect of the Electronic Bill of Leading (Maritime Transport Document)

The regression results indicate that the coefficient associated with a maritime transport document is positive and significant at the 10% threshold (0.334). Its use leads to an increase in cross-border trade between countries. These trades are often subject to controls, thus allowing for better mobilization of port tax revenues on the PAD. The development of port activities is generally carried out within a structured framework given the requirement for certain port infrastructures.

From the indicator of use of electronic or robotic handling to the indicator of Smart Ports, the regression results have negative and statistically insignificant effects at the respective thresholds of : 0.058; 0220 ; 0.011; 0.671; 0.071; 0.056. The negative contribution of the shares of these variables can be explained by the difficulty of port authorities to appropriate these new tools, but also the ability to mobilize the means to implement them. This state of affairs does not facilitate the compliance of the mobilization of port revenues. Control of corruption does not limit the revenue losses linked to the bargaining of authorities who divert port revenues to their own benefit.

Conclusion

This paper aimed to analyze the contribution of digital transformation on the mobilization of port revenues. Theoretical and empirical work on the relationship between digitalization and the mobilization of port revenues is not unequivocal. Dematerialization offers efficient means in terms of performance for the mobilization of revenues. However, in addition to the benefits it can generate, it is a source of questions. It has controversial effects on the use of the Internet of Things. It can have a significantly negative effect on the indicator of use of electronic or robotic handling to the indicator of Smart Ports. Referring to the theories of endogenous growth, we note that digitalization by contributing to the reduction of transaction costs promotes economic activity and has a significantly positive effect on the mobilization of port revenues in the Cameroonian PAD.

We specified a multiple linear regression model by introducing the digitalization variables as explanatory variables. Statistical tests of the statistical series and validation of the models allowed us to make estimates. The results indicate overall from digitalization through its components that: digitalization positively influences the mobilization of port revenues. Digitalization through CAMCIS has positive and significant effects on the mobilization of port revenues. The associated coefficient is at the threshold of 1% (0.000). The digitalization of the single window for foreign trade (GUCE) by an e-GUCE positively influences the mobilization of port revenues in the PAD of Cameroon. The results of the regression analyses establish that the cloud computing has a positive influence at the threshold of 0.006 on the performance of port revenue mobilization.

Furthermore, the use of the Internet of Things has negative and statistically insignificant effects at the threshold of 0.430 on the mobilization of port revenues. Also, from the indicator of use of electronic or robotic handling to the indicator of Smart Ports, the results of the regression have negative and statistically insignificant effects.

Based on these results, we suggest to the public authorities of the PAD of Cameroon some economic policy measures likely to contribute more to the mobilization of port revenues:

- To establish the PCS, a project that will take at least three years and is a solution adapted to 4th generation smart ports.
- To insert the module that will facilitate the export of goods in a cargo web, using the customs declaration as a reference document, serving as an export manifest upon entry of goods to the PAD.
- An interconnection between PAD terminals and the authorities, in addition to terminal operators, in order to facilitate the monitoring and control of the passage of goods in a comprehensive manner.
- Nationalize the management of port terminals, which should comply with digital standards for the export or import of goods, and enable the PAD to gain more in terms of efficiency and competitiveness at the same rate as other competing ports in Africa.
- These recommendations should help improve port revenue generation. These solutions are not only relevant to port terminals, but could also be adapted to other sectors of activity within the port platform of the autonomous port of Douala in Cameroon.

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